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ANNOTATED BIBLIOGRAPHY OF ENVIRONMENTAL STUDIES ON THE PAJARITO PLATEAU

Roger W. Ferenbaugh

INTRODUCTION

In September of 1999, the Department of Energy (DOE) issued the Record of Decision (ROD) for the Site-Wide Environmental Impact Statement (SWEIS) for Continued Operation of the Los Alamos National Laboratory in the State of New Mexico. Commitments in the ROD included a number of mitigation measures to lessen any potential adverse impact from the decision. DOE subsequently issued a Mitigation Action Plan (MAP) providing specific milestones to achieve these mitigations. The MAP was issued in October of 1999. The mitigation measures include preparation of cultural resource, natural resource, biological resource, and forest and wildfire management plans. The DOE tasked the Laboratory with implementation of the MAP.

The Laboratory has chosen to coordinate the required mitigation actions through the development of an Integrated Resource Management Plan (IRMP). A critical step in the development of the IRMP is the identification of knowledge gaps that should be addressed in order to have an informed basis for making resource management decisions. This annotated bibliography was prepared to assist in the gap analysis process. It builds on previous annotated bibliographies (LA-UR-90-3216, LA-UR-96-2907) that were prepared, respectively, to fulfill special permit conditions for the Laboratory's Hazardous and Solid Waste Amendments (HSWA) permit and to compile information relevant to the preparation of the Laboratory SWEIS.

To facilitate use of this bibliography, the information that is presented is delineated by subject category. Entries appear in as many categories as appropriate. Although some information on hydrology, water quality, and soil studies that appeared relevant to the gap analysis are included in the bibliography, no attempt was made to comprehensively address these topics.

By Category

- Amphibians and Reptiles
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CATEGORIZED ENTRIES

Amphibians and Reptiles

Bowker, R.G. 1993. The Thermoregulation of the Lizards *Cnemidophorus exsanguis* and *C. velox*: Some Consequences of High Body Temperature. In: Biology of Whiptail Lizards (genus *Cnemidophorus)*. W. Wright and L. Vitt, eds. Pp. 117-132. Oklahoma Museum of Natural History. Norman.

Cnemidophorus exsanguis *and* C. velox *are parthenogenic triploid lizards found in the southwestern United States. Like other* Cnemidophorus*, they are widely foraging lizards with relatively short daily activity periods and thus must be able to gather sufficient energy during a comparatively short foraging day. Diurnal desert lizards face the problems of thermoregulating under hot summer conditions, maintaining water balance often during the driest times of the day, and obtaining sufficient energy when insect prey abundance may be very low. The purpose of the work discussed in this paper was to examine and compare the patterns of temperature regulation of* C. exsanguis *and* C. velox*. The secondary goal was to examine influences of gradients on the thermoregulation of the animals. The results are discussed in terms of precision of temperature regulation, relationship to activity periods, and implications of weight loss and water conservation.*

Bowker, R.G., D.K. Anderson, and A.M. Sweet. 1986. The Temperature Dependence of CO_2 Production of the North American Lizards *Cnemidophorus velox* and *Sceloporus undulatus*. Amphibia-Reptilia 7: 347-351.

The relationship between body temperature and resting CO_2 production was examined for the lizards Cnemidophorus velox *and* Sceloporus undulatus*. The CO_2 production of both species was characterized by broad temperature ranges in which no dependence of CO_2 production was observed. Also, both species showed considerable between-individual variability. The metabolic rate of the widely-foraging* C. velox *is significantly higher than that of the wait-and-ambush species,* S. undulatus*. However, this difference is eliminated when the size of the animals and activity times are considered: both species then have similar estimated average daily energy costs.*

Bowker, R.G., S. Damschroder, A.M. Sweet, and D.K. Anderson. 1986. Thermoregulatory Behavior of the North American Lizards *Cnemidophorus velox* and *Sceloporus undulatus.* Amphibia-Reptilia 7: 335-346.

The patterns of thermoregulation of Cnemidophorus velox *and* Sceloporus undulatus *were compared and related to their foraging modes. In nature,* C. velox *are widely-foraging lizards and most individuals actively shuttled in temperature enclosures in order to regulate body temperature.* Sceloporus undulatus *are wait-and-ambush predators and were relatively inactive in the enclosures. The terms active and inactive thermoregulation were used to describe these categories of behavior. There were no interspecific differences between active and inactive individuals, either in choice of body temperature or precision of regulation of body temperature.* Cnemidophorus velox *was more thermophilic than* S. undulatus*; however, the other thermoregulatory attributes of the species were similar. Both species regulated body temperature with equal precision and the between-individual variability was essentially the same for the two species. However,* C. velox *shuttled between temperature regimes more frequently in order to achieve the same precision as* S. undulatus.

Domingues, M.J., P.A. Robinson, and R.G. Bowker. 1992. Patterns of Intraspecific Behavioral Interactions in *Podarcis bocagei* and *Cnemidophorus velox.* In: Proc. Sixth Ord. Gen. Meet. S. E. H. Z. Korsós and I. Kiss, eds. Pp. 143-149. Budapest.

Interactions between lizards may differ depending on whether they encounter conspecifics or different species, and agonistic behavior and tolerance have been the subject of many studies. Podarcis bocagei *is a common arboreal/saxicolous lizard in north central Portugal. Males and females are sexually dimorphic.* Cnemidophorus velox *is a terrestrial, all-female, triploid, parthenogenic lizard found in deserts at relatively high altitudes in New Mexico, USA. Both*

species are widely foraging insectivores; however, P. bocagei *is territorial and has extended foraging times both daily and seasonally, whereas* C. velox *is not territorial and is active briefly during the day in the summer. Both species frequently encounter conspecifics in nature. In this study, social interactions occurring when conspecifics meet under laboratory conditions designed to encourage social interactions were examined. The overall goals were to determine if a dominance hierarchy exists, to determine the intensity of intraspecific interactions, and finally to establish correlates with dominance and aggressive/submissive behavior. The concept of dominance theory seems to fit well with the social structure of* Podarcus bocagei. *However, for the asexual and non-territorial* C. velox*, the relationships are less clear. Smaller animals most frequently win the encounters and are the most aggressive. They also have the greatest expectation of future offspring and hence the most to gain. In other* Cnemidophorus *species, conspecific tolerance seems to be more common among parthenogenic than bisexual species; increased aggression between bisexuals may reflect their greater genetic diversity. The experiments reported in this paper were designed to encourage animals to interact, whereas in nature they may avoid these encounters by increasing spacing. Nevertheless, these species display a tendency for aggressive interaction; and, in these experiments both species invested considerable time, and presumably energy, in aggressive encounters with conspecifics.*

Foxx, T.S., T.K. Haarmann, and D.C. Keller. 1999. Amphibians and Reptiles of Los Alamos County. Report No. LA-13626-MS. Los Alamos National Laboratory. 84 pp.

This is an atlas of the reptiles and amphibians found in Los Alamos County. It provides baseline information about the amphibians and reptiles found on the Pajarito Plateau. The publication represents approximately 10 years of data collection and observations by a number of researchers working at Los Alamos National Laboratory, the University of New Mexico, the New Mexico Department of Game and Fish, and various hobbyists. Information is included on all species that have been identified in the area. Additionally, information is included on some species that have not been identified within Los Alamos County but are found in adjoining counties and likely occur within Los Alamos County.

Ladyman, J.A.R., and M. Altenbach. 1998. Pilot Study to Evaluate the Use of Microhabitat Plant Species Characteristics for Predicting the Presence of Jemez Mountains Salamander (*Plethodon neomexicanus*). Report No. LA-UR-98-4576. Los Alamos National Laboratory. 75 pp.

This pilot study tested two hypotheses. The first is that the microhabitat of Jemez Mountains salamanders can be characterized by other life forms that specifically require similar environmental conditions. The second is that areas of high phytodiversity are the preferred salamander habitat. The project consisted of two interlinked parts. The first was to characterize and compare the ground cover, especially the cryptogamic cover, of transects that were laid in areas where salamanders were known to be either present or absent. The second entailed photographing defined areas and characterizing and comparing the spectral profiles of these areas. The aim of the latter procedure was to make the process more objective and less reliant on expert biological knowledge. A very good start was made in identifying some of the microhabitat characteristics of Jemez Mountains salamander habitat. In general, lichen and moss species were both in greater abundance at the sites where salamanders were found. In addition, a greater cover of foliose rock lichen was found at the salamander positive sites. The model that has been developed needs to be improved, and one important future addition may be to add foliose rock lichen. A preliminary attempt to use owl scat, elk scat, and cow dung as indicators of disturbance and biodiversity led to no statistically significant conclusions, although there was some indication that there was more owl and elk scat at positive sites and no cow dung.

Nelson, E.I., T.K. Haarmann, D.C. Keller, T.S. Foxx, and M.A. Mullen. 1998. Studies of Annual and Seasonal Variations in Four Species of Reptiles and Amphibians at Los Alamos National Laboratory. Report No. LA-13476-MS. Los Alamos National Laboratory. 14 pp.

Data collected over the time period 1990-1997 were evaluated to describe the annual and seasonal population changes for four species of reptiles and amphibians over the seven-year period. The four species studies were the Woodhouse toad, the western chorus frog, the many-lined skink, and the plateau striped whiptail lizard. Statistical analyses indicated a significant

seasonal change for the western chorus frog and many-lined skink populations, as well as a significant annual change for populations of the Woodhouse toad.

Trippe, L., and T.K. Haarmann. 1996. Evaluation of the Use of Satellite Imagery as a Tool to Predict Habitat of the Jemez Mountains Salamander, *Plethodon neomexicanus*. Report No. LA-UR-96-3392. Los Alamos National Laboratory. 12 pp.

A study to determine the accuracy and feasibility of using satellite imagery technology to locate or predict specific habitat, using the Jemez Mountains salamander as a model species, was conducted. Satellite imagery maps, based solely on a small suite of physical characteristics (e.g.: elevation, vegetation, gradient), did not appear to be successful in predicting salamander habitat. Inclusion of additional habitat features would be required to strengthen the predictive power of the map. However, satellite imagery could be used as an initial screening process to determine potential habitat.

Aquatic Studies

Bennett, K. 1994. Aquatic Macroinvertebrates and Water Quality in Sandia Canyon. Report No. LA-12738-MS. Los Alamos National Laboratory Report. 24 pp.

In 1990, field studies were initiated in Sandia Canyon to establish baseline data for water quality and stream macroinvertebrate communities. The studies were designed to establish baseline data and to determine the effects of routine discharges of industrial and sanitary waste. Stations where the stream routinely receives industrial and sanitary waste effluents exhibited a low diversity of macroinvertebrates and slightly degraded water quality. The downstream station, located approximately 0.4 km downstream of the nearest wastewater outfall, appeared to be in a zone of recovery where the water quality parameters more closely resembled those found in natural streams in the Los Alamos area. A large increase in macroinvertebrate diversity also was observed at the downstream station.

Booher, J.L., P.R. Fresquez, L.F. Carter, B.M. Gallaher, and M.A. Mullen. 1998. Radionuclide Concentrations in Bed Sediment and Fish Tissue within the Rio Grande Drainage Basin. Report No. LA-13366. Los Alamos National Laboratory. 12 pp.

In 1992-1993, Los Alamos National Laboratory collaborated with the U.S. Geological Survey in an effort to characterize radionuclide concentrations in bed sediment and fish tissue within the Rio Grande drainage basin from Colorado to Texas. Bed sediment was sampled from 18 locations for ^{137}Cs, ^{3}H, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{241}Am, ^{tot}U, and alpha, beta, and gamma activity. Fish tissue was sampled from 12 locations for ^{137}Cs, ^{90}Sr, ^{238}Pu, ^{239}Pu, and ^{tot}U. Detailed data tables are presented.

Cross, S. 1994. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory: December 1992-October 1993. Report No. LA-12734-SR. Los Alamos National Laboratory. 38 pp.

This report summarizes the results of water quality and macroinvertebrate diversity investigations in Sandia Canyon during 1993 as a followup to the results reported for 1990 in Report No. 12738 by K. Bennett. During 1993, five stations were sampled in the canyon. The two uppermost stations are located near outfalls that discharge industrial and sanitary waste effluent. The third station is located in a natural cattail marsh located about 0.4 km downstream of the uppermost stations. Two additional stations were located further downstream. Water quality parameters at the upper three stations are different from those of natural streams, suggesting degraded water quality. The macroinvertebrate communities exhibit low diversity and poorly-developed community structures. The two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams in the area, macroinvertebrate diversity increases, and community structure becomes more complex.

Cross, S. 1995. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory, November 1993 to October 1994. Report No. LA-12971-SR. Los Alamos National Laboratory. 58 pp.

This report summarizes the results of water quality and macroinvertebrate diversity investigations in Sandia Canyon during 1994 as a followup to previous investigations in 1990 (LA-12738-MS) and 1993 (LA-12734-SR). During 1994, five stations were sampled in the canyon. The two upstream stations are located below outfalls that discharge industrial and sanitary waste effluent into the stream, thereby maintaining year-round flow. Some water quality parameters are different at the first three stations from those expected of natural streams in the area, indicating degraded water quality resulting from effluent discharges. The aquatic habitat at the upper stations has also been degraded by sedimentation and channelization. The macroinvertebrate communities at these stations are characterized by low diversities and unstable communities. In contrast, the two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams of the area. The two lower stations have increased macroinvertebrate diversity and stable communities, further indications of downstream water quality improvement.

Cross, S. 1995. Aquatic Invertebrate Sampling at Selected Outfalls in Operable Unit 1082; Technical Areas 9,11,16,and 22. Report No. LA-13019-MS. Los Alamos National Laboratory. 57 pp.

Preliminary sampling for aquatic invertebrates, hydrological condition, physico-chemical parameters, wildlife uses, and vegetation was conducted for eleven outfalls within Operable Unit 1082 and nearby "natural waterways." The physico-chemical parameters at most outfalls and natural waterways fell within the normal range of natural waters in the area. However, the outfalls are characterized by low biodiversity and severely stressed communities composed of a restricted number of taxa. The habitat at some outfalls could probably support well-developed aquatic communities if sufficient water was available. At present, the hydrology at these outfalls is too slight and/or too sporadic to support such a community in the foreseeable future. In contrast to the outfalls, the natural waterways had greater densities of aquatic invertebrates, higher biodiversities, and lower community tolerance quotients.

Cross, S. 1995. Aquatic Macroinvertebrates and Water Quality in Guaje and Los Alamos Canyons, (1993 and 1994). In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 91-194. Report No. LA-13065-MS. Los Alamos National Laboratory.

Water quality parameter samples and aquatic macroinvertebrates were collected from sampling stations in Guaje and Los Alamos Canyons in 1993 and 1994. The relatively undisturbed stream in Guaje Canyon was used as a control to evaluate impacts to the stream in Los Alamos Canyon. All monthly pH, conductivity, and dissolved measurements taken in both streams were within acceptable water quality ranges. The Los Alamos Canyon Reservoir impounds all incoming water except for warmed overflow, which significantly elevates temperatures at lower Los Alamos Canyon stations. At times, the dam design causes the stream to dry up completely, eliminating macroinvertebrate communities at the lower stations. This is the most significant impact to downstream communities. Rapid Biological Protocols (RBP) III analysis shows that aquatic communities are richer and more complex in Guaje Canyon than Los Alamos Canyon. The data also suggest that, within each canyon, diversity and density increase with distance downstream; but this trend is not as pronounced because the middle Guaje station had higher diversities and densities than the lowest station. According to RBP III analysis, water quality is unimpaired at LA1 and severely impaired at LA2 and LA3.

Cross, S.P., and J. Davila. 1996. Aquatic Macroinvertebrates and Water Quality on Guaje and Los Alamos Canyons, 1995. Report No. LA-UR-96-998. Los Alamos National Laboratory. 80 pp.

The streams within Guaje and Los Alamos Canyons were sampled on three dates in 1995 for water quality parameters and aquatic macroinvertebrates. The relatively undisturbed stream in Guaje Canyon was used as a control to evaluate impacts to the stream in Los Alamos Canyon.

Habitat assessment scores were lower in Los Alamos Canyon than in Guaje, but all stations in both canyons scored lower than in 1994 because of large volumes of fine sediments. All pH, conductivity, and dissolved oxygen measurements taken in both streams were within acceptable water quality ranges and met high-quality cold-water fisheries standards. The Los Alamos County Reservoir impounds all incoming water except for warmed overflow, producing elevated water temperatures and periodic stream drought at the lower Los Alamos stations. These represent the most significant impacts to downstream invertebrate communities in Los Alamos Canyon. Aquatic communities are richer and more developed in Guaje than Los Alamos Canyon. The 1995 water quality was slightly impaired at LA1, moderately impaired at LA2, and severely impaired at LA3. This pattern of increasing downstream impairment was also substantiated by decreasing standing crop numbers and biodiversity values.

Cross, S., and H. Nottelman. 1996. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory 1995. Report No. LA-UR-96-3684. 59 pp.

This report updates and expands previous aquatic studies in Sandia reported by Bennett and Cross. Water quality data and aquatic macroinvertebrate samples were collected monthly at three sampling stations in Sandia Canyon during 1995. The two upstream stations occur near a cattail marsh downstream from outfalls that discharge industrial and sanitary waste effluent. The third station is approximately 1.5 miles downstream in a mixed conifer forest. All water quality parameters measured during 1995 fell within acceptable State limits and scored in the good or excellent range when compared to an Environmental Quality Index. However, aquatic macroinvertebrate habitats have been degraded by widespread erosion, channelization, loss of wetlands due to deposition and stream lowering, scour, limited acceptable substrates, LANL releases and spills, and other stressors. The stream continues to be threatened by erosion and potential landslides from the Los Alamos County landfill whose towering sides of loose fill material are perched at a 45^{o} angle above the northern edge of the entire Sandia Canyon wetlands. Macroinvertebrate communities at all of the stations had low diversities, low densities, and erratic numbers of individuals. These results indicate that, although the stream possess acceptable water chemistry, it has reduced aquatic biota. The best developed aquatic community occurs at the sampling station with the best habitat and whose downstream location partially mitigates the effects of upstream impairments.

Cross, S., L. Sandoval, and T. Gonzales. 1996. Aquatic Macroinvertebrates and Water Quality of Springs and Streams in White Rock Canyon along the Rio Grande, 1995. Report No. LA-UR-96-510. 53 pp.

In April and September of 1995, aquatic invertebrate collections were made up-canyon from three major stream confluences and at 6 springs near the Rio Grande. Physical and chemical parameters were measured at all locations and habitats were assessed at each of the streams. On the basis of these limited samples, several observations were tentatively advanced:

- *pH values of both springs and streams appear to decrease between spring and autumn;*
- *the springs have more stable temperature regimes than do the streams;*
- *great variations in flow rates exist between the individual springs and streams;*
- *aquatic habitats vary greatly between the streams and seasonally;*
- *the dominant taxa frequently change seasonally in both springs and streams;*
- *differences between invertebrate samples may obscure differences in site densities; and*
- *despite variations in community compositions, most of the springs and streams appear capable of supporting well-developed aquatic communities.*

Ford-Schmid, R.E. 1996. Reference Conditions for Los Alamos National Laboratory Streams Using Benthic Macroinvertebrate Assessment in Upper Pajarito Canyon. New Mexico Geological Survey Guidebook. 47th Field Congress. Jemez Mountains Region. Pp. 441-447.

Benthic macroinvertebrates and water samples were collected at three stations in upper Pajarito Creek and at one station in each of two first-order tributaries to Pajarito Creek at Los Alamos National Laboratory (LANL). A total of 63 taxa were identified from the five stations. Number of taxa per study location ranged from 25 to 35, and standing crop ranged from 2351

(no/m^2) to 11,212 (no/m^2). EPT/EPT + Chironomid ratios, a measure of community balance, ranged from 0.17 to 0.84, while another measure of community balance, the Shannon-Weaver's index of diversity, ranged from 2.48 to 3.53. The Winget and Mangum CTQd index, a measure of non-organic perturbations, ranged from 72.5 to 89.1, and the Hilsonhoff Biotic Index (HBI), a measure of the presence of organic perturbation, ranged from 4.20 to 6.92. Habitat assessments indicate that four of the five stations were comparable, whereas the station farthest downstream in Pajarito Canyon displayed effects of embeddedness, channel alteration, scouring, and reduced flow. The HBI = 6.92 calculated for Starmer Spring station indicates fairly poor water quality with substantial organic pollution likely. The compete absence of the scraper functional feeding group, the dominance of the community by one tolerant midge, and the presence of mats of filamentous algae at Starmer Spring indicate a community structure that is tolerant of nutrient enrichment. The State of New Mexico water quality standards for livestock watering and wildlife habitat were met at all stations, while the fisheries acute standard for aluminum (750 μg/L) was exceeded at the station farthest downstream in Pajarito Canyon. The 11 metrics used to compare sites indicate that the farthest upstream station in Pajarito Canyon is appropriate for use as the reference condition for future comparisons of streams at LANL.

Foxx, T., and B. Blea-Edeskuty. 1995. Wildlife Use of NPDES Outfalls at Los Alamos National Laboratory. Report No. LA-13009-MS. Los Alamos National Laboratory. 47 pp.

During the summer and fall of 1991, a preliminary survey of 133 NPDES outfalls was conducted to determine wildlife usage of these outfalls. Usage was determined on the basis of observed scat, tracks or bedding. Indications were that about 56% of the outfalls were being used by 35 vertebrate species as a drinking water source. Additionally, hydrophytic vegetation grows in association with approximately 40% of the outfalls – a characteristic that could make these areas eligible for wetland status. Additional study is necessary to determine usage by small mammals, amphibians, and aquatic macroinvertebrates. Wetland assessments may be necessary to ensure compliance with wetland regulations if LANL activities affect any of the outfalls supporting hydrophytic vegetation.

Fresquez, P.R., D.R. Armstrong, and L. Naranjo, Jr. 1996. Radionuclide and Heavy Metal Concentrations in Soil, Vegetation, and Fish Collected Around and Within Tsicoma Lake in Santa Clara Canyon. Report No. LA-13144-MS. Los Alamos National Laboratory. 99 pp.

This study was undertaken at the request of Santa Clara Pueblo officials as Tsicoma Lake is slightly downwind of Los Alamos National Laboratory. Radionuclide and heavy metal concentrations were determined in soil, vegetation (overstory and understory), and fish (rainbow trout) collected around and within Tsicoma Lake in Santa Clara Canyon in 1995. All heavy metal and most radionuclide concentrations, with the exception of uranium in soil, vegetation, and fish, were within or just above upper limit background concentrations. Detectable levels (where the analytical result was greater than two times the counting uncertainty) of uranium in soils, vegetation, and fish were found in slightly higher concentrations than in background samples. Overall, however, the maximum total committed effective dose equivalent (CEDE)(0.066 mrem/yr), based on the consumption of 46 lb of fish, was within the maximum CEDE from the ingestion of fish from the Mescalero National Fish Hatchery (background)(0.113 mrem/yr).

Fresquez, P.R., D.R. Armstrong, and L. Naranho, Jr. 1998. Radionuclides and Heavy Metals in Rainbow Trout from Tsichomo, Nana Ka, Won Povi, and Pin De Lakes in Santa Clara Canyon. Report No. LA-13441-MS. Los Alamos National Laboratory. 38 pp.

Radionuclide and heavy metal concentrations were determined in rainbow trout collected from Tsichomo, Nana Ka, Won Povi, and Pin De Lakes in Santa Clara Canyon in 1997. Most radionuclide and heavy metal concentrations in fish collected from these four lakes were within or just above upper limit background concentrations (Abiquiu reservoir) and as a group were statistically similar to background. Consequently, the committed effective dose equivalent (CEDE) from the ingestion of 46 lb of fish from Santa Clara Canyon (0.028 mrem/yr) was within the CEDE from the ingestion of fish from Abiquiu reservoir (0.037 mrem/yr). Moreover, the upper level net positive total CEDE – a dose that potentially could be attributed to Laboratory operations – was only 0.042 mrem/yr. This dose is far below the International Commission on Radiological

Protection permissible dose level of 100 mrem/yr from all pathways and corresponds to an excess cancer fatality risk of $2.1x10^{-8}$ – which also is far below the EPA guideline of 10^{-4}.

Fresquez, P.R., D.A. Armstrong, and J.G. Salazar. 1994. Radionuclide Concentrations in Game and Nongame Fish Upstream and Downstream of Los Alamos National Laboratory: 1981-1993. Report No. LA-12818-MS. Los Alamos National Laboratory. 22 pp. Also In: Proceedings of the New Mexico Conference on the Environment. Pp. 684-689. April 24-26. Albuquerque.

Radionuclide concentrations were determined in game (surface-feeding) and nongame (bottom-feeding) fish collected from reservoirs upstream (Abiquiu, Heron, and El Vado) and downstream (Cochiti) of Los Alamos National Laboratory from 1981 to 1993. The average levels of ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239}Pu in both game and nongame fish collected from Cochiti reservoir were not significantly different from fish collected from reservoirs upstream of the Laboratory. Total uranium was the only radionuclide that was found to be significantly higher in both game and nongame fish from Cochiti as compared to fish from Abiquiu, Heron, and El Vado. The uranium concentrations in fish collected from Cochiti, however, significantly decreased from 1981 to 1983, and no evidence of depleted uranium was found in fish samples collected from Cochiti in 1993. Based on the average concentration of radionuclides over the years, the effective radiation dose equivalent from consuming 46 lb of game and nongame fish from Cochiti reservoir after natural background has been subtracted was 0.005 and 0.009 mrem/yr, respectively. The highest dose was <0.01% of the International Commission on Radiation Protection permissible dose limit for protecting members of the public.

Fresquez, P.R., D.A. Armstrong, and J.G. Salazar. 1995. Radionuclide Concentrations in Fish Collected from Jemez, Nambe, and San Ildefonso Tribal Lakes. Report No. 12899-MS. Los Alamos National Laboratory. 7 pp.

Radionuclide concentrations (^{90}Sr,. ^{137}Cs, ^{238}PU, ^{239}Pu, and total uranium) were determined in fish collected from Jemez, Nambe, and San Ildefonso tribal lakes. With the exception of ^{137}Cs, all other radionuclides were not significantly different in (stocked) rainbow trout collected from Jemez and Nambe as compared with game fish collected from Abiquiu, Heron, and El Vado Reservoirs. Although ^{137}Cs levels in trout from Jemez and Nambe were significantly higher than ^{137}Cs concentrations in fish from Abiquiu, Heron, and El Vado, they were still well below the regional statistical (worldwide fallout) reference level. Game and nongame fish collected from San Ildefonso contained higher concentrations or uranium, respectively, as compared with fish collected from Abiquiu, Heron, and El Vado. The higher uranium concentrations in fish from San Ildefonso were attributed to the higher natural uranium contents in the area as compared with the geology of the area upstream of San Ildefonso. The effective (radiation) dose equivalent (EDE) from consuming 46 lb of game fish from Jemez, Nambe, and San Ildefonso lakes, after natural background has been subtracted, was 0.013, 0.019, and 0.017 mrem/yr, respectively. Similarly, the EDE from consuming nongame fish from San Ildefonso was 0.0092 mrem/yr. The highest calculated dose, based on the mean + 2 standard deviations (95% confidence level), was 0.073 mrem/yr. This is 0.08% of the International Commission on Radiological Protection permissible dose limit for protecting members of the public.

Fresquez, P.R., J.D. Huchton, and M.A. Mullen. 1999. Trace Elements, With Special Reference to Mercury, in Fish Collected Upstream and Downstream of Los Alamos National Laboratory. Report No. LA-13658-MS. Los Alamos National Laboratory. 12 pp.

Trace elements were determined in muscle of fish (mostly carp, catfish, and sucker) collected from the confluences of major canyons that cross LANL lands with the Rio Grande. Trace elements also were determined in fish from reservoirs upstream and downstream of LANL from 1991 through 1999. In general, all of the trace elements, including mercury, were either at the limits of detection or in low concentrations at all study sites. Of the trace elements (Ba, Cu, Hg) that were found to be above the limit of detection in fish collected from LANL canyon confluences, none were significantly higher than background locations. Mercury concentrations in fish from Abiquiu Reservoir were significantly higher than in fish from Cochiti Reservoir, but concentrations from both reservoirs exhibited significantly decreasing trends over time.

Fresquez, P.R., D.H. Kraig, M.A. Mullen, and L. Naranjo, Jr.
1)1999. Radionuclides and Trace Elements in Fish Collected Upstream and Downstream of Los Alamos National Laboratory and the Doses to Humans from the Consumption of Muscle and Bone. Report No. LA-UR-99-953. Los Alamos National Laboratory.
2)1999. Radionuclide and Heavy Metal Concentration in Fish from the Confluences of Major Canyons That Cross Los Alamos National Laboratory Lands with the Rio Grande. Report No. LA-13564-MS. Los Alamos National Laboratory. 20 pp.
3)1999. Radionuclides and Trace Elements in Fish Collected Upstream and Downstream of Los Alamos National Laboratory and the Doses to Humans from the Consumption of Muscle and Bone. Journal of Environmental Science and Health B34: 885-899.

The purpose of this study was to determine radionuclide and trace element concentrations in bottom-feeding fish (catfish, carp, and suckers) collected from the confluences of some of the major canyons that cross Los Alamos National Laboratory (LANL) with the Rio Grande and the potential radiological doses from the ingestion of these fish. Samples of muscle and bone (and viscera in some cases) were analyzed for ^{3}H, ^{90}Sr, ^{137}Cs, ^{tot}U, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am and for Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl. Most radionuclides in the muscle plus bone portions of fish collected from LANL canyons and the Rio Grande, with the exception of ^{90}Sr, were not significantly higher from fish collected upstream (San Ildefonso/background) of LANL. Strontium-90 in fish muscle plus bone tissue significantly increased in concentration from Los Alamos Canyon, the most upstream confluence to Frijoles Canyon, the most down stream confluence. However, the differences in ^{90}Sr concentrations were very small. Based on the average concentrations of radionuclides in fish tissue from the four LANL confluences, the committed effective dose equivalent from the ingestion of 46 lb (21 kg) (maximum ingestion rate per person per year) of fish muscle plus bone, after the subtraction of background, was far below the International Commission on Radiological Protection (all pathways) permissible dose limit of 100 mrem per year. Of the trace elements that were found above the limits of detection (Ba, Cu, and Hg) in fish muscle, none were found in significantly higher concentrations than in muscle of fish collected from background locations.

Gonzales, G.J., P.R. Fresquez, and J.W. Beveridge. 1999. Organic Contaminant Levels in Three Fish Species Downchannel from the Los Alamos National Laboratory. Report No. LA-13612-MS. Los Alamos National Laboratory. 106 pp.

Three species of fish from sites upriver and downriver of Los Alamos National Laboratory in the Rio Grande were analyzed for pesticides and PCBs. Data were used to implicate potential sources of the contaminants and to discuss potential risk to fish, the bald eagle, and humans. Eight of 28 contaminants were measurable in at least one sample of fish muscle tissue, including DDE, Aroclor-1254, dichloroethane, DDT, endosulfan sulfate, chlordane, and Aroclor-1260. The LANL contribution, if any, to organic contaminant levels in the common carp, the channel catfish, and the white sucker in the Rio Grande appear to be small. Consumption restrictions based on EPA recommendations are presented.

Pippin, W.F., and B.D. Pippin, 1984. Aquatic Invertebrates from Capulin Creek, Bandelier National Monument, New Mexico. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 107-113. Report No. LA-9236-NERP. Los Alamos National Laboratory.

During the summer of 1980, a limited survey was made of the invertebrate fauna of Capulin Creek within Bandelier National Monument. The stream originates in the Santa Fe National Forest, enters at the western edge of the Monument, and flows for approximately 11.5 km through Capulin Canyon into the Rio Grande. The stream flows steadily for approximately 6.4 km, then becomes intermittent or dry, especially in the summer months. The stream is small and shallow and varies in width according to the topography, but averages about 1 m. The flow varies with the season and time of day. The purpose of this study was (1) to establish a preliminary check list of the invertebrate fauna of the stream, primarily macroinvertebrates of the Class Insecta, (2) to assess the relative abundance of various taxa between test sites, and (3) to compare the number and kind of taxa collected with those found in the Rito de la Frijoles. The results showed that the greater diversity of species and, in general, the overall population

numbers occurred in the upper reaches of Capulin Creek. The same pattern was noted in the Rito de la Frijoles. Capulin Creek from Base Camp to its headwaters is a relatively stable but fragile environment.

Thibault, J.R., D.L. Moyer, C.N. Dahm, H.M. Valett, and M.C. Marshall. 1999. Effects of Livestock Grazing on Morphology, Hydrology and Nutrient Retention in Four Riparian/Stream Ecosystems, New Mexico, USA. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 123-128... Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Land-use practices such as livestock grazing influence the structure and function of riparian/stream ecosystems. In New Mexico, four streams were selected to determine the impact of moderate livestock grazing on morphology, solute transport, and nutrient retention. Each stream contained a reach currently exposed to grazing and an exclosed, ungrazed reach. Channel width/depth ratios and in-stream standing stock of plant biomass were greater in the grazed reaches. Solute transport was determined by injecting a conservative tracer (NaBr) and applying a one-dimensional transport with inflow and storage (OTIS) model. Grazed reaches exhibited enhanced transient storage, represented by a larger cross-sectional area of storage zone relative to wetted channel area (A_s/A). The extent of nutrient retention was determined by co-injecting a reactive tracer ($NaNO_3$) with the conservative tracer. Nitrate uptake lengths were shorter in grazed reaches, an indication of more effective nutrient retention. The results suggest that moderate livestock grazing alters channel structure and vegetation, influencing ecosystem-level processes.

Wallwork-Barber, M.K., K. Lyall, and R.W. Ferenbaugh. 1985. Thallium Movement in a Simple Aquatic Ecosystem. Journal of Environmental Science and Health A20: 689-700.

Very little is known about the behavior of thallium in aquatic systems. Because of its toxicity and pollution potential, a greater understanding of thallium transport pathways in aquatic systems is needed. This study examined the transport of thallium among four basic aquatic components: water, sand, vegetation, and fish. Definite transport of thallium occurred among water, vegetation, and fish; but no significant transport was seen between the sand and the other ecosystem components. The concentration of thallium decreased very slowly in the water and increased tenfold in the vegetation and fish. Thallium concentration in the sand remained essentially constant throughout the experiments.

Atlases and Checklists

Biggs, J., K. Bennett, and M. Martinez. 1997. A Checklist of Mammals Found at Los Alamos National Laboratory and Surrounding Areas. Report No. LA-UR-97-4786. Los Alamos National Laboratory. 13 pp.

This report presents an annotated checklist of mammals of Los Alamos National Laboratory compiled from numerous biological surveys and studies conducted on and adjacent to Laboratory property. The checklist also includes species that are known to occur on adjacent properties, such as Bandelier National Monument and Santa Fe National Forest. However, there may be additional species that are not listed. The draft list of species that was prepared from LANL ESH-20 and other surveys was checked against the Biological Information System of New Mexico (BISON-M) developed by the New Mexico Department of Game and Fish. Some species on the draft list were not identified in the BISON-M database as occurring in Los Alamos County. However, this is to be expected, as reports from only a few of the wildlife studies conducted at LANL have been readily available outside of the Laboratory.

Earth Environmental Consultants. 1978. Soil Survey of the Bandelier National Monument. Report prepared for Office of Natural Science, Southwest Region, National Park Service. 34 pp.

The Bandelier National Monument was surveyed to determine soil characteristics and conditions. That part of the Monument, about 7 square miles, that is in Santa Fe County was mapped by the USDA Soil Conservation Service during 1960-1968 and is published in the 1975 "Soil Survey of Santa Fe Area." The southern two-thirds of the Monument, about 25 square

miles, was surveyed by Earth Environmental Consultants, Inc. (EECI) in the summer of 1974. The remainder of the Monument was surveyed by EECI in April and May of 1978. This includes the area north of Frijoles Canyon to State Highway 4 in Los Alamos County, the recently acquired lands on the Baca Location in Sandoval County, and the upper Frijoles Canyon in Los Alamos County. These areas also comprise about 25 square miles. The entire Monument comprises about 25 square miles and, except for the discrete area in Santa Fe County, is in one contiguous unit comprising parts of Los Alamos and Sandoval Counties. The soils are classified according to "Soil Taxonomy," USDA-SCS, Agricultural Handbook No. 436, 1975 (although several of the soil names were tentative at the time of the report awaiting finalization of some of the soil names that were used).

Folks, J.J. 1975. Soil Survey of Santa Fe Area, New Mexico (Santa Fe County and Part of Rio Arriba County). Report Prepared for USDA Soil Conservation Service and Forest Service and USDI Bureau of Indian Affairs in cooperation with the New Mexico Agricultural Experiment Station. 114 pp. + maps.

Soil scientists made this survey to learn what kinds of soils are in the Santa Fe area and how they can be used. The soil scientists went into the area knowing they likely would find many soils they had already seen and perhaps some that they had not. They observed the steepness, length, and shape of slopes, the size of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soil. They dug many holes to expose soil profiles. They made comparisons among the profiles that they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. Major fieldwork for the survey was done in the period 1960-1968, and soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in this publication refer to conditions in the area in 1968.

Foxx, T.S., T.K. Haarmann, and D.C. Keller. 1999. Amphibians and Reptiles of Los Alamos County. Report No. LA-13626-MS. Los Alamos National Laboratory. 84 pp.

This is an atlas of the reptiles and amphibians found in Los Alamos County. It provides baseline information about the amphibians and reptiles found on the Pajarito Plateau. The publication represents approximately 10 years of data collection and observations by a number of researchers working at Los Alamos National Laboratory, the University of New Mexico, the New Mexico Department of Game and Fish, and various hobbyists. Information is included on all species that have been identified in the area. Additionally, information is included on some species that have not been identified within Los Alamos County but are found in adjoining counties and likely occur within Los Alamos County.

Foxx, T.S., L. Pierce, G.D. Tierny, and L.A. Hansen. 1998. Annotated Checklist and Database for Vascular Plants of the Jemez Mountains. Report No. LA-13408. Los Alamos National Laboratory. 164 pp.

Studies performed over the past 40 years were used to construct a checklist of plants of the Jemez Mountains. This checklist is annotated with taxonomic information, geographic and biological information, economic uses, wildlife cover, revegetation potential, and ethnographic uses. Nearly 1000 species have been noted.

Foxx, T.S., and G.D. Tierney. 1985. Status of the Flora of the Los Alamos National Environmental Research Park. Checklist of Vascular Plants of the Pajarito Plateau and Jemez Mountains. Report No. LA-8050-NERP, Volume III. Los Alamos National Laboratory. 142 pp.

This report lists all taxonomic identifications recorded from the Pajarito Plateau, Valles del los Sierros, Valles Caldera, and portions of the Jemez Plateau of the Jemez Mountains in north-central New Mexico. Approximately 900 plants representing more than 80 families are documented. The report is superceded by Report No. LA-13408.

Hinojosa, H. 1997. A Checklist of Plant and Animal Species at Los Alamos National Laboratory and Surrounding Areas. Report No. LA-UR-97-4501. 61 pp.

Many biological assessments and other studies have been conducted at or around Los Alamos National Laboratory. The checklists contained in this document are a compilation of all of the species lists and references compiled from a review of published and unpublished reports, surveys, and databases that pertain to the biota of this and similar areas.

Hinojosa, H., and L.K. Nguyen. 1996. Threatened, Endangered, and Sensitive Species Profile. Report No. LA-UR-96-1269. Los Alamos National Laboratory. 19 pp.

This document provides a thumbnail description of various plant and animal species that may inhabit or potentially inhabit areas in and around Los Alamos National Laboratory and that are included in lists on the federal, state, or local level proclaiming them to be at some degree of risk.

Jarmie, N., and F.J. Rogers. 1997. A Survey of Macromycete Diversity at Los Alamos National Laboratory, Bandelier National Monument, and Los Alamos County. A Preliminary Report. Report No. LA-13384-MS. Los Alamos National Laboratory. 90 pp.

A five-year survey of macromycetes found in Los Alamos County, Los Alamos National Laboratory, and Bandelier National Monument has resulted in a database of 1048 collections, their characteristics, and identifications. The database represents 123 genera and 175 species reliably identified. Issues of habitat loss, species extinction, and ecological relationships are addressed, and comparisons with other surveys are made.

Nyhan, J.W., L.W. Hacker, T.E. Calhoun, and D.L. Young. 1978. Soil Survey of Los Alamos County, New Mexico. Report No. LA-6779-MS. Los Alamos National Laboratory.

This soil survey covers about 79% of the soils in Los Alamos County. Soil survey maps and detailed soil information are provided. Past and present land use in the Los Alamos area is discussed and general information about soils and their formation is evaluated, including the regional soil formation factors of geologic parent materials, climate, living organisms, topography, and time. The soils of the area are classified according to the current system of soil classification. The relationship of soil formation to classification is discussed, and the current soil classification system is explained. General and detailed descriptions are given for each of the 61 soil mapping units, which includes information on soil color, texture, structure, consistence, clay films, coarse and fine fragment distributions, permeability, depth, hydrologic properties, pores, pH, and soil horizon boundaries.

Racinez, E., and T.S. Foxx. 1999. A Notebook of Sedges and Rushes of the Jemez Mountains. Report No. LA-UR-99-5185. Los Alamos National Laboratory.

Floodplains are recognized as areas of land between meandering rivers and wetlands that are characterized by their hydrophytic soils and vegetation. These greenbelts along streams and rivers provide important habitats for many species in the arid southwest. Many rare and endangered species rely on wetlands for part or all of their lifecycle. In Los Alamos County, there are a number of wetland areas that either occur naturally or are manmade. Identification of wetlands requires knowledge about hydrophytic vegetation, which includes sedges and rushes (Cyperaceae and Juncaceae). While describing the importance of wetlands, this study focused on the vegetation that is characteristic of wetland, riparian, and floodplain habitats. These groups of plants generally are difficult to identify, and few references on the taxonomy of plants in these groups exist. This report is an attempt to provide information on sedges and rushes for persons doing fieldwork in wetlands ecology, wetlands delineation, and riparian zone studies.

Travis, J.R. 1992. Atlas of the Breeding Birds of Los Alamos County, New Mexico. Report No. LA-12206. Los Alamos National Laboratory. 281 pp.

This atlas shows the geographic distribution of 112 species of breeding birds found within Los Alamos County. Breeding dates and other information on breeding behavior are presented, and species distribution patterns and species-habitat relationships are discussed. The information presented is based on field surveys from 1984 through 1988.

Bats

Bogan, M.A., T.J. O'Shea, P.M. Cryan, A.M. Ditto, W.H. Schaedla, and L. Ellison. 1996. Status and Trends of Bat Populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico. Report No. LA-UR-96-3528. Los Alamos National Laboratory. 91 pp.

The goal of this study was to assess the current status of bats , elucidate distribution and relative abundance, and obtain information on sites used as roosting sites. Data are reported from two years of study, during which 15 species of bats were observed. Netting sites were located in a variety of habitats from piñon-juniper through mixed coniferous forest. Most of the most abundant species are typical of ponderosa pine-mixed coniferous forests. Males outnumber females for most species. Reasons for the observed distribution of sexes are unknown, but climatic and elevational influences or sites chosen for netting may be involved. In 1996, radiotracking studies were initiated in which selected bats were equipped with miniaturized radios and followed to roosts.

Bogan, M.A., T.J. O'Shea, P.M. Cryan, A.M. Ditto, W.H. Schaedla, E.W. Valdez, K.T. Castle, and L. Ellison. 1998. A Study of Bat Populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico. Report No. LA-UR-98-2418. 133 pp.

Although previous work on bats has been conducted in the Jemez Mountains of New Mexico, the status and trends of bat populations there are not well known. In 1995, a three-year study was initiated to assess the current status of bat species of concern, elucidate distribution and relative abundance, and obtain information on roosting sites. Fifteen hundred thirty two bats of 15 species were captured and released. Thirty two bats of 8 species were followed to 51 active diurnal roosts. Most of the species observed were typical inhabitants of ponderosa pine-mixed coniferous forests. Captured males outnumbered females for many species. Only 5 species were captured in about equal numbers of both sexes. Exact reasons for the observed distribution of sexes is unknown; but climate, elevational influences, and sites chosen for netting may be involved. Eight bat species of concern were netted, with four of these species captured frequently. For a variety of reasons, smaller numbers of the other four species of concern were captured; but moderate- to large-size roosting aggregations of three of these were identified. Only 7 individuals of Corynorhinus townsendii *were captured, lending credence to the possibility that this species is of concern in this area.*

Bogan, M.A., T.J. O'Shea, E.W. Valdez, A.M. Ditto, and K.T. Castle. 1998. Continued Studies of Bat Species of Concern in the Jemez Mountains, New Mexico. Report No. LA-UR-98-5691. 29 pp.

In 1995,a three-year study was initiated to assess the current status of bat species of concern, elucidate distribution and relative abundance, and obtain information on roosting sites. In 1998, finding was provided for an additional year to obtain more information on bat species of concern, especially the spotted bat and the big free-tailed bat. During 1998, 328 bats of 15 species were captured and released. The most abundant species were typical inhabitants of ponderosa pine-mixed coniferous forests, where most of the study sites were located. As previously noted, captured males outnumber captured females for many species. In only one species were both sexes captured in equal numbers. Exact reasons for the observed distribution of sexes are unknown; but weather, elevation, migration, gender-specific roosting requirements, and sites chosen for netting are likely explanations. Eight bat species of concern were netted, with four of these being captured frequently. In 1998, smaller numbers of the other four species of concern were captured, and there is reliable knowledge of moderate- to large-size roosting aggregations of two of these. Moderately high levels of activity of the spotted bat were recorded along cliffs in Los Alamos Canyon at LANL, and both the spotted bat and the big free-tailed bat continued to use roosts that were located in 1997. Numbers of big free-tailed bats counted at roosts varied over the course of the summer in 1998, which suggests that this species may have been using alternative roosting sites elsewhere. The 1998 capture of only a single individual of Corynorhinus townsendii *and similar low capture frequencies in previous years suggest that this bat is truly a species of concern for the Jemez Mountains region. In 1998, radio-transmitters also*

were attached to five bats of three species (the spotted bat, the big free-tailed bat, and C. townsendii*), three of which were tracked to diurnal roosts. One female spotted bat was tracked to a roost on a cliff face, near a big free-tailed bat roost, but the male was not found. The single male* C. townsendii *was located in a cavity in a large boulder, near where the bat was captured. One of two tagged lactating big free-tailed bats returned to a roost originally located in 1997; the other individual was not found. The 1998 work helped to refine understanding of bat distributions in the Jemez Mountains, provided important information on site and roost fidelity for spotted and big free-tailed bats, and enhanced the amount of available baseline information on status and trends of eight bat species of concern in the area.*

Bee Studies

Fresquez, P.R., D.R. Armstrong, and L.H. Pratt. 1997. Tritium Concentrations in Bees and Honey at Los Alamos National Laboratory: 1979-1996. Report No. LA-13202-MS. Los Alamos National Laboratory. 14 pp.

The objective of this study was to summarize tritium concentrations in bees and honey collected from within and around Los Alamos National Laboratory over an 18 year period. Based on the long-term average, bees from nine out of eleven hives and honey from six out of eleven hives on LANL lands contained tritium concentrations significantly higher than background. The highest average concentration of tritium in bees was from TA-54, a low level radioactive waste disposal site. The highest average concentration of tritium in honey was from a hive located near three tritium storage ponds at TA-53. Although concentrations of tritium in bees and honey from most LANL and perimeter (White Rock/Pajarito Acres) areas were significantly higher than background, most areas (with the exceptions of TA-53 and TA-54) generally exhibit decreasing tritium concentrations over time.

Fresquez, P.R., D.A. Armstrong, and J.G. Salazar. 1994. Tritium Concentrations in Bees and Honey at Los Alamos National Laboratory. Report No. LA-12872-MS. Los Alamos National Laboratory. 11 pp.

Los Alamos National Laboratory (LANL) has maintained a network of honey bee colonies at LANL, perimeter (Los Alamos townsite and White Rock/Pajarito acres), and regional (background) locations for over 15 years. The main objective of this honey bee network was to help determine the bioavailability of certain radionuclides in the environment. Of all the radionuclides studies (^{3}H, ^{57}Co, ^{7}Be, ^{22}Na, ^{54}Mn, ^{83}Rb, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{90}Sr, and total U), tritium was consistently detected in bees and was most readily transferred to the honey. In fact, honey collected from hives located at TA-21, TA-33, TA-50, TA-53, and TA-54 and from White Rock/Pajarito Acres contained significantly higher concentrations of ^{3}H than regional background hives. Based on the average concentration of all radionuclides measured over the years, the effective dose equivalent (EDE) from consuming 5 kg (11 lb) of honey collected from Los Alamos (townsite) and White Rock/Pajarito Acres, after regional background has been subtracted, was 0.0186 ± 0.0507 and 0.0016 ± 0.0010 mrem/yr, respectively. The highest EDE was 0.1200 mrem/yr, which is <0.2% of the International Commission on Radiological Protection permissible dose limit of 100 mrem/yr from all pathways.

Gladney, E.S., M.K. Wallwork-Barber, and R.W. Ferenbaugh. 1983. Enriched Uranium as an Activatable Tracer in Environmental Research. Journal of Radioanalytical Chemistry 78: 209-212.

The Los Alamos National Laboratory has explored the use of honey bees for environmental monitoring. During the spring of 1981, mesh enclosures were set up in which captive nuclear honey bee colonies were provided with pollen substitute and sugar-water solution spiked with uranium. Various components of the hives were sampled at intervals throughout the summer and analyzed for uranium content using delayed neutron activation. Uranium was easily detected in all components in hive samples from the experimental hives, allowing an analysis of the internal dynamics of uranium behavior within the hive. The preliminary data appear to demonstrate the advantages of the activatable tracer method.

Haarmann, T.K. 1997. Honey Bees As Indicators of Radionuclide Contamination: Exploring Colony Variability and Temporal Contaminant Accumulation. Journal of Apicultural Research 36: 77-87.

Two aspects of using honey bees as indicators of environmental radionuclide contamination were investigated: colony variability and temporal contaminant accumulation. Two separate field experiments were conducted in areas with bioavailable radionuclide contamination. Bees were collected from colonies and analyzed for concentrations of radionuclides. The first experiment indicated generally a low variability exists between samples collected within the same colony. A higher variability exists between samples collected from adjacent colonies. Levels of tritium and sodium-22 found in samples taken from similar colonies were inconsistent, while levels of cobalt-57, cobalt-60, and manganese-54 were consistent. A second experiment investigated the accumulation of radionuclides over time by comparing colonies that had been in the study area for different periods of time. This experiment demonstrated that there is indeed a significant accumulation of radionuclides within colonies.

Haarmann, T.K. 1998. Honey Bees As Indicators of Radionuclide Contamination: Comparative Studies of Contaminant Levels in Forager and Nurse Bees and in the Flowers of Three Plant Species. Archives of Environmental Contamination and Toxicology 35: 287-294.

Two separate field experiments were conducted as part of ongoing research concerning the use of honey bees as indicators of environmental radionuclide contamination. The experiments were conducted at a study site containing radionuclide concentrations above background levels. The first experiment compared levels of radionuclides found in forager bees to levels found in nurse bees. Bees were collected from colonies and analyzed for concentrations of radionuclides. Results indicated that there was no significant difference between the contaminant levels in forager and nurse bees. A second experiment compared the levels of radionuclides found in the flowers of three plant species growing at the study site: salt cedar, white sweet clover, and rabbit brush. Results indicated that there was no significant difference among the amounts of radionuclides found in the flowers of these three plants.

Haarmann, T.K. 1998. Honey Bees (Hymenoptera: Apidae) As Indicators of Radionuclide Contamination: Investigating Contaminant Redistribution Using Concentrations in Water, Flowers, and Honey Bees. Journal of Economic Entomology 91: 1072-1077.

As part of ongoing research concerning the use of honey bees as indicators of environmental radionuclide contamination, samples of water, flowers, and honey bees were collected for two consecutive years from a study site containing radionuclide concentrations above background levels. The samples were analyzed for concentrations of radionuclides, and the analytical results used to assess the redistribution pathway of radionuclides within the study site. The results indicated that honey bees received the majority of their contamination directly from the source, which was a radioactive waste lagoon. The amount of contamination that the bees received from flowers during nectar collection appeared to be insignificant compared to the amount received during water collection. Results did not demonstrate significant patterns of correlation or trend between the lagoon, bees, or flowers. Sample results indicated a significant bioaccumulation of cobalt-60 and sodium-22 within the honey bees but no significant bioaccumulation within the flowers.

Haarmann, T.K. 1998. Honey Bees (*Apis mellifera*) as Indicators of Radionuclide Contamination. Ph.D. Thesis. University of New Mexico. Albuquerque. 80 pp.

Various aspects of using honey bees as indicators of environmental radionuclide contamination were investigated at Los Alamos National Laboratory. Five field experiments were conducted within a study site that contained bioavailable radionuclides. The first experiment investigated variability of radionuclides within the colony. Results indicated that generally a low variability existed between samples collected within the same colony. A higher variability existed between samples collected from adjacent colonies. Levels of tritium and sodium-22 found in samples taken from similar colonies were inconsistent, while levels of cobolt-57, cobolt-60, and manganese-64 were consistent. Another experiment investigated the accumulation of radionuclides over time by comparing colonies that had been in the study sites for different

periods of time. This experiment demonstrated that there was a significant temporal accumulation of radionuclides within colonies. A third experiment compared levels of radionuclides found in forager bees to those levels found in nurse bees. Results indicated that there was no significant difference between the levels in forager and nurse bees. A fourth experiment compared the levels of radionuclides found in the flowers of three plant species growing in the study site: salt cedar, white sweet clover, and rabbit brush. Results indicated that there was no significant difference in the amounts of radionuclides found in the flowers of these three plants. Lastly, samples of water, flowers, and honey bees were collected for two consecutive years. Results were then used to assess the redistribution pathway of radionuclides within the study site. Results indicated that the honey bees received the majority of their contamination directly from the source, a radioactive waste lagoon. The amount of contamination that the honey bees received from flowers during nectar collection appeared to be insignificant compared to the amount received during water collection. Results from statistical analysis did not demonstrate significant patterns of correlation or trend between the lagoon, bees, or flowers. Sample results showed a significant bioaccumulation of cobalt-60 and sodium-22 within the honey bees, but no significant bioaccumulation within the flowers. Recommendations concerning the use of honey bees as indicators of contamination are included in the summary chapter of this dissertation.

Haarmann, T.K., and P.R. Fresquez. 1998. Radionuclide Concentrations in Honey Bees from Area G at TA-54 during 1997. Report No. LA-13480-PR. Los Alamos National Laboratory. 32 pp.

Honey bees were collected from two colonies located at Los Alamos National Laboratory's Area G and from one control (background) colony located near Jemez Springs, NM. The samples were analyzed for ^{137}Cs, ^{241}Am, ^{238}Pu, $^{239,240}Pu$, ^{3}H, total uranium, and gross gamma activity. The results from both Area G colonies were higher than the upper level background concentrations for ^{238}Pu and ^{3}H.

Haarmann, T.K., and P.R. Fresquez. 1999. Radionuclide Concentrations in Honey Bees from Area G at TA-54 during 1998. Report No. LA-13613-PR. Los Alamos National Laboratory. 37 pp.

Honey bees were collected from two colonies located at LANL's Area G, TA-54, and from one control colony located near Jemez Springs. Samples were analyzed for various radionuclides. Area G samples from both colonies were higher than the upper level background concentrations for $^{239,240}Pu$, tritium, and total uranium. Samples from one colony were higher than the upper level background concentrations for ^{238}Pu.

Hakonson, T.E., and K.V. Bostick. 1976. The Availability of Environmental Radioactivity to Honey Bee Colonies at Los Alamos. Journal of Environmental Quality 5: 307-309.

Data are presented on the availability of tritium, cesium-137, and plutonium to honey bee colonies foraging in the environment surrounding the Los Alamos Scientific Laboratory (LASL). Sources of these radionuclides in the Laboratory environs include liquid and atmospheric effluents and buried waste. Honey bee colonies were placed in three canyon liquid waste disposal areas and were sampled frequently, along with honey, surface water, and surrounding vegetation, to qualitatively determine the availability of these radionuclides to bees and to identify potential food chain sources of the elements. Tritium concentrations in bee and honey samples from the canyons increased rapidly from initial values of < 1 pCi/ml moisture to as much as 9.2 nCi/ml in 75 days after placement of the hives in the canyons. Seasonal patterns in foraging activities as influenced by weather and food availability were apparent in the data. It appears that several sources of tritium were utilized by the colonies, including surface water in the canyons and vegetation receiving tritium from atmospheric effluents and buried solid waste. Concentrations of cesium-137 and plutonium were generally low or undetectable in bees throughout the study. However, levels of both nuclides increased by factors of 10-20 in bees from two of the canyon study areas during a 3-month period in 1973. The speculation was that the liquid effluents in the two canyons were the source of the increased concentrations, as this was the only source of ^{137}Cs in the environment. The existence of at least three radionuclide

sources in the LASL environs complicates the interpretation of the data. However, it is apparent that honey bees can acquire ^{3}H, ^{137}Cs, and Pu from multiple sources in the environment.

Wallwork-Barber, M.K., R.W. Ferenbaugh, and E.S. Gladney. 1982. The Use of Honey Bees as Monitors of Environmental Pollution. American Bee Journal 122: 770-772.

This paper is an overview of the use of honey bees as monitors of environmental pollution, with emphasis on research performed at Los Alamos National Laboratory. Bee colonies are discussed as a feasible, long-term, self-sustaining system for environmental monitoring. The success of ongoing investigations indicates that the use of honey bee hives to assess environmental impacts of potential pollution sources deserves further investigation.

White, G.C., T.E. Hakonson, and K.V. Bostick. 1983. Fitting a Model of Tritium Uptake by Honey Bees to Data. Ecological Modelling 18: 241-251.

A compartmental model of tritium kinetics in honey bee hives was developed from a microcosm experiment. Transfer coefficients (parameters) were estimated from observed tritium concentrations in the source, bee, and honey compartments with nonlinear least squares. Application of this model to a field study with tritium released from a vent stack was not particularly successful because of the inability to model the spatial distribution process of the tritium. The environmental processes driving the distribution of tritium are highly stochastic. The predictive capability of models developed with rigorous parameter estimates from data obtained on the system being modeled is felt to be superior to other approaches.

Biotic Contaminant Data

Bennett, K., J. Biggs, and P. Fresquez. 1996. Radionuclide Contaminant Analysis of Small Mammals, Plants and Sediments within Mortandad Canyon, 1994. Report No. LA-13104-MS. Los Alamos National Laboratory. 31 pp.

Small mammals, plants, and sediments were sampled at one upstream location (Site 1) and two downstream locations (Sites 2 and 3) from NPDES outfall #051-051 in Mortandad Canyon. The purpose of the sampling was to identify radionuclides potentially present, to quantitatively estimate and compare the amount of radionuclide uptake at specific locations (Sites 2 and 3) as compared to the upstream site (Site 1), and to identify the primary mode (inhalation/ingestion or surface contact) of contamination to small mammals. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were analyzed separately. In addition, three composite samples also were collected for plants and sediments at each site. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, and total U. With the exception of total U, all mean radionuclide concentrations in small mammal carcasses and sediments were significantly higher at Site 2 than at Site 1 or Site 3. No differences were detected in the mean radionuclide concentration of plant samples between sites. However, some radionuclide concentrations found at all three sites were higher than regional background. No differences were found between mean carcass radionuclide concentrations and mean pelt radionuclide concentrations, indicating that the two primary modes of contamination may be occurring equally.

Bennett, K., J. Biggs, and P. Fresquez. 1997. Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, Los Alamos National Laboratory, 1995. Report No. LA-13242-MS. Los Alamos National Laboratory. 20 pp.

Small mammals were sampled at two waste burial sites (Site 1 – recently disturbed and Site 2 – partially disturbed) at Area G, Technical Area 54 and a control site on Frijoles Mesa (Site 4) in 1995. The objectives were 1) to identify radionuclides that are present within surface and subsurface soils, 2) to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and 3) to identify if the primary mode of contamination to small mammals is by surface contact or ingestion/inhalation. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, ^{137}Cs, and ^{3}H. Significantly higher levels of total U, ^{241}Am, ^{238}Pu, and ^{239}Pu were detected

in pelts than in carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in pelts. The results generally show higher concentrations in pelts compared to carcasses, which is similar to what has been found at waste burial/contaminated sites outside of LANL. Site 1 had a significantly higher mean tritium concentration in both carcasses and pelts than Sites 2 or 4. Site 2 had a significantly higher mean ^{239}Pu concentration in carcasses than Sites 1 or 4.

Bennett, K.D., J.R. Biggs, and P.R. Fresquez. 1998. Radionuclide Contaminant Analysis of Small Mammals at Area G, Technical Area 54, 1997 (with cumulative summary 1994-1997). Report No. LA-13517-MS. Los Alamos National Laboratory. 18 pp.

In 1997, small mammals were sampled to four locations at Area G, Technical Area 54, a control site within the proposed Area G expansion area, and a background site on Frijoles Mesa. The purpose of the sampling was to (1) identify radionuclides that are present within rodent tissues at waste burial sites, (2) compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and (3) identify the primary mode of contamination to small mammals, either through surface contact or through ingestion/inhalation. Three composite samples of approximately five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, ^{137}Cs, and ^{3}H Higher levels of total U and ^{137}Cs were detected in pelts as compared to carcasses of small mammals, and ^{90}Sr was found to be higher in carcasses. Concentrations of other measured radionuclides in carcasses were not found to be statistically different from concentrations in pelts. However, pelts generally had higher concentrations than carcasses, indicating that surface contamination may be the primary contamination mode. Low sample sized in total number of animals captured during 1997 prevented statistical analysis to compare site to site for all but four sites. Mean concentrations of ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{3}H in small mammal carcasses were found to be statistically greater at the transuranic (TRU) waste pad #2. In addition, mean concentrations of total U, ^{241}Am, and ^{3}H in pelts of small mammals also were statistically greater. The control site and background site consistently had the lowest mean concentrations of radionuclides. Year to year comparison of mean radionuclide concentrations was conducted where sufficient sample size existed. Mean concentrations of ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{3}H in carcasses were statistically greater in 1997 than in previous years at TRU waste pad #2. However, mean concentrations of ^{137}Cs in small mammal carcasses were higher at the TRU waste pad #2 and at Pits 17 and 18 during 1996.

Bennett, K., J. Biggs, and G. Gonzales. 1999. Evaluation of PCB Concentrations in Archived Small Mammal Samples from Sandia Canyon. Report No. LA-UR-99-5891. Los Alamos National Laboratory. 35 pp.

Archived small mammal samples (vole, harvest mouse, vagrant shrew, and deer mouse) from Sandia Canyon comprised of adipose tissue and internal organs from 1995 (30 samples) and 1996 (34 samples) were analyzed for PCB mixtures known as Aroclors. During the summer of 1998, 30 samples from a reference site in the Jemez Mountains were analyzed for 7 PCBs. Nine samples from 1995 and 19 samples from 1996 had detectable or estimated concentrations of Aroclor 1260, whereas no samples from the reference site had detectable levels. Preliminary evaluation of the data indicates that the maximum levels of Aroclor 1260 detected approached minimum levels for which effects have been noted.

Biggs, J., K. Bennett, and P. Fresquez. 1995. Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, 1994. Report No. LA-13015-MS. Los Alamos National Laboratory. 34 pp.

Small mammals were sampled at two waste burial sites (1 and 2) at Area G, TA-54 and a control site outside Area G (Site 3) to identify radionuclides that are present within surface and subsurface soils at waste burial sites, to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and to identify the primary mode of contamination to small mammals, either through surface contact or ingestion/inhalation. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am,

^{90}Sr, ^{238}Pu, ^{239}Pu, total U, and gamma spectroscopy (including ^{137}Cs). Significantly higher levels of total U, ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{40}K were detected in pelts as compared to the carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in the pelts. The results show higher concentrations in pelts than in carcasses, which is similar to what has been found at waste burial/contaminated sites outside of Los Alamos National Laboratory. Site 1 had significantly higher total U concentrations in carcasses than Sites 2 and 3. Site 2 had significantly higher ^{239}Pu concentrations in carcasses than either Site 1 or Site 3. A significant difference in ^{90}Sr concentration existed between Sites 1 and 2, and concentrations of ^{40}K at Site 1 were significantly different from Site 3.

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1997. Radionuclide Contaminant Analysis of Small Mammals at Area G, Technical Area 54, 1996 (with cumulative summary for 1994-1996). Report No. LA-13345-MS. Los Alamos National Laboratory. 16 pp.

Small mammals were sampled at two waste burial sites at Area G and a control site within the proposed Area G expansion to (1) identify radionuclides that are present within rodent tissues at waste burial sites, (2) to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and (3) to identify the primary mode of contamination to small mammals, either through surface contact or ingestion/inhalation. Pelts and carcasses of each animal were separated and analyzed independently for several radionuclides. Higher levels of total U, Am-241, Pu-238, and Pu-239 were detected in pelts. Concentrations of other measured radionuclides were nearly equal in pelts and carcasses. Due to low sample sizes, statistical site to site comparisons could not be conducted.

Biggs, J.R., K.D.. Bennett, P.R. Fresquez, and R.J. Robinson, 1996. Movements, Disease Analysis, and Tritium Concentrations of Rocky Mountain Elk of the Pajarito Plateau. LA-UR-96-3395. Presentation at the Symposium of Biological Research in the Jemez Mountains, New Mexico. October 26, 1996.

Seasonal movement patterns of four elk (3 cows/1 bull) and one deer fitted with VHF (very high frequency) units were investigated from spring 1995 to spring 1996. Results also are presented on disease analysis of six elk captured in 1996, as well as tritium analysis of all animals (n=11). The deer remained within three miles of its original capture location (n=39 fixes) throughout the study period. The bull elk remained on the Pajarito Plateau in winter and spring, then migrated to the Valle Grande during late spring and summer (n=49 fixes). One of the three cows died within 6 weeks of collaring, apparently following calving, near the north edge of Bandelier National Monument. The surviving cow elk remained on the east slope of the Jemez Mountains and the Pajarito Plateau during winter and early spring, then moved to the Valle Grande during calving and summer months (n=93 fixes). Based on radiotelemetry data, herds occurring in the southern portion of the Laboratory appear to migrate and calve along the eastern portion of the Valle Grande. Four of the six elk captured in 1996 had moderate to high titers for vesicular stomatitis, and one elk had a moderate titer for toxoplasmosis. One cow elk, sampled near Pajarito Road, and one male deer, sampled at TA-49, exhibited concentrations of tritium (2.2 and 1.1 pCi/ml, respectively) above the upper background limit of 0.9 pCi/ml.

Booher, J.L., P.R. Fresquez, L.F. Carter, B.M. Gallaher, and M.A. Mullen. 1998. Radionuclide Concentrations in Bed Sediment and Fish Tissue within the Rio Grande Drainage Basin. Report No. LA-13366. Los Alamos National Laboratory. 12 pp.

In 1992-1993, Los Alamos National Laboratory collaborated with the U.S. Geological Survey in an effort to characterize radionuclide concentrations in bed sediment and fish tissue within the Rio Grande drainage basin from Colorado to Texas. Bed sediment was sampled from 18 locations for ^{137}Cs, ^{3}H, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{241}Am, ^{tot}U, and alpha, beta, and gamma activity. Fish tissue was sampled from 12 locations for ^{137}Cs, ^{90}Sr, ^{238}Pu, ^{239}Pu, and ^{tot}U. Detailed data tables are presented.

Brooks, G.H., Jr. 1989. The Comparative Uptake and Interaction of Several Radionuclides in the Trophic Levels Surrounding the Los Alamos Meson Physics Facility (LAMPF) Waste Water

Ponds. Report No. LA-11487-T. Los Alamos National Laboratory. 151 pp. (M.S. Dissertation, San Jose State University)

This report documents the results of a study designed to examine the uptake, distribution, and interaction of five activation products (^{57}Co, ^{7}Be, ^{134}Cs, ^{83}Rb, and ^{54}Rb) within the biotic and abiotic components surrounding the Los Alamos Meson Physics Facility (LAMPF) lagoons in the days when the lagoons discharged into the canyon below LAMPF. Preliminary estimates of trophic level radionuclide transfer are presented.

Ferenbaugh, J.K. 1999. Radionuclide Uptake by Elk and Deer and the Associated Health Risks from a Low-Level Radioactive Waste Disposal Site. Report No. LA-13622-T. Los Alamos National Laboratory. (M.S. Dissertation, University of Minnesota)

Material Disposal Area G (Area G) is the primary low-level radioactive waste disposal site at Los Alamos National Laboratory (LANL) and occupies an area adjacent to Pueblo of San Ildefonso lands. Analyses of soil and vegetation collected from the perimeter of Area G show radionuclide concentrations greater than background (BG) concentrations for northern New Mexico. Pueblo residents are concerned about ingesting contaminants from Area G by consuming ungulates that forage near Area G and then migrate on to tribal land. The uptake of ^{3}H, ^{90}Sr, ^{tot}U, ^{238}Pu, ^{239}Pu, ^{241}Am, and ^{137}Cs by Rocky Mountain elk (Cervus elaphus) and mule deer (Odocoileus hemionus) that forage near Area G and the associated dose to the animals were estimated using equations modified from the literature coded into a spreadsheet (steady-state) model. Additionally, the dose to humans who consume the meat was estimated using the RESRAD program. Radionuclide concentrations in soil and water collected from the perimeter of Area G and from BG regions averaged over a four year period were used as input data. Concentration estimates generated by the spreadsheet model correspond well to the concentration range measured in tissue samples taken from animals collected at LANL, and the maximum estimated net dose (mean + 2SD minus background) was 2.8×10^{-4} mGy d^{-1} (elk). The maximum estimated net dose to humans consuming elk meat at the most conservative ingestion rate (23 kg y^{-1}) was 4.0×10^{-4} mSv y^{-1}. All estimated worst case doses were less than guidelines established to protect the environment (1 mGy d^{-1}) and the public (1 mSv y^{-1}) from radionuclides.

Ferenbaugh, J.K., P.R. Fresquez, M.H. Ebinger, G.J. Gonzales, and P.A. Jordan. 1999. Elk and Deer Study, Material Disposal Area G, Technical Area 54: Source Document. Report No. LA-13596-MS. Los Alamos National Laboratory. 74 pp. Also abstracted at Health Physics 74(6): s28 (1998).

Material Disposal Area G is the primary low-level radioactive waste disposal site at LANL and occupies an area adjacent to the Pueblo of San Ildefonso. Analyses of soil and Vegetation collected from the perimeter of Area G have shown concentrations of radionuclides greater than background concentrations established for Northern New Mexico. As a result, Pueblo residents have become concerned that contaminants from area G could enter tribal lands through various ecological pathways. The residents specifically questioned the safety of consuming meat from elk and deer that forage near Area G and then migrate onto tribal lands. Consequently, this study addresses the uptake of radionuclides by elk and deer that forage around the perimeter of Area G and the associated doses to the animals and to humans who consume these animals. Concentration estimates generated by the models used in the study correspond to the concentration range measured in actual tissue samples from elk and deer collected at LANL. The highest doses for both animals and humans were well below guidelines established to protect the environment and the public from radiological health risks.

Ferenbaugh, R.W., and E.S. Gladney. 1997. Mortandad Canyon: Elemental Concentrations in Vegetation, Streambank Soils, and Stream Sediments – 1979. Report No. LA-13325-MS. Los Alamos National Laboratory. 7 pp.

In 1979, stream sediments, streambank soils, and streambank vegetation were sampled at 100 m intervals downstream of the outfall of the TA-50 radioactive liquid waste treatment facility in Mortandad Canyon. Sampling was discontinued at a distance of 3260 m at the location of the sediment traps in the canyon. The purpose of the sampling was to investigate the effect of the

residual contaminants in the waste treatment facility effluent on elemental concentrations in environmental media. Data are presented for Be, Cd, Cl, Cr, F, NO_3, PO_4, SO_4, ^3H, and Hg.

Ferenbaugh, R.W., E.S. Gladney, and G.H. Brooks, Jr. 1990. Sigma Mesa: Background Elemental Concentrations in Soil and Vegetation, 1979. Report No. LA-11941-MS. Los Alamos National Laboratory. 22 pp.

In 1979, soil and vegetation samples were collected on Sigma Mesa to provide background data prior to the advent of construction on the mesa. Elemental data are presented for soil, grass, juniper, piñon pine, and oak. Analytical data are presented for Al, As, B, Ba, Be, Br, Cd, Cl, Cu, F, Fe, Hg, Li, Mg, Mn, Ni, NO_3, Pb, PO_4, Rb, SO_4, Ti, and Zn. None of the data looks out of the ordinary.

Ferenbaugh, R.W., W.D. Spall, and D.M. LaCombe. 1981. Detection of Bromacil Herbicide in Ponderosa Pine. Bulletin of Environmental Contamination and Toxicology 27: 268-273.

This paper describes an investigation into the cause of tree mortality at Los Alamos National Laboratory (LANL) during the spring and summer of 1978. Prior to this time period, bromacil herbicide(Tradename – HYVAR) was used as part of a vegetation control program along roadways at the LANL preserve. There are about 180 miles of paved roads on Laboratory property, and vegetation control is required for both safety and road surface maintenance. The prescribed bromacil application method was to spray a four-foot wide strip of bromacil solution along the edges of roadways with a spray-bar. The application rate was 2.5-5.0 lb/acre. The application usually was made in the fall of the year so that melting snow in the spring would leach the bromacil into the soil, from which it would be taken up by vegetation during the spring growing season. During the late spring and early summer of 1978, bromacil was determined to be the proximate cause of damage to numerous trees at substantial distances away from roadways at Los Alamos. Little snow fell during the winter of 1977-78. As a result, bromacil was not leached into the soil by snowmelt but was washed away from pavement edges by heavy rainfall in the spring, resulting in unanticipated treekill away from the highway. Coniferous vegetation is known to be sensitive to bromacil pesticide, and gas chromatographic analysis showed substantial bromacil concentrations in tree foliage from the affected trees.

Fresquez, P.R. 1998. Baseline Tritium Concentrations in Soils and Vegetation: The Tshirege Woodland Site at TA-54. Report No. LA-UR-98-1079. Los Alamos National Laboratory. 4 pp.

A preoperational survey for tritium was conducted for the Tshirege woodland site, an experimental area managed by ESH-15, where tritium will be injected 10 cm deep in and around the base of piñon and juniper trees during the summer of 1990. The site is located at the lower end of Canada del Buey close to the intersection of Pajarito and State Road 4. Baseline values of ^3H were measured in soil and plant samples from five locations immediately surrounding the study area. Mean values of ^3H in soils collected from the 0-5 and 25-30 cm depths were 1.24 ± 0.22 and 1.08 ± 0.41 pCi/mL, respectively. Piñon needles averages 1.68 ± 0.18 pCi/mL, and blue grama grass averaged 1.16 ± 0.95 pCi/mL.

Fresquez, P.R., D.R. Armstrong, M.A. Mullen, and L. Naranjo, Jr. 1997. Radionuclide Concentrations in Pinto Beans, Sweet Corn, and Zucchini Squash Grown in Los Alamos Canyon at Los Alamos National Laboratory. Report No. LA-13304-MS. Los Alamos National Laboratory. 31 pp. Also In: Journal of Environmental Science and Health B33: 99-115.

Pinto beans, sweet corn, and zucchini squash were grown at a site that contained the highest observed levels of surface gross gamma radioactivity within Los Alamos Canyon. Soils as well as washed edible and nonedible crop tissues were analyzed for various radionuclides and heavy metals. Most radionuclides in soil from LAC, with the exception of tritium and total uranium, were detected in significantly higher concentrations than in soil from regional background (RBG) locations. Similarly, most radionuclides in edible crop portions of beans, squash, and corn were detected in significantly higher concentrations than RGB. Most soil-to-plant concentration ratios for radionuclides in edible and non-edible crop tissues were within the default values given by the Nuclear Regulatory Commission and Environmental Protection Agency. All heavy metals in soils and both edible and nonedible crop tissues were within RBG concentrations.

Fresquez, P.R., D.R. Armstrong, and L. Naranjo, Jr. 1996. Radionuclide and Heavy Metal Concentrations in Soil, Vegetation, and Fish Collected Around and Within Tsicoma Lake in Santa Clara Canyon. Report No. LA-13144-MS. Los Alamos National Laboratory. 99 pp.

This study was undertaken at the request of Santa Clara Pueblo officials as Tsicoma Lake is slightly downwind of Los Alamos National Laboratory. Radionuclide and heavy metal concentrations were determined in soil, vegetation (overstory and understory), and fish (rainbow trout) collected around and within Tsicoma Lake in Santa Clara Canyon in 1995. All heavy metal and most radionuclide concentrations, with the exception of uranium in soil, vegetation, and fish, were within or just above upper limit background concentrations. Detectable levels (where the analytical result was greater than two times the counting uncertainty) of uranium in soils, vegetation, and fish were found in slightly higher concentrations than in background samples. Overall, however, the maximum total committed effective dose equivalent (CEDE)(0.066 mrem/yr), based on the consumption of 46 lb of fish, was within the maximum CEDE from the ingestion of fish from the Mescalero National Fish Hatchery (background)(0.113 mrem/yr).

Fresquez, P.R., D.R. Armstrong, and L. Naranho, Jr. 1998. Radionuclides and Heavy Metals in Rainbow Trout from Tsichomo, Nana Ka, Won Povi, and Pin De Lakes in Santa Clara Canyon. Report No. LA-13441-MS. Los Alamos National Laboratory. 38 pp.

Radionuclide and heavy metal concentrations were determined in rainbow trout collected from Tsichomo, Nana Ka, Won Povi, and Pin De Lakes in Santa Clara Canyon in 1997. Most radionuclide and heavy metal concentrations in fish collected from these four lakes were within or just above upper limit background concentrations (Abiquiu reservoir) and as a group were statistically similar to background. Consequently, the committed effective dose equivalent (CEDE) from the ingestion of 46 lb of fish from Santa Clara Canyon (0.028 mrem/yr) was within the CEDE from the ingestion of fish from Abiquiu reservoir (0.037 mrem/yr). Moreover, the upper level net positive total CEDE – a dose that potentially could be attributed to Laboratory operations – was only 0.042 mrem/yr. This dose is far below the International Commission on Radiological Protection permissible dose level of 100 mrem/yr from all pathways and corresponds to an excess cancer fatality risk of 2.1×10^{-8} – which also is far below the EPA guideline of 10^{-4}.

Fresquez, P.R., D.R. Armstrong, and L.H. Pratt. 1997. Tritium Concentrations in Bees and Honey at Los Alamos National Laboratory: 1979-1996. Report No. LA-13202-MS. Los Alamos National Laboratory. 14 pp.

The objective of this study was to summarize tritium concentrations in bees and honey collected from within and around Los Alamos National Laboratory over an 18 year period. Based on the long-term average, bees from nine out of eleven hives and honey from six out of eleven hives on LANL lands contained tritium concentrations significantly higher than background. The highest average concentration of tritium in bees was from TA-54, a low level radioactive waste disposal site. The highest average concentration of tritium in honey was from a hive located near three tritium storage ponds at TA-53. Although concentrations of tritium in bees and honey from most LANL and perimeter (White Rock/Pajarito Acres) areas were significantly higher than background, most areas (with the exceptions of TA-53 and TA-54) generally exhibit decreasing tritium concentrations over time.

Fresquez, P.R., D.A. Armstrong, and J.G. Salazar. 1994. Radionuclide Concentrations in Elk That Winter On Los Alamos National Laboratory Lands. Report No. LA-12795-MS. Los Alamos National Laboratory. 5 pp. Also In: Health Physics 68: 64.

Elk spend the winter in areas at LANL that may contain radioactivity above natural and/or worldwide fallout levels. This study was initiated to determine the levels of ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239}Pu, and total uranium in various tissues (brain, hair, heart, jawbone, kidneys, leg bone, liver, and muscle) of adult cow elk that use LANL lands during the fall/winter months. No significant differences in radionuclide contents were detected in any of the tissue samples collected from elk on LANL lands as compared with elk collected from off-site locations. The total effective (radiation) dose equivalent that a person would receive from consuming 3.2 lb of heart, 5.6 lb of liver, and 226 lb of muscle from elk that winter on LANL lands, after natural background has been

subtracted, was 0.00008, 0.0001, and 0.008 mrem/yr, respectively. The highest dose was less than 0.01% of the International Commission on Radiological Protection permissible dose limit for protecting the public.

Fresquez, P.R., D.A. Armstrong, and J.G. Salazar. 1994. Radionuclide Concentrations in Game and Nongame Fish Upstream and Downstream of Los Alamos National Laboratory: 1981-1993. Report No. LA-12818-MS. Los Alamos National Laboratory. 22 pp. Also In: Proceedings of the New Mexico Conference on the Environment. Pp. 684-689. April 24-26. Albuquerque.

Radionuclide concentrations were determined in game (surface-feeding) and nongame (bottom-feeding) fish collected from reservoirs upstream (Abiquiu, Heron, and El Vado) and downstream (Cochiti) of Los Alamos National Laboratory from 1981 to 1993. The average levels of ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239}Pu in both game and nongame fish collected from Cochiti reservoir were not significantly different from fish collected from reservoirs upstream of the Laboratory. Total uranium was the only radionuclide that was found to be significantly higher in both game and nongame fish from Cochiti as compared to fish from Abiquiu, Heron, and El Vado. The uranium concentrations in fish collected from Cochiti, however, significantly decreased from 1981 to 1983, and no evidence of depleted uranium was found in fish samples collected from Cochiti in 1993. Based on the average concentration of radionuclides over the years, the effective radiation dose equivalent from consuming 46 lb of game and nongame fish from Cochiti reservoir after natural background has been subtracted was 0.005 and 0.009 mrem/yr, respectively. The highest dose was <0.01% of the International Commission on Radiation Protection permissible dose limit for protecting members of the public.

Fresquez, P.R., D.A. Armstrong, and J.G. Salazar. 1994. Tritium Concentrations in Bees and Honey at Los Alamos National Laboratory. Report No. LA-12872-MS. Los Alamos National Laboratory. 11 pp.

Los Alamos National Laboratory (LANL) has maintained a network of honey bee colonies at LANL, perimeter (Los Alamos townsite and White Rock/Pajarito acres), and regional (background) locations for over 15 years. The main objective of this honey bee network was to help determine the bioavailability of certain radionuclides in the environment. Of all the radionuclides studies (^{3}H, ^{57}Co, ^{7}Be, ^{22}Na, ^{54}Mn, ^{83}Rb, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{90}Sr, and total U), tritium was consistently detected in bees and was most readily transferred to the honey. In fact, honey collected from hives located at TA-21, TA-33, TA-50, TA-53, and TA-54 and from White Rock/Pajarito Acres contained significantly higher concentrations of ^{3}H than regional background hives. Based on the average concentration of all radionuclides measured over the years, the effective dose equivalent (EDE) from consuming 5 kg (11 lb) of honey collected from Los Alamos (townsite) and White Rock/Pajarito Acres, after regional background has been subtracted, was 0.0186 ± 0.0507 and 0.0016 ± 0.0010 mrem/yr, respectively. The highest EDE was 0.1200 mrem/yr, which is <0.2% of the International Commission on Radiological Protection permissible dose limit of 100 mrem/yr from all pathways.

Fresquez, P.R., D.A. Armstrong, and J.G. Salazar. 1995. Radionuclide Concentrations in Fish Collected from Jemez, Nambe, and San Ildefonso Tribal Lakes. Report No. 12899-MS. Los Alamos National Laboratory. 7 pp.

Radionuclide concentrations (^{90}Sr,.^{137}Cs, ^{238}PU, ^{239}Pu, and total uranium) were determined in fish collected from Jemez, Nambe, and San Ildefonso tribal lakes. With the exception of ^{137}Cs, all other radionuclides were not significantly different in (stocked) rainbow trout collected from Jemez and Nambe as compared with game fish collected from Abiquiu, Heron, and El Vado Reservoirs. Although ^{137}Cs levels in trout from Jemez and Nambe were significantly higher than ^{137}Cs concentrations in fish from Abiquiu, Heron, and El Vado, they were still well below the regional statistical (worldwide fallout) reference level. Game and nongame fish collected from San Ildefonso contained higher concentrations or uranium, respectively, as compared with fish collected from Abiquiu, Heron, and El Vado. The higher uranium concentrations in fish from San Ildefonso were attributed to the higher natural uranium contents in the area as compared with the geology of the area upstream of San Ildefonso. The effective (radiation) dose equivalent (EDE) from consuming 46 lb of game fish from Jemez, Nambe, and San Ildefonso lakes, after natural

background has been subtracted, was 0.013, 0.019, and 0.017 mrem/yr, respectively. Similarly, the EDE from consuming nongame fish from San Ildefonso was 0.0092 mrem/yr. The highest calculated dose, based on the mean + 2 standard deviations (95% confidence level), was 0.073 mrem/yr. This is 0.08% of the International Commission on Radiological Protection permissible dose limit for protecting members of the public.

Fresquez, P.R., D.R. Armstrong, and J.G. Salazar. 1995. Radionuclide Concentrations in Soils and Produce from Cochiti, Jemez, Taos, and San Ildefonso Pueblo Gardens. Report No. LA-12932-MS. Los Alamos National Laboratory. 9 pp.

Radionuclide (^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239}Pu, and total uranium) concentrations were determined in soils and produce collected from Cochiti, Jemez, Taos, and San Ildefonso Pueblo Gardens. All radionuclides in soils from Pueblo gardens were within or just above regional statistical (natural and/or worldwide fallout) reference levels. Similarly, the average levels of radionuclides in produce collected from Cochiti, Jemez, Taos, and San Ildefonso Pueblo gardens were not significantly different than in produce collected from regional (background) locations. The effective (radiation) dose equivalent from consuming 352 lb of produce from Cochiti, Jemez, Taos, and San Ildefonso, after natural background had been subtracted, was 0.036±0.016, 0.072±0.051, 0.,012±0.027, and 0.110±0.102 mrem/yr, respectively. The highest calculated dose was 0.314 mrem/yr, which is <0.4% of the International Commission on Radiological Protection permissible dose limit for protecting members of the public.

Fresquez, P.R., J.R. Biggs, and K.D. Bennett. 1995. Radionuclide Concentrations in Vegetation at Radioactive-Waste Disposal Area G During the 1994 Growing Season. Report No. LA-12954-MS. Los Alamos National Laboratory. 8 pp.

Overstory (piñon pine) and understory (grass and forb) vegetation samples were collected within and around selected points at Area G for radionuclide analysis. In general, most vegetation samples collected within and around Area G contained radionuclide levels in higher concentrations than vegetation collected from background areas. Tritium, in particular, was detected as high as 5,800 pCi/mL in overstory vegetation collected outside the fence just west of the tritium shafts. This suggests that tritium is migrating from this waste repository through subsurface pathways. Also, understory vegetation collected north of the TRU pads (outside the Area G fence) contained the highest values for several radionuclides, which may be a result of surface holding, storage, and/or disposal activities.

Fresquez, P.R., J.R. Biggs, K.D. Bennett, D.H. Kraig, M.A. Mullen, and J.K. Ferenbaugh. (1)1998. Radionuclide Concentrations in Deer and Elk from Los Alamos National Laboratory: 1991-1998. Report No. LA-13553-MS. Los Alamos National Laboratory. 33 pp.
(2)1999. Radionuclides in Deer and Elk from Los Alamos National Laboratory and the Doses to Humans from the Ingestion of Muscle and Bone. Journal of Environmental Science and Health B34: 901-915.

Mule deer and Rocky Mountain elk forage in many areas at Los Alamos National Laboratory (LANL) that may contain radioactivity above natural and/or worldwide fallout levels. This paper and report summarize radionuclide concentrations (^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and ^{tot}U) in muscle and bone tissue of deer and elk collected from LANL lands from 1991 through 1998. Also, the committed effective dose equivalent (CEDE) and the risk of excess cancer fatalities (RECF) to people who ingest muscle and bone from deer and elk collected from LANL lands were estimated. Most radionuclide concentrations in muscle and bone from individual deer and elk collected from LANL lands were either at less than detectable quantities and/or within the upper 95% confidence level for background (BG) concentrations. As a group, most radionuclides in muscle and bone of deer and elk from LANL lands were not significantly higher than in similar tissues from deer and elk collected from BG locations. Also, elk that had been radiocollared and tracked for two years and that spent an average of 50% on LANL lands were not significantly different in most radionuclides from road kill elk that had been collected as part of the environmental surveillance program. Overall, the upper 95% confidence level net CEDEs at the most conservative ingestion rate (51 lb of muscle and 13 lb of bone) were as follows: deer muscle = 0.220, deer bone = 3.762, elk muscle = 0.117, and elk bone = 1.67 mrem/yr. All CEDEs were

far below the International Commission on Radiological Protection guideline of 100 mrem/yr, and the highest muscle plus bone CEDE (4.0 mrem/yr) corresponded to a RECF of 2E-06, which is far below the EPA upper level guidance of 1E-04.

Fresquez, P.R., M.H. Ebinger, H.T. Haagenstad, and L. Naranjo, Jr. 1999. Baseline Concentrations of Radionuclides and Trace Elements in Soils and Vegetation around the DARHT Facility: Construction Phase (1998). Report No. LA-13669-MS. Los Alamos National Laboratory. 77 pp.

The Mitigation Action Plan for the Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility at Los Alamos National Laboratory mandates the establishment of baseline concentrations for potential environmental contaminants. To this end, concentrations of ^{3}H, ^{137}CS, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and ^{tot}U radionuclides and Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl metals were determined in surface and subsurface soils, sediments, and vegetation (overstory and understory) around the DARHT facility during the construction phase in 1998. (This is the third year of a four year baseline study.) Also, volatile (VOC) and semivolatile (SVOC) organic compounds were measured in soils and sediments. Most radionuclides and trace metals in soil, sediment, and vegetation were similar to past years at DARHT and were within regional background concentrations. Exceptions were concentrations of ^{90}Sr, Be, Ba, and total U in some samples. These elements exceeded upper limit (i.e., mean plus two standard deviations) regional background concentrations. No VOCs and very few SVOCs were detected in soils and sediments. Mean ($\pm$ standard deviation) radionuclide and trace element concentrations measured in soil, sediment, and vegetation over a three-year period (construction phase) are summarized.

Fresquez, P.R., M.H. Ebinger, R.J. Wechsler, and L. Naranjo, Jr. 1999. Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G During the 1998 Growing Season (with a Cumulative Summary of ^{3}H and ^{239}Pu over Time). Report No. LA-13647-PR. Los Alamos National Laboratory. 91 pp.

Soils and unwashed overstory and understory vegetation were collected at 8 locations within and around Area G and analyzed for various radionuclides. Most of the radionuclide concentrations were within the upper level of background concentrations except for tritium and ^{239}Pu. Tritium concentrations in vegetation from most sites were greater than background concentrations. Concentrations of ^{239}Pu in soils and understory vegetation were largest in samples collected several meters north of the transuranic waste pad area. Based on tritium and ^{239}Pu data through 1998, concentrations were significantly greater than background in soils and vegetation collected from most locations, and there was no apparent systematic change with time.

Fresquez, P.R., and M. Ennis. 1995. Baseline Radionuclide Concentrations in Soils and Vegetation Around the Proposed Weapons Engineering Tritium Facility and the Weapons Subsystems Laboratory at TA-16. Report No. LA-13028-MS. Los Alamos National Laboratory. 15 pp.

An environmental survey was conducted over the proposed site of the Weapons Engineering Tritium Facility (WETF) and the Weapons Subsystems Laboratory (WSL) at Los Alamos National Laboratory (LANL) at TA-16. Baseline concentrations of tritium (^{3}H), plutonium (^{238}Pu and ^{239}Pu), and total uranium were measured in soils, vegetation (pine needles and oak leaves), and ground litter. Tritium also was measured in air samples, while cesium (^{137}Cs) was measured in soils. The mean concentration of airborne tritiated water during 1987 was 3.9 pCi/m^{3}. Although the mean annual concentration of ^{3}H in soil moisture in the 0-5 (2 in) soil depth was measured at 0.6 pCi/mL, a better background level, based on long-term regional data, was considered to be 2.6 pCi/mL. Mean values for ^{137}Cs, ^{238}Pu, ^{239}Pu, and total uranium in soils collected from the 0-5 cm depth were 1.08 pCi/g, 0.0014 pCi/g, 0.0325 pCi/g, and 4.01 μg/g, respectively. Ponderosa pine needles contained higher values of ^{238}Pu, ^{239}Pu, and total uranium than did leaves collected from Gambel's oak. In contrast, leaves collected from Gambel's oak contained higher levels of ^{137}Cs than pine needles did.

Fresquez, P.R., T.S. Foxx, and L. Naranjo, Jr. 1995. Strontium Concentrations in Chamisa (*Chrysothamnus nauseosus*) Shrub Plants Growing in a Former Liquid Waste Disposal Area in Bayo Canyon. Report No. LA-13050-MS. Los Alamos National Laboratory. 8 pp.

Chamisa shrub plants growing in a former liquid waste disposal site in Bayo Canyon at Los Alamos National Laboratory were collected and analyzed for strontium (^{90}Sr) and total uranium. Surface soil samples also were collected from below (understory) and between (interspace) shrub canopies. Both chamisa plants growing over the waste disposal site contained significantly higher concentrations of ^{90}Sr than a control plant. One plant, in particular, contained 90,500 pCi of ^{90}Sr per g ash in top-growth material. Similarly, soil samples collected underneath and between plants contained ^{90}Sr concentrations above background and LANL screening action levels. This probably occurred as a result of chamisa plant leaf fall contaminating the soil understory area followed by water and/or wind moving the ^{90}Sr into the interspace area. Although some soil surface migration of ^{90}Sr from the waste disposal site has occurred, the level of ^{90}Sr in sediments collected downstream of the waste disposal site at the Bayo Canyon/State Road 4 intersection was still within regional (background) concentrations.

Fresquez, P.R., H.T. Haagenstad, and L. Naranjo, Jr. 1997. Baseline Concentrations of Radionuclides and Heavy Metals in Soils and Vegetation around the DARHT Facility: Construction Phase (1996). Report No. LA-13273. Los Alamos National Laboratory. 90 pp.

As part of the DOE's Mitigation Action Plan for the DARHT Facility at LANL, baseline concentrations of radionuclides (^{3}H, ^{137}Cs, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{241}Am, total U) and heavy metals (Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl) in soil, sediment, and vegetation (overstory and understory) were determined around the DARHT facility during the construction phase in 1996. Also, U and Be concentrations in soil samples collected in 1993 from within the proposed DARHT facility area are reported. Most radionuclides in soils, sediments, and vegetation were within current background and/or long-term regional statistical reference levels.

Fresquez, P.R., H.T. Haagenstad, and L. Naranjo, Jr. 1998. Baseline Concentrations of Radionuclides and Heavy Metals in Soils and Vegetation around the DARHT Facility: Construction Phase (1997). Report No. LA-13470-PR. Los Alamos National Laboratory. 112 pp.

As part of the DOE's Mitigation Action Plan for the DARHT Facility at LANL, baseline concentrations of radionuclides (^{3}H, ^{137}Cs, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{241}Am, total U) and heavy metals (Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl) in soil, sediment, and vegetation (overstory and understory) were determined during the construction phase in 1997. Most radionuclides in soils, sediments, and vegetation, with the exception of ^{90}Sr in soils and sediments, were within upper limit background concentrations. Although the levels of ^{90}Sr in soils and sediments were higher than background, they were below LANL screening action levels and are of no concern.

Fresquez, P.R., J.D. Huchton, and M.A. Mullen. 1999. Trace Elements, With Special Reference to Mercury, in Fish Collected Upstream and Downstream of Los Alamos National Laboratory. Report No. LA-13658-MS. Los Alamos National Laboratory. 12 pp.

Trace elements were determined in muscle of fish (mostly carp, catfish, and sucker) collected from the confluences of major canyons that cross LANL lands with the Rio Grande. Trace elements also were determined in fish from reservoirs upstream and downstream of LANL from 1991 through 1999. In general, all of the trace elements, including mercury, were either at the limits of detection or in low concentrations at all study sites. Of the trace elements (Ba, Cu, Hg) that were found to be above the limit of detection in fish collected from LANL canyon confluences, none were significantly higher than background locations. Mercury concentrations in fish from Abiquiu Reservoir were significantly higher than in fish from Cochiti Reservoir, but concentrations from both reservoirs exhibited significantly decreasing trends over time.

Fresquez, P.R., J.D. Huchton, M.A. Mullen, and L. Naranjo, Jr. 2000. Radionuclides in Piñon Pine (*Pinus edulis*) nuts from Los Alamos National Laboratory Lands and the Dose from Consumption. Journal of Environmental Science and Health B35: 611-622.

*One of the dominant tree species growing within and around the eastern portion of Los Alamos National Laboratory (LANL), Los Alamos, NM, lands is the piñon pine (*Pinus edulis*). Piñon pine is used for firewood, fence posts, and building materials and also is a source of nuts for food. The seeds are consumed by a wide variety of animals and also are gathered by people in the area and eaten raw or roasted. This study investigated (1) the concentration of ^{3}H, ^{137}Cs, ^{90}Sr, ^{tot}U, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am in soils (0-12 in depth underneath the tree), piñon pine shoots (PPS), and piñon pine nuts (PPN) collected from LANL lands and regional background (BG) locations, (2) committed effective dose equivalent (CEDE) from the ingestion of nuts, and (3) soil to PPS to PPN concentration ratios (CRs). Most radionuclides, with the exception of ^{3}H in soils, were not significantly higher in soils, PPS, and PPN collected from LANL as compared to BG locations; and concentrations of most radionuclides in PPN from LANL have decreased over time. The maximum net CEDE (i.e., CEDE plus two sigma minus BG) at the most conservative ingestion rate (10 lb) was 0.0018 mrem. This is far below the International Commission on Radiological Protection (all pathway) permissible dose limit of 100 mrem. Soil-to-nut CRs for most radionuclides were within the range of default values in the literature for common fruits and vegetables.*

Fresquez, P.R., D.H. Kraig, M.A. Mullen, and L. Naranjo, Jr.
1)1999. Radionuclides and Trace Elements in Fish Collected Upstream and Downstream of Los Alamos National Laboratory and the Doses to Humans from the Consumption of Muscle and Bone. Report No. LA-UR-99-953. Los Alamos National Laboratory.
2)1999. Radionuclide and Heavy Metal Concentration in Fish from the Confluences of Major Canyons That Cross Los Alamos National Laboratory Lands with the Rio Grande. Report No. LA-13564-MS. Los Alamos National Laboratory. 20 pp.
3)1999. Radionuclides and Trace Elements in Fish Collected Upstream and Downstream of Los Alamos National Laboratory and the Doses to Humans from the Consumption of Muscle and Bone. Journal of Environmental Science and Health B34: 885-899.

The purpose of this study was to determine radionuclide and trace element concentrations in bottom-feeding fish (catfish, carp, and suckers) collected from the confluences of some of the major canyons that cross Los Alamos National Laboratory (LANL) with the Rio Grande and the potential radiological doses from the ingestion of these fish. Samples of muscle and bone (and viscera in some cases) were analyzed for ^{3}H, ^{90}Sr, ^{137}Cs, ^{tot}U, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am and for Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl. Most radionuclides in the muscle plus bone portions of fish collected from LANL canyons and the Rio Grande, with the exception of ^{90}Sr, were not significantly higher from fish collected upstream (San Ildefonso/background) of LANL. Strontium-90 in fish muscle plus bone tissue significantly increased in concentration from Los Alamos Canyon, the most upstream confluence to Frijoles Canyon, the most down stream confluence. However, the differences in ^{90}Sr concentrations were very small. Based on the average concentrations of radionuclides in fish tissue from the four LANL confluences, the committed effective dose equivalent from the ingestion of 46 lb (21 kg) (maximum ingestion rate per person per year) of fish muscle plus bone, after the subtraction of background, was far below the International Commission on Radiological Protection (all pathways) permissible dose limit of 100 mrem per year. Of the trace elements that were found above the limits of detection (Ba, Cu, and Hg) in fish muscle, none were found in significantly higher concentrations than in muscle of fish collected from background locations.

Fresquez, P.R., E.L. Vold, and L. Naranjo, Jr. 1996. Radionuclide Concentrations in/on Vegetation at Radioactive-Waste Disposal Area G during the 1995 Growing Season. Report No. 13124-PR. Los Alamos National Laboratory. 37 pp.

Overstory (piñon pine) and understory (grass and forb) vegetation were collected within and around selected points at Area G – a low-level radioactive solid-waste disposal facility at Los Alamos National Laboratory – for the analysis of tritium (^{3}H), strontium (^{90}Sr), plutonium (^{238}Pu and ^{239}Pu), cesium (^{137}Cs), and total uranium. Also, heavy metals (Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl) in/on vegetation were determined. In general, most (unwashed) vegetation collected within and around Area G contained ^{3}H, uranium, ^{238}Pu, and ^{239}Pu in higher concentrations than vegetation collected from background areas. Tritium, in particular, was

detected as high as 7,300 pCi/mL in understory vegetation collected from the west side of the transuranic (TRU) pads. The south and west ends of the tritium shaft field also contained elevated levels of ^{3}H in overstory, and especially in understory vegetation, as compared to background. This suggests that ^{3}H may be migrating from this waste repository through surface and subsurface pathways. Also, understory vegetation collected north of the TRU pads (adjacent to the fence line of Area G) contained the highest values of ^{238}Pu and ^{239}Pu as compared to background. This may be a result of surface holding, storage, and/or disposal activities.

Fresquez, P.R., E.L. Vold, and L. Naranjo, Jr. 1997. Radionuclide Concentrations in Soils and Vegetation at Radioactive-Waste Disposal Area G during the 1996 Growing Season. Report No. LA-13332-PR. Los Alamos National Laboratory. 113 pp.

Soil and overstory and understory vegetation (washed and unwashed) collected at eight locations within and around Area G – a low-level radioactive solid waste disposal facility at Los Alamos National Laboratory – were analyzed for ^{3}H, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{137}Cs, ^{234}U, ^{235}U, ^{238}U, ^{tot}U, ^{228}Ac, ^{214}Bi, ^{60}Co, ^{40}K, ^{54}Mn, ^{22}Na, ^{214}Pb, and ^{208}Tl. Also, heavy metals (Ag, As, Ba, Be, Cd, Cr, Hg, Ni, Pb, Sb, Se, and Tl) in soil and vegetation were determined. In general, most radionuclide concentrations, with the exception of ^{3}H and ^{239}Pu, in soils and washed and unwashed overstory and understory vegetation collected from within and around Area G were within upper limit background concentrations. Tritium was detected as high as 14,744 pCi/mL in understory vegetation collected from transuranic (TRU) waste pad #4, and the TRU waste pad area contained the highest levels of ^{239}Pu in soils and in understory vegetation as compared to other areas at Area G,

Fresquez, P.R., R.J. Wechsler, and L. Naranjo, Jr. 1998. Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 1997 Growing Season. Report No. LA-13495-PR. Los Alamos National Laboratory. 47 pp.

Soil and overstory and understory vegetation were collected at Area G and analyzed for radionuclides and heavy metals. In general, most radionuclide concentrations in soils and both washed and unwashed overstory and understory vegetation, with the exception of tritium and Pu-239, were within upper limit background concentrations. Although tritium concentrations in vegetation from most sites were significantly higher than background, concentrations decreased markedly in comparison to previous year's results. Also, as in the past, the transuranic waste pad area contained the highest levels of ^{239}Pu in soils and in understory vegetation as compared to other areas at Area G,

Gladney, E.S., R.W. Ferenbaugh, R.G. Bowker, E.A. Jones, M.G. Bell, J.D. Morgan, E.A. Stallings, L.A. Nelson, and C. Lundstrom. 1993. An Investigation of Sulfur Concentrations in Soils and Pine Needles in Bandelier National Monument, New Mexico. Report No. LA-12417-MS. Los Alamos National Laboratory. 48 pp.

Sulfur measurements in different age groups of piñon pine needles and adjacent soil samples from ten sampling sites at Bandelier National Monument were determined using combustion elemental analysis and chromatographic techniques. The primary goal was to establish base-line levels for elemental sulfur in the Monument. Sulfur levels in foliage and soils were evaluated using analysis of variance techniques. Foliage sulfur concentrations differed significantly among the 10 sampling sites and among trees within sites; however, needles of different ages did not differ significantly in sulfur content. Average soil concentrations were very low, approximately 12% of the average needle concentrations. Soil sulfur concentrations also differed significantly among the 10 sampling sites and at different depths in the soil. No statistical differences were evident in soils sampled at the four compass points (N, E, S, W) around each tree. These differences imply that large numbers of samples are needed to identify small effects from anthropogenic inputs of sulfur into the system, or that the effects must be large relative to the differences among sampling sites and individual trees in order to be detected. Detailed tables of sulfur concentrations are presented.

Gonzales, G.J., P.R. Fresquez, and J.W. Beveridge. 1999. Organic Contaminant Levels in Three Fish Species Downchannel from the Los Alamos National Laboratory. Report No. LA-13612-MS. Los Alamos National Laboratory. 106 pp.

Three species of fish from sites upriver and downriver of Los Alamos National Laboratory in the Rio Grande were analyzed for pesticides and PCBs. Data were used to implicate potential sources of the contaminants and to discuss potential risk to fish, the bald eagle, and humans. Eight of 28 contaminants were measurable in at least one sample of fish muscle tissue, including DDE, Aroclor-1254, dichloroethane, DDT, endosulfan sulfate, chlordane, and Aroclor-1260. The LANL contribution, if any, to organic contaminant levels in the common carp, the channel catfish, and the white sucker in the Rio Grande appear to be small. Consumption restrictions based on EPA recommendations are presented.

Gonzales, G.J., P.R. Fresquez, M.A. Mullen, and L. Naranjo, Jr. 2000. Radionuclide Concentrations in Vegetation at the Los Alamos National Laboratory in 1998. Report No. LA-13704-PR. Los Alamos National Laboratory.

This report summarizes and evaluates the concentrations of various radionuclides in understory and overstory vegetation collected from LANL, its perimeter, and regional background areas in 1998. Comparisons to conservative toxicity reference value "safe limits" were made. Concentrations of radionuclides and total U in both understory and overstory vegetation generally were not statistically higher than in perimeter and regional background vegetation. The exceptions were LANL tritium greater than perimeter tritium for understory and LANL tritium greater than background tritium for overstory. All maximum radionuclide concentrations were lower than toxicity reference values. With the exception of total U, the relationship between contaminant concentration in soil vs. vegetation was insignificant. Generally, as the concentration of total U in soil decreased, the concentration in vegetation increased. This held true for both understory and overstory and regardless of whether or not data were separated by location. There was no apparent relationship between contaminant concentrations in understory vs. overstory.

Graham, E.R. 1963. Plants As Monitors of Radioactive Contamination of the Environment of Los Alamos, New Mexico. Report No. LAMS-2879. Los Alamos Scientific Laboratory. 18 pp.

Grass clippings and pine needles were collected from Los Alamos and adjacent areas and analyzed for radioactivity and radiological constituents. The low values obtained on most of the samples from Los Alamos were higher than the highest values obtained on samples from Española and Santa Fe. The beta activity in the ashed samples resulting from potassium-40 was in no case more than 10% of the observed activity. Gamma-ray spectrum analysis of the grass and pine needle pellets along with analysis of digested air filters revealed the principal gamma activity to result from the fission products zirconium-niobium, ruthenium-rhodium, and cerium-praesodymium. There were some samples that contained a small amount of iodine-131.

Haarmann, T.K., and P.R. Fresquez. 1998. Radionuclide Concentrations in Honey Bees from Area G at TA-54 during 1997. Report No. LA-13480-PR. Los Alamos National Laboratory. 32 pp.

Honey bees were collected from two colonies located at Los Alamos National Laboratory's Area G and from one control (background) colony located near Jemez Springs, NM. The samples were analyzed for ^{137}Cs, ^{241}Am, ^{238}Pu, $^{239,240}Pu$, ^{3}H, total uranium, and gross gamma activity. The results from both Area G colonies were higher than the upper level background concentrations for ^{238}Pu and ^{3}H.

Haarmann, T.K., and P.R. Fresquez. 1999. Radionuclide Concentrations in Honey Bees from Area G at TA-54 during 1998. Report No. LA-13613-PR. Los Alamos National Laboratory. 37 pp.

Honey bees were collected from two colonies located at LANL's Area G, TA-54, and from one control colony located near Jemez Springs. Samples were analyzed for various radionuclides. Area G samples from both colonies were higher than the upper level background concentrations

for ^{239,240}Pu, tritium, and total uranium. Samples from one colony were higher than the upper level background concentrations for ^{238}Pu.

Hanson, W.C., and F.R. Miera, Jr. 1976. Long-Term Ecological Effects of Exposure to Uranium. Report No. LA-6269. Los Alamos Scientific Laboratory. 34 pp.

The consequences of releasing natural and depleted uranium to terrestrial ecosystems during development and testing of depleted uranium munitions were investigated. Two explosives-testing areas at the Los Alamos Scientific Laboratory (LASL) were selected because of their use history. E-F Site soil averaged 2400 ppm of uranium in the upper 5 cm and 1600 ppm at 5-10 cm. Lower Slobbovia Site soil from two subplots averaged about 2.5 and 0.6% of the E-F Site concentrations. Important uranium concentration differences with depth and distance from detonation points were ascribed to the different explosive tests conducted in each area. E-F site vegetation samples contained about 320 ppm of uranium in November 1974 and about 125 ppm in June 1975. Small mammals trapped in the study areas in November contained a maximum of 210 ppm of uranium in the gastrointestinal tract contents, 24 ppm in the pelt, and 4 ppm in the remaining carcass. In June, maximum concentrations were 110, 50, and 2 ppm in similar samples and 6ppm in lungs. These data emphasize the importance of resuspension of respirable particles in the upper few millimeters of soil as a contamination mechanism for several components of the LASL ecosystem.

Hanson, W.C., and F.R. Miera, Jr. 1978. Further Studies of Long-Term Ecological Effects of Exposure to Uranium. Report No. LA-7162. Los Alamos Scientific Laboratory. 26 pp.

Soils, small mammals, and invertebrates were sampled at E-f Site for uranium analysis. Spatial variability in sampling for soil uranium distribution by a polar coordinate system was evaluated in randomly selected soil cores. Uranium concentrations in tissues of deer mice and pocket gophers was sufficiently different to conclude that the greater bioavailability of uranium in the top few millimeters of soil, combined with the difference in grooming and food habits of the animals, resulted in greater contamination of deer mice than pocket gophers. There was no conclusive evidence of a differential response of invertebrate populations to areas of relatively high uranium concentrations and to control areas.

Kasunic, C.A. 1982. The Toxicity of Spent Photographic Solutions and Other Silver Compounds and Their Migration in Soil. M.S. Dissertation. University of Arizona. Tucson. 142 pp.

The silver content of the waters, stream sediments, soils, and vegetation in a canyon contaminated with spent photographic fixing bath solutions at Los Alamos National Laboratory was determined. The total silver concentration in the canyon decreased with increasing distance from the mouth of the waste outfall. At a distance of approximately 300 m, the silver levels of the vegetation approached those of the background. The silver content of the sediments and soils, however, remained significantly higher than background for a distance of 420 m. Soil column experiments showed that the silver solutions are attenuated by soil at rates and apparently by different mechanisms. The silver thiosulfate complex in the spent fixing bath solution is believed to be reduced to silver nitrate in the soil. The silver ion in silver nitrate and silver sulfate solutions probably replaces the Na^+ and/or K^+ ion in the clays present in clayey-skeletal Typic Eutroboralf soils. The phytotoxicity of the spent fixing bath solutions then is due primarily to the presence of excess sodium ion. This reduces the ability of a plant to absorb water and essential mineral nutrients and leads to a decrease in productivity.

Meadows, S.D., and J. Salazar. 1982. An Investigation of Radionuclide Concentrations in Tissues of Elk Utilizing Los Alamos National Laboratory. Health Physics 43(4): 595-598.

The Los Alamos National Laboratory is responsible for monitoring the impact of its activities on the local environment, which requires the sampling of air, water, soil, flora, and fauna for chemical analysis. Vertebrates previously sampled on Laboratory lands included small mammals, birds, and mule deer. Rocky Mountain elk were first sampled in March 1980 with the inception of this study. These animals are of particular concern because they are members of a heard that is the target of an annual public hunt. Consequently, they may be considered a potential pathway of environmental contaminants to humans. Therefore, the objective of this

study was to gather baseline data on elk of the Jemez Mountains to determine if a contamination problem exists with respect to those animals that utilize Laboratory lands in winter. Radiotelemetry and analytical data are presented. The results of the study indicate that concentrations of radionuclides found in various tissues are generally not different in Jemez Mountain elk utilizing Los Alamos National Laboratory lands in winter from Jemez Mountain elk that do not. Although ^{90}Sr concentrations were higher in elk bone sampled on Laboratory lands, probably as a result of differences in fallout in the two areas, these considerations would result in a negligible dose to a human consumer of elk meat.

Miera, F.R., Jr. 1980. Measurements of Uranium in Soils and Small Mammals. Report No. LA-8624-T. Los Alamos Scientific Laboratory. 42 pp. (M.S. Dissertation, New Mexico Highlands University)

The objective of this study was to evaluate the bioavailability of uranium to a single species of small mammal, white-footed deer mouse, from two different source terms: a Los Alamos National Laboratory dynamic weapons testing site in north central New Mexico, where an estimated 70,000 kg of uranium were expended over a 31-yr period; and an inactive uranium mill tailings pile located in west central New Mexico near Grants, which received wastes over a 5-yr period from the milling of $2.7x10^9$ kg of uranium ore. Uranium concentrations were generally higher in all small mammal tissue groupings for the LANL site when compared to values obtained for tissue samples from the mill tailings study area. Gastrointestinal and pelt sample uranium concentrations were significantly different from internal tissue values for both sites. Perhaps one of the more significant findings was that median uranium concentrations in kidneys of mice from the mill tailings study area were six times greater and significantly different from values for other internal tissues. This was not detected at the LANL study area. Low uranium values detected in lung tissues for both study sites indicated that inhalation of respirable size particles was not occurring appreciable during the sampling period and that the major route of contamination was via ingestion. Observed concentration ratios of animal tissue uranium to soil uranium for all tissue groupings composited were larger for mill tailings samples than for LANL samples. The observed concentration ratios were used to provide an estimate of the amount of uranium moving across physiological barriers under conditions of passage through the biological system. The LANL results indicated that only a small portion of ingested uranium was metabolically assimilated, while the mill tailings results indicated a larger amount to be metabolically assimilated. This is attributed to a more soluble form of uranium at the mill tailings site.

Salazar, J.G. 1979. Radionuclide Content of Piñon Nuts in the Vicinity of the Los Alamos Scientific Laboratory. Report No. LA-UR-79-238. Los Alamos Scientific Laboratory. 7 pp.

Over half of the Los Alamos National Laboratory's land area contains piñon-juniper woodland that is the source of the piñon nut, a speciality food of the southwest. Because employees and some members of the general public harvest piñon nuts on Laboratory property, this study was undertaken to assess the radionuclide pathways to man through piñon nuts. The results indicate that eating 1.5 kg of whole unwashed nuts from the area with the maximum ^{90}Sr concentration would give a 50 yr dose commitment to bone of 0.45 mrem. Eating 1.5 kg of nuts from the area of known high tritium concentration would give a whole body dose of 0.002 mrem. Analyses for $^{238,239}Pu$ and ^{137}Cs yielded values below detection limits. One composite sample was high in uranium. The sampling locations were located in areas with no record of contamination and no noticed increase of the contaminants in the soil. The ^{90}Sr is believed to be due to fallout, the uranium present in soil on the shell. Future studies will attempt to separate nut meats from shells for separate analysis.

Wenzel, W.J., T.S. Foxx, A.F. Gallegos, G. Tierney, and J.C. Rodgers. 1987. Cesium-137, Plutonium-239/240, Total Uranium, and Scandium in Trees and Shrubs Growing in Transuranic Waste at Area B. Report No. LA-11126-MS. Los Alamos National Laboratory. 62 pp.

A unique radioecological study was carried out at a Los Alamos National Laboratory (LANL) shallow land burial site called Area B. Area B was the first common transuranic waste burial site for LANL from 1944 to 1948 and had lain fallow for 34 years. During this time, secondary succession resulted in invasion of many native trees, shrubs, forbs, and grasses. The purpose of

this study was to determine whether any trees or shrubs were rooting directly in waste material, to examine rooting patterns in a shallow land burial site, and to study the distribution patterns of different radionuclides by dissecting vegetative samples into representative compartments. Scandium, ^{137}Cs, $^{239/240}Pu$, and total uranium were measured in soil, litter, leaf, bark, wood, and root samples from excavated trees and shrubs. Several trees and shrubs were found rooted in transuranic waste material. The radiochemical data were used to calibrate the UPTAKE subroutine of the BIOTRAN model for the Los Alamos environs. The simulation results indicated that higher resolution sampling is needed for ^{137}Cs and $^{239/240}Pu$ to interpret surveillance data and to produce reliable risk assessments. This study attempted to draw together and interpret the radionuclide data for Area B from several investigations. There is a need to standardize the grid methods and sampling site markers to develop a permanent system wherein sampling sites can be accurately relocated and tied to engineering drawings. This would allow subsequent studies to use the existing temporal data and hence produce reliable assessments, especially for sites where heterogeneous source terms require high resolution sampling on small grids over long time frames.

Wolok, M. and T. Foxx. 1995. Literature Review, Metal, Beryllium, and Organic Toxicity in Wildlife, Selected Bibliography. Report No. LA-UR-95-3601. Los Alamos National Laboratory. 65 pp.

This report presents listings of relevant publications resulting from literature searches on substances potentially toxic to wildlife. Information on radioactive materials is not included, and summaries of the publications are not provided. This literature review is not an exhaustive search, but rather supplies information on wildlife and several plants as related to the following:

aluminum
arsenic
beryllium
cadmium
copper
fluoride
gallium
gold
iron
lead
zinc
mercuric chloride
mercury
methylmercury
nickel
organochlorines
PCBs
pesticides
selenium
silver
trace metals

Bird Studies

Finch, D.M., and J.F. Kelly. 1999. Status and Migration of the Southwestern Willow Flycatcher in New Mexico. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 197-203. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

In the Southwestern United States, recent degradation of riparian habitats has been linked to decline of the Southwestern Willow Flycatcher. During a 2-year banding effort, migration patterns and bird fat content were analyzed. This paper gives a brief overview of Willow Flycatcher breeding status throughout the State of New Mexico and describes its migration pattern throughout the middle Rio Grande Valley. Recommendations for managers and outlines for conservation plans also are discussed.

Gallegos, A.F., G.J. Gonzales, K.D. Bennett, and L.E. Pratt. 1997. Preliminary Risk Assessment of the Mexican Spotted Owl under a Spatially-Weighted Foraging Regime at the Los Alamos National Laboratory. Report No. LA-[13259-MS. Los Alamos National Laboratory. 62 pp.

This report presents the results of a preliminary risk assessment for the Mexican spotted owl on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated doses to the owl under a spatially-weighted foraging regime were compared against toxicological reference doses for three risk source types. Under the risk

parameter assumptions made, hazard quotient (HQ) results indicated no unacceptable risk to the owl, including a measure of cumulative effects from multiple contaminants that assumes a linear additive toxicity type. A Hazard Index of 1.0 was used as the evaluative criterion for determining the acceptability of risk. This value was exceeded (1.06) in only one of 200 simulated potential nest sites. Cesium-137, Ni, ^{239}Pu, Al, and ^{234}U were among the constituents with the highest partial HQs. Improving model realism by weighting simulated owl foraging based on distance from potential nests decreased the estimated risk. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, owl habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at acceptable low levels.

Gallegos, A.F., G.J. Gonzales, K.D. Bennett, L.E. Pratt, and D.S. Cram. 1997. A Spatially-Dynamic Preliminary Risk Assessment of the American Peregrine Falcon at the Los Alamos National Laboratory (Version 1). Report No. LA-13321-MS. Los Alamos National Laboratory. 114 pp.

This report presents the results of a preliminary risk assessment for the peregrine falcon on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated doses to the falcon were compared against toxicity reference values to generate hazard indices. Hazard index results indicated no unacceptable risk to the falcon from the soil ingestion pathway, including a measure of cumulative effects from multiple contaminants that assumes a linear additive toxicity type. Scaling home ranges on the basis of maximizing falcon height for viewing prey decreased estimated risk by 69% in a canyons-based home range and increased estimated risk by 40% in a river-based home range. Improving model realism by weighting simulated falcon foraging based on distance from potential nest sites decreased risk. Choice of toxicity reference values can have a substantial impact on risk estimates. Adding bioaccumulation factors for several organics increased partial hazard quotients by a factor of 110, but increased the mean hazard index by only 0.02 units. Adding a food consumption exposure pathway in the form of biomagnification factors for 15 contaminants of potential ecological concern increased the mean hazard index to 1.16, which is above the level of acceptability (1.0). Aerochlor-1254, DDT, and DDE accounted for 81% of the estimated risk that includes soil ingestion and food consumption pathways and a biomagnification component. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, falcon habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at acceptably low levels.

Gonzales, G.J., A.F. Gallegos, and T.S. Foxx,. 1997. Second Annual Review Update: Preliminary Risk Assessment of Federally Listed Species at the Los Alamos National Laboratory. Report No. LA-UR-97-4732. Los Alamos National Laboratory. 9 pp.

The ECORSK model that was used to perform the initial risk assessments for the peregrine falcon, bald eagle, and Mexican spotted owl was modified to include updated contaminant uptake and accumulation information as well as updated TRV values. This report presents updated results for the spotted owl and peregrine falcon using the new model. Overall, the results indicate a small potential for impact to the peregrine falcon but no appreciable impact to the spotted owl or bald eagle.

Gonzales, G.J., A.F. Gallegos, T.S. Foxx, P.R. Fresquez, M.A. Mullen, L.E. Pratt, and P.E. Gomez. 1998. A Spatially-Dynamic Preliminary Risk Assessment of the Bald Eagle at the Los Alamos National Laboratory. Report No. LA-13399-MS. Los Alamos National Laboratory. 64 pp.

This report presents the results of a preliminary risk assessment for the bald eagle on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated exposure doses to the eagle for radionuclide, inorganic metal, and organic contaminants were derived for varying ratios of aquatic vs. terrestrial simulated diet and compared against toxicity reference values to generate hazard indices (HIs). The HI results indicate that no appreciable impact to the bald eagle is expected from contaminants at LANL from

soil ingestion and food consumption pathways. This includes a measure of cumulative effects from multiple contaminants that assumes linear additive toxicity. Improving model realism by weighting simulated eagle foraging based on distance from potential roost sites increased the HI by 76%, but still to inconsequential levels. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, eagle habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at low levels.

Gonzales, G.J., A.F. Gallegos, M.A. Mullen, K.D. Bennett, and T.S. Foxx. 1998. Preliminary Risk Assessment of the Southwestern Willow Flycatcher (*Empidonax trallii extimus*) at the Los Alamos National Laboratory. Report No. LA-13508-MS. Los Alamos National Laboratory. 43 pp.

This report presents the results of a preliminary risk assessment for the southwestern willow flycatcher on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. The southwestern willow flycatcher is the fourth threatened or endangered species to undergo a preliminary assessment for estimating potential risk from environmental contaminants at the Los Alamos National Laboratory. These assessments are being conducted as part of a three-year project to develop a habitat management plan for threatened or endangered species and species of concern at the Laboratory. For the preliminary assessment, estimated doses were compared against toxicity reference values to generate hazard indices (HIs). This assessment includes a measure of cumulative effects from multiple contaminants (radionuclides, metals, and organic chemicals) to 100 simulated nest sites located within flycatcher potential habitat. Sources of contaminant values were 10.000 ft^2 grid cells within an Ecological Exposure Unit (EEU). This EEU was estimated around the potential habitat and was based on the maximum home range for the flycatcher identified in the scientific literature. Food consumption and soil ingestion contaminant pathways were addressed in the assessment. Using a four-category risk evaluation, HI results indicate no appreciable impact is expected to the southwestern willow flycatcher. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, flycatcher habitat, facility siting, and/or facility operations in order to maintain low levels of risk from contaminants.

Johnson, T.H., and R.H. Wauer. 1996. Avifaunal Response to the 1977 La Mesa Fire. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 71-94. General Technical Report No. RM-GTR-286. USDA Forest Service.

Three of four breeding bird transects in habitats ranging from mixed conifer to piñon-juniper were burned by the 1977 La Mesa Fire. Large portions (25-80%) of the three burned transects suffered forest loss from crown fire or scorching, but the piñon-juniper transect did not burn. The transects were surveyed during the breeding season before the fire and 1, 2, 4, 6, and 14 years afterward. Species diversity increased after the fire, but breeding populations generally declined for several years before increasing above prefire levels. This temporary population decline was more pronounced and lasted longer on the most severely burned transects. Conversely, the population on the unburned piñon-juniper transect temporarily increased after the fire. After 14 years, avian diversity and populations in the burn remained well above prefire levels, except on the transect with 80% forest loss, where the population was 22% lower due to a reduction in insectivores. Populations of seed-eating birds and raptors were consistently higher than before the fire. All three burned transects experienced both immediate and successional changes in species composition. Even an uncontrolled crown fire such as La Mesa Fire can increase the diversity and population of breeding birds. High fire intensity appears to delay recovery of avian populations from short-term postfire declines, and extensive crown fire appears to reduce populations after most snags have fallen, but even the most severely burned areas of La Mesa Fire generally retained some live trees and snags and supported diverse, substantial populations of breeding birds after the fire. Application of moderate intensity prescribed fire to relatively dense stands such as those burned by La Mesa Fire can enhance avian diversity and populations without the disadvantages of high intensity crown fires.

Keller, D.C. 1995. Results of Bird Surveys Conducted at Guaje Canyon, Los Alamos Canyon, and Puye Mesa in the Summers of 1993 and 1994. In: Ecological Baseline Studies in Los

Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 239-254. Report No. LA-13065-MS. Los Alamos National Laboratory.

Many birds are important indicator species; changes in species diversity and population size may signal environmental change. Bird surveys were conducted at Guaje Canyon, Los Alamos Canyon, and Puye Mesa to determine the use of these locations by birds. Statistically significant differences were found among the locations. Preliminary work indicated that Los Alamos Canyon has the greatest numbers of birds.

Moeur, S., and D.A. Guthrie. 1984. The Effects of Clearing Fire-Killed Trees on Wildlife. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 135-144. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Rapid recovery of the forest after a fire should be an important objective of forest management. Following a severe fire in the Jemez Mountains in north central New Mexico, two management approaches were instituted on adjacent burn sites. On Bandelier National Monument property, burned forest areas were heavily seeded from the air with a variety of grasses. This was the only action taken. However, on Los Alamos National Laboratory property, all dead trees were cut down and removed. The purpose of the study reported upon in this paper was to compare the effects of the two management policies on the flora and fauna of the sites. The results show that slight differences in vegetation and insect populations were found between the Bandelier and Laboratory sites, but these differences were not significant. No difference was found in mammal populations between the two sites. Bird populations differed, with greater populations of both resident and visiting species on the Bandelier site. This difference is thought to be due to the presence of nesting sites and perches provided by dead trees rather than to differences in food supply. The few trees left standing on the Laboratory site were used by birds and lessen the differences observed between the two sites. The effects of the two strategies of forest management thus have their greatest effect on bird populations. Effects of the Laboratory approach on vegetation are minor but could be minimized even more by restricting vehicular traffic in the process of wood removal (requiring cut wood to be carried to existing roads rather than allowing vehicles to drive to the cutting site). The effects on birds could be greatly reduced by leaving a certain percentage of dead trees standing, particularly large trees that were partially dead before the fire and that were used by hole-nesting species.

Myers, O.B., and J.M. Fair. 1998. Testing Predictions from Ecological Risk Assessment with Cavity-Nesting Birds. Poster presentation at the Annual Meeting of the Ecological Society of America. Baltimore.

This poster was a preliminary report on an ongoing study of cavity-nesting birds at Los Alamos National Laboratory. The primary purpose of the study is to determine effects of contaminated sites on cavity-nesting birds, but it also is one of a very few studies on bird populations and behavior on the LANL preserve (exclusive of studies on Threatened and Endangered Species).

Myers, O.B., and J.M. Fair. 1999. Integrated Biological Experiments. Modeling, and Monitoring for Natural Resources Damage Assessment and Ecological Risk Assessment. Poster presentation at the University of California President's Council of the National Laboratories Environment, Safety, & Health Panel. August 11-13. Los Alamos.

Cavity-nesting birds are being used to determine if wildlife has been adversely affected by exposure to environmental contaminants at Los Alamos National Laboratory. Study measurements test predictions from ecological risk analyses performed at LANL and establish if wildlife has been injured for Natural Resource Damage Assessment purposes. The primary objectives of the study are (1) to estimate the form of the relationship between simple risk assessment calculations and observed risk to wildlife, and (2) to develop and test nonlethal indicators of adverse ecological effects that are applicable to multiple spatial scales. Western bluebird and ash-throated flycatcher nesting boxes were placed across a putative hazard gradient to test whether calculated hazard index values are correlated with ecological risk at nest box to landscape scales. Some boxes containing western bluebirds are used for field experiments that manipulate exposure to metallic lead. Measurements are being made on nestling growth rates,

developmental asymmetry, immune system function, parasitism, and survival. Results indicate that western bluebirds show lower rates of parasitism than ash-throated flycatchers, and nestling survival of western bluebirds shows significant variation across the LANL landscape. Experimental exposures indicate that risks from metallic lead are much less than predicted by simple risk assessment models.

Stacey, P.B., and A. Hodgson. 1999. Biological Diversity in Montane Riparian Ecosystems: the Case of the Mexican Spotted Owl. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 204-210. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Although usually considered to be a bird of old growth mixed conifer forests, the Mexican spotted owl historically occurred in a wide range of habitats from lowland cottonwood bosques to montane canyon systems. In a recent study of habitat use in central New Mexico, owls were found to roost primarily in canyon bottoms; and sites that were selected were characterized by deciduous trees and high structural complexity of vegetation rather than by large diameter conifer trees per se. Intact riparian areas in montane canyons typically have considerable structure, yet, as in the lowlands, these habitats have undergone extensive modification and reduction. The unexpected diversity of habitat use of the Mexican spotted owl suggests that historic changes in upland riparian systems in the Rio Grande Basin may have impacted more species than originally believed.

Travis, J.R. 1992. Atlas of the Breeding Birds of Los Alamos County, New Mexico. Report No. LA-12206. Los Alamos National Laboratory. 281 pp.

This atlas shows the geographic distribution of 112 species of breeding birds found within Los Alamos County. Breeding dates and other information on breeding behavior are presented, and species distribution patterns and species-habitat relationships are discussed. The information presented is based on field surveys from 1984 through 1988.

Wauer, R.H., and T. Johnson. 1984. La Mesa Fire Effects on Avifauna. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 145-172. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Prior to La Mesa Fire, an avian population study had been initiated on seven vegetative units within Bandelier National Monument. Three of these units were burned during La Mesa Fire. This report compares the avifauna present within these three units before and immediately after the fire and during the breeding seasons for two additional years. La Mesa Fire affected the avifauna in a number of ways. In general, populations and biomass values declined immediately after the fire in Burnt and Escobas Mesas but exhibited increases on the higher, less severely burned Apache Springs unit. All three units displayed small to extensive increases in 1978 but exhibited minor to moderate declines, with a few exceptions, in 1979. In comparing 1979 data with prefire values, considerable variations are evident. Species richness returned to the same values on Burnt and Escobas Mesas as before the fire but remained 12.5% higher at Apache Springs. Species density values declined 16% on the average; on Burnt and Escobas Mesas, they declined 35% and 14%, respectively, but at Apache Springs they increased by 2%. Species diversity increased on all three units: 2% on Burnt Mesa, 5% on Escobas Mesa, and 8.5% at Apache Springs. Evenness values increased on all three units as well: 1%, 5.5%, and 5% on Burnt Escobas Mesas and Apache Springs, respectively. Biomass analysis reveals that middle-sized species increased more than larger species and considerably more than smaller species. Four of the 10 feeding guilds exhibited population increases between the prefire period and 1979, and 6 guilds exhibited declines. Timber-drilling-insect and foliar-nectar feeders received the greatest benefit; and timber-searching-insect, ground-predator, and air-perching-insect feeders were most critically affected. Two of the four nesting guilds (parasitic and cavity-depression nesters) exhibited positive responses, and two (ground and foliage nesters) exhibited negative responses. Evidence accumulated from this study suggests that Bandelier's avifauna, particularly species diversity, is increased by fire when the habitat receives light to moderate fire. Of the three categories of fire, severe fire has the most drastic effect on avifauna, and the longest period of time is required to adjust. Severe burns also subject the environment to greater probabilities

for other adverse effects, such as erosion, overgrazing, and infestations. These, in turn, will affect the avifauna in secondary ways and extend the period of adjustment.

Contaminant Transport

Becker, N.M. 1993. Influence of Hydraulic and Geomorphologic Components of a Semi-Arid Watershed on Depleted Uranium Transport. Report No. LA-UR-93-2165. Los Alamos National Laboratory. 253 pp. (Ph.D. Thesis, University of Wisconsin)

Investigations were undertaken to determine the fate and transport of depleted uranium away from high explosive firing sites at Los Alamos National Laboratory in north-central New Mexico. Investigations concentrated on a small, semi-arid watershed that drains five firing sites. Sampling for uranium in spring/summer/fall runoff, snowmelt runoff, fallout, and soil and sediments revealed that surface water is the main transport mechanism. Although the watershed is less than 8 km^2, flow discontinuity was observed between the divide and the outlet. Flow discontinuity occurs in semi-arid and arid watersheds, it was unexpected at this scale. This region, termed a discharge sink, is an area where all flow infiltrates and all sediment, including uranium, deposits during nearly all flow events. The estimate is that this discharge sink has provided the locale for uranium detention during the last 23 years. Mass balance calculations indicate that over 90% of uranium expended still remains at or nearby the firing sites. Leaching experiments determined that uranium can rapidly dissolve from the solid phase. The postulation is that precipitation and runoff that percolate vertically through uranium-contaminated soil and sediment are capable of transporting uranium in the dissolved phase to deeper strata. This may be the key mechanism that moves uranium out of the watershed.

Becker, N.M. 1995. Fate of Selected High Explosives in the Environment: A Literature Review. Report No. LA-UR-95-1018. Los Alamos National Laboratory. 19 pp.

The objective of this document is to report on the current literature of environmental fate of four explosives: TNT, RDX, HMX, and NTO. The report is not intended to be an exhaustive search of the literature but rather to present the current status on the subject. General properties and history of the explosives are presented, along with recommended exposure limits, followed by a compilation of their degradation products and a brief review of results of some environmental sampling for high explosives in soil and groundwater.

Davenport, D.W., B.P. Wilcox, and B.L. Allen. 1995. Micromorphology of Pedogenically Derived Fracture Fills in Bandelier Tuff, New Mexico. Soil Science Society of America Journal 59: 1672-1683.

Fractures in the Bandelier Tuff are potential paths for water movement and transport of contaminants from waste disposal sites and other contaminated areas at Los Alamos National Laboratory. This study was conducted to determine (1) the morphology and origin of soil-like material in the fractures and (2) the likelihood of significant water movement through the fractures. Fracture fills consist of clay, calcium carbonate, or combinations of the two with minor inclusions of tuff and sand grains. Clay consists of thick, highly oriented argillans aligned parallel to fracture walls and of discrete books in fracture interiors. Carbonate consists of massive microcrystalline calcite, which completely fills some fractures, and laminae or infillings between clay lamelae or books in clay-dominated fractures. The carbonate was precipitated after clay deposition, suggesting a change to a more arid climate. Weaker development of argillans and carbonate features in the soils suggests that the fractures may be derived from older soils that have been stripped by erosion. The presence of live roots throughout the fracture fills indicates the presence of water, but the smetitic clay and massive carbonate makes it unlikely that significant water movement is now taking place through the fractures. The potential creation of new macropores by a variety of processes, however, including seismic activity and biologic disturbance, could allow rapid water movement and contaminant transport.

Ferenbaugh, R.W., and E.S. Gladney. 1997. Mortandad Canyon: Elemental Concentrations in Vegetation, Streambank Soils, and Stream Sediments – 1979. Report No. LA-13325-MS. Los Alamos National Laboratory. 7 pp.

In 1979, stream sediments, streambank soils, and streambank vegetation were sampled at 100 m intervals downstream of the outfall of the TA-50 radioactive liquid waste treatment facility in Mortandad Canyon. Sampling was discontinued at a distance of 3260 m at the location of the sediment traps in the canyon. The purpose of the sampling was to investigate the effect of the residual contaminants in the waste treatment facility effluent on elemental concentrations in environmental media. Data are presented for Be, Cd, Cl, Cr, F, NO_3, PO_4, SO_4, ^3H, and Hg.

Ferenbaugh, R.W., W.D. Spall, and D.M. LaCombe. 1981. Detection of Bromacil Herbicide in Ponderosa Pine. Bulletin of Environmental Contamination and Toxicology 27: 268-273.

This paper describes an investigation into the cause of tree mortality at Los Alamos National Laboratory (LANL) during the spring and summer of 1978. Prior to this time period, bromacil herbicide(Tradename – HYVAR) was used as part of a vegetation control program along roadways at the LANL preserve. There are about 180 miles of paved roads on Laboratory property, and vegetation control is required for both safety and road surface maintenance. The prescribed bromacil application method was to spray a four-foot wide strip of bromacil solution along the edges of roadways with a spray-bar. The application rate was 2.5-5.0 lb/acre. The application usually was made in the fall of the year so that melting snow in the spring would leach the bromacil into the soil, from which it would be taken up by vegetation during the spring growing season. During the late spring and early summer of 1978, bromacil was determined to be the proximate cause of damage to numerous trees at substantial distances away from roadways at Los Alamos. Little snow fell during the winter of 1977-78. As a result, bromacil was not leached into the soil by snowmelt but was washed away from pavement edges by heavy rainfall in the spring, resulting in unanticipated treekill away from the highway. Coniferous vegetation is known to be sensitive to bromacil pesticide, and gas chromatographic analysis showed substantial bromacil concentrations in tree foliage from the affected trees.

Fresquez, P.R., W.R. Velasquez, and L. Naranjo, Jr. 2000. Effects of the Cerro Grande Fire (Smoke and Fallout Ash) on Soil Chemical Properties within and around Los Alamos National Laboratory. Report No. 13769-MS. Los Alamos National Laboratory. 11 pp.

Soil surface (0-2 in depth) samples were collected from areas within and around Los Alamos National Laboratory (LANL) immediately after the Cerro Grande Fire, analyzed for radionuclides, radioactivity, and trace elements (heavy metals), and compared to soil samples collected in 1999 from the same sites. In addition, many types of organic substances (volatile and semivolatile organic compounds, organochlorine pesticides, PCBs, high explosives, and dioxin and dioxin-like compounds) were assessed in soils from LANL, perimeter, and regional sites after the fire. Results show that impacts to regional, perimeter, and on-site (mesa top) areas from smoke and fallout ash as a result of the Cerro Grande Fire were minimal.

Gonzales, G.J., M.T. Saladen, and T.E. Hakonson. 1995. Effects of Pocket Gopher Burrowing on Cesium-133 Distribution on Engineered Test Plots. Journal of Environmental Quality 24: 1056-1062.

A field study on the surface and subsurface erosional transport of surface-applied ^{133}Cs as affected by pocket gopher burrowing was conducted on simulated waste landfill caps at the Los Alamos National Laboratory in north central New Mexico. Surface loss of Cs, adhered to five soil particle size ranges, was measured several times over an 18-month period while simulated rainfalls were in progress. Gophers reduced Cs surface loss by significant amounts, 43%. Cesium surface loss on plots with only gophers was 0.8 kg total for the study period. This compared with 1.4 kg for control plots, 0.5 kg for vegetated plots, and 0.2 kg for plots with both gophers and vegetation. Relatively little subsurface Cs was measured in plots containing only gophers (0.7 g/kg). Vegetation-bearing plots had significantly more total subsurface Cs (1.7 g/kg) than plots without vegetation (0.8 g/kg). An average of 97% of the subsurface Cs in plots with vegetation was located in the upper 15 cm of soil compared with 67% for plots without vegetation. Vegetation moderated the influence of gopher activity on the transport of Cs to soil subsurfaces and stabilized subsurface Cs by concentrating it in the rhizosphere. Gopher activity may have caused Cs transport to depths below that sampled, 30 cm. The results provide distribution coefficients for models of contaminant migration where animal burrowing occurs.

Graf, W.L. 1996. Transport and Deposition of Plutonium-Contaminated Sediments by Fluvial Processes, Los Alamos Canyon, New Mexico. GSA Bulletin 108: 1342-1355.

The stated purpose of this paper was to explore the connection between the disposal of treated and untreated wastes into Acid Canyon and the Rio Grande through the fluvial system of Acid, Pueblo, and Los Alamos Canyons. The study was based on 15 years of annual sediment sampling throughout the canyon system. The study addresses contaminant distribution, fluctuations, and deposition. A computer model was used to simulate future redistribution transport of contaminated sediments.

Haarmann, T.K. 1997. Honey Bees As Indicators of Radionuclide Contamination: Exploring Colony Variability and Temporal Contaminant Accumulation. Journal of Apicultural Research 36: 77-87.

Two aspects of using honey bees as indicators of environmental radionuclide contamination were investigated: colony variability and temporal contaminant accumulation. Two separate field experiments were conducted in areas with bioavailable radionuclide contamination. Bees were collected from colonies and analyzed for concentrations of radionuclides. The first experiment indicated generally a low variability exists between samples collected within the same colony. A higher variability exists between samples collected from adjacent colonies. Levels of tritium and sodium-22 found in samples taken from similar colonies were inconsistent, while levels of cobalt-57, cobalt-60, and manganese-54 were consistent. A second experiment investigated the accumulation of radionuclides over time by comparing colonies that had been in the study area for different periods of time. This experiment demonstrated that there is indeed a significant accumulation of radionuclides within colonies.

Haarmann, T.K. 1998. Honey Bees As Indicators of Radionuclide Contamination: Comparative Studies of Contaminant Levels in Forager and Nurse Bees and in the Flowers of Three Plant Species. Archives of Environmental Contamination and Toxicology 35: 287-294.

Two separate field experiments were conducted as part of ongoing research concerning the use of honey bees as indicators of environmental radionuclide contamination. The experiments were conducted at a study site containing radionuclide concentrations above background levels. The first experiment compared levels of radionuclides found in forager bees to levels found in nurse bees. Bees were collected from colonies and analyzed for concentrations of radionuclides. Results indicated that there was no significant difference between the contaminant levels in forager and nurse bees. A second experiment compared the levels of radionuclides found in the flowers of three plant species growing at the study site: salt cedar, white sweet clover, and rabbit brush. Results indicated that there was no significant difference among the amounts of radionuclides found in the flowers of these three plants.

Haarmann, T.K. 1998. Honey Bees (Hymenoptera: Apidae) As Indicators of Radionuclide Contamination: Investigating Contaminant Redistribution Using Concentrations in Water, Flowers, and Honey Bees. Journal of Economic Entomology 91: 1072-1077.

As part of ongoing research concerning the use of honey bees as indicators of environmental radionuclide contamination, samples of water, flowers, and honey bees were collected for two consecutive years from a study site containing radionuclide concentrations above background levels. The samples were analyzed for concentrations of radionuclides, and the analytical results used to assess the redistribution pathway of radionuclides within the study site. The results indicated that honey bees received the majority of their contamination directly from the source, which was a radioactive waste lagoon. The amount of contamination that the bees received from flowers during nectar collection appeared to be insignificant compared to the amount received during water collection. Results did not demonstrate significant patterns of correlation or trend between the lagoon, bees, or flowers. Sample results indicated a significant bioaccumulation of cobalt-60 and sodium-22 within the honey bees but no significant bioaccumulation within the flowers.

Haarmann, T.K. 1998. Honey Bees (*Apis mellifera*) as Indicators of Radionuclide Contamination. Ph.D. Thesis. University of New Mexico. Albuquerque. 80 pp.

Various aspects of using honey bees as indicators of environmental radionuclide contamination were investigated at Los Alamos National Laboratory. Five field experiments were conducted within a study site that contained bioavailable radionuclides. The first experiment investigated variability of radionuclides within the colony. Results indicated that generally a low variability existed between samples collected within the same colony. A higher variability existed between samples collected from adjacent colonies. Levels of tritium and sodium-22 found in samples taken from similar colonies were inconsistent, while levels of cobolt-57, cobolt-60, and manganese-64 were consistent. Another experiment investigated the accumulation of radionuclides over time by comparing colonies that had been in the study sites for different periods of time. This experiment demonstrated that there was a significant temporal accumulation of radionuclides within colonies. A third experiment compared levels of radionuclides found in forager bees to those levels found in nurse bees. Results indicated that there was no significant difference between the levels in forager and nurse bees. A fourth experiment compared the levels of radionuclides found in the flowers of three plant species growing in the study site: salt cedar, white sweet clover, and rabbit brush. Results indicated that there was no significant difference in the amounts of radionuclides found in the flowers of these three plants. Lastly, samples of water, flowers, and honey bees were collected for two consecutive years. Results were then used to assess the redistribution pathway of radionuclides within the study site. Results indicated that the honey bees received the majority of their contamination directly from the source, a radioactive waste lagoon. The amount of contamination that the honey bees received from flowers during nectar collection appeared to be insignificant compared to the amount received during water collection. Results from statistical analysis did not demonstrate significant patterns of correlation or trend between the lagoon, bees, or flowers. Sample results showed a significant bioaccumulation of cobalt-60 and sodium-22 within the honey bees, but no significant bioaccumulation within the flowers. Recommendations concerning the use of honey bees as indicators of contamination are included in the summary chapter of this dissertation.

Hakonson, T.E. 1999. The Effects of Pocket Gopher Burrowing on Water Balance and Erosion from Landfill Covers. Journal of Environmental Quality 28: 659-665.

This paper reports the results of a two-year field study to evaluate the impact of burrowing and soil casting by pocket gophers on runoff, soil loss, soil moisture status, and transport of surface-applied cesium 133. The presence of surface castings decreased erosion and runoff and increased infiltration. Vegetation also decreased runoff, erosion, and concomitant cesium loss. Both vegetation and gophers enhanced movement of cesium into the soil. The effects of gopher burrowing on degradation of waste covers were minimal when vegetation was a component of the cover.

Hakonson, T.E., G.C. White, E.S. Gladney, and M. Dreicer. 1980. The Distribution of Mercury, Cesium-137, and Plutonium in an Intermittent Stream at Los Alamos. Journal of Environmental Quality 9: 289-292.

This paper summarizes the results of a study on the distribution of Hg, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$ in channel sediments and adjacent bank soils in an intermittent stream used for treated liquid effluent disposal since 1963. Concentrations of the three radionuclides and Hg in stream bank soils were comparable to adjacent channel sediments, demonstrating that the stream bank serves as a deposition site for chemicals released to the channel. This finding has important implications on the long-term behavior of effluent contaminants since other studies at Los Alamos have shown that the vegetated stream banks retard downstream movement of chemicals bound to soils and provide a pathway for transport of these chemicals to biota. Concentrations of the radionuclides and mercury were more uniformly distributed with distance and depth in the channel sediments than in the bank soils. The action of periodic surface water in the channel partially explains those differences. Statistical analysis of the data revealed that 50 to 85% of the variability in contaminant concentrations in bank and channel locations was due to variation with distance while depth contributed relatively little to variability.

Hanson, W.C., and F.R. Miera, Jr. 1977. Continued Studies of Long-Term Ecological Effects of Exposure to Uranium. Report No. LA-6742. Los Alamos Scientific Laboratory. 19 pp.

The *E-F explosive testing site at Los Alamos was selected for intensive study of uranium redistribution during its 13 year use. Highest surface soil concentrations occurred 0 and 10m from the detonation point. Concentrations in surface soil 50 and 200m from the firing point were usually <15% of that. The distribution to 30cm depths showed significant penetration into the soil. Alluvium collected 250m from the detonation point in Potrillo Canyon indicated that the surface concentrations were about 10% of those at the detonation point, and at 2.8 km they were twice background levels.*

Hayes, A.C., P.R. Fresquez, and W.F. Whicker. 2000. Uranium Uptake Study, Nambe, New Mexico: Source Document. Report No. LA-13614-MS. Los Alamos National Laboratory. 38 pp.

Over 50% of the wells in the Nambe region of northern New Mexico exceed the U.S. Environmental Protection Agency's recommended drinking water standard of 20 $\mu g\ L^{-1}$ for ^{238}U. Uranium uptake was estimated in tomato, squash, lettuce, and radish irrigated with Nambe well water containing <1, 150, 500, and 1200 $\mu g\ U\ L^{-1}$. Plant uptake and human dose and toxicity associated with ingestion of water and produce and inhalation of irrigated soil related to gardening activities were evaluated. Uranium concentration in plants increased linearly with increasing U concentration in irrigation water, particularly in lettuce and radish. The estimated total committed effective dose equivalent for 70 years of maximum continuous exposure, via the three pathways to well water containing 1200 $\mu g\ U\ L^{-1}$, was 0.17 mSv (17 mrem) with a corresponding kidney concentration of 0.8 $\mu g\ U\ g^{-1}$ kidney.

Kasunic, C.A. 1982. The Toxicity of Spent Photographic Solutions and Other Silver Compounds and Their Migration in Soil. M.S. Dissertation. University of Arizona. Tucson. 142 pp.

The silver content of the waters, stream sediments, soils, and vegetation in a canyon contaminated with spent photographic fixing bath solutions at Los Alamos National Laboratory was determined. The total silver concentration in the canyon decreased with increasing distance from the mouth of the waste outfall. At a distance of approximately 300 m, the silver levels of the vegetation approached those of the background. The silver content of the sediments and soils, however, remained significantly higher than background for a distance of 420 m. Soil column experiments showed that the silver solutions are attenuated by soil at rates and apparently by different mechanisms. The silver thiosulfate complex in the spent fixing bath solution is believed to be reduced to silver nitrate in the soil. The silver ion in silver nitrate and silver sulfate solutions probably replaces the Na^+ and/or K^+ ion in the clays present in clayey-skeletal Typic Eutroboralf soils. The phytotoxicity of the spent fixing bath solutions then is due primarily to the presence of excess sodium ion. This reduces the ability of a plant to absorb water and essential mineral nutrients and leads to a decrease in productivity.

Lane, L.J., W.D. Purtymun, and N.M. Becker. 1985. New Estimating Procedures for Surface Runoff, Sediment Yield, and Contaminant Transport in Los Alamos County, New Mexico. Report No. LA-10335-MS. Los Alamos National Laboratory.

Simplified procedures are developed to predict runoff, sediment yield, and contaminant transport from semiarid watersheds with alluvial stream channels. The procedures represent a synthesis of simplified models to approximate the complex processes of runoff generation, streamflow-routing and hydrograph development, sediment transport and yield, particle sorting and enrichment, and transport of sediment-associated contaminants. The procedures are applied to a complex watershed-channel system et Los Alamos, New Mexico, and are used to compute the transport and redistribution of plutonium in alluvial stream channels. Mass-balance calculations are used to compute plutonium outflows from the channel system and to compute the amount of plutonium remaining in the channel alluvium.

Newman, B.D. 1996. Geochemical Investigations of Calcite Fracture Fills and Mesa-Top Water Dynamics on the Pajarito Plateau, New Mexico. Report No. LA-UR-96-1441. Los Alamos

National Laboratory. 254 pp. (Ph.D. Dissertation, New Mexico Institute of Mining and Technology)

This dissertation describes how recent developments in analytical techniques, such as quadrupole mass-spectrometric of fluid inclusion gases and the creation of models describing the behavior of meteoric stable isotopes and chloride in the vadose zone, were used to examine aspects of the geochemistry and hydrology of the Pajarito Plateau. These investigations were intended to improve the general understanding of semiarid processes and also identify some of the hydrogeologic factors that affect contaminant transport at Los Alamos National Laboratory.

Perkins, B., and G.L. DePoorter. 1985. Plants and Their Relationship to Soil Moisture and Tracer Movement. Report No. La-10216-MS. Los Alamos National Laboratory. 68 pp.

To obtain a better understanding of the mechanisms for possible movement of radionuclides or other toxic materials from waste burial sites in arid to semiarid regions, changes in soil moisture and tracer (Co, Cs, Sr, and tritium) movement were compared for bare vs vegetated soils. During the course of two growing seasons, comparing vegetation with bare soils, plant transpiration processes significantly reduced the soil moisture. In the vegetated soils, most of the Co, Cs, and Sr remained in the region of original emplacement. In bare soils, Co and Cs underwent minimal movement, but the peak concentration of Sr moved downward. For all tracers in the vegetated soils, there was some evidence that slight amounts of tracer had been absorbed in the plant roots and brought to the surface through plant translocation processes. In all cases, there was no significant upward movement of Co, Cs, and Sr. For tritium, the vegetated soils, compared with the bare soils, retained the maximum inventories near the original emplacement location. Although all soils showed some tritium loss, it was greatest in the vegetated soils. A literature review associated with the experiment indicated that plant species alone does not determine rooting depth, rate of transpiration, nutrient uptake, and other plant-associated processes. Environmental conditions are just as important as plant species and must be included in modeling plant-related effects. More data are needed on the effects of tracer concentration, soil water composition, variations in precipitation with time and intensity, evaporation rates, variations in soil composition, soil microorganisms, other invertebrates and vertebrates that inhabit soils, litter decay, and colloid movement on contaminant movement under conditions of saturated flow.

Purtymun, W.D., J.R. Buchholz, and T.E. Hakonson. 1977. Chemical Quality of Effluents and Their Influence on Water Quality in a Shallow Aquifer. Journal of Environmental Quality 6: 29-32.

The chemical quality of liquid effluent released from an industrial waste treatment plant at Los Alamos Scientific Laboratory controls the quality of water in a shallow aquifer in the alluvium of Mortandad Canyon. The dilution of the effluent with surface flow in the canyon reduces the concentration of the chemicals as they move down gradient into the aquifer. Mass estimates of residual chemicals in solution in the aquifer average 1-6% of the total chemicals released to the canyon from 1963-1974. The average annual concentration of sodium, nitrate, chloride, and total dissolved solids in the aquifer through a 12-year period was directly correlated with annual average concentrations in the effluent. This relationship provides a means of predicting the impact of the chemical effluents on the quality of water in the aquifer.

Purtymun, W.D., R. Peters, and M.N. Maes. 1990. Transport of Plutonium in Snowmelt runoff. Report No. LA-11795-MS. Los Alamos National Laboratory. 15 pp.

Plutonium in treated low-level radioactive effluents released into intermittent streams is bound by ion exchange or adsorption to bed sediments in the stream channel. These sediments are subject to transport with summer and spring snowmelt run-off. A study was made of the transport of plutonium during seven spring run-off events in Los Alamos and Pueblo Canyons. The melting of the snowpack during these years resulted in run-off that was large enough to reach the eastern edge of the Laboratory. However, of these seven run-off events, only five had sufficient flow to reach the Rio Grande. Data on amounts of transport are presented.

Wallwork-Barber, M.K., K. Lyall, and R.W. Ferenbaugh. 1985. Thallium Movement in a Simple Aquatic Ecosystem. Journal of Environmental Science and Health A20: 689-700.

Very little is known about the behavior of thallium in aquatic systems. Because of its toxicity and pollution potential, a greater understanding of thallium transport pathways in aquatic systems is needed. This study examined the transport of thallium among four basic aquatic components: water, sand, vegetation, and fish. Definite transport of thallium occurred among water, vegetation, and fish; but no significant transport was seen between the sand and the other ecosystem components. The concentration of thallium decreased very slowly in the water and increased tenfold in the vegetation and fish. Thallium concentration in the sand remained essentially constant throughout the experiments.

Ecological Risk Assessment and NRDA

Bennett, K. 1995. Use of Geographic Positioning System and Geographic Information System in an Ecological Risk Study. In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 271-275. Report No. LA-13065-MS. Los Alamos National Laboratory.

A global positioning system was used to obtain coordinate data for all of the study plots used in Guaje and Los Alamos Canyons. These coordinates were transferred to an Arc/Info Geographic Information System, and maps of the locations were generated. Attribute data collected during the studies will be linked to the spatial data of the plots for further analysis.

Biggs, J. 1995. Small Mammal Population Studies for Ecological Risk Assessments. In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 255-270. Report No. LA-13065-MS. Los Alamos National Laboratory.

The primary purpose of collecting small mammal data in Guaje and Los Alamos Canyons was to obtain sufficient information to estimate population size, density, and species diversity. Trapping sites were located in mixed conifer, ponderosa pine, and a transition zone between the two. Very poor capture rates were experienced during two years of trapping in 1993 and 1994. Deer mice were captured in all trapping locations except middle Los Alamos Canyon. Shrews and voles were captured only in the upper locations in each canyon, and deer mice and a small number of harvest mice were the only species captured in the ponderosa pine habitat of the lower portions of each canyon. The upper portions of the canyon systems had a much higher species diversity and a much greater number of captures compared to the lower areas, resulting in higher population estimates and densities in those locations. The relative percentage of males was much higher than females, but overall mean body weights appeared similar. The overall species diversity was similar for both canyons.

Fair, J.M., S.J. Whitaker, and O.B. Myers. 1996. Scaling of Body Size and Home Range in Terrestrial Ecological Risk Assessment. Poster presentation at the Annual Meeting of the Rocky Mountain Chapter of the Society of Environmental Toxicology and Chemistry. Denver.

Published allometric models for predicting home range from body mass and foraging strategy were tested against new data.

Ferenbaugh, R.W. 1995. Implementation of the Natural Resource Damage Assessment Preassessment Screen at Los Alamos National Laboratory. Report No. LA-UR-95-1667. Los Alamos National Laboratory. 3 pp.

This is a very brief report that simply outlines the requirements of the Natural Resource Damage Assessment preassessment screening phase as they apply to Los Alamos National Laboratory.

Ferenbaugh, R.W., M.H. Ebinger, and W.R. Hansen. 1997. Preliminary Ecological Risk Assessment Methodology for Los Alamos National Laboratory. Report No. LA-UR-97-4950. Los Alamos National Laboratory. Los Alamos. 86 pp.

Risk assessment for ecological effects differs from that for human health effects in several respects. The methodology for human health risk assessment is well-established and has been

in use for some time, whereas ecological risk assessment is relatively new and approaches still are being developed. In addition, ecological risk assessment is more complex in that there are more potential receptors and assessment endpoints. In applying the EPA framework and related guidance to large terrestrial sites, several issues arise that are not addressed in the framework: (1) large complexes may have complex topography with multiple habitat types; (2) multiple contaminated sites, each with multiple contaminants, may need to be considered; and (3) the role of temporal variability and disturbance processes needs to be considered. The objectives of the methodology described in this document are to present a preliminary ecological risk assessment methodology that (1) addresses the three issues enumerated above (multiple habitat types, multiple contaminated sites and contaminants, and high "background" variability and disturbance); and (2) provides the technical foundation for baseline ecological risk assessments that are consistent with the preliminary assessment approach that is presented.

Ferenbaugh, R.W., M.H. Ebinger, and O.B. Myers. 1997. TA-33 pilot study ecological screening assessment. Report No. LA-UR-97-5133. Los Alamos National Laboratory. Los Alamos. 53 pp.

The LANL risk screening methodology (see LANL Report No. LA-UR-97-4950), utilizing the Ecological Exposure Unit concept, was applied to TA-33 as a pilot study to determine the applicability of the methodology. The results of the pilot study are presented. They demonstrate that Hazard Indices calculated for the entire exposure unit cannot be used to screen out sites. This screening failure is the result of a number of limitations and assumptions that, in combination, lead to high Hazard Index values. The limitations and potential mitigations are discussed.

Gallegos, A.F. and G.J. Gonzales. 1999. Documentation of the Ecological Risk Assessment Computer Model ECORSK.5. Report No. LA-13571-MS. Los Alamos National Laboratory.

The FORTRAN77 ecological risk computer model – ECORSK.5 – has been used to estimate the potential toxicity of surficial deposits of radioactive and non-radioactive contaminants to several threatened and endangered (T&E) species at the Los Alamos National Laboratory. This report summarizes and documents the ECORSK.5 code, the mathematical models used in the development of ECORSK.5, and the input and other requirements for its operations. Other FORTRAN77 codes used for processing and graphing output from ECORSK.5 also are discussed. The reader may refer to reports cited in the introduction to obtain greater detail on past applications of ECORSK.5 and assumptions used in deriving model parameters. A FORTRAN90 version of the code is under development.

Gallegos, A.F., G.J. Gonzales, K.D. Bennett, and L.E. Pratt. 1997. Preliminary Risk Assessment of the Mexican Spotted Owl under a Spatially-Weighted Foraging Regime at the Los Alamos National Laboratory. Report No. LA-13259-MS. Los Alamos National Laboratory. 62 pp.

This report presents the results of a preliminary risk assessment for the Mexican spotted owl on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated doses to the owl under a spatially-weighted foraging regime were compared against toxicological reference doses for three risk source types. Under the risk parameter assumptions made, hazard quotient (HQ) results indicated no unacceptable risk to the owl, including a measure of cumulative effects from multiple contaminants that assumes a linear additive toxicity type. A Hazard Index of 1.0 was used as the evaluative criterion for determining the acceptability of risk. This value was exceeded (1.06) in only one of 200 simulated potential nest sites. Cesium-137, Ni, ^{239}Pu, Al, and ^{234}U were among the constituents with the highest partial HQs. Improving model realism by weighting simulated owl foraging based on distance from potential nests decreased the estimated risk. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, owl habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at acceptable low levels.

Gallegos, A.F., G.J. Gonzales, K.D. Bennett, L.E. Pratt, and D.S. Cram. 1997. A Spatially-Dynamic Preliminary Risk Assessment of the American Peregrine Falcon at the Los Alamos National Laboratory (Version 1). Report No. LA-13321-MS. Los Alamos National Laboratory. 114 pp.

This report presents the results of a preliminary risk assessment for the peregrine falcon on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated doses to the falcon were compared against toxicity reference values to generate hazard indices. Hazard index results indicated no unacceptable risk to the falcon from the soil ingestion pathway, including a measure of cumulative effects from multiple contaminants that assumes a linear additive toxicity type. Scaling home ranges on the basis of maximizing falcon height for viewing prey decreased estimated risk by 69% in a canyons-based home range and increased estimated risk by 40% in a river-based home range. Improving model realism by weighting simulated falcon foraging based on distance from potential nest sites decreased risk. Choice of toxicity reference values can have a substantial impact on risk estimates. Adding bioaccumulation factors for several organics increased partial hazard quotients by a factor of 110, but increased the mean hazard index by only 0.02 units. Adding a food consumption exposure pathway in the form of biomagnification factors for 15 contaminants of potential ecological concern increased the mean hazard index to 1.16, which is above the level of acceptability (1.0). Aerochlor-1254, DDT, and DDE accounted for 81% of the estimated risk that includes soil ingestion and food consumption pathways and a biomagnification component. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, falcon habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at acceptably low levels.

Gonzales, G.J., A.F. Gallegos, and T.S. Foxx,. 1997. Second Annual Review Update: Preliminary Risk Assessment of Federally Listed Species at the Los Alamos National Laboratory. Report No. LA-UR-97-4732. Los Alamos National Laboratory. 9 pp.

The ECORSK model that was used to perform the initial risk assessments for the peregrine falcon, bald eagle, and Mexican spotted owl was modified to include updated contaminant uptake and accumulation information as well as updated TRV values. This report presents updated results for the spotted owl and peregrine falcon using the new model. Overall, the results indicate a small potential for impact to the peregrine falcon but no appreciable impact to the spotted owl or bald eagle.

Gonzales, G.J., A.F. Gallegos, T.S. Foxx, P.R. Fresquez, M.A. Mullen, L.E. Pratt, and P.E. Gomez. 1998. A Spatially-Dynamic Preliminary Risk Assessment of the Bald Eagle at the Los Alamos National Laboratory. Report No. LA-13399-MS. Los Alamos National Laboratory. 64 pp.

This report presents the results of a preliminary risk assessment for the bald eagle on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated exposure doses to the eagle for radionuclide, inorganic metal, and organic contaminants were derived for varying ratios of aquatic vs. terrestrial simulated diet and compared against toxicity reference values to generate hazard indices (HIs). The HI results indicate that no appreciable impact to the bald eagle is expected from contaminants at LANL from soil ingestion and food consumption pathways. This includes a measure of cumulative effects from multiple contaminants that assumes linear additive toxicity. Improving model realism by weighting simulated eagle foraging based on distance from potential roost sites increased the HI by 76%, but still to inconsequential levels. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, eagle habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at low levels.

Gonzales, G.J., A.F. Gallegos, M.A. Mullen, K.D. Bennett, and T.S. Foxx. 1998. Preliminary Risk Assessment of the Southwestern Willow Flycatcher (*Empidonax trallii extimus*) at the Los Alamos National Laboratory. Report No. LA-13508-MS. Los Alamos National Laboratory. 43 pp.

This report presents the results of a preliminary risk assessment for the southwestern willow flycatcher on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. The southwestern willow flycatcher is the fourth threatened or endangered species to undergo a preliminary assessment for estimating potential risk from environmental contaminants at the Los Alamos National Laboratory. These assessments are being conducted as part of a three-year project to develop a habitat management plan for threatened or endangered species and species of concern at the Laboratory. For the preliminary assessment, estimated doses were compared against toxicity reference values to generate hazard indices (HIs). This assessment includes a measure of cumulative effects from multiple contaminants (radionuclides, metals, and organic chemicals) to 100 simulated nest sites located within flycatcher potential habitat. Sources of contaminant values were 10.000 ft^2 grid cells within an Ecological Exposure Unit (EEU). This EEU was estimated around the potential habitat and was based on the maximum home range for the flycatcher identified in the scientific literature. Food consumption and soil ingestion contaminant pathways were addressed in the assessment. Using a four-category risk evaluation, HI results indicate no appreciable impact is expected to the southwestern willow flycatcher. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, flycatcher habitat, facility siting, and/or facility operations in order to maintain low levels of risk from contaminants.

Hlohowskyj, I. 1994. An Overview of the Natural Resource Damage Assessment Process and Its Applicability to the Environmental Restoration Activities at the Los Alamos National Laboratory. Report prepared for the Environmental Restoration Program at Los Alamos National Laboratory. Argonne National Laboratory. 23 pp.

This report was prepared to provide the Operable Unit Project Leaders and their staff at Los Alamos National Laboratory (LANL) with an overview of the Natural Resource Damage Assessment (NRDA) process. The goal is to provide a basic overview of the NRDA process and to serve as an initial reference for NRDA-related questions that may arise during environmental restoration activities. Specifically, this report (1) provides a summary of the regulatory requirements of the NRDA process, (2) identifies the role and responsibilities of the U.S. Department of Energy (DOE) as the primary Federal Natural Resource Trustee for LANL, (3) discusses the roles and responsibilities of other Natural Resource Trustees for natural resources that may have been affected by past activities at LANL, (4) discusses the applicability of the NRDA process to the Resource Conservation and Recovery Act (RCRA) activities underway at LANL, (5) discusses DOE Headquarters guidance regarding the integration and implementation of NRDA activities into environmental restoration activities across the DOE complex, and (6) summarizes the specific elements of the NRDA process that should be addressed during RCRA activities at LANL.

Kelly E, G.J. Gonzales, L Soholt, M. Hooten and R. Ryti, 1998. Screening Level Ecological Risk Assessment Approach for the Environmental Restoration Project at Los Alamos National Laboratory. Report No. LA-UR-98-1822. Los Alamos National Laboratory. 70 pp. (Superceded by Report No. LA-UR-99-1405.)

This document describes the approach used by the LANL Environmental Restoration (ER) Project for screening level assessments of potential, adverse impacts to ecological resources resulting from legacy wastes, which are wastes resulting from past operations at the Laboratory. The approach follows the New Mexico Environment Department's Hazardous and Radioactive Materials Bureau guidance dated 3/4/98, the "Ecological Risk Assessment Guidance for Superfund" issued by EPA in 1997, and the EPA's 1996 "Proposed Guidelines for Ecological Risk Assessment." The purpose of this document is twofold: (1) to provide a basis for reaching consensus with regulators, managers, and other interested parties as to the best approach for conducting screening level ecological risk investigations at the Laboratory, and (2) to provide guidance to ER ecological risk assessors that will promote consistence in ecological screening investigations and the reporting of investigation results.

Kelly, E., M. Kramer, C. McDaniel, P. Newell, K. Sasser, D. Stack, and A. Gallegos. 1995. Integrating Ecological Risk Assessment and Hazards Analysis: A Pilot Project for the Proposed Los Alamos Waste Treatment and Storage Facilities. Report No. LA-UR-95-2555. Los Alamos National Laboratory. 62 pp.

This report describes the Ecological Risk Assessment Pilot Project that was conducted to augment the Preliminary Hazards Analysis (PHA) and the limited Probabilistic Risk Assessment (PRA) conducted for the proposed Waste Treatment and Storage Facilities at Los Alamos National Laboratory TA-63. This pilot project explored the possibility of using an ecological risk assessment approach to explicitly incorporate environmental consequence analysis into the PHA/PRA process for the proposed waste facilities. The PHA for the Waste Treatment and Storage Facilities identified the release of toxic gases from compressed cylinders as the most serious risk scenario because of the potential extent of the release and because the toxic gases presented the greatest risks to human health. However, this scenario is not the most serious in terms of ecological effects at TA-63 and the surrounding areas. The potential accidents with the most serious ecological effects are those that release long-lasting toxic materials to surface soils and plants. The hazardous waste facilities PHA is a classic example of what can happen when ecological effects are not specifically addressed and human health effects and off-site contaminant dispersal levels are used as the only measures of environmental impacts. Thus, the purpose of this pilot project was to explore an approach to remedy this problem. The approach used is based on ecological risk assessment methods; it is tiered to provide a timely, cost-effective procedure and consistency with the graded approach traditionally used in hazards analysis. The first phase of this tiered approach combined a conservative ecological screening model and the worst-case accident scenario (based on ecological criteria) to determine if ecological impacts could be excluded from further investigation or would require a more detailed assessment. Is a more detailed assessment was required, the screening model was used to narrow the investigation by identifying the sensitive ecological/geographical areas, the major contaminants of concern, and the most sensitive species.

Myers, O.B. 1999. On Aggregating Species for Risk Assessment. Human and Ecological Risk Assessment 5: 559-574.

Different combinations of species characteristics such as dietary strategies and foraging tactics define unique pathways for material cycling and energy flow. Such clusters of species may also have similar functions in ecosystems because they use similar resources in similar ways. By using species characteristics to aggregate and define assessments, more ecologically relevant assessment endpoints can be defined.

Myers, O.B., and J.M. Fair. 1998. Testing Predictions from Ecological Risk Assessment with Cavity-Nesting Birds. Poster presentation at the Annual Meeting of the Ecological Society of America. Baltimore.

This poster was a preliminary report on an ongoing study of cavity-nesting birds at Los Alamos National Laboratory. The primary purpose of the study is to determine effects of contaminated sites on cavity-nesting birds, but it also is one of a very few studies on bird populations and behavior on the LANL preserve (exclusive of studies on Threatened and Endangered Species).

Myers, O.B., and J.M. Fair. 1999. Integrated Biological Experiments. Modeling, and Monitoring for Natural Resources Damage Assessment and Ecological Risk Assessment. Poster presentation at the University of California President's Council of the National Laboratories Environment, Safety, & Health Panel. August 11-13. Los Alamos.

Cavity-nesting birds are being used to determine if wildlife has been adversely affected by exposure to environmental contaminants at Los Alamos National Laboratory. Study measurements test predictions from ecological risk analyses performed at LANL and establish if wildlife has been injured for Natural Resource Damage Assessment purposes. The primary objectives of the study are (1) to estimate the form of the relationship between simple risk assessment calculations and observed risk to wildlife, and (2) to develop and test nonlethal indicators of adverse ecological effects that are applicable to multiple spatial scales. Western

bluebird and ash-throated flycatcher nesting boxes were placed across a putative hazard gradient to test whether calculated hazard index values are correlated with ecological risk at nest box to landscape scales. Some boxes containing western bluebirds are used for field experiments that manipulate exposure to metallic lead. Measurements are being made on nestling growth rates, developmental asymmetry, immune system function, parasitism, and survival. Results indicate that western bluebirds show lower rates of parasitism than ash-throated flycatchers, and nestling survival of western bluebirds shows significant variation across the LANL landscape. Experimental exposures indicate that risks from metallic lead are much less than predicted by simple risk assessment models.

Ryti, R., E. Kelly, M. Hooten, G. Gonzales, G. McDermott, and L/ Soholt. 1999. Screening Level Ecological Risk Assessment Methods. Report No. LA-UR-99-1405. Los Alamos National Laboratory. 110 pp.

This document builds on and clarifies the methods and ideas provided in the previous screening approach document, "Screening Level Ecological Risk Assessment (SLERA) Approach for the Environmental Restoration Project at Los Alamos National Laboratory" (Report No. LA-UR-98-1822). This document, as did the previous document, provides guidance for screening level assessments of potential adverse impacts to ecological resources from wastes resulting from past operations at LANL. This document responds to the New Mexico Environment Department comments on the previous document. Major changes made in response to those comments include the addition of guidance for sediment, water, and multi-media screening levels, the inclusion of additional receptors to account for on-site bioaccumulation and some biomagnification concerns, the emphasis on interim actions during the scoping evaluation, the inclusion of multi-media evaluations, and the simplification and clarification of multi-contaminant evaluations. The guidance provided in this document follows the Environmental Protection Agency's "Ecological Risk Assessment Guidance for Superfund" and "Guidelines for Ecological Risk Assessment." This document supercedes the previous SLERA document.

Wilcox, B.P., and D.D. Breshears. 1997. Interflow in Semiarid Environments: An Overlooked Process in Risk Assessment. Human and Ecological Risk Assessment 3: 187-203.

The lateral movement of water through the soil, or interflow, is frequently a component of risk assessments for humid environments, but not of those for semiarid environments. However, interflow can be important in semiarid environments and is, therefore, an essential consideration for risk assessment in these regions. To illustrate and assess the effect of interflow on estimates of risk, (1) a simple conceptual model to describe the role that interflow may have in the redistribution of surface and near-surface contamination was developed; and (2) RESRAD, as exposure model for assessing radionuclide doses to humans, was used to evaluate the effectiveness of landfill covers in mitigating doses of three contaminates at a site in northern New Mexico where interflow is known to be occurring. Only those calculations of the model that took interflow into account yielded the result that radionuclides would contaminate groundwater – underscoring the importance of interflow as a mechanism for the transport of contaminants. The conclusion is that failure to take interflow into account can render risk assessments inaccurate and remediation ineffective.

Ecophysiology/Biochemistry

Barnes, F.J. 1984. Water Relations on the Dominant Grasses on La Mesa Burn. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 57-72. Report No. LA-9236-NERP. Los Alamos National Laboratory.

One month after La Mesa Fire, the burned areas of Bandelier National Monument were seeded with a mixture of native and nonnative grass species. Studies on the recovery of mature ponderosa pine and on the success of the seeding operation suggested that the high density of two of the seeded grasses may have contributed to the reduced viability of fire-damaged mature trees in areas where the grass density was especially high. In addition, it was hypothesized that the dense grass stands might interfere with the natural regeneration of ponderosa pine in those areas where seed trees survived. This study was made to determine whether there is significant

niche overlap between ponderosa pine seedlings and the grasses on La Mesa burn. As availability of water is probably the most important factor in ponderosa pine seedling establishment in the arid Southwest. field observations were made on root structure and seasonal patterns of plant water status and soil moisture in order to investigate the partitioning of the soil water resource among coexisting species. Because too few pine seedlings for study could be found in the severely burned areas, the water relations study was confined to the three dominant grasses, and inferences were made about the possible competition with pine seedlings. Of the three grass species studies, Agropyron trachycaulum *and* Festuca ovina *appear to partition the soil water resource, and coexistence of these two species could presumably be long term.* Muhlenbergis montana *and* F. ovina*, although having complementary phenologies, have conflicting patterns of water usage, and thus it seems likely that the native* M. montana *experiences severe competition from* F. ovina*.* M. montana *might also experience significant competition from* A. trachycaulum*.* M. montana *has some roots that penetrate the soil profile quite deeply, probably giving the species increased survival during especially dry seasons. These deeper roots would come into direct competition with the very dense deep root system of* A. trachycaulum*. Previous studies have shown that grass roots will produce several "flushes" of new growth during a season, but ponderosa pine seedings will produce only a few additional roots after the initial spring growth period. Given the data on grass root distribution and water usage, this suggests that young pine seedlings would experience severe competition from* F. ovina *because this species has an extremely dense root mat that would be difficult for the roots of newly germinated seedlings to penetrate. In addition, the phenology of this grass conflicts with that of ponderosa pine in that both use winter precipitation during early spring growth. Also, older pine seedlings likely would experience considerable competition from* A. tachucaulum *because of its extensive deep root system and continued growth and water uptake during the summer drought. Ponderosa pine seedlings would compete much less with the native* M. montana *than with the other two dominant grasses because they have fundamental differences in niche space. The native grass has a phenology complementary to the growth patterns of ponderosa pine, including a somewhat sparse growth system that is likely to result in less water withdrawal from the soil during the spring and summer and allow root penetration of newly germinated pine seedlings. However, as the two seeded grasses are dominant in the severely burned areas of Bandelier, any attempts to plant or seed ponderosa pine on the burns will have to consider ways to mitigate the severe competition that the seedlings will experience from the dense stands of* A. trachucaulum *and* F. ovina *that currently exist.*

Breshears, D.D., and F.J. Barnes. 1999. Interrelationships between Plant Functional Types and Soil Moisture Heterogeneity for Semiarid Landscapes within the Grassland/Forest Continuum: A Unified Conceptual Model. Landscape Ecology 14: 465-478.

This paper presents a new conceptual model for determining the ratio of herbaceous to woody plant biomass in semiarid environments. Previous models were based either on differences in soil moisture with depth or on differences in soil moisture between canopy and intercanopy patches resulting from disturbances associated with land use. The new model unifies these two perspectives by (1) recognizing that soil moisture varies horizontally between canopy and intercanopy patches not only due to land disturbance, but also due to the physical nature of the canopy itself, and (2) while retaining the assumption that woody plants obtain moisture from deeper soil layers than herbaceous plants, also recognizing the existence of two types of woody plants: those that extract a substantial proportion of their moisture from deeper layers and those that extract mainly from shallow layers. This model integrates three key concepts in semiarid ecology: (1) the proportion of woody cover increases as moisture in the deeper layers increases, (2) land use practices that cause a reduction in herbaceous vegetation and compaction of intercanopy soil lead to a long-term increase in the proportion of woody plants, and (3) changes in the ratios of herbaceous to woody plant biomass exhibit complex behavior (i.e., changes can happen quickly and are not directly reversible without intensive management).

Breshears, D.D., O.B. Myers, S.R. Johnson, C.W. Meyer, and S.N. Martens. 1997. Differential Use of Spatially Heterogeneous Soil Moisture by Two Semiarid Woody Species: *Pinus edulis* and *Juniperous monosperma.* Journal of Ecology 85: 289-299.

Soil moisture in semiarid woodlands varies both vertically with depth and horizontally between canopy patches beneath woody plants and the intercanopy patches that separate them, such that shallow soil layers in intercanopy patches are wettest. Three hypotheses were tested relative to the use of shallow water in intercanopy locations by two coexisting semiarid-woodland tree species, piñon pine and juniper. (1) Both piñon and juniper can use shallow water from intercanopy locations. (2) Juniper is able to obtain more shallow water from intercanopy locations than piñon. (3) The spatial arrangement of the trees influences the amount of water that they can obtain. Although both species responded to the addition of shallow water in intercanopy locations, the juniper response was significantly greater than that of piñon pine. The responses were not influenced by spatial arrangement. In addition, the amount of depletion was correlated with basal area of juniper but not of piñon pine. These results are consistent with differences in relative abundance of the two species across locations, suggesting that species differences in ability to use shallow water in intercanopy locations is important in structuring semiarid woodlands. Furthermore, the results suggest that current theoretical concepts for semiarid ecosystems, which ignore either vertical or horizontal variability in soil moisture, may be inadequate for predicting changes in the ratio of woody to herbaceous plant biomass, particularly for plant communities with co-dominant woody species that differ in ability to acquire spatially heterogeneous resources.

Breshears, D.D., J.W. Nyhan, C.E. Heil, and B.P. Wilcox. 1998. Effects of Woody Plants on Microclimate in a Semiarid Woodland: Soil Temperature and Evaporation in Canopy and Intercanopy Patches. International Journal of Plant Science 159: 1010-1017.

The canopies of woody plants in semiarid environments modify the microclimate beneath and around them, with canopy patches usually having lower soil temperatures than intercanopy patches. However, information is lacking on how heterogeneity in soil temperature, induced by woody plant canopies, influences soil evaporation rates and the consequent effects on plant-available water. In the study reported in this paper, soil temperatures were measured and soil evaporation rates were estimated for canopy and intercanopy patches in a semiarid piñon-juniper woodland in northern New Mexico. Maximum soil temperature in intercanopy patches was greater than in canopy patches between May and September by as much as 10^{o}C, while soil temperatures in intercanopy patches were lower than in canopy patches during colder parts of the day in the fall and winter months. Drying rates were disproportionately greater at high soil moisture and high soil temperature. Intercanopy patches were predicted to dry more than canopy patches for days in April through September by as much as 2% volumetric soil content per day. These results quantify the effects of woody plants on the microclimate with respect to soil temperature and evaporation, which in turn affects herbaceous and woody plants by modifying factors such as germination, the potential for facilitation, and the amount of plant-available water.

Breshears, D.D., P.M. Rich, F.J. Barnes, and K. Campbell. 1997. Overstory-Imposed Heterogeneity in Solar Radiation and Soil Moisture in a Semiarid Woodland. Ecological Applications 7: 1201-1215.

Degradation of semiarid ecosystems is a major environmental problem worldwide, characterized by a reduction in the ratio of herbaceous to woody plant biomass. These ecosystems can be described as a set of canopy patches comprising woody plants and the intercanopy patches that separate them. This study tested for relationships among spatial patterns of the overstory, near-ground solar radiation, and soil moisture in a semiarid piñon-juniper woodland in northern New Mexico that had a highly heterogeneous overstory and was not degraded with respect to ground cover and erosion rates. For near-ground solar radiation, there was spatial variation between patches (canopy < intercanopy), within patches for centers versus edges, and for north vs. south edges. For soil moisture, canopy locations were significantly drier than intercanopy locations, and edge locations were significantly wetter than center locations both overall and within both patch types. Spatial heterogeneity in soil moisture was attributed primarily to canopy interception and drip on the basis of large differences in snow cover between canopy and intercanopy locations. The spatial heterogenieties in near-ground solar radiation and soil moisture are of sufficient magnitude to affect biotic processes of woody and herbaceous plants,

such as growth and seedling establishment. The results also demonstrate how the physical presence of woody canopies reinforces spatial heterogeneity in microclimate.

Hayes, A.C., P.R. Fresquez, and W.F. Whicker. 2000. Uranium Uptake Study, Nambe, New Mexico: Source Document. Report No. LA-13614-MS. Los Alamos National Laboratory. 38 pp.

Over 50% of the wells in the Nambe region of northern New Mexico exceed the U.S. Environmental Protection Agency's recommended drinking water standard of 20 $\mu g\ L^{-1}$ for ^{238}U. Uranium uptake was estimated in tomato, squash, lettuce, and radish irrigated with Nambe well water containing <1, 150, 500, and 1200 $\mu g\ U\ L^{-1}$. Plant uptake and human dose and toxicity associated with ingestion of water and produce and inhalation of irrigated soil related to gardening activities were evaluated. Uranium concentration in plants increased linearly with increasing U concentration in irrigation water, particularly in lettuce and radish. The estimated total committed effective dose equivalent for 70 years of maximum continuous exposure, via the three pathways to well water containing 1200 $\mu g\ U\ L^{-1}$, was 0.17 mSv (17 mrem) with a corresponding kidney concentration of 0.8 $\mu g\ U\ g^{-1}$ kidney.

Kasunic, C.A. 1982. The Toxicity of Spent Photographic Solutions and Other Silver Compounds and Their Migration in Soil. M.S. Dissertation. University of Arizona. Tucson. 142 pp.

The silver content of the waters, stream sediments, soils, and vegetation in a canyon contaminated with spent photographic fixing bath solutions at Los Alamos National Laboratory was determined. The total silver concentration in the canyon decreased with increasing distance from the mouth of the waste outfall. At a distance of approximately 300 m, the silver levels of the vegetation approached those of the background. The silver content of the sediments and soils, however, remained significantly higher than background for a distance of 420 m. Soil column experiments showed that the silver solutions are attenuated by soil at rates and apparently by different mechanisms. The silver thiosulfate complex in the spent fixing bath solution is believed to be reduced to silver nitrate in the soil. The silver ion in silver nitrate and silver sulfate solutions probably replaces the Na^+ and/or K^+ ion in the clays present in clayey-skeletal Typic Eutroboralf soils. The phytotoxicity of the spent fixing bath solutions then is due primarily to the presence of excess sodium ion. This reduces the ability of a plant to absorb water and essential mineral nutrients and leads to a decrease in productivity.

Lin, T., P.M. Rich, D.A. Heisler, and F.J. Barnes. 1992. Influences of Canopy Geometry on Near-Ground Solar Radiation and Water Balances of Piñon-Juniper and Ponderosa Pine Woodlands. 1992. In: Proceedings of the Annual Meeting of the American Society for Photogrammetry and Remote Sensing. Pp. 285-294.

This paper discusses the influences of canopy geometry on near-ground solar radiation and water balances in piñon-juniper and ponderosa pine woodlands. The conclusion is that canopy geometry directly influences near-ground solar radiation penetration, which in turn correlates negatively with soil moisture, particularly during the summer.

Martens, S.N., D.D. Breshears, and C.W. Meyer. Spatial Distributions of Understory Light along the Grassland/Forest Continuum: Effects of Cover, Height, and Spatial Pattern of Tree Canopies. Ecological Modelling (in press).

Understory light was modeled over a growing season for two types of plots; (1) generated plots in which cover, spatial pattern, and height of trees were varied systematically, and (2) three actual plots using stand data from piñon-juniper woodland sites for which cover, spatial pattern, and height varied concurrently. Mean understory light decreased with increasing canopy cover and was sensitive to changes in height, as expected, but was not sensitive to spatial pattern. Variance in understory light was maximum at an intermediate value of cover that was dependent on both spatial pattern and cover – maximum variance occurred at lower values of cover as height increased and as spatial pattern progressed from regular to random to aggregated. These trends in the overall patterns of understory light were also examined with respect to changes in understory light in canopy and intercanopy locations. Variance in understory light for intercanopy locations was less than that for canopy locations at low canopy cover, but exceeded that for canopy locations as canopy cover increased. The value of canopy cover at which variance in

intercanopy locations exceeded that in canopy locations was sensitive to variation in height but not in spatial pattern. The distributions of understory light for the actual plots were generally similar to those for corresponding generated plots, with dissimilarities attributable to differences in cover and height.

Newberry, T.L. 1999. Effect of Spatial and Temporal Variability on Water Relations and Growth in Pinyon Pine: III. Whole Tree Response. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 99-105.. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

The purpose of this study was to explore the physiological response of piñon pine to spatial and temporal variability on a whole tree level using information on physiology and growth recorded in tree-rings. The rationale of this approach is that water relations of piñon pine or any long-lived species can only be truly understood in the context of the spatiotemporal heterogeneity inherent to natural environments. This paper is the final report in the larger study of water relations in piñon pine ecosystems. This last study looks at whole-tree response to climatic variability. Water use efficiency was studied using ^{13}C measurements of tree-rings. The results indicate that water use efficiency in piñon is variable from year to year in response to the Palmer Drought Severity Index (PDSI). Precipitation plays a secondary role relative to PDSI in determining water use efficiency, especially in the summer months when evaporative demand is high. Both winter and summer PDSI are equally important in determining water use efficiencies. Winter PDSI is most likely important because the winter precipitation recharges soil water through snowfall prior to the next year's growing season. The results also suggest that the overall water use efficiency of the whole tree is a function of physiological factors such as the instantaneous response of stomata to changes in water status rather than anatomical factors such as wax layers, number of stomata, sunkenness of stomata, photosynthetic efficiency, etc. Furthermore, decreased water use efficiency due to aging of needles does not appear to be an important factor in determining the overall water use efficiency of the whole tree and the ^{13}C composition of the tree.

Nowak, R.S., D.J. Moore, and R.J. Tausch. 1999. Ecophysiological Patterns of Pinyon and Juniper. In: Proceedings of the Workshop on Ecology and Management of Piñon-Juniper Communities within the Interior West, Provo, 9/15-18/97. S.B. Monsen and R. Stevens, eds. Pp. 35-46/

Although species that dominate on over 30 million ha may be expected to have aggressive ecophysiological traits, piñon and juniper generally are conservative in their acquisition and use of resources when measured on a per gram of foliage basis. Assimilation rates of piñon and especially of juniper are very uniform over different types and scales of environmental gradients. Although piñon and juniper often intermix, some subtle ecophysiological differences exist between the two genera that appear to influence plant distribution. These conservative ecophysiological traits help piñon and juniper dominate the landscape in two ways: first, they allow the conifers to support a much greater amount of foliage biomass than co-occurring shrubs, given the same amount of resources; and second, when coupled with distinct ecophysiological differences between juvenile and adult plants, they help piñon and juniper establish under, then tolerate, and ultimately outsize and outlive their shrub-steppe nurse plants. The primary purpose of this paper is to provide a summary review of the physiological ecology of piñons and junipers, with the ultimate goal of understanding how their ecophysiological traits may explain plant distribution, population dynamics, and the ability of these species to invade and ultimately dominate shrub communities.

Perkins, B., and G.L. DePoorter. 1985. Plants and Their Relationship to Soil Moisture and Tracer Movement. Report No. La-10216-MS. Los Alamos National Laboratory. 68 pp.

To obtain a better understanding of the mechanisms for possible movement of radionuclides or other toxic materials from waste burial sites in arid to semiarid regions, changes in soil moisture and tracer (Co, Cs, Sr, and tritium) movement were compared for bare vs vegetated soils. During the course of two growing seasons, comparing vegetation with bare soils, plant transpiration processes significantly reduced the soil moisture. In the vegetated soils, most of the

Co, Cs, and Sr remained in the region of original emplacement. In bare soils, Co and Cs underwent minimal movement, but the peak concentration of Sr moved downward. For all tracers in the vegetated soils, there was some evidence that slight amounts of tracer had been absorbed in the plant roots and brought to the surface through plant translocation processes. In all cases, there was no significant upward movement of Co, Cs, and Sr. For tritium, the vegetated soils, compared with the bare soils, retained the maximum inventories near the original emplacement location. Although all soils showed some tritium loss, it was greatest in the vegetated soils. A literature review associated with the experiment indicated that plant species alone does not determine rooting depth, rate of transpiration, nutrient uptake, and other plant-associated processes. Environmental conditions are just as important as plant species and must be included in modeling plant-related effects. More data are needed on the effects of tracer concentration, soil water composition, variations in precipitation with time and intensity, evaporation rates, variations in soil composition, soil microorganisms, other invertebrates and vertebrates that inhabit soils, litter decay, and colloid movement on contaminant movement under conditions of saturated flow.

Elk/Deer

Allen, C.D. 1996. Elk Response to the La Mesa Fire and Current Status in the Jemez Mountains. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 179-195. General Technical Report No. RM-GTR-286. USDA Forest Service.

Faunal remains in local archaeological sites and historic information suggest that elk populations in the Jemez Mountains were low from ca. 1200 A.D. through ca. 1900 A.D., when they were extirpated from this region. Elk were reintroduced to the Jemez country in 1948 and 1964-65, and their population has apparently grown exponentially, reaching 1000 animals in the 1970s and about 7000 by 1991. Elk populations in Bandelier National Monument and adjoining areas increased rapidly after the 1977 La Mesa Fire. Winter use by elk in the La Mesa Fire area, centered on Bandelier, grew from about 100 animals in 1978 to around 1500 by 1992. The dramatic increase in the Bandelier elk herd (an annual growth rate of 21.3% and a 3.6 year population doubling time) was due in part to the creation of about 6000 hectares of grassy winter range in and around the park as a result of the fire. Some of this local population increase reflects concentration of elk in this favorable winter habitat from surrounding portions of the Jemez Mountains. Existing data are inadequate to determine whether elk populations are still growing rapidly in the Jemez Mountains. While annual aerial surveys since 1990 in Bandelier reveal no clear population trend, a variety of observations demonstrate increasing elk use of lower elevation areas. Negative resource impacts from today's high elk populations are beginning to be widely noted across the Jemez Mountains, especially in high-use portions of the Bandelier National Monument area. Affected resources range from plant communities to soils and even archaeological sites. Given the large uncertainties associated with the current data on elk populations, care should be taken to avoid further population increases until the resource impacts of this new phenomenon (large numbers of elk) can be identified, desirable population levels identified (based to a significant degree upon ecological information and resource carrying capacities, as well as social considerations), and appropriate cooperative management strategies implemented.

Bennett, K.D., J. Biggs, and P.R. Fresquez. 1997. Determination of Locational Error Associated with Global Positioning System (GPS) Radio Collars in Relation to Vegetation and Topography in North-Central New Mexico. Report No. LA-13252-MS. Los Alamos National Laboratory. 14 pp.

In 1996, a study was initiated to assess seasonal habitat use and movement patterns of Rocky Mountain elk using global positioning system (GPS) radio collars. As part of the study, an attempt was made to assess the accuracies of GPS (non-differentially corrected) positions under various vegetation canopies and terrain conditions with the use of a "test" collar. The test collar was placed on a stand equivalent to the neck height of an adult elk and placed within three different treatment categories: (1) topographical influence (canyon and mesa tops), (2) canopy influence (open and closed canopy), and (3) vegetation type influence (ponderosa pine and piñon

pine juniper). The collar was kept at each location for one hour and was activated every 20 minutes to obtain a position location via a continuous uplink to Argos satellites to transfer position data files. A hand-held GPS unit was also used to obtain a position of the test collar at the same time and location. The hand held unit was differentially corrected, and previous tests had indicated that its accuracy was within 2 meters of an actual position. There were no statistical differences between either ponderosa pine and piñon pine-juniper vegetation types, open and closed canopies, or canyons and mesa tops.

Biggs, J., K. Bennett, and P.R. Fresquez. 1997. Evaluation of Habitat Use by Rocky Mountain Elk (*Cervus elaphus nelsoni*) in North-Central New Mexico using Global Positioning System (GPS) Radio Collars. Report No. LA-13279-MS. Los Alamos National Laboratory. 18 pp.

Global Positioning System (GPS) radio collars were used to determine habitat use on the LANL preserve. Locations and types of habitat occupied were documented with frequency of use of various habitat types. Results were compared to previous studies to document changes in utilization patterns. Based on habitat use and availability analysis, use of grass/shrub and piñon/juniper habitats was generally higher than expected during most seasons, and use of forested habitats (ponderosa pine, mixed conifer) was lower than expected. Most of the collared elk remained on LANL property year-round. The application of GPS collars to elk studies in north-central New Mexico appears to be a more efficient and effective method than use of VHF radio collars.

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1998. Estimation of Observation Rates of Global Positioning Collars Deployed on Elk. Report No. LA-UR-98-1080. Los Alamos National Laboratory.

A comparison was made of the ability of global positioning system (GPS) radio collars deployed on elk to obtain valid positions (position acquisition rate – PAR) in seasonal home ranges with differing vegetation and topographical characteristics. GPS collar PARs also were compared under varying levels of cloud cover and between differing daily time periods. A mean PAR of 69% was recorded for collared elk. Multiple regression analysis of seasonal home range characteristics indicated that vegetation cover type and slope, either as individual variables or in combination with one another, were not significant predictors of GPS collar PARs. Statistical differences in position acquisition rates between cloud cover classes or varying cloud base heights were not observed. The PAR was significantly higher between 1600-2000 h (mountain standard time) compared to 0000-1200 h, which may have been due to elk behavior. We believe that the use of GPS collars is a more effective and efficient method of tracking elk in our study area compared to very high frequency (VHF) collars, as GPS collars can be programmed to obtain fixes automatically, have fewer logistical problems, and are more economical with long-term data collection efforts.

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1998. Movements and Activity Patterns of Rocky Mountain Elk at the Los Alamos National Laboratory. LA-UR-98-4535. Presentation at the Third Symposium of Biological Research in the Jemez Mountains. November 6, 1998. Santa Fe.

From 1996 to 1998, the Ecology Group evaluated daily/seasonal movements and activity patterns of elk on and near Los Alamos National Laboratory (LANL) property by plotting global positioning system (GPS) locational fixes of collared elk onto geographic information system (GIS) coverages of topography and physical structures (i.e., security fences, roads, buildings), resulting in the identification of 6-8 primary elk-traveled corridors on LANL property. Travel corridors in the east portion of LANL are dictated by security fences and other structures, and there are two areas where corridors pass between LANL property and San Ildefonso Pueblo property. The primary travel corridor for collared animals moving west off LANL property is near Pajarito Mountain, which extends off the west-central portion of the Laboratory. The daily use of different land-cover types and terrain were evaluated seasonally by comparing data from six 4-h periods to one another: 0000-0400, 0400-0800, 0800-1200, 1200-1600, 1600-2000, and 2000-2400. Elk were found to utilize piñon-juniper significantly more frequently than all other cover types between the hours of 0400-1200. Through the 2000-h period, they utilized piñon-juniper significantly more frequently more frequently than all other cover types except ponderosa pine. In

general, the use of piñon-juniper increased during daylight hours and decreased during evening hours. Conversely, the use of grasslands decreased during daylight hours and increased during evening hours. The data showed that the elk utilized the northwest and west-facing slopes significantly less than almost all other slopes. Significant differences also were observed between northwest and west-facing slopes versus south-facing and east-facing slopes during the spring. Use of 0%-5% slopes was significantly greater than all other slope classes between the evening and early morning hours of 1600-0400 and significantly greater than slopes above 10% for all hourly subperiods except 0800-1200. During spring, use of 0%-5% slopes decreased during midday hours (0800-1600) and increased during evening and early morning hours (1600-0800). Animals increased their proportion of use on steeper slopes during most subperiods during the summer. By understanding more about movement and activity patterns of elk on LANL property, management strategies to reduce adverse impacts caused by elk (i.e., automobile accidents, overuse of sensitive habitats) can be developed while minimizing the impact of the strategies on elk movement patterns to off-site locations.

Biggs, J.R., K.D.. Bennett, P.R. Fresquez, and R.J. Robinson, 1996. Movements, Disease Analysis, and Tritium Concentrations of Rocky Mountain Elk of the Pajarito Plateau. LA-UR-96-3395. Presentation at the Symposium of Biological Research in the Jemez Mountains, New Mexico. October 26, 1996.

Seasonal movement patterns of four elk (3 cows/1 bull) and one deer fitted with VHF (very high frequency) units were investigated from spring 1995 to spring 1996. Results also are presented on disease analysis of six elk captured in 1996, as well as tritium analysis of all animals (n=11). The deer remained within three miles of its original capture location (n=39 fixes) throughout the study period. The bull elk remained on the Pajarito Plateau in winter and spring, then migrated to the Valle Grande during late spring and summer (n=49 fixes). One of the three cows died within 6 weeks of collaring, apparently following calving, near the north edge of Bandelier National Monument. The surviving cow elk remained on the east slope of the Jemez Mountains and the Pajarito Plateau during winter and early spring, then moved to the Valle Grande during calving and summer months (n=93 fixes). Based on radiotelemetry data, herds occurring in the southern portion of the Laboratory appear to migrate and calve along the eastern portion of the Valle Grande. Four of the six elk captured in 1996 had moderate to high titers for vesicular stomatitis, and one elk had a moderate titer for toxoplasmosis. One cow elk, sampled near Pajarito Road, and one male deer, sampled at TA-49, exhibited concentrations of tritium (2.2 and 1.1 pCi/ml, respectively) above the upper background limit of 0.9 pCi/ml.

Biggs, J.R., K.D.. Bennett, P.R. Fresquez, and R.J. Robinson, 1999. Resource Use, Activity Patterns, and Disease Analysis of Rocky Mountain Elk (*Cervus elaphus nelsoni*) at the Los Alamos National Laboratory. Report No. LA-13536-MS. Los Alamos National Laboratory. 83 pp.

To form the basis for the development of management strategies for elk and other large herbivores, understanding how, when, where, and why animals move with respect to the landscape and availability of essential habitats (i.e., foraging, watering) is essential. From 1996 to 1998, daily/seasonal movements, habitat use, and activity patterns of elk on and near Los Alamos National Laboratory (LANL) were evaluated through the use of global positioning system collars and a geographic information system. Primary travel corridors on and immediately adjacent to LANL property and identified travel routes for collared animals moving west off LANL property in the vicinity of Pajarito Mountain were identified. Daily use of different land cover types and terrain was evaluated seasonally by comparing six four-hour periods to one another. There were significantly more locational fixes of elk in piñon/juniper compared to all other cover types during the hours of 0400-1200, and significantly more than all other cover types except ponderosa pine through the 2000 hour period. In general, use of piñon/juniper increased during daylight hours and decreased during evening hours. Use of grasslands decreased during day hours while increasing during evening hours. Generally, northeast slopes were used greater than expected and west and northwest slopes less than expected. There were significantly greater fixes on 0^{o}-5^{o} slopes compared to all other slope classes between the evening and early morning hours of 1600-0400 and significantly greater than slopes above 10^{o} for all hourly subperiods except 0800-1200. During spring, use of 0^{o}-5^{o} slopes decreased during midday hours while

increasing during evening and early morning hours, and animals tended to increase their proportion of use on steeper slopes during most subperiods during summer. Diseases of animals through blood analysis drawn from all collared elk also was examined. Vesicular stomatitis was the most commonly observed disease among tested elk. By understanding movement and activity patterns of elk on LANL property, management strategies can be developed and applied to reduce adverse impacts (i.e., automobile accidents, overuse of sensitive habitats) associated with this species.

Eberhardt, L.E., and G.C. White. 1979. Movements of Mule Deer on the Los Alamos National Environmental Research Park. Report No. LA-7742. Los Alamos National Laboratory. 29 pp.

The movements of mule deer on the Los Alamos National Environmental Research Park (LA/NERP) in north-central New Mexico were studied during 1975-1978. A total of 36 deer were live-trapped, marked, and released; 24 of these were equipped with visual markings including ear tags, ear streamers, and neck collars, and 11 were fitted with radio transmitters. Disturbance caused by trapping may have caused some unusual movements. Deer home ranges appear to be elongated in shape, possibly because the deer tend to move parallel to the steep canyon-mesa systems and along the elevational gradient. The average home range size for six deer radiotracked for 18-20 months was 13.7±5.0 km^2. There was no indication that marked deer made extensive seasonal migrations. Resident deer appear to be habituated to much of the human activity on the LA/NERP and did not appear to avoid areas of high human use within their home ranges. However, the 2.6-m-high security fences did affect deer movement.

Ferenbaugh, J.K. 1999. Radionuclide Uptake by Elk and Deer and the Associated Health Risks from a Low-Level Radioactive Waste Disposal Site. Report No. LA-13622-T. Los Alamos National Laboratory. (M.S. Dissertation, University of Minnesota)

Material Disposal Area G (Area G) is the primary low-level radioactive waste disposal site at Los Alamos National Laboratory (LANL) and occupies an area adjacent to Pueblo of San Ildefonso lands. Analyses of soil and vegetation collected from the perimeter of Area G show radionuclide concentrations greater than background (BG) concentrations for northern New Mexico. Pueblo residents are concerned about ingesting contaminants from Area G by consuming ungulates that forage near Area G and then migrate on to tribal land. The uptake of ^{3}H, ^{90}Sr, ^{tot}U, ^{238}Pu, ^{239}Pu, ^{241}Am, and ^{137}Cs by Rocky Mountain elk (Cervus elaphus) and mule deer (Odocoileus hemionus) that forage near Area G and the associated dose to the animals were estimated using equations modified from the literature coded into a spreadsheet (steady-state) model. Additionally, the dose to humans who consume the meat was estimated using the RESRAD program. Radionuclide concentrations in soil and water collected from the perimeter of Area G and from BG regions averaged over a four year period were used as input data. Concentration estimates generated by the spreadsheet model correspond well to the concentration range measured in tissue samples taken from animals collected at LANL, and the maximum estimated net dose (mean + 2SD minus background) was 2.8×10^{-4} mGy d^{-1} (elk). The maximum estimated net dose to humans consuming elk meat at the most conservative ingestion rate (23 kg y^{-1}) was 4.0×10^{-4} mSv y^{-1}. All estimated worst case doses were less than guidelines established to protect the environment (1 mGy d^{-1}) and the public (1 mSv y^{-1}) from radionuclides.

Ferenbaugh, J.K., P.R. Fresquez, M.H. Ebinger, G.J. Gonzales, and P.A. Jordan. 1999. Elk and Deer Study, Material Disposal Area G, Technical Area 54: Source Document. Report No. LA-13596-MS. Los Alamos National Laboratory. 74 pp. Also abstracted at Health Physics 74(6): s28 (1998).

Material Disposal Area G is the primary low-level radioactive waste disposal site at LANL and occupies an area adjacent to the Pueblo of San Ildefonso. Analyses of soil and Vegetation collected from the perimeter of Area G have shown concentrations of radionuclides greater than background concentrations established for Northern New Mexico. As a result, Pueblo residents have become concerned that contaminants from area G could enter tribal lands through various ecological pathways. The residents specifically questioned the safety of consuming meat from elk and deer that forage near Area G and then migrate onto tribal lands. Consequently, this study addresses the uptake of radionuclides by elk and deer that forage around the perimeter of Area G

and the associated doses to the animals and to humans who consume these animals. Concentration estimates generated by the models used in the study correspond to the concentration range measured in actual tissue samples from elk and deer collected at LANL. The highest doses for both animals and humans were well below guidelines established to protect the environment and the public from radiological health risks.

Fresquez, P.R., D.A. Armstrong, and J.G. Salazar. 1994. Radionuclide Concentrations in Elk That Winter On Los Alamos National Laboratory Lands. Report No. LA-12795-MS. Los Alamos National Laboratory. 5 pp. Also In: Health Physics 68: 64.

Elk spend the winter in areas at LANL that may contain radioactivity above natural and/or worldwide fallout levels. This study was initiated to determine the levels of ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239}Pu, and total uranium in various tissues (brain, hair, heart, jawbone, kidneys, leg bone, liver, and muscle) of adult cow elk that use LANL lands during the fall/winter months. No significant differences in radionuclide contents were detected in any of the tissue samples collected from elk on LANL lands as compared with elk collected from off-site locations. The total effective (radiation) dose equivalent that a person would receive from consuming 3.2 lb of heart, 5.6 lb of liver, and 226 lb of muscle from elk that winter on LANL lands, after natural background has been subtracted, was 0.00008, 0.0001, and 0.008 mrem/yr, respectively. The highest dose was less than 0.01% of the International Commission on Radiological Protection permissible dose limit for protecting the public.

Fresquez, P.R., J.R. Biggs, K.D. Bennett, D.H. Kraig, M.A. Mullen, and J.K. Ferenbaugh. (1)1998. Radionuclide Concentrations in Deer and Elk from Los Alamos National Laboratory: 1991-1998. Report No. LA-13553-MS. Los Alamos National Laboratory. 33 pp. (2)1999. Radionuclides in Deer and Elk from Los Alamos National Laboratory and the Doses to Humans from the Ingestion of Muscle and Bone. Journal of Environmental Science and Health B34: 901-915.

Mule deer and Rocky Mountain elk forage in many areas at Los Alamos National Laboratory (LANL) that may contain radioactivity above natural and/or worldwide fallout levels. This paper and report summarize radionuclide concentrations (^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and ^{tot}U) in muscle and bone tissue of deer and elk collected from LANL lands from 1991 through 1998. Also, the committed effective dose equivalent (CEDE) and the risk of excess cancer fatalities (RECF) to people who ingest muscle and bone from deer and elk collected from LANL lands were estimated. Most radionuclide concentrations in muscle and bone from individual deer and elk collected from LANL lands were either at less than detectable quantities and/or within the upper 95% confidence level for background (BG) concentrations. As a group, most radionuclides in muscle and bone of deer and elk from LANL lands were not significantly higher than in similar tissues from deer and elk collected from BG locations. Also, elk that had been radiocollared and tracked for two years and that spent an average of 50% on LANL lands were not significantly different in most radionuclides from road kill elk that had been collected as part of the environmental surveillance program. Overall, the upper 95% confidence level net CEDEs at the most conservative ingestion rate (51 lb of muscle and 13 lb of bone) were as follows: deer muscle = 0.220, deer bone = 3.762, elk muscle = 0.117, and elk bone = 1.67 mrem/yr. All CEDEs were far below the International Commission on Radiological Protection guideline of 100 mrem/yr, and the highest muscle plus bone CEDE (4.0 mrem/yr) corresponded to a RECF of 2E-06, which is far below the EPA upper level guidance of 1E-04.

Meadows, S.D., and J. Salazar. 1982. An Investigation of Radionuclide Concentrations in Tissues of Elk Utilizing Los Alamos National Laboratory. Health Physics 43(4): 595-598.

The Los Alamos National Laboratory is responsible for monitoring the impact of its activities on the local environment, which requires the sampling of air, water, soil, flora, and fauna for chemical analysis. Vertebrates previously sampled on Laboratory lands included small mammals, birds, and mule deer. Rocky Mountain elk were first sampled in March 1980 with the inception of this study. These animals are of particular concern because they are members of a heard that is the target of an annual public hunt. Consequently, they may be considered a potential pathway of environmental contaminants to humans. Therefore, the objective of this

study was to gather baseline data on elk of the Jemez Mountains to determine if a contamination problem exists with respect to those animals that utilize Laboratory lands in winter. Radiotelemetry and analytical data are presented. The results of the study indicate that concentrations of radionuclides found in various tissues are generally not different in Jemez Mountain elk utilizing Los Alamos National Laboratory lands in winter from Jemez Mountain elk that do not. Although ^{90}Sr concentrations were higher in elk bone sampled on Laboratory lands, probably as a result of differences in fallout in the two areas, these considerations would result in a negligible dose to a human consumer of elk meat.

White, G.C. 1981. Biotelemetry Studies on Elk. Report No. LA-8529-NERP. Los Alamos National Laboratory. 24 pp.

The movements of Rocky Mountain elk in the eastern Jemez Mountains in north-central New Mexico were studied from 1978 to 1980. Thirty-six elk were trapped, marked, and released; and 30 of these animals were radio-collared. The June 1977 La Mesa fire created a wintering habitat that was used heavily by the radio-collared elk. The 10-year-old clear cuts on Cerro del Medio on the Baca Land and Cattle Company property were used for calving and nursing areas. In general, radio-collared elk used areas in an early successional state, and they did not use areas at the Los Alamos National Laboratory where there was human activity.

Wolters, G.L. 1996. Elk Effects on Bandelier National Monument Meadows and Grasslands. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 196-205.. Report No. RM-GTR-286. USDA Rocky Mountain Forest and Range Experiment Station.

This study was designed to quantify current vegetation composition and determine forage production, use, and preference by elk on a seasonal basis on two Bandelier National Monument habitat types – mesa grasslands and montane meadows. In 1993, the mesa grassland habitat, created by the 1977 La Mesa Fire, was dominated by sheep fesque and other grasses. Montane meadows were dominated by low to mid-seral introduced species such as Kentucky bluegrass, white clover, and common dandelion. Kentucky bluegrass provided over twice as much cover and total plant cover was about 40% greater on a portion of one meadow protected from grazing by elk for several years. The change in species composition and litter after a few years' protection from elk suggests that montane meadows may respond rapidly to reduced elk grazing pressure. Annual production averaged about 1600 and 1000 kg/ha on montane meadows and grassland sites, respectively. Utilization averaged about 50% on the meadows and only about 25% on the grasslands. Warm season grasses such as blue grama, little bluestem, spike muhly, and Arizona three-awn were the principal forage species consumed on grassland sites, while Kentucky bluegrass, beauty cinquefoil, and bedstraw were the most common species consumed on montane meadows.

Erosion Studies

Davenport, D.W., D.D. Breshears, B.P. Wilcox, and C.D. Allen. 1998. Viewpoint: Sustainability of Piñon-Juniper Ecosystems – A Unifying Perspective of Soil Erosion Thresholds. Journal of Range Management 51: 231-240.

This paper presents a conceptual model of soil erosion in piñon-juniper ecosystems that views soil erosion as a function of ground cover and site erosion potential, which is determined by climate, geomorphology, and soil erodibility. Much of the work involved in developing this model was based on studies conducted on the Pajarito Plateau.

Hakonson, T.E. 1999. The Effects of Pocket Gopher Burrowing on Water Balance and Erosion from Landfill Covers. Journal of Environmental Quality 28: 659-665.

This paper reports the results of a two-year field study to evaluate the impact of burrowing and soil casting by pocket gophers on runoff, soil loss, soil moisture status, and transport of surface-applied cesium 133. The presence of surface castings decreased erosion and runoff and increased infiltration. Vegetation also decreased runoff, erosion, and concomitant cesium loss. Both vegetation and gophers enhanced movement of cesium into the soil. The effects of gopher

burrowing on degradation of waste covers were minimal when vegetation was a component of the cover.

McLin, S.G. 1992. Determination of 100-year Floodplain Elevations at Los Alamos National Laboratory. Report No. LA-12195-MS. Los Alamos National Laboratory. 84 pp.

Under existing permit requirements, the US EPA stipulates that facilities regulated by RCRA must delineate all 100-yr floodplain elevations within their boundaries. At Los Alamos, these floodplains are located within ungaged watersheds that drain the Pajarito Plateau. This report documents the floodplain computational mapping procedure and, along with supporting maps, is intended to satisfy this permit requirement. About 65% of the Laboratory has 2-ft topographic contour interval coverage, while 35% has 10-ft coverage. The approach used employs a 100-yr, 6-h design storm event, but alternative floodplain elevations produced by different storm events are easily computed. In this particular application, 11 separate watersheds traverse LANL lands, with individual channels ranging up to 9 mi in length. The 100-yr floodplain was defined on each channel segment at 250-ft intervals, and detailed 1:4800-scale maps were generated.

Reid, K.D., B.P. Wilcox, D.D. Breshears, and L. MacDonald. 1999. Runoff and Erosion in a Piñon-Juniper Woodland: Influence of Vegetation Patches. Soil Science Society of America Journal 63:

In many semiarid regions, runoff and erosion differ according to vegetation patch type; i.e., runoff may be insignificant until vegetation is reduced to some threshold, below which there is no longer enough vegetation to facilitate infiltration. This paper reports the results of a study that evaluated runoff and erosion from the three patch types that comprise semiarid piñon-juniper woodlands: canopy patches (below woody plants), vegetated patches in intercanopy areas, and bare patches in intercanopy areas. Bare intercanopy patches exhibited the highest rates, followed by vegetated intercanopy patches and then by canopy patches. Large convective storms, though relatively infrequent, generated much of the runoff and most of the sediment. Prolonged frontal storms were capable of generating considerable runoff but little sediment. The results indicate that there are significant and important differences in runoff and sediment production from the three patch types; that bare intercanopy patches act as sources of both water and sediment for vegetated intercanopy patches; and that the transfer of water and sediment at small scales is both frequent enough and substantial enough to be considered ecologically significant.

White, C.S., S.R. Loftin, and S.C. Hofstad. 1999. Response of Vegetation, Soil Nitrogen, and Sediment Transport to a Prescribed Fire in Semiarid Grasslands. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 83-92. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Shrubs and trees have invaded semiarid grasslands throughout much of the Southwestern United States. This invasion has not only decreased grass cover but has also increased runoff and erosion. In fact, sediment from rangelands constitutes the single largest source of nonpoint stream pollutants within the State of New Mexico. Fire, which was a natural factor that shaped and maintained the grasslands, is a management tool that may aid in restoring and maintaining grass cover. However, fire also poses the risk of increasing erosion and further degradation because protection afforded by vegetation is reduced immediately after the fire. This study measured vegetation cover, soil inorganic nitrogen (N) levels, and erosion amounts associated with the first application of prescribed fire on two semiarid grasslands. The potential for adverse effects from these fires was great because they were performed at the beginning of a drought period. After the first growing season following the fire, grass cover returned to pre-burn levels, and both soil N and erosion amounts were similar to the unburned areas. Thus, prescribed fire for reducing shrub and tree cover may pose minimal adverse risk even under drought conditions.

White, W.D. 1996. Geomorphic Response of Six Headwater Basins Fifteen Years after the La Mesa Fire, Bandelier National Monument. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 95-113. General Technical Report No. RM-GTR-286. USDA Forest Service.

Factors important to hillside erosion immediately following La Mesa forest fire included: 1) degree of ash development; 2) amount of upslope catchment area; 3)degree of slope; and 4) type or complexity of slope. Efficiency of transport of fire-derived sediment proved to be related to the density and continuity of drainage lines. Early controls to fire related erosion proved to be needle cast from unburned crowns and climatic variability (e.g., the precipitation differences between elevations). Fifteen years following La Mesa Fire, hillside erosion was interrupted by: 1) downed, burned trees and 2) increased ground surface microtopography afforded by the aggradational building of grass pedestals and cryptogamic crusts. The increased ground surface roughness encourages infiltration from the intensely burned areas. Infiltration becomes shallow groundwater interflow that surfaces at the top margins of tributary canyons. The gathering of sediment-free runoff in the tributary and trunk canyons entrains the temporarily stored sediment derived from the mesa tops immediately following the fire. Present day sediment delivery from burned areas of the mesa tops appears to derived primarily from moderately burned basins. While the characteristic needle cast protects the moderately burned basin's ground surface from rain drop impact and channelized overland flow (rilling), the needle cast discourages the growth of cryptogamic crusts. Without the combined infiltration-encouraging factors of cryptogamic crusts and downed trees (which are fewer in moderately burned basins), precipitation in moderately burned areas generally concentrates in the drainages, and channel incision results. Storage of this sediment occurs where drainages widen, such as the mouth of the moderate burn basin on Burnt Mesa, and on the lower gradient, mesa top trunk channels.

White, W.D., and S.G. Wells. 1984. Geomorphic Effects of La Mesa Fire. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 73-90. Report No. LA-9236-NERP. Los Alamos National Laboratory.

The Rito de los Frijoles watershed, the northernmost portion of Bandelier National Monument, experienced the greatest areal extent of devegetation by La Mesa Fire. This study was initiated to assess the impact of devegetation on geomorphic processes in selected portions of the Rito de los Frijoles watershed, including hillslope erosion, channel sedimentation, and concomitant modification of the land. Assessing the impact of La Mesa Fire involved four main aspects: (1) identification of sediment-source areas, (2) determination of rates and controls of sediment production (erosion rates), (3) characterization of the adjustments of the ephemeral channels to increased sediment supply, and (4) characterization of the morphologic adjustments of the perennial master stream (Rito de los Frijoles) to increased runoff and sediment supply. This study evaluated the geomorphic processes and adjustments to devegetated conditions for a 3-year period. Thus, results discussed herein are restricted to short time periods (several years) rather than periods of tens of years. A morphometric analysis of the Frijoles Canyon watershed provided baseline information on the spatial arrangement of hillslopes and channels. The geomorphic responses of noninstrumented, devegetated watersheds developed on the volcanic plateaus surrounding the Jemez Mountains may be predicted based upon a synthesis of the field studies, morphometric analysis, and geomorphic mapping performed in this study.

Wilcox, B.P. 1994. Runoff and Erosion in Intercanopy Zones of Piñon-Juniper Woodlands. Journal of Range Management 47: 285-295.

In semiarid piñon-juniper environments, the principal mechanisms of redistribution of water, sediments, nutrients, and contaminants are runoff and erosion. This paper presents the results of a two-year study on disturbed and undisturbed plots to investigate this phenomenon. Runoff accounted for a higher percentage of the water budget than observed in most other piñon-juniper woodlands, which is perhaps attributable in part to the higher elevation of the study site. Both runoff and erosion were observed to be higher from the disturbed plots, which was more evident in the summer. The study resulted in the following hypotheses. (1) Runoff amounts vary with scale, decreasing as the size of the contributing area increases and provides more opportunities for infiltration. (2) The infiltration capacity of soils is dynamic; it is closely tied to soil moisture content and/or frost conditions and is a major determinant of runoff amounts. (3) Soil erodability follows an annual cycle; it is highest at the end of the freeze-thaw period of late winter and lowest at the end of the summer rainy season when soils have been compacted by repeated rainfall.

Wilcox, B.P., B.D. Newman, C.D. Allen, K.D. Reid, D. Brandes, J. Pitlick, and D.W. Davenport. 1996. Runoff and Erosion on the Pajarito Plateau: Observations from the Field. New Mexico Geological Society Guidebook. 47th Field Conference, Jemez Mountain Region. Pp. 433-440.

The major mechanism by which contaminants are moved and redistributed is surface runoff and associated soil erosion. This paper reports observations and measurements made at sites in ponderosa pine, stable piñon-juniper, and eroding piñon-juniper sites on the Pajarito Plateau. For the ponderosa pine site, both surface runoff (overland flow) and subsurface runoff (interflow) are important. Overland flow can be generated by intense summer rain storms, more gentle frontal storms, or snowmelt while soils are frozen. Interflow, although generated mostly by melting snow, can occur at any time of the year. For the piñon-juniper sites, the most important producer of runoff is summer thunderstorms, but at all scales snowmelt runoff can be important as well. The eroding piñon-juniper site produces more runoff that the stable piñon-juniper site and hundreds of time more erosion than either the stable piñon-juniper site or ponderosa site.

Wilcox, B.P., J. Pitlick, C.D. Allen, and D.W. Davenport. 1996. Runoff and Erosion from a Rapidly Eroding Piñon-Juniper Hillslope. In: Advances in Hillslope Processes. Volume 1. M.G. Anderson and S.M. Brooks, eds. Pp. 61-77. John Wiley and Sons Ltd.

This book chapter discusses erosional effects in piñon-juniper woodlands and presents data from an ongoing study on a rapidly eroding piñon-juniper hillside in Bandelier National Monument. The long-term objectives of the study are to (1) estimate water and sediment budgets for rapidly eroding semi-arid woodlands; (2) determine the effect of 20th century vegetation change on erosion processes; (3) develop a conceptual and quantitative understanding of the relationships between runoff and erosion; and (4) determine what effect scale has on runoff and erosion in rapidly eroding semi-arid woodlands.

Fenton Hill

Becker, N.M., W.D. Purtymun, and W.C. Ballance. 1981. Aquifer Evaluation at Fenton Hill, October and November 1980. Report No. LA-8964-MS. Los Alamos National Laboratory. 15 pp.

An aquifer test at the Fenton Hill Geothermal Site was performed on a volcanic aquifer used for water supply. The test was made to determine the yield from the aquifer and to predict the amount of depletion that would occur with increased production during the period 1981-1985. A step-discharge test indicated that the aquifer would comfortably yield 100 gal per min (gpm) without excessive water level drawdown in the pumping well. Drawdown test results indicated that the average aquifer transmissivity and storage coefficient are 5000 gal per day per foot (gpd/ft) and 0.07, respectively. Using these parameters, a drawdown was estimated to be at least 42 ft at the pumping well due to a withdrawal of 500 acre-ft of water over 5 yr. However, the presence of ground water boundaries indicates that the aquifer is of limited extent; and, because of this, the water level decline would probably be much greater. Past water level data indicate that there is little recharge to the aquifer and that the ground water is being depleted

Miera, F.R. Jr., G. Langhorst, S. McEllin, and C. Montoya. 1984. Environmental Studies Conducted at the Fenton Hill Hot Dry Rock Geothermal Development Site. Report No. LA-9967-MS. Los Alamos National Laboratory. 19 pp.

An environmental investigation of Hot Dry Rock (HDR) geothermal development was conducted at Fenton Hill, New Mexico, during 1976-1979. The objective of the environmental program was to evaluate the potential environmental impediments for HDR technologies simultaneously with the development of the energy resource. Activities at the Fenton Hill Site included an evaluation of baseline data for biotic and abiotic ecosystem components. Identification of contaminants produced by HDR processes that had the potential for reaching the surrounding environment is also discusses. This report presents findings for the interim 1976-1979. Three dominant vegetative communities were identified in the vicinity of the site. These included grass-forb, aspen, and mixed conifer communities. The grass-forb area was identified as having the highest number of species encountered, with Phleum pratense *and* Dactylis glomerata *being the dominant grass species. Frequency of occurrence and mean coverage values also are given for other species in the three main vegetative complexes. Live trapping of*

small mammals was conducted to determine species composition, densities, population, and diversity estimates for this component of the ecosystem. The data indicate that Peromyscus maniculatus *was the dominant species across all trapping sites during the study. Comparisons of relative density of small mammals among the various trapping sites show the grass-forb vegetative community to have had the highest overall density. Comparisons of small mammal diversity for the three main vegetative complexes indicate that the aspen habitat had the highest diversity and the grass-forb habitat had the lowest. The effluent receiving canyon study area, a mixture of vegetative types, had the highest overall diversity. Additionally, meteorological data for the four year period at the site are summarized and presented. Analyses of waste waters from the closed circulation loop indicate that several trace contaminants (e.g.: arsenic, cadmium, boron, fluoride, and lithium) were present at concentrations greater than those reported for surface waters of the region. However, these values were generally within the range of concentrations reported for these elements from thermal springs in the area.*

Purtymun, W.D., W.H. Adams, and J.W. Owens. 1975. Water Quality in Vicinity of Fenton Hill Site, 1974. Report No. LA-6093. Los Alamos Scientific Laboratory. 16 pp.

The water quality at nine surface water stations, eight ground water stations, and the drilling operations at the Fenton Hill Site have been studied as a measure of the environmental impact of the Los Alamos Scientific Laboratory geothermal experimental studies in the Jemez Mountains. Surface water quality in the Jemez River drainage area is affected by the quality of the inflow from thermal and mineral springs. Ground water discharges from the Cenozoic Volcanics are similar in chemical quality. Water in the main zone of saturation penetrated by test hole GT-2 is highly mineralized, whereas water in the lower section of the hole, which is in granite, contains a higher concentration of uranium.

Purtymun, W.D., W.H. Adams, and A.K. Stoker. 1978. Water Quality in the Vicinity of Fenton Hill Site, 1976. Report No. LA-7307-MS. Los Alamos Scientific Laboratory. 17 pp.

Water quality data have been collected at nine surface-water stations, eleven ground-water stations, and three ponds at the Fenton Hill Geothermal Site in the Jemez Mountains. Insignificant changes (within expected normal seasonal fluctuations) in the chemical quality of water at individual stations were observed during the year. Predominant ions and total dissolved solids remained essentially stable.

Purtymun, W.D., W.H. Adams, A.K. Stoker, and F.G. West. 1976. Water Quality in Vicinity of Fenton Hill Site, 1975. Report No. LA-6511-MS. Los Alamos Scientific Laboratory. 21 pp.

Water quality at nine surface water stations, 14 ground water stations, and drilling and testing operations at the Fenton Hill Site has been studies as a measure of the environmental impact on the Los Alamos Scientific Laboratory's geothermal site in the Jemez Mountains. Slight variations in the chemical quality of the water at individual stations were observed during the year. Predominant ions and total dissolved solids in the surface and ground water declined slightly in comparison to previous data. These variations in quality are not considered significant considering seasonal and annual stream flow variations. Surface water discharge records from three U.S. Geological Survey gaging stations on the Rio Guadalupe and Jemez River were analyzed to provide background data for the impact study. Direct correlations were determined between mean annual discharge at each of two stations in the upper reach of the drainage and at the station in the lower reach.

Purtymun, W.D., R.W. Ferenbaugh, and W.H. Adams. 1981. Water Quality in the Vicinity of Fenton Hill, 1980. Report No. LA-9007-PR. Los Alamos National Laboratory. 16 pp.

Water quality data have been collected from established surface and ground water stations and from ponds and pond discharges at the Fenton Hill Site located in the Jemez Mountains. Most of these stations were established in 1973 with water quality data having been collected since that time. There have been slight variations in the chemical quality of water from the surface and ground water locations; however, there variations are within normal seasonal fluctuations. Water in the ponds used for storage at the site is highly mineralized because of drilling operations or discharge from circulation tests in the fractured reservoir of the deep

geothermal holes. Water from the ponds or direct discharges from the circulation tests are discharged into an adjacent dry canyon. The discharge infiltrates into the alluvium of the canyon within 400 m of the ponds. Monitoring of surface and spring discharge downgradient from the ponds failed to detect any effects resulting from release of water from the ponds. Analyses of water from the supply well at the site indicated that the chemical concentrations were below U.S. Environmental Protection Agency and State of New Mexico standards or criteria for domestic or municipal uses.

Purtymun, W.D., R.W. Ferenbaugh, N.M. Becker, W.H. Adams, and M.N. Maes. 1983. Water Quality in the Vicinity of Fenton Hill, 1981 and 1982. Report No. LA-9854-PR. Los Alamos National Laboratory. 30 pp.

As part of a continuing program of environmental studies, water quality data have been collected from established surface and ground water stations and from ponds and pond discharges at Fenton Hill Site located in the Jemez Mountains. Most of these stations were established in 1973, and water quality data have been collected since that time. There have been slight variations in the chemical quality of water from the surface and ground water locations; however, these variations are within normal seasonal fluctuations. The discharge from the ponds at Fenton Hill infiltrates into canyon alluvium within 400 m of the site. Monitoring surface and spring discharges downgradient from the ponds failed to detect any effects resulting from water released from the ponds. Total dissolved solids and calcium have increased in water from well FH-1, which furnishes the water supply for the site. This increase is caused by the decreasing water level in the well resulting in yield from beds with a slightly different quality than has been found in previous years. Data also are presented on chemical analysis of vegetation and soils from the channel bottom and canyon bank into which pond effluent discharges. These data show accumulation trends for certain minerals found the discharge effluent.

Purtymun, W.D., R.W. Ferenbaugh, N.M. Becker, M.C. Williams, and M. Maes. 1987. Water Quality in the Vicinity of Fenton Hill, 1983 and 1984. Report No. LA-10892-PR. Los Alamos National Laboratory. 37 pp.

Water quality data have been collected since 1974 from established surface and groundwater stations at and in the vicinity of Fenton Hill (Hot Dry Rock Geothermal Demonstration Site) located in the Jemez Mountains. There has been a slight variation in chemical quality of water from the surface and groundwater stations; however, these variations are within normal seasonal fluctuations. Water supply at the site is pumped from the aquifer in the Abiquiu Tuff. Cumulative production from 1976 through 1984 has been 41.5×10^6 gal. The water level in the supply well declined from 365 ft in 1976 to 379 ft in 1984. Soil and vegetation analyses from the canyon below the retention ponds indicate that previously detected accumulation of minerals from the pond discharges may be dissipating since the discharges from the ponds have ceased.

Purtymun, W.D., R.W. Ferenbaugh, M.N. Maes, and M.C. Williams. 1991. Water Quality in the Vicinity of Fenton Hill, 1987 and 1988. Report No. LA-12030-PR. Los Alamos National Laboratory. 33 pp.

Water quality data have been collected since 1974 from established surface- and ground-water stations at and in the vicinity of Fenton Hill (site of the Laboratory's Hot Dry Rock Geothermal Project). The site is located on the southwest edge of the Valles Caldera in the Jemez Mountains. To determine the chemical quality of water, data were collected in 1987 and 1988 from thirteen surface-water stations and nineteen ground-water stations. The classification of the water quality is made on the basis of predominant ions and total dissolved solids. There are four classifications of surface-water (sodium and chloride, calcium and bicarbonate, calcium and sulfate, and sodium and bicarbonate) and three classifications of ground-water (sodium and chloride, calcium and bicarbonate, and sodium and bicarbonate). Variations in the chemical quality of the surface- and ground-water in 1987 and 1988 are apparent when data are compared with each other and with previous analyses. These variations are not considered to be significant, as they are within the range of normal seasonal variation. Cumulative production since 1976 from the supply well at Fenton Hill has been about 63×10^6 gal., with a decline in the water level of the well of about 14 ft, or about 1.4 ft/yr. The aquifer penetrated by the well still is

capable of reliable supply to the site for a number of years, based on past production. The quality of water from the well has deteriorated slightly; however, the water quality is in compliance with drinking water standards. The effects of discharges from the storage ponds into an adjacent canyon have been monitored by trace metal analyses of vegetation and soil. The study indicates minimal effects, which will be undetectable in a few years if there are no further releases of effluents into the canyon.

Purtymun, W.D., R.W. Ferenbaugh, A.K. Stoker, and W.H. Adams. 1980. Water Quality in the Vicinity of Fenton Hill, 1979. Report No. LA-8424-PR. Los Alamos Scientific Laboratory. 21 pp.

Water quality data have been collected from established surface and ground water stations and from ponds and point discharges at the Fenton Hill Site located in the Jemez Mountains. There have been slight variations in the chemical quality of water from surface and ground water locations; however, these variations are within normal seasonal fluctuations. Water in the ponds is highly mineralized because of drilling operations and circulation tests at the site. Water quality in the ponds deteriorates further as it is reused. Most notable increases were in sulfates and total dissolved solids (TDS) in 1979. Discharge and overflow from the ponds infiltrates into the alluvium of the dry canyon within 300 m below the ponds. Monitoring of surface water and spring discharge downgradient from the ponds in the release area failed to detect any effects from release of water from the ponds. Analyses of water from the supply well at the site indicated that metallic and nonmetallic ions were below the U.S. Environmental Protection Agency and State of New Mexico standards or criteria for domestic or municipal uses.

Purtymun, W.D., R.W. Ferenbaugh, A.K. Stoker, W.H. Adams, and J.W. Owens. 1980. Water Quality in the Vicinity of Fenton Hill Site, 1978. Report No. LA-8217-PR. Los Alamos Scientific Laboratory. 21 pp.

Water quality data have been collected from surface and ground water stations and from ponds at the Fenton Hill Site located in the Jemez Mountains. There have been slight variations in the chemical quality at individual stations; however, these variations in water quality are within normal seasonal fluctuations. Evaluation of the aquifer furnishing water to the Fenton Hill Site indicates a transmissivity of about 1200 m^2/day. The specific capacity over a five day test was 28 l/s/m of drawdown. There was a slight increase in total dissolved solids in the well water between 1977 and 1978. Water quality and soluble fluoride and chloride in sediments in the canyon that receives excess water from the ponds indicate that these constituents decrease to background within 300 m of the ponds. A water balance of amount produced at the site indicates 7% of the water lost to evaporation from the ponds, 31% lost by infiltration into tuff beneath the ponds, 21% of the water discharged from the ponds, and 41% used for downhole experiments, drilling operations, and general site use.

Purtymun, W.D., R.W. Ferenbaugh, M.C. Williams, and M.N. Maes. 1988. Water Quality in the Vicinity of Fenton Hill, 1985 and 1986. Report No. LA-11210-PR. 36 pp.

Water quality data have been collected since 1974 from established surface and groundwater stations at and in the vicinity of Fenton Hill (Hot Dry Rock Geothermal Demonstration Site) located in the Jemez Mountains. Data on chemical quality of water were determined for samples collected from 13 surface water and 19 groundwater stations in 1985 and 1986. There were slight variations in the chemical quality of the ground and surface water in 1985 and 1986 as compared with previous analyses; however, these variations are within normal seasonal fluctuations. Chemical uptake in soil, roots, and foliage is monitored in the canyon that receives intermittent effluent release of water from tests in the geothermal circulation loop and occasional fluids from drilling operations. The chemical concentrations found in soil, roots, and vegetation as the result of effluent release have shown a decrease in concentration down-canyon and also have decreased in concentration with time since the larger releases that took place in the late 1970s and early 1980s.

Purtymun, W.D., A.K. Stoker, W.H. Adams, and J.W. Owens. 1978. Water Quality in the Vicinity of Fenton Hill Site, 1977. Report No. LA-7468-PR. Los Alamos Scientific Laboratory. 16 pp.

Water quality data have been collected from nine surface water stations, eleven ground water stations, and three ponds at the Fenton Hill Site, located in the Jemez Mountains. There have been slight variations in chemical quality at individual stations during the year; however, these variations in water quality are within expected normal seasonal fluctuations and are not considered significant. In addition to the fourteen routine chemical analyses performed twice annually, seventeen trace metal analyses were run on one set of samples collected during the year.

Purtymun, W.D., F.G. West, and W.H. Adams. 1974. Preliminary Study of the Quality of Water in the Drainage Area of the Jemez River and Rio Guadalupe. Report No. LA-5595-MS. Los Alamos Scientific Laboratory. 26 pp.

A preliminary study of the quality of surface and ground water was made in the area of a proposed geothermal test hole and experiment by Los Alamos Scientific Laboratory. The study was made to establish background data prior to the geothermal experiment by the Laboratory. The data compiled prior to 1971 were taken from a literature search, while data from 1971-1973 were collected from field surveys. Analyses are reported from 17 surface water stations, 15 mineral and thermal springs, and 53 ground water stations (wells, test holes, and springs). A general description of sampling stations is presented with a brief description of the chemical quality of the water based on concentrations of dissolved solids. Additional water quality data will be collected prior to, during, and after the experiment.

Purtymun, W.D., F.G. West, and R.A. Pettitt. 1974. Geology of Geothermal Test Hole GT-2, Fenton Hill Site, July 1974. Report No. LA-5780-MS. Los Alamos Scientific Laboratory. 15 pp.

The test hole GT-2, drilled at the Fenton Hill Site, was completed at a depth of 6346 ft (1934.3 m) below land surface. The hole penetrated 450 ft (137.2 m) of Cenozoic volcanics, 1945 ft (592.8 m) of sediments of Permian and Pennsylvanian age, and 3951 ft (1204.3 m) of granitic rocks of Precambrian age. This report presents the field geologic log of the hole and hydrologic data compiled during the drilling phase of the program.

Fungi

Balice, R.G., N. Jarmie, and F.J. Rogers. 1997. Distribution and Diversity of Fungal Species in and Adjacent to the Los Alamos National Laboratory. Report No. LA-13385-MS. Los Alamos National Laboratory. 45 pp.

Previously archived information representing 43 sample locations was used to perform a preliminary evaluation of the distribution and diversity of fungal species at the Los Alamos National Laboratory and in adjacent environments. Presence-absence data for 71 species of fungi in five habitats were analyzed. The results indicate that, even though fungi occur in each of the habitats, fungal species are not evenly distributed. The richness of fungal species is greater in the canyon-bottom mixed conifer and mixed conifer habitats than in the piñon-juniper, canyon-bottom ponderosa pine, or ponderosa pine habitats.

Caplan, T.R., H.A. Pratt, and S.R. Loftin. 1999. Influence of Mycorrhizal Source and Seedling Methods on Native Grass Species Grown in Soils from a Disturbed Site. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 170-174. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Mycorrhizal fungi are crucial elements in native plant communities, and restoring these fungi to disturbed sites is known to improve revegetation success. The seedball method of plant dispersal for restoration of plants and mycorrhizal fungi to disturbed ecosystems was tested. The seedball method was tested with a native mycorrhizal fungi inoculum and a commercial inoculum. Neither the native culture nor the commercial inoculum was a viable source of mycorrhizae. In spite of the complications encountered in this experiment, seedballs are still believed to be an excellent method of seed dispersal for restoration projects. Incorporating root segments of the native culture host plants containing hyphae into the seedballs may accomplish both goals of restoring not only the seeds of native plants, but also the native arbuscular mycorrhizal fungi that have been removed from a disturbed area.

Jarmie, N., and F.J. Rogers. 1996. A Survey of Macromycete Diversity in Bandelier National Monument, 1991-1993. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 149-160. General Technical Report No. RM-GTR-286. USDA Forest Service.

This paper reports the progress of an ongoing project to develop an initial inventory of the fungi of the Bandelier area and describes their relationships with vascular plants and fire ecology. The goal of this ongoing survey has been to collect and identify (at least to genus) as many macroscopic fungi species as possible and thereby inventory the diversity of such fungi in Bandelier National Monument and adjoining Los Alamos County. The survey covered the three summer seasons of 1991-1993, during which 836 species were collected from a variety of habitats. These were identified to the extent possible, recorded in a computer database, dried, and stored in an herbarium. There were 228 species in 118 genera. About 95% of the specimens were identified to genus and 81% to species. In Bandelier alone, 145 specimens were collected in 1991-1992 and 270 specimens in 1993, representing at least 75 genera and 93 species. All three basic types of fungi were found: parasitic, saprophytic (feeding on dead wood and litter), and Mycorrhizal (in a beneficial symbiosis with a plant). A variety of sites were studied, with special attention to sites at Bandelier that have burned in recent years or are planned for burning soon. The fruitings varied widely (and wildly), making correlation with site location, burns, and other parameters difficult or impossible. The only distinct correlation was with precipitation (and thus elevation). Future needs and possible studies are discussed.

Jarmie, N., and F.J. Rogers. 1997. A Survey of Macromycete Diversity at Los Alamos National Laboratory, Bandelier National Monument, and Los Alamos County. A Preliminary Report. Report No. LA-13384-MS. Los Alamos National Laboratory. 90 pp.

A five-year survey of macromycetes found in Los Alamos County, Los Alamos National Laboratory, and Bandelier National Monument has resulted in a database of 1048 collections, their characteristics, and identifications. The database represents 123 genera and 175 species reliably identified. Issues of habitat loss, species extinction, and ecological relationships are addressed, and comparisons with other surveys are made.

GIS and Telemetry

Balice, R.G., S.G. Ferran, and T.S. Foxx. 1997. Preliminary Vegetation and Land Cover Classification for the Los Alamos Region. Report No. LA-UR-97-4627. Los Alamos National Laboratory. 52 pp.

The major vegetation and Land Cover types in the Los Alamos Region were classified into Level I and Level II cover types. Level I classes reflect major physiognomic and floristic groupings, and Level II classes are based on the dominant or codominant species and the characteristics of the physical environment. The implications of these land cover classes to management of vegetation and wildlife are discussed where appropriate.

Bennett, K. 1995. Use of Geographic Positioning System and Geographic Information System in an Ecological Risk Study. In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 271-275. Report No. LA-13065-MS. Los Alamos National Laboratory.

A global positioning system was used to obtain coordinate data for all of the study plots used in Guaje and Los Alamos Canyons. These coordinates were transferred to an Arc/Info Geographic Information System, and maps of the locations were generated. Attribute data collected during the studies will be linked to the spatial data of the plots for further analysis.

Bennett, K.D., J. Biggs, and P.R. Fresquez. 1997. Determination of Locational Error Associated with Global Positioning System (GPS) Radio Collars in Relation to Vegetation and Topography in North-Central New Mexico. Report No. LA-13252-MS. Los Alamos National Laboratory. 14 pp.

In 1996, a study was initiated to assess seasonal habitat use and movement patterns of Rocky Mountain elk using global positioning system (GPS) radio collars. As part of the study, an

attempt was made to assess the accuracies of GPS (non-differentially corrected) positions under various vegetation canopies and terrain conditions with the use of a "test" collar. The test collar was placed on a stand equivalent to the neck height of an adult elk and placed within three different treatment categories: (1) topographical influence (canyon and mesa tops), (2) canopy influence (open and closed canopy), and (3) vegetation type influence (ponderosa pine and piñon pine juniper). The collar was kept at each location for one hour and was activated every 20 minutes to obtain a position location via a continuous uplink to Argos satellites to transfer position data files. A hand-held GPS unit was also used to obtain a position of the test collar at the same time and location. The hand held unit was differentially corrected, and previous tests had indicated that its accuracy was within 2 meters of an actual position. There were no statistical differences between either ponderosa pine and piñon pine-juniper vegetation types, open and closed canopies, or canyons and mesa tops.

Bennett, K.D., T.E. Garrison, M.E. Salisbury, and S.W. Koch. 1996. Threatened and Endangered Species Plan, GIS Phase. Report No. LA-UR-96-3527. Los Alamos National Laboratory. 77 pp.

This report documents the development of a Geographical Information System (GIS) data base for the Threatened and Endangered Species Habitat Management Plan. The data base will be used to store both spatial and tabular ecological data and will be available for use as a screening tool in the performance of assessments for new projects.

Biggs, J., K. Bennett, and P.R. Fresquez. 1997. Evaluation of Habitat Use by Rocky Mountain Elk (*Cervus elaphus nelsoni*) in North-Central New Mexico using Global Positioning System (GPS) Radio Collars. Report No. LA-13279-MS. Los Alamos National Laboratory. 18 pp.

Global Positioning System (GPS) radio collars were used to determine habitat use on the LANL preserve. Locations and types of habitat occupied were documented with frequency of use of various habitat types. Results were compared to previous studies to document changes in utilization patterns. Based on habitat use and availability analysis, use of grass/shrub and piñon/juniper habitats was generally higher than expected during most seasons, and use of forested habitats (ponderosa pine, mixed conifer) was lower than expected. Most of the collared elk remained on LANL property year-round. The application of GPS collars to elk studies in north-central New Mexico appears to be a more efficient and effective method than use of VHF radio collars.

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1998. Estimation of Observation Rates of Global Positioning Collars Deployed on Elk. Report No. LA-UR-98-1080. Los Alamos National Laboratory.

A comparison was made of the ability of global positioning system (GPS) radio collars deployed on elk to obtain valid positions (position acquisition rate – PAR) in seasonal home ranges with differing vegetation and topographical characteristics. GPS collar PARs also were compared under varying levels of cloud cover and between differing daily time periods. A mean PAR of 69% was recorded for collared elk. Multiple regression analysis of seasonal home range characteristics indicated that vegetation cover type and slope, either as individual variables or in combination with one another, were not significant predictors of GPS collar PARs. Statistical differences in position acquisition rates between cloud cover classes or varying cloud base heights were not observed. The PAR was significantly higher between 1600-2000 h (mountain standard time) compared to 0000-1200 h, which may have been due to elk behavior. We believe that the use of GPS collars is a more effective and efficient method of tracking elk in our study area compared to very high frequency (VHF) collars, as GPS collars can be programmed to obtain fixes automatically, have fewer logistical problems, and are more economical with long-term data collection efforts.

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1998. Movements and Activity Patterns of Rocky Mountain Elk at the Los Alamos National Laboratory. LA-UR-98-4535. Presentation at the Third Symposium of Biological Research in the Jemez Mountains. November 6, 1998. Santa Fe.

From 1996 to 1998, the Ecology Group evaluated daily/seasonal movements and activity patterns of elk on and near Los Alamos National Laboratory (LANL) property by plotting global positioning system (GPS) locational fixes of collared elk onto geographic information system (GIS) coverages of topography and physical structures (i.e., security fences, roads, buildings), resulting in the identification of 6-8 primary elk-traveled corridors on LANL property. Travel corridors in the east portion of LANL are dictated by security fences and other structures, and there are two areas where corridors pass between LANL property and San Ildefonso Pueblo property. The primary travel corridor for collared animals moving west off LANL property is near Pajarito Mountain, which extends off the west-central portion of the Laboratory. The daily use of different land-cover types and terrain were evaluated seasonally by comparing data from six 4-h periods to one another: 0000-0400, 0400-0800, 0800-1200, 1200-1600, 1600-2000, and 2000-2400. Elk were found to utilize piñon-juniper significantly more frequently than all other cover types between the hours of 0400-1200. Through the 2000-h period, they utilized piñon-juniper significantly more frequently more frequently than all other cover types except ponderosa pine. In general, the use of piñon-juniper increased during daylight hours and decreased during evening hours. Conversely, the use of grasslands decreased during daylight hours and increased during evening hours. The data showed that the elk utilized the northwest and west-facing slopes significantly less than almost all other slopes. Significant differences also were observed between northwest and west-facing slopes versus south-facing and east-facing slopes during the spring. Use of 0%-5% slopes was significantly greater than all other slope classes between the evening and early morning hours of 1600-0400 and significantly greater than slopes above 10% for all hourly subperiods except 0800-1200. During spring, use of 0%-5% slopes decreased during midday hours (0800-1600) and increased during evening and early morning hours (1600-0800). Animals increased their proportion of use on steeper slopes during most subperiods during the summer. By understanding more about movement and activity patterns of elk on LANL property, management strategies to reduce adverse impacts caused by elk (i.e., automobile accidents, overuse of sensitive habitats) can be developed while minimizing the impact of the strategies on elk movement patterns to off-site locations.

Biggs, J.R., K.D.. Bennett, P.R. Fresquez, and R.J. Robinson, 1996. Movements, Disease Analysis, and Tritium Concentrations of Rocky Mountain Elk of the Pajarito Plateau. LA-UR-96-3395. Presentation at the Symposium of Biological Research in the Jemez Mountains, New Mexico. October 26, 1996.

Seasonal movement patterns of four elk (3 cows/1 bull) and one deer fitted with VHF (very high frequency) units were investigated from spring 1995 to spring 1996. Results also are presented on disease analysis of six elk captured in 1996, as well as tritium analysis of all animals (n=11). The deer remained within three miles of its original capture location (n=39 fixes) throughout the study period. The bull elk remained on the Pajarito Plateau in winter and spring, then migrated to the Valle Grande during late spring and summer (n=49 fixes). One of the three cows died within 6 weeks of collaring, apparently following calving, near the north edge of Bandelier National Monument. The surviving cow elk remained on the east slope of the Jemez Mountains and the Pajarito Plateau during winter and early spring, then moved to the Valle Grande during calving and summer months (n=93 fixes). Based on radiotelemetry data, herds occurring in the southern portion of the Laboratory appear to migrate and calve along the eastern portion of the Valle Grande. Four of the six elk captured in 1996 had moderate to high titers for vesicular stomatitis, and one elk had a moderate titer for toxoplasmosis. One cow elk, sampled near Pajarito Road, and one male deer, sampled at TA-49, exhibited concentrations of tritium (2.2 and 1.1 pCi/ml, respectively) above the upper background limit of 0.9 pCi/ml.

Biggs, J.R., K.D.. Bennett, P.R. Fresquez, and R.J. Robinson, 1999. Resource Use, Activity Patterns, and Disease Analysis of Rocky Mountain Elk (*Cervus elaphus nelsoni*) at the Los Alamos National Laboratory. Report No. LA-13536-MS. Los Alamos National Laboratory. 83 pp.

To form the basis for the development of management strategies for elk and other large herbivores, understanding how, when, where, and why animals move with respect to the landscape and availability of essential habitats (i.e., foraging, watering) is essential. From 1996 to 1998, daily/seasonal movements, habitat use, and activity patterns of elk on and near Los

Alamos National Laboratory (LANL) were evaluated through the use of global positioning system collars and a geographic information system. Primary travel corridors on and immediately adjacent to LANL property and identified travel routes for collared animals moving west off LANL property in the vicinity of Pajarito Mountain were identified. Daily use of different land cover types and terrain was evaluated seasonally by comparing six four-hour periods to one another. There were significantly more locational fixes of elk in piñon/juniper compared to all other cover types during the hours of 0400-1200, and significantly more than all other cover types except ponderosa pine through the 2000 hour period. In general, use of piñon/juniper increased during daylight hours and decreased during evening hours. Use of grasslands decreased during day hours while increasing during evening hours. Generally, northeast slopes were used greater than expected and west and northwest slopes less than expected. There were significantly greater fixes on 0^{o}-5^{o} slopes compared to all other slope classes between the evening and early morning hours of 1600-0400 and significantly greater than slopes above 10^{o} for all hourly subperiods except 0800-1200. During spring, use of 0^{o}-5^{o} slopes decreased during midday hours while increasing during evening and early morning hours, and animals tended to increase their proportion of use on steeper slopes during most subperiods during summer. Diseases of animals through blood analysis drawn from all collared elk also was examined. Vesicular stomatitis was the most commonly observed disease among tested elk. By understanding movement and activity patterns of elk on LANL property, management strategies can be developed and applied to reduce adverse impacts (i.e., automobile accidents, overuse of sensitive habitats) associated with this species.

Bogan, M.A., T.J. O'Shea, P.M. Cryan, A.M. Ditto, W.H. Schaedla, and L. Ellison. 1996. Status and Trends of Bat Populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico. Report No. LA-UR-96-3528. Los Alamos National Laboratory. 91 pp.

The goal of this study was to assess the current status of bats , elucidate distribution and relative abundance, and obtain information on sites used as roosting sites. Data are reported from two years of study, during which 15 species of bats were observed. Netting sites were located in a variety of habitats from piñon-juniper through mixed coniferous forest. Most of the most abundant species are typical of ponderosa pine-mixed coniferous forests. Males outnumber females for most species. Reasons for the observed distribution of sexes are unknown, but climatic and elevational influences or sites chosen for netting may be involved. In 1996, radiotracking studies were initiated in which selected bats were equipped with miniaturized radios and followed to roosts.

Bogan, M.A., T.J. O'Shea, E.W. Valdez, A.M. Ditto, and K.T. Castle. 1998. Continued Studies of Bat Species of Concern in the Jemez Mountains, New Mexico. Report No. LA-UR-98-5691. 29 pp.

In 1995,a three-year study was initiated to assess the current status of bat species of concern, elucidate distribution and relative abundance, and obtain information on roosting sites. In 1998, finding was provided for an additional year to obtain more information on bat species of concern, especially the spotted bat and the big free-tailed bat. During 1998, 328 bats of 15 species were captured and released. The most abundant species were typical inhabitants of ponderosa pine-mixed coniferous forests, where most of the study sites were located. As previously noted, captured males outnumber captured females for many species. In only one species were both sexes captured in equal numbers. Exact reasons for the observed distribution of sexes are unknown; but weather, elevation, migration, gender-specific roosting requirements, and sites chosen for netting are likely explanations. Eight bat species of concern were netted, with four of these being captured frequently. In 1998, smaller numbers of the other four species of concern were captured, and there is reliable knowledge of moderate- to large-size roosting aggregations of two of these. Moderately high levels of activity of the spotted bat were recorded along cliffs in Los Alamos Canyon at LANL, and both the spotted bat and the big free-tailed bat continued to use roosts that were located in 1997. Numbers of big free-tailed bats counted at roosts varied over the course of the summer in 1998, which suggests that this species may have been using alternative roosting sites elsewhere. The 1998 capture of only a single individual of

Corynorhinus townsendii *and similar low capture frequencies in previous years suggest that this bat is truly a species of concern for the Jemez Mountains region. In 1998, radio-transmitters also were attached to five bats of three species (the spotted bat, the big free-tailed bat, and* C. townsendii*), three of which were tracked to diurnal roosts. One female spotted bat was tracked to a roost on a cliff face, near a big free-tailed bat roost, but the male was not found. The single male* C. townsendii *was located in a cavity in a large boulder, near where the bat was captured. One of two tagged lactating big free-tailed bats returned to a roost originally located in 1997; the other individual was not found. The 1998 work helped to refine understanding of bat distributions in the Jemez Mountains, provided important information on site and roost fidelity for spotted and big free-tailed bats, and enhanced the amount of available baseline information on status and trends of eight bat species of concern in the area.*

Eberhardt, L.E., and G.C. White. 1979. Movements of Mule Deer on the Los Alamos National Environmental Research Park. Report No. LA-7742. Los Alamos National Laboratory. 29 pp.

The movements of mule deer on the Los Alamos National Environmental Research Park (LA/NERP) in north-central New Mexico were studied during 1975-1978. A total of 36 deer were live-trapped, marked, and released; 24 of these were equipped with visual markings including ear tags, ear streamers, and neck collars, and 11 were fitted with radio transmitters. Disturbance caused by trapping may have caused some unusual movements. Deer home ranges appear to be elongated in shape, possibly because the deer tend to move parallel to the steep canyon-mesa systems and along the elevational gradient. The average home range size for six deer radiotracked for 18-20 months was 13.7±5.0 km^2. There was no indication that marked deer made extensive seasonal migrations. Resident deer appear to be habituated to much of the human activity on the LA/NERP and did not appear to avoid areas of high human use within their home ranges. However, the 2.6-m-high security fences did affect deer movement.

Haarmann, T., and T. Haagenstad. 1999. Quantitative Habitat Evaluation of the Conveyance and Transfer Project. LA-UR-99-4215. Los Alamos National Laboratory. 28 pp.

The transfer of federally controlled, ecologically sensitive land has become the focus of recent controversy. Assessment of the potential impact of transferring such lands and the associated natural resources has become increasingly important. As part of natural resource planning for the Conveyance and Transport Project, a quantitative field evaluation was conducted to assess and rank various habitats in or near the proposed transfer tracts. This report describes the quantitative habitat evaluation approach that was used for the Conveyance and Transfer Project, which is a method that was developed by The Nature Conservancy. In this approach, both GIS-based landscape analysis and results of field studies are used to develop plant community element occurrence quality ranks, which are then averaged to obtain a site quality rank. The details of this process are described in the report. The results of the study indicate that the overall habitat rankings of the proposed C&T tracts do not differ from the habitat rankings of the canyons in which they are located. Therefore, it is likely that the transfer of these tracts would not result in a decrease in the overall habitat rankings of the canyons.

Muldavin, E., and S. Yanoff. 1999. Ecology-Based Biodiversity Evaluation for Los Alamos National Laboratory. An Integrated GIS Spatial Analysis and Field Assessment Approach. Report No. LA-UR-99-5593. Los Alamos National Laboratory. 76 pp.

This report describes an ecology-based biodiversity assessment protocol that was developed by the New Mexico Heritage Program at the University of New Mexico to support the Los Alamos National Laboratory Threatened and Endangered Species Habitat Management Plan and for general long-term biological resources management. It relies on a combination of field assessments and GIS spatial analysis. The details of the protocol are presented and discussed in the report.

Trippe, L., and T.K. Haarmann. 1996. Evaluation of the Use of Satellite Imagery as a Tool to Predict Habitat of the Jemez Mountains Salamander, *Plethodon neomexicanus*. Report No. LA-UR-96-3392. Los Alamos National Laboratory. 12 pp.

A study to determine the accuracy and feasibility of using satellite imagery technology to locate or predict specific habitat, using the Jemez Mountains salamander as a model species, was conducted. Satellite imagery maps, based solely on a small suite of physical characteristics (e.g.: elevation, vegetation, gradient), did not appear to be successful in predicting salamander habitat. Inclusion of additional habitat features would be required to strengthen the predictive power of the map. However, satellite imagery could be used as an initial screening process to determine potential habitat.

White, G.C. 1981. Biotelemetry Studies on Elk. Report No. LA-8529-NERP. Los Alamos National Laboratory. 24 pp.

The movements of Rocky Mountain elk in the eastern Jemez Mountains in north-central New Mexico were studied from 1978 to 1980. Thirty-six elk were trapped, marked, and released; and 30 of these animals were radio-collared. The June 1977 La Mesa fire created a wintering habitat that was used heavily by the radio-collared elk. The 10-year-old clear cuts on Cerro del Medio on the Baca Land and Cattle Company property were used for calving and nursing areas. In general, radio-collared elk used areas in an early successional state, and they did not use areas at the Los Alamos National Laboratory where there was human activity.

Habitat Evaluation and Use

Barnes, F.J. 1983. Habitat Types in Piñon-Juniper Woodland on the Pajarito Plateau and Range Conditions in Bandelier National Monument. Final Report to the Southwest Region of the National Park Service. 64 pp.

Fifty piñon-juniper sites in Los Alamos County and Bandelier National Monument were evaluated using the Daubenmire habitat typing approach. Habitat typing relies on the use of plant communities as indicators of site quality, using the characteristic climax plant community on a site as an indication of the integrated effects of all biotic and environmental factors that contribute to site quality. The purpose of the study was to assess the impact of overgrazing by feral burros in Bandelier National Monument and predict recovery trends.

Biggs, J., K. Bennett, and P.R. Fresquez. 1997. Evaluation of Habitat Use by Rocky Mountain Elk (*Cervus elaphus nelsoni*) in North-Central New Mexico using Global Positioning System (GPS) Radio Collars. Report No. LA-13279-MS. Los Alamos National Laboratory. 18 pp.

Global Positioning System (GPS) radio collars were used to determine habitat use on the LANL preserve. Locations and types of habitat occupied were documented with frequency of use of various habitat types. Results were compared to previous studies to document changes in utilization patterns. Based on habitat use and availability analysis, use of grass/shrub and piñon/juniper habitats was generally higher than expected during most seasons, and use of forested habitats (ponderosa pine, mixed conifer) was lower than expected. Most of the collared elk remained on LANL property year-round. The application of GPS collars to elk studies in north-central New Mexico appears to be a more efficient and effective method than use of VHF radio collars.

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1998. Movements and Activity Patterns of Rocky Mountain Elk at the Los Alamos National Laboratory. LA-UR-98-4535. Presentation at the Third Symposium of Biological Research in the Jemez Mountains. November 6, 1998. Santa Fe.

From 1996 to 1998, the Ecology Group evaluated daily/seasonal movements and activity patterns of elk on and near Los Alamos National Laboratory (LANL) property by plotting global positioning system (GPS) locational fixes of collared elk onto geographic information system (GIS) coverages of topography and physical structures (i.e., security fences, roads, buildings), resulting in the identification of 6-8 primary elk-traveled corridors on LANL property. Travel corridors in the east portion of LANL are dictated by security fences and other structures, and there are two areas where corridors pass between LANL property and San Ildefonso Pueblo property. The primary travel corridor for collared animals moving west off LANL property is near Pajarito Mountain, which extends off the west-central portion of the Laboratory. The daily use of different land-cover types and terrain were evaluated seasonally by comparing data from six 4-h

periods to one another: 0000-0400, 0400-0800, 0800-1200, 1200-1600, 1600-2000, and 2000-2400. Elk were found to utilize piñon-juniper significantly more frequently than all other cover types between the hours of 0400-1200. Through the 2000-h period, they utilized piñon-juniper significantly more frequently more frequently than all other cover types except ponderosa pine. In general, the use of piñon-juniper increased during daylight hours and decreased during evening hours. Conversely, the use of grasslands decreased during daylight hours and increased during evening hours. The data showed that the elk utilized the northwest and west-facing slopes significantly less than almost all other slopes. Significant differences also were observed between northwest and west-facing slopes versus south-facing and east-facing slopes during the spring. Use of 0%-5% slopes was significantly greater than all other slope classes between the evening and early morning hours of 1600-0400 and significantly greater than slopes above 10% for all hourly subperiods except 0800-1200. During spring, use of 0%-5% slopes decreased during midday hours (0800-1600) and increased during evening and early morning hours (1600-0800). Animals increased their proportion of use on steeper slopes during most subperiods during the summer. By understanding more about movement and activity patterns of elk on LANL property, management strategies to reduce adverse impacts caused by elk (i.e., automobile accidents, overuse of sensitive habitats) can be developed while minimizing the impact of the strategies on elk movement patterns to off-site locations.

Biggs, J.R., K.D.. Bennett, P.R. Fresquez, and R.J. Robinson, 1996. Movements, Disease Analysis, and Tritium Concentrations of Rocky Mountain Elk of the Pajarito Plateau. LA-UR-96-3395. Presentation at the Symposium of Biological Research in the Jemez Mountains, New Mexico. October 26, 1996.

Seasonal movement patterns of four elk (3 cows/1 bull) and one deer fitted with VHF (very high frequency) units were investigated from spring 1995 to spring 1996. Results also are presented on disease analysis of six elk captured in 1996, as well as tritium analysis of all animals (n=11). The deer remained within three miles of its original capture location (n=39 fixes) throughout the study period. The bull elk remained on the Pajarito Plateau in winter and spring, then migrated to the Valle Grande during late spring and summer (n=49 fixes). One of the three cows died within 6 weeks of collaring, apparently following calving, near the north edge of Bandelier National Monument. The surviving cow elk remained on the east slope of the Jemez Mountains and the Pajarito Plateau during winter and early spring, then moved to the Valle Grande during calving and summer months (n=93 fixes). Based on radiotelemetry data, herds occurring in the southern portion of the Laboratory appear to migrate and calve along the eastern portion of the Valle Grande. Four of the six elk captured in 1996 had moderate to high titers for vesicular stomatitis, and one elk had a moderate titer for toxoplasmosis. One cow elk, sampled near Pajarito Road, and one male deer, sampled at TA-49, exhibited concentrations of tritium (2.2 and 1.1 pCi/ml, respectively) above the upper background limit of 0.9 pCi/ml.

Biggs, J.R., K.D.. Bennett, P.R. Fresquez, and R.J. Robinson, 1999. Resource Use, Activity Patterns, and Disease Analysis of Rocky Mountain Elk (*Cervus elaphus nelsoni*) at the Los Alamos National Laboratory. Report No. LA-13536-MS. Los Alamos National Laboratory. 83 pp.

To form the basis for the development of management strategies for elk and other large herbivores, understanding how, when, where, and why animals move with respect to the landscape and availability of essential habitats (i.e., foraging, watering) is essential. From 1996 to 1998, daily/seasonal movements, habitat use, and activity patterns of elk on and near Los Alamos National Laboratory (LANL) were evaluated through the use of global positioning system collars and a geographic information system. Primary travel corridors on and immediately adjacent to LANL property and identified travel routes for collared animals moving west off LANL property in the vicinity of Pajarito Mountain were identified. Daily use of different land cover types and terrain was evaluated seasonally by comparing six four-hour periods to one another. There were significantly more locational fixes of elk in piñon/juniper compared to all other cover types during the hours of 0400-1200, and significantly more than all other cover types except ponderosa pine through the 2000 hour period. In general, use of piñon/juniper increased during daylight hours and decreased during evening hours. Use of grasslands decreased during day hours while increasing during evening hours. Generally, northeast slopes were used greater than

expected and west and northwest slopes less than expected. There were significantly greater fixes on 0^o-5^o slopes compared to all other slope classes between the evening and early morning hours of 1600-0400 and significantly greater than slopes above 10^o for all hourly subperiods except 0800-1200. During spring, use of 0^o-5^o slopes decreased during midday hours while increasing during evening and early morning hours, and animals tended to increase their proportion of use on steeper slopes during most subperiods during summer. Diseases of animals through blood analysis drawn from all collared elk also was examined. Vesicular stomatitis was the most commonly observed disease among tested elk. By understanding movement and activity patterns of elk on LANL property, management strategies can be developed and applied to reduce adverse impacts (i.e., automobile accidents, overuse of sensitive habitats) associated with this species.

Biggs, J., M. Mullen, and K. Bennett. 1999. Development and Application of a Habitat Suitability Ranking Model for the New Mexico Meadow Jumping Mouse (*Zapus hudsonium luteus*). Report No. LA-13659-MS. Los Alamos National Laboratory. 16 pp.

The New Mexico meadow jumping mouse currently is listed as a state-threatened species in New Mexico and has been identified as potentially occurring within the Los Alamos National Laboratory boundary. This report describes the development of a model to identify and rank habitat at LANL that may be suitable for occupation by this species. The model calculates a habitat suitability ranking based on total plant cover, plant species composition, total number of plant species, and plant height. Input data for the model is based on the measurement of these variables to known locations where this species has been found in the Jemez Mountains. Model development included the selection of habitat variables, developing a probability distribution for each variable, and applying weights to each variable based on its overall importance in defining the suitability of the habitat. Based on the probability values and weighting factors, Habitat Suitability Ranking (HSR) values are calculated. Once calculated, The HSR values are placed into one of four habitat categorical groupings by which management strategies are applied.

Eberhardt, L.E., and G.C. White. 1979. Movements of Mule Deer on the Los Alamos National Environmental Research Park. Report No. LA-7742. Los Alamos National Laboratory. 29 pp.

The movements of mule deer on the Los Alamos National Environmental Research Park (LA/NERP) in north-central New Mexico were studied during 1975-1978. A total of 36 deer were live-trapped, marked, and released; 24 of these were equipped with visual markings including ear tags, ear streamers, and neck collars, and 11 were fitted with radio transmitters. Disturbance caused by trapping may have caused some unusual movements. Deer home ranges appear to be elongated in shape, possibly because the deer tend to move parallel to the steep canyon-mesa systems and along the elevational gradient. The average home range size for six deer radiotracked for 18-20 months was 13.7 ± 5.0 km^2. There was no indication that marked deer made extensive seasonal migrations. Resident deer appear to be habituated to much of the human activity on the LA/NERP and did not appear to avoid areas of high human use within their home ranges. However, the 2.6-m-high security fences did affect deer movement.

Fair, J.M., S.J. Whitaker, and O.B. Myers. 1996. Scaling of Body Size and Home Range in Terrestrial Ecological Risk Assessment. Poster presentation at the Annual Meeting of the Rocky Mountain Chapter of the Society of Environmental Toxicology and Chemistry. Denver. (Manuscript in preparation)

Published allometric models for predicting home range from body mass and foraging strategy were tested against new data.

Fleming, B. 1999. Watershed Health: an Evaluation Index for New Mexico. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 93-96. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Although watersheds are not equally healthy, there are no generally accepted criteria for evaluating and comparing them. This paper suggests several criteria which numerically evaluate watersheds in four ways: (1) riparian health, (2) aquatic macroinvertebrate biodiversity, (3) hillslope soil loss, and (4) upland land use/flood peak potential. Each criterion is semi-

quantitatively evaluated on a scale of 1 to 10, with 1 the healthiest and 10 the least healthy. The four methodologies are described and then combined to form a watershed health index. An example is presented comparing two adjacent watersheds with different land uses near Santa Fe, New Mexico.

Foxx, T.S. 1998. Threatened and Endangered Species Habitat Management Plan Overview. Report No. LA-LP-98-112. Los Alamos National Laboratory. 37 pp.

The relative isolation and undisturbed natural setting of much of Los Alamos National Laboratory make this facility ideally suited for its defense-related mission. These factors, combined with limited public access, also have resulted in the preservation of habitat that can sustain a number of species receiving protection under the Endangered Species Act. The Threatened and Endangered (T&E) Species Habitat Management Plan (HMP) for LANL was developed over a three-year period with the dual intent of providing protection for T&E species at LANL as well as facilitating the DOE mission at LANL. This document provides an overview of the HMP, including:

- *Regulatory requirements and reviews that led to its development;*
- *Existing conditions at LANL that give rise to the need for an HMP;*
- *Goals, objectives, and implementing strategies;*
- *HMP components;*
- *A summary of roles & responsibilities of key organizations involved in implementing the HMP;*
- *Long-term activities required to implement the HMP;*
- *Methods for modifying the HMP; and*
- *Methods for tracking the success of the plan and for implementing corrective measures where needed.*

Foxx, T.S., K.D. Bennett, H.T. Haagenstad, S.W. Koch, and M.E. Salisbury. 1996. Integrating Project Requirements with Threatened and Endangered Species Habitat Requirements, a Pilot Demonstration. Report No. LA-UR-96-3616. Los Alamos National Laboratory. 8 pp.

The mission task of the Threatened and Endangered Species (TES) Habitat Management Plan (HMP) identifies and considers the current DOE and UC mission and tactical goals for Los Alamos National Laboratory as translated into projects and activities. The objective of the current task is to create an element within the TES HMP that considers the projects and activities and their relationship to TES and Species of Concern (SOC) and the habitats that these organisms use. In the first phase of this task, data related to projects were examined to define a process for evaluation of projects. A pilot demonstration was performed to evaluate a hypothetical project using a geographic information system ArcView application. This application evaluates the interactions between projects and activities and TES, SOC, and their habitats.

Foxx, T.S., and G.D. Tierney. 1982. Vegetational Analysis of a Canyon Ecosystem at Los Alamos. Report No. LA-9576-MS. Los Alamos National Laboratory. 27 pp.

The purpose of this study was to determine the floristic composition of a canyon located immediately below a peregrine falcon nesting site with the goal of determining whether maintenance of the disturbed site could contribute to habitat enhancement for peregrine prey. Data are presented on presence and importance of plant species known to be preferred food sources for doves and small rodents. The preliminary conclusion is that the disturbed site does not contain an abundance of these key food species.

Foxx, T.S., and G.D. Tierney. 1984. Status of the Flora of the Los Alamos National Environmental Research Park. A Historical Perspective. Report No. LA-8050-NERP, Volume II. Los Alamos National Laboratory. 50 pp.

Studies of the flora of the Los Alamos National Environmental Research Park (LA/NERP) are continued in Water and Pajarito Canyons and their extensions to natural boundaries outside of the LA/NERP. Six plant communities and sixteen plant habitats are described for the study area. The status of endangered, threatened, and rare plant species in the study area is reviewed, and

land-use history of the Pajarito Plateau is related to the levels of apparent anthropogenic disturbance in the study areas' six plant communities.

Gonzales, G.J., R.J. Robinson, S. Cross, H. Nottleman, and T.S. Foxx. 1996. Literature Review and Species Habitat Use Documentation, Report No. LA-UR-96-3526. Los Alamos National Laboratory. 30 pp.

A literature review was conducted to find information about Threatened and Endangered Species that inhabit the Los Alamos National Laboratory preserve. This information was collected into a database and used to develop habitat use and feeding habit tables for ten species.

Haarmann, T., and T. Haagenstad. 1999. Quantitative Habitat Evaluation of the Conveyance and Transfer Project. LA-UR-99-4215. Los Alamos National Laboratory. 28 pp.

The transfer of federally controlled, ecologically sensitive land has become the focus of recent controversy. Assessment of the potential impact of transferring such lands and the associated natural resources has become increasingly important. As part of natural resource planning for the Conveyance and Transport Project, a quantitative field evaluation was conducted to assess and rank various habitats in or near the proposed transfer tracts. This report describes the quantitative habitat evaluation approach that was used for the Conveyance and Transfer Project, which is a method that was developed by The Nature Conservancy. In this approach, both GIS-based landscape analysis and results of field studies are used to develop plant community element occurrence quality ranks, which are then averaged to obtain a site quality rank. The details of this process are described in the report. The results of the study indicate that the overall habitat rankings of the proposed C&T tracts do not differ from the habitat rankings of the canyons in which they are located. Therefore, it is likely that the transfer of these tracts would not result in a decrease in the overall habitat rankings of the canyons.

Haarman, T.K., and L.A. Hansen. 1998. Biological Evaluation of the Impacts for the Implementation of the Threatened and Endangered Species Habitat Management Plan. Report No. LA-UR-98-6005. Los Alamos National Laboratory. 47 pp.

The Los Alamos National Laboratory Threatened and Endangered Species Habitat Management Plan (HMP) was prepared by the Los Alamos National Laboratory (LANL) Ecology Group for the Department of Energy (DOE) as part of the Dual-Axis Radiographic Hydrodynamics Test Facility (DAHRT) Mitigation Action Plan. The purpose of the HMP is to provide for the protection of threatened and endangered species and their habitats at LANL. The HMP consists of three components: an Overview Document, Site Plans, and Monitoring Plans. All three components must be used together to assure proper management of threatened and endangered species. If all the restrictions and protective measures outlined in the HMP are strictly followed, the implementation of the management plan may affect but is not likely to adversely affect the Mexican spotted owl, the American peregrine falcon, the bald eagle, and the southwestern willow flycatcher. Additionally, the implementation of the management plan should have no effect on the black-footed ferret, the Artic peregrine falcon, and the whooping crane.

Keller, D.C., J.R. Biggs, and T.H. Johnson. 1996. Threatened and Endangered Species Surveys and Habitat Management at Los Alamos National Laboratory. Report No. LA-UR-96-3444. Los Alamos National Laboratory.

This report provides information on Threatened and Endangered Species and Species of Concern that potentially can be found at Los Alamos National Laboratory. Documentation is provided on surveys that have been conducted to determine presence on and usage of Laboratory property. Species that are addressed include bald eagle, black-footed ferret, Goat Peak pika, golden eagle, Mexican spotted owl, New Mexico meadow jumping mouse, peregrine falcon, and southwestern willow flycatcher.

Marsh, L.K., and T. Haarman. Quantitative Habitat Analysis: Final Report for FY00. Report No. LA-UR-00-6016. Los Alamos National Laboratory. 289 pp.

There is a need for a Quantitative Habitat Analysis (QHA) process that provides an objective, standardized, replicable, and accessible system. This report details the efforts during FY00 to begin the development of such a process. The development of the QHA is broken down into four phases. Phase I: During Phase I, literature searches and web searches were conducted to assemble information on habitat models. This information was compiled in a 16 page report entitled, "QHA Progress Report on Phase I of Work Plan." (LA-UR-00-6018) Phases II & III: In Phase II, the format of the QHA process was determined. This included the four categories of Ecosystem Health, Forestry Management, Wildlife/T&E, and Ecorisk. Phase III reviewed and refined the format (LA-UR-6017). Phase IV: Phase IV, which is documented in this report, was a pilot study that was conducted with the following objectives: (1) compare field data collection methods; (2) ultimately select a standard field method; (3) gain preliminary comparisons between field sites; and (4) begin analysis. Because Phase IV was only a pilot study, there will be a need for further discussion covering options and possible new paths to pursue in terms of methodology and analysis.

Muldavin, E., and S. Yanoff. 1999. Ecology-Based Biodiversity Evaluation for Los Alamos National Laboratory. An Integrated GIS Spatial Analysis and Field Assessment Approach. Report No. LA-UR-99-5593. Los Alamos National Laboratory. 76 pp.

This report describes an ecology-based biodiversity assessment protocol that was developed by the New Mexico Heritage Program at the University of New Mexico to support the Los Alamos National Laboratory Threatened and Endangered Species Habitat Management Plan and for general long-term biological resources management. It relies on a combination of field assessments and GIS spatial analysis. The details of the protocol are presented and discussed.

Thibault, J.R., D.L. Moyer, C.N. Dahm, H.M. Valett, and M.C. Marshall. 1999. Effects of Livestock Grazing on Morphology, Hydrology and Nutrient Retention in Four Riparian/Stream Ecosystems, New Mexico, USA. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 123-128... Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Land-use practices such as livestock grazing influence the structure and function of riparian/stream ecosystems. In New Mexico, four streams were selected to determine the impact of moderate livestock grazing on morphology, solute transport, and nutrient retention. Each stream contained a reach currently exposed to grazing and an exclosed, ungrazed reach. Channel width/depth ratios and in-stream standing stock of plant biomass were greater in the grazed reaches. Solute transport was determined by injecting a conservative tracer (NaBr) and applying a one-dimensional transport with inflow and storage (OTIS) model. Grazed reaches exhibited enhanced transient storage, represented by a larger cross-sectional area of storage zone relative to wetted channel area (A_s/A). The extent of nutrient retention was determined by co-injecting a reactive tracer ($NaNO_3$) with the conservative tracer. Nitrate uptake lengths were shorter in grazed reaches, an indication of more effective nutrient retention. The results suggest that moderate livestock grazing alters channel structure and vegetation, influencing ecosystem-level processes.

Hydrology

McCord, V.A.S. 1996. Flood History Reconstruction in Frijoles Canyon Using Flood-Scarred Trees. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 114-122. General Technical Report No. RM-GTR-286. USDA Forest Service.

Unexceptional summer storms triggered large floods on the Rito de Los Frijoles in 1977 and 1978, shortly after the intense La Mesa Fire of 1977 burned this watershed. Large numbers of trees growing on or near the stream bank in Frijoles Canyon were scarred during these flood events. These scars provide a record of the occurrence of past flood events that were used to reconstruct flood history with existing fire history data to test the hypothesis that large floods have occurred following large-scale fires in the past. Thirty-six scarred trees at several localities along the Rito de los Frijoles were sampled, and the flood scars crossdated using reference

chronologies developed from scarred and unscarred trees in the canyon. Channel cross-sections and the top heights of the flood scars above the stream level were surveyed, followed by reconstruction of paleoflood discharges using the slope-area method. The riparian tree-ring chronology extends to the early 1600s, represented by at least five trees back to the mid-1700s. The scar dates range from 1773 to 1985, with most of the scar dates falling in 1977 and 1978. Floods were also identified for 1866, 1904, 1951, and 1972. Other than 1977, only the 1773 flood(?) scar matches a major fire year in the local fire scar record. This suggests that fire intensity, rather than fire extensiveness, is the major factor leading to post-fire flooding in this watershed. Flood discharge estimates reconstructed from flood scars correspond well with the USGS estimates for the historic floods of 1977 and 1978. The flood scar evidence in Frijoles Canyon indicates that there have been at least four floods comparable to the 1978 flood in the last two centuries and at least seven floods as large as the flood of 1977 during that time.

Newman, B.D. 1996. Geochemical Investigations of Calcite Fracture Fills and Mesa-Top Water Dynamics on the Pajarito Plateau, New Mexico. Report No. LA-UR-96-1441. Los Alamos National Laboratory. 254 pp. (Ph.D. Dissertation, New Mexico Institute of Mining and Technology)

This dissertation describes how recent developments in analytical techniques, such as quadrupole mass-spectrometric of fluid inclusion gases and the creation of models describing the behavior of meteoric stable isotopes and chloride in the vadose zone, were used to examine aspects of the geochemistry and hydrology of the Pajarito Plateau. These investigations were intended to improve the general understanding of semiarid processes and also identify some of the hydrogeologic factors that affect contaminant transport at Los Alamos National Laboratory.

Newman, B.D., A.R. Campbell, and B.P. Wilcox. 1998. Lateral Subsurface Flow Pathways in a Semiarid Ponderosa Pine Hillslope. Water Resources Research 34: 3485-3496.

This paper reports the results of a study designed to better understand lateral subsurface flow processes in semiarid environments. The study used chemical tracers to investigate the lateral subsurface flow process. The results indicate that macropores conduct lateral subsurface flow that is not in chemical or hydrological equilibrium with the soil matrix. The size of precipitation events appears to have a strong influence on variations in old/new water percentages, and examples of both old and new water dominated events were observed.

Salisbury, M. 1995. Stream Channel Characteristics in Los Alamos and Guaje Canyons. In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 203-208. Report No. LA-13065-MS. Los Alamos National Laboratory.

During the summer of 1992, stream channel surveys were conducted in Los Alamos and Guaje Canyons, Data were collected every forty feet for approximately 1005 feet. Data included channel and water depths, channel and stream widths, bank heights and undercuts, bottom characterizations, and tree and shrub species.

Shaull, D.A., M.R. Alexander, and R.P. Reynolds. 1996. Surface Water Data at Los Alamos National Laboratory: 1995 Water Year. Report No. LA-13177-PR. Los Alamos National Laboratory. 42 pp.

Surface water discharge data were collected from 15 stream gauging stations that cover most of Los Alamos National Laboratory. Included in the report are data from one seepage run conducted in Los Alamos Canyon during the 1995 water year.

Shaull, D.A., M.R. Alexander, R.P. Reynolds, and C.T. McLean. 1996. Surface Water Data at Los Alamos National Laboratory: 1996 Water Year. Report No. LA-13234-PR. Los Alamos National Laboratory. 53 pp.

Surface water discharge data were collected from 17 stream gauging stations that cover most of Los Alamos National Laboratory. The data show less runoff than do data for the 1995 water year. Water chemistry data from larger storm events occurring at some stations are also published here.

Shaull, D.A., M.R. Alexander, R.P. Reynolds, and C.T. McLean. 1998. Surface Water Data at Los Alamos National Laboratory: 1997 Water Year. Report No. LA-13403-PR. Los Alamos National Laboratory. 56 pp.

Surface water discharge data were collected from 19 stream gauging stations that cover most of Los Alamos National Laboratory. Also included are discharge data from three springs that flow into Cañon de Valle.

Shaull, D.A., M.R. Alexander, R.P. Reynolds, C.T. McLean, and R.P. Romero. 1999. Surface Water Data at Los Alamos National Laboratory: 1998 Water Year. Report No. LA-13551-PR. Los Alamos National Laboratory. 56 pp.

Surface water discharge data were collected and computed from 19 stream gauging stations that cover most of Los Alamos National Laboratory. Also included are discharge data from three springs that flow into Cañon de Valle.

White, W.D. 1996. Geomorphic Response of Six Headwater Basins Fifteen Years after the La Mesa Fire, Bandelier National Monument. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 95-113. General Technical Report No. RM-GTR-286. USDA Forest Service.

Factors important to hillside erosion immediately following La Mesa forest fire included: 1) degree of ash development; 2) amount of upslope catchment area; 3)degree of slope; and 4) type or complexity of slope. Efficiency of transport of fire-derived sediment proved to be related to the density and continuity of drainage lines. Early controls to fire related erosion proved to be needle cast from unburned crowns and climatic variability (e.g., the precipitation differences between elevations). Fifteen years following La Mesa Fire, hillside erosion was interrupted by: 1) downed, burned trees and 2) increased ground surface microtopography afforded by the aggradational building of grass pedestals and cryptogamic crusts. The increased ground surface roughness encourages infiltration from the intensely burned areas. Infiltration becomes shallow groundwater interflow that surfaces at the top margins of tributary canyons. The gathering of sediment-free runoff in the tributary and trunk canyons entrains the temporarily stored sediment derived from the mesa tops immediately following the fire. Present day sediment delivery from burned areas of the mesa tops appears to derived primarily from moderately burned basins. While the characteristic needle cast protects the moderately burned basin's ground surface from rain drop impact and channelized overland flow (rilling), the needle cast discourages the growth of cryptogamic crusts. Without the combined infiltration-encouraging factors of cryptogamic crusts and downed trees (which are fewer in moderately burned basins), precipitation in moderately burned areas generally concentrates in the drainages, and channel incision results. Storage of this sediment occurs where drainages widen, such as the mouth of the moderate burn basin on Burnt Mesa, and on the lower gradient, mesa top trunk channels.

Wilcox, B.P., and D.D. Breshears. 1995. Hydrology and Ecology of Piñon-Juniper Woodlands: Conceptual Framework and Field Studies. In: Desired Future Conditions for Piñon-Juniper Ecosystems. D.W. Shaw, E.F. Aldon, and C. LoSapio, Eds. General Technical Report No. RM-258. USDA Forest Service. Pp. 109-119.

This paper describes a conceptual framework designed to increase the understanding of water and vegetation in piñon-juniper woodlands. The framework comprises five different scales, at each of which the landscape is divided into "functional units" on the basis of hydrological characteristics. The hydrologic behavior of each unit and the connections between units are being evaluated using an extensive network of hydrological and ecological field studies on the Pajarito Plateau.

Wilcox, B.P., and D.D. Breshears. 1997. Interflow in Semiarid Environments: An Overlooked Process in Risk Assessment. Human and Ecological Risk Assessment 3: 187-203.

The lateral movement of water through the soil, or interflow, is frequently a component of risk assessments for humid environments, but not of those for semiarid environments. However, interflow can be important in semiarid environments and is, therefore, an essential consideration

for risk assessment in these regions. To illustrate and assess the effect of interflow on estimates of risk, (1) a simple conceptual model to describe the role that interflow may have in the redistribution of surface and near-surface contamination was developed; and (2) RESRAD, as exposure model for assessing radionuclide doses to humans, was used to evaluate the effectiveness of landfill covers in mitigating doses of three contaminates at a site in northern New Mexico where interflow is known to be occurring. Only those calculations of the model that took interflow into account yielded the result that radionuclides would contaminate groundwater – underscoring the importance of interflow as a mechanism for the transport of contaminants. The conclusion is that failure to take interflow into account can render risk assessments inaccurate and remediation ineffective.

Wilcox, B.P., B.D. Newman, D. Brandes, D.W. Davenport, and K. Reid. 1997. Runoff from a Semiarid Ponderosa Pine Hillslope in New Mexico. Water Resources Research 33: 2301-2314.

This paper reports the results of a 4-year study investigating runoff processes in semiarid regions. The results indicate that lateral subsurface flow is a major mechanism of runoff generation. The major generation mechanisms of surface runoff are intense summer thunderstorms, prolonged frontal storms, and snowmelt over frozen soils. At the ponderosa pine site investigated, surface runoff appeared as infiltration-excess overland flow; but this type of surface runoff does not dominate at other ponderosa pine sites.

Invertebrates

Bennett, K. 1994. Aquatic Macroinvertebrates and Water Quality in Sandia Canyon. Report No. LA-12738-MS. Los Alamos National Laboratory Report. 24 pp.

In 1990, field studies were initiated in Sandia Canyon to establish baseline data for water quality and stream macroinvertebrate communities. The studies were designed to establish baseline data and to determine the effects of routine discharges of industrial and sanitary waste. Stations where the stream routinely receives industrial and sanitary waste effluents exhibited a low diversity of macroinvertebrates and slightly degraded water quality. The downstream station, located approximately 0.4 km downstream of the nearest wastewater outfall, appeared to be in a zone of recovery where the water quality parameters more closely resembled those found in natural streams in the Los Alamos area. A large increase in macroinvertebrate diversity also was observed at the downstream station.

Cross, S. 1994. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory: December 1992-October 1993. Report No. LA-12734-SR. Los Alamos National Laboratory. 38 pp.

This report summarizes the results of water quality and macroinvertebrate diversity in Sandia Canyon during 1993 as a followup to the results reported for 1990 in Report No. 12738 by K. Bennett. During 1993, five stations were sampled in the canyon. The two uppermost stations are located near outfalls that discharge industrial and sanitary waste effluent. The third station is located in a natural cattail marsh located about 0.4 km downstream of the uppermost stations. Two additional stations were located further downstream. Water quality parameters at the upper three stations are different from those of natural streams, suggesting degraded water quality. The macroinvertebrate communities exhibit low diversity and poorly-developed community structures. The two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams in the area, macroinvertebrate diversity increases, and community structure becomes more complex.

Cross, S. 1995. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory, November 1993 to October 1994. Report No. LA-12971-SR. Los Alamos National Laboratory. 58 pp.

This report summarizes the results of water quality and macroinvertebrate diversity investigations in Sandia Canyon during 1994 as a followup to previous investigations in 1990 (LA-12738-MS) and 1993 (LA-12734-SR). During 1994, five stations were sampled in the canyon. The two upstream stations are located below outfalls that discharge industrial and sanitary waste

effluent into the stream, thereby maintaining year-round flow. Some water quality parameters are different at the first three stations from those expected of natural streams in the area, indicating degraded water quality resulting from effluent discharges. The aquatic habitat at the upper stations has also been degraded by sedimentation and channelization. The macroinvertebrate communities at these stations are characterized by low diversities and unstable communities. In contrast, the two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams of the area. The two lower stations have increased macroinvertebrate diversity and stable communities, further indications of downstream water quality improvement.

Cross, S. 1995. Aquatic Invertebrate Sampling at Selected Outfalls in Operable Unit 1082; Technical Areas 9,11,16,and 22. Report No. LA-13019-MS. Los Alamos National Laboratory. 57 pp.

Preliminary sampling for aquatic invertebrates, hydrological condition, physico-chemical parameters, wildlife uses, and vegetation was conducted for eleven outfalls within Operable Unit 1082 and nearby "natural waterways." The physico-chemical parameters at most outfalls and natural waterways fell within the normal range of natural waters in the area. However, the outfalls are characterized by low biodiversity and severely stressed communities composed of a restricted number of taxa. The habitat at some outfalls could probably support well-developed aquatic communities if sufficient water was available. At present, the hydrology at these outfalls is too slight and/or too sporadic to support such a community in the foreseeable future. In contrast to the outfalls, the natural waterways had greater densities of aquatic invertebrates, higher biodiversities, and lower community tolerance quotients.

Cross, S. 1995. Aquatic Macroinvertebrates and Water Quality in Guaje and Los Alamos Canyons, (1993 and 1994). In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 91-194. Report No. LA-13065-MS. Los Alamos National Laboratory.

Water quality parameter samples and aquatic macroinvertebrates were collected from sampling stations in Guaje and Los Alamos Canyons in 1993 and 1994. The relatively undisturbed stream in Guaje Canyon was used as a control to evaluate impacts to the stream in Los Alamos Canyon. All monthly pH, conductivity, and dissolved measurements taken in both streams were within acceptable water quality ranges. The Los Alamos Canyon Reservoir impounds all incoming water except for warmed overflow, which significantly elevates temperatures at lower Los Alamos Canyon stations. At times, the dam design causes the stream to dry up completely, eliminating macroinvertebrate communities at the lower stations. This is the most significant impact to downstream communities. Rapid Biological Protocols (RBP) III analysis shows that aquatic communities are richer and more complex in Guaje Canyon than Los Alamos Canyon. The data also suggest that, within each canyon, diversity and density increase with distance downstream; but this trend is not as pronounced because the middle Guaje station had higher diversities and densities than the lowest station. According to RBP III analysis, water quality is unimpaired at LA1 and severely impaired at LA2 and LA3.

Cross, S. 1995. Terrestrial Mollusks of Guaje and Los Alamos Canyons. In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 195-202. Report No. LA-13065-MS. Los Alamos National Laboratory.

In 1993 and 1994, six plant litter samples were collected from below deciduous trees or shrubs in Guaje and Los Alamos Canyons. Using standardized sorting and identification techniques, a total of 997 individual snails representing 8 families and 13 species were sorted and identified. Species richness and numbers of individuals varied greatly between samples. Species diversity was high in four of the six samples, with low diversity in one sample from each of the canyons.

Cross, S.P., and J. Davila. 1996. Aquatic Macroinvertebrates and Water Quality on Guaje and Los Alamos Canyons, 1995. Report No. LA-UR-96-998. Los Alamos National Laboratory. 80 pp.

The streams within Guaje and Los Alamos Canyons were sampled on three dates in 1995 for water quality parameters and aquatic macroinvertebrates. The relatively undisturbed stream in Guaje Canyon was used as a control to evaluate impacts to the stream in Los Alamos Canyon. Habitat assessment scores were lower in Los Alamos Canyon than in Guaje, but all stations in both canyons scored lower than in 1994 because of large volumes of fine sediments. All pH, conductivity, and dissolved oxygen measurements taken in both streams were within acceptable water quality ranges and met high-quality cold-water fisheries standards. The Los Alamos County Reservoir impounds all incoming water except for warmed overflow, producing elevated water temperatures and periodic stream drought at the lower Los Alamos stations. These represent the most significant impacts to downstream invertebrate communities in Los Alamos Canyon. Aquatic communities are richer and more developed in Guaje than Los Alamos Canyon. The 1995 water quality was slightly impaired at LA1, moderately impaired at LA2, and severely impaired at LA3. This pattern of increasing downstream impairment was also substantiated by decreasing standing crop numbers and biodiversity values.

Cross, S., and H. Nottelman. 1996. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory 1995. Report No. LA-UR-96-3684. 59 pp.

This report updates and expands previous aquatic studies in Sandia reported by Bennett and Cross. Water quality data and aquatic macroinvertebrate samples were collected monthly at three sampling stations in Sandia Canyon during 1995. The two upstream stations occur near a cattail marsh downstream from outfalls that discharge industrial and sanitary waste effluent. The third station is approximately 1.5 miles downstream in a mixed conifer forest. All water quality parameters measured during 1995 fell within acceptable State limits and scored in the good or excellent range when compared to an Environmental Quality Index. However, aquatic macroinvertebrate habitats have been degraded by widespread erosion, channelization, loss of wetlands due to deposition and stream lowering, scour, limited acceptable substrates, LANL releases and spills, and other stressors. The stream continues to be threatened by erosion and potential landslides from the Los Alamos County landfill whose towering sides of loose fill material are perched at a 45^{o} angle above the northern edge of the entire Sandia Canyon wetlands. Macroinvertebrate communities at all of the stations had low diversities, low densities, and erratic numbers of individuals. These results indicate that, although the stream possess acceptable water chemistry, it has reduced aquatic biota. The best developed aquatic community occurs at the sampling station with the best habitat and whose downstream location partially mitigates the effects of upstream impairments.

Cross, S., L. Sandoval, and T. Gonzales. 1996. Aquatic macroinvertebrates and Water Quality of Springs and Streams in White Rock Canyon along the Rio Grande, 1995. Report No. LA-UR-96-510. 53 pp.

In April and September of 1995, aquatic invertebrate collections were made up-canyon from three major stream confluences and at 6 springs near the Rio Grande. Physical and chemical parameters were measured at all locations and habitats were assessed at each of the streams. On the basis of these limited samples, several observations were tentatively advanced:

- *pH values of both springs and streams appear to decrease between spring and autumn;*
- *the springs have more stable temperature regimes than do the streams;*
- *great variations in flow rates exist between the individual springs and streams;*
- *aquatic habitats vary greatly between the streams and seasonally;*
- *the dominant taxa frequently change seasonally in both springs and streams;*
- *differences between invertebrate samples may obscure differences in site densities; and*
- *despite variations in community compositions, most of the springs and streams appear capable of supporting well-developed aquatic communities.*

Ford-Schmid, R.E. 1996. Reference Conditions for Los Alamos National Laboratory Streams Using Benthic Macroinvertebrate Assessment in Upper Pajarito Canyon. New Mexico Geological Survey Guidebook. 47th Field Congress. Jemez Mountains Region. Pp. 441-447.

Benthic macroinvertebrates and water samples were collected at three stations in upper Pajarito Creek and at one station in each of two first-order tributaries to Pajarito Creek at Los Alamos National Laboratory (LANL). A total of 63 taxa were identified from the five stations. Number of taxa per study location ranged from 25 to 35, and standing crop ranged from 2351 (no/m^2) to 11,212 (no/m^2). EPT/EPT + Chironomid ratios, a measure of community balance, ranged from 0.17 to 0.84, while another measure of community balance, the Shannon-Weaver's index of diversity, ranged from 2.48 to 3.53. The Winget and Mangum CTQd index, a measure of non-organic perturbations, ranged from 72.5 to 89.1, and the Hilsonhoff Biotic Index (HBI), a measure of the presence of organic perturbation, ranged from 4.20 to 6.92. Habitat assessments indicate that four of the five stations were comparable, whereas the station farthest downstream in Pajarito Canyon displayed effects of embeddedness, channel alteration, scouring, and reduced flow. The HBI = 6.92 calculated for Starmer Spring station indicates fairly poor water quality with substantial organic pollution likely. The compete absence of the scraper functional feeding group, the dominance of the community by one tolerant midge, and the presence of mats of filamentous algae at Starmer Spring indicate a community structure that is tolerant of nutrient enrichment. The State of New Mexico water quality standards for livestock watering and wildlife habitat were met at all stations, while the fisheries acute standard for aluminum (750 μg/L) was exceeded at the station farthest downstream in Pajarito Canyon. The 11 metrics used to compare sites indicate that the farthest upstream station in Pajarito Canyon is appropriate for use as the reference condition for future comparisons of streams at LANL.

Haarmann, T. 1995. Survey of Terrestrial Arthropods in Los Alamos and Guaje Canyons (1993). In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 209-223. Report No. LA-13065-MS. Los Alamos National Laboratory.

For two consecutive years, terrestrial arthropod studies were conducted in Los Alamos and Guaje Canyons. Guaje Canyon was considered the control for the experiments. A total of more than 22,500 arthropods were captured and identified. All arthropods were identified down to the family level. Relative abundance comparisons were made between the canyons in 1993 and in 1994. Comparisons were not made between years as there are too many factors that can contribute to insect population numbers. No significant differences between arthropods were found in either year; however, there were some interesting patterns that could be observed when comparing the two canyons. Data for 1993 are presented.

Haarmann, T. 1995. Survey of Terrestrial Arthropods in Los Alamos and Guaje Canyons (1994). In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 225-238. Report No. LA-13065-MS. Los Alamos National Laboratory.

For two consecutive years, terrestrial arthropod studies were conducted in Los Alamos and Guaje Canyons. Guaje Canyon was considered the control for the experiments. A total of more than 22,500 arthropods were captured and identified. All arthropods were identified down to the family level. Relative abundance comparisons were made between the canyons in 1993 and in 1994. Comparisons were not made between years as there are too many factors that can contribute to insect population numbers. No significant differences between arthropods were found in either year; however, there were some interesting patterns that could be observed when comparing the two canyons. Data for 1994 are presented

Hanson, W.C., and F.R. Miera, Jr. 1978. Further Studies of Long-Term Ecological Effects of Exposure to Uranium. Report No. LA-7162. Los Alamos Scientific Laboratory. 26 pp.

Soils, small mammals, and invertebrates were sampled at E-f Site for uranium analysis. Spatial variability in sampling for soil uranium distribution by a polar coordinate system was evaluated in randomly selected soil cores. Uranium concentrations in tissues of deer mice and pocket gophers was sufficiently different to conclude that the greater bioavailability of uranium in the top few millimeters of soil, combined with the difference in grooming and food habits of the animals, resulted in greater contamination of deer mice than pocket gophers. There was no

conclusive evidence of a differential response of invertebrate populations to areas of relatively high uranium concentrations and to control areas.

Lightfoot, D.C. 1996. A Comparison of Ground-Dwelling Arthropod Assemblages Among Different Habitats Resulting from the 1977 La Mesa Fire. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 166-178. General Technical Report No. RM-GTR-286. USDA Forest Service.

This study was conducted to determine whether or not post-fire habitats resulting from the 1977 La Mesa Fire support different assemblages of ground-dwelling arthropods. Four principal post-fire vegetation habitats were identified: 1) ponderosa pine forest, 2) ponderosa pine savanna, 3) Gambel oak thickets, and 4) open grasslands. Ground-dwelling arthropods were sampled from each of the four habitats during the summer of 1993. Numerically important arthropod groups found in the samples included spiders, harvestmen, bristletails, crickets, fungus beetles, rove beetles, ground beetles, and darkling beetles. Total arthropod abundances were significantly different among the four habitats and changed throughout the summer. Total species diversity differed little among the habitats. Each arthropod group was significantly more abundant in one or two habitat types, and the different arthropod groups had dissimilar abundance patterns among the habitats. These findings are consistent with other studies of post-fire patterns of ground-dwelling arthropod assemblages and have important implications for differences in decomposition and nutrient cycling rates among habitats and food resource availability to vertebrate predators in those habitats.

Moeur, S., and D.A. Guthrie. 1984. The Effects of Clearing Fire-Killed Trees on Wildlife. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 135-144. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Rapid recovery of the forest after a fire should be an important objective of forest management. Following a severe fire in the Jemez Mountains in north central New Mexico, two management approaches were instituted on adjacent burn sites. On Bandelier National Monument property, burned forest areas were heavily seeded from the air with a variety of grasses. This was the only action taken. However, on Los Alamos National Laboratory property, all dead trees were cut down and removed. The purpose of the study reported upon in this paper was to compare the effects of the two management policies on the flora and fauna of the sites. The results show that slight differences in vegetation and insect populations were found between the Bandelier and Laboratory sites, but these differences were not significant. No difference was found in mammal populations between the two sites. Bird populations differed, with greater populations of both resident and visiting species on the Bandelier site. This difference is thought to be due to the presence of nesting sites and perches provided by dead trees rather than to differences in food supply. The few trees left standing on the Laboratory site were used by birds and lessen the differences observed between the two sites. The effects of the two strategies of forest management thus have their greatest effect on bird populations. Effects of the Laboratory approach on vegetation are minor but could be minimized even more by restricting vehicular traffic in the process of wood removal (requiring cut wood to be carried to existing roads rather than allowing vehicles to drive to the cutting site). The effects on birds could be greatly reduced by leaving a certain percentage of dead trees standing, particularly large trees that were partially dead before the fire and that were used by hole-nesting species.

Pippin, W.F., and B. Nichols. 1996. Observations of Arthropod Populations Following the La Mesa Fire of 1977. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 161-165.. General Technical Report No. RM-GTR-286. USDA Forest Service.

(Note: This paper was presented at the 1st La Mesa Fire Symposium and inadvertently omitted from that symposium proceedings.) Sampling sites were selected in burned and unburned areas where transects for bird surveys had previously been established. Plots were selected randomly in each site and sampled weekly. A 50 m^2 plot was selected in a severely burned area and an unburned area nearby, and observations were made on arthropod populations. There were more genera collected in the unburned than the burned areas.

Generally, the most common arthropods collected in both the burned and unburned areas were ants and spiders. A New Jersey light trap operated at Ponderosa Campground in 1977, before the fire, collected several hundred specimens per trap night. In 1978, the volume of specimens collected in the trap was similar to that collected before the fire. In some areas, the drastic reduction in arthropod populations might have had an adverse effect on populations of some insectivorous birds or other animals.

Pippin, W.F., and B.D. Pippin, 1984. Aquatic Invertebrates from Capulin Creek, Bandelier National Monument, New Mexico. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 107-113. Report No. LA-9236-NERP. Los Alamos National Laboratory.

During the summer of 1980, a limited survey was made of the invertebrate fauna of Capulin Creek within Bandelier National Monument. The stream originates in the Santa Fe National Forest, enters at the western edge of the Monument, and flows for approximately 11.5 km through Capulin Canyon into the Rio Grande. The stream flows steadily for approximately 6.4 km, then becomes intermittent or dry, especially in the summer months. The stream is small and shallow and varies in width according to the topography, but averages about 1 m. The flow varies with the season and time of day. The purpose of this study was (1) to establish a preliminary check list of the invertebrate fauna of the stream, primarily macroinvertebrates of the Class Insecta, (2) to assess the relative abundance of various taxa between test sites, and (3) to compare the number and kind of taxa collected with those found in the Rito de la Frijoles. The results showed that the greater diversity of species and, in general, the overall population numbers occurred in the upper reaches of Capulin Creek. The same pattern was noted in the Rito de la Frijoles. Capulin Creek from Base Camp to its headwaters is a relatively stable but fragile environment.

Miscellaneous Assessments

Bennett, K., and M. Salisbury. 1996. Floodplain/Wetland Assessment for Circuit Shop Waste Reduction and Outfall Termination. Report No. LA-UR-96-279. 11 pp.

Los Alamos National Laboratory proposes to improve its treatment of wastewater from a printed circuit shop located within Operable Unit 1111 at TA-22, Building 91, and eliminate discharge from Outfall 128-128. The proposed project would focus on a concerted effort to eliminate discharges of wastewater. This would entail removal of the existing treatment system, upgrade of transfer lines, and installation of the new system. The thrust of these modifications would be to prevent hazardous chemicals from entering the wastewater system and to curtail water use in circuit shop operations. In accordance with procedural regulations of the DOE, 10 CFR 1022, "Compliance with Floodplain/Wetland Environmental Review Requirements," a floodplain/wetland assessment was completed for those areas that will be affected by the Proposed Circuit Shop Waste Reduction and Outfall Termination. Replacement of the old treatment system with the new treatment system will not require activities to occur within the boundary of any wetlands. However, the new treatment system will stop the flow from Outfall 128-128, resulting in a plant community structure change from a wetland community to an upland community. Species associated with the wetland community may be displaced and replaced with upland associated species. Currently, the wetland habitat below the outfall supports habitat for a limited diversity of aquatic macroinvertebrates, amphibians, large and small mammals, and a variety of bird species, all of which use the wetland habitat for watering, breeding, bedding, or hunting. None of the proposed new treatment system falls within adjacent floodplains.

Biggs, J.R. 1996. Biological Assessment for the ISF Gasline – Townsite Portion. Report No. LA-UR-96-1889. Los Alamos National Laboratory. 83 pp.

The Department of Energy is proposing to replace deteriorated portions of a 10" natural gas transmission line extending from Bloomfield, NM to Los Alamos. The current pipeline was installed between 1948 and 1951 and does not meet current Department of Transportation standards. This document reports on the biological assessment of the new Phase A (Townsite) portion of the replacement process and summarizes the results of a biological field investigation

of the proposed gas line route through Los Alamos Townsite. Based on the field survey and previous studies, it includes a discussion of the actual and potentially existing plant and wildlife species in the project area. It also includes a discussion of threatened, endangered, and sensitive species (listed by the state and federal governments) known to occur or potentially occur in the project area.

Cross, S. 1996. Biological and Water Quality Assessments for the Material Disposal Area P Project Area, 1995 and 1996. Report No. LA-UR-96-4670. 56 pp.

Material Disposal Area (MDA) P is located within LANL TA-16 where high explosives (HE) production and development are the main activities. The waste pile was active until 1984. It lies along a slope located on the southern rim of Cañon de Valle, just north of TA-16 thermal treatment area pad TA-16-387. The landfill area extends almost to a small flowing stream in the bottom of the canyon, approximately 150 ft below the summit of the waste pile. The debris in the waste pile is very heterogeneous, consisting of burned HE-contaminated equipment, building materials, empty drums and bottles, and general trash. Waste materials include metals, arsenic, nitrates, HE residue, and possibly aromatic hydrocarbons, asbestos, solvents, and depleted uranium. This report provides a detailed description and history of the site and describes the results of biotic surveys in the area. In general, the surveys showed that all water quality parameters for Cañon de Valle were within the ranges set by the State of New Mexico for high-quality cold-water fisheries, although a series of metrics used to evaluate the stream indicated that it is slightly impaired. A federally-endangered T&E species known to inhabit the area is discussed, as are project restrictions due to species and habitat requirements. A New Mexico-endangered plant may occur in the area. The report includes best management practices addressing biological concerns, which are presented in terms of T&E species, erosion control, water quality, and restoration of the area following clean closure.

Cross, S. 1996. Biological Assessments for the Low Energy Demonstration Accelerator, 1996. Report No. LA-UR-96-4785. Los Alamos National Laboratory. 49 pp.

Cooling water from the Low Energy Demonstration Accelerator (LEDA) will be discharged at Outfall 03A113 behind buildings 5e-293 and 53-294. Effluent will be discharged at the mesa's edge and onto a steep hillside on Sandia Canyon's northern side. It is expected to reach the main channel of Sandia Canyon, which lies to the south of East Jemez Road. USFWS reviewers of the biological assessment for the project insisted that the main drainage be monitored to measure and document changes to vegetation, soils, wildlife, and habitats resulting from LEDA discharges. Initial surveys documented 29 plant species, including 9 grasses. A bird survey found 25 bird species, the most common being robins, chipping sparrows, mountain chickadees, and pygmy nuthatches. Pitfall traps captured 32 individuals of 4 reptile and amphibian species. Only 1 amphibian, a tiger salamander, was caught. LEDA discharges are expected to increase the numbers and relative abundances of amphibians within mid-Sandia Canyon. Increased water in the canyon also should increase habitat attractiveness to both deer and elk. In terms of T&E species, there may be habitat improvement for a federally protected raptor and several species of concern as a result of the addition of non-contaminated water to a typically dry section of the canyon. Thus, the LEDA project may beneficially affect but is unlikely to adversely affect potential foraging habitat for these species.

Cross, C., and D. Usner. 1996. Biological Assessment for the Mixed Waste Storage and Disposal Facility, Technical Areas 67 and 15, Los Alamos National Laboratory. Report No. LA-UR-94-1400. Los Alamos National Laboratory. 63 pp.

Los Alamos National Laboratory proposes to build the Mixed Waste Storage and Disposal Facility, a 29 hectare facility to permanently dispose of solid waste mixed waste that would derive from environmental remediation, research and development, and decommissioning and decontamination activities at the Laboratory. Located within DOE property on Pajarito Mesa, the proposed facility includes surface storage facilities and disposal pits. The surface facilities would include access roads, perimeter fencing, utilities, and buildings housing administrative offices and decontamination areas. This report summarizes the results of several surveys within Technical Areas 15 and 67, where the facility would be located. The purpose of the surveys was to (1) to

determine if threatened, endangered, or sensitive species or critical habitat exist within or near the proposed site; (2) to identify and characterize sensitive habitats, such as floodplains or wetlands, in the vicinity of the proposed facilities; and (3) to compile data on plant and wildlife species within the proposed site.

Department of Energy. 2000. Special Environmental Analysis: Actions Taken in Response to the Cerro Grande Fire at Los Alamos National Laboratory, Los Alamos, New Mexico. Report No. DOE/SEA-03. Los Alamos Area Office. 142 pp.

The US Department of Energy (DOE), National Nuclear Security Administration, is issuing this special environmental analysis (SEA) to document its assessment of impacts associated with emergency activities conducted at Los Alamos National Laboratory (LANL) in response to major disaster conditions caused by the Cerro Grande Fire. The wildfire burned about 7,650 acres within LANL boundaries and about 35,500 acres in neighboring areas. As a result of this wildfire event, DOE identified the need to take actions on an emergency basis to protect human life and property. DOE considered that its actions should not be just protective of the lives of its employees, contractors, and subcontractors, but also the lives and property of all people living and working in the LANL region. Because of the urgent nature of the actions required of DOE to address the effects of the fire and the need for immediate post-fire recovery and protective actions, DOE had to act immediately and could not comply with normal National Environmental Policy Act (NEPA) requirements. The emergency circumstances clause of the Council on Environmental Quality's NEPA Implementing Regulations was invoked, and this Special Environmental Analysis (SEA) subsequently has been prepared. This SEA provides an assessment of the impacts that have resulted because of actions taken by or on behalf of DOE to address a major disaster emergency situation. It includes descriptions of the actions, the resulting impacts, mitigation measures taken to reduce or eliminate impacts, and a cumulative impact analysis.

Dunham, D. 1996. Biological and Floodplain/Wetland Assessment for the Steam Plant Replacement Project (TA-16 and TA-9). Report No. LA-UR-96-108. Los Alamos National Laboratory. 30 pp.

Information gathered from previous field surveys was compared with habitat requirements of protected species (threatened, endangered, or sensitive) for the purpose of compliance with the Federal Endangered Species Act, New Mexico's endangered species laws, and the Floodplain and Wetland Executive Orders 11990 and 11998. The purpose of the surveys was threefold: to determine if species protected by the state or federal government were present; to determine if sensitive habitats were present; and to gather baseline data for future studies on plant and wildlife species in the project area. Survey data indicated that the general area of the proposed project could incorporate habitat for several protected species: the northern goshawk, Mexican spotted owl, spotted bat, Jemez Mountain Salamander, meadow jumping mouse, willow flycatcher, wood lily, and Helleborine orchid. No extraordinary mitigation measures are required to ensure that no adverse impacts affect these species because the project area (impact zone) is in previously disturbed areas or near buildings. National Inventory Wetlands maps and field checks were used to record all floodplains and wetlands, and the project is not expected to have an adverse effect on any wetland. Information has been provided to aid in revegetating any area disturbed by the proposed project, including any disturbance caused by off-road vehicular travel.

ESH-20. 1999. Environmental Analysis for the Proposed Field Research Center for Bioremediation Technologies. Report No. LA-UR-99-1860. Los Alamos National Laboratory. 16 pp.

The proposed site for the Field Research Center (FRC) is at the bottom of Los Alamos Canyon in an undeveloped area. A dirt road provides access to Los Alamos Canyon from State Road 4 near the White Rock Y. The FRC site is vegetated primarily by ponderosa pine with some patches of piñon-juniper forest at the east end and mixed conifer in the higher elevations at the west end. There is no permanent source of surface water in Los Alamos Canyon, but the shallow alluvial groundwater receives flow from the Los Alamos Reservoir and from NPDES-permitted effluents from TA-2, TA-53, and TA-21. Surface water flows on an intermittent basis,

either during snowmelt or after a rainstorm. There are no springs in the section of the canyon under consideration for this project, nor are there any permanent surface water features. The canyon has steep walls with relatively small flood plains. The depth to the main aquifer is at least 700 ft, although there are several perched aquifers beneath the proposed site. Los Alamos Canyon has been designated as potential habitat for the Mexican spotted owl and the American peregrine falcon, which are federally listed threatened and endangered species. However, surveys have been conducted for each of the past five years, and there is no evidence of occupancy by these species. In addition, there may be some habitat on the steep north-facing slopes for the Jemez Mountain salamander, which is a state-identified rare species.

Foxx, T, and K. Bennett. 1996. Ecological Survey Report for the Proposed Location of the Tourist Information and Visitor Center, White Rock, New Mexico. Report No. LA-UR-96-208. 14 pp.

Approximately 3 hectares in lower Cañada del Buey, Los Alamos National Laboratory, New Mexico, at Technical Area 54, were surveyed for endangered, threatened, and sensitive species. This site is the location of the proposed Tourist Information and Visitor Center for the County of Los Alamos. No endangered, threatened, or endangered plant or animal species that occur within the County of Los Alamos were noted within the survey area. The Tourist Center is not within the floodplain of Cañada del Buey. The site is within a piñon, one-seed juniper/blue grama habitat type. his project complies with the Endangered Species Act of 1973 and Executive Order 11988, "Floodplain Management."

Fresquez, P.R. 1998. Baseline Tritium Concentrations in Soils and Vegetation: The Tshirege Woodland Site at TA-54. Report No. LA-UR-98-1079. Los Alamos National Laboratory. 4 pp.

A preoperational survey for tritium was conducted for the Tshirege woodland site, an experimental area managed by ESH-15, where tritium will be injected 10 cm deep in and around the base of piñon and juniper trees during the summer of 1990. The site is located at the lower end of Canada del Buey close to the intersection of Pajarito and State Road 4. Baseline values of ^{3}H were measured in soil and plant samples from five locations immediately surrounding the study area. Mean values of ^{3}H in soils collected from the 0-5 and 25-30 cm depths were 1.24±0.22 and 1.08±0.41 pCi/mL, respectively. Piñon needles averages 1.68±0.18 pCi/mL, and blue grama grass averaged 1.16±0.95 pCi/mL.

Fresquez, P.R., M.H. Ebinger, H.T. Haagenstad, and L. Naranjo, Jr. 1999. Baseline Concentrations of Radionuclides and Trace Elements in Soils and Vegetation around the DARHT Facility: Construction Phase (1998). Report No. LA-13669-MS. Los Alamos National Laboratory. 77 pp.

The Mitigation Action Plan for the Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility at Los Alamos National Laboratory mandates the establishment of baseline concentrations for potential environmental contaminants. To this end, concentrations of ^{3}H, ^{137}CS, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and ^{tot}U radionuclides and Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl metals were determined in surface and subsurface soils, sediments, and vegetation (overstory and understory) around the DARHT facility during the construction phase in 1998. (This is the third year of a four year baseline study.) Also, volatile (VOC) and semivolatile (SVOC) organic compounds were measured in soils and sediments. Most radionuclides and trace metals in soil, sediment, and vegetation were similar to past years at DARHT and were within regional background concentrations. Exceptions were concentrations of ^{90}Sr, Be, Ba, and total U in some samples. These elements exceeded upper limit (i.e., mean plus two standard deviations) regional background concentrations. No VOCs and very few SVOCs were detected in soils and sediments. Mean (± standard deviation) radionuclide and trace element concentrations measured in soil, sediment, and vegetation over a three-year period (construction phase) are summarized.

Fresquez, P.R., and M. Ennis. 1995. Baseline Radionuclide Concentrations in Soils and Vegetation Around the Proposed Weapons Engineering Tritium Facility and the Weapons

Subsystems Laboratory at TA-16. Report No. LA-13028-MS. Los Alamos National Laboratory. 15 pp.

An environmental survey was conducted over the proposed site of the Weapons Engineering Tritium Facility (WETF) and the Weapons Subsystems Laboratory (WSL) at Los Alamos National Laboratory (LANL) at TA-16. Baseline concentrations of tritium (^{3}H), plutonium (^{238}Pu and ^{239}Pu), and total uranium were measured in soils, vegetation (pine needles and oak leaves), and ground litter. Tritium also was measured in air samples, while cesium (^{137}Cs) was measured in soils. The mean concentration of airborne tritiated water during 1987 was 3.9 pCi/m^{3}. Although the mean annual concentration of ^{3}H in soil moisture in the 0-5 (2 in) soil depth was measured at 0.6 pCi/mL, a better background level, based on long-term regional data, was considered to be 2.6 pCi/mL. Mean values for ^{137}Cs, ^{238}Pu, ^{239}Pu, and total uranium in soils collected from the 0-5 cm depth were 1.08 pCi/g, 0.0014 pCi/g, 0.0325 pCi/g, and 4.01 μg/g, respectively. Ponderosa pine needles contained higher values of ^{238}Pu, ^{239}Pu, and total uranium than did leaves collected from Gambel's oak. In contrast, leaves collected from Gambel's oak contained higher levels of ^{137}Cs than pine needles did.

Fresquez, P.R., H.T. Haagenstad, and L. Naranjo, Jr. 1998. Baseline Concentrations of Radionuclides and Heavy Metals in Soils and Vegetation around the DARHT Facility: Construction Phase (1997). Report No. LA-13470-PR. Los Alamos National Laboratory. 112 pp.

As part of the DOE's Mitigation Action Plan for the DARHT Facility at LANL, baseline concentrations of radionuclides (^{3}H, ^{137}Cs, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{241}Am, total U) and heavy metals (Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl) in soil, sediment, and vegetation (overstory and understory) were determined during the construction phase in 1997. Most radionuclides in soils, sediments, and vegetation, with the exception of ^{90}Sr in soils and sediments, were within upper limit background concentrations. Although the levels of ^{90}Sr in soils and sediments were higher than background, they were below LANL screening action levels and are of no concern.

Gonzales, G.J., and P.G. Newell. 1996. Ecotoxicological Screen of Potential Release Site 50-006(D) of Operable Unit 1147 of Mortandad Canyon and Relationship to the Radioactive Liquid Waste Treatment Facilities Project. Report No. LA-13148-MS. Los Alamos National Laboratory. 52 pp. (Also released as LA-UR-96-12)

Potential ecological risk associated with soil contaminants in PRS 50-006(d) of Mortandad Canyon at LANL was assessed by performing an ecotoxicological risk screen. The PRS surrounds Outfall 051, which discharges treated effluent from the Radioactive Liquid Waste Treatment Facility. Discharge at the outfall is permitted under the CWA NPDES. Radionuclide discharge is regulated by DOE Order 5400.5. Ecotoxicological Screening Action Levels (ESALs) were computed for nonradionuclide constituents in the soil, and human risk SALs were used as ESALs for radionuclides. Within the PRS and beginning at Outfall 051, soil was sampled at three points along each of nine linear transects at 100-ft intervals. Soil samples from three depths for each sampling point were analyzed for the concentration of a total of 121 constituents. Only the results of the surface sampling are reported in this report. The spatial change in radionuclide concentrations from the outfall to the downcanyon sample locations was statistically insignificant. The average concentration (19.7 pCi/g) of alpha-emitting radionuclides was higher that the values reported in a different study for all 15 onsite locations for the period 1976-1981 and is 242% of the mean gross alpha concentration measured in the same area between 1975 and 1977. The variation between transect means in this study was high. Although the results of subsurface sampling are not reported here, a cursory review of the data revealed that the concentrations of several of the Potential Contaminants of Concern (PCOCs) are highest at the intermediate sampling depth, 1.5-2.5 ft. Of 121 screened soil constituents, 42 met the criteria for PCOCs. However, 25 of the 42 PCOCs were constituents for which the maximum soil concentration was equal to or less than the lowest required analytical limit, which is known as the "contractor-required quantitation limits" (crql's). Excluding the crql-related PCOCs, there were no semi-volatile PCOCs, 1 volatile PCOC, 5 inorganic PCOVs, and 11 radionuclide PCOCs. The inorganic PCOCs are heavy metals and are of concern because of their susceptibility to biomagnification. There were inadequate data to make a determination on 20 constituents.

Animal guild sensitivities, in descending order, were small herbivores, small omnivore, small carnivore, and large herbivore. In general, PRS 50-006(d), as a whole, cannot be proposed for No Further Action at this time from the perspective of potential ecological impact. The results may be compliance issues related to NRDA, CWA, and/or CERCLA. At least 17 PCOCs require further investigation in an Ecological Risk Assessment. Planned discharge of "supercleaned" waste water from a new plant will add to the complexity of PRS considerations. In theory, radionuclides could be remobilized, making them available for vertical and horizontal transport and for biotic uptake.

Gonzalez, T.C., T.S. Foxx, and J. Biggs. 1995. Analysis of Animal-Related Accidents in Los Alamos County. Report No. LA-UR-95-3950. Los Alamos National Laboratory. 8pp.

Since Los Alamos National Laboratory inception, a multitude of changes have occurred throughout Laboratory property that have included large-scale developments at various Technical Areas. These developments have resulted in seemingly significant alterations in the terrain and the general landscape of the Pajarito Plateau. Although not documented, this in turn has likely caused significant changes in land use by most groups of wildlife species, particularly those that have large seasonal and/or daily ranges, such as birds and large mammals. These changes have undoubtedly caused some species of wildlife, such as elk and deer, to alter their land use patterns by way of cutting off travel corridors to wintering areas, breeding habitat, foraging habitat, and bedding areas, as well as other necessary habitats. In this report, animal-related accidents from January 1990 to February 1995 were tabulated and analyzed to determine relationship to various parameters such as species, location, time of day, and season. Elk and Mule deer were by far the most common species involved in accidents.

Haarmann, T. 1995. Ecological Surveys of the Proposed High Explosives Wastewater Treatment Facility Region. Report No. LA-12967-MS. Los Alamos National Laboratory. 51 pp.

Los Alamos National Laboratory proposes to improve its treatment of wastewater from high explosives (HE) research and development activities. The proposed project would focus on a concerted waste minimization effort to greatly reduce the amount of wastewater needing treatment. The result would be a 99% decrease in the HE wastewater volume. This reduction would entail closure of HE wastewater outfalls, affecting some wetland areas that depend on HE wastewater effluents. The outfalls also provide drinking water for many wildlife species. Terminating the flow of effluents at outfalls would represent an improvement in water quality in the LANL region but locally could have a negative effect on some wetlands and wildlife species. None of the affected species are protected by any state or federal endangered species laws. The purpose of this report is to briefly discuss the different biological studies that have been done in the region of the project area. It is written to give biological information and baseline data on the biota of the project area.

Haarmann, T., and T. Haagenstad. 1999. Quantitative Habitat Evaluation of the Conveyance and Transfer Project. LA-UR-99-4215. Los Alamos National Laboratory. 28 pp.

The transfer of federally controlled, ecologically sensitive land has become the focus of recent controversy. Assessment of the potential impact of transferring such lands and the associated natural resources has become increasingly important. As part of natural resource planning for the Conveyance and Transport Project, a quantitative field evaluation was conducted to assess and rank various habitats in or near the proposed transfer tracts. This report describes the quantitative habitat evaluation approach that was used for the Conveyance and Transfer Project, which is a method that was developed by The Nature Conservancy. In this approach, both GIS-based landscape analysis and results of field studies are used to develop plant community element occurrence quality ranks, which are then averaged to obtain a site quality rank. The details of this process are described in the report. The results of the study indicate that the overall habitat rankings of the proposed C&T tracts do not differ from the habitat rankings of the canyons in which they are located. Therefore, it is likely that the transfer of these tracts would not result in a decrease in the overall habitat rankings of the canyons.

Huchton, K., S.W. Koch, and R. Robinson. 1997. An Analysis of Background Noise in Selected Canyons of Los Alamos Canyon. Report No. LA-13372-MS. Los Alamos National Laboratory. 21 pp.

Background noise levels in six canyons (upper and lower Los Alamos, Cañada del Buey, Water, Mortandad, and Rendija) within Los Alamos County were recorded in order to establish a baseline for future comparisons and to discover what noises animals are being exposed to. Noise level measurements were taken within each canyon, beginning at an established starting point and at one-mile intervals up to four miles. The primary source of noise above 55 dBA was vehicular traffic. One clap of thunder provided the highest recorded noise level (76 dBA). In general, the level of noise, once away from highways and parking lots, was well below 60 dBA.

Keller, D., and D. Dunham. Biological Assessment for the Norton Powerline Pole Replacement.
(1) Fiscal Year 1996 Replacements. Report No. LA-UR-95-850. Los Alamos National Laboratory. 41 pp. (1995)
(2) Fiscal Year 1997 and 1998 Replacements. Report No. LA-UR-95-3715. Los Alamos National Laboratory. 51 pp. (1996)

Los Alamos National Laboratory (LANL) proposes to replace antiquated 115 kV powerpole lines in the Norton Powerline on LANL, U.S. Forest Service, and Bureau of Land Management land. Trucks and heavy equipment will obtain access by using previously established or approved access routes. Minimal environmental damage should result, as the proposed pole replacement is in an area of 75% to 100% prior disturbance from the utility corridor. A Presence and Absence Study for vegetation and wildlife species, including threatened, endangered, and sensitive (TES) species, was conducted to determine if habitat along the powerline could potentially support TES species. The study was performed specifically to address the impact of the power pole replacement. Other incidental purposes were to determine if sensitive habitats are present and to gather baseline data for future studies on plant and wildlife species in the area. All wetlands, floodplains, and riparian areas near the powerline also were documented.

Keller, D.C., and D. Risberg. 1995. Biological and Floodplain/Wetland Assessment for the Dual-Axis Radiographic Hydrodynamics Test Facility (DARHT). Report No. LA-UR-95-647. Los Alamos National Laboratory. 149 pp.

Construction of the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility began in May of 1994. As a result of a preliminary injunction issued in 1995, construction was halted until completion of an Environmental Impact Statement (EIS). A Mitigation Action Plan prepared for the EIS will include measures discussed in this Biological Assessment to prevent any likely adverse affect to any threatened or endangered species, or any modification to critical habitat. During the planning stage for DARHT in 1988, the area was surveyed for threatened and endangered species, but only plant species were addressed because no wildlife species listed then were identified as potentially occurring in the project area. This report contains current, updated biological information on the area, including threatened and endangered species.

Pierce, L., and T. Foxx. 1996. Plant Information Database for EF Site, TA-15, Los Alamos National Laboratory from the Plant Information Database for the Pajarito Plateau and the Jemez Mountains. Report No. LA-UR-95-3602. Los Alamos National Laboratory.

During 1992, field surveys were conducted for the site characterization of Operable Unit 1086, TA-15. Surveys were conducted on mesa tops and in Pajarito, Three Mile, Potrillo, and Water Canyons, which are contiguous to the mesa tops where facilities and firing sites are located. This summary provides some information necessary to conduct screening models for a portion of TA-15, EF Site, which includes the following types of data:

- *quantitative data on cover, relative cover, frequency, relative frequency, and an importance index;*
- *results of the comparison of habitat data with the habitat requirements of the threatened and endangered species; and*
- *a listing from the Plant Information Database of all information that has been compiled on species known to occur on EF Site and Potrillo Canyon adjacent to the site.*

Sigler, J.W. 1998. A Status Report on Threatened and Endangered Species, Wetlands, and Floodplains for the Proposed Conveyance and Transfer Tracts at Los Alamos National Laboratory, Los Alamos, New Mexico. Report No. LA-UR-98-3361. Los Alamos National Laboratory.

The U.S. Department of Energy (DOE) announced its intent in the May 6, 1998 issue of the Federal Register (V63, No. 87) to prepare an environmental impact statement (EIS) to assess the potential environmental impacts of conveying and transferring certain land tracts located within Los Alamos and Santa Fe Counties at Los Alamos National Laboratory. The purpose of this document is to provide:

- *A brief summary of actions mandated by Congress in Public Law 105-119;*
- *A description of the regional and site specific setting of the proposed action in Los Alamos and Santa Fe Counties;*
- *Ecological baseline information at the proposed action locations;*
- *Endangered Species Act Considerations;*
- *DOE requirements regarding floodplains and wetlands, including their identification and assessment, and other aspects of DOE real property transfers; and*
- *Other regulatory concerns pertaining to fish and wildlife.*

Models and Modeling

Gallegos, A.F. 1997. Documentation and Utilization of the Ecological Transport Model BIOTRAN.2. Report No. LA-UR-97-1469. Los Alamos National Laboratory. 726 pp.

Inclusive of appendices, this document describes the purpose, rationale, construction, and use of an ecological transport model (BIOTRAN.2). This model is used to predict the flow of organic and inorganic contaminants, including radionuclides, through specified plant and animal environments using biomass as a vector. The model also predicts the movement of contaminants through the physical environment through soil erosive processes, air, the movement of soil moisture, and moisture movement in shallow aquifers along prescribed channel beds. The main text is presented with a specific format which uses a minimum of space, yet is adequate for tracking most relationships from their first appearance in the text to their locations in the code. The code itself is heavily commented to assist in this effort. Because relationships are treated individually in this matter and rely strongly on appendix material for understanding, the reader should also become familiar with these materials as well.

Gallegos, A.F. and G.J. Gonzales. 1999. Documentation of the Ecological Risk Assessment Computer Model ECORSK.5. Report No. LA-13571-MS. Los Alamos National Laboratory.

The FORTRAN77 ecological risk computer model – ECORSK.5 – has been used to estimate the potential toxicity of surficial deposits of radioactive and non-radioactive contaminants to several threatened and endangered (T&E) species at the Los Alamos National Laboratory. This report summarizes and documents the ECORSK.5 code, the mathematical models used in the development of ECORSK.5, and the input and other requirements for its operations. Other FORTRAN77 codes used for processing and graphing output from ECORSK.5 also are discussed. The reader may refer to reports cited in the introduction to obtain greater detail on past applications of ECORSK.5 and assumptions used in deriving model parameters. A FORTRAN90 version of the code is under development.

Gallegos, A.F., G.J. Gonzales, K.D. Bennett, and L.E. Pratt. 1997. Preliminary Risk Assessment of the Mexican Spotted Owl under a Spatially-Weighted Foraging Regime at the Los Alamos National Laboratory. Report No. LA-13259-MS. Los Alamos National Laboratory. 62 pp.

This report presents the results of a preliminary risk assessment for the Mexican spotted owl on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated doses to the owl under a spatially-weighted foraging regime were compared against toxicological reference doses for three risk source types. Under the risk parameter assumptions made, hazard quotient (HQ) results indicated no unacceptable risk to the

owl, including a measure of cumulative effects from multiple contaminants that assumes a linear additive toxicity type. A Hazard Index of 1.0 was used as the evaluative criterion for determining the acceptability of risk. This value was exceeded (1.06) in only one of 200 simulated potential nest sites. Cesium-137, Ni, ^{239}Pu, Al, and ^{234}U were among the constituents with the highest partial HQs. Improving model realism by weighting simulated owl foraging based on distance from potential nests decreased the estimated risk. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, owl habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at acceptable low levels.

Gallegos, A.F., G.J. Gonzales, K.D. Bennett, L.E. Pratt, and D.S. Cram. 1997. A Spatially-Dynamic Preliminary Risk Assessment of the American Peregrine Falcon at the Los Alamos National Laboratory (Version 1). Report No. LA-13321-MS. Los Alamos National Laboratory. 114 pp.

This report presents the results of a preliminary risk assessment for the peregrine falcon on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated doses to the falcon were compared against toxicity reference values to generate hazard indices. Hazard index results indicated no unacceptable risk to the falcon from the soil ingestion pathway, including a measure of cumulative effects from multiple contaminants that assumes a linear additive toxicity type. Scaling home ranges on the basis of maximizing falcon height for viewing prey decreased estimated risk by 69% in a canyons-based home range and increased estimated risk by 40% in a river-based home range. Improving model realism by weighting simulated falcon foraging based on distance from potential nest sites decreased risk. Choice of toxicity reference values can have a substantial impact on risk estimates. Adding bioaccumulation factors for several organics increased partial hazard quotients by a factor of 110, but increased the mean hazard index by only 0.02 units. Adding a food consumption exposure pathway in the form of biomagnification factors for 15 contaminants of potential ecological concern increased the mean hazard index to 1.16, which is above the level of acceptability (1.0). Aerochlor-1254, DDT, and DDE accounted for 81% of the estimated risk that includes soil ingestion and food consumption pathways and a biomagnification component. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, falcon habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at acceptably low levels.

Gallegos, A.F., and K.P. Starmer. 1997. BIOTRAN.2 User's Manual. Report No. LA-UR-97-1468. Los Alamos National Laboratory. 243 pp.

BIOTRAN.2 is an ecological transport model that is used to predict the flow of organic and inorganic contaminants, including radionuclides, through simulated ecosystems – which can include plant, animal, and human populations – using biomass as a vector. The model is written in FORTRAN77 and consists of 22 coupled subroutines that utilize daily and yearly loops driven by a Monte Carlo simulated climate. These subroutines include variables within the disciplines of meteorology, soil physics, hydrology, geology, plant and animal physiology, limnology, radiation biology, ecology, epidemiology, risk analysis, and health physics. The flexibility of the model allows the user to develop simple scenarios using only a few subroutines or complex scenarios using all of the subroutines. Furthermore, the model can simulate an ecosystem for whatever time period in years that the user desires. The purpose of this manual is to assist the user in developing site-specific and generic simulations using user-selected nuclides, heavy metals, organics, and several nutrients in air, soil, aquifers, water, vegetation, animals, and man. Three input examples are used throughout the manual. One is based on a site in Amarillo, Texas, and the other two are based on the Los Alamos National Laboratory site. These examples illustrate most of the model's capabilities and will assist in verifying BIOTRAN.2 operation on a subroutine-by-subroutine basis.

Gallegos, A.F., and W.J. Wenzel. 1989. Runoff and Sediment Yield Model for Predicting Nuclide Transport in Watersheds Using BIOTRAN. Report No. LA-11851-MS. Los Alamos National Laboratory. 118 pp.

The environmental risk simulation model BIOTRAN was interfaced with a series of new subroutines (RUNOFF, GEOFLEX, EROSION, and AQUIFER) to predict the movement of nuclides, elements, and pertinent chemical compounds in association with sediments through lateral and channel flow of runoff water. In addition, the movement of water into and out of segmented portions of runoff channels was modeled to simulate the dynamics of moisture flow through specified aquifers within the watershed. The BIOTRAN soil water flux subroutine, WATFLZ, was modified to interface the relationships found in the SPUR model for runoff and sediment transport into channels with the particle sorting relationships utilized by Lane to predict radionuclide enrichment and movement in watersheds. The new subroutines were applied specifically to Mortandad Canyon within Los Alamos National Laboratory by simultaneous simulation of eight surface vegetational subdivisions and associated channel and aquifer segments of this watershed. This report focuses on descriptions of the construction and rationale for the new subroutines and on discussing both input characteristics and output relationships to known runoff events from Mortandad Canyon. Limitations of the simplified input on model behavior also are discussed. Uranium-238 was selected as the nuclide for demonstration of the model because it could be assumed to be homogeneously distributed over the water shed surface.

Gonzales, G.J., A.F. Gallegos, and T.S. Foxx,. 1997. Second Annual Review Update: Preliminary Risk Assessment of Federally Listed Species at the Los Alamos National Laboratory. Report No. LA-UR-97-4732. Los Alamos National Laboratory. 9 pp.

The ECORSK model that was used to perform the initial risk assessments for the peregrine falcon, bald eagle, and Mexican spotted owl was modified to include updated contaminant uptake and accumulation information as well as updated TRV values. This report presents updated results for the spotted owl and peregrine falcon using the new model. Overall, the results indicate a small potential for impact to the peregrine falcon but no appreciable impact to the spotted owl or bald eagle.

Gonzales, G.J., A.F. Gallegos, T.S. Foxx, P.R. Fresquez, M.A. Mullen, L.E. Pratt, and P.E. Gomez. 1998. A Spatially-Dynamic Preliminary Risk Assessment of the Bald Eagle at the Los Alamos National Laboratory. Report No. LA-13399-MS. Los Alamos National Laboratory. 64 pp.

This report presents the results of a preliminary risk assessment for the bald eagle on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated exposure doses to the eagle for radionuclide, inorganic metal, and organic contaminants were derived for varying ratios of aquatic vs. terrestrial simulated diet and compared against toxicity reference values to generate hazard indices (HIs). The HI results indicate that no appreciable impact to the bald eagle is expected from contaminants at LANL from soil ingestion and food consumption pathways. This includes a measure of cumulative effects from multiple contaminants that assumes linear additive toxicity. Improving model realism by weighting simulated eagle foraging based on distance from potential roost sites increased the HI by 76%, but still to inconsequential levels. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, eagle habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at low levels.

Gonzales, G.J., A.F. Gallegos, M.A. Mullen, K.D. Bennett, and T.S. Foxx. 1998. Preliminary Risk Assessment of the Southwestern Willow Flycatcher (*Empidonax trallii extimus*) at the Los Alamos National Laboratory. Report No. LA-13508-MS. Los Alamos National Laboratory. 43 pp.

This report presents the results of a preliminary risk assessment for the southwestern willow flycatcher on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. The southwestern willow flycatcher is the fourth threatened or endangered species to undergo a preliminary assessment for estimating potential risk from

environmental contaminants at the Los Alamos National Laboratory. These assessments are being conducted as part of a three-year project to develop a habitat management plan for threatened or endangered species and species of concern at the Laboratory. For the preliminary assessment, estimated doses were compared against toxicity reference values to generate hazard indices (HIs). This assessment includes a measure of cumulative effects from multiple contaminants (radionuclides, metals, and organic chemicals) to 100 simulated nest sites located within flycatcher potential habitat. Sources of contaminant values were 10.000 ft^2 grid cells within an Ecological Exposure Unit (EEU). This EEU was estimated around the potential habitat and was based on the maximum home range for the flycatcher identified in the scientific literature. Food consumption and soil ingestion contaminant pathways were addressed in the assessment. Using a four-category risk evaluation, HI results indicate no appreciable impact is expected to the southwestern willow flycatcher. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, flycatcher habitat, facility siting, and/or facility operations in order to maintain low levels of risk from contaminants.

Lane, L.J., W.D. Purtymun, and N.M. Becker. 1985. New Estimating Procedures for Surface Runoff, Sediment Yield, and Contaminant Transport in Los Alamos County, New Mexico. Report No. LA-10335-MS. Los Alamos National Laboratory.

Simplified procedures are developed to predict runoff, sediment yield, and contaminant transport from semiarid watersheds with alluvial stream channels. The procedures represent a synthesis of simplified models to approximate the complex processes of runoff generation, streamflow-routing and hydrograph development, sediment transport and yield, particle sorting and enrichment, and transport of sediment-associated contaminants. The procedures are applied to a complex watershed-channel system at Los Alamos, New Mexico, and are used to compute the transport and redistribution of plutonium in alluvial stream channels. Mass-balance calculations are used to compute plutonium outflows from the channel system and to compute the amount of plutonium remaining in the channel alluvium.

McLin, S.G. 1992. Determination of 100-year Floodplain Elevations at Los Alamos National Laboratory. Report No. LA-12195-MS. Los Alamos National Laboratory. 84 pp.

Under existing permit requirements, the US EPA stipulates that facilities regulated by RCRA must delineate all 100-yr floodplain elevations within their boundaries. At Los Alamos, these floodplains are located within ungaged watersheds that drain the Pajarito Plateau. This report documents the floodplain computational mapping procedure and, along with supporting maps, is intended to satisfy this permit requirement. About 65% of the Laboratory has 2-ft topographic contour interval coverage, while 35% has 10-ft coverage. The approach used employs a 100-yr, 6-h design storm event, but alternative floodplain elevations produced by different storm events are easily computed. In this particular application, 11 separate watersheds traverse LANL lands, with individual channels ranging up to 9 mi in length. The 100-yr floodplain was defined on each channel segment at 250-ft intervals, and detailed 1:4800-scale maps were generated.

Wenzel, W.J., T.S. Foxx, A.F. Gallegos, G. Tierney, and J.C. Rodgers. 1987. Cesium-137, Plutonium-239/240, Total Uranium, and Scandium in Trees and Shrubs Growing in Transuranic Waste at Area B. Report No. LA-11126-MS. Los Alamos National Laboratory. 62 pp.

A unique radioecological study was carried out at a Los Alamos National Laboratory (LANL) shallow land burial site called Area B. Area B was the first common transuranic waste burial site for LANL from 1944 to 1948 and had lain fallow for 34 years. During this time, secondary succession resulted in invasion of many native trees, shrubs, forbs, and grasses. The purpose of this study was to determine whether any trees or shrubs were rooting directly in waste material, to examine rooting patterns in a shallow land burial site, and to study the distribution patterns of different radionuclides by dissecting vegetative samples into representative compartments. Scandium, ^{137}Cs, $^{239/240}Pu$, and total uranium were measured in soil, litter, leaf, bark, wood, and root samples from excavated trees and shrubs. Several trees and shrubs were found rooted in transuranic waste material. The radiochemical data were used to calibrate the UPTAKE subroutine of the BIOTRAN model for the Los Alamos environs. The simulation results indicated that higher resolution sampling is needed for ^{137}Cs and $^{239/240}Pu$ to interpret surveillance data and

to produce reliable risk assessments. This study attempted to draw together and interpret the radionuclide data for Area B from several investigations. There is a need to standardize the grid methods and sampling site markers to develop a permanent system wherein sampling sites can be accurately relocated and tied to engineering drawings. This would allow subsequent studies to use the existing temporal data and hence produce reliable assessments, especially for sites where heterogeneous source terms require high resolution sampling on small grids over long time frames.

Operable Unit Reports

During the early 1990s, the Biological Resource Evaluations Team of the Environmental Protection Group (EM-8) conducted Operable Unit (OU) field surveys for LANL's Environmental Restoration (ER) Program. The surveys were conducted to provide background information to the ER Program preparatory to site soil sampling characterization studies to determine the nature and extent of hazardous waste releases from Solid Waste Management Units (SWMUs). The purpose of the surveys was threefold. First, the surveys were to determine, before site characterization sampling, if there were state or federally threatened, endangered, or sensitive plant or wildlife species or critical habitat within the OU boundaries. Second, the surveys were to identify any sensitive habitats, such as floodplains or wetlands, within the proposed sampling areas, the extent of these habitats, and their general characteristics. Third, the surveys were to provide additional plant and wildlife data to help define habitat types within the OU. Data from the surveys will provide baseline information about the biological components of the site for site characterization. The data also will aid in determining presampling conditions, which can be compared to data collected at the same locations in future similar studies. Furthermore, the information collected is necessary to support National Environmental Policy Act (NEPA) documentation and may possibly determine a Categorical Exclusion for the site characterization sampling plan. As a result of these surveys, the following reports were generated.

Banar, A. 1996. Biological Assessment for Environmental Restoration Program Operable Unit 1148, TA-54 and TA-51. Report No. LA-UR-1054. Los Alamos National Laboratory. 110 pp.

Banar, A. 1996. Biological Assessment for Environmental Restoration Program Operable Unit 1157, TA-8, TA-9, TA-23, and TA-69. Report No. LA-UR-93-4184. Los Alamos National Laboratory. 123 pp.

Bennett, K. 1996. Biological and Floodplain/Wetlands Assessment for Environmental Restoration Program Operable Units 1106 and 1078, TA-1 and TA-21, Los Alamos and DP Canyons. Report No. LA-UR-93-107. Los Alamos National Laboratory. 108 pp.

Benson, J., S. Cross, and T. Foxx. 1996. Biological and Floodplain/Wetlands Assessment for Environmental Restoration Program Operable Unit 1085, TAs 14 and 67. Report No. LA-UR-95-648. Los Alamos National Laboratory. 131 pp.

Biggs, J. 1996. Biological and Floodplain/Wetlands Assessment for Environmental Restoration Program Operable Unit 1071, TAs 0, 19, 26, 73, and 74. Report No. LA-UR-93-1168. Los Alamos National Laboratory. 156 pp.

Biggs, J.R. 1996. Biological Assessment for Environmental Restoration Program Operable Unit 1079, TAs 10, 31, 32, and 45. Report No. LA-UR-93-1169. Los Alamos National Laboratory. 81 pp.

Biggs, J., and S. Cross. 1996. Biological and Floodplain/Wetland Assessment for Environmental Restoration Program Operable Unit 1140, TA-46. 49 pp.

Cross, S. 1995. Biological Evaluation for Environmental Restoration Program Operable Unit 1098, TA-2 and TA-41. Report No. LA-UR-95-4117. Los Alamos National Laboratory. 140 pp.

Cross, S. 1996. Biological Evaluation for Environmental Restoration Program Operable Unit 1114, Technical Areas 3, 30, 59, 60, 61, and 64. Report No. LA-UR-94-21. Los Alamos National Laboratory. 146 pp.

Cross, S. 1996. Biological Assessment for Environmental Restoration Program Operable Unit 1130, TAs 36, 68, and 71. Report No. LA-UR-94-26. Los Alamos National Laboratory. 142 pp.

Dunham, D.A. 1995. Biological and Floodplain/Wetland Assessment for Environmental Restoration Program Operable Unit 1132, TA-39. Report No. LA-UR-95-204. Los Alamos National Laboratory. 119 pp.

Dunham, D.A. 1995. Biological and Floodplain/Wetland Assessment for Environmental Restoration Program Operable Unit 1086, TA-15. Report No. LA-UR-95-649. Los Alamos National Laboratory. 127 pp.

Dunham, D.A. 1996. Biological and Floodplain/Wetlands Assessment for the Environmental Restoration Program, Operable Unit 1129, TAs -4, -5, -35, -42, -48, -52, -55, -63, and –66, and Operable Unit 1147, TA-50. Report No. LA-UR-93-1055. Los Alamos National Laboratory. 96 pp.

Foxx, T. 1996. Biological and Floodplain/Wetland Assessment for Environmental Restoration Program Operable Unit 1122, TA-33 and TA-70. Report No. LA-UR-93-106. Los Alamos National Laboratory. 163 pp.

Haarmann, T. 1995. Biological and Floodplain/Wetland Assessment for Environmental Restoration Program Operable Unit 1100, Technical Areas 53 and 72. Report No. LA-UR-95-11. Los Alamos National Laboratory. 63 pp.

Raymer, D.F. 1996. Biological Assessment for the Environmental Restoration Program, Operable Unit 1144, Technical Area 49. Report No. LA-UR-93-105. Los Alamos National Laboratory. 137 pp.

Raymer, D.F. 1996. Biological and Floodplain/Wetland Assessment for Environmental Restoration Program Operable Unit 1082, TAs 11, 13, 16, 24, 37, and 38. Report No. LA-UR-93-4182. Los Alamos National Laboratory. 146 pp.

Salisbury, M. 1995. Biological Assessment for Environmental Restoration Program Operable Unit 1111, TA-6, -7, -22, -40, -58, and -62. Report No. LA-UR-95-4118. Los Alamos National Laboratory. 161 pp.

Pedology

Davenport, D.W., B.P. Wilcox, and B.L. Allen. 1995. Micromorphology of Pedogenically Derived Fracture Fills in Bandelier Tuff, New Mexico. Soil Science Society of America Journal 59: 1672-1683.

Fractures in the Bandelier Tuff are potential paths for water movement and transport of contaminants from waste disposal sites and other contaminated areas at Los Alamos National Laboratory. This study was conducted to determine (1) the morphology and origin of soil-like material in the fractures and (2) the likelihood of significant water movement through the fractures. Fracture fills consist of clay, calcium carbonate, or combinations of the two with minor inclusions of tuff and sand grains. Clay consists of thick, highly oriented argillans aligned parallel to fracture walls and of discrete books in fracture interiors. Carbonate consists of massive microcrystalline calcite, which completely fills some fractures, and laminae or infillings between clay lamelae or books in clay-dominated fractures. The carbonate was precipitated after clay deposition, suggesting a change to a more arid climate. Weaker development of argillans and

carbonate features in the soils suggests that the fractures may be derived from older soils that have been stripped by erosion. The presence of live roots throughout the fracture fills indicates the presence of water, but the smetitic clay and massive carbonate makes it unlikely that significant water movement is now taking place through the fractures. The potential creation of new macropores by a variety of processes, however, including seismic activity and biologic disturbance, could allow rapid water movement and contaminant transport.

Davenport, D.W., B.P. Wilcox, and D.D. Breshears. 1996. Soil Morphology of Canopy and Intercanopy Sites in a Piñon-Juniper Woodland. Soil Science Society of America Journal 60: 1881-1887.

Piñon-juniper woodlands in the semiarid western United States have expanded as much as fivefold during the last 150 years, often accompanied by losses of understory vegetation and increasing soil erosion. This study was conducted to determine the differences in soil morphology between canopy and intercanopy locations within a piñon-juniper woodland near Los Alamos, NM, with uniform parent material, topography and climate and a mean tree age of 135 years. Only two of the 17 morphological properties compared showed significant differences. The B horizons make up a slightly greater proportion of total profile thickness in intercanopy soils, and there are higher percentages of coarse fragments in the lower portions of canopy profiles. Canopy soils have lower mean pH and higher mean organic C than intercanopy soils. Regression analyses showed that mean soil properties did not closely correspond with tree size; but total soil thickness and B horizon thickness are significantly greater under the largest piñon trees, and soil reaction is lower under the largest juniper trees. The findings suggest that, during the period in which piñon-juniper woodlands have been expanding, the trees have had only minor effects on soil morphology.

Longmire, P.A., S.L. Reneau, P.M.Watt, L.D. McFadden, J.N. Gardner, C.J. Duffy, and R.T. Ryti. 1996. Natural Background Geochemistry, Geomorphology, and Pedogenesis of Selected Soil Profiles and Bandelier Tuff, Los Alamos, New Mexico. Report No. LA-12913-MS. Los Alamos National Laboratory. 176 pp.

During 1992 and 1993, the Bandelier Tuff and several soil profiles were sampled to determine background elemental concentrations for Los Alamos National Laboratory. Soil analyses were performed in such a manner as to provide a comparison of elements incorporated within the primary minerals with those elements concentrated in surface coatings. Soils present on the Pajarito Plateau are extremely variable in physical and chemical properties, such as particle size, percent calcium carbonate, clay mineralogy, iron oxides, and trace element chemistry. Soils have higher concentrations of aluminum, arsenic, barium, calcium, cerium, cobalt, chromium, and iron than the Bandelier Tuff samples. The Bandelier Tuff has higher concentrations of beryllium, lead, sodium, potassium, thorium, and uranium than the soils. Higher concentrations of trace elements are found in well-developed soils than in the weakly developed soils on the Pajarito Plateau. Clay minerals and iron oxides, which have relatively high surface areas, occur within B horizons and control trace-element distributions in soils. The B horizons contain higher concentrations of trace elements relative to A and C horizons. Variations in soil-element concentrations are also affected by climate, topography, and the parent materials, which include alluvial fans, sheet wash material, colluvium, wind-blown sediment, El Cajete pumice, and the Bandelier Tuff. Because background-element concentrations in soils forming on the Pajarito Plateau vary with parent material, the degree of soil development and other site-specific conditions must be considered to select the most appropriate samples. The results of chemical analyses discussed in this report represent the most appropriate (noncontaminated) published data available to establish background-elemental distributions in soils throughout the Laboratory.

Piñon-Juniper Woodland

Allen, C.D., and D.D. Breshears. 1998. Drought-Induced Shift of a Forest-Woodland Ecotone: Rapid Landscape Shift Response to Climate Variation. Proceedings of the National Academy of Sciences USA 95: 14839-14842.

This paper reports the most rapid landscape-scale shift of a woody ecotone ever documented. In northern New Mexico in the 1950s, the ecotone between semiarid ponderosa pine forest and piñon-juniper woodland shifted extensively (2 km or more) and rapidly (<5 years) through mortality of ponderosa pine in response to a severe drought. Forest patched within the shift zone became more fragmented, and soil erosion greatly accelerated. This shift has persisted for 40 years.

Breshears, D.D., O.B. Myers, S.R. Johnson, C.W. Meyer, and S.N. Martens. 1997. Differential Use of Spatially Heterogeneous Soil Moisture by Two Semiarid Woody Species: *Pinus edulis* and *Juniperous monosperma.* Journal of Ecology 85: 289-299.

Soil moisture in semiarid woodlands varies both vertically with depth and horizontally between canopy patches beneath woody plants and the intercanopy patches that separate them, such that shallow soil layers in intercanopy patches are wettest. Three hypotheses were tested relative to the use of shallow water in intercanopy locations by two coexisting semiarid-woodland tree species, piñon pine and juniper. (1) Both piñon and juniper can use shallow water from intercanopy locations. (2) Juniper is able to obtain more shallow water from intercanopy locations than piñon. (3) The spatial arrangement of the trees influences the amount of water that they can obtain. Although both species responded to the addition of shallow water in intercanopy locations, the juniper response was significantly greater than that of piñon pine. The responses were not influenced by spatial arrangement. In addition, the amount of depletion was correlated with basal area of juniper but not of piñon pine. These results are consistent with differences in relative abundance of the two species across locations, suggesting that species differences in ability to use shallow water in intercanopy locations is important in structuring semiarid woodlands. Furthermore, the results suggest that current theoretical concepts for semiarid ecosystems, which ignore either vertical or horizontal variability in soil moisture, may be inadequate for predicting changes in the ratio of woody to herbaceous plant biomass, particularly for plant communities with co-dominant woody species that differ in ability to acquire spatially heterogeneous resources.

Breshears, D.D., J.W. Nyhan, C.E. Heil, and B.P. Wilcox. 1998. Effects of Woody Plants on Microclimate in a Semiarid Woodland: Soil Temperature and Evaporation in Canopy and Intercanopy Patches. International Journal of Plant Science 159: 1010-1017.

The canopies of woody plants in semiarid environments modify the microclimate beneath and around them, with canopy patches usually having lower soil temperatures than intercanopy patches. However, information is lacking on how heterogeneity in soil temperature, induced by woody plant canopies, influences soil evaporation rates and the consequent effects on plant-available water. In the study reported in this paper, soil temperatures were measured and soil evaporation rates were estimated for canopy and intercanopy patches in a semiarid piñon-juniper woodland in northern New Mexico. Maximum soil temperature in intercanopy patches was greater than in canopy patches between May and September by as much as 10^{o}C, while soil temperatures in intercanopy patches were lower than in canopy patches during colder parts of the day in the fall and winter months. Drying rates were disproportionately greater at high soil moisture and high soil temperature. Intercanopy patches were predicted to dry more than canopy patches for days in April through September by as much as 2% volumetric soil content per day. These results quantify the effects of woody plants on the microclimate with respect to soil temperature and evaporation, which in turn affects herbaceous and woody plants by modifying factors such as germination, the potential for facilitation, and the amount of plant-available water.

Breshears, D.D., P.M. Rich, F.J. Barnes, and K. Campbell. 1997. Overstory-Imposed Heterogeneity in Solar Radiation and Soil Moisture in a Semiarid Woodland. Ecological Applications 7: 1201-1215.

Degradation of semiarid ecosystems is a major environmental problem worldwide, characterized by a reduction in the ratio of herbaceous to woody plant biomass. These ecosystems can be described as a set of canopy patches comprising woody plants and the intercanopy patches that separate them. This study tested for relationships among spatial patterns of the overstory, near-ground solar radiation, and soil moisture in a semiarid piñon-

juniper woodland in northern New Mexico that had a highly heterogeneous overstory and was not degraded with respect to ground cover and erosion rates. For near-ground solar radiation, there was spatial variation between patches (canopy < intercanopy), within patches for centers versus edges, and for north vs. south edges. For soil moisture, canopy locations were significantly drier than intercanopy locations, and edge locations were significantly wetter than center locations both overall and within both patch types. Spatial heterogeneity in soil moisture was attributed primarily to canopy interception and drip on the basis of large differences in snow cover between canopy and intercanopy locations. The spatial heterogenieties in near-ground solar radiation and soil moisture are of sufficient magnitude to affect biotic processes of woody and herbaceous plants, such as growth and seedling establishment. The results also demonstrate how the physical presence of woody canopies reinforces spatial heterogeneity in microclimate.

Chambers, J.C., E.W. Schupp, and S.B. Vander Wall. 1999. Seed Dispersal and Seedling Establishment of Piñon and Juniper Species within the Piñon-Juniper Woodland. In: Proceedings of the Workshop on Ecology and Management of Piñon-Juniper Communities within the Interior West, Prove, 9/15-18/97. S.B. Monsen and R. Stevens, eds. Pp. 29-34. Document No. RMRS-P-9. USDA Forest Service. Fort Collins.

Understanding the prehistoric and historic dynamics of piñon-juniper woodland requires knowledge of the seed dispersal mechanisms and seedling establishment requirements of the tree species. In this paper, the types and effectiveness of the different seed dispersers and the environmental requirements for seedling establishment are compared and contrasted for the various piñon and juniper species within the woodlands. The importance of long-distance vs short-distance dispersal and the role of ecotones and disturbance in woodland dynamics are discussed. Recommendations for future research are given.

Davenport, D.W., D.D. Breshears, B.P. Wilcox, and C.D. Allen. 1998. Viewpoint: Sustainability of Piñon-Juniper Ecosystems – A Unifying Perspective of Soil Erosion Thresholds. Journal of Range Management 51: 231-240.

This paper presents a conceptual model of soil erosion in piñon-juniper ecosystems that views soil erosion as a function of ground cover and site erosion potential, which is determined by climate, geomorphology, and soil erodibility. Much of the work involved in developing this model was based on studies conducted on the Pajarito Plateau.

Davenport, D.W., B.P. Wilcox, and D.D. Breshears. 1996. Soil Morphology of Canopy and Intercanopy Sites in a Piñon-Juniper Woodland. Soil Science Society of America Journal 60: 1881-1887.

Piñon-juniper woodlands in the semiarid western United States have expanded as much as fivefold during the last 150 years, often accompanied by losses of understory vegetation and increasing soil erosion. This study was conducted to determine the differences in soil morphology between canopy and intercanopy locations within a piñon-juniper woodland near Los Alamos, NM, with uniform parent material, topography and climate and a mean tree age of 135 years. Only two of the 17 morphological properties compared showed significant differences. The B horizons make up a slightly greater proportion of total profile thickness in intercanopy soils, and there are higher percentages of coarse fragments in the lower portions of canopy profiles. Canopy soils have lower mean pH and higher mean organic C than intercanopy soils. Regression analyses showed that mean soil properties did not closely correspond with tree size; but total soil thickness and B horizon thickness are significantly greater under the largest piñon trees, and soil reaction is lower under the largest juniper trees. The findings suggest that, during the period in which piñon-juniper woodlands have been expanding, the trees have had only minor effects on soil morphology.

Fresquez, P.R., J.D. Huchton, M.A. Mullen, and L. Naranjo, Jr. 2000. Radionuclides in Piñon Pine (*Pinus edulis*) nuts from Los Alamos National Laboratory Lands and the Dose from Consumption. Journal of Environmental Science and Health B35: 611-622.

*One of the dominant tree species growing within and around the eastern portion of Los Alamos National Laboratory (LANL), Los Alamos, NM, lands is the piñon pine (*Pinus edulis*).*

Piñon pine is used for firewood, fence posts, and building materials and also is a source of nuts for food. The seeds are consumed by a wide variety of animals and also are gathered by people in the area and eaten raw or roasted. This study investigated (1) the concentration of ^{3}H, ^{137}Cs, ^{90}Sr, ^{tot}U, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am in soils (0-12 in depth underneath the tree), piñon pine shoots (PPS), and piñon pine nuts (PPN) collected from LANL lands and regional background (BG) locations, (2) committed effective dose equivalent (CEDE) from the ingestion of nuts, and (3) soil to PPS to PPN concentration ratios (CRs). Most radionuclides, with the exception of ^{3}H in soils, were not significantly higher in soils, PPS, and PPN collected from LANL as compared to BG locations; and concentrations of most radionuclides in PPN from LANL have decreased over time. The maximum net CEDE (i.e., CEDE plus two sigma minus BG) at the most conservative ingestion rate (10 lb) was 0.0018 mrem. This is far below the International Commission on Radiological Protection (all pathway) permissible dose limit of 100 mrem. Soil-to-nut CRs for most radionuclides were within the range of default values in the literature for common fruits and vegetables.

Gladney, E.S., R.W. Ferenbaugh, R.G. Bowker, E.A. Jones, M.G. Bell, J.D. Morgan, E.A. Stallings, L.A. Nelson, and C. Lundstrom. 1993. An Investigation of Sulfur Concentrations in Soils and Pine Needles in Bandelier National Monument, New Mexico. Report No. LA-12417-MS. Los Alamos National Laboratory. 48 pp.

Sulfur measurements in different age groups of piñon pine needles and adjacent soil samples from ten sampling sites at Bandelier National Monument were determined using combustion elemental analysis and chromatographic techniques. The primary goal was to establish base-line levels for elemental sulfur in the Monument. Sulfur levels in foliage and soils were evaluated using analysis of variance techniques. Foliage sulfur concentrations differed significantly among the 10 sampling sites and among trees within sites; however, needles of different ages did not differ significantly in sulfur content. Average soil concentrations were very low, approximately 12% of the average needle concentrations. Soil sulfur concentrations also differed significantly among the 10 sampling sites and at different depths in the soil. No statistical differences were evident in soils sampled at the four compass points (N, E, S, W) around each tree. These differences imply that large numbers of samples are needed to identify small effects from anthropogenic inputs of sulfur into the system, or that the effects must be large relative to the differences among sampling sites and individual trees in order to be detected. Detailed tables of sulfur concentrations are presented.

Jacobs, B.F., and R.G. Gatewood. 1999. Restoration Studies in Degraded Piñon-Juniper Woodlands of North-Central New Mexico. In: Proceedings of the Workshop on Ecology and management of Piñon-Juniper Communities within the Interior West, Provo, 9/15-18/97. S.B. Monsen and R. Stevens, eds. Pp. 294-298. Document No. RMRS-P-9. USDA Forest Service. Fort Collins.

Small scale experiments were initiated in 1994 at two degraded piñon-juniper woodland sites in north-central New Mexico to evaluate the efficacy of restoration methodologies for reestablishment of native herbaceous cover. Results after three years post-treatment were highly significant. The primary effect was that overstory reduction and slash mulching treatment produced two to sevenfold increases in total herbaceous cover relative to both controls and pretreatment condition. A secondary result was that soil surface preparation and seeding treatments appeared to confer no significant benefits over the primary treatment herbaceous response.

Lin, T., P.M. Rich, D.A. Heisler, and F.J. Barnes. 1992. Influences of Canopy Geometry on Near-Ground Solar Radiation and Water Balances of Piñon-Juniper and Ponderosa Pine Woodlands. 1992. In: Proceedings of the Annual Meeting of the American Society for Photogrammetry and Remote Sensing. Pp. 285-294.

This paper discusses the influences of canopy geometry on near-ground solar radiation and water balances in piñon-juniper and ponderosa pine woodlands. The conclusion is that canopy geometry directly influences near-ground solar radiation penetration, which in turn correlates negatively with soil moisture, particularly during the summer.

Loftin, S.R. 1999. Initial Response of a Soil and Understory Vegetation to a Simulated Fuelwood Cut of a Piñon-Juniper Woodland in the Santa Fe National Forest. In: Proceedings of the Workshop on Ecology and Management of Piñon-Juniper Communities within the Interior West, Provo, 9/15-18/97. S.B. Monsen and R. Stevens, eds. Pp. 311-314. Document No. RMRS-P-9. USDA Forest Service. Fort Collins.

The Santa Fe National Forest, Española Ranger District, Bandelier National Monument, and Rocky Mountain Research Station are evaluating a treatment designed to stabilize the soils and increase the abundance of herbaceous plants in degraded piñon-juniper ecosystems. This paper discusses the results of a study in which all piñon less than 8 inches in diameter and all juniper were removed from the study site. The trees were felled, lopped, and the wood and limbs (slash) were scattered across the site. Cover of herbaceous vegetation nearly doubled on the treated site after one growing season and more than doubled after two growing seasons. Significantly higher plant species richness was recorded on the treated site. The preliminary results indicate that this could be an effective pretreatment to the reintroduction of fire.

Martens, S.N., D.D. Breshears, and C.W. Meyer. Spatial Distributions of Understory Light along the Grassland/Forest Continuum: Effects of Cover, Height, and Spatial Pattern of Tree Canopies. Ecological Modelling (in press).

Understory light was modeled over a growing season for two types of plots; (1) generated plots in which cover, spatial pattern, and height of trees were varied systematically, and (2) three actual plots using stand data from piñon-juniper woodland sites for which cover, spatial pattern, and height varied concurrently. Mean understory light decreased with increasing canopy cover and was sensitive to changes in height, as expected, but was not sensitive to spatial pattern. Variance in understory light was maximum at an intermediate value of cover that was dependent on both spatial pattern and cover – maximum variance occurred at lower values of cover as height increased and as spatial pattern progressed from regular to random to aggregated. These trends in the overall patterns of understory light were also examined with respect to changes in understory light in canopy and intercanopy locations. Variance in understory light for intercanopy locations was less than that for canopy locations at low canopy cover, but exceeded that for canopy locations as canopy cover increased. The value of canopy cover at which variance in intercanopy locations exceeded that in canopy locations was sensitive to variation in height but not in spatial pattern. The distributions of understory light for the actual plots were generally similar to those for corresponding generated plots, with dissimilarities attributable to differences in cover and height.

Martens, S.N., D.D. Breshears, C.W. Meyer, and F.J. Barnes. 1997. Scales of Above-Ground and Below-Ground Competition in a Semi-Arid Woodland Detected from Spatial Pattern. Journal of Vegetation Science 8: 655-664.

The spatial pattern of trees in a piñon pine-juniper woodland in northern New Mexico was investigated to determine if both above-ground competition (within canopy patches) and below-ground competition (between canopy patches) would be important structuring processes in these communities. Crown centers of both species were always less aggregated than stem centers at scales less than canopy patch size, indicating morphological plasticity of competing crowns. In the smallest size classes of both species, aggregation was most intense and occurred over a larger range of scales. Aggregation decreased with increasing size, as is consistent with density-dependent mortality from intraspecific competition. Within canopy patches, younger trees were associated with older trees of the other species. At scales larger than canopy patches, younger trees showed repulsion from older conspecifics, indicating below-ground competition. Hence, intraspecific competition was stronger than interspecific competition, probably because the species differ in rooting depth.

Newberry, T.L. 1999. Effect of Spatial and Temporal Variability on Water Relations and Growth in Pinyon Pine: III. Whole Tree Response. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 99-105.. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

The purpose of this study was to explore the physiological response of piñon pine to spatial and temporal variability on a whole tree level using information on physiology and growth recorded in tree-rings. The rationale of this approach is that water relations of piñon pine or any long-lived species can only be truly understood in the context of the spatiotemporal heterogeneity inherent to natural environments. This paper is the final report in the larger study of water relations in piñon pine ecosystems. This last study looks at whole-tree response to climatic variability. Water use efficiency was studied using ^{13}C measurements of tree-rings. The results indicate that water use efficiency in piñon is variable from year to year in response to the Palmer Drought Severity Index (PDSI). Precipitation plays a secondary role relative to PDSI in determining water use efficiency, especially in the summer months when evaporative demand is high. Both winter and summer PDSI are equally important in determining water use efficiencies. Winter PDSI is most likely important because the winter precipitation recharges soil water through snowfall prior to the next year's growing season. The results also suggest that the overall water use efficiency of the whole tree is a function of physiological factors such as the instantaneous response of stomata to changes in water status rather than anatomical factors such as wax layers, number of stomata, sunkenness of stomata, photosynthetic efficiency, etc. Furthermore, decreased water use efficiency due to aging of needles does not appear to be an important factor in determining the overall water use efficiency of the whole tree and the ^{13}C composition of the tree.

Nowak, R.S., D.J. Moore, and R.J. Tausch. 1999. Ecophysiological Patterns of Pinyon and Juniper. In: Proceedings of the Workshop on Ecology and Management of Piñon-Juniper Communities within the Interior West, Provo, 9/15-18/97. . S.B. Monsen and R. Stevens, eds. Pp. 35-46/

Although species that dominate on over 30 million ha may be expected to have aggressive ecophysiological traits, piñon and juniper generally are conservative in their acquisition and use of resources when measured on a per gram of foliage basis. Assimilation rates of piñon and especially of juniper are very uniform over different types and scales of environmental gradients. Although piñon and juniper often intermix, some subtle ecophysiological differences exist between the two genera that appear to influence plant distribution. These conservative ecophysiological traits help piñon and juniper dominate the landscape in two ways: first, they allow the conifers to support a much greater amount of foliage biomass than co-occurring shrubs, given the same amount of resources; and second, when coupled with distinct ecophysiological differences between juvenile and adult plants, they help piñon and juniper establish under, then tolerate, and ultimately outsize and outlive their shrub-steppe nurse plants. The primary purpose of this paper is to provide a summary review of the physiological ecology of piñons and junipers, with the ultimate goal of understanding how their ecophysiological traits may explain plant distribution, population dynamics, and the ability of these species to invade and ultimately dominate shrub communities.

Reid, K.D., B.P. Wilcox, D.D. Breshears, and L. MacDonald. 1999. Runoff and Erosion in a Piñon-Juniper Woodland: Influence of Vegetation Patches. Soil Science Society of America Journal 63:

In many semiarid regions, runoff and erosion differ according to vegetation patch type; i.e., runoff may be insignificant until vegetation is reduced to some threshold, below which there is no longer enough vegetation to facilitate infiltration. This paper reports the results of a study that evaluated runoff and erosion from the three patch types that comprise semiarid piñon-juniper woodlands: canopy patches (below woody plants), vegetated patches in intercanopy areas, and bare patches in intercanopy areas. Bare intercanopy patches exhibited the highest rates, followed by vegetated intercanopy patches and then by canopy patches. Large convective storms, though relatively infrequent, generated much of the runoff and most of the sediment. Prolonged frontal storms were capable of generating considerable runoff but little sediment. The results indicate that there are significant and important differences in runoff and sediment production from the three patch types; that bare intercanopy patches act as sources of both water and sediment for vegetated intercanopy patches; and that the transfer of water and sediment at

small scales is both frequent enough and substantial enough to be considered ecologically significant.

Roundy, B.A., and J.L. Vernon. 1999. Watershed Values and Conditions Associated with Pinyon-Juniper Communities. In: Proceedings of the Workshop on Ecology and Management of Piñon-Juniper Communities within the Interior West, Provo, 9/15-18/97. S.B. Monsen and R. Stevens, eds. Pp. 172-187. Document No. RMRS-P-9. USDA Forest Service. Fort Collins.

Piñon-juniper watersheds are important seasonal transition areas for grazing and wildlife habitat. Tree control to improve habitat and hydrologic responses have been questioned because low precipitation, high evapotranspiration, and coarse surface soils of many sites suggest that runoff, erosion, and subsurface water yield should be minimal anyway. Lack of measured data and highly variable site conditions prevent applying these generalities to all sites. Invasion sites with high soil erosion potential may quickly degrade when a small decrease in interspace vegetation cover and water storage capacity increases connectedness of runoff pathways during intense summer thunderstorms. Tree control practices that leave downed trees and debris in place and increase interspace vegetation cover may help save such sites from permanent degradation. This paper reviews the hydrology of piñon pine and juniper lands relative to their function and ecology and discusses watershed responses to vegetation manipulations as a basis for more informed management of these lands.

Wilcox, B.P. 1994. Runoff and Erosion in Intercanopy Zones of Piñon-Juniper Woodlands. Journal of Range Management 47: 285-295.

In semiarid piñon-juniper environments, the principal mechanisms of redistribution of water, sediments, nutrients, and contaminants are runoff and erosion. This paper presents the results of a two-year study on disturbed and undisturbed plots to investigate this phenomenon. Runoff accounted for a higher percentage of the water budget than observed in most other piñon-juniper woodlands, which is perhaps attributable in part to the higher elevation of the study site. Both runoff and erosion were observed to be higher from the disturbed plots, which was more evident in the summer. The study resulted in the following hypotheses. (1) Runoff amounts vary with scale, decreasing as the size of the contributing area increases and provides more opportunities for infiltration. (2) The infiltration capacity of soils is dynamic; it is closely tied to soil moisture content and/or frost conditions and is a major determinant of runoff amounts. (3) Soil erodability follows an annual cycle; it is highest at the end of the freeze-thaw period of late winter and lowest at the end of the summer rainy season when soils have been compacted by repeated rainfall.

Wilcox, B.P., and D.D. Breshears. 1995. Hydrology and Ecology of Piñon-Juniper Woodlands: Conceptual Framework and Field Studies. In: Desired Future Conditions for Piñon-Juniper Ecosystems. D.W. Shaw, E.F. Aldon, and C. LoSapio, Eds. General Technical Report No. RM-258. USDA Forest Service. Pp. 109-119.

This paper describes a conceptual framework designed to increase the understanding of water and vegetation in piñon-juniper woodlands. The framework comprises five different scales, at each of which the landscape is divided into "functional units" on the basis of hydrological characteristics. The hydrologic behavior of each unit and the connections between units are being evaluated using an extensive network of hydrological and ecological field studies on the Pajarito Plateau.

Wilcox, B.P., B.D. Newman, C.D. Allen, K.D. Reid, D. Brandes, J. Pitlick, and D.W. Davenport. 1996. Runoff and Erosion on the Pajarito Plateau: Observations from the Field. New Mexico Geological Society Guidebook. 47th Field Conference, Jemez Mountain Region. Pp. 433-440.

The major mechanism by which contaminants are moved and redistributed is surface runoff and associated soil erosion. This paper reports observations and measurements made at sites in ponderosa pine, stable piñon-juniper, and eroding piñon-juniper sites on the Pajarito Plateau. For the ponderosa pine site, both surface runoff (overland flow) and subsurface runoff (interflow) are important. Overland flow can be generated by intense summer rain storms, more gentle frontal storms, or snowmelt while soils are frozen. Interflow, although generated mostly by melting snow, can occur at any time of the year. For the piñon-juniper sites, the most important producer

of runoff is summer thunderstorms, but at all scales snowmelt runoff can be important as well. The eroding piñon-juniper site produces more runoff that the stable piñon-juniper site and hundreds of time more erosion than either the stable piñon-juniper site or ponderosa site.

Wilcox, B.P., J. Pitlick, C.D. Allen, and D.W. Davenport. 1996. Runoff and Erosion from a Rapidly Eroding Piñon-Juniper Hillslope. In: Advances in Hillslope Processes. Volume 1. M.G. Anderson and S.M. Brooks, eds. Pp. 61-77. John Wiley and Sons Ltd.

This book chapter discusses erosional effects in piñon-juniper woodlands and presents data from an ongoing study on a rapidly eroding piñon-juniper hillside in Bandelier National Monument. The long-term objectives of the study are to (1) estimate water and sediment budgets for rapidly eroding semi-arid woodlands; (2) determine the effect of 20th century vegetation change on erosion processes; (3) develop a conceptual and quantitative understanding of the relationships between runoff and erosion; and (4) determine what effect scale has on runoff and erosion in rapidly eroding semi-arid woodlands.

Ponderosa Pine Forest

Allen, C.D., and D.D. Breshears. 1998. Drought-Induced Shift of a Forest-Woodland Ecotone: Rapid Landscape Shift Response to Climate Variation. Proceedings of the National Academy of Sciences USA 95: 14839-14842.

This paper reports the most rapid landscape-scale shift of a woody ecotone ever documented. In northern New Mexico in the 1950s, the ecotone between semiarid ponderosa pine forest and piñon-juniper woodland shifted extensively (2 km or more) and rapidly (<5 years) through mortality of ponderosa pine in response to a severe drought. Forest patched within the shift zone became more fragmented, and soil erosion greatly accelerated. This shift has persisted for 40 years.

Ferenbaugh, R.W., W.D. Spall, and D.M. LaCombe. 1981. Detection of Bromacil Herbicide in Ponderosa Pine. Bulletin of Environmental Contamination and Toxicology 27: 268-273.

This paper describes an investigation into the cause of tree mortality at Los Alamos National Laboratory (LANL) during the spring and summer of 1978. Prior to this time period, bromacil herbicide(Tradename – HYVAR) was used as part of a vegetation control program along roadways at the LANL preserve. There are about 180 miles of paved roads on Laboratory property, and vegetation control is required for both safety and road surface maintenance. The prescribed bromacil application method was to spray a four-foot wide strip of bromacil solution along the edges of roadways with a spray-bar. The application rate was 2.5-5.0 lb/acre. The application usually was made in the fall of the year so that melting snow in the spring would leach the bromacil into the soil, from which it would be taken up by vegetation during the spring growing season. During the late spring and early summer of 1978, bromacil was determined to be the proximate cause of damage to numerous trees at substantial distances away from roadways at Los Alamos. Little snow fell during the winter of 1977-78. As a result, bromacil was not leached into the soil by snowmelt but was washed away from pavement edges by heavy rainfall in the spring, resulting in unanticipated treekill away from the highway. Coniferous vegetation is known to be sensitive to bromacil pesticide, and gas chromatographic analysis showed substantial bromacil concentrations in tree foliage from the affected trees.

Lin, T., P.M. Rich, D.A. Heisler, and F.J. Barnes. 1992. Influences of Canopy Geometry on Near-Ground Solar Radiation and Water Balances of Piñon-Juniper and Ponderosa Pine Woodlands. 1992. In: Proceedings of the Annual Meeting of the American Society for Photogrammetry and Remote Sensing. Pp. 285-294.

This paper discusses the influences of canopy geometry on near-ground solar radiation and water balances in piñon-juniper and ponderosa pine woodlands. The conclusion is that canopy geometry directly influences near-ground solar radiation penetration, which in turn correlates negatively with soil moisture, particularly during the summer.

Potter, L.D., and T. Foxx. 1984. Postfire Recovery and Mortality of the Ponderosa Pine Forest after La Mesa Fire. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 39-55. Report No. LA-9236-NERP. Los Alamos National Laboratory.

In the wake of all except the most severe fires, a number of trees are not killed outright but retain an unsinged portion of the crown. The health, vigor, and recovery of these trees can determine which trees should be salvaged. Accurate prediction of which trees will live is essential because these trees provide the seed source for natural regeneration. A few studies have examined postfire mortality in fire-damaged trees. One study found that trees of sawtimber size with 40% or more of the canopy singed did not survive 6 years. In another, 57% of trees with 50% or more of the crown singed were dead after 3 years, compared with 26% mortality for trees with less than 50% of the crown singed. As a result of the man-caused La Mesa fire in north-central New Mexico and a previous investigation of the fire history of several stands of ponderosa pine before La Mesa Fire, postfire mortality, as well as recovery of ponderosa pine stands two growing seasons after a fire, could be examined. Factors examined included fire history, stand density of living trees after the fire, crown damage, and competition of herbaceous vegetation.

Potter, L.D., T.S. Foxx, and F.J. Barnes. 1982. Natural Regeneration of Ponderosa Pine as Related to Land Use and Fire History on the Pajarito Plateau. Report No. LA-9293-NERP. Los Alamos National Laboratory. 26 pp.

Problems of ponderosa pine regeneration have been of concern in the Southwest for years. When sources of seeds are removed either by fire or logging, problems of regeneration become paramount. This study was designed to look at natural regeneration of ponderosa pine after the La Mesa fire as related to the various types of land management and restoration processes. The study had various aspects. (1) Using aerial photo coverage, the total area burned by the La Mesa fire was calculated and the amount of area devoid of seed trees was determined. The total acreage burned was 60.7 km^2, with a total of 21 km^2 (36.3%) devoid of seed trees. (2) Leaf water potentials (LWP) of three grass species were measured periodically. Soil samples at two sites were taken from 10, 20, 30, and 40 cm depths whenever LWP was measured. The results indicate that ponderosa pine seedlings would experience severe competition for water from sheep fescue early in the growing season and continued competition with slender wheatgrass through the summer. Mountain muhly seems to have a water usage pattern and phenology that coordinates well with known requirements for ponderosa pine seedling survival. The results indicate that artificial or natural regeneration of pine seedlings can be facilitated by seedling undercover species that will stabilize soils yet have niche requirements that are complimentary to those of regenerating tree seedlings. (3) A population of 1431 seedlings with heights of 1 to 150 cm was examined for microsite characteristics such as soil texture, litter depth, litter composition, living ground cover, phylogeny of ground cover, growth form of ground cover, vertical canopy, potential tree shade, seedling proximity, need for protective objects, relation to trees, distance to trees, slope, and slope direction. The best ponderosa pine seedling survival was in fine soils; that is, conifer litter less than 1 cm, sparse ground cover and some shade, or ground cover of bearberry or mountain muhly and no shade. Overhead canopy or proximity to protective objects is not required. There was a high association of the common native grass mountain muhly and bearberry. The relationship through which bearberry acts as a nurse plant should be investigated.

Touchan, R., C.D. Allen, and T.W. Swetnam. 1996. Fire History and Climatic Patterns in Ponderosa Pine and Mixed-Conifer Forests of the Jemez Mountains, Northern New Mexico. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 33-46. General Technical Report No. RM-GTR-286. USDA Forest Service.

The fire history in ponderosa pine and mixed conifer forests across the Jemez Mountains in northern New Mexico was reconstructed by collecting fire-scarred samples from ten ponderosa pine areas and three mesic, mixed-conifer areas. Prior to 1900, ponderosa pine forests were characterized by high frequency, low intensity surface fire regimes. The mixed-conifer stands sustained somewhat less frequent surface fires, along with patchy crown fires. The associations between past fires and winter-spring precipitation also were examined. In both ponderosa pine and mixed-conifer forests, precipitation was significantly reduced in the winter-spring period

immediately prior to fire occurrence. In addition, winter-spring precipitation during the second year preceding major fire years was significantly increased in the ponderosa pine forest. The results of this study provide baseline knowledge concerning the ecological role of fire in ponderosa pine and mixed-conifer forests. This information is vital to support ongoing ecosystem management efforts in the Jemez Mountains.

Wilcox, B.P., B.D. Newman, D. Brandes, D.W. Davenport, and K. Reid. 1997. Runoff from a Semiarid Ponderosa Pine Hillslope in New Mexico. Water Resources Research 33: 2301-2314.

This paper reports the results of a 4-year study investigating runoff processes in semiarid regions. The results indicate that lateral subsurface flow is a major mechanism of runoff generation. The major generation mechanisms of surface runoff are intense summer thunderstorms, prolonged frontal storms, and snowmelt over frozen soils. At the ponderosa pine site investigated, surface runoff appeared as infiltration-excess overland flow; but this type of surface runoff does not dominate at other ponderosa pine sites.

Previous Annotated Bibliographies

Bennett, K.D. 1990. Annotated Bibliography of Geologic, Hydrogeologic, and Environmental Studies Relevant to Solid Waste Management Units at Los Alamos National Laboratory. Report No. LA-UR-90-3216. Los Alamos National Laboratory.

This annotated bibliography was prepared in 1989 as one of the special conditions for the Hazardous and Solid Waste Amendments (HSWA) permit that was issued to the Laboratory for implementation of the Environmental Restoration Project. It was presented to EPA Region 6 in 1990 to fulfill the HSWA permit requirement. It was an attempt to compile a comprehensive annotated bibliography of all publications that might contain information relevant to the potential release sites being investigated under Environmental Restoration Project auspices.

Brashar, L.R., A.R. Loyal, K.D. Bennett, and R.W. Ferenbaugh. 1996. Annotated Bibliography of Environmental and Geohydrological Studies. Report No. LA-UR-96-2907. Los Alamos National Laboratory. 475 pp.

This annotated bibliography was prepared as part of the Laboratory's effort to compile information relevant to the preparation of the Laboratory Site-Wide Environmental Impact Statement (SWEIS). It contains an annotated bibliography of environmental and geohydrological reports, publications, and other information sources pertinent to the environmental setting of the Laboratory. It incorporates a previous annotated bibliography of environmental and geohydrological information published as Laboratory Report Number LA-UR-90-3216, which was prepared as one of the special conditions for the Hazardous and Solid Waste Amendments (HSWA) permit that was issued to the Laboratory for implementation of the Environmental Restoration Project. This bibliography is available as an ACCESS electronic database that is searchable by author, title, or keyword. The electronic database is archived in ESH-20, the Laboratory's Ecology Group.

Sandia Canyon

Bennett, K. 1994. Aquatic Macroinvertebrates and Water Quality in Sandia Canyon. Report No. LA-12738-MS. Los Alamos National Laboratory Report. 24 pp.

In 1990, field studies were initiated in Sandia Canyon to establish baseline data for water quality and stream macroinvertebrate communities. The studies were designed to establish baseline data and to determine the effects of routine discharges of industrial and sanitary waste. Stations where the stream routinely receives industrial and sanitary waste effluents exhibited a low diversity of macroinvertebrates and slightly degraded water quality. The downstream station, located approximately 0.4 km downstream of the nearest wastewater outfall, appeared to be in a zone of recovery where the water quality parameters more closely resembled those found in natural streams in the Los Alamos area. A large increase in macroinvertebrate diversity also was observed at the downstream station.

Bennett, K., and J. Biggs. 1996. Small Mammal Study of Sandia Canyon, 1994 and 1995. Report No. LA-13199-MS. Los Alamos National Laboratory. 25 pp.

A wide range of plant and wildlife species utilize water discharged from facilities at Los Alamos National Laboratory (LANL). The purpose of this study was to gather baseline data on small mammal populations and to compare small mammal characteristics (species diversity and composition, small mammal density, biomass, physical characteristics, and lean body mass) within three areas of Sandia Canyon (a canyon that receives outfall effluents from multiple sources). The head of Sandia Canyon is near the University House in TA-3 at LANL. Three small mammal trapping webs were placed in the upper portion of Sandia Canyon. The first two webs were centered within a cattail-dominated marsh with a ponderosa pine overstory, and the third web was placed in a transition area with a ponderosa pine overstory. The third area was much drier that the habitat surrounding the first two webs and is more riparian than marsh in nature. Capture-recapture trapping of small mammals occurred for 1-2 weeks. Webs 1 and 2 had the highest species diversity indices, with deer mice the most commonly captured species in all webs. However, at Web 1, voles, shrews, and harvest mice, species more commonly found in moist habitats, made up a much greater overall percentage (65.6%) than did deer mice and brush mice. The highest densities and biomass of animals were found in Web 1, with a continual decrease in density estimates in each web downstream. Results demonstrate that there is no statistical difference between the mean body weights of deer mice and brush mice among the webs. Length also was determined not to be statistically different among the webs. Furthermore, no statistical difference among webs was found for the lean body masses of deer and brush mice. Additional monitoring studies should be conducted in Sandia Canyon so that comparisons over time can be made. In addition, rodent tissues should be sampled for contaminants and then compared to background or control populations elsewhere at the Laboratory or at an off-site location.

Bennett, K., J. Biggs, and G. Gonzales. 1999. Evaluation of PCB Concentrations in Archived Small Mammal Samples from Sandia Canyon. Report No. LA-UR-99-5891. Los Alamos National Laboratory. 35 pp.

Archived small mammal samples (vole, harvest mouse, vagrant shrew, and deer mouse) from Sandia Canyon comprised of adipose tissue and internal organs from 1995 (30 samples) and 1996 (34 samples) were analyzed for PCB mixtures known as Aroclors. During the summer of 1998, 30 samples from a reference site in the Jemez Mountains were analyzed for 7 PCBs. Nine samples from 1995 and 19 samples from 1996 had detectable or estimated concentrations of Aroclor 1260, whereas no samples from the reference site had detectable levels. Preliminary evaluation of the data indicates that the maximum levels of Aroclor 1260 detected approached minimum levels for which effects have been noted.

Cross, S. 1994. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory: December 1992-October 1993. Report No. LA-12734-SR. Los Alamos National Laboratory. 38 pp.

This report summarizes the results of water quality and macroinvertebrate diversity in Sandia Canyon during 1993 as a followup to the results reported for 1990 in Report No. 12738 by K. Bennett. During 1993, five stations were sampled in the canyon. The two uppermost stations are located near outfalls that discharge industrial and sanitary waste effluent. The third station is located in a natural cattail marsh located about 0.4 km downstream of the uppermost stations. Two additional stations were located further downstream. Water quality parameters at the upper three stations are different from those of natural streams, suggesting degraded water quality. The macroinvertebrate communities exhibit low diversity and poorly-developed community structures. The two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams in the area, macroinvertebrate diversity increases, and community structure becomes more complex.

Cross, S. 1995. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory, November 1993 to October 1994. Report No. LA-12971-SR. Los Alamos National Laboratory. 58 pp.

This report summarizes the results of water quality and macroinvertebrate diversity investigations in Sandia Canyon during 1994 as a followup to previous investigations in 1990 (LA-12738-MS) and 1993 (LA-12734-SR). During 1994, five stations were sampled in the canyon. The two upstream stations are located below outfalls that discharge industrial and sanitary waste effluent into the stream, thereby maintaining year-round flow. Some water quality parameters are different at the first three stations from those expected of natural streams in the area, indicating degraded water quality resulting from effluent discharges. The aquatic habitat at the upper stations has also been degraded by sedimentation and channelization. The macroinvertebrate communities at these stations are characterized by low diversities and unstable communities. In contrast, the two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams of the area. The two lower stations have increased macroinvertebrate diversity and stable communities, further indications of downstream water quality improvement.

Cross, S., and H. Nottelman. 1996. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory 1995. Report No. LA-UR-96-3684. 59 pp.

This report updates and expands previous aquatic studies in Sandia reported by Bennett and Cross. Water quality data and aquatic macroinvertebrate samples were collected monthly at three sampling stations in Sandia Canyon during 1995. The two upstream stations occur near a cattail marsh downstream from outfalls that discharge industrial and sanitary waste effluent. The third station is approximately 1.5 miles downstream in a mixed conifer forest. All water quality parameters measured during 1995 fell within acceptable State limits and scored in the good or excellent range when compared to an Environmental Quality Index. However, aquatic macroinvertebrate habitats have been degraded by widespread erosion, channelization, loss of wetlands due to deposition and stream lowering, scour, limited acceptable substrates, LANL releases and spills, and other stressors. The stream continues to be threatened by erosion and potential landslides from the Los Alamos County landfill whose towering sides of loose fill material are perched at a 45^{o} angle above the northern edge of the entire Sandia Canyon wetlands. Macroinvertebrate communities at all of the stations had low diversities, low densities, and erratic numbers of individuals. These results indicate that, although the stream possess acceptable water chemistry, it has reduced aquatic biota. The best developed aquatic community occurs at the sampling station with the best habitat and whose downstream location partially mitigates the effects of upstream impairments.

Fevig, R., M.G. Bell, M.F. Brown, R.W. Ferenbaugh, C.R. Richardson, and R.H. Goldie. 1990. Class C Investigative Report for the Accidental Release of Sulfuric Acid (H_2SO_4) at TA-3-22, May 19-21, 1990. Report No. HSE 90-2. Los Alamos National Laboratory.

A release of approximately 1400 gallons of concentrated (97-98%) sulfuric acid from the TA-3-22 Power Plant into Sandia Canyon occurred on or about May 20, 1990. Although there were no reportable injuries to personnel from this incident and the report deals primarily with the investigation of how the accident occurred, Appendix G of the report briefly addresses the ecological situation in Sandia Canyon.

Small Mammal Studies

Bennett, K., and J. Biggs. 1996. Small Mammal Study of Sandia Canyon, 1994 and 1995. Report No. LA-13199-MS. Los Alamos National Laboratory. 25 pp.

A wide range of plant and wildlife species utilize water discharged from facilities at Los Alamos National Laboratory (LANL). The purpose of this study was to gather baseline data on small mammal populations and to compare small mammal characteristics (species diversity and composition, small mammal density, biomass, physical characteristics, and lean body mass) within three areas of Sandia Canyon (a canyon that receives outfall effluents from multiple sources). The head of Sandia Canyon is near the University House in TA-3 at LANL. Three small mammal trapping webs were placed in the upper portion of Sandia Canyon. The first two webs were centered within a cattail-dominated marsh with a ponderosa pine overstory, and the third web was placed in a transition area with a ponderosa pine overstory. The third area was

much drier that the habitat surrounding the first two webs and is more riparian than marsh in nature. Capture-recapture trapping of small mammals occurred for 1-2 weeks. Webs 1 and 2 had the highest species diversity indices, with deer mice the most commonly captured species in all webs. However, at Web 1, voles, shrews, and harvest mice, species more commonly found in moist habitats, made up a much greater overall percentage (65.6%) than did deer mice and brush mice. The highest densities and biomass of animals were found in Web 1, with a continual decrease in density estimates in each web downstream. Results demonstrate that there is no statistical difference between the mean body weights of deer mice and brush mice among the webs. Length also was determined not to be statistically different among the webs. Furthermore, no statistical difference among webs was found for the lean body masses of deer and brush mice. Additional monitoring studies should be conducted in Sandia Canyon so that comparisons over time can be made. In addition, rodent tissues should be sampled for contaminants and then compared to background or control populations elsewhere at the Laboratory or at an off-site location.

Bennett, K., J. Biggs, and P. Fresquez. 1996. Radionuclide Contaminant Analysis of Small Mammals, Plants and Sediments within Mortandad Canyon, 1994. Report No. LA-13104-MS. Los Alamos National Laboratory. 31 pp.

Small mammals, plants, and sediments were sampled at one upstream location (Site 1) and two downstream locations (Sites 2 and 3) from NPDES outfall #051-051 in Mortandad Canyon. The purpose of the sampling was to identify radionuclides potentially present, to quantitatively estimate and compare the amount of radionuclide uptake at specific locations (Sites 2 and 3) as compared to the upstream site (Site 1), and to identify the primary mode (inhalation/ingestion or surface contact) of contamination to small mammals. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were analyzed separately. In addition, three composite samples also were collected for plants and sediments at each site. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, and total U. With the exception of total U, all mean radionuclide concentrations in small mammal carcasses and sediments were significantly higher at Site 2 than at Site 1 or Site 3. No differences were detected in the mean radionuclide concentration of plant samples between sites. However, some radionuclide concentrations found at all three sites were higher than regional background. No differences were found between mean carcass radionuclide concentrations and mean pelt radionuclide concentrations, indicating that the two primary modes of contamination may be occurring equally.

Bennett, K., J. Biggs, and P. Fresquez. 1997. Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, Los Alamos National Laboratory, 1995. Report No. LA-13242-MS. Los Alamos National Laboratory. 20 pp.

Small mammals were sampled at two waste burial sites (Site 1 – recently disturbed and Site 2 – partially disturbed) at Area G, Technical Area 54 and a control site on Frijoles Mesa (Site 4) in 1995. The objectives were 1) to identify radionuclides that are present within surface and subsurface soils, 2) to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and 3) to identify if the primary mode of contamination to small mammals is by surface contact or ingestion/inhalation. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, ^{137}Cs, and ^{3}H. Significantly higher levels of total U, ^{241}Am, ^{238}Pu, and ^{239}Pu were detected in pelts than in carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in pelts. The results generally show higher concentrations in pelts compared to carcasses, which is similar to what has been found at waste burial/contaminated sites outside of LANL. Site 1 had a significantly higher mean tritium concentration in both carcasses and pelts than Sites 2 or 4. Site 2 had a significantly higher mean ^{239}Pu concentration in carcasses than Sites 1 or 4.

Bennett, K.D., J.R. Biggs, and P.R. Fresquez. 1998. Radionuclide Contaminant Analysis of Small Mammals at Area G, Technical Area 54, 1997 (with cumulative summary 1994-1997). Report No. LA-13517-MS. Los Alamos National Laboratory. 18 pp.

In 1997, small mammals were sampled to four locations at Area G, Technical Area 54, a control site within the proposed Area G expansion area, and a background site on Frijoles Mesa. The purpose of the sampling was to (1) identify radionuclides that are present within rodent tissues at waste burial sites, (2) compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and (3) identify the primary mode of contamination to small mammals, either through surface contact or through ingestion/inhalation. Three composite samples of approximately five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, ^{137}Cs, and ^{3}H Higher levels of total U and ^{137}Cs were detected in pelts as compared to carcasses of small mammals, and ^{90}Sr was found to be higher in carcasses. Concentrations of other measured radionuclides in carcasses were not found to be statistically different from concentrations in pelts. However, pelts generally had higher concentrations than carcasses, indicating that surface contamination may be the primary contamination mode. Low sample sized in total number of animals captured during 1997 prevented statistical analysis to compare site to site for all but four sites. Mean concentrations of ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{3}H in small mammal carcasses were found to be statistically greater at the transuranic (TRU) waste pad #2. In addition, mean concentrations of total U, ^{241}Am, and ^{3}H in pelts of small mammals also were statistically greater. The control site and background site consistently had the lowest mean concentrations of radionuclides. Year to year comparison of mean radionuclide concentrations was conducted where sufficient sample size existed. Mean concentrations of ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{3}H in carcasses were statistically greater in 1997 than in previous years at TRU waste pad #2. However, mean concentrations of ^{137}Cs in small mammal carcasses were higher at the TRU waste pad #2 and at Pits 17 and 18 during 1996.

Bennett, K., J. Biggs, and G. Gonzales. 1999. Evaluation of PCB Concentrations in Archived Small Mammal Samples from Sandia Canyon. Report No. LA-UR-99-5891. Los Alamos National Laboratory. 35 pp.

Archived small mammal samples (vole, harvest mouse, vagrant shrew, and deer mouse) from Sandia Canyon comprised of adipose tissue and internal organs from 1995 (30 samples) and 1996 (34 samples) were analyzed for PCB mixtures known as Aroclors. During the summer of 1998, 30 samples from a reference site in the Jemez Mountains were analyzed for 7 PCBs. Nine samples from 1995 and 19 samples from 1996 had detectable or estimated concentrations of Aroclor 1260, whereas no samples from the reference site had detectable levels. Preliminary evaluation of the data indicates that the maximum levels of Aroclor 1260 detected approached minimum levels for which effects have been noted.

Biggs, J. 1995. Small Mammal Population Studies for Ecological Risk Assessments. In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 255-270. Report No. LA-13065-MS. Los Alamos National Laboratory.

The primary purpose of collecting small mammal data in Guaje and Los Alamos Canyons was to obtain sufficient information to estimate population size, density, and species diversity. Trapping sites were located in mixed conifer, ponderosa pine, and a transition zone between the two. Very poor capture rates were experienced during two years of trapping in 1993 and 1994. Deer mice were captured in all trapping locations except middle Los Alamos Canyon. Shrews and voles were captured only in the upper locations in each canyon, and deer mice and a small number of harvest mice were the only species captured in the ponderosa pine habitat of the lower portions of each canyon. The upper portions of the canyon systems had a much higher species diversity and a much greater number of captures compared to the lower areas, resulting in higher population estimates and densities in those locations. The relative percentage of males was much higher than females, but overall mean body weights appeared similar. The overall species diversity was similar for both canyons.

Biggs, J., K. Bennett, T. Foxx, M. Salisbury, E. Pacheco, L. Payne, A. Banar, D. Raymer, T. Haarmann, D. Keller, and D. Dunham. 1995. Hantavirus Testing in Small Mammal Populations of Northcentral New Mexico. Report No. LA-12966-MS. Los Alamos National Laboratory. 16 pp.

In 1993 and 1994, blood samples were collected from small mammal populations in Los Alamos County and analyzed for seroprevalence of hantavirus by the University of New Mexico School of Medicine. The deer mouse was the most commonly captured species, but other species sampled included harvest mice, least chipmunk, long-tailed vole, Mexican woodrat, and brush mouse. The 1993 and 1994 hantavirus testing identified a total overall seroprevalence of approximately 5.5% and 4.2%, respectively. The highest seroprevalence rates were found in deer mice, but results on several species were inconclusive.

Biggs, J., K. Bennett, and P. Fresquez. 1995. Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, 1994. Report No. LA-13015-MS. Los Alamos National Laboratory. 34 pp.

Small mammals were sampled at two waste burial sites (1 and 2) at Area G, TA-54 and a control site outside Area G (Site 3) to identify radionuclides that are present within surface and subsurface soils at waste burial sites, to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and to identify the primary mode of contamination to small mammals, either through surface contact or ingestion/inhalation. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, and gamma spectroscopy (including ^{137}Cs). Significantly higher levels of total U, ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{40}K were detected in pelts as compared to the carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in the pelts. The results show higher concentrations in pelts than in carcasses, which is similar to what has been found at waste burial/contaminated sites outside of Los Alamos National Laboratory. Site 1 had significantly higher total U concentrations in carcasses than Sites 2 and 3. Site 2 had significantly higher ^{239}Pu concentrations in carcasses than either Site 1 or Site 3. A significant difference in ^{90}Sr concentration existed between Sites 1 and 2, and concentrations of ^{40}K at Site 1 were significantly different from Site 3.

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1997. Radionuclide Contaminant Analysis of Small Mammals at Area G, Technical Area 54, 1996 (with cumulative summary for 1994-1996). Report No. LA-13345-MS. Los Alamos National Laboratory. 16 pp.

Small mammals were sampled at two waste burial sites at Area G and a control site within the proposed Area G expansion to (1) identify radionuclides that are present within rodent tissues at waste burial sites, (2) to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and (3) to identify the primary mode of contamination to small mammals, either through surface contact or ingestion/inhalation. Pelts and carcasses of each animal were separated and analyzed independently for several radionuclides. Higher levels of total U, Am-241, Pu-238, and Pu-239 were detected in pelts. Concentrations of other measured radionuclides were nearly equal in pelts and carcasses. Due to low sample sizes, statistical site to site comparisons could not be conducted.

Biggs, J., K. Bennett, and M. Martinez. 1997. A Checklist of Mammals Found at Los Alamos National Laboratory and Surrounding Areas. Report No. LA-UR-97-4786. Los Alamos National Laboratory. 13 pp.

This report presents an annotated checklist of mammals of Los Alamos National Laboratory compiled from numerous biological surveys and studies conducted on and adjacent to Laboratory property. The checklist also includes species that are known to occur on adjacent properties, such as Bandelier National Monument and Santa Fe National Forest. However, there may be additional species that are not listed. The draft list of species that was prepared from LANL ESH-20 and other surveys was checked against the Biological Information System of New Mexico (BISON-M) developed by the New Mexico Department of Game and Fish. Some species on the draft list were not identified in the BISON-M database as occurring in Los Alamos County.

However, this is to be expected, as reports from only a few of the wildlife studies conducted at LANL have been readily available outside of the Laboratory.

Biggs, J.R., K.D. Bennett, M.A. Mullen, T.K. Haarmann, M. Salisbury, R.J Robinson, D. Keller, N. Torrez-Martinez, and B. Hjelle.
1.) 1998. Relationship of Ecological Variables to Sin Nombre Virus Antibody Seroprevalence in Deer Mouse Populations. Report No. LA-UR-98-519. Los Alamos National Laboratory.
2.) 2000. Relationship of Ecological Variables to Sin Nombre Virus Antibody Seroprevalence in Populations of Deer Mice. Journal of Mammalogy 81: 676-682.

*Because recent studies have not demonstrated a strong relationship between rodent density and Sin Nombre virus (SNV) seroprevalence, there is speculation that seroprevalence may be related to other factors, including habitat quality and food availability. Densities of deer mice (*Peromyscus maniculatus*), plant cover and biomass, and terrestrial arthropod biomass at two sites in the southwestern United States were evaluated to identify factors that might affect the seroprevalence rate of SNV within a rodent population. Seroprevalence differed significantly between years. Although interaction of deer mouse density, plant cover and biomass, and arthropod biomass was not a strong predictor of seroprevalence, a significant contribution to a repeated-measures model by deer mouse density was observed. The data suggest that as rodent density increases, so does the seroprevalence rate within that population. Although not significantly correlated, the lowest levels of arthropod biomass were observed when seroprevalence was highest. Based on these results, evaluating changes in habitat quality and incorporating measurement of local ecological variables with studies of fluctuations in rodent density may aid in predicting human outbreaks of hantavirus disease.*

Biggs, J., K. Bennett, M. Salisbury, D. Keller, E. Pacheco, and L. Payne. 1996. Hantavirus Testing in Rodents of North-Central New Mexico 1993-1995. Report No. LA-13136-MS. Los Alamos National Laboratory. 15 pp.

In 1993, 1994, and 1995, blood samples were taken from small mammal populations in Los Alamos County and analyzed to determine seroprevalence of hantavirus in this region. The deer mouse was the most commonly captured species at all locations except one where voles were predominant. Other species samples included harvest mice, woodrats, shrews, white-footed mice, piñon mice, and brush mice. Results of the 1993, 1994, and 1995 testing showed total overall seroprevalence rates among deer mice of approximately 5.5%, 4.2%, and 0%, respectively. Several other species tested positive for hantavirus, but it is uncertain if it is Sin Nombre virus. Higher seroprevalence rates were found in males than females. Seroprevalence rates for Los Alamos County were much lower than elsewhere in the region.

Biggs, J.R., K.D. Bennett, N. Torrez-Martinez, and B.L. Hjelle. 2000. Sin Nombre Virus Antibody Prevalence in Rodents of North-Central New Mexico. The Southwestern Naturalist 45: 61-66.

*From 1993 to 1998, the Biology Team at Los Alamos National Laboratory surveyed small mammal populations in north-central New Mexico using live capture-recapture methods to determine hantavirus seroprevalences. Deer mice (*Peromyscus maniculatus*), western harvest mice (*Reithrodontomys megalotis*), white-footed mice (*P. leucopus*), and voles (*Microtis *sp.) tested positive for hantavirus. A decreasing trend in seroprevalence of deer mice from 1993 to 1995-1996 was observed, but there was an increasing trend in voles. Seroprevalences and deer mouse density were not correlated and varied substantially at sampling locations. Therefore, microhabitat (i.e., cover, food availability) should be more closely examined as to its relationship with hantavirus in rodent populations.*

Biggs, J., M. Mullen, and K. Bennett. 1999. Development and Application of a Habitat Suitability Ranking Model for the New Mexico Meadow Jumping Mouse (*Zapus hudsonium luteus*). Report No. LA-13659-MS. Los Alamos National Laboratory. 16 pp.

The New Mexico meadow jumping mouse currently is listed as a state-threatened species in New Mexico and has been identified as potentially occurring within the Los Alamos National Laboratory boundary. This report describes the development of a model to identify and rank habitat at LANL that may be suitable for occupation by this species. The model calculates a

habitat suitability ranking based on total plant cover, plant species composition, total number of plant species, and plant height. Input data for the model is based on the measurement of these variables to known locations where this species has been found in the Jemez Mountains. Model development included the selection of habitat variables, developing a probability distribution for each variable, and applying weights to each variable based on its overall importance in defining the suitability of the habitat. Based on the probability values and weighting factors, Habitat Suitability Ranking (HSR) values are calculated. Once calculated, The HSR values are placed into one of four habitat categorical groupings by which management strategies are applied.

Gonzales, G.J., M.T. Saladen, and T.E. Hakonson. 1995. Effects of Pocket Gopher Burrowing on Cesium-133 Distribution on Engineered Test Plots. Journal of Environmental Quality 24: 1056-1062.

A field study on the surface and subsurface erosional transport of surface-applied ^{133}Cs as affected by pocket gopher burrowing was conducted on simulated waste landfill caps at the Los Alamos National Laboratory in north central New Mexico. Surface loss of Cs, adhered to five soil particle size ranges, was measured several times over an 18-month period while simulated rainfalls were in progress. Gophers reduced Cs surface loss by significant amounts, 43%. Cesium surface loss on plots with only gophers was 0.8 kg total for the study period. This compared with 1.4 kg for control plots, 0.5 kg for vegetated plots, and 0.2 kg for plots with both gophers and vegetation. Relatively little subsurface Cs was measured in plots containing only gophers (0.7 g/kg). Vegetation-bearing plots had significantly more total subsurface Cs (1.7 g/kg) than plots without vegetation (0.8 g/kg). An average of 97% of the subsurface Cs in plots with vegetation was located in the upper 15 cm of soil compared with 67% for plots without vegetation. Vegetation moderated the influence of gopher activity on the transport of Cs to soil subsurfaces and stabilized subsurface Cs by concentrating it in the rhizosphere. Gopher activity may have caused Cs transport to depths below that sampled, 30 cm. The results provide distribution coefficients for models of contaminant migration where animal burrowing occurs.

Guthrie, D.A. 1984. Effects of Fire on Small Mammals within Bandelier National Monument. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 115-134. Report No. LA-9236-NERP. Los Alamos National Laboratory.

*A study of the effects of fire and subsequent plant succession on small-mammal populations within Bandelier National Monument began in June of 1977. The locations and sizes of past fires within the Monument were obtained from Monument personnel, and trapping grids were planned for the largest burns. Soon after the start of this project, La Mesa Fire occurred, burning much of the Monument, including most previous burn areas. Those sites not reburned by La Mesa Fire were, in general, too small (less than 1 acre) for any differences in mammal populations independent of edge effects to be observed. Consequently, the study was redirected to an examination of the effects of La Mesa Fire on small mammal populations. This report on the initial changes in small-mammal populations after the fire is based on work during the summers of 1977, 1978, and 1979. The immediate effect of La Mesa Fire on small-mammal populations was to reduce populations of nonburrowing species within the fire area, particularly arboreal forms such as red squirrel. Most burrowing rodents survived the fire. Changes in vegetation after the fire, for example, greater development of grasses and annual plants and the death of many evergreens, caused changes in small-mammal populations within the burn area. Populations of species heavily dependent upon evergreens decreased (red squirrel in ponderosa and fir and piñon mouse in piñon-juniper). Species increasing in population were the deer mouse, which increased in all burned areas. Populations of meadow mice (*Microtus montanus *and* M. longicaudis*, the latter at higher elevations) also increased in grassy areas. Finally, chipmunks showed increases in ponderosa and fir zones. Because of seasonal changes, all rodent populations undergo periodic population decreases. Therefore, little change in carnivore populations can be expected. Also, these seasonal decreases should keep rodent populations from overeating food supplies or affecting reseeding or reforestation efforts.*

Hakonson, T.E. 1999. The Effects of Pocket Gopher Burrowing on Water Balance and Erosion from Landfill Covers. Journal of Environmental Quality 28: 659-665.

This paper reports the results of a two-year field study to evaluate the impact of burrowing and soil casting by pocket gophers on runoff, soil loss, soil moisture status, and transport of surface-applied cesium 133. The presence of surface castings decreased erosion and runoff and increased infiltration. Vegetation also decreased runoff, erosion, and concomitant cesium loss. Both vegetation and gophers enhanced movement of cesium into the soil. The effects of gopher burrowing on degradation of waste covers were minimal when vegetation was a component of the cover.

Hakonson, T.E., J.L. Martinez, and G.C. White. 1982. Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers. Health Physics 42(6): 868-871.

Biological intrusion of low-level waste sites has been identified as a potential problem in isolating waste radionuclides for extended periods of time. Studies on current and decommissioned low-level waste sites in the western United States have shown that radionuclides present in the waste can be mobilized by plant roots and burrowing animals that penetrate through the waste covers. Biological activity also can modify chemical and physical processes within the soil profile. For example, burrowing animals can change the rates of water infiltration and surface soil erosion. This paper presents the results of a study to characterize the amount of disturbance of a low-level waste cover resulting from the burrowing activities of pocket gophers. Data are presented on the amount of soil excavated from the cover profile, the amount of tunnel system created by these soil mining activities, and the particle size distribution and radionuclide content of the cast soil. The results of the study indicate that the amount of soil brought to the surface of low-level waste sites is small relative to the volume of cover material. However, the void space created by the burrowing activity represents a substantial network of tunnel system within the waste cover profile. The effects that plants and animals have in altering the soil profile must be considered in developing reclamation procedures that have long term effectiveness.

Hansen, L.A., P.R. Fresquez, R.J. Robinson, J.D. Huchton, and T.S. Foxx. 1999. Medium-Sized Mammals around a Radioactive Liquid Waste Lagoon at Los Alamos National Laboratory: Uptake of Contaminants and Evaluation of Radio-Frequency Identification Technology. Report No. LA-13660-MS. Los Alamos National Laboratory. 29 pp.

*Use of a radioactive waste lagoon by medium-sized mammals and levels of tritium, other selected radionuclides, and metals in biological tissues of the animals were documented at TA-53 at Los Alamos National Laboratory during 1997 and 1998. Rock Squirrel (*Spermophilus variegatus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and bobcat (*Lynx rufus*) were captured both at TA-53 and at a control site in the Santa Fe National Forest. Captured animals were anesthetized and marked with radiofrequency identification (RFID) tags and/or ear tags. Urine and hair samples were collected and analyzed for tritium and metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and thallium). In addition, muscle and bone samples from two rock squirrels collected from each of TA-53, perimeter, and regional background sites were analyzed for tritium, ^{137}CS, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and total uranium. Animals at TA-53 were monitored entering and leaving the lagoon area using an RFID monitor to read identification numbers from the tags of marked animals and a separate camera system to photograph all animals passing through the monitor. Cottontail Rabbit (*Sylvilagus *spp), rock squirrel, and raccoon were the species most frequently photographed going through the RFID monitor. Male and female rock squirrels from the lagoon area had significantly higher tritium concentrations compared to rock squirrels from the control area. Metal concentrations were not significantly higher in rock squirrels from TA-53, although there was a trend toward increased levels of lead in some individuals. Muscle and bone samples from squirrels in the lagoon area appeared to have higher levels of tritium, total uranium, and ^{137}Cs than samples collected from perimeter and background locations. However, the committed effective dose equivalent estimated from the potential human consumption of the muscle and bone tissue from these rock squirrels did not suggest any human health risk. Indirect routes of tritium uptake, possibly through consumption of vegetation, are important for animals in the lagoon area.*

Hanson, W.C., and F.R. Miera, Jr. 1976. Long-Term Ecological Effects of Exposure to Uranium. Report No. LA-6269. Los Alamos Scientific Laboratory. 34 pp.

The consequences of releasing natural and depleted uranium to terrestrial ecosystems during development and testing of depleted uranium munitions were investigated. Two explosives-testing areas at the Los Alamos Scientific Laboratory (LASL) were selected because of their use history. E-F Site soil averaged 2400 ppm of uranium in the upper 5 cm and 1600 ppm at 5-10 cm. Lower Slobbovia Site soil from two subplots averaged about 2.5 and 0.6% of the E-F Site concentrations. Important uranium concentration differences with depth and distance from detonation points were ascribed to the different explosive tests conducted in each area. E-F site vegetation samples contained about 320 ppm of uranium in November 1974 and about 125 ppm in June 1975. Small mammals trapped in the study areas in November contained a maximum of 210 ppm of uranium in the gastrointestinal tract contents, 24 ppm in the pelt, and 4 ppm in the remaining carcass. In June, maximum concentrations were 110, 50, and 2 ppm in similar samples and 6ppm in lungs. These data emphasize the importance of resuspension of respirable particles in the upper few millimeters of soil as a contamination mechanism for several components of the LASL ecosystem.

Hanson, W.C., and F.R. Miera, Jr. 1978. Further Studies of Long-Term Ecological Effects of Exposure to Uranium. Report No. LA-7162. Los Alamos Scientific Laboratory. 26 pp.

Soils, small mammals, and invertebrates were sampled at E-f Site for uranium analysis. Spatial variability in sampling for soil uranium distribution by a polar coordinate system was evaluated in randomly selected soil cores. Uranium concentrations in tissues of deer mice and pocket gophers was sufficiently different to conclude that the greater bioavailability of uranium in the top few millimeters of soil, combined with the difference in grooming and food habits of the animals, resulted in greater contamination of deer mice than pocket gophers. There was no conclusive evidence of a differential response of invertebrate populations to areas of relatively high uranium concentrations and to control areas.

Miera, F.R., Jr. 1980. Measurements of Uranium in Soils and Small Mammals. Report No. LA-8624-T. Los Alamos Scientific Laboratory. 42 pp. (M.S. Dissertation, New Mexico Highlands University)

The objective of this study was to evaluate the bioavailability of uranium to a single species of small mammal, white-footed deer mouse, from two different source terms: a Los Alamos National Laboratory dynamic weapons testing site in north central New Mexico, where an estimated 70,000 kg of uranium were expended over a 31-yr period; and an inactive uranium mill tailings pile located in west central New Mexico near Grants, which received wastes over a 5-yr period from the milling of $2.7x10^9$ kg of uranium ore. Uranium concentrations were generally higher in all small mammal tissue groupings for the LANL site when compared to values obtained for tissue samples from the mill tailings study area. Gastrointestinal and pelt sample uranium concentrations were significantly different from internal tissue values for both sites. Perhaps one of the more significant findings was that median uranium concentrations in kidneys of mice from the mill tailings study area were six times greater and significantly different from values for other internal tissues. This was not detected at the LANL study area. Low uranium values detected in lung tissues for both study sites indicated that inhalation of respirable size particles was not occurring appreciable during the sampling period and that the major route of contamination was via ingestion. Observed concentration ratios of animal tissue uranium to soil uranium for all tissue groupings composited were larger for mill tailings samples than for LANL samples. The observed concentration ratios were used to provide an estimate of the amount of uranium moving across physiological barriers under conditions of passage through the biological system. The LANL results indicated that only a small portion of ingested uranium was metabolically assimilated, while the mill tailings results indicated a larger amount to be metabolically assimilated. This is attributed to a more soluble form of uranium at the mill tailings site.

Miera, F.R., Jr., K.V. Bostick, T.E. Hakonson, and J.W. Nyhan. 1977. Biotic Survey of Los Alamos Radioactive Liquid-Effluent Receiving Areas. Report. No. LA-6503-MS. Los Alamos Scientific Laboratory. 23 pp.

A preliminary study was completed of the vegetation and small mammal communities and associated climatology in three canyon liquid waste receiving areas at the Los Alamos Scientific Laboratory. Data were gathered on plant and animal composition, distribution, and biomass, along with air temperature, humidity, and precipitation, as a function of elevation and where data were available with season. Initial studies of the understory vegetation in the spring of 1974 indicate grass species to be dominant at higher elevations, with forb species becoming dominant at lower elevations. Generally, the highest total mass estimates for standing green vegetation were obtained in the study sites located in the upper portions of the canyons where precipitation is greatest and where the terrain and intermittent stream flow result in a wetter habitat. Fourteen species of small mammals were trapped or observed in canyon study areas during two trapping sessions of May-June 1974 and December 1974-February 1975. A greater number of species and the highest rodent biomass estimates in the spring were generally associated with the ponderosa pine/piñon-juniper woodland in the upper reaches of the canyons and were lowest in the piñon-juniper woodland at the lower portions of the canyons. This trend was observed in only one of the canyons during the winter season. Climatological data gathered in the three canyons since 1973 also are presented to serve as a data base for future reference.

Moeur, S., and D.A. Guthrie. 1984. The Effects of Clearing Fire-Killed Trees on Wildlife. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 135-144. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Rapid recovery of the forest after a fire should be an important objective of forest management. Following a severe fire in the Jemez Mountains in north central New Mexico, two management approaches were instituted on adjacent burn sites. On Bandelier National Monument property, burned forest areas were heavily seeded from the air with a variety of grasses. This was the only action taken. However, on Los Alamos National Laboratory property, all dead trees were cut down and removed. The purpose of the study reported upon in this paper was to compare the effects of the two management policies on the flora and fauna of the sites. The results show that slight differences in vegetation and insect populations were found between the Bandelier and Laboratory sites, but these differences were not significant. No difference was found in mammal populations between the two sites. Bird populations differed, with greater populations of both resident and visiting species on the Bandelier site. This difference is thought to be due to the presence of nesting sites and perches provided by dead trees rather than to differences in food supply. The few trees left standing on the Laboratory site were used by birds and lessen the differences observed between the two sites. The effects of the two strategies of forest management thus have their greatest effect on bird populations. Effects of the Laboratory approach on vegetation are minor but could be minimized even more by restricting vehicular traffic in the process of wood removal (requiring cut wood to be carried to existing roads rather than allowing vehicles to drive to the cutting site). The effects on birds could be greatly reduced by leaving a certain percentage of dead trees standing, particularly large trees that were partially dead before the fire and that were used by hole-nesting species.

Raymer, D.F., and J.R. Biggs. 1994. Comparison of Small Mammal Species Diversity Near Wastewater Outfalls, Natural Streams, and Dry Canyons. Report No. LA-12725-MS. Los Alamos National Laboratory. 16 pp.

A wide range of plant and wildlife species utilizes water discharges from facilities at Los Alamos National Laboratory (LANL). The purpose of this study was to compare nocturnal small mammal communities at wet areas created by wastewater outfalls with communities in naturally wet and dry areas. Thirteen locations within LANL boundaries were selected for small mammal mark-recapture trapping. Three of these locations lacked surface water sources and were classified as "dry," whereas seven sites were associated with wastewater outfalls and three were located near natural sources of surface water. Data were collected on site type (dry, outfall, or natural), location, species trapped, and the tag number of each individual captured. These data were used to calculate mean number of species, percent capture rate, and species diversity at each type of site. When data from each type of site were pooled, there was no significant differences in these variables among dry, outfall, and natural types. However, when data from individual sites were compared, significant differences were revealed. All sites in natural areas

were significantly higher than dry areas in daily mean number of species, percent capture rate, and species diversity. Most outfall sites were significantly higher than dry areas in all three variables tested. When volume of water from each outfall site was considered, the data indicated that the number of species, percent capture rate, and species diversity of nocturnal small mammals were directly related to the volume of water at a given outfall.

Soil Chemistry and Ecology

Ferenbaugh, R.W., E.S. Gladney, L.F. Soholt, K.A. Lyall, M.K. Wallwork-Barber, and L.E. Hersman. 1992. Environmental Interactions of Sulphlex Pavement. Environmental Pollution 76: 141-145.

Sulphlex, a mixture of elemental sulfur and plasticizers, has been considered for use as an asphalt substitute in road construction at Los Alamos National Laboratory. Because this material contains substantial quantities of elemental sulfur, it is a potential substrate for growth of sulfur-oxidizing bacteria. Experiments performed to determine the susceptibility of Sulphlex in Sulphlex-containing media to degradation by Thiobacillus thiooxidans *resulted in breakdown of the Sulphlex material and concomitant production of acid. In concurrent studies, plants were grown in Sulphlex-amended soil. These plants exhibited higher sulfur content and reduced productivity as compared with plants grown in unamended soils, indicating that Sulphlex was being broken down in the soil and that the breakdown products were apparently having a detrimental effect on plant productivity. These experiments indicate that naturally occurring sulfur-oxidizing bacteria have the potential to break down Sulphlex paving material, resulting in adverse effects on both the structural integrity of the pavement and the local environment.*

Freeman, C.E. 1984. The Effect of La Mesa Fire on Total Soil Nitrogen in Bandelier National Monument, New Mexico. Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 91-96. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Nitrogen availability in ecosystems is often a critical or limiting factor regulating plant growth and productivity on a site. Typically, nearly all (70-98%) of ecosystem nitrogen is in the soil. This is true from deserts to the more mesic grassland and forest ecosystems. Most of the rest of the nitrogen is in the standing crop of the producers. Any environmental factor that can cause substantial loss of nitrogen from an ecosystem, then, can greatly influence productivity and succession on a site. One such factor is fire. Nitrogen in both the soil and standing crop is readily volatilized by heat and lost from the ecosystem. Significant amounts of nitrogen can be lost as gas at temperatures above 300^{o}C, and temperatures above 700^{o}C can easily volatilize substantial amounts. Because the largest concentrations of soil nitrogen are near the surface, a considerable portion of the total soil nitrogen may be lost during a fire. Large variations in maximum soil temperature and duration of soil heating can occur over small distances because of different fuel loadings and local burning conditions. The large and destructive La Mesa Fire swept through the ponderosa pine forests in Bandelier National Monument, New Mexico, between June 16, 1977, when the fire began in the adjacent Santa Fe National Forest, and June 23, 1977, when the fire was finally extinguished. This study estimated the effects of La Mesa Fire on total soil nitrogen and gathered data on the nitrogen content of similar soils from unburned regions.

Kasunic, C.A. 1982. The Toxicity of Spent Photographic Solutions and Other Silver Compounds and Their Migration in Soil. M.S. Dissertation. University of Arizona. Tucson. 142 pp.

The silver content of the waters, stream sediments, soils, and vegetation in a canyon contaminated with spent photographic fixing bath solutions at Los Alamos National Laboratory was determined. The total silver concentration in the canyon decreased with increasing distance from the mouth of the waste outfall. At a distance of approximately 300 m, the silver levels of the vegetation approached those of the background. The silver content of the sediments and soils, however, remained significantly higher than background for a distance of 420 m. Soil column experiments showed that the silver solutions are attenuated by soil at rates and apparently by different mechanisms. The silver thiosulfate complex in the spent fixing bath solution is believed to be reduced to silver nitrate in the soil. The silver ion in silver nitrate and silver sulfate solutions

probably replaces the Na^+ and/or K^+ ion in the clays present in clayey-skeletal Typic Eutroboralf soils. The phytotoxicity of the spent fixing bath solutions then is due primarily to the presence of excess sodium ion. This reduces the ability of a plant to absorb water and essential mineral nutrients and leads to a decrease in productivity.

Loftin, S.R., and C.S. White. 1996. Potential Nitrogen Contribution of Soil Cryptogams to Post-Disturbance Forest Ecosystems in Bandelier National Monument, NM. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 140-148. General Technical Report No. RM-GTR-286. USDA Forest Service.

The nitrogen-fixation (N_2-fixation) potential and annual N contribution of soil cryptogamic crusts were estimated in three previously burned ponderosa pine and one previously grazed piñon/juniper forest ecosystems in Bandelier National Monument, NM. The ponderosa pine forest sites were burned in the 1977 La Mesa Fire, and burro grazing on the piñon/juniper site ended in approximately 1983. The objective of the research was to determine whether estimated post-disturbance cryptogamic N inputs could offset N losses from the disturbance. Surface cover in each habitat was divided into litter cover, herbaceous cover, bare soil, and obvious cryptogams in an attempt to quantify the spatial heterogeneity of soil properties. Line intercept transects were used to estimate percent surface cover of each cover type. Soil samples from each cover type were analyzed for total N, C, P, $\delta^{15}N$, and N_2-fixation potential. At this stage in the recovery process, the potential for cryptogamic N_2- fixation was determined to occur in all sampled habitats and cover types. Correlations between N_2- fixation potential and other soil variables indicated that none is suitable as an indirect estimator of N_2-fixation potential. Estimates of ecosystem N input as a result of cryptogamic N_2-fixation range from 3.6-27.0 kg/ha/yr. Evidence from soil analyses indicated that soil loss was greatest at the piñon/juniper site.

Longmire, P.A., S.L. Reneau, P.M.Watt, L.D. McFadden, J.N. Gardner, C.J. Duffy, and R.T. Ryti. 1996. Natural Background Geochemistry, Geomorphology, and Pedogenesis of Selected Soil Profiles and Bandelier Tuff, Los Alamos, New Mexico. Report No. LA-12913-MS. Los Alamos National Laboratory. 176 pp.

During 1992 and 1993, the Bandelier Tuff and several soil profiles were sampled to determine background elemental concentrations for Los Alamos National Laboratory. Soil analyses were performed in such a manner as to provide a comparison of elements incorporated within the primary minerals with those elements concentrated in surface coatings. Soils present on the Pajarito Plateau are extremely variable in physical and chemical properties, such as particle size, percent calcium carbonate, clay mineralogy, iron oxides, and trace element chemistry. Soils have higher concentrations of aluminum, arsenic, barium, calcium, cerium, cobalt, chromium, and iron than the Bandelier Tuff samples. The Bandelier Tuff has higher concentrations of beryllium, lead, sodium, potassium, thorium, and uranium than the soils. Higher concentrations of trace elements are found in well-developed soils than in the weakly developed soils on the Pajarito Plateau. Clay minerals and iron oxides, which have relatively high surface areas, occur within B horizons and control trace-element distributions in soils. The B horizons contain higher concentrations of trace elements relative to A and C horizons. Variations in soil-element concentrations are also affected by climate, topography, and the parent materials, which include alluvial fans, sheet wash material, colluvium, wind-blown sediment, El Cajete pumice, and the Bandelier Tuff. Because background-element concentrations in soils forming on the Pajarito Plateau vary with parent material, the degree of soil development and other site-specific conditions must be considered to select the most appropriate samples. The results of chemical analyses discussed in this report represent the most appropriate (noncontaminated) published data available to establish background-elemental distributions in soils throughout the Laboratory.

Perkins, B., and G.L. DePoorter. 1985. Plants and Their Relationship to Soil Moisture and Tracer Movement. Report No. La-10216-MS. Los Alamos National Laboratory. 68 pp.

To obtain a better understanding of the mechanisms for possible movement of radionuclides or other toxic materials from waste burial sites in arid to semiarid regions, changes in soil moisture and tracer (Co, Cs, Sr, and tritium) movement were compared for bare vs vegetated soils. During the course of two growing seasons, comparing vegetation with bare soils, plant

transpiration processes significantly reduced the soil moisture. In the vegetated soils, most of the Co, Cs, and Sr remained in the region of original emplacement. In bare soils, Co and Cs underwent minimal movement, but the peak concentration of Sr moved downward. For all tracers in the vegetated soils, there was some evidence that slight amounts of tracer had been absorbed in the plant roots and brought to the surface through plant translocation processes. In all cases, there was no significant upward movement of Co, Cs, and Sr. For tritium, the vegetated soils, compared with the bare soils, retained the maximum inventories near the original emplacement location. Although all soils showed some tritium loss, it was greatest in the vegetated soils. A literature review associated with the experiment indicated that plant species alone does not determine rooting depth, rate of transpiration, nutrient uptake, and other plant-associated processes. Environmental conditions are just as important as plant species and must be included in modeling plant-related effects. More data are needed on the effects of tracer concentration, soil water composition, variations in precipitation with time and intensity, evaporation rates, variations in soil composition, soil microorganisms, other invertebrates and vertebrates that inhabit soils, litter decay, and colloid movement on contaminant movement under conditions of saturated flow.

White, C.S. 1996. The Effects of Fire on Nitrogen Cycling Processes within Bandelier National Monument, NM. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 123-139. General Technical Report No. RM-GTR-286. USDA Forest Service.

Nitrogen is often the nutrient limiting production in conifer forests. Fire acts as a mineralizing agent, releasing nutrients in available forms; however, nitrogen is often lost during fires, which can further deplete this limiting nutrient. Without fire, nitrogen becomes tied up in partially decomposed litter (needles and woody debris). The problems faced in management of forest systems are how and when to use fire from a nutrient perspective. A chronosequence of fire intervals in ponderosa pine forests was studied to determine (1) if nitrogen cycling processes decrease and (2) if concentrations of organics that inhibit these processes increase along the fire chronosequence. Patterns were not statistically significant, but fairly clear trends occurred. Nitrogen mineralization and nitrification patterns were higher in sites recently burned (within two years) and were lowest in sites without fires since the 1890s. The patterns at intermediate age sites varied, perhaps because of different usage by elk and variable amounts of needle scorch that resulted in differential needle litterfall after fire. Within a site, concentrations of certain monoterpenes were consistently negatively correlated with rates of nitrification and mineralization. In these systems, fire promotes more rapid cycling of nitrogen, in part through combustion of monoterpene inhibitors.

White, C.S., S.R. Loftin, and S.C. Hofstad. 1999. Response of Vegetation, Soil Nitrogen, and Sediment Transport to a Prescribed Fire in Semiarid Grasslands. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 83-92. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Shrubs and trees have invaded semiarid grasslands throughout much of the Southwestern United States. This invasion has not only decreased grass cover but has also increased runoff and erosion. In fact, sediment from rangelands constitutes the single largest source of nonpoint stream pollutants within the State of New Mexico. Fire, which was a natural factor that shaped and maintained the grasslands, is a management tool that may aid in restoring and maintaining grass cover. However, fire also poses the risk of increasing erosion and further degradation because protection afforded by vegetation is reduced immediately after the fire. This study measured vegetation cover, soil inorganic nitrogen (N) levels, and erosion amounts associated with the first application of prescribed fire on two semiarid grasslands. The potential for adverse effects from these fires was great because they were performed at the beginning of a drought period. After the first growing season following the fire, grass cover returned to pre-burn levels, and both soil N and erosion amounts were similar to the unburned areas. Thus, prescribed fire for reducing shrub and tree cover may pose minimal adverse risk even under drought conditions.

Soil/Sediment Contaminant Data

Booher, J.L., P.R. Fresquez, L.F. Carter, B.M. Gallaher, and M.A. Mullen. 1998. Radionuclide Concentrations in Bed Sediment and Fish Tissue within the Rio Grande Drainage Basin. Report No. LA-13366. Los Alamos National Laboratory. 12 pp.

In 1992-1993, Los Alamos National Laboratory collaborated with the U.S. Geological Survey in an effort to characterize radionuclide concentrations in bed sediment and fish tissue within the Rio Grande drainage basin from Colorado to Texas. Bed sediment was sampled from 18 locations for ^{137}Cs, ^{3}H, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{241}Am, ^{tot}U, and alpha, beta, and gamma activity. Fish tissue was sampled from 12 locations for ^{137}Cs, ^{90}Sr, ^{238}Pu, ^{239}Pu, and ^{tot}U. Detailed data tables are presented.

Ferenbaugh, R.W., and E.S. Gladney. 1997. Mortandad Canyon: Elemental Concentrations in Vegetation, Streambank Soils, and Stream Sediments – 1979. Report No. LA-13325-MS. Los Alamos National Laboratory. 7 pp.

In 1979, stream sediments, streambank soils, and streambank vegetation were sampled at 100 m intervals downstream of the outfall of the TA-50 radioactive liquid waste treatment facility in Mortandad Canyon. Sampling was discontinued at a distance of 3260 m at the location of the sediment traps in the canyon. The purpose of the sampling was to investigate the effect of the residual contaminants in the waste treatment facility effluent on elemental concentrations in various environmental media. Data are presented for Be, Cd, Cl, Cr, F, NO_3, PO_4, SO_4, ^{3}H, and Hg.

Ferenbaugh, R.W., E.S. Gladney, and G.H. Brooks, Jr. 1990. Sigma Mesa: Background Elemental Concentrations in Soil and Vegetation, 1979. Report No. LA-11941-MS. Los Alamos National Laboratory. 22 pp.

In 1979, soil and vegetation samples were collected on Sigma Mesa to provide background data prior to the advent of construction on the mesa. Elemental data are presented for soil, grass, juniper, piñon pine, and oak. Analytical data are presented for Al, As, B, Ba, Be, Br, Cd, Cl, Cu, F, Fe, Hg, Li, Mg, Mn, Ni, NO_3, Pb, PO_4, Rb, SO_4, Ti, and Zn. None of the data looks out of the ordinary.

Fresquez, P.R. 1998. Baseline Tritium Concentrations in Soils and Vegetation: The Tshirege Woodland Site at TA-54. Report No. LA-UR-98-1079. Los Alamos National Laboratory. 4 pp.

A preoperational survey for tritium was conducted for the Tshirege woodland site, an experimental area managed by ESH-15, where tritium will be injected 10 cm deep in and around the base of piñon and juniper trees during the summer of 1990. The site is located at the lower end of Canada del Buey close to the intersection of Pajarito and State Road 4. Baseline values of ^{3}H were measured in soil and plant samples from five locations immediately surrounding the study area. Mean values of ^{3}H in soils collected from the 0-5 and 25-30 cm depths were 1.24±0.22 and 1.08±0.41 pCi/mL, respectively. Piñon needles averages 1.68±0.18 pCi/mL, and blue grama grass averaged 1.16±0.95 pCi/mL.

Fresquez, P.R., D.R. Armstrong, and M.A. Mullen. 1998. Radionuclides in Soils Collected from within and around Los Alamos National Laboratory: 1974-1996. Journal of Environmental Science and Health A33: 263-278.

The purpose of this paper was (1) to evaluate 20+ years of soil sampling data to determine if there are any statistical differences in radionuclides and radioactivity as a function of air emissions and fugitive dust in surface soils, (2) to determine if radionuclide concentrations are increasing or decreasing over time, and (3) to estimate total effective dose equivalent and corresponding risk of excess cancer fatalities to a perimeter community. Based on the long-term average, nine of the ten radionuclide parameters measured in LANL soils were significantly higher than background. Perimeter soils, on the other hand, showed less differences with only four of the ten parameters being statistically higher than background. Most radionuclides in both LANL and perimeter soils, with the exception of ^{238}Pu in perimeter soils, significantly decreased in concentration over time, so that by 1996 most radionuclide concentrations were approaching

values similar to background. The maximum net positive TEDE for a resident living around the perimeter of LANL, as modeled by RESRAD for 1974-1996, 1993-1996, and 1993, was 2.9 mrem/yr, 2.3 mrem/yr, and 0.8 mrem/yr, respectively. All upper bound TEDEs were far below the International Commission of Radiological Protection permissible dose limit for all pathways, and the highest TEDE corresponds to a residual excess cancer frequency of $1.5x10^{-6}$, which is far below the Environmental Protection Agency guideline of 10^{-4}.

Fresquez, P.R., D.R. Armstrong, M.A. Mullen, and L. Naranjo, Jr. 1997. Radionuclide Concentrations in Pinto Beans, Sweet Corn, and Zucchini Squash Grown in Los Alamos Canyon at Los Alamos National Laboratory. Report No. LA-13304-MS. Los Alamos National Laboratory. 31 pp. Also In: Journal of Environmental Science and Health B33: 99-115.

Pinto beans, sweet corn, and zucchini squash were grown at a site that contained the highest observed levels of surface gross gamma radioactivity within Los Alamos Canyon. Soils as well as washed edible and nonedible crop tissues were analyzed for various radionuclides and heavy metals. Most radionuclides in soil from LAC, with the exception of tritium and total uranium, were detected in significantly higher concentrations than in soil from regional background (RBG) locations. Similarly, most radionuclides in edible crop portions of beans, squash, and corn were detected in significantly higher concentrations than RGB. Most soil-to-plant concentration ratios for radionuclides in edible and non-edible crop tissues were within the default values given by the Nuclear Regulatory Commission and Environmental Protection Agency. All heavy metals in soils and both edible and nonedible crop tissues were within RBG concentrations.

Fresquez, P.R., D.R. Armstrong, and L. Naranjo, Jr. 1996. Radionuclide and Heavy Metal Concentrations in Soil, Vegetation, and Fish Collected Around and Within Tsicoma Lake in Santa Clara Canyon. Report No. LA-13144-MS. Los Alamos National Laboratory. 99 pp.

This study was undertaken at the request of Santa Clara Pueblo officials as Tsicoma Lake is slightly downwind of Los Alamos National Laboratory. Radionuclide and heavy metal concentrations were determined in soil, vegetation (overstory and understory), and fish (rainbow trout) collected around and within Tsicoma Lake in Santa Clara Canyon in 1995. All heavy metal and most radionuclide concentrations, with the exception of uranium in soil, vegetation, and fish, were within or just above upper limit background concentrations. Detectable levels (where the analytical result was greater than two times the counting uncertainty) of uranium in soils, vegetation, and fish were found in slightly higher concentrations than in background samples. Overall, however, the maximum total committed effective dose equivalent (CEDE)(0.066 mrem/yr), based on the consumption of 46 lb of fish, was within the maximum CEDE from the ingestion of fish from the Mescalero National Fish Hatchery (background)(0.113 mrem/yr).

Fresquez, P.R., D.R. Armstrong, and J.G. Salazar. 1995. Radionuclide Concentrations in Soils and Produce from Cochiti, Jemez, Taos, and San Ildefonso Pueblo Gardens. Report No. LA-12932-MS. Los Alamos National Laboratory. 9 pp.

Radionuclide (^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239}Pu, and total uranium) concentrations were determined in soils and produce collected from Cochiti, Jemez, Taos, and San Ildefonso Pueblo Gardens. All radionuclides in soils from Pueblo gardens were within or just above regional statistical (natural and/or worldwide fallout) reference levels. Similarly, the average levels of radionuclides in produce collected from Cochiti, Jemez, Taos, and San Ildefonso Pueblo gardens were not significantly different than in produce collected from regional (background) locations. The effective (radiation) dose equivalent from consuming 352 lb of produce from Cochiti, Jemez, Taos, and San Ildefonso, after natural background had been subtracted, was 0.036±0.016, 0.072±0.051, 0.,012±0.027, and 0.110±0.102 mrem/yr, respectively. The highest calculated dose was 0.314 mrem/yr, which is <0.4% of the International Commission on Radiological Protection permissible dose limit for protecting members of the public.

Fresquez, P.R., M.H. Ebinger, H.T. Haagenstad, and L. Naranjo, Jr. 1999. Baseline Concentrations of Radionuclides and Trace Elements in Soils and Vegetation around the DARHT Facility: Construction Phase (1998). Report No. LA-13669-MS. Los Alamos National Laboratory. 77 pp.

The Mitigation Action Plan for the Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility at Los Alamos National Laboratory mandates the establishment of baseline concentrations for potential environmental contaminants. To this end, concentrations of ^{3}H, ^{137}CS, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and ^{tot}U radionuclides and Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl metals were determined in surface and subsurface soils, sediments, and vegetation (overstory and understory) around the DARHT facility during the construction phase in 1998. (This is the third year of a four year baseline study.) Also, volatile (VOC) and semivolatile (SVOC) organic compounds were measured in soils and sediments. Most radionuclides and trace metals in soil, sediment, and vegetation were similar to past years at DARHT and were within regional background concentrations. Exceptions were concentrations of ^{90}Sr, Be, Ba, and total U in some samples. These elements exceeded upper limit (i.e., mean plus two standard deviations) regional background concentrations. No VOCs and very few SVOCs were detected in soils and sediments. Mean ($\pm$ standard deviation) radionuclide and trace element concentrations measured in soil, sediment, and vegetation over a three-year period (construction phase) are summarized.

Fresquez, P.R., and M. Ennis. 1995. Baseline Radionuclide Concentrations in Soils and Vegetation Around the Proposed Weapons Engineering Tritium Facility and the Weapons Subsystems Laboratory at TA-16. Report No. LA-13028-MS. Los Alamos National Laboratory. 15 pp.

An environmental survey was conducted over the proposed site of the Weapons Engineering Tritium Facility (WETF) and the Weapons Subsystems Laboratory (WSL) at Los Alamos National Laboratory (LANL) at TA-16. Baseline concentrations of tritium (^{3}H), plutonium (^{238}Pu and ^{239}Pu), and total uranium were measured in soils, vegetation (pine needles and oak leaves), and ground litter. Tritium also was measured in air samples, while cesium (^{137}Cs) was measured in soils. The mean concentration of airborne tritiated water during 1987 was 3.9 pCi/m^{3}. Although the mean annual concentration of ^{3}H in soil moisture in the 0-5 (2 in) soil depth was measured at 0.6 pCi/mL, a better background level, based on long-term regional data, was considered to be 2.6 pCi/mL. Mean values for ^{137}Cs, ^{238}Pu, ^{239}Pu, and total uranium in soils collected from the 0-5 cm depth were 1.08 pCi/g, 0.0014 pCi/g, 0.0325 pCi/g, and 4.01 μg/g, respectively. Ponderosa pine needles contained higher values of ^{238}Pu, ^{239}Pu, and total uranium than did leaves collected from Gambel's oak. In contrast, leaves collected from Gambel's oak contained higher levels of ^{137}Cs than pine needles did.

Fresquez, P.R., T.S. Foxx, and L. Naranjo, Jr. 1995. Strontium Concentrations in Chamisa (*Chrysothamnus nauseosus*) Shrub Plants Growing in a Former Liquid Waste Disposal Area in Bayo Canyon. Report No. LA-13050-MS. Los Alamos National Laboratory. 8 pp.

Chamisa shrub plants growing in a former liquid waste disposal site in Bayo Canyon at Los Alamos National Laboratory were collected and analyzed for strontium (^{90}Sr) and total uranium. Surface soil samples also were collected from below (understory) and between (interspace) shrub canopies. Both chamisa plants growing over the waste disposal site contained significantly higher concentrations of ^{90}Sr than a control plant. One plant, in particular, contained 90,500 pCi of ^{90}Sr per g ash in top-growth material. Similarly, soil samples collected underneath and between plants contained ^{90}Sr concentrations above background and LANL screening action levels. This probably occurred as a result of chamisa plant leaf fall contaminating the soil understory area followed by water and/or wind moving the ^{90}Sr into the interspace area. Although some soil surface migration of ^{90}Sr from the waste disposal site has occurred, the level of ^{90}Sr in sediments collected downstream of the waste disposal site at the Bayo Canyon/State Road 4 intersection was still within regional (background) concentrations.

Fresquez, P.R., H.T. Haagenstad, and L. Naranjo, Jr. 1997. Baseline Concentrations of Radionuclides and Heavy Metals in Soils and Vegetation around the DARHT Facility: Construction Phase (1996). Report No. LA-13273. Los Alamos National Laboratory. 90 pp.

As part of the DOE's Mitigation Action Plan for the DARHT Facility at LANL, baseline concentrations of radionuclides (^{3}H, ^{137}Cs, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{241}Am, total U) and heavy metals (Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl) in soil, sediment, and vegetation

(overstory and understory) were determined around the DARHT facility during the construction phase in 1996. Also, U and Be concentrations in soil samples collected in 1993 from within the proposed DARHT facility area are reported. Most radionuclides in soils, sediments, and vegetation were within current background and/or long-term regional statistical reference levels.

Fresquez, P.R., H.T. Haagenstad, and L. Naranjo, Jr. 1998. Baseline Concentrations of Radionuclides and Heavy Metals in Soils and Vegetation around the DARHT Facility: Construction Phase (1997). Report No. LA-13470-PR. Los Alamos National Laboratory. 112 pp.

As part of the DOE's Mitigation Action Plan for the DARHT Facility, baseline concentrations of radionuclides and heavy metals in soil, sediment, and vegetation (overstory and understory) were determined during the construction phase in 1997. Most radionuclides in soils, sediments, and vegetation, with the exception of ^{90}Sr in soils and sediments, were within upper limit background concentrations. Although the levels of ^{90}Sr in soils and sediments were higher than background, they were below LANL screening action levels and are of no concern.

Fresquez, P.R., M.A. Mullen, J.K. Ferenbaugh, and R.A. Perona. 1996. Radionuclides and Radioactivity in Soils Within and Around Los Alamos National Laboratory, 1974 through 1994: Concentrations, Trends, and Dose Comparison. Report No. LA-13149-MS. Los Alamos National Laboratory. 42 pp. Also In: Los Alamos National Laboratory Report LA-UR-95-3671.

This report summarizes and evaluates the concentrations of ^{3}H, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, ^{241}Am, ^{90}Sr, total uranium, and gross alpha, beta, and gamma activity in soils collected from LANL perimeter and regional (background) areas over a 21-year period (1974 through 1994). Also, trends in radionuclide concentrations and radioactivity over time and the total effective dose equivalent (TEDE) were determined for each site. Based on the average over the years, most LANL and perimeter soils contained three or more radionuclides and/or gross radioactivity that were significantly higher in concentration than regional background. The higher concentrations in perimeter soils were attributed to worldwide fallout and to naturally occurring radioactivity in Bandelier tuff soils, whereas the higher concentrations in LANL soils were attributed to worldwide fallout, natural radioactivity, and Laboratory operations. Most radionuclides and radioactivity detected in LANL and perimeter soils showed generally decreasing trends over time. Many radionuclides, like ^{3}H and uranium, exhibited significantly decreasing trends over time at most LANL sites. The net dose (TEDE minus background) for residents living onsite at LANL or along its perimeter ranged from –0.3 mrem/y (east of TA-54) to 3.8 mrem/y (east of TA-53) and from –0.4 mrem/y (White Rock) to 3.6 mrem/y (west of LANL on Forest Service land across from TA-8/GT site). All net doses were far below the International Commission on Radiological Protection permissible dose limit of 100 mrem/y.

Fresquez, P.R., W.R. Velasquez, and L. Naranjo, Jr. 2000. Effects of the Cerro Grande Fire (Smoke and Fallout Ash) on Soil Chemical Properties within and around Los Alamos National Laboratory. Report No. 13769-MS. Los Alamos National Laboratory. 11 pp.

Soil surface (0-2 in depth) samples were collected from areas within and around Los Alamos National Laboratory (LANL) immediately after the Cerro Grande Fire, analyzed for radionuclides, radioactivity, and trace elements (heavy metals), and compared to soil samples collected in 1999 from the same sites. In addition, many types of organic substances (volatile and semivolatile organic compounds, organochlorine pesticides, PCBs, high explosives, and dioxin and dioxin-like compounds) were assessed in soils from LANL, perimeter, and regional sites after the fire. Results show that impacts to regional, perimeter, and on-site (mesa top) areas from smoke and fallout ash as a result of the Cerro Grande Fire were minimal.

Fresquez, P.R., R.J. Wechsler, and L. Naranjo, Jr. 1998. Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 1997 Growing Season. Report No. LA-13495-PR. Los Alamos National Laboratory. 47 pp.

Soil and overstory and understory vegetation were collected at Area G and analyzed for radionuclides and heavy metals. In general, most radionuclide concentrations in soils and both washed and unwashed overstory and understory vegetation, with the exception of tritium and Pu-239, were within upper limit background concentrations. Although tritium concentrations in

vegetation from most sites were significantly higher than background, concentrations decreased markedly in comparison to previous year's results. Also, as in the past, the transuranic waste pad area contained the highest levels of ^{239}Pu in soils and in understory vegetation as compared to other areas at Area G,

Gallaher, B.M., D.W. Efurd, D.J. Rokop, and T.M. Benjamin. 1999. Plutonium and Uranium Atom Ratios and Activity Levels in Cochiti Lake Bottom Sediments Provided by Pueblo de Cochiti. Report No. LA-13605-MS. Los Alamos National Laboratory. 21 pp.

Using a new analytical "fingerprinting" technique, the presence of plutonium from Los Alamos National Laboratory has been confirmed in sediments collected from Cochiti Lake. The new data shows that approximately one-half of the plutonium is derived from Laboratory sources. The remaining half comes from erosion of soils in northern New Mexico that contain plutonium deposited on the landscape from worldwide fallout. Laboratory-derived uranium, however, was not identifiable. While Laboratory contributions of plutonium are identifiable in the lake sediments, the overall plutonium content is 1000 times below levels that would generally trigger cleanup. The net increase in radioactivity over background would be difficult to recognize using conventional analytical techniques.

Gladney, E.S., R.W. Ferenbaugh, R.G. Bowker, E.A. Jones, M.G. Bell, J.D. Morgan, E.A. Stallings, L.A. Nelson, and C. Lundstrom. 1993. An Investigation of Sulfur Concentrations in Soils and Pine Needles in Bandelier National Monument, New Mexico. Report No. LA-12417-MS. Los Alamos National Laboratory. 48 pp.

Sulfur measurements in different age groups of piñon pine needles and adjacent soil samples from ten sampling sites at Bandelier National Monument were determined using combustion elemental analysis and chromatographic techniques. The primary goal was to establish base-line levels for elemental sulfur in the Monument. Sulfur levels in foliage and soils were evaluated using analysis of variance techniques. Foliage sulfur concentrations differed significantly among the 10 sampling sites and among trees within sites; however, needles of different ages did not differ significantly in sulfur content. Average soil concentrations were very low, approximately 12% of the average needle concentrations. Soil sulfur concentrations also differed significantly among the 10 sampling sites and at different depths in the soil. No statistical differences were evident in soils sampled at the four compass points (N, E, S, W) around each tree. These differences imply that large numbers of samples are needed to identify small effects from anthropogenic inputs of sulfur into the system, or that the effects must be large relative to the differences among sampling sites and individual trees in order to be detected. Detailed tables of sulfur concentrations are presented.

Gunderson, T., T. Buhl, R. Romero, and J. Salazar. 1983. Radiological Survey Following Decontamination Activities Near the TA-45 Site. Report No. LA-9831-MS. Los Alamos National Laboratory. 15 pp.

Three areas at the site of a former radioactive liquid waste treatment plant were decontaminated during 1982. Data are presented showing that after cleanup operations, radionuclide concentrations in surface soils at all three sites were within decontamination guidelines.

Hakonson, T.E., G.C. White, E.S. Gladney, and M. Dreicer. 1980. The Distribution of Mercury, Cesium-137, and Plutonium in an Intermittent Stream at Los Alamos. Journal of Environmental Quality 9: 289-292.

This paper summarizes the results of a study on the distribution of Hg, ^{137}Cs, ^{238}Pu, and ^{239,240}Pu in channel sediments and adjacent bank soils in an intermittent stream used for treated liquid effluent disposal since 1963. Concentrations of the three radionuclides and Hg in stream bank soils were comparable to adjacent channel sediments, demonstrating that the stream bank serves as a deposition site for chemicals released to the channel. This finding has important implications on the long-term behavior of effluent contaminants since other studies at Los Alamos have shown that the vegetated stream banks retard downstream movement of chemicals bound to soils and provide a pathway for transport of these chemicals to biota. Concentrations of the

radionuclides and mercury were more uniformly distributed with distance and depth in the channel sediments than in the bank soils. The action of periodic surface water in the channel partially explains those differences. Statistical analysis of the data revealed that 50 to 85% of the variability in contaminant concentrations in bank and channel locations was due to variation with distance while depth contributed relatively little to variability.

Hanson, W.C., and F.R. Miera, Jr. 1976. Long-Term Ecological Effects of Exposure to Uranium. Report No. LA-6269. Los Alamos Scientific Laboratory. 34 pp.

The consequences of releasing natural and depleted uranium to terrestrial ecosystems during development and testing of depleted uranium munitions were investigated. Two explosives-testing areas at the Los Alamos Scientific Laboratory (LASL) were selected because of their use history. E-F Site soil averaged 2400 ppm of uranium in the upper 5 cm and 1600 ppm at 5-10 cm. Lower Slobbovia Site soil from two subplots averaged about 2.5 and 0.6% of the E-F Site concentrations. Important uranium concentration differences with depth and distance from detonation points were ascribed to the different explosive tests conducted in each area. E-F site vegetation samples contained about 320 ppm of uranium in November 1974 and about 125 ppm in June 1975. Small mammals trapped in the study areas in November contained a maximum of 210 ppm of uranium in the gastrointestinal tract contents, 24 ppm in the pelt, and 4 ppm in the remaining carcass. In June, maximum concentrations were 110, 50, and 2 ppm in similar samples and 6ppm in lungs. These data emphasize the importance of resuspension of respirable particles in the upper few millimeters of soil as a contamination mechanism for several components of the LASL ecosystem.

Kasunic, C.A. 1982. The Toxicity of Spent Photographic Solutions and Other Silver Compounds and Their Migration in Soil. M.S. Dissertation. University of Arizona. Tucson. 142 pp.

The silver content of the waters, stream sediments, soils, and vegetation in a canyon contaminated with spent photographic fixing bath solutions at Los Alamos National Laboratory was determined. The total silver concentration in the canyon decreased with increasing distance from the mouth of the waste outfall. At a distance of approximately 300 m, the silver levels of the vegetation approached those of the background. The silver content of the sediments and soils, however, remained significantly higher than background for a distance of 420 m. Soil column experiments showed that the silver solutions are attenuated by soil at rates and apparently by different mechanisms. The silver thiosulfate complex in the spent fixing bath solution is believed to be reduced to silver nitrate in the soil. The silver ion in silver nitrate and silver sulfate solutions probably replaces the Na^+ and/or K^+ ion in the clays present in clayey-skeletal Typic Eutroboralf soils. The phytotoxicity of the spent fixing bath solutions then is due primarily to the presence of excess sodium ion. This reduces the ability of a plant to absorb water and essential mineral nutrients and leads to a decrease in productivity.

Mayfield, D.L., A.K. Stoker, and A.J. Ahlquist. 1979. Radiological Survey of the Bayo Canyon, Los Alamos, New Mexico. Report No. DOE/EV-0005/15. U.S. Department of Energy. 111 pp.

This report presents the results of a resurvey of Bayo Canyon that was conducted in 1976-77 for the purpose of thoroughly documenting and assessing conditions within Bayo Canyon. The Bayo canyon site contained firing sites and chemistry laboratories that were used until 1963, when it was decommissioned. The resurvey was designed to collect information to use as a basis for determining whether any additional corrective measures would be desirable.

Miera, F.R., Jr. 1980. Measurements of Uranium in Soils and Small Mammals. Report No. LA-8624-T. Los Alamos Scientific Laboratory. 42 pp. (M.S. Dissertation, New Mexico Highlands University)

The objective of this study was to evaluate the bioavailability of uranium to a single species of small mammal, white-footed deer mouse, from two different source terms: a Los Alamos National Laboratory dynamic weapons testing site in north central New Mexico, where an estimated 70,000 kg of uranium were expended over a 31-yr period; and an inactive uranium mill tailings pile located in west central New Mexico near Grants, which received wastes over a 5-yr period from the milling of 2.7×10^9 kg of uranium ore. Uranium concentrations were generally higher in all

small mammal tissue groupings for the LANL site when compared to values obtained for tissue samples from the mill tailings study area. Gastrointestinal and pelt sample uranium concentrations were significantly different from internal tissue values for both sites. Perhaps one of the more significant findings was that median uranium concentrations in kidneys of mice from the mill tailings study area were six times greater and significantly different from values for other internal tissues. This was not detected at the LANL study area. Low uranium values detected in lung tissues for both study sites indicated that inhalation of respirable size particles was not occurring appreciable during the sampling period and that the major route of contamination was via ingestion. Observed concentration ratios of animal tissue uranium to soil uranium for all tissue groupings composited were larger for mill tailings samples than for LANL samples. The observed concentration ratios were used to provide an estimate of the amount of uranium moving across physiological barriers under conditions of passage through the biological system. The LANL results indicated that only a small portion of ingested uranium was metabolically assimilated, while the mill tailings results indicated a larger amount to be metabolically assimilated. This is attributed to a more soluble form of uranium at the mill tailings site.

Purtymun, W.D., R.J. Peters, T.E. Buhl, M.N. Maes, and F.H. Brown. 1987. Background Concentrations of Radionuclides in Soils and River Sediments in Northern New Mexico, 1974-1986. Report No. LA-11134-MS. Los Alamos National Laboratory. 16 pp.

This report documents the range and the upper limit for background concentrations of radionuclides and radioactivity in soils and river sediments that occur as a result of natural rock-forming minerals and worldwide fallout from atmospheric nuclear weapons tests. Documentation is based on the collection of soil and sediment in northern New Mexico and analyzed for ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, total uranium, gross gamma, and tritium. The data used to establish the statistical range and upper limit of background concentration cover a 9- or 13-year period ending in 1986. The knowledge of background levels is necessary to interpret soil and sediment data collected for the annual environmental surveillance report and other reports relating to radionuclides or radioactivity in soils and sediments.

Purtymun, W.D., R.J. Peters, and A.K. Stoker. 1980. Radioactivity in Soils and Sediments in and Adjacent to the Los Alamos Area, 1974-1977. Report No. LA-8234-MS. Los Alamos Scientific Laboratory. 17 pp.

Soil and sediments are analyzed for gross alpha, gross beta, ^{238}Pu, ^{239}Pu, ^{137}Cs, ^{90}Sr, and total uranium as part of the continuing Environmental Monitoring Program at the Los Alamos Scientific Laboratory. This report documents the levels of radioactivity of radionuclides in soils and sediments in northern New Mexico from natural sources and worldwide fallout as well as at seven on-site soil and sediment stations that contain radioactivity contributed by the Laboratory for the period 1974-1977.

Stoker, A.K., A.J. Ahlquist, D.L. Mayfield, W.R. Hansen, A.D. Talley, and W.D. Purtymun. 1981. Radiological Survey of the Site of a Former Radioactive Liquid Waste Treatment Plant (TA-45) and the Effluent Receiving Areas of Acid, Pueblo, and Los Alamos Canyons, Los Alamos, New Mexico. Report No. LA-8890-ENV. Los Alamos National Laboratory. 252 pp.

Current radiological conditions were evaluated for the site of a former radioactive liquid waste treatment plant and the interconnected canyons that received both treated and untreated effluents between 1944 and 1951. Some residual radioactivity attributable to the effluents remains and is found on soils and sediments at the former plant site and in the channels of the canyons. The largest total reservoir of residual radioactivity is in lower Pueblo Canyon, but concentrations are extremely low. Potential exposures to radiation were evaluated for conditions of current and possible future land uses.

White, G.C., J.C. Simpson, and K.V. Bostick. 1980. Studies of Long-Term Ecological Effects of Exposure to Uranium V. Report No. LA-8221. Los Alamos Scientific Laboratory. 19 pp.

A statistical technique called kriging was used to analyze the uranium concentrations in surface soil at E-F site. kriging provides a much more realistic contour surface than either a polynomial trend analysis or contouring the original data. The major advantages of kriging are

that a measure of the uncertainty of the contoured surface is provided and that the nonparametric nature of the method allows very irregular surfaces to be fitted. For the variable type of data collected at E-F site, kriging appears to be the most useful approach to estimating mean concentration.

Threatened and Endangered Species

Bennett, K. 1995. Endangered and Threatened Species Potentially Occurring in Los Alamos and Guaje Canyons. In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 277-283. Report No. LA-13065-MS. Los Alamos National Laboratory.

A search of the LANL T&E species database identified 23 species potentially present in Guaje and Los Alamos Canyons. However, only four species (Mexican spotted owl, spotted bat, meadow jumping mouse, and Jemez Mountain salamander) have a high or high-to-moderate potential for actually occurring. Eight other species require more data to determine their presence in either canyon system.

Bennett, K.D., T.E. Garrison, M.E. Salisbury, and S.W. Koch. 1996. Threatened and Endangered Species Plan, GIS Phase. Report No. LA-UR-96-3527. Los Alamos National Laboratory. 77 pp.

This report documents the development of a Geographical Information System (GIS) data base for the Threatened and Endangered Species Habitat Management Plan. The data base will be used to store both spatial and tabular ecological data and will be available for use as a screening tool in the performance of assessments for new projects.

Finch, D.M., and J.F. Kelly. 1999. Status and Migration of the Southwestern Willow Flycatcher in New Mexico. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 197-203. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

In the Southwestern United States, recent degradation of riparian habitats has been linked to decline of the Southwestern Willow Flycatcher. During a 2-year banding effort, migration patterns and bird fat content were analyzed. This paper gives a brief overview of Willow Flycatcher breeding status throughout the State of New Mexico and describes its migration pattern throughout the middle Rio Grande Valley. Recommendations for managers and outlines for conservation plans also are discussed.

Foxx, T.S. 1998. Threatened and Endangered Species Habitat Management Plan Overview. Report No. LA-LP-98-112. Los Alamos National Laboratory. 37 pp.

The relative isolation and undisturbed natural setting of much of Los Alamos National Laboratory make this facility ideally suited for its defense-related mission. These factors, combined with limited public access, also have resulted in the preservation of habitat that can sustain a number of species receiving protection under the Endangered Species Act. The Threatened and Endangered (T&E) Species Habitat Management Plan (HMP) for LANL was developed over a three-year period with the dual intent of providing protection for T&E species at LANL as well as facilitating the DOE mission at LANL. This document provides an overview of the HMP, including:

- *Regulatory requirements and reviews that led to its development;*
- *Existing conditions at LANL that give rise to the need for an HMP;*
- *Goals, objectives, and implementing strategies;*
- *HMP components;*
- *A summary of roles & responsibilities of key organizations involved in implementing the HMP;*
- *Long-term activities required to implement the HMP;*
- *Methods for modifying the HMP; and*
- *Methods for tracking the success of the plan and for implementing corrective measures where needed.*

Foxx, T.S., K.D. Bennett, H.T. Haagenstad, S.W. Koch, and M.E. Salisbury. 1996. Integrating Project Requirements with Threatened and Endangered Species Habitat Requirements, a Pilot Demonstration. Report No. LA-UR-96-3616. Los Alamos National Laboratory. 8 pp.

The mission task of the Threatened and Endangered Species (TES) Habitat Management Plan (HMP) identifies and considers the current DOE and UC mission and tactical goals for Los Alamos National Laboratory as translated into projects and activities. The objective of the current task is to create an element within the TES HMP that considers the projects and activities and their relationship to TES and Species of Concern (SOC) and the habitats that these organisms use. In the first phase of this task, data related to projects were examined to define a process for evaluation of projects. A pilot demonstration was performed to evaluate a hypothetical project using a geographic information system ArcView application. This application evaluates the interactions between projects and activities and TES, SOC, and their habitats.

Foxx, T.S., and G.D. Tierney. 1980. Status of the Flora of the Los Alamos National Environmental Research Park. Report No. LA-8050-NERP, Volume I. Los Alamos National Laboratory. 51 pp.

Under the Endangered Species Act of 1973, it became necessary to locate critical habitats of plant species in danger of extinction on State and Federal lands. In 1976, the Los Alamos Environmental Research Park (LA/NERP) was established to provide a study area that would contribute to the understanding of how man can best live in balance with nature while enjoying the benefits of technology. Under this mandate, a study to provide information regarding the locations of possible endangered, threatened, protected, and rare species within the LA/NERP was initiated in August of 1977. This report presents the results of this study and discusses the status of Threatened and Endangered Species and New Mexico Protected Species in the LA/NERP.

Foxx, T.S., and G.D. Tierney. 1982. Vegetational Analysis of a Canyon Ecosystem at Los Alamos. Report No. LA-9576-MS. Los Alamos National Laboratory. 27 pp.

The purpose of this study was to determine the floristic composition of a canyon located immediately below a peregrine falcon nesting site with the goal of determining whether maintenance of the disturbed site could contribute to habitat enhancement for peregrine prey. Data are presented on presence and importance of plant species known to be preferred food sources for doves and small rodents. The preliminary conclusion is that the disturbed site does not contain an abundance of these key food species.

Foxx, T.S., and G.D. Tierney. 1984. Status of the Flora of the Los Alamos National Environmental Research Park. A Historical Perspective. Report No. LA-8050-NERP, Volume II. Los Alamos National Laboratory. 50 pp.

Studies of the flora of the Los Alamos National Environmental Research Park (LA/NERP) are continued in Water and Pajarito Canyons and their extensions to natural boundaries outside of the LA/NERP. Six plant communities and sixteen plant habitats are described for the study area. The status of endangered, threatened, and rare plant species in the study area is reviewed, and land-use history of the Pajarito Plateau is related to the levels of apparent anthropogenic disturbance in the study areas' six plant communities.

Gallegos, A.F., G.J. Gonzales, K.D. Bennett, and L.E. Pratt. 1997. Preliminary Risk Assessment of the Mexican Spotted Owl under a Spatially-Weighted Foraging Regime at the Los Alamos National Laboratory. Report No. LA-13259-MS. Los Alamos National Laboratory. 62 pp.

This report presents the results of a preliminary risk assessment for the Mexican spotted owl on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated doses to the owl under a spatially-weighted foraging regime were compared against toxicological reference doses for three risk source types. Under the risk parameter assumptions made, hazard quotient (HQ) results indicated no unacceptable risk to the owl, including a measure of cumulative effects from multiple contaminants that assumes a linear

additive toxicity type. A Hazard Index of 1.0 was used as the evaluative criterion for determining the acceptability of risk. This value was exceeded (1.06) in only one of 200 simulated potential nest sites. Cesium-137, Ni, ^{239}Pu, Al, and ^{234}U were among the constituents with the highest partial HQs. Improving model realism by weighting simulated owl foraging based on distance from potential nests decreased the estimated risk. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, owl habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at acceptable low levels.

Gallegos, A.F., G.J. Gonzales, K.D. Bennett, L.E. Pratt, and D.S. Cram. 1997. A Spatially-Dynamic Preliminary Risk Assessment of the American Peregrine Falcon at the Los Alamos National Laboratory (Version 1). Report No. LA-13321-MS. Los Alamos National Laboratory. 114 pp.

This report presents the results of a preliminary risk assessment for the peregrine falcon on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated doses to the falcon were compared against toxicity reference values to generate hazard indices. Hazard index results indicated no unacceptable risk to the falcon from the soil ingestion pathway, including a measure of cumulative effects from multiple contaminants that assumes a linear additive toxicity type. Scaling home ranges on the basis of maximizing falcon height for viewing prey decreased estimated risk by 69% in a canyons-based home range and increased estimated risk by 40% in a river-based home range. Improving model realism by weighting simulated falcon foraging based on distance from potential nest sites decreased risk. Choice of toxicity reference values can have a substantial impact on risk estimates. Adding bioaccumulation factors for several organics increased partial hazard quotients by a factor of 110, but increased the mean hazard index by only 0.02 units. Adding a food consumption exposure pathway in the form of biomagnification factors for 15 contaminants of potential ecological concern increased the mean hazard index to 1.16, which is above the level of acceptability (1.0). Aerochlor-1254, DDT, and DDE accounted for 81% of the estimated risk that includes soil ingestion and food consumption pathways and a biomagnification component. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, falcon habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at acceptably low levels.

Gonzales, G.J., A.F. Gallegos, and T.S. Foxx,. 1997. Second Annual Review Update: Preliminary Risk Assessment of Federally Listed Species at the Los Alamos National Laboratory. Report No. LA-UR-97-4732. Los Alamos National Laboratory. 9 pp.

The ECORSK model that was used to perform the initial risk assessments for the peregrine falcon, bald eagle, and Mexican spotted owl was modified to include updated contaminant uptake and accumulation information as well as updated TRV values. This report presents updated results for the spotted owl and peregrine falcon using the new model. Overall, the results indicate a small potential for impact to the peregrine falcon but no appreciable impact to the spotted owl or bald eagle.

Gonzales, G.J., A.F. Gallegos, T.S. Foxx, P.R. Fresquez, M.A. Mullen, L.E. Pratt, and P.E. Gomez. 1998. A Spatially-Dynamic Preliminary Risk Assessment of the Bald Eagle at the Los Alamos National Laboratory. Report No. LA-13399-MS. Los Alamos National Laboratory. 64 pp.

This report presents the results of a preliminary risk assessment for the bald eagle on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. Estimated exposure doses to the eagle for radionuclide, inorganic metal, and organic contaminants were derived for varying ratios of aquatic vs. terrestrial simulated diet and compared against toxicity reference values to generate hazard indices (HIs). The HI results indicate that no appreciable impact to the bald eagle is expected from contaminants at LANL from soil ingestion and food consumption pathways. This includes a measure of cumulative effects from multiple contaminants that assumes linear additive toxicity. Improving model realism by

weighting simulated eagle foraging based on distance from potential roost sites increased the HI by 76%, but still to inconsequential levels. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, eagle habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at low levels.

Gonzales, G.J., A.F. Gallegos, M.A. Mullen, K.D. Bennett, and T.S. Foxx. 1998. Preliminary Risk Assessment of the Southwestern Willow Flycatcher (*Empidonax trallii extimus*) at the Los Alamos National Laboratory. Report No. LA-13508-MS. Los Alamos National Laboratory. 43 pp.

This report presents the results of a preliminary risk assessment for the southwestern willow flycatcher on Los Alamos National Laboratory property using a spatially-dynamic computer simulation model and based on the quotient method described in US EPA Ecological Risk Assessment Guidance. The southwestern willow flycatcher is the fourth threatened or endangered species to undergo a preliminary assessment for estimating potential risk from environmental contaminants at the Los Alamos National Laboratory. These assessments are being conducted as part of a three-year project to develop a habitat management plan for threatened or endangered species and species of concern at the Laboratory. For the preliminary assessment, estimated doses were compared against toxicity reference values to generate hazard indices (HIs). This assessment includes a measure of cumulative effects from multiple contaminants (radionuclides, metals, and organic chemicals) to 100 simulated nest sites located within flycatcher potential habitat. Sources of contaminant values were 10.000 ft^2 grid cells within an Ecological Exposure Unit (EEU). This EEU was estimated around the potential habitat and was based on the maximum home range for the flycatcher identified in the scientific literature. Food consumption and soil ingestion contaminant pathways were addressed in the assessment. Using a four-category risk evaluation, HI results indicate no appreciable impact is expected to the southwestern willow flycatcher. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, flycatcher habitat, facility siting, and/or facility operations in order to maintain low levels of risk from contaminants.

Gonzales, G.J., R.J. Robinson, S. Cross, H. Nottleman, and T.S. Foxx. 1996. Literature Review and Species Habitat Use Documentation, Report No. LA-UR-96-3526. Los Alamos National Laboratory. 30 pp.

A literature review was conducted to find information about Threatened and Endangered Species that inhabit the Los Alamos National Laboratory preserve. This information was collected into a database and used to develop habitat use and feeding habit tables for ten species.

Gonzales, G.J., R.J. Robinson, T.S. Foxx, S. Cross, D. Cram, J. Hagstrom, and H. Nottleman. 1998. Literature Review of the Site Nonspecific Habitat Use and Feeding Habits of Threatened and Endangered Species Concerning the Los Alamos National Laboratory. Report No. LA-UR-98-2978. Los Alamos National Laboratory.

During Fiscal Years 1996 and 1997, a systematic search of published and unpublished literature was conducted for information about biological species that are federally- or state-listed as threatened, endangered, or species of concern that have the potential to inhabit, use, or migrate through the 43 mi^2 of Los Alamos National Laboratory or adjacent lands. To date, about 403 references related to these species have been entered into a ProCite bibliographic database. Habitat use and feeding habits tables have been developed for 21 species.

Haarman, T.K., and L.A. Hansen. 1998. Biological Evaluation of the Impacts for the Implementation of the Threatened and Endangered Species Habitat Management Plan. Report No. LA-UR-98-6005. Los Alamos National Laboratory.

The Los Alamos National Laboratory Threatened and Endangered Species Habitat Management Plan (HMP) was prepared by the Los Alamos National Laboratory (LANL) Ecology Group for the Department of Energy (DOE) as part of the Dual-Axis Radiographic Hydrodynamics Test Facility (DAHRT) Mitigation Action Plan. The purpose of the HMP is to provide for the protection of threatened and endangered species and their habitats at LANL. The HMP consists of three components: an Overview Document, Site Plans, and Monitoring Plans. All three

components must be used together to assure proper management of threatened and endangered species. If all the restrictions and protective measures outlined in the HMP are strictly followed, the implementation of the management plan may affect but is not likely to adversely affect the Mexican spotted owl, the American peregrine falcon, the bald eagle, and the southwestern willow flycatcher. Additionally, the implementation of the management plan should have no effect on the black-footed ferret, the Artic peregrine falcon, and the whooping crane.

Hinojosa, H., and L.K. Nguyen. 1996. Threatened, Endangered, and Sensitive Species Profile. Report No. LA-UR-96-1269. Los Alamos National Laboratory. 19 pp.

This document is intended to provide a thumbnail description of various plant and animal species that may inhabit or potentially inhabit areas in and around Los Alamos National Laboratory and that are included in lists on the federal, state, or local level proclaiming them to be at some degree of risk.

Keller, D.C., J.R. Biggs, and T.H. Johnson. 1996. Threatened and Endangered Species Surveys and Habitat Management at Los Alamos National Laboratory. Report No. LA-UR-96-3444. Los Alamos National Laboratory.

This report provides information on Threatened and Endangered Species and Species of Concern that potentially can be found at Los Alamos National Laboratory. Documentation is provided on surveys that have been conducted to determine presence on and usage of Laboratory property. Species that are addressed include bald eagle, black-footed ferret, Goat Peak pika, golden eagle, Mexican spotted owl, New Mexico meadow jumping mouse, peregrine falcon, and southwestern willow flycatcher.

Sigler, J.W. 1998. A Status Report on Threatened and Endangered Species, Wetlands, and Floodplains for the Proposed Conveyance and Transfer Tracts at Los Alamos National Laboratory, Los Alamos, New Mexico. Report No. LA-UR-98-3361. Los Alamos National Laboratory.

The U.S. Department of Energy (DOE) announced its intent in the May 6, 1998 issue of the Federal Register (V63, No. 87) to prepare an environmental impact statement (EIS) to assess the potential environmental impacts of conveying and transferring certain land tracts located within Los Alamos and Santa Fe Counties at Los Alamos National Laboratory. The purpose of this document is to provide:

- *A brief summary of actions mandated by Congress in Public Law 105-119;*
- *A description of the regional and site specific setting of the proposed action in Los Alamos and Santa Fe Counties;*
- *Ecological baseline information at the proposed action locations;*
- *Endangered Species Act Considerations;*
- *DOE requirements regarding floodplains and wetlands, including their identification and assessment, and other aspects of DOE real property transfers; and*
- *Other regulatory concerns pertaining to fish and wildlife.*

Stacey, P.B., and A. Hodgson. 1999. Biological Diversity in Montane Riparian Ecosystems: the Case of the Mexican Spotted Owl. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 204-210. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Although usually considered to be a bird of old growth mixed conifer forests, the Mexican spotted owl historically occurred in a wide range of habitats from lowland cottonwood bosques to montane canyon systems. In a recent study of habitat use in central New Mexico, owls were found to roost primarily in canyon bottoms; and sites that were selected were characterized by deciduous trees and high structural complexity of vegetation rather than by large diameter conifer trees per se. Intact riparian areas in montane canyons typically have considerable structure, yet, as in the lowlands, these habitats have undergone extensive modification and reduction. The unexpected diversity of habitat use of the Mexican spotted owl suggests that historic changes in

upland riparian systems in the Rio Grande Basin may have impacted more species than originally believed.

Vegetation Studies

Allen, C.D. 1989. Changes in the Landscape of the Jemez Mountains, New Mexico. Ph.D. Dissertation. University of California at Berkeley. 346 pp.

This dissertation contains detailed information on the fire history of the Pajarito Plateau and fire effects on the Plateau environment.

Balice, R.G. 1998. A Preliminary Survey of Terrestrial Plant Communities in the Sierra de los Valles. Report No. LA-13523-MS. Los Alamos National Laboratory. 52 pp.

To more fully understand the species composition and environmental relationships of high-elevation terrestrial plant communities in the Los Alamos region, 30 plots in randomly selected, upland locations were sampled for vegetation, topographic, and soils characteristics. The locations of these plots were constrained to be above 7000 ft above mean sea level. The field results were summarized, analyzed, and incorporated into a previously developed classification of vegetation and land cover types. The revised and updated discussions of the environmental relationships at these sites and their associated species compositions are included in the report. A key to the major land cover types in the Los Alamos region was revised according to the new information and is also presented in its entirety.

Balice, R.G., S.G. Ferran, and T.S. Foxx. 1997. Preliminary Vegetation and Land Cover Classification for the Los Alamos Region. Report No. LA-UR-97-4627. Los Alamos National Laboratory. 52 pp.

The major vegetation and Land Cover types in the Los Alamos Region were classified into Level I and Level II cover types. Level I classes reflect major physiognomic and floristic groupings, and Level II classes are based on the dominant or codominant species and the characteristics of the physical environment. The implications of these land cover classes to management of vegetation and wildlife are discussed where appropriate.

Banar, A. 1995. Results of Canyon Bottom and Stream Channel Vegetation Surveys in Guaje and Los Alamos Canyons (1993). In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 1-39. Report No. LA-13065-MS. Los Alamos National Laboratory.

The purpose of this study was to determine plant species diversity and community composition for Guaje and Los Alamos Canyons. Many plants are indicator species and changes in species diversity or community composition could signal an environmental change. The study of these two canyons should provide a measure of the effect man has on naturally occurring plant populations. The relatively undisturbed environment in Guaje Canyon will be used as a control to evaluate impacts in Los Alamos Canyon. This report summarizes findings from the first year of data. New data will be presented as it becomes available.

Caplan, T.R., H.A. Pratt, and S.R. Loftin. 1999. Influence of Mycorrhizal Source and Seedling Methods on Native Grass Species Grown in Soils from a Disturbed Site. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 170-174. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Mycorrhizal fungi are crucial elements in native plant communities, and restoring these fungi to disturbed sites is known to improve revegetation success. The seedball method of plant dispersal for restoration of plants and mycorrhizal fungi to disturbed ecosystems was tested. The seedball method was tested with a native mycorrhizal fungi inoculum and a commercial inoculum. Neither the native culture nor the commercial inoculum was a viable source of mycorrhizae. In spite of the complications encountered in this experiment, seedballs are still believed to be an excellent method of seed dispersal for restoration projects. Incorporating root segments of the native culture host plants containing hyphae into the seedballs may accomplish both goals of

restoring not only the seeds of native plants, but also the native arbuscular mycorrhizal fungi that have been removed from a disturbed area.

Cross, S. 1995. Aquatic Invertebrate Sampling at Selected Outfalls in Operable Unit 1082; Technical Areas 9,11,16,and 22. Report No. LA-13019-MS. Los Alamos National Laboratory. 57 pp.

Preliminary sampling for aquatic invertebrates, hydrological condition, physico-chemical parameters, wildlife uses, and vegetation was conducted for eleven outfalls within Operable Unit 1082 and nearby "natural waterways." The physico-chemical parameters at most outfalls and natural waterways fell within the normal range of natural waters in the area. However, the outfalls are characterized by low biodiversity and severely stressed communities composed of a restricted number of taxa. The habitat at some outfalls could probably support well-developed aquatic communities if sufficient water was available. At present, the hydrology at these outfalls is too slight and/or too sporadic to support such a community in the foreseeable future. In contrast to the outfalls, the natural waterways had greater densities of aquatic invertebrates, higher biodiversities, and lower community tolerance quotients.

Dunham, D.A. 1995. Results of North- and South-Facing Slope Vegetation Surveys in Guaje and Los Alamos Canyons. In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 41-57. Report No. LA-13065-MS. Los Alamos National Laboratory.

This paper addresses studies conducted on the north- and south-facing slopes of Guaje and Los Alamos Canyons. The purpose was to continue the vegetation studies completed in the canyon bottoms in 1993. The completion of the two years of work in these canyons should provide a measure of the effect man has on naturally occurring plant populations. The relatively undisturbed environment in Guaje Canyon will be used as a control to evaluate impacts in Los Alamos Canyon.

Dunham, D.A. 1995. Biomass Estimation in Two Canyon Ecosystems. In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 59-89. Report No. LA-13065-MS. Los Alamos National Laboratory.

Tree measurements and herbaceous clip plots were used to estimate total aboveground biomass in Guaje and Los Alamos Canyons. Tree biomass values aid in quantifying mineral cycles and contaminant pathways in forest ecosystems. A comparison of the two canyons will provide a controlled means to study these cycles and pathways. The relatively undisturbed environment in Guaje Canyon will be used as a control to evaluate impacts in Los Alamos Canyon.

Foxx, T.S. 1996. Vegetation Succession After the La Mesa Fire at Bandelier National Monument. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 47-69. General Technical Report No. RM-GTR-286. USDA Forest Service.

In 1977, La Mesa Fire burned over four areas of known fire history within Bandelier National Monument, all of which had been selected for study prior to the fire. Data were collected on two of the four study areas in 1976 immediately prior to the fire and provide pre-fire information. All four study areas were examined post-fire in 1977, 1978, 1985, and 1993 (1 year, 2 years, 8 years, and 16 years post-fire). Each study area was re-examined for density and cover of the understory and overstory components. Additionally, tree crown damage and recovery and growth of trees also were monitored. Detailed evaluations of each plot are presented, and the following general summary observations were made.

- *In areas where the tree canopy was destroyed, the successional recovery of understory cover was linear. However, in areas where there was tree canopy, there was a reduced cover the second year and then a continued increase from 1978 through 1993.*
- *Soil crusts appeared to be more extensive on sites that burned more intensely and that have less tree canopy and ground litter cover.*

- *The seeded grass, slender wheatgrass, was a dominant species early in the post-fire succession but vanished from the ecosystem after 1985.*
- *Where there was little tree canopy cover, the seeded grass, sheep fescue, became more dominant than in the areas with more canopy cover. However, the grass does not seem to have markedly inhibited tree reproduction.*
- *Certain plant species appear to be fire related, although post-fire successional patterns vary. For example, goosefoot was abundant after the fire through 1978 but disappeared from the ecosystem by 1985, whereas big bluestem has increased markedly through time at several sites since the fire.*
- *Trees that sustained less fire damage to their crowns grew faster than trees that suffered more severe crown damage, but there seems to be little correlation between tree size and post-fire growth rate.*

Foxx, T.S., L. Pierce, G.D. Tierny, and L.A. Hansen. 1998. Annotated Checklist and Database for Vascular Plants of the Jemez Mountains. Report No. LA-13408. Los Alamos National Laboratory. 164 pp.

Studies performed over the past 40 years were used to construct a checklist of plants of the Jemez Mountains. This checklist is annotated with taxonomic information, geographic and biological information, economic uses, wildlife cover, revegetation potential, and ethnographic uses. Nearly 1000 species have been noted.

Foxx, T.S., and G.D. Tierney. 1980. Status of the Flora of the Los Alamos National Environmental Research Park. Report No. LA-8050-NERP, Volume I. Los Alamos National Laboratory. 51 pp.

Under the Endangered Species Act of 1973, it became necessary to locate critical habitats of plant species in danger of extinction on State and Federal lands. In 1976, the Los Alamos Environmental Research Park (LA/NERP) was established to provide a study area that would contribute to the understanding of how man can best live in balance with nature while enjoying the benefits of technology. Under this mandate, a study to provide information regarding the locations of possible endangered, threatened, protected, and rare species within the LA/NERP was initiated in August of 1977. This report presents the results of this study and discusses the status of Threatened and Endangered Species and New Mexico Protected Species in the LA/NERP.

Foxx, T.S., and G.D. Tierney. 1982. Vegetational Analysis of a Canyon Ecosystem at Los Alamos. Report No. LA-9576-MS. Los Alamos National Laboratory. 27 pp.

The purpose of this study was to determine the floristic composition of a canyon located immediately below a peregrine falcon nesting site with the goal of determining whether maintenance of the disturbed site could contribute to habitat enhancement for peregrine prey. Data are presented on presence and importance of plant species known to be preferred food sources for doves and small rodents. The preliminary conclusion is that the disturbed site does not contain an abundance of these key food species.

Foxx, T.S., and G.D. Tierney. 1984. Status of the Flora of the Los Alamos National Environmental Research Park. A Historical Perspective. Report No. LA-8050-NERP, Volume II. Los Alamos National Laboratory. 50 pp.

Studies of the flora of the Los Alamos National Environmental Research Park (LA/NERP) are continued in Water and Pajarito Canyons and their extensions to natural boundaries outside of the LA/NERP. Six plant communities and sixteen plant habitats are described for the study area. The status of endangered, threatened, and rare plant species in the study area is reviewed, and land-use history of the Pajarito Plateau is related to the levels of apparent anthropogenic disturbance in the study areas' six plant communities.

Foxx, T.S., and G.D. Tierney. 1985. Status of the Flora of the Los Alamos National Environmental Research Park. Checklist of Vascular Plants of the Pajarito Plateau and Jemez Mountains. Report No. LA-8050-NERP, Volume III. Los Alamos National Laboratory. 142 pp.

This report lists all taxonomic identifications recorded from the Pajarito Plateau, Valles del los Sierros, Valles Caldera, and portions of the Jemez Plateau of the Jemez Mountains in north-central New Mexico. Approximately 900 plants representing more than 80 families are documented. The report is superceded by Report No. LA-13408.

Foxx, T., G. Tierney, M. Mullen, and M. Salisbury. 1997. Old-Field Succession on the Pajarito Plateau. Report No. LA-13350. Los Alamos National Laboratory. 109 pp.

Several fallow historic fields within ponderosa pine and piñon-juniper cover types were surveyed to determine species composition and distribution. The purpose of the study was to understand plant succession on old fields as related to mechanically manipulated sites such as material disposal areas. The study provides a description of each site, historic information about the site, a photographic record, and a listing of species found at each site. Among other information, the study provides a listing of species that will invade disturbed sites, which are species that may be used in site reclamation.

Foxx, T.S., G.D. Tierney, and J.M. Williams. 1984. Rooting Depths of Plants on Low-Level Waste Disposal Sites. Report No. LA-10253-MS. Los Alamos National Laboratory. 23 pp.

Data from the bibliographic data base on rooting depths of native plants in the United States (see next citation) were analyzed for rooting depths relative to species found on low-level waste (LLW) sites at Los Alamos National Laboratory. Average rooting depth and rooting frequencies were determined and related to present LLW site maintenance.

Foxx, T.S., G.D. Tierney, and J.M. Williams. 1984. Rooting Depths of Plants Relative to Biological and Environmental Factors. Report No. LA-10254-MS. Los Alamos National Laboratory. 26 pp.

This report summarizes the results of an extensive bibliographic study to document rooting depths of native plants in the United States. The data are analyzed for rooting depths as related to life form, soil type, geographical region, root type, family, root depth-to-shoot height ratios, and root depth to root lateral ratios.

Keller, C.F. 1999. White Rock Canyon and its Riparian Areas. Report No. LA-UR-99-6260. Los Alamos National Laboratory. 14 pp.

This report presents a floristic inventory of White Rock Canyon north of Bandelier National Monument.

Miera, F.R., Jr., K.V. Bostick, T.E. Hakonson, and J.W. Nyhan. 1977. Biotic Survey of Los Alamos Radioactive Liquid-Effluent Receiving Areas. Report. No. LA-6503-MS. Los Alamos Scientific Laboratory. 23 pp.

A field study on the surface and subsurface erosional transport of surface-applied ^{133}Cs as affected by pocket gopher burrowing was conducted on simulated waste landfill caps at the Los Alamos National Laboratory in north central New Mexico. Surface loss of Cs, adhered to five soil particle size ranges, was measured several times over an 18-month period while simulated rainfalls were in progress. Gophers reduced Cs surface loss by significant amounts, 43%. Cesium surface loss on plots with only gophers was 0.8 kg total for the study period. This compared with 1.4 kg for control plots, 0.5 kg for vegetated plots, and 0.2 kg for plots with both gophers and vegetation. Relatively little subsurface Cs was measured in plots containing only gophers (0.7 g/kg). Vegetation-bearing plots had significantly more total subsurface Cs (1.7 g/kg) than plots without vegetation (0.8 g/kg). An average of 97% of the subsurface Cs in plots with vegetation was located in the upper 15 cm of soil compared with 67% for plots without vegetation. Vegetation moderated the influence of gopher activity on the transport of Cs to soil subsurfaces and stabilized subsurface Cs by concentrating it in the rhizosphere. Gopher activity may have caused Cs transport to depths below that sampled, 30 cm. The results provide distribution coefficients for models of contaminant migration where animal burrowing occurs.

Pierce, L., and T. Foxx. 1996. Plant Information Database for EF Site, TA-15, Los Alamos National Laboratory from the Plant Information Database for the Pajarito Plateau and the Jemez Mountains. Report No. LA-UR-95-3602. Los Alamos National Laboratory.

During 1992, field surveys were conducted for the site characterization of Operable Unit 1086, TA-15. Surveys were conducted on mesa tops and in Pajarito, Three Mile, Potrillo, and Water Canyons, which are contiguous to the mesa tops where facilities and firing sites are located. This summary provides some information necessary to conduct screening models for a portion of TA-15, EF Site, which includes the following types of data:

- *quantitative data on cover, relative cover, frequency, relative frequency, and an importance index;*
- *results of the comparison of habitat data with the habitat requirements of the threatened and endangered species; and*
- *a listing from the Plant Information Database of all information that has been compiled on species known to occur on EF Site and Potrillo Canyon adjacent to the site.*

Racinez, E., and T.S. Foxx. 1999. A Notebook of Sedges and Rushes of the Jemez Mountains. Report No. LA-UR-99-5185. Los Alamos National Laboratory.

Floodplains are recognized as areas of land between meandering rivers and wetlands that are characterized by their hydrophytic soils and vegetation. These greenbelts along streams and rivers provide important habitats for many species in the arid southwest. Many rare and endangered species rely on wetlands for part or all of their lifecycle. In Los Alamos County, there are a number of wetland areas that either occur naturally or are manmade. Identification of wetlands requires knowledge about hydrophytic vegetation, which includes sedges and rushes (Cyperaceae and Juncaceae). While describing the importance of wetlands, this study focused on the vegetation that is characteristic of wetland, riparian, and floodplain habitats. These groups of plants generally are difficult to identify, and few references on the taxonomy of plants in these groups exist. This report is an attempt to provide information on sedges and rushes for persons doing fieldwork in wetlands ecology, wetlands delineation, and riparian zone studies.

Tierney, G.D., and T.S. Foxx. 1982. Floristic Composition and Plant Succession on Near-Surface Radioactive Waste Disposal Facilities in the Los Alamos National Laboratory. Report No. LA-9219-MS. Los Alamos National Laboratory. 59 pp.

Since 1946, low-level radioactive waste has been buried in shallow landfills within the confines of the Los Alamos National Laboratory. Five of these sites were studies for plant composition and successional patterns by reconnaissance and vegetation mapping. The data show a slow rate of recovery for all sites, regardless of age, in both the piñon-juniper and ponderosa pine communities. The sites are not comparable in succession or composition because of location and previous land use. The two oldest sites have the highest species diversity and the only mature trees. All sites allowed to revegetate naturally tend to be colonized by the same species that originally surrounded the sites. Sites on historic fields are colonized by the old field flora, whereas those in areas disturbed only by grazing are revegetated by the local native flora.

Tierney, G.D., and T.S. Foxx. 1987. Root Lengths of Plants on Los Alamos National Laboratory Lands. Report, No. LA-10865-MS. Los Alamos National Laboratory. 59 pp.

Maximum root lengths of 22 plant species occurring on Los Alamos National Laboratory lands were measured. An average of the two longest roots from each species were dug up and their lengths, typical shapes, and qualitative morphologics were noted along with the overstory dimensions of the plant individual with which the roots were associated. Maximum root lengths were compared with overstory (height times width) dimensions. Among the life forms studied, the shrubs tend to show the longest roots in relation to overstory size. Forbs show the shortest roots in relation to overstory size. Measurements of tree roots suggest only that immature trees on the Pajarito Plateau may have root-length to overstory-size ratios near one.

White, C.S., S.R. Loftin, and S.C. Hofstad. 1999. Response of Vegetation, Soil Nitrogen, and Sediment Transport to a Prescribed Fire in Semiarid Grasslands. In: Rio Grande Ecosystems:

Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 83-92. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Shrubs and trees have invaded semiarid grasslands throughout much of the Southwestern United States. This invasion has not only decreased grass cover but has also increased runoff and erosion. In fact, sediment from rangelands constitutes the single largest source of nonpoint stream pollutants within the State of New Mexico. Fire, which was a natural factor that shaped and maintained the grasslands, is a management tool that may aid in restoring and maintaining grass cover. However, fire also poses the risk of increasing erosion and further degradation because protection afforded by vegetation is reduced immediately after the fire. This study measured vegetation cover, soil inorganic nitrogen (N) levels, and erosion amounts associated with the first application of prescribed fire on two semiarid grasslands. The potential for adverse effects from these fires was great because they were performed at the beginning of a drought period. After the first growing season following the fire, grass cover returned to pre-burn levels, and both soil N and erosion amounts were similar to the unburned areas. Thus, prescribed fire for reducing shrub and tree cover may pose minimal adverse risk even under drought conditions.

Waste Site Investigations

Bennett, K., J. Biggs, and P. Fresquez. 1996. Radionuclide Contaminant Analysis of Small Mammals, Plants and Sediments within Mortandad Canyon, 1994. Report No. LA-13104-MS. Los Alamos National Laboratory. 31 pp.

Small mammals, plants, and sediments were sampled at one upstream location (Site 1) and two downstream locations (Sites 2 and 3) from NPDES outfall #051-051 in Mortandad Canyon. The purpose of the sampling was to identify radionuclides potentially present, to quantitatively estimate and compare the amount of radionuclide uptake at specific locations (Sites 2 and 3) as compared to the upstream site (Site 1), and to identify the primary mode (inhalation/ingestion or surface contact) of contamination to small mammals. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were analyzed separately. In addition, three composite samples also were collected for plants and sediments at each site. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, and total U. With the exception of total U, all mean radionuclide concentrations in small mammal carcasses and sediments were significantly higher at Site 2 than at Site 1 or Site 3. No differences were detected in the mean radionuclide concentration of plant samples between sites. However, some radionuclide concentrations found at all three sites were higher than regional background. No differences were found between mean carcass radionuclide concentrations and mean pelt radionuclide concentrations, indicating that the two primary modes of contamination may be occurring equally.

Bennett, K., J. Biggs, and P. Fresquez. 1997. Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, Los Alamos National Laboratory, 1995. Report No. LA-13242-MS. Los Alamos National Laboratory. 20 pp.

Small mammals were sampled at two waste burial sites (Site 1 – recently disturbed and Site 2 – partially disturbed) at Area G, Technical Area 54 and a control site on Frijoles Mesa (Site 4) in 1995. The objectives were 1) to identify radionuclides that are present within surface and subsurface soils, 2) to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and 3) to identify if the primary mode of contamination to small mammals is by surface contact or ingestion/inhalation. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, ^{137}Cs, and ^{3}H. Significantly higher levels of total U, ^{241}Am, ^{238}Pu, and ^{239}Pu were detected in pelts than in carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in pelts. The results generally show higher concentrations in pelts compared to carcasses, which is similar to what has been found at waste burial/contaminated sites outside of LANL. Site 1 had a significantly higher mean tritium concentration in both carcasses and pelts than Sites 2 or 4. Site 2 had a significantly higher mean ^{239}Pu concentration in carcasses than Sites 1 or 4.

Bennett, K.D., J.R. Biggs, and P.R. Fresquez. 1998. Radionuclide Contaminant Analysis of Small Mammals at Area G, Technical Area 54, 1997 (with cumulative summary 1994-1997). Report No. LA-13517-MS. Los Alamos National Laboratory. 18 pp.

In 1997, small mammals were sampled to four locations at Area G, Technical Area 54, a control site within the proposed Area G expansion area, and a background site on Frijoles Mesa. The purpose of the sampling was to (1) identify radionuclides that are present within rodent tissues at waste burial sites, (2) compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and (3) identify the primary mode of contamination to small mammals, either through surface contact or through ingestion/inhalation. Three composite samples of approximately five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, ^{137}Cs, and ^{3}H Higher levels of total U and ^{137}Cs were detected in pelts as compared to carcasses of small mammals, and ^{90}Sr was found to be higher in carcasses. Concentrations of other measured radionuclides in carcasses were not found to be statistically different from concentrations in pelts. However, pelts generally had higher concentrations than carcasses, indicating that surface contamination may be the primary contamination mode. Low sample sized in total number of animals captured during 1997 prevented statistical analysis to compare site to site for all but four sites. Mean concentrations of ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{3}H in small mammal carcasses were found to be statistically greater at the transuranic (TRU) waste pad #2. In addition, mean concentrations of total U, ^{241}Am, and ^{3}H in pelts of small mammals also were statistically greater. The control site and background site consistently had the lowest mean concentrations of radionuclides. Year to year comparison of mean radionuclide concentrations was conducted where sufficient sample size existed. Mean concentrations of ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{3}H in carcasses were statistically greater in 1997 than in previous years at TRU waste pad #2. However, mean concentrations of ^{137}Cs in small mammal carcasses were higher at the TRU waste pad #2 and at Pits 17 and 18 during 1996.

Biggs, J., K. Bennett, and P. Fresquez. 1995. Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, 1994. Report No. LA-13015-MS. Los Alamos National Laboratory. 34 pp.

Small mammals were sampled at two waste burial sites (1 and 2) at Area G, TA-54 and a control site outside Area G (Site 3) to identify radionuclides that are present within surface and subsurface soils at waste burial sites, to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and to identify the primary mode of contamination to small mammals, either through surface contact or ingestion/inhalation. Three composite samples of at least five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, ^{239}Pu, total U, and gamma spectroscopy (including ^{137}Cs). Significantly higher levels of total U, ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{40}K were detected in pelts as compared to the carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in the pelts. The results show higher concentrations in pelts than in carcasses, which is similar to what has been found at waste burial/contaminated sites outside of Los Alamos National Laboratory. Site 1 had significantly higher total U concentrations in carcasses than Sites 2 and 3. Site 2 had significantly higher ^{239}Pu concentrations in carcasses than either Site 1 or Site 3. A significant difference in ^{90}Sr concentration existed between Sites 1 and 2, and concentrations of ^{40}K at Site 1 were significantly different from Site 3.

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1997. Radionuclide Contaminant Analysis of Small Mammals at Area G, Technical Area 54, 1996 (with cumulative summary for 1994-1996). Report No. LA-13345-MS. Los Alamos National Laboratory. 16 pp.

Small mammals were sampled at two waste burial sites at Area G and a control site within the proposed Area G expansion to (1) identify radionuclides that are present within rodent tissues at waste burial sites, (2) to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and (3) to identify the primary mode of contamination to small

mammals, either through surface contact or ingestion/inhalation. Pelts and carcasses of each animal were separated and analyzed independently for several radionuclides. Higher levels of total U, Am-241, Pu-238, and Pu-239 were detected in pelts. Concentrations of other measured radionuclides were nearly equal in pelts and carcasses. Due to low sample sizes, statistical site to site comparisons could not be conducted.

Brooks, G.H., Jr. 1989. The Comparative Uptake and Interaction of Several Radionuclides in the Trophic Levels Surrounding the Los Alamos Meson Physics Facility (LAMPF) Waste Water Ponds. Report No. LA-11487-T. Los Alamos National Laboratory. 151 pp. (M.S. Dissertation, San Jose State University)

This report documents the results of a study designed to examine the uptake, distribution, and interaction of five activation products (^{57}Co, ^{7}Be, ^{134}Cs, ^{83}Rb, and ^{54}Rb) within the biotic and abiotic components surrounding the Los Alamos Meson Physics Facility (LAMPF) lagoons in the days when the lagoons discharged into the canyon below LAMPF. Preliminary estimates of trophic level radionuclide transfer are presented.

Cross, S. 1996. Biological and Water Quality Assessments for the Material Disposal Area P Project Area, 1995 and 1996. Report No. LA-UR-96-4670. 56 pp.

Material Disposal Area (MDA) P is located within LANL TA-16 where high explosives (HE) production and development are the main activities. The waste pile was active until 1984. It lies along a slope located on the southern rim of Cañon de Valle, just north of TA-16 thermal treatment area pad TA-16-387. The landfill area extends almost to a small flowing stream in the bottom of the canyon, approximately 150 ft below the summit of the waste pile. The debris in the waste pile is very heterogeneous, consisting of burned HE-contaminated equipment, building materials, empty drums and bottles, and general trash. Waste materials include metals, arsenic, nitrates, HE residue, and possibly aromatic hydrocarbons, asbestos, solvents, and depleted uranium. This report provides a detailed description and history of the site and describes the results of biotic surveys in the area. In general, the surveys showed that all water quality parameters for Cañon de Valle were within the ranges set by the State of New Mexico for high-quality cold-water fisheries, although a series of metrics used to evaluate the stream indicated that it is slightly impaired. A federally-endangered T&E species known to inhabit the area is discussed, as are project restrictions due to species and habitat requirements. A New Mexico-endangered plant may occur in the area. The report includes best management practices addressing biological concerns, which are presented in terms of T&E species, erosion control, water quality, and restoration of the area following clean closure.

Ferenbaugh, J.K. 1999. Radionuclide Uptake by Elk and Deer and the Associated Health Risks from a Low-Level Radioactive Waste Disposal Site. Report No. LA-13622-T. Los Alamos National Laboratory. (M.S. Dissertation, University of Minnesota)

Material Disposal Area G (Area G) is the primary low-level radioactive waste disposal site at Los Alamos National Laboratory (LANL) and occupies an area adjacent to Pueblo of San Ildefonso lands. Analyses of soil and vegetation collected from the perimeter of Area G show radionuclide concentrations greater than background (BG) concentrations for northern New Mexico. Pueblo residents are concerned about ingesting contaminants from Area G by consuming ungulates that forage near Area G and then migrate on to tribal land. The uptake of ^{3}H, ^{90}Sr, ^{tot}U, ^{238}Pu, ^{239}Pu, ^{241}Am, and ^{137}Cs by Rocky Mountain elk (Cervus elaphus) and mule deer (Odocoileus hemionus) that forage near Area G and the associated dose to the animals were estimated using equations modified from the literature coded into a spreadsheet (steady-state) model. Additionally, the dose to humans who consume the meat was estimated using the RESRAD program. Radionuclide concentrations in soil and water collected from the perimeter of Area G and from BG regions averaged over a four year period were used as input data. Concentration estimates generated by the spreadsheet model correspond well to the concentration range measured in tissue samples taken from animals collected at LANL, and the maximum estimated net dose (mean + 2SD minus background) was 2.8×10^{-4} mGy d^{-1} (elk). The maximum estimated net dose to humans consuming elk meat at the most conservative ingestion

rate (23 kg y^{-1}) was 4.0 $\times$ 10^{-4} mSv y^{-1}. All estimated worst case doses were less than guidelines established to protect the environment (1 mGy d^{-1}) and the public (1 mSv y^{-1}) from radionuclides.

Ferenbaugh, J.K., P.R. Fresquez, M.H. Ebinger, G.J. Gonzales, and P.A. Jordan. 1999. Elk and Deer Study, Material Disposal Area G, Technical Area 54: Source Document. Report No. LA-13596-MS. Los Alamos National Laboratory. 74 pp. Also abstracted at Health Physics 74(6): s28 (1998).

Material Disposal Area G is the primary low-level radioactive waste disposal site at LANL and occupies an area adjacent to the Pueblo of San Ildefonso. Analyses of soil and Vegetation collected from the perimeter of Area G have shown concentrations of radionuclides greater than background concentrations established for Northern New Mexico. As a result, Pueblo residents have become concerned that contaminants from area G could enter tribal lands through various ecological pathways. The residents specifically questioned the safety of consuming meat from elk and deer that forage near Area G and then migrate onto tribal lands. Consequently, this study addresses the uptake of radionuclides by elk and deer that forage around the perimeter of Area G and the associated doses to the animals and to humans who consume these animals. Concentration estimates generated by the models used in the study correspond to the concentration range measured in actual tissue samples from elk and deer collected at LANL. The highest doses for both animals and humans were well below guidelines established to protect the environment and the public from radiological health risks.

Ferenbaugh, R.W., T.E. Buhl. A.K. Stoker, N.M. Becker, J.C. Rodgers, and W.R. Hansen. 1994. Environmental Analysis of Lower Pueblo/Lower Los Alamos Canyon, Los Alamos, New Mexico. Report No. LA-12857-ENV. Los Alamos National Laboratory. 117 pp.

This report evaluated three alternatives for Lower Pueblo/Lower Los Alamos Canyon: (1) no action, (2) construction of a sediment trap in lower Pueblo Canyon to prevent further transport of residual radioactivity onto San Ildefonso Indian Pueblo land, and (3) cleanup of residual radioactivity from the canyon system. The report concluded that Alternative 3 is not a viable alternative because of the thousands of truckloads of sediment with extremely low levels of contamination that would have to be removed and disposed of. Although construction of a sediment trap is a viable alternative, this effort also is unwarranted because projected transport of contaminated sediments will not result in any residual radioactivity concentrations any higher than those already existing. Thus, no action is the preferred alternative.

Ferenbaugh, R.W., T.E. Buhl, A.K. Stoker, and W.R. Hansen. 1982. Environmental Analysis of the Bayo Canyon (TA-10) Site, Los Alamos, New Mexico. Report No. LA-9252-MS. Los Alamos National Laboratory. 87 pp.

This report evaluated three alternatives for the Bayo Canyon Site: (1) no action, (2) minimal action – restricted use of the area of known subsurface contamination, and (3) cleanup of subsurface contamination. The report concluded that no impacts were associated with the no action or minimal action alternatives and that impact associated with the cleanup alternative were minimal. Nevertheless, the recommended alternative was the minimal action alternative in which 0.6 hectare of land with subsurface contamination would be demarcated and restricted to surface activities.

Ferenbaugh, R.W., T.E. Buhl, A.K. Stoker, and W.R. Hansen. 1982. Environmental Analysis of Acid/Pueblo Canyon, Los Alamos, New Mexico. Report No. LA-9409-MS. Los Alamos National Laboratory. 100 pp.

This report evaluated three alternatives for Acid/Pueblo Canyon: (1) no action, (2) minimal action – fencing areas where residual radioactivity exceeds proposed criteria, and (3) cleanup of hot spots. The report concluded that no impacts were associated with the no action or minimal action alternatives. The recommended alternative was to clean up areas around the former vehicle decontamination facility and the untreated waste outfall. This action was recommended not because of any real danger associated with the residual radioactivity, but rather because cleanup is a minor operation and conforms with the ALARA philosophy..

Foxx, T., and B. Blea-Edeskuty. 1995. Wildlife Use of NPDES Outfalls at Los Alamos National Laboratory. Report No. LA-13009-MS. Los Alamos National Laboratory. 47 pp.

During the summer and fall of 1991, a preliminary survey of 133 NPDES outfalls was conducted to determine wildlife usage of these outfalls. Usage was determined on the basis of observed scat, tracks or bedding. Indications were that about 56% of the outfalls were being used by 35 vertebrate species as a drinking water source. Additionally, hydrophytic vegetation grows in association with approximately 40% of the outfalls – a characteristic that could make these areas eligible for wetland status. Additional study is necessary to determine usage by small mammals, amphibians, and aquatic macroinvertebrates. Wetland assessments may be necessary to ensure compliance with wetland regulations if LANL activities affect any of the outfalls supporting hydrophytic vegetation.

Foxx, T.S., G.D. Tierney, and J.M. Williams. 1984. Rooting Depths of Plants on Low-Level Waste Disposal Sites. Report No. LA-10253-MS. Los Alamos National Laboratory. 23 pp.

Data from the bibliographic data base on rooting depths of native plants in the United States (see next citation) were analyzed for rooting depths relative to species found on low-level waste (LLW) sites at Los Alamos National Laboratory. Average rooting depth and rooting frequencies were determined and related to present LLW site maintenance.

Fresquez, P.R., J.R. Biggs, and K.D. Bennett. 1995. Radionuclide Concentrations in Vegetation at Radioactive-Waste Disposal Area G During the 1994 Growing Season. Report No. LA-12954-MS. Los Alamos National Laboratory. 8 pp.

Overstory (piñon pine) and understory (grass and forb) vegetation samples were collected within and around selected points at Area G for radionuclide analysis. In general, most vegetation samples collected within and around Area G contained radionuclide levels in higher concentrations than vegetation collected from background areas. Tritium, in particular, was detected as high as 5,800 pCi/mL in overstory vegetation collected outside the fence just west of the tritium shafts. This suggests that tritium is migrating from this waste repository through subsurface pathways. Also, understory vegetation collected north of the TRU pads (outside the Area G fence) contained the highest values for several radionuclides, which may be a result of surface holding, storage, and/or disposal activities.

Fresquez, P.R., M.H. Ebinger, R.J. Wechsler, and L. Naranjo, Jr. 1999. Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G During the 1998 Growing Season (with a Cumulative Summary of ^{3}H and ^{239}Pu over Time). Report No. LA-13647-PR. Los Alamos National Laboratory. 91 pp.

Soils and unwashed overstory and understory vegetation were collected at 8 locations within and around Area G and analyzed for various radionuclides. Most of the radionuclide concentrations were within the upper level of background concentrations except for tritium and ^{239}Pu. Tritium concentrations in vegetation from most sites were greater than background concentrations. Concentrations of ^{239}Pu in soils and understory vegetation were largest in samples collected several meters north of the transuranic waste pad area. Based on tritium and ^{239}Pu data through 1998, concentrations were significantly greater than background in soils and vegetation collected from most locations, and there was no apparent systematic change with time.

Fresquez, P.R., T.S. Foxx, and L. Naranjo, Jr. 1995. Strontium Concentrations in Chamisa (*Chrysothamnus nauseosus*) Shrub Plants Growing in a Former Liquid Waste Disposal Area in Bayo Canyon. Report No. LA-13050-MS. Los Alamos National Laboratory. 8 pp.

Chamisa shrub plants growing in a former liquid waste disposal site in Bayo Canyon at Los Alamos National Laboratory were collected and analyzed for strontium (^{90}Sr) and total uranium. Surface soil samples also were collected from below (understory) and between (interspace) shrub canopies. Both chamisa plants growing over the waste disposal site contained significantly higher concentrations of ^{90}Sr than a control plant. One plant, in particular, contained 90,500 pCi of ^{90}Sr per g ash in top-growth material. Similarly, soil samples collected underneath and between plants contained ^{90}Sr concentrations above background and LANL screening action

levels. This probably occurred as a result of chamisa plant leaf fall contaminating the soil understory area followed by water and/or wind moving the ^{90}Sr into the interspace area. Although some soil surface migration of ^{90}Sr from the waste disposal site has occurred, the level of ^{90}Sr in sediments collected downstream of the waste disposal site at the Bayo Canyon/State Road 4 intersection was still within regional (background) concentrations.

Fresquez, P.R., E.L. Vold, and L. Naranjo, Jr. 1996. Radionuclide Concentrations in/on Vegetation at Radioactive-Waste Disposal Area G during the 1995 Growing Season. Report No. 13124-PR. Los Alamos National Laboratory. 37 pp.

Overstory (piñon pine) and understory (grass and forb) vegetation were collected within and around selected points at Area G – a low-level radioactive solid-waste disposal facility at Los Alamos National Laboratory – for the analysis of tritium (^{3}H), strontium (^{90}Sr), plutonium (^{238}Pu and ^{239}Pu), cesium (^{137}Cs), and total uranium. Also, heavy metals (Ag, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Tl) in/on vegetation were determined. In general, most (unwashed) vegetation collected within and around Area G contained ^{3}H, uranium, ^{238}Pu, and ^{239}Pu in higher concentrations than vegetation collected from background areas. Tritium, in particular, was detected as high as 7,300 pCi/mL in understory vegetation collected from the west side of the transuranic (TRU) pads. The south and west ends of the tritium shaft field also contained elevated levels of ^{3}H in overstory, and especially in understory vegetation, as compared to background. This suggests that ^{3}H may be migrating from this waste repository through surface and subsurface pathways. Also, understory vegetation collected north of the TRU pads (adjacent to the fence line of Area G) contained the highest values of ^{238}Pu and ^{239}Pu as compared to background. This may be a result of surface holding, storage, and/or disposal activities.

Fresquez, P.R., E.L. Vold, and L. Naranjo, Jr. 1997. Radionuclide Concentrations in Soils and Vegetation at Radioactive-Waste Disposal Area G during the 1996 Growing Season. Report No. LA-13332-PR. Los Alamos National Laboratory. 113 pp.

Soil and overstory and understory vegetation (washed and unwashed) collected at eight locations within and around Area G – a low-level radioactive solid waste disposal facility at Los Alamos National Laboratory – were analyzed for ^{3}H, ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{137}Cs, ^{234}U, ^{235}U, ^{238}U, ^{tot}U, ^{228}Ac, ^{214}Bi, ^{60}Co, ^{40}K, ^{54}Mn, ^{22}Na, ^{214}Pb, and ^{208}Tl. Also, heavy metals (Ag, As, Ba, Be, Cd, Cr, Hg, Ni, Pb, Sb, Se, and Tl) in soil and vegetation were determined. In general, most radionuclide concentrations, with the exception of ^{3}H and ^{239}Pu, in soils and washed and unwashed overstory and understory vegetation collected from within and around Area G were within upper limit background concentrations. Tritium was detected as high as 14,744 pCi/mL in understory vegetation collected from transuranic (TRU) waste pad #4, and the TRU waste pad area contained the highest levels of ^{239}Pu in soils and in understory vegetation as compared to other areas at Area G,

Fresquez, P.R., R.J. Wechsler, and L. Naranjo, Jr. 1998. Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 1997 Growing Season. Report No. LA-13495-PR. Los Alamos National Laboratory. 47 pp.

Soil and overstory and understory vegetation were collected at Area G and analyzed for radionuclides and heavy metals. In general, most radionuclide concentrations in soils and both washed and unwashed overstory and understory vegetation, with the exception of tritium and Pu-239, were within upper limit background concentrations. Although tritium concentrations in vegetation from most sites were significantly higher than background, concentrations decreased markedly in comparison to previous year's results. Also, as in the past, the transuranic waste pad area contained the highest levels of ^{239}Pu in soils and in understory vegetation as compared to other areas at Area G,

Gonzales, G.J., and P.G. Newell. 1996. Ecotoxicological Screen of Potential Release Site 50-006(D) of Operable Unit 1147 of Mortandad Canyon and Relationship to the Radioactive Liquid Waste Treatment Facilities Project. Report No. LA-13148-MS. Los Alamos National Laboratory. 52 pp. (Also released as LA-UR-96-12)

Potential ecological risk associated with soil contaminants in PRS 50-006(d) of Mortandad Canyon at LANL was assessed by performing an ecotoxicological risk screen. The PRS surrounds Outfall 051, which discharges treated effluent from the Radioactive Liquid Waste Treatment Facility. Discharge at the outfall is permitted under the CWA NPDES. Radionuclide discharge is regulated by DOE Order 5400.5. Ecotoxicological Screening Action Levels (ESALs) were computed for nonradionuclide constituents in the soil, and human risk SALs were used as ESALs for radionuclides. Within the PRS and beginning at Outfall 051, soil was sampled at three points along each of nine linear transects at 100-ft intervals. Soil samples from three depths for each sampling point were analyzed for the concentration of a total of 121 constituents. Only the results of the surface sampling are reported in this report. The spatial change in radionuclide concentrations from the outfall to the downcanyon sample locations was statistically insignificant. The average concentration (19.7 pCi/g) of alpha-emitting radionuclides was higher that the values reported in a different study for all 15 onsite locations for the period 1976-1981 and is 242% of the mean gross alpha concentration measured in the same area between 1975 and 1977. The variation between transect means in this study was high. Although the results of subsurface sampling are not reported here, a cursory review of the data revealed that the concentrations of several of the Potential Contaminants of Concern (PCOCs) are highest at the intermediate sampling depth, 1.5-2.5 ft. Of 121 screened soil constituents, 42 met the criteria for PCOCs. However, 25 of the 42 PCOCs were constituents for which the maximum soil concentration was equal to or less than the lowest required analytical limit, which is known as the "contractor-required quantitation limits" (crql's). Excluding the crql-related PCOCs, there were no semi-volatile PCOCs, 1 volatile PCOC, 5 inorganic PCOVs, and 11 radionuclide PCOCs. The inorganic PCOCs are heavy metals and are of concern because of their susceptibility to biomagnification. There were inadequate data to make a determination on 20 constituents. Animal guild sensitivities, in descending order, were small herbivores, small omnivore, small carnivore, and large herbivore. In general, PRS 50-006(d), as a whole, cannot be proposed for No Further Action at this time from the perspective of potential ecological impact. The results may be compliance issues related to NRDA, CWA, and/or CERCLA. At least 17 PCOCs require further investigation in an Ecological Risk Assessment. Planned discharge of "supercleaned" waste water from a new plant will add to the complexity of PRS considerations. In theory, radionuclides could be remobilized, making them available for vertical and horizontal transport and for biotic uptake.

Gunderson, T., T. Buhl, R. Romero, and J. Salazar. 1983. Radiological Survey Following Decontamination Activities Near the TA-45 Site. Report No. LA-9831-MS. Los Alamos National Laboratory. 15 pp.

Three areas at the site of a former radioactive liquid waste treatment plant were decontaminated during 1982. Data are presented showing that after cleanup operations, radionuclide concentrations in surface soils at all three sites were within decontamination guidelines.

Haarmann, T.K., and P.R. Fresquez. 1998. Radionuclide Concentrations in Honey Bees from Area G at TA-54 during 1997. Report No. LA-13480-PR. Los Alamos National Laboratory. 32 pp.

Honey bees were collected from two colonies located at Los Alamos National Laboratory's Area G and from one control (background) colony located near Jemez Springs, NM. The samples were analyzed for ^{137}Cs, ^{241}Am, ^{238}Pu, $^{239,240}Pu$, ^{3}H, total uranium, and gross gamma activity. The results from both Area G colonies were higher than the upper level background concentrations for ^{238}Pu and ^{3}H.

Haarmann, T.K., and P.R. Fresquez. 1999. Radionuclide Concentrations in Honey Bees from Area G at TA-54 during 1998. Report No. LA-13613-PR. Los Alamos National Laboratory. 37 pp.

Honey bees were collected from two colonies located at LANL's Area G, TA-54, and from one control colony located near Jemez Springs. Samples were analyzed for various radionuclides. Area G samples from both colonies were higher than the upper level background concentrations

for ^{239,240}Pu, tritium, and total uranium. Samples from one colony were higher than the upper level background concentrations for ^{238}Pu.

Hakonson, T.E., J.L. Martinez, and G.C. White. 1982. Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers. Health Physics 42(6): 868-871.

Biological intrusion of low-level waste sites has been identified as a potential problem in isolating waste radionuclides for extended periods of time. Studies on current and decommissioned low-level waste sites in the western United States have shown that radionuclides present in the waste can be mobilized by plant roots and burrowing animals that penetrate through the waste covers. Biological activity also can modify chemical and physical processes within the soil profile. For example, burrowing animals can change the rates of water infiltration and surface soil erosion. This paper presents the results of a study to characterize the amount of disturbance of a low-level waste cover resulting from the burrowing activities of pocket gophers. Data are presented on the amount of soil excavated from the cover profile, the amount of tunnel system created by these soil mining activities, and the particle size distribution and radionuclide content of the cast soil. The results of the study indicate that the amount of soil brought to the surface of low-level waste sites is small relative to the volume of cover material. However, the void space created by the burrowing activity represents a substantial network of tunnel system within the waste cover profile. The effects that plants and animals have in altering the soil profile must be considered in developing reclamation procedures that have long term effectiveness.

Hansen, L.A., P.R. Fresquez, R.J. Robinson, J.D. Huchton, and T.S. Foxx. 1999. Medium-Sized Mammals around a Radioactive Liquid Waste Lagoon at Los Alamos National Laboratory: Uptake of Contaminants and Evaluation of Radio-Frequency Identification Technology. Report No. LA-13660-MS. Los Alamos National Laboratory. 29 pp.

*Use of a radioactive waste lagoon by medium-sized mammals and levels of tritium, other selected radionuclides, and metals in biological tissues of the animals were documented at TA-53 at Los Alamos National Laboratory during 1997 and 1998. Rock Squirrel (*Spermophilus variegatus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and bobcat (*Lynx rufus*) were captured both at TA-53 and at a control site in the Santa Fe National Forest. Captured animals were anesthetized and marked with radiofrequency identification (RFID) tags and/or ear tags. Urine and hair samples were collected and analyzed for tritium and metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and thallium). In addition, muscle and bone samples from two rock squirrels collected from each of TA-53, perimeter, and regional background sites were analyzed for tritium, ^{137}CS, ^{90}Sr, ^{238}Pu, ^{239,240}Pu, ^{241}Am, and total uranium. Animals at TA-53 were monitored entering and leaving the lagoon area using an RFID monitor to read identification numbers from the tags of marked animals and a separate camera system to photograph all animals passing through the monitor. Cottontail Rabbit (*Sylvilagus *spp), rock squirrel, and raccoon were the species most frequently photographed going through the RFID monitor. Male and female rock squirrels from the lagoon area had significantly higher tritium concentrations compared to rock squirrels from the control area. Metal concentrations were not significantly higher in rock squirrels from TA-53, although there was a trend toward increased levels of lead in some individuals. Muscle and bone samples from squirrels in the lagoon area appeared to have higher levels of tritium, total uranium, and ^{137}Cs than samples collected from perimeter and background locations. However, the committed effective dose equivalent estimated from the potential human consumption of the muscle and bone tissue from these rock squirrels did not suggest any human health risk. Indirect routes of tritium uptake, possibly through consumption of vegetation, are important for animals in the lagoon area.*

Hanson, W.C., and F.R. Miera, Jr. 1976. Long-Term Ecological Effects of Exposure to Uranium. Report No. LA-6269. Los Alamos Scientific Laboratory. 34 pp.

The consequences of releasing natural and depleted uranium to terrestrial ecosystems during development and testing of depleted uranium munitions were investigated. Two explosives-testing areas at the Los Alamos Scientific Laboratory (LASL) were selected because of their use

history. E-F Site soil averaged 2400 ppm of uranium in the upper 5 cm and 1600 ppm at 5-10 cm. Lower Slobbovia Site soil from two subplots averaged about 2.5 and 0.6% of the E-F Site concentrations. Important uranium concentration differences with depth and distance from detonation points were ascribed to the different explosive tests conducted in each area. E-F site vegetation samples contained about 320 ppm of uranium in November 1974 and about 125 ppm in June 1975. Small mammals trapped in the study areas in November contained a maximum of 210 ppm of uranium in the gastrointestinal tract contents, 24 ppm in the pelt, and 4 ppm in the remaining carcass. In June, maximum concentrations were 110, 50, and 2 ppm in similar samples and 6ppm in lungs. These data emphasize the importance of resuspension of respirable particles in the upper few millimeters of soil as a contamination mechanism for several components of the LASL ecosystem.

Hanson, W.C., and F.R. Miera, Jr. 1978. Further Studies of Long-Term Ecological Effects of Exposure to Uranium. Report No. LA-7162. Los Alamos Scientific Laboratory. 26 pp.

Soils, small mammals, and invertebrates were sampled at E-f Site for uranium analysis. Spatial variability in sampling for soil uranium distribution by a polar coordinate system was evaluated in randomly selected soil cores. Uranium concentrations in tissues of deer mice and pocket gophers was sufficiently different to conclude that the greater bioavailability of uranium in the top few millimeters of soil, combined with the difference in grooming and food habits of the animals, resulted in greater contamination of deer mice than pocket gophers. There was no conclusive evidence of a differential response of invertebrate populations to areas of relatively high uranium concentrations and to control areas.

Mayfield, D.L., A.K. Stoker, and A.J. Ahlquist. 1979. Radiological Survey of the Bayo Canyon, Los Alamos, New Mexico. Report No. DOE/EV-0005/15. U.S. Department of Energy. 111 pp.

This report presents the results of a resurvey of Bayo Canyon that was conducted in 1976-77 for the purpose of thoroughly documenting and assessing conditions within Bayo Canyon. The Bayo canyon site contained firing sites and chemistry laboratories that were used until 1963, when it was decommissioned. The resurvey was designed to collect information to use as a basis for determining whether any additional corrective measures would be desirable.

Miera, F.R., Jr., K.V. Bostick, T.E. Hakonson, and J.W. Nyhan. 1977. Biotic Survey of Los Alamos Radioactive Liquid-Effluent Receiving Areas. Report. No. LA-6503-MS. Los Alamos Scientific Laboratory. 23 pp.

A field study on the surface and subsurface erosional transport of surface-applied ^{133}Cs as affected by pocket gopher burrowing was conducted on simulated waste landfill caps at the Los Alamos National Laboratory in north central New Mexico. Surface loss of Cs, adhered to five soil particle size ranges, was measured several times over an 18-month period while simulated rainfalls were in progress. Gophers reduced Cs surface loss by significant amounts, 43%. Cesium surface loss on plots with only gophers was 0.8 kg total for the study period. This compared with 1.4 kg for control plots, 0.5 kg for vegetated plots, and 0.2 kg for plots with both gophers and vegetation. Relatively little subsurface Cs was measured in plots containing only gophers (0.7 g/kg). Vegetation-bearing plots had significantly more total subsurface Cs (1.7 g/kg) than plots without vegetation (0.8 g/kg). An average of 97% of the subsurface Cs in plots with vegetation was located in the upper 15 cm of soil compared with 67% for plots without vegetation. Vegetation moderated the influence of gopher activity on the transport of Cs to soil subsurfaces and stabilized subsurface Cs by concentrating it in the rhizosphere. Gopher activity may have caused Cs transport to depths below that sampled, 30 cm. The results provide distribution coefficients for models of contaminant migration where animal burrowing occurs.

Raymer, D.F., and J.R. Biggs. 1994. Comparison of Small Mammal Species Diversity Near Wastewater Outfalls, Natural Streams, and Dry Canyons. Report No. LA-12725-MS. Los Alamos National Laboratory. 16 pp.

A wide range of plant and wildlife species utilizes water discharges from facilities at Los Alamos National Laboratory (LANL). The purpose of this study was to compare nocturnal small mammal communities at wet areas created by wastewater outfalls with communities in naturally

wet and dry areas. Thirteen locations within LANL boundaries were selected for small mammal mark-recapture trapping. Three of these locations lacked surface water sources and were classified as "dry," whereas seven sites were associated with wastewater outfalls and three were located near natural sources of surface water. Data were collected on site type (dry, outfall, or natural), location, species trapped, and the tag number of each individual captured. These data were used to calculate mean number of species, percent capture rate, and species diversity at each type of site. When data from each type of site were pooled, there was no significant differences in these variables among dry, outfall, and natural types. However, when data from individual sites were compared, significant differences were revealed. All sites in natural areas were significantly higher than dry areas in daily mean number of species, percent capture rate, and species diversity. Most outfall sites were significantly higher than dry areas in all three variables tested. When volume of water from each outfall site was considered, the data indicated that the number of species, percent capture rate, and species diversity of nocturnal small mammals were directly related to the volume of water at a given outfall.

Rogers, D.B. 1998. Impact of Tritium Disposal on Surface Water and Groundwater at Los Alamos National Laboratory through 1997. Report No. LA-13465-SR. Los Alamos National Laboratory. 31 pp.

Beginning in the 1940s, Los Alamos National Laboratory has utilized tritium in its research programs and has discharged tritium into the environment. This report documents the quantity of tritium that has been disposed, either as liquid effluent or by burial in waste disposal areas, and evaluates the impact on surface water and groundwater of these tritium disposal operations. Since the early 1980s, the Laboratory has sharply reduced both the number of tritium discharge locations and the total amount of tritium discharged. Furthermore, because of reduced discharges, dilution by stream flow, high evapotranspiration rates, and a relatively short half life, tritium levels in most shallow groundwater and surface water at the Laboratory have decreased significantly since the early 1980s. The Laboratory now discharges tritium as liquid effluent only into Mortandad Canyon from the TA-50 Radioactive Liquid Waste Treatment Facility. Regarding solid waste disposal sites, available data suggest that tritium migration from these areas has been limited in extent. Trace levels of tritium have been detected in regional aquifer test wells beneath areas of past and present liquid effluent discharges. Nonetheless, based on 30 years of environmental monitoring, tritium has not significantly impacted the regional aquifer.

Stoker, A.K., A.J. Ahlquist, D.L. Mayfield, W.R. Hansen, A.D. Talley, and W.D. Purtymun. 1981. Radiological Survey of the Site of a Former Radioactive Liquid Waste Treatment Plant (TA-45) and the Effluent Receiving Areas of Acid, Pueblo, and Los Alamos Canyons, Los Alamos, New Mexico. Report No. LA-8890-ENV. Los Alamos National Laboratory. 252 pp.

Current radiological conditions were evaluated for the site of a former radioactive liquid waste treatment plant and the interconnected canyons that received both treated and untreated effluents between 1944 and 1951. Some residual radioactivity attributable to the effluents remains and is found on soils and sediments at the former plant site and in the channels of the canyons. The largest total reservoir of residual radioactivity is in lower Pueblo Canyon, but concentrations are extremely low. Potential exposures to radiation were evaluated for conditions of current and possible future land uses.

Tierney, G.D., and T.S. Foxx. 1982. Floristic Composition and Plant Succession on Near-Surface Radioactive Waste Disposal Facilities in the Los Alamos National Laboratory. Report No. LA-9219-MS. Los Alamos National Laboratory. 59 pp.

Since 1946, low-level radioactive waste has been buried in shallow landfills within the confines of the Los Alamos National Laboratory. Five of these sites were studies for plant composition and successional patterns by reconnaissance and vegetation mapping. The data show a slow rate of recovery for all sites, regardless of age, in both the piñon-juniper and ponderosa pine communities. The sites are not comparable in succession or composition because of location and previous land use. The two oldest sites have the highest species diversity and the only mature trees. All sites allowed to revegetate naturally tend to be colonized by the same species that originally surrounded the sites. Sites on historic fields are colonized by

the old field flora, whereas those in areas disturbed only by grazing are revegetated by the local native flora.

Usner, D.J. 1996. The Biological Environment at Area G Los Alamos National Laboratory. Report No. LA-UR-95-3600. Los Alamos National Laboratory. 57 pp.

This paper describes the biological environment at Area G, Los Alamos National Laboratory's low-level radioactive waste disposal site. Vegetation analyses and surveys in canyons and on mesa tops in the vicinity of Area G indicate that the area once supported plant communities typical of lower elevations on the Pajarito Plateau. However, excavation and filling of disposal pits at Area G have disturbed the vegetation causing an alteration of natural vegetation patterns and species diversity. Waste disposal activities also have disrupted wildlife habitat and have probably altered natural wildlife communities. The few surveys done to date have revealed no threatened, endangered, or sensitive species in the Area G vicinity. However, a review of their habitat requirements shows that some of these species potentially could survive in or near Area G. Information on the physical and biotic setting of Area G is presented.

Wenzel, W.J., T.S. Foxx, A.F. Gallegos, G. Tierney, and J.C. Rodgers. 1987. Cesium-137, Plutonium-239/240, Total Uranium, and Scandium in Trees and Shrubs Growing in Transuranic Waste at Area B. Report No. LA-11126-MS. Los Alamos National Laboratory. 62 pp.

A unique radioecological study was carried out at a Los Alamos National Laboratory (LANL) shallow land burial site called Area B. Area B was the first common transuranic waste burial site for LANL from 1944 to 1948 and had lain fallow for 34 years. During this time, secondary succession resulted in invasion of many native trees, shrubs, forbs, and grasses. The purpose of this study was to determine whether any trees or shrubs were rooting directly in waste material, to examine rooting patterns in a shallow land burial site, and to study the distribution patterns of different radionuclides by dissecting vegetative samples into representative compartments. Scandium, ^{137}Cs, $^{239/240}Pu$, and total uranium were measured in soil, litter, leaf, bark, wood, and root samples from excavated trees and shrubs. Several trees and shrubs were found rooted in transuranic waste material. The radiochemical data were used to calibrate the UPTAKE subroutine of the BIOTRAN model for the Los Alamos environs. The simulation results indicated that higher resolution sampling is needed for ^{137}Cs and $^{239/240}Pu$ to interpret surveillance data and to produce reliable risk assessments. This study attempted to draw together and interpret the radionuclide data for Area B from several investigations. There is a need to standardize the grid methods and sampling site markers to develop a permanent system wherein sampling sites can be accurately relocated and tied to engineering drawings. This would allow subsequent studies to use the existing temporal data and hence produce reliable assessments, especially for sites where heterogeneous source terms require high resolution sampling on small grids over long time frames.

White, G.C., J.C. Simpson, and K.V. Bostick. 1980. Studies of Long-Term Ecological Effects of Exposure to Uranium V. Report No. LA-8221. Los Alamos Scientific Laboratory. 19 pp.

A statistical technique called kriging was used to analyze the uranium concentrations in surface soil at E-F site. kriging provides a much more realistic contour surface than either a polynomial trend analysis or contouring the original data. The major advantages of kriging are that a measure of the uncertainty of the contoured surface is provided and that the nonparametric nature of the method allows very irregular surfaces to be fitted. For the variable type of data collected at E-F site, kriging appears to be the most useful approach to estimating mean concentration.

Water Quality

Adams, A.I., F. Goff, and D. Counce. 1995. Chemical and Isotopic Variations of Precipitation in the Los Alamos Region, New Mexico. Report No. LA-12895-MS. Los Alamos National Laboratory. 35 pp.

Precipitation collectors were installed at 14 locations on the Pajarito Plateau and surrounding areas to study variations in chemistry, stable isotopes, and tritium for the years 1990 to 1993.

The volume of precipitation was measured and samples were collected and analyzed every three to four months. All precipitation samples contained >2.50 mg/kg Cl and had pH values ranging from 5.4 to 6.7. The stable isotope ($\delta D/\delta^{18}O$) results record seasonal variations in precipitation as the weather patterns shift from sources in the Pacific Ocean to sources in the Gulf of Mexico. The stable isotope results also show isotopic variations due to elevational differences among the collection points. The tritium contents (^3H) in rain samples vary from 6.54 T.U. to 141 T.U. Contouring of high tritium values (e.g. >20 T.U.) from each collection period clearly shows that Laboratory activities release some tritium to the atmosphere. The effects of these releases are well below the limits set by the Environmental Protection Agency for drinking water (about 6200 T.U.). The magnitude of the releases is apparently greatest during the summer months. However, anomalous tritium values are detected as far north as Española, New Mexico for many collection periods. Tritium releases by the Laboratory are not constant; thus, the actual amount of tritium in each release has been diluted in the composite samples of our three to four month collection periods.

Bennett, K. 1994. Aquatic Macroinvertebrates and Water Quality in Sandia Canyon. Report No. LA-12738-MS. Los Alamos National Laboratory Report. 24 pp.

In 1990, field studies were initiated in Sandia Canyon to establish baseline data for water quality and stream macroinvertebrate communities. The studies were designed to establish baseline data and to determine the effects of routine discharges of industrial and sanitary waste. Stations where the stream routinely receives industrial and sanitary waste effluents exhibited a low diversity of macroinvertebrates and slightly degraded water quality. The downstream station, located approximately 0.4 km downstream of the nearest wastewater outfall, appeared to be in a zone of recovery where the water quality parameters more closely resembled those found in natural streams in the Los Alamos area. A large increase in macroinvertebrate diversity also was observed at the downstream station.

Blake, W.D., F. Goff, A.I. Adams, and D. Counce. 1995. Environmental Geochemistry for Surface and Subsurface Waters in the Pajarito Plateau and Outlying Areas, New Mexico. Report No. LA-12912-MS. Los Alamos National Laboratory. 43 pp.

This report contains a data base of major element, trace element, and isotope analyses of 130 water samples from 94 different springs, wells, and water bodies located in and around Los Alamos National Laboratory. Most waters in the study are calcium-bicarbonate waters. Well waters in the region generally have higher concentrations of conservative constituents than local surface waters because of their greater temperatures and ages at depth. Anthropogenic contamination, mixing with deep water, or significant water movement among aquifers can cause some cooler surface waters to actually become the most enriched in conservative constituents. The sites most impacted by man are located within Pueblo , Los Alamos, and DP Canyons, where the most likely contaminant sources are the older Laboratory facilities. Other impacted areas include the San Ildefonso reservation, where fertilizer and stock seem the most likely contaminant sources, and the southwestern part of the Laboratory, which at places shows elevated lead. Only two samples in nitrate and three samples in lead exceeded the EPA drinking water limits for any of the most common contaminants. Locations with tritium concentrations above 300 T.U. caused by Laboratory activities include DP Spring at TA-21 (≤845 T.U.), the sewage outfall water at TA-21 (2800 T.U.), the drains at TA-33 (>1500 T.U.), and water residing in Test Well 2A (700 T.U. ^3H in 1992 and 1993). Stable isotope analyses indicate that most waters discharging in White Rock Canyon and located under the Pajarito Plateau and San Ildefonso reservation have been precipitated locally or possibly have migrated from the north. These waters are isotopically different from those precipitated in the Valles Caldera and higher elevations in the Jemez Mountains.

Cross, S. 1994. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory: December 1992-October 1993. Report No. LA-12734-SR. Los Alamos National Laboratory. 38 pp.

This report summarizes the results of water quality and macroinvertebrate diversity in Sandia Canyon during 1993 as a followup to the results reported for 1990 in Report No. 12738 by K.

Bennett. During 1993, five stations were sampled in the canyon. The two uppermost stations are located near outfalls that discharge industrial and sanitary waste effluent. The third station is located in a natural cattail marsh located about 0.4 km downstream of the uppermost stations. Two additional stations were located further downstream. Water quality parameters at the upper three stations are different from those of natural streams, suggesting degraded water quality. The macroinvertebrate communities exhibit low diversity and poorly-developed community structures. The two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams in the area, macroinvertebrate diversity increases, and community structure becomes more complex.

Cross, S. 1995. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory, November 1993 to October 1994. Report No. LA-12971-SR. Los Alamos National Laboratory. 58 pp.

This report summarizes the results of water quality and macroinvertebrate diversity investigations in Sandia Canyon during 1994 as a followup to previous investigations in 1990 (LA-12738-MS) and 1993 (LA-12734-SR). During 1994, five stations were sampled in the canyon. The two upstream stations are located below outfalls that discharge industrial and sanitary waste effluent into the stream, thereby maintaining year-round flow. Some water quality parameters are different at the first three stations from those expected of natural streams in the area, indicating degraded water quality resulting from effluent discharges. The aquatic habitat at the upper stations has also been degraded by sedimentation and channelization. The macroinvertebrate communities at these stations are characterized by low diversities and unstable communities. In contrast, the two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams of the area. The two lower stations have increased macroinvertebrate diversity and stable communities, further indications of downstream water quality improvement.

Cross, S. 1995. Aquatic Invertebrate Sampling at Selected Outfalls in Operable Unit 1082; Technical Areas 9,11,16,and 22. Report No. LA-13019-MS. Los Alamos National Laboratory. 57 pp.

Preliminary sampling for aquatic invertebrates, hydrological condition, physico-chemical parameters, wildlife uses, and vegetation was conducted for eleven outfalls within Operable Unit 1082 and nearby "natural waterways." The physico-chemical parameters at most outfalls and natural waterways fell within the normal range of natural waters in the area. However, the outfalls are characterized by low biodiversity and severely stressed communities composed of a restricted number of taxa. The habitat at some outfalls could probably support well-developed aquatic communities if sufficient water was available. At present, the hydrology at these outfalls is too slight and/or too sporadic to support such a community in the foreseeable future. In contrast to the outfalls, the natural waterways had greater densities of aquatic invertebrates, higher biodiversities, and lower community tolerance quotients.

Cross, S. 1995. Aquatic Macroinvertebrates and Water Quality in Guaje and Los Alamos Canyons, (1993 and 1994). In: Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico. T.S. Foxx (ed.) Pp. 91-194. Report No. LA-13065-MS. Los Alamos National Laboratory.

Water quality parameter samples and aquatic macroinvertebrates were collected from sampling stations in Guaje and Los Alamos Canyons in 1993 and 1994. The relatively undisturbed stream in Guaje Canyon was used as a control to evaluate impacts to the stream in Los Alamos Canyon. All monthly pH, conductivity, and dissolved measurements taken in both streams were within acceptable water quality ranges. The Los Alamos Canyon Reservoir impounds all incoming water except for warmed overflow, which significantly elevates temperatures at lower Los Alamos Canyon stations. At times, the dam design causes the stream to dry up completely, eliminating macroinvertebrate communities at the lower stations. This is the most significant impact to downstream communities. Rapid Biological Protocols (RBP) III analysis shows that aquatic communities are richer and more complex in Guaje Canyon than Los Alamos Canyon. The data also suggest that, within each canyon, diversity and density increase

with distance downstream; but this trend is not as pronounced because the middle Guaje station had higher diversities and densities than the lowest station. According to RBP III analysis, water quality is unimpaired at LA1 and severely impaired at LA2 and LA3.

Cross, S. 1996. Biological and Water Quality Assessments for the Material Disposal Area P Project Area, 1995 and 1996. Report No. LA-UR-96-4670. 56 pp.

Material Disposal Area (MDA) P is located within LANL TA-16 where high explosives (HE) production and development are the main activities. The waste pile was active until 1984. It lies along a slope located on the southern rim of Cañon de Valle, just north of TA-16 thermal treatment area pad TA-16-387. The landfill area extends almost to a small flowing stream in the bottom of the canyon, approximately 150 ft below the summit of the waste pile. The debris in the waste pile is very heterogeneous, consisting of burned HE-contaminated equipment, building materials, empty drums and bottles, and general trash. Waste materials include metals, arsenic, nitrates, HE residue, and possibly aromatic hydrocarbons, asbestos, solvents, and depleted uranium. This report provides a detailed description and history of the site and describes the results of biotic surveys in the area. In general, the surveys showed that all water quality parameters for Cañon de Valle were within the ranges set by the State of New Mexico for high-quality cold-water fisheries, although a series of metrics used to evaluate the stream indicated that it is slightly impaired. A federally-endangered T&E species known to inhabit the area is discussed, as are project restrictions due to species and habitat requirements. A New Mexico-endangered plant may occur in the area. The report includes best management practices addressing biological concerns, which are presented in terms of T&E species, erosion control, water quality, and restoration of the area following clean closure.

Cross, S.P., and J. Davila. 1996. Aquatic Macroinvertebrates and Water Quality on Guaje and Los Alamos Canyons, 1995. Report No. LA-UR-96-998. Los Alamos National Laboratory. 80 pp.

The streams within Guaje and Los Alamos Canyons were sampled on three dates in 1995 for water quality parameters and aquatic macroinvertebrates. The relatively undisturbed stream in Guaje Canyon was used as a control to evaluate impacts to the stream in Los Alamos Canyon. Habitat assessment scores were lower in Los Alamos Canyon than in Guaje, but all stations in both canyons scored lower than in 1994 because of large volumes of fine sediments. All pH, conductivity, and dissolved oxygen measurements taken in both streams were within acceptable water quality ranges and met high-quality cold-water fisheries standards. The Los Alamos County Reservoir impounds all incoming water except for warmed overflow, producing elevated water temperatures and periodic stream drought at the lower Los Alamos stations. These represent the most significant impacts to downstream invertebrate communities in Los Alamos Canyon. Aquatic communities are richer and more developed in Guaje than Los Alamos Canyon. The 1995 water quality was slightly impaired at LA1, moderately impaired at LA2, and severely impaired at LA3. This pattern of increasing downstream impairment was also substantiated by decreasing standing crop numbers and biodiversity values.

Cross, S., L. Sandoval, and T. Gonzales. 1996. Aquatic macroinvertebrates and Water Quality of Springs and Streams in White Rock Canyon along the Rio Grande, 1995. Report No. LA-UR-96-510. 53 pp.

In April and September of 1995, aquatic invertebrate collections were made up-canyon from three major stream confluences and at 6 springs near the Rio Grande. Physical and chemical parameters were measured at all locations and habitats were assessed at each of the streams. On the basis of these limited samples, several observations were tentatively advanced:

- *pH values of both springs and streams appear to decrease between spring and autumn;*
- *the springs have more stable temperature regimes than do the streams;*
- *great variations in flow rates exist between the individual springs and streams;*
- *aquatic habitats vary greatly between the streams and seasonally;*
- *the dominant taxa frequently change seasonally in both springs and streams;*
- *differences between invertebrate samples may obscure differences in site densities; and*

- *despite variations in community compositions, most of the springs and streams appear capable of supporting well-developed aquatic communities.*

Ford-Schmid, R.E. 1996. Reference Conditions for Los Alamos National Laboratory Streams Using Benthic Macroinvertebrate Assessment in Upper Pajarito Canyon. New Mexico Geological Survey Guidebook. 47th Field Congress. Jemez Mountains Region. Pp. 441-447.

Benthic macroinvertebrates and water samples were collected at three stations in upper Pajarito Creek and at one station in each of two first-order tributaries to Pajarito Creek at Los Alamos National Laboratory (LANL). A total of 63 taxa were identified from the five stations. Number of taxa per study location ranged from 25 to 35, and standing crop ranged from 2351 (no/m^2) to 11,212 (no/m^2). EPT/EPT + Chironomid ratios, a measure of community balance, ranged from 0.17 to 0.84, while another measure of community balance, the Shannon-Weaver's index of diversity, ranged from 2.48 to 3.53. The Winget and Mangum CTQd index, a measure of non-organic perturbations, ranged from 72.5 to 89.1, and the Hilsonhoff Biotic Index (HBI), a measure of the presence of organic perturbation, ranged from 4.20 to 6.92. Habitat assessments indicate that four of the five stations were comparable, whereas the station farthest downstream in Pajarito Canyon displayed effects of embeddedness, channel alteration, scouring, and reduced flow. The HBI = 6.92 calculated for Starmer Spring station indicates fairly poor water quality with substantial organic pollution likely. The compete absence of the scraper functional feeding group, the dominance of the community by one tolerant midge, and the presence of mats of filamentous algae at Starmer Spring indicate a community structure that is tolerant of nutrient enrichment. The State of New Mexico water quality standards for livestock watering and wildlife habitat were met at all stations, while the fisheries acute standard for aluminum (750 μg/L) was exceeded at the station farthest downstream in Pajarito Canyon. The 11 metrics used to compare sites indicate that the farthest upstream station in Pajarito Canyon is appropriate for use as the reference condition for future comparisons of streams at LANL.

Purtymun, W.D. 1984. Chemical Quality of Surface Water in Bandelier National Monument. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 103-106. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Perennial and intermittent streams have cut the surface of the Pajarito Plateau into a number of narrow southeast-trending mesas separated by deep canyons. Perennial surface flow occurs in Cañon de los Frijoles and in the upper and middle reaches of Alamo and Capulin Canyons. Water quality data have been collected in Cañon de los Frijoles since 1957. After La Mesa Fire, water quality data were collected in Cañon de los Frijoles and Alamo and Capulin Canyons to evaluate the effects of the fire on the quality of surface water. These data show that the chemical quality of surface water (base flow) in Cañon de los Frijoles changed slightly after La Mesa Fire. The most noticeable change was an increase in calcium, chloride, bicarbonate, and TDS. Analyses over a 20-month period after the burn indicated a general decline in most of these constituents. Similar analyses of surface water in Alamo and Capulin Canyons indicated similar results over a 12-month period. Analyses of samples of summer storm runoff compared with base flow samples from Cañon de los Frijoles and Capulin Canyon indicated that higher concentrations of barium, calcium, iron, bicarbonate, manganese, and phenols occurred in storm runoff than in base flow. The presence of lead in storm runoff in Cañon de los Frijoles maybe attributed to lead from automobile emissions as it was not reported in a similar runoff event in Capulin Canyon, which is remote from vehicular traffic. Precipitation and runoff from the burn area will remove the fire debris, and the quality of the water in the streams will return to normal. The past two years of data indicate that water quality of base flow should return to normal within 3 to 5 years.

Purtymun, W.D., J.R. Buchholz, and T.E. Hakonson. 1977. Chemical Quality of Effluents and Their Influence on Water Quality in a Shallow Aquifer. Journal of Environmental Quality 6: 29-32.

The chemical quality of liquid effluent released from an industrial waste treatment plant at Los Alamos Scientific Laboratory controls the quality of water in a shallow aquifer in the alluvium of Mortandad Canyon. The dilution of the effluent with surface flow in the canyon reduces the concentration of the chemicals as they move down gradient into the aquifer. Mass estimates of

residual chemicals in solution in the aquifer average 1-6% of the total chemicals released to the canyon from 1963-1974. The average annual concentration of sodium, nitrate, chloride, and total dissolved solids in the aquifer through a 12-year period was directly correlated with annual average concentrations in the effluent. This relationship provides a means of predicting the impact of the chemical effluents on the quality of water in the aquifer.

Purtymun, W.D., R.W. Ferenbaugh, and M. Maes. 1988. Quality of Surface and Ground Water at and adjacent to the Los Alamos National Laboratory: Reference Organic Compounds. Report No. LA-11333-MS. Los Alamos National Laboratory. 25 pp.

Surface and ground water samples were collected from 43 stations representing the major occurrences of natural and municipal water and industrial and sanitary effluents in the Los Alamos area. The investigation was performed to find possible areas of organic contamination, but the impact of organic contamination at the stations sampled was minimal.

Purtymun, W.D., R.J. Peters, and J.W. Owens. 1980. Geohydrology of White Rock Canyon of the Rio Grande from Otowi to Frijoles Canyon. Report No. LA-8635-MS. Los Alamos National Laboratory. 15 pp.

Twenty-seven springs discharge from the Totavi Lentil and Tesuque Formation in White Rock Canyon. The spring waters generally acquires its chemical characteristics from rock units that comprise the spring aquifer. Twenty-two of the springs are separated into three groups of similar aquifer-related chemical quality. The five remaining springs make up a fourth group with a chemical quality that differs due to localized conditions in the aquifer. These localized conditions may be related to recharge or discharge in or near basalt intrusion or through faults. Streams from Pajarito, Ancho, and Frijoles Canyons discharge into the Rio Grande in White Rock Canyon. The base flow in the streams is from springs. Sanitary effluent in Mortandad Canyon from the treatment plant at White Rock also reaches the Rio Grande.

Rogers, D.B. 1998. Impact of Tritium Disposal on Surface Water and Groundwater at Los Alamos National Laboratory through 1997. Report No. LA-13465-SR. Los Alamos National Laboratory. 31 pp.

Beginning in the 1940s, Los Alamos National Laboratory has utilized tritium in its research programs and has discharged tritium into the environment. This report documents the quantity of tritium that has been disposed, either as liquid effluent or by burial in waste disposal areas, and evaluates the impact on surface water and groundwater of these tritium disposal operations. Since the early 1980s, the Laboratory has sharply reduced both the number of tritium discharge locations and the total amount of tritium discharged. Furthermore, because of reduced discharges, dilution by stream flow, high evapotranspiration rates, and a relatively short half life, tritium levels in most shallow groundwater and surface water at the Laboratory have decreased significantly since the early 1980s. The Laboratory now discharges tritium as liquid effluent only into Mortandad Canyon from the TA-50 Radioactive Liquid Waste Treatment Facility. Regarding solid waste disposal sites, available data suggest that tritium migration from these areas has been limited in extent. Trace levels of tritium have been detected in regional aquifer test wells beneath areas of past and present liquid effluent discharges. Nonetheless, based on 30 years of environmental monitoring, tritium has not significantly impacted the regional aquifer.

Shaull, D.A., M.R. Alexander, R.P. Reynolds, and C.T. McLean. 1996. Surface Water Data at Los Alamos National Laboratory: 1996 Water Year. Report No. LA-13234-PR. Los Alamos National Laboratory. 53 pp.

Surface water discharge data were collected from 17 stream gauging stations that cover most of Los Alamos National Laboratory. The data show less runoff than do data for the 1995 water year. Water chemistry data from larger storm events occurring at some stations are also published here.

Wetlands, Floodplains, and Riparian Habitats

Bennett, K. 1994. Aquatic Macroinvertebrates and Water Quality in Sandia Canyon. Report No. LA-12738-MS. Los Alamos National Laboratory Report. 24 pp.

In 1990, field studies were initiated in Sandia Canyon to establish baseline data for water quality and stream macroinvertebrate communities. The studies were designed to establish baseline data and to determine the effects of routine discharges of industrial and sanitary waste. Stations where the stream routinely receives industrial and sanitary waste effluents exhibited a low diversity of macroinvertebrates and slightly degraded water quality. The downstream station, located approximately 0.4 km downstream of the nearest wastewater outfall, appeared to be in a zone of recovery where the water quality parameters more closely resembled those found in natural streams in the Los Alamos area. A large increase in macroinvertebrate diversity also was observed at the downstream station.

Cross, S. 1994. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory: December 1992-October 1993. Report No. LA-12734-SR. Los Alamos National Laboratory. 38 pp.

This report summarizes the results of water quality and macroinvertebrate diversity in Sandia Canyon during 1993 as a followup to the results reported for 1990 in Report No. 12738 by K. Bennett. During 1993, five stations were sampled in the canyon. The two uppermost stations are located near outfalls that discharge industrial and sanitary waste effluent. The third station is located in a natural cattail marsh located about 0.4 km downstream of the uppermost stations. Two additional stations were located further downstream. Water quality parameters at the upper three stations are different from those of natural streams, suggesting degraded water quality. The macroinvertebrate communities exhibit low diversity and poorly-developed community structures. The two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams in the area, macroinvertebrate diversity increases, and community structure becomes more complex.

Cross, S. 1995. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory, November 1993 to October 1994. Report No. LA-12971-SR. Los Alamos National Laboratory. 58 pp.

This report summarizes the results of water quality and macroinvertebrate diversity investigations in Sandia Canyon during 1994 as a followup to previous investigations in 1990 (LA-12738-MS) and 1993 (LA-12734-SR). During 1994, five stations were sampled in the canyon. The two upstream stations are located below outfalls that discharge industrial and sanitary waste effluent into the stream, thereby maintaining year-round flow. Some water quality parameters are different at the first three stations from those expected of natural streams in the area, indicating degraded water quality resulting from effluent discharges. The aquatic habitat at the upper stations has also been degraded by sedimentation and channelization. The macroinvertebrate communities at these stations are characterized by low diversities and unstable communities. In contrast, the two downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams of the area. The two lower stations have increased macroinvertebrate diversity and stable communities, further indications of downstream water quality improvement.

Cross, S., and H. Nottelman. 1996. Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory 1995. Report No. LA-UR-96-3684. 59 pp.

This report updates and expands previous aquatic studies in Sandia reported by Bennett and Cross. Water quality data and aquatic macroinvertebrate samples were collected monthly at three sampling stations in Sandia Canyon during 1995. The two upstream stations occur near a cattail marsh downstream from outfalls that discharge industrial and sanitary waste effluent. The third station is approximately 1.5 miles downstream in a mixed conifer forest. All water quality parameters measured during 1995 fell within acceptable State limits and scored in the good or excellent range when compared to an Environmental Quality Index. However, aquatic macroinvertebrate habitats have been degraded by widespread erosion, channelization, loss of

wetlands due to deposition and stream lowering, scour, limited acceptable substrates, LANL releases and spills, and other stressors. The stream continues to be threatened by erosion and potential landslides from the Los Alamos County landfill whose towering sides of loose fill material are perched at a 45^{o} angle above the northern edge of the entire Sandia Canyon wetlands. Macroinvertebrate communities at all of the stations had low diversities, low densities, and erratic numbers of individuals. These results indicate that, although the stream possess acceptable water chemistry, it has reduced aquatic biota. The best developed aquatic community occurs at the sampling station with the best habitat and whose downstream location partially mitigates the effects of upstream impairments.

Keller, C.F. 1999. White Rock Canyon and its Riparian Areas. Report No. LA-UR-99-6260. Los Alamos National Laboratory. 14 pp.

This report presents a floristic inventory of White Rock Canyon north of Bandelier National Monument.

McLin, S.G. 1992. Determination of 100-year Floodplain Elevations at Los Alamos National Laboratory. Report No. LA-12195-MS. Los Alamos National Laboratory. 84 pp.

Under existing permit requirements, the US EPA stipulates that facilities regulated by RCRA must delineate all 100-yr floodplain elevations within their boundaries. At Los Alamos, these floodplains are located within ungaged watersheds that drain the Pajarito Plateau. This report documents the floodplain computational mapping procedure and, along with supporting maps, is intended to satisfy this permit requirement. About 65% of the Laboratory has 2-ft topographic contour interval coverage, while 35% has 10-ft coverage. The approach used employs a 100-yr, 6-h design storm event, but alternative floodplain elevations produced by different storm events are easily computed. In this particular application, 11 separate watersheds traverse LANL lands, with individual channels ranging up to 9 mi in length. The 100-yr floodplain was defined on each channel segment at 250-ft intervals, and detailed 1:4800-scale maps were generated.

Racinez, E., and T.S. Foxx. 1999. A Notebook of Sedges and Rushes of the Jemez Mountains. Report No. LA-UR-99-5185. Los Alamos National Laboratory.

Floodplains are recognized as areas of land between meandering rivers and wetlands that are characterized by their hydrophytic soils and vegetation. These greenbelts along streams and rivers provide important habitats for many species in the arid southwest. Many rare and endangered species rely on wetlands for part or all of their lifecycle. In Los Alamos County, there are a number of wetland areas that either occur naturally or are manmade. Identification of wetlands requires knowledge about hydrophytic vegetation, which includes sedges and rushes (Cyperaceae and Juncaceae). While describing the importance of wetlands, this study focused on the vegetation that is characteristic of wetland, riparian, and floodplain habitats. These groups of plants generally are difficult to identify, and few references on the taxonomy of plants in these groups exist. This report is an attempt to provide information on sedges and rushes for persons doing fieldwork in wetlands ecology, wetlands delineation, and riparian zone studies.

Sigler, J.W. 1998. A Status Report on Threatened and Endangered Species, Wetlands, and Floodplains for the Proposed Conveyance and Transfer Tracts at Los Alamos National Laboratory, Los Alamos, New Mexico. Report No. LA-UR-98-3361. Los Alamos National Laboratory.

The U.S. Department of Energy (DOE) announced its intent in the May 6, 1998 issue of the Federal Register (V63, No. 87) to prepare an environmental impact statement (EIS) to assess the potential environmental impacts of conveying and transferring certain land tracts located within Los Alamos and Santa Fe Counties at Los Alamos National Laboratory. The purpose of this document is to provide:

- *A brief summary of actions mandated by Congress in Public Law 105-119;*
- *A description of the regional and site specific setting of the proposed action in Los Alamos and Santa Fe Counties;*
- *Ecological baseline information at the proposed action locations;*
- *Endangered Species Act Considerations;*

- *DOE requirements regarding floodplains and wetlands, including their identification and assessment, and other aspects of DOE real property transfers; and*
- *Other regulatory concerns pertaining to fish and wildlife.*

Thibault, J.R., D.L. Moyer, C.N. Dahm, H.M. Valett, and M.C. Marshall. 1999. Effects of Livestock Grazing on Morphology, Hydrology and Nutrient Retention in Four Riparian/Stream Ecosystems, New Mexico, USA. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 123-128... Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Land-use practices such as livestock grazing influence the structure and function of riparian/stream ecosystems. In New Mexico, four streams were selected to determine the impact of moderate livestock grazing on morphology, solute transport, and nutrient retention. Each stream contained a reach currently exposed to grazing and an exclosed, ungrazed reach. Channel width/depth ratios and in-stream standing stock of plant biomass were greater in the grazed reaches. Solute transport was determined by injecting a conservative tracer (NaBr) and applying a one-dimensional transport with inflow and storage (OTIS) model. Grazed reaches exhibited enhanced transient storage, represented by a larger cross-sectional area of storage zone relative to wetted channel area (A_s/A). The extent of nutrient retention was determined by co-injecting a reactive tracer ($NaNO_3$) with the conservative tracer. Nitrate uptake lengths were shorter in grazed reaches, an indication of more effective nutrient retention. The results suggest that moderate livestock grazing alters channel structure and vegetation, influencing ecosystem-level processes.

Wildfire and Fuels

Allen, C.D. 1996. Elk Response to the La Mesa Fire and Current Status in the Jemez Mountains. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 179-195. General Technical Report No. RM-GTR-286. USDA Forest Service.

Faunal remains in local archaeological sites and historic information suggest that elk populations in the Jemez Mountains were low from ca. 1200 A.D. through ca. 1900 A.D., when they were extirpated from this region. Elk were reintroduced to the Jemez country in 1948 and 1964-65, and their population has apparently grown exponentially, reaching 1000 animals in the 1970s and about 7000 by 1991. Elk populations in Bandelier National Monument and adjoining areas increased rapidly after the 1977 La Mesa Fire. Winter use by elk in the La Mesa Fire area, centered on Bandelier, grew from about 100 animals in 1978 to around 1500 by 1992. The dramatic increase in the Bandelier elk herd (an annual growth rate of 21.3% and a 3.6 year population doubling time) was due in part to the creation of about 6000 hectares of grassy winter range in and around the park as a result of the fire. Some of this local population increase reflects concentration of elk in this favorable winter habitat from surrounding portions of the Jemez Mountains. Existing data are inadequate to determine whether elk populations are still growing rapidly in the Jemez Mountains. While annual aerial surveys since 1990 in Bandelier reveal no clear population trend, a variety of observations demonstrate increasing elk use of lower elevation areas. Negative resource impacts from today's high elk populations are beginning to be widely noted across the Jemez Mountains, especially in high-use portions of the Bandelier National Monument area. Affected resources range from plant communities to soils and even archaeological sites. Given the large uncertainties associated with the current data on elk populations, care should be taken to avoid further population increases until the resource impacts of this new phenomenon (large numbers of elk) can be identified, desirable population levels identified (based to a significant degree upon ecological information and resource carrying capacities, as well as social considerations), and appropriate cooperative management strategies implemented.

Allen, C.D. (ed.). 1996.. Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. General Technical Report No. RM-GTR-286. USDA Forest Service. 216 pp.

This report documents the proceedings of the Second La Mesa Fire Symposium held at Los Alamos National Laboratory on March 29-31, 1994. It contains the following papers:

- *Overview of La Mesa Fire Studies (Allen)*
- *Remembering La Mesa Fire (Lissoway)*
- *Historic Fire Regime Patterns in the Southwestern United States Since AD 1700 (Swetnam and Baisan)*
- *Fire History and Climactic Patterns in Ponderosa Pine and Mixed-Conifer Forests of the Jemez Mountains, Northern New Mexico (Touchan, Allen, and Swetnam)*
- *Vegetation Succession After La Mesa Fire at Bandelier National Monument (Foxx)*
- *Avifaunal Response to the 1977 La Mesa Fire (Johnson and Wauer)*
- *Geomorphic Response of Six Headwater Basins Fifteen Years after La Mesa Fire (White)*
- *Flood History Reconstruction in Frijoles Canyon Using Flood-Scarred Trees (McCord)*
- *The Effects of Fire on Nitrogen Cycling Processes Within Bandelier National Monument, NM (White)*
- *Potential Nitrogen Contribution of Soil Cryptogams to Post-Disturbance Forest Ecosystems in Bandelier National Monument, NM (Loftin and White)*
- *A Survey of Macromycete (Fungi) Diversity in Bandelier National Monument, 1991-1993 (Jarmie and Rogers)*
- *Observations of Arthropod Populations Following La Mesa Fire of 1977 (Pippin and Nichols)*
- *A Comparison of Ground-Dwelling Arthropod Assemblages Among Different Habitats Resulting From the 1977 La Mesa Fire (Lightfoot)*
- *Elk Population Response to La Mesa Fire and Current Status in the Jemez Mountains (Allen)*
- *Elk Effects on Bandelier National Monument Meadows and Grasslands (Wolters)*
- *Heritage Resources and Fire Management: A Resource Management Crossroad (Cartledge)*
- *Management Lessons of La Mesa Fire (Fletcher)*

Balice, R.G., B.P. Oswald, S.W. Koch, and S.R. Yool. 1999. Fuels Inventories and Spatial Modeling of Fire Hazards in the Los Alamos Region. Proceedings of the Crossing the Millennium: Integrating Spatial Technologies and Ecological Principles for a New Age in Fire Management Conference and Workshop. June 15-17. Boise. (in press)

This presentation summarizes and provides a status report on the results of the Interagency collaboration among LANL. Bandelier National Monument, the Forest Service, Los Alamos County, and adjacent Pueblos with respect to cooperative efforts to reduce the regional threats from wildfire. The goals of this collaboration are to define the problem and combine research and management efforts to identify and develop cost-effective mitigation strategies. This effort includes developing vegetation profiles, inventorying fuel loading, and modeling both fuel levels and wildfire behavior. The most credible wildfire scenario is identified as a ground fire that is elevated to a crown fire as a result of hot and windy conditions that elevate the fire through fuel ladders to the overstory.

Balice, R.G., B.P. Oswald, and C. Martin. 1999. Fuels Inventories in the Los Alamos National Laboratory Region: 1997. Report No. LA-13572-MS. Los Alamos National Laboratory. 29 pp.

Fifty four sites, mostly on Los Alamos National Laboratory property were surveyed for fuel levels, vegetational structures, and topographic characteristics. The results of the surveys indicated that understory fuels are greatest in mixed conifer forests and overstory fuels are greatest in both mixed conifer and ponderosa pine forests on mesas. The survey results indicate a "most credible" wildfire scenario for the Los Alamos Region.

Barnes, F.J. 1984. Water Relations on the Dominant Grasses on La Mesa Burn. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 77-72. Report No. LA-9236-NERP. Los Alamos National Laboratory.

One month after La Mesa Fire, the burned areas of Bandelier National Monument were seeded with a mixture of native and nonnative grass species. Studies on the recovery of mature ponderosa pine and on the success of the seeding operation suggested that the high density of two of the seeded grasses may have contributed to the reduced viability of fire-damaged mature trees in areas where the grass density was especially high. In addition, it was hypothesized that the dense grass stands might interfere with the natural regeneration of ponderosa pine in those areas where seed trees survived. This study was made to determine whether there is significant niche overlap between ponderosa pine seedlings and the grasses on La Mesa burn. As availability of water is probably the most important factor in ponderosa pine seedling establishment in the arid Southwest. field observations were made on root structure and seasonal patterns of plant water status and soil moisture in order to investigate the partitioning of the soil water resource among coexisting species. Because too few pine seedlings for study could be found in the severely burned areas, the water relations study was confined to the three dominant grasses, and inferences were made about the possible competition with pine seedlings. Of the three grass species studies, Agropyron trachycaulum *and* Festuca ovina *appear to partition the soil water resource, and coexistence of these two species could presumably be long term.* Muhlenbergis montana *and* F. ovina*, although having complementary phenologies, have conflicting patterns of water usage, and thus it seems likely that the native* M. montana *experiences severe competition from* F. ovina*.* M. montana *might also experience significant competition from* A. trachycaulum. M. montana *has some roots that penetrate the soil profile quite deeply, probably giving the species increased survival during especially dry seasons. These deeper roots would come into direct competition with the very dense deep root system of* A. trachycaulum*. Previous studies have shown that grass roots will produce several "flushes" of new growth during a season, but ponderosa pine seedings will produce only a few additional roots after the initial spring growth period. Given the data on grass root distribution and water usage, this suggests that young pine seedlings would experience severe competition from* F. ovina *because this species has an extremely dense root mat that would be difficult for the roots of newly germinated seedlings to penetrate. In addition, the phenology of this grass conflicts with that of ponderosa pine in that both use winter precipitation during early spring growth. Also, older pine seedlings likely would experience considerable competition from* A. tachucaulum *because of its extensive deep root system and continued growth and water uptake during the summer drought. Ponderosa pine seedlings would compete much less with the native* M. montana *than with the other two dominant grasses because they have fundamental differences in niche space. The native grass has a phenology complementary to the growth patterns of ponderosa pine, including a somewhat sparse growth system that is likely to result in less water withdrawal from the soil during the spring and summer and allow root penetration of newly germinated pine seedlings. However, as the two seeded grasses are dominant in the severely burned areas of Bandelier, any attempts to plant or seed ponderosa pine on the burns will have to consider ways to mitigate the severe competition that the seedlings will experience from the dense stands of* A. trachucaulum *and* F. ovina *that currently exist.*

Cartledge, T.R. 1996. Heritage Resources and Fire Management: A Resource Management Crossroads. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 206-214. General Technical Report No. RM-GTR-286. USDA Forest Service.

Until the past few years, Forest Service fire management had been characterized by a program of total wildfire suppression coupled with relatively small scale prescribed burning, having fuels reduction as the principle objective. As the organization moves toward "ecosystem management," the fire program is developing multiple, complex objectives employing a combination of wildfire suppression, prescribed natural fire, and both small and large scale prescribed burning. These changes raise some concerns with regard to heritage resource management and protection. However, fire managers and heritage resource specialists have a history of close working relationships in the Southwest, and through continued cooperation they are working to develop implementation strategies appropriate to changing land management objectives.

Department of Energy. 2000. Special Environmental Analysis: Actions Taken in Response to the Cerro Grande Fire at Los Alamos National Laboratory, Los Alamos, New Mexico. Report No. DOE/SEA-03. Los Alamos Area Office. 142 pp.

The US Department of Energy (DOE), National Nuclear Security Administration, is issuing this special environmental analysis (SEA) to document its assessment of impacts associated with emergency activities conducted at Los Alamos National Laboratory (LANL) in response to major disaster conditions caused by the Cerro Grande Fire. The wildfire burned about 7,650 acres within LANL boundaries and about 35,500 acres in neighboring areas. As a result of this wildfire event, DOE identified the need to take actions on an emergency basis to protect human life and property. DOE considered that its actions should not be just protective of the lives of its employees, contractors, and subcontractors, but also the lives and property of all people living and working in the LANL region. Because of the urgent nature of the actions required of DOE to address the effects of the fire and the need for immediate post-fire recovery and protective actions, DOE had to act immediately and could not comply with normal National Environmental Policy Act (NEPA) requirements. The emergency circumstances clause of the Council on Environmental Quality's NEPA Implementing Regulations was invoked, and this Special Environmental Analysis (SEA) subsequently has been prepared. This SEA provides an assessment of the impacts that have resulted because of actions taken by or on behalf of DOE to address a major disaster emergency situation. It includes descriptions of the actions, the resulting impacts, mitigation measures taken to reduce or eliminate impacts, and a cumulative impact analysis.

Foxx, T.S. (ed.). 1984. La Mesa Fire Symposium Proceedings. Report No. LA-9236-NERP. Los Alamos National Laboratory. 172 pp.

This report documents the proceedings of La Mesa Fire Symposium held at Los Alamos National Laboratory on Oct. 6-7, 1981. It contains the following papers:

- *Fire Ecology at Bandelier National Monument (Foxx and Potter)*
- *Postfire Recovery and Mortality of the Ponderosa Pine Forest after La Mesa Fire (Potter and Foxx)*
- *Water Relations on the Dominant Grasses on La Mesa Burn (Barnes)*
- *Geomorphic Effects of La Mesa Fire (White and Wells)*
- *The Effect of La Mesa Fire on Total Soil Nitrogen in Bandelier National Monument, New Mexico (Freeman)*
- *Effects of La Mesa Fire on Bandelier's Cultural Resources (Traylor)*
- *Chemical Quality of Surface Water in Bandelier National Monument (Purtymun)*
- *Aquatic Invertebrates from Capulin Creek, Bandelier National Monument, New Mexico (Pippin and Pippin)*
- *Effects of Fire on Small Mammals within Bandelier National Monument (Guthrie)*
- *The Effects of Clearing Fire-Killed Trees on Wildlife (Moeur and Guthrie)*
- *La Mesa Fire Effects on Avifauna: Changes in Avian Populations and Biomass (Wauer and Johnson)*

Foxx, T.S. 1996. Vegetation Succession After the La Mesa Fire at Bandelier National Monument. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 47-69. General Technical Report No. RM-GTR-286. USDA Forest Service.

In 1977, La Mesa Fire burned over four areas of known fire history within Bandelier National Monument, all of which had been selected for study prior to the fire. Data were collected on two of the four study areas in 1976 immediately prior to the fire and provide pre-fire information. All four study areas were examined post-fire in 1977, 1978, 1985, and 1993 (1 year, 2 years, 8 years, and 16 years post-fire). Each study area was re-examined for density and cover of the understory and overstory components. Additionally, tree crown damage and recovery and growth of trees also were monitored. Detailed evaluations of each plot are presented, and the following general summary observations were made.

- *In areas where the tree canopy was destroyed, the successional recovery of understory cover was linear. However, in areas where there was tree canopy, there was a reduced cover the second year and then a continued increase from 1978 through 1993.*
- *Soil crusts appeared to be more extensive on sites that burned more intensely and that have less tree canopy and ground litter cover.*
- *The seeded grass, slender wheatgrass, was a dominant species early in the post-fire succession but vanished from the ecosystem after 1985.*
- *Where there was little tree canopy cover, the seeded grass, sheep fescue, became more dominant than in the areas with more canopy cover. However, the grass does not seem to have markedly inhibited tree reproduction.*
- *Certain plant species appear to be fire related, although post-fire successional patterns vary. For example, goosefoot was abundant after the fire through 1978 but disappeared from the ecosystem by 1985, whereas big bluestem has increased markedly through time at several sites since the fire.*
- *Trees that sustained less fire damage to their crowns grew faster than trees that suffered more severe crown damage, but there seems to be little correlation between tree size and post-fire growth rate.*

Foxx, T.S., and L.D. Potter. 1984. Fire Ecology at Bandelier National Monument. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 11-37. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Before the coming of white man to the North American continent, the forests of the Southwest were subject to frequent and periodic fires. Evidence gained through dating of fire scars (pyrodendrology) shows that, before modern fire suppression, ponderosa forests burned every 8-12 years. These frequent fires were important in keeping the forest a mosaic of even-aged stands in an uneven-aged forest. Years of fire suppression, however, have changed the composition of the forest and increased fuel loads such that wildfire is now often intense and destructive. In 1975, as a result of many years of fire suppression, the management of Bandelier National Monument adopted a policy of controlled or management fires to reduce fuel loads and thereby reduce the potential destruction by wildfire. Before establishing a prescription for management fire, basic data as to succession, previous fire history, and fuel loadings were necessary. A study was undertaken in 1976 to provide some of these data; but, before the study was completed, a major fire (La Mesa Fire, 1977) changed the nature and complexity of the research. Before the fire, two approaches were used to collect the necessary data. To determine fire history, both historic records and dendrochronology were used. To determine succession, vegetational analyses were conducted on areas known to have burned at specific times. With these baseline data, postfire studies were also more experimental and less conjectural. This paper is a composite of two major parts of the study that are separate but related - the fire history and the fire damage of various sites as related to their fire history.

Freeman, C.E. 1984. The Effect of La Mesa Fire on Total Soil Nitrogen in Bandelier National Monument, New Mexico. Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 91-96. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Nitrogen availability in ecosystems is often a critical or limiting factor regulating plant growth and productivity on a site. Typically, nearly all (70-98%) of ecosystem nitrogen is in the soil. This is true from deserts to the more mesic grassland and forest ecosystems. Most of the rest of the nitrogen is in the standing crop of the producers. Any environmental factor that can cause substantial loss of nitrogen from an ecosystem, then, can greatly influence productivity and succession on a site. One such factor is fire. Nitrogen in both the soil and standing crop is readily volatilized by heat and lost from the ecosystem. Significant amounts of nitrogen can be lost as gas at temperatures above 300^{o}C, and temperatures above 700^{o}C can easily volatilize substantial amounts. Because the largest concentrations of soil nitrogen are near the surface, a considerable portion of the total soil nitrogen may be lost during a fire. Large variations in maximum soil temperature and duration of soil heating can occur over small distances because of different fuel loadings and local burning conditions. The large and destructive La Mesa Fire

swept through the ponderosa pine forests in Bandelier National Monument, New Mexico, between June 16, 1977, when the fire began in the adjacent Santa Fe National Forest, and June 23, 1977, when the fire was finally extinguished. This study estimated the effects of La Mesa Fire on total soil nitrogen and gathered data on the nitrogen content of similar soils from unburned regions.

Fresquez, P.R., W.R. Velasquez, and L. Naranjo, Jr. 2000. Effects of the Cerro Grande Fire (Smoke and Fallout Ash) on Soil Chemical Properties within and around Los Alamos National Laboratory. Report No. 13769-MS. Los Alamos National Laboratory. 11 pp.

Soil surface (0-2 in depth) samples were collected from areas within and around Los Alamos National Laboratory (LANL) immediately after the Cerro Grande Fire, analyzed for radionuclides, radioactivity, and trace elements (heavy metals), and compared to soil samples collected in 1999 from the same sites. In addition, many types of organic substances (volatile and semivolatile organic compounds, organochlorine pesticides, PCBs, high explosives, and dioxin and dioxin-like compounds) were assessed in soils from LANL, perimeter, and regional sites after the fire. Results show that impacts to regional, perimeter, and on-site (mesa top) areas from smoke and fallout ash as a result of the Cerro Grande Fire were minimal.

Garvey, D., K. Rea, C. Del Signore, and S. Johnson. 2000. A Special Edition of the SWEIS Yearbook Wildfire 2000. Report No. LA-UR-00-3471. Los Alamos National Laboratory. 34 pp.

This report provides information on the Cerro Grande fire, including conditions before the fire, a description of the fire itself, conditions after the fire, and a comparison of the actual fire with the scenario described in the Sitewide Environmental Impact Statement.

Guthrie, D.A. 1984. Effects of Fire on Small Mammals within Bandelier National Monument. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 115-134. Report No. LA-9236-NERP. Los Alamos National Laboratory.

*A study of the effects of fire and subsequent plant succession on small-mammal populations within Bandelier National Monument began in June of 1977. The locations and sizes of past fires within the Monument were obtained from Monument personnel, and trapping grids were planned for the largest burns. Soon after the start of this project, La Mesa Fire occurred, burning much of the Monument, including most previous burn areas. Those sites not reburned by La Mesa Fire were, in general, too small (less than 1 acre) for any differences in mammal populations independent of edge effects to be observed. Consequently, the study was redirected to an examination of the effects of La Mesa Fire on small mammal populations. This report on the initial changes in small-mammal populations after the fire is based on work during the summers of 1977, 1978, and 1979. The immediate effect of La Mesa Fire on small-mammal populations was to reduce populations of nonburrowing species within the fire area, particularly arboreal forms such as red squirrel. Most burrowing rodents survived the fire. Changes in vegetation after the fire, for example, greater development of grasses and annual plants and the death of many evergreens, caused changes in small-mammal populations within the burn area. Populations of species heavily dependent upon evergreens decreased (red squirrel in ponderosa and fir and piñon mouse in piñon-juniper). Species increasing in population were the deer mouse, which increased in all burned areas. Populations of meadow mice (*Microtus montanus *and* M. longicaudis*, the latter at higher elevations) also increased in grassy areas. Finally, chipmunks showed increases in ponderosa and fir zones. Because of seasonal changes, all rodent populations undergo periodic population decreases. Therefore, little change in carnivore populations can be expected. Also, these seasonal decreases should keep rodent populations from overeating food supplies or affecting reseeding or reforestation efforts.*

Koch, S.W., and R.G. Balice. 1999. Input Data Development for the FARSITE Fire Area Simulator for the Los Alamos National Laboratory Region. Poster presentation at the Environmental Systems Research Institute User Conference. June 26. San Diego.

This poster presented an overview of progress toward creating a database of relevant environmental information for use in the development of the FARSITE Fire Area Simulator for LANL region. FARSITE is a Forest Service model that simulates fire growth and behavior under

complex conditions of terrain, fuels, and weather. Subsequent phases of the project involve generating the computer algorithm for evaluating relative risks from wildfire, evaluating the long-term expected loss to LANL from wildfire, performing an experiment to evaluate the potential efficacy of selected wildfire hazard reduction treatments, and proposing a system of optimal, cost-effective mitigation action strategies.

Jarmie, N., and F.J. Rogers. 1996. A Survey of Macromycete Diversity in Bandelier National Monument, 1991-1993. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 149-160. General Technical Report No. RM-GTR-286. USDA Forest Service.

This paper reports the progress of an ongoing project to develop an initial inventory of the fungi of the Bandelier area and describes their relationships with vascular plants and fire ecology. The goal of this ongoing survey has been to collect and identify (at least to genus) as many macroscopic fungi species as possible and thereby inventory the diversity of such fungi in Bandelier National Monument and adjoining Los Alamos County. The survey covered the three summer seasons of 1991-1993, during which 836 species were collected from a variety of habitats. These were identified to the extent possible, recorded in a computer database, dried, and stored in an herbarium. There were 228 species in 118 genera. About 95% of the specimens were identified to genus and 81% to species. In Bandelier alone, 145 specimens were collected in 1991-1992 and 270 specimens in 1993, representing at least 75 genera and 93 species. All three basic types of fungi were found: parasitic, saprophytic (feeding on dead wood and litter), and Mycorrhizal (in a beneficial symbiosis with a plant). A variety of sites were studied, with special attention to sites at Bandelier that have burned in recent years or are planned for burning soon. The fruitings varied widely (and wildly), making correlation with site location, burns, and other parameters difficult or impossible. The only distinct correlation was with precipitation (and thus elevation). Future needs and possible studies are discussed.

Johnson, T.H., and R.H. Wauer. 1996. Avifaunal Response to the 1977 La Mesa Fire. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 71-94. General Technical Report No. RM-GTR-286. USDA Forest Service.

Three of four breeding bird transects in habitats ranging from mixed conifer to piñon-juniper were burned by the 1977 La Mesa Fire. Large portions (25-80%) of the three burned transects suffered forest loss from crown fire or scorching, but the piñon-juniper transect did not burn. The transects were surveyed during the breeding season before the fire and 1, 2, 4, 6, and 14 years afterward. Species diversity increased after the fire, but breeding populations generally declined for several years before increasing above prefire levels. This temporary population decline was more pronounced and lasted longer on the most severely burned transects. Conversely, the population on the unburned piñon-juniper transect temporarily increased after the fire. After 14 years, avian diversity and populations in the burn remained well above prefire levels, except on the transect with 80% forest loss, where the population was 22% lower due to a reduction in insectivores. Populations of seed-eating birds and raptors were consistently higher than before the fire. All three burned transects experienced both immediate and successional changes in species composition. Even an uncontrolled crown fire such as La Mesa Fire can increase the diversity and population of breeding birds. High fire intensity appears to delay recovery of avian populations from short-term postfire declines, and extensive crown fire appears to reduce populations after most snags have fallen, but even the most severely burned areas of La Mesa Fire generally retained some live trees and snags and supported diverse, substantial populations of breeding birds after the fire. Application of moderate intensity prescribed fire to relatively dense stands such as those burned by La Mesa Fire can enhance avian diversity and populations without the disadvantages of high intensity crown fires.

Lightfoot, D.C. 1996. A Comparison of Ground-Dwelling Arthropod Assemblages Among Different Habitats Resulting from the 1977 La Mesa Fire. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 166-178. General Technical Report No. RM-GTR-286. USDA Forest Service.

This study was conducted to determine whether or not post-fire habitats resulting from the 1977 La Mesa Fire support different assemblages of ground-dwelling arthropods. Four principal post-fire vegetation habitats were identified: 1) ponderosa pine forest, 2) ponderosa pine savanna, 3) Gambel oak thickets, and 4) open grasslands. Ground-dwelling arthropods were sampled from each of the four habitats during the summer of 1993. Numerically important arthropod groups found in the samples included spiders, harvestmen, bristletails, crickets, fungus beetles, rove beetles, ground beetles, and darkling beetles. Total arthropod abundances were significantly different among the four habitats and changed throughout the summer. Total species diversity differed little among the habitats. Each arthropod group was significantly more abundant in one or two habitat types, and the different arthropod groups had dissimilar abundance patterns among the habitats. These findings are consistent with other studies of post-fire patterns of ground-dwelling arthropod assemblages and have important implications for differences in decomposition and nutrient cycling rates among habitats and food resource availability to vertebrate predators in those habitats.

Lissoway, J.D. 1996. Remembering the La Mesa Fire. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 7-10. General Technical Report No. RM-GTR-286. USDA Forest Service

In June, 1977, La Mesa Fire burned across 15,444 acres of land in and around Bandelier National Monument. This was the largest and most intense fire to have occurred in the Jemez Mountains during the 20th century. The conditions that led to, and occurred during, La Mesa Fire are reviewed here.

Loftin, S.R. 1999. Trial by Fire: Restoration of Middle Rio Grande Upland Ecosystems. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 119-122.. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

The majority of upland ecosystems (desert scrub, grassland, piñon-juniper, ponderosa pine, and higher elevation conifer forests) in the Middle Rio Grande Basin were historically dependent on periodic fire to maintain their composition, productivity, and distribution. The cultural practices of European man have altered the function, structure, and composition of virtually all Middle Rio Grande Basin ecosystems. Centuries of widespread livestock grazing have altered natural fire frequencies and intensities in upland habitat types. Fire suppression has led to an increase in woody plant abundance on many upland sites, from grassland to ponderosa pine forests. The negative consequences range from increased surface runoff and soil erosion in grasslands, shrublands, and piñon-juniper woodlands to increased potential for severe wildfire in ponderosa pine forests. The goal of restoration in these systems is to reintroduce fire. Unfortunately, due to varying levels of degradation, simply burning areas and expecting them to recover their former attributes may not be possible. Successful restoration requires some knowledge of the extent of degradation and the potential for recovery. This paper discusses the process of identifying problems, determining land status, and defining realistic objectives. Three case studies are presented as examples of ecosystems in different stages of degradation that required different restoration procedures for reintroduction of fire.

Loftin, S.R., and C.S. White. 1996. Potential Nitrogen Contribution of Soil Cryptogams to Post-Disturbance Forest Ecosystems in Bandelier National Monument, NM. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 140-148. General Technical Report No. RM-GTR-286. USDA Forest Service.

The nitrogen-fixation (N_2-fixation) potential and annual N contribution of soil cryptogamic crusts were estimated in three previously burned ponderosa pine and one previously grazed piñon/juniper forest ecosystems in Bandelier National Monument, NM. The ponderosa pine forest sites were burned in the 1977 La Mesa Fire, and burro grazing on the piñon/juniper site ended in approximately 1983. The objective of the research was to determine whether estimated post-disturbance cryptogamic N inputs could offset N losses from the disturbance. Surface cover in each habitat was divided into litter cover, herbaceous cover, bare soil, and obvious cryptogams in an attempt to quantify the spatial heterogeneity of soil properties. Line intercept transects were

used to estimate percent surface cover of each cover type. Soil samples from each cover type were analyzed for total N, C, P, $\delta^{15}N$, and N_2-fixation potential. At this stage in the recovery process, the potential for cryptogamic N_2- fixation was determined to occur in all sampled habitats and cover types. Correlations between N_2- fixation potential and other soil variables indicated that none is suitable as an indirect estimator of N_2-fixation potential. Estimates of ecosystem N input as a result of cryptogamic N_2-fixation range from 3.6-27.0 kg/ha/yr. Evidence from soil analyses indicated that soil loss was greatest at the piñon/juniper site.

McCord, V.A.S. 1996. Flood History Reconstruction in Frijoles Canyon Using Flood-Scarred Trees. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 114-122. General Technical Report No. RM-GTR-286. USDA Forest Service.

Unexceptional summer storms triggered large floods on the Rito de Los Frijoles in 1977 and 1978, shortly after the intense La Mesa Fire of 1977 burned this watershed. Large numbers of trees growing on or near the stream bank in Frijoles Canyon were scarred during these flood events. These scars provide a record of the occurrence of past flood events that were used to reconstruct flood history with existing fire history data to test the hypothesis that large floods have occurred following large-scale fires in the past. Thirty-six scarred trees at several localities along the Rito de los Frijoles were sampled, and the flood scars crossdated using reference chronologies developed from scarred and unscarred trees in the canyon. Channel cross-sections and the top heights of the flood scars above the stream level were surveyed, followed by reconstruction of paleoflood discharges using the slope-area method. The riparian tree-ring chronology extends to the early 1600s, represented by at least five trees back to the mid-1700s. The scar dates range from 1773 to 1985, with most of the scar dates falling in 1977 and 1978. Floods were also identified for 1866, 1904, 1951, and 1972. Other than 1977, only the 1773 flood(?) scar matches a major fire year in the local fire scar record. This suggests that fire intensity, rather than fire extensiveness, is the major factor leading to post-fire flooding in this watershed. Flood discharge estimates reconstructed from flood scars correspond well with the USGS estimates for the historic floods of 1977 and 1978. The flood scar evidence in Frijoles Canyon indicates that there have been at least four floods comparable to the 1978 flood in the last two centuries and at least seven floods as large as the flood of 1977 during that time.

Moeur, S., and D.A. Guthrie. 1984. The Effects of Clearing Fire-Killed Trees on Wildlife. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 135-144. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Rapid recovery of the forest after a fire should be an important objective of forest management. Following a severe fire in the Jemez Mountains in north central New Mexico, two management approaches were instituted on adjacent burn sites. On Bandelier National Monument property, burned forest areas were heavily seeded from the air with a variety of grasses. This was the only action taken. However, on Los Alamos National Laboratory property, all dead trees were cut down and removed. The purpose of the study reported upon in this paper was to compare the effects of the two management policies on the flora and fauna of the sites. The results show that slight differences in vegetation and insect populations were found between the Bandelier and Laboratory sites, but these differences were not significant. No difference was found in mammal populations between the two sites. Bird populations differed, with greater populations of both resident and visiting species on the Bandelier site. This difference is thought to be due to the presence of nesting sites and perches provided by dead trees rather than to differences in food supply. The few trees left standing on the Laboratory site were used by birds and lessen the differences observed between the two sites. The effects of the two strategies of forest management thus have their greatest effect on bird populations. Effects of the Laboratory approach on vegetation are minor but could be minimized even more by restricting vehicular traffic in the process of wood removal (requiring cut wood to be carried to existing roads rather than allowing vehicles to drive to the cutting site). The effects on birds could be greatly reduced by leaving a certain percentage of dead trees standing, particularly large trees that were partially dead before the fire and that were used by hole-nesting species.

Pippin, W.F., and B. Nichols. 1996. Observations of Arthropod Populations Following the La Mesa Fire of 1977. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 161-165.. General Technical Report No. RM-GTR-286. USDA Forest Service.

(Note: This paper was presented at the 1st La Mesa Fire Symposium and inadvertently omitted from that symposium proceedings.) Sampling sites were selected in burned and unburned areas where transects for bird surveys had previously been established. Plots were selected randomly in each site and sampled weekly. A 50 m^2 plot was selected in a severely burned area and an unburned area nearby, and observations were made on arthropod populations. There were more genera collected in the unburned than the burned areas. Generally, the most common arthropods collected in both the burned and unburned areas were ants and spiders. A New Jersey light trap operated at Ponderosa Campground in 1977, before the fire, collected several hundred specimens per trap night. In 1978, the volume of specimens collected in the trap was similar to that collected before the fire. In some areas, the drastic reduction in arthropod populations might have had an adverse effect on populations of some insectivorous birds or other animals.

Pippin, W.F., and B.D. Pippin, 1984. Aquatic Invertebrates from Capulin Creek, Bandelier National Monument, New Mexico. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 107-113. Report No. LA-9236-NERP. Los Alamos National Laboratory.

During the summer of 1980, a limited survey was made of the invertebrate fauna of Capulin Creek within Bandelier National Monument. The stream originates in the Santa Fe National Forest, enters at the western edge of the Monument, and flows for approximately 11.5 km through Capulin Canyon into the Rio Grande. The stream flows steadily for approximately 6.4 km, then becomes intermittent or dry, especially in the summer months. The stream is small and shallow and varies in width according to the topography, but averages about 1 m. The flow varies with the season and time of day. The purpose of this study was (1) to establish a preliminary check list of the invertebrate fauna of the stream, primarily macroinvertebrates of the Class Insecta, (2) to assess the relative abundance of various taxa between test sites, and (3) to compare the number and kind of taxa collected with those found in the Rito de la Frijoles. The results showed that the greater diversity of species and, in general, the overall population numbers occurred in the upper reaches of Capulin Creek. The same pattern was noted in the Rito de la Frijoles. Capulin Creek from Base Camp to its headwaters is a relatively stable but fragile environment.

Potter, L.D., and T. Foxx. 1984. Postfire Recovery and Mortality of the Ponderosa Pine Forest after La Mesa Fire. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 38-55. Report No. LA-9236-NERP. Los Alamos National Laboratory.

In the wake of all except the most severe fires, a number of trees are not killed outright but retain an unsinged portion of the crown. The health, vigor, and recovery of these trees can determine which trees should be salvaged. Accurate prediction of which trees will live is essential because these trees provide the seed source for natural regeneration. A few studies have examined postfire mortality in fire-damaged trees. One study found that trees of sawtimber size with 40% or more of the canopy singed did not survive 6 years. In another, 57% of trees with 50% or more of the crown singed were dead after 3 years, compared with 26% mortality for trees with less than 50% of the crown singed. As a result of the man-caused La Mesa fire in north-central New Mexico and a previous investigation of the fire history of several stands of ponderosa pine before La Mesa Fire, postfire mortality, as well as recovery of ponderosa pine stands two growing seasons after a fire, could be examined. Factors examined included fire history, stand density of living trees after the fire, crown damage, and competition of herbaceous vegetation.

Potter, L.D., T.S. Foxx, and F.J. Barnes. 1982. Natural Regeneration of Ponderosa Pine as Related to Land Use and Fire History on the Pajarito Plateau. Report No. LA-9293-NERP. Los Alamos National Laboratory. 26 pp.

Problems of ponderosa pine regeneration have been of concern in the Southwest for years. When sources of seeds are removed either by fire or logging, problems of regeneration become paramount. This study was designed to look at natural regeneration of ponderosa pine after the La Mesa fire as related to the various types of land management and restoration processes. The study had various aspects. (1) Using aerial photo coverage, the total area burned by the La Mesa fire was calculated and the amount of area devoid of seed trees was determined. The total acreage burned was 60.7 km^2, with a total of 21 km^2 (36.3%) devoid of seed trees. (2) Leaf water potentials (LWP) of three grass species were measured periodically. Soil samples at two sites were taken from 10, 20, 30, and 40 cm depths whenever LWP was measured. The results indicate that ponderosa pine seedlings would experience severe competition for water from sheep fescue early in the growing season and continued competition with slender wheatgrass through the summer. Mountain muhly seems to have a water usage pattern and phenology that coordinates well with known requirements for ponderosa pine seedling survival. The results indicate that artificial or natural regeneration of pine seedlings can be facilitated by seedling undercover species that will stabilize soils yet have niche requirements that are complimentary to those of regenerating tree seedlings. (3) A population of 1431 seedlings with heights of 1 to 150 cm was examined for microsite characteristics such as soil texture, litter depth, litter composition, living ground cover, phylogeny of ground cover, growth form of ground cover, vertical canopy, potential tree shade, seedling proximity, need for protective objects, relation to trees, distance to trees, slope, and slope direction. The best ponderosa pine seedling survival was in fine soils; that is, conifer litter less than 1 cm, sparse ground cover and some shade, or ground cover of bearberry or mountain muhly and no shade. Overhead canopy or proximity to protective objects is not required. There was a high association of the common native grass mountain muhly and bearberry. The relationship through which bearberry acts as a nurse plant should be investigated.

Purtymun, W.D. 1984. Chemical Quality of Surface Water in Bandelier National Monument. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 103-106. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Perennial and intermittent streams have cut the surface of the Pajarito Plateau into a number of narrow southeast-trending mesas separated by deep canyons. Perennial surface flow occurs in Cañon de los Frijoles and in the upper and middle reaches of Alamo and Capulin Canyons. Water quality data have been collected in Cañon de los Frijoles since 1957. After La Mesa Fire, water quality data were collected in Cañon de los Frijoles and Alamo and Capulin Canyons to evaluate the effects of the fire on the quality of surface water. These data show that the chemical quality of surface water (base flow) in Cañon de los Frijoles changed slightly after La Mesa Fire. The most noticeable change was an increase in calcium, chloride, bicarbonate, and TDS. Analyses over a 20-month period after the burn indicated a general decline in most of these constituents. Similar analyses of surface water in Alamo and Capulin Canyons indicated similar results over a 12-month period. Analyses of samples of summer storm runoff compared with base flow samples from Cañon de los Frijoles and Capulin Canyon indicated that higher concentrations of barium, calcium, iron, bicarbonate, manganese, and phenols occurred in storm runoff than in base flow. The presence of lead in storm runoff in Cañon de los Frijoles maybe attributed to lead from automobile emissions as it was not reported in a similar runoff event in Capulin Canyon, which is remote from vehicular traffic. Precipitation and runoff from the burn area will remove the fire debris, and the quality of the water in the streams will return to normal. The past two years of data indicate that water quality of base flow should return to normal within 3 to 5 years.

Swetnam, T.W., and C.H. Baisan. 1996. Historical Fire Regime Patterns in the Southwestern United States Since AD 1700. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 11-32. General Technical Report No. RM-GTR-286. USDA Forest Service.

Fire-scar chronologies from a network of 63 sites in the Southwestern United States are listed and described. These data characterize the natural range and variability of fire regimes from low elevation pine forests to higher elevation mixed-conifer forests since AD 1700. A general pattern

of increasing length of intervals between low intensity surface fires was observed along gradients of low to high elevations and from the relatively drier pine sites to the wetter mixed-conifer sites. However, large variability in the measures of central tendency and higher moments of the fire interval distributions suggest that elevation and forest type were often weak determinants of fire frequency. Some of the variations in fire interval distributions between similar elevation or forest types were probably due to unique site characteristics, such as landscape connectivity (i.e., ability of fires to spread into the sites) and land use history. Differences in the sizes of sampled areas and fire-scar collections among the sites also limited the ability to compare and interpret fire interval summary statistics. Comparison of both the fire-scar network data (1700-1900) and documentary records of area burned on all Southwestern Region National Forests (1920-1978) with a Palmer Drought Severity Index time series clearly shows the association between severe droughts and large fire years, and wet periods and small fire years. Moreover, important lagging relations between climate and fire occurrence also are revealed. In particular, large fire years in ponderosa pine dominated forests were typically preceded by wet conditions in the prior one to three years. In contrast, large fire years in mixed-conifer forests were associated with extreme drought years, but no consistent lagging relations were observed. The hypothesis is that both fuel production (especially grasses and pine needles) and fuel moisture were important climate-linked factors in ponderosa pine fire regimes, while fuel moisture was the primary factor controlling mixed-conifer fire regimes. These results provide two important types of information for management. (1) Baselines of fire regime ranges and variations are documented across the most economically important and widespread forest types in the Southwest. These data will be useful for guiding, developing, and justifying ecosystem management plans, particularly for the restoration of fire regimes and forest structures to improve forest health and sustainability. (2) The fire-climate relations suggest that a long-range fire hazard forecasting model could be developed that would be a valuable tool for planning and implementing both prescribed fire and fire suppression programs in the Southwest.

Touchan, R., C.D. Allen, and T.W. Swetnam. 1996. Fire History and Climatic Patterns in Ponderosa Pine and Mixed-Conifer Forests of the Jemez Mountains, Northern New Mexico. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 33-46. General Technical Report No. RM-GTR-286. USDA Forest Service.

The fire history in ponderosa pine and mixed conifer forests across the Jemez Mountains in northern New Mexico was reconstructed by collecting fire-scarred samples from ten ponderosa pine areas and three mesic, mixed-conifer areas. Prior to 1900, ponderosa pine forests were characterized by high frequency, low intensity surface fire regimes. The mixed-conifer stands sustained somewhat less frequent surface fires, along with patchy crown fires. The associations between past fires and winter-spring precipitation also were examined. In both ponderosa pine and mixed-conifer forests, precipitation was significantly reduced in the winter-spring period immediately prior to fire occurrence. In addition, winter-spring precipitation during the second year preceding major fire years was significantly increased in the ponderosa pine forest. The results of this study provide baseline knowledge concerning the ecological role of fire in ponderosa pine and mixed-conifer forests. This information is vital to support ongoing ecosystem management efforts in the Jemez Mountains.

Trayler, D. 1984. Effects of La Mesa Fire on Bandelier's Cultural Resources. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 97-102. Report No. LA-9236-NERP. Los Alamos National Laboratory.

In June, 1977, during the fire in Bandelier National Monument and adjacent Federal lands, archaeologists attempted to assist firefighters in reducing or preventing damage to cultural resources. A hastily called-together team of archaeologists organized a plan to monitor handline construction and bulldozer activities during La Mesa Fire. A postfire survey showed that, although these efforts were siccessful in preventing damage to sites during initial line cuts, damage and destruction did occur during subsequent line widening, rehabilitation, and reseeding because the team was not informed of these activities

Wauer, R.H., and T. Johnson. 1984. La Mesa Fire Effects on Avifauna. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 145-172. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Prior to La Mesa Fire, an avian population study had been initiated on seven vegetative units within Bandelier National Monument. Three of these units were burned during La Mesa Fire. This report compares the avifauna present within these three units before and immediately after the fire and during the breeding seasons for two additional years. La Mesa Fire affected the avifauna in a number of ways. In general, populations and biomass values declined immediately after the fire in Burnt and Escobas Mesas but exhibited increases on the higher, less severely burned Apache Springs unit. All three units displayed small to extensive increases in 1978 but exhibited minor to moderate declines, with a few exceptions, in 1979. In comparing 1979 data with prefire values, considerable variations are evident. Species richness returned to the same values on Burnt and Escobas Mesas as before the fire but remained 12.5% higher at Apache Springs. Species density values declined 16% on the average; on Burnt and Escobas Mesas, they declined 35% and 14%, respectively, but at Apache Springs they increased by 2%. Species diversity increased on all three units: 2% on Burnt Mesa, 5% on Escobas Mesa, and 8.5% at Apache Springs. Evenness values increased on all three units as well: 1%, 5.5%, and 5% on Burnt Escobas Mesas and Apache Springs, respectively. Biomass analysis reveals that middle-sized species increased more than larger species and considerably more than smaller species. Four of the 10 feeding guilds exhibited population increases between the prefire period and 1979, and 6 guilds exhibited declines. Timber-drilling-insect and foliar-nectar feeders received the greatest benefit; and timber-searching-insect, ground-predator, and air-perching-insect feeders were most critically affected. Two of the four nesting guilds (parasitic and cavity-depression nesters) exhibited positive responses, and two (ground and foliage nesters) exhibited negative responses. Evidence accumulated from this study suggests that Bandelier's avifauna, particularly species diversity, is increased by fire when the habitat receives light to moderate fire. Of the three categories of fire, severe fire has the most drastic effect on avifauna, and the longest period of time is required to adjust. Severe burns also subject the environment to greater probabilities for other adverse effects, such as erosion, overgrazing, and infestations. These, in turn, will affect the avifauna in secondary ways and extend the period of adjustment.

White, C.S. 1996. The Effects of Fire on Nitrogen Cycling Precesses within Bandelier National Monument, NM. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 123-139. General Technical Report No. RM-GTR-286. USDA Forest Service.

Nitrogen is often the nutrient limiting production in conifer forests. Fire acts as a mineralizing agent, releasing nutrients in available forms; however, nitrogen is often lost during fires, which can further deplete this limiting nutrient. Without fire, nitrogen becomes tied up in partially decomposed litter (needles and woody debris). The problems faced in management of forest systems are how and when to use fire from a nutrient perspective. A chronosequence of fire intervals in ponderosa pine forests was studied to determine (1) if nitrogen cycling processes decrease and (2) if concentrations of organics that inhibit these processes increase along the fire chronosequence. Patterns were not statistically significant, but fairly clear trends occurred. Nitrogen mineralization and nitrification patterns were higher in sites recently burned (within two years) and were lowest in sites without fires since the 1890s. The patterns at intermediate age sites varied, perhaps because of different usage by elk and variable amounts of needle scorch that resulted in differential needle litterfall after fire. Within a site, concentrations of certain monoterpenes were consistently negatively correlated with rates of nitrification and mineralization. In these systems, fire promotes more rapid cycling of nitrogen, in part through combustion of monoterpene inhibitors.

White, C.S., S.R. Loftin, and S.C. Hofstad. 1999. Response of Vegetation, Soil Nitrogen, and Sediment Transport to a Prescribed Fire in Semiarid Grasslands. In: Rio Grande Ecosystems: Linking Land, Water, and People. Toward a Sustainable Future for the Middle Rio Grande Basin. Pp. 83-92. Report No. RMRS-P-7. USDA Forest Service. Fort Collins.

Shrubs and trees have invaded semiarid grasslands throughout much of the Southwestern United States. This invasion has not only decreased grass cover but has also increased runoff and erosion. In fact, sediment from rangelands constitutes the single largest source of nonpoint stream pollutants within the State of New Mexico. Fire, which was a natural factor that shaped and maintained the grasslands, is a management tool that may aid in restoring and maintaining grass cover. However, fire also poses the risk of increasing erosion and further degradation because protection afforded by vegetation is reduced immediately after the fire. This study measured vegetation cover, soil inorganic nitrogen (N) levels, and erosion amounts associated with the first application of prescribed fire on two semiarid grasslands. The potential for adverse effects from these fires was great because they were performed at the beginning of a drought period. After the first growing season following the fire, grass cover returned to pre-burn levels, and both soil N and erosion amounts were similar to the unburned areas. Thus, prescribed fire for reducing shrub and tree cover may pose minimal adverse risk even under drought conditions.

White, W.D. 1996. Geomorphic Response of Six Headwater Basins Fifteen Years after the La Mesa Fire, Bandelier National Monument. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 95-113. General Technical Report No. RM-GTR-286. USDA Forest Service.

Factors important to hillside erosion immediately following La Mesa forest fire included: 1) degree of ash development; 2) amount of upslope catchment area; 3)degree of slope; and 4) type or complexity of slope. Efficiency of transport of fire-derived sediment proved to be related to the density and continuity of drainage lines. Early controls to fire related erosion proved to be needle cast from unburned crowns and climatic variability (e.g., the precipitation differences between elevations). Fifteen years following La Mesa Fire, hillside erosion was interrupted by: 1) downed, burned trees and 2) increased ground surface microtopography afforded by the aggradational building of grass pedestals and cryptogamic crusts. The increased ground surface roughness encourages infiltration from the intensely burned areas. Infiltration becomes shallow groundwater interflow that surfaces at the top margins of tributary canyons. The gathering of sediment-free runoff in the tributary and trunk canyons entrains the temporarily stored sediment derived from the mesa tops immediately following the fire. Present day sediment delivery from burned areas of the mesa tops appears to derived primarily from moderately burned basins. While the characteristic needle cast protects the moderately burned basin's ground surface from rain drop impact and channelized overland flow (rilling), the needle cast discourages the growth of cryptogamic crusts. Without the combined infiltration-encouraging factors of cryptogamic crusts and downed trees (which are fewer in moderately burned basins), precipitation in moderately burned areas generally concentrates in the drainages, and channel incision results. Storage of this sediment occurs where drainages widen, such as the mouth of the moderate burn basin on Burnt Mesa, and on the lower gradient, mesa top trunk channels.

White, W.D., and S.G. Wells. 1984. Geomorphic Effects of La Mesa Fire. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 73-90. Report No. LA-9236-NERP. Los Alamos National Laboratory.

The Rito de los Frijoles watershed, the northernmost portion of Bandelier National Monument, experienced the greatest areal extent of devegetation by La Mesa Fire. This study was initiated to assess the impact of devegetation on geomorphic processes in selected portions of the Rito de los Frijoles watershed, including hillslope erosion, channel sedimentation, and concomitant modification of the land. Assessing the impact of La Mesa Fire involved four main aspects: (1) identification of sediment-source areas, (2) determination of rates and controls of sediment production (erosion rates), (3) characterization of the adjustments of the ephemeral channels to increased sediment supply, and (4) characterization of the morphologic adjustments of the perennial master stream (Rito de los Frijoles) to increased runoff and sediment supply. This study evaluated the geomorphic processes and adjustments to devegetated conditions for a 3-year period. Thus, results discussed herein are restricted to short time periods (several years) rather than periods of tens of years. A morphometric analysis of the Frijoles Canyon watershed provided baseline information on the spatial arrangement of hillslopes and channels. The geomorphic responses of noninstrumented, devegetated watersheds developed on the volcanic

plateaus surrounding the Jemez Mountains may be predicted based upon a synthesis of the field studies, morphometric analysis, and geomorphic mapping performed in this study.

Wolters, G.L. 1996. Elk Effects on Bandelier National Monument Meadows and Grasslands. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 196-205.. Report No. RM-GTR-286. USDA Rocky Mountain Forest and Range Experiment Station.

This study was designed to quantify current vegetation composition and determine forage production, use, and preference by elk on a seasonal basis on two Bandelier National Monument habitat types – mesa grasslands and montane meadows. In 1993, the mesa grassland habitat, created by the 1977 La Mesa Fire, was dominated by sheep fesque and other grasses. Montane meadows were dominated by low to mid-seral introduced species such as Kentucky bluegrass, white clover, and common dandelion. Kentucky bluegrass provided over twice as much cover and total plant cover was about 40% greater on a portion of one meadow protected from grazing by elk for several years. The change in species composition and litter after a few years' protection from elk suggests that montane meadows may respond rapidly to reduced elk grazing pressure. Annual production averaged about 1600 and 1000 kg/ha on montane meadows and grassland sites, respectively. Utilization averaged about 50% on the meadows and only about 25% on the grasslands. Warm season grasses such as blue grama, little bluestem, spike muhly, and Arizona three-awn were the principal forage species consumed on grassland sites, while Kentucky bluegrass, beauty cinquefoil, and bedstraw were the most common species consumed on montane meadows.

Yool, S.R., J.D. Miller, R.G. Balice, B.P. Oswald, and C. Edminster. 1999. Mapping Fuel Risk at the Los Alamos Urban-Wildland Interface. In: Proceedings of the Crossing the Millennium: Integrating Spatial Technologies and Ecological Principles for a New Age in Fire Management Conference and Workshop. June 15-17. Boise. (in press)

This paper documents the initial efforts to map overstory and understory fuel loads within the ponderosa pine fuel type at the Los Alamos urban-wildland interface using remote sensing and GIS technologies. Overall overstory fuel classification accuracy was 96.1%. Average modeled understory fuel loads increase from 4.89 tons/acre in grass to 28.29 tons/acre in ponderosa pine, 31.53 tons/acre in aspen, and 52.05 tons/acre in mixed conifer. Ground surveys are underway to establish and fine-tune map accuracies. Mapped fuel models are being reconciled with an accompanying digital terrain database, providing an inventory showing the topographic positions and total acreage of all NFDRS fuel classes. Data and methods used to produce the overstory and understory fuel risk maps are presented.

Wildlife/Ecosystem Management

Allen, C.D. 1996. Elk Response to the La Mesa Fire and Current Status in the Jemez Mountains. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 179-195. General Technical Report No. RM-GTR-286. USDA Forest Service.

Faunal remains in local archaeological sites and historic information suggest that elk populations in the Jemez Mountains were low from ca. 1200 A.D. through ca. 1900 A.D., when they were extirpated from this region. Elk were reintroduced to the Jemez country in 1948 and 1964-65, and their population has apparently grown exponentially, reaching 1000 animals in the 1970s and about 7000 by 1991. Elk populations in Bandelier National Monument and adjoining areas increased rapidly after the 1977 La Mesa Fire. Winter use by elk in the La Mesa Fire area, centered on Bandelier, grew from about 100 animals in 1978 to around 1500 by 1992. The dramatic increase in the Bandelier elk herd (an annual growth rate of 21.3% and a 3.6 year population doubling time) was due in part to the creation of about 6000 hectares of grassy winter range in and around the park as a result of the fire. Some of this local population increase reflects concentration of elk in this favorable winter habitat from surrounding portions of the Jemez Mountains. Existing data are inadequate to determine whether elk populations are still growing rapidly in the Jemez Mountains. While annual aerial surveys since 1990 in Bandelier reveal no clear population trend, a variety of observations demonstrate increasing elk use of

lower elevation areas. Negative resource impacts from today's high elk populations are beginning to be widely noted across the Jemez Mountains, especially in high-use portions of the Bandelier National Monument area. Affected resources range from plant communities to soils and even archaeological sites. Given the large uncertainties associated with the current data on elk populations, care should be taken to avoid further population increases until the resource impacts of this new phenomenon (large numbers of elk) can be identified, desirable population levels identified (based to a significant degree upon ecological information and resource carrying capacities, as well as social considerations), and appropriate cooperative management strategies implemented.

Biggs, J., K. Bennett, and P.R. Fresquez. 1997. Evaluation of Habitat Use by Rocky Mountain Elk (*Cervus elaphus nelsoni*) in North-Central New Mexico using Global Positioning System (GPS) Radio Collars. Report No. LA-13279-MS. Los Alamos National Laboratory. 18 pp.

Global Positioning System (GPS) radio collars were used to determine habitat use on the LANL preserve. Locations and types of habitat occupied were documented with frequency of use of various habitat types. Results were compared to previous studies to document changes in utilization patterns. Based on habitat use and availability analysis, use of grass/shrub and piñon/juniper habitats was generally higher than expected during most seasons, and use of forested habitats (ponderosa pine, mixed conifer) was lower than expected. Most of the collared elk remained on LANL property year-round. The application of GPS collars to elk studies in north-central New Mexico appears to be a more efficient and effective method than use of VHF radio collars

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1998. Movements and Activity Patterns of Rocky Mountain Elk at the Los Alamos National Laboratory. LA-UR-98-4535. Presentation at the Third Symposium of Biological Research in the Jemez Mountains. November 6, 1998. Santa Fe.

From 1996 to 1998, the Ecology Group evaluated daily/seasonal movements and activity patterns of elk on and near Los Alamos National Laboratory (LANL) property by plotting global positioning system (GPS) locational fixes of collared elk onto geographic information system (GIS) coverages of topography and physical structures (i.e., security fences, roads, buildings), resulting in the identification of 6-8 primary elk-traveled corridors on LANL property. Travel corridors in the east portion of LANL are dictated by security fences and other structures, and there are two areas where corridors pass between LANL property and San Ildefonso Pueblo property. The primary travel corridor for collared animals moving west off LANL property is near Pajarito Mountain, which extends off the west-central portion of the Laboratory. The daily use of different land-cover types and terrain were evaluated seasonally by comparing data from six 4-h periods to one another: 0000-0400, 0400-0800, 0800-1200, 1200-1600, 1600-2000, and 2000-2400. Elk were found to utilize piñon-juniper significantly more frequently than all other cover types between the hours of 0400-1200. Through the 2000-h period, they utilized piñon-juniper significantly more frequently more frequently than all other cover types except ponderosa pine. In general, the use of piñon-juniper increased during daylight hours and decreased during evening hours. Conversely, the use of grasslands decreased during daylight hours and increased during evening hours. The data showed that the elk utilized the northwest and west-facing slopes significantly less than almost all other slopes. Significant differences also were observed between northwest and west-facing slopes versus south-facing and east-facing slopes during the spring. Use of 0%-5% slopes was significantly greater than all other slope classes between the evening and early morning hours of 1600-0400 and significantly greater than slopes above 10% for all hourly subperiods except 0800-1200. During spring, use of 0%-5% slopes decreased during midday hours (0800-1600) and increased during evening and early morning hours (1600-0800). Animals increased their proportion of use on steeper slopes during most subperiods during the summer. By understanding more about movement and activity patterns of elk on LANL property, management strategies to reduce adverse impacts caused by elk (i.e., automobile accidents, overuse of sensitive habitats) can be developed while minimizing the impact of the strategies on elk movement patterns to off-site locations.

Biggs, J.R., K.D. Bennett, and P.R. Fresquez. 1998. Estimation of Observation Rates of Global Positioning Collars Deployed on Elk. Report No. LA-UR-98-1080. Los Alamos National Laboratory.

A comparison was made of the ability of global positioning system (GPS) radio collars deployed on elk to obtain valid positions (position acquisition rate – PAR) in seasonal home ranges with differing vegetation and topographical characteristics. GPS collar PARs also were compared under varying levels of cloud cover and between differing daily time periods. A mean PAR of 69% was recorded for collared elk. Multiple regression analysis of seasonal home range characteristics indicated that vegetation cover type and slope, either as individual variables or in combination with one another, were not significant predictors of GPS collar PARs. Statistical differences in position acquisition rates between cloud cover classes or varying cloud base heights were not observed. The PAR was significantly higher between 1600-2000 h (mountain standard time) compared to 0000-1200 h, which may have been due to elk behavior. We believe that the use of GPS collars is a more effective and efficient method of tracking elk in our study area compared to very high frequency (VHF) collars, as GPS collars can be programmed to obtain fixes automatically, have fewer logistical problems, and are more economical with long-term data collection efforts.

Biggs, J.R., K.D.. Bennett, P.R. Fresquez, and R.J. Robinson, 1996. Movements, Disease Analysis, and Tritium Concentrations of Rocky Mountain Elk of the Pajarito Plateau. LA-UR-96-3395. Presentation at the Symposium of Biological Research in the Jemez Mountains, New Mexico. October 26, 1996.

Seasonal movement patterns of four elk (3 cows/1 bull) and one deer fitted with VHF (very high frequency) units were investigated from spring 1995 to spring 1996. Results also are presented on disease analysis of six elk captured in 1996, as well as tritium analysis of all animals (n=11). The deer remained within three miles of its original capture location (n=39 fixes) throughout the study period. The bull elk remained on the Pajarito Plateau in winter and spring, then migrated to the Valle Grande during late spring and summer (n=49 fixes). One of the three cows died within 6 weeks of collaring, apparently following calving, near the north edge of Bandelier National Monument. The surviving cow elk remained on the east slope of the Jemez Mountains and the Pajarito Plateau during winter and early spring, then moved to the Valle Grande during calving and summer months (n=93 fixes). Based on radiotelemetry data, herds occurring in the southern portion of the Laboratory appear to migrate and calve along the eastern portion of the Valle Grande. Four of the six elk captured in 1996 had moderate to high titers for vesicular stomatitis, and one elk had a moderate titer for toxoplasmosis. One cow elk, sampled near Pajarito Road, and one male deer, sampled at TA-49, exhibited concentrations of tritium (2.2 and 1.1 pCi/ml, respectively) above the upper background limit of 0.9 pCi/ml.

Biggs, J.R., K.D.. Bennett, P.R. Fresquez, and R.J. Robinson, 1999. Resource Use, Activity Patterns, and Disease Analysis of Rocky Mountain Elk (*Cervus elaphus nelsoni*) at the Los Alamos National Laboratory. Report No. LA-13536-MS. Los Alamos National Laboratory. 83 pp.

To form the basis for the development of management strategies for elk and other large herbivores, understanding how, when, where, and why animals move with respect to the landscape and availability of essential habitats (i.e., foraging, watering) is essential. From 1996 to 1998, daily/seasonal movements, habitat use, and activity patterns of elk on and near Los Alamos National Laboratory (LANL) were evaluated through the use of global positioning system collars and a geographic information system. Primary travel corridors on and immediately adjacent to LANL property and identified travel routes for collared animals moving west off LANL property in the vicinity of Pajarito Mountain were identified. Daily use of different land cover types and terrain was evaluated seasonally by comparing six four-hour periods to one another. There were significantly more locational fixes of elk in piñon/juniper compared to all other cover types during the hours of 0400-1200, and significantly more than all other cover types except ponderosa pine through the 2000 hour period. In general, use of piñon/juniper increased during daylight hours and decreased during evening hours. Use of grasslands decreased during day hours while increasing during evening hours. Generally, northeast slopes were used greater than expected and west and northwest slopes less than expected. There were significantly greater

fixes on 0^{o}-5^{o} slopes compared to all other slope classes between the evening and early morning hours of 1600-0400 and significantly greater than slopes above 10^{o} for all hourly subperiods except 0800-1200. During spring, use of 0^{o}-5^{o} slopes decreased during midday hours while increasing during evening and early morning hours, and animals tended to increase their proportion of use on steeper slopes during most subperiods during summer. Diseases of animals through blood analysis drawn from all collared elk also was examined. Vesicular stomatitis was the most commonly observed disease among tested elk. By understanding movement and activity patterns of elk on LANL property, management strategies can be developed and applied to reduce adverse impacts (i.e., automobile accidents, overuse of sensitive habitats) associated with this species.

Cartledge, T.R. 1996. Heritage Resources and Fire Management: A Resource Management Crossroads. In: Fire Effects in Southwestern Forests. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 206-214. General Technical Report No. RM-GTR-286. USDA Forest Service.

Until the past few years, Forest Service fire management had been characterized by a program of total wildfire suppression coupled with relatively small scale prescribed burning, having fuels reduction as the principle objective. As the organization moves toward "ecosystem management," the fire program is developing multiple, complex objectives employing a combination of wildfire suppression, prescribed natural fire, and both small and large scale prescribed burning. These changes raise some concerns with regard to heritage resource management and protection. However, fire managers and heritage resource specialists have a history of close working relationships in the Southwest, and through continued cooperation they are working to develop implementation strategies appropriate to changing land management objectives.

Eberhardt, L.E., and G.C. White. 1979. Movements of Mule Deer on the Los Alamos National Environmental Research Park. Report No. LA-7742. Los Alamos National Laboratory. 29 pp.

The movements of mule deer on the Los Alamos National Environmental Research Park (LA/NERP) in north-central New Mexico were studied during 1975-1978. A total of 36 deer were live-trapped, marked, and released; 24 of these were equipped with visual markings including ear tags, ear streamers, and neck collars, and 11 were fitted with radio transmitters. Disturbance caused by trapping may have caused some unusual movements. Deer home ranges appear to be elongated in shape, possibly because the deer tend to move parallel to the steep canyon-mesa systems and along the elevational gradient. The average home range size for six deer radiotracked for 18-20 months was 13.7 ± 5.0 km^2. There was no indication that marked deer made extensive seasonal migrations. Resident deer appear to be habituated to much of the human activity on the LA/NERP and did not appear to avoid areas of high human use within their home ranges. However, the 2.6-m-high security fences did affect deer movement.

Fair, J.M., S.J. Whitaker, and O.B. Myers. 1996. Scaling of Body Size and Home Range in Terrestrial Ecological Risk Assessment. Poster presentation at the Annual Meeting of the Rocky Mountain Chapter of the Society of Environmental Toxicology and Chemistry. Denver. (Manuscript in preparation)

Published allometric models for predicting home range from body mass and foraging strategy were tested against new data.

Foxx, T., and B. Blea-Edeskuty. 1995. Wildlife Use of NPDES Outfalls at Los Alamos National Laboratory. Report No. LA-13009-MS. Los Alamos National Laboratory. 47 pp.

During the summer and fall of 1991, a preliminary survey of 133 NPDES outfalls was conducted to determine wildlife usage of these outfalls. Usage was determined on the basis of observed scat, tracks or bedding. Indications were that about 56% of the outfalls were being used by 35 vertebrate species as a drinking water source. Additionally, hydrophytic vegetation grows in association with approximately 40% of the outfalls – a characteristic that could make these areas eligible for wetland status. Additional study is necessary to determine usage by small mammals, amphibians, and aquatic macroinvertebrates. Wetland assessments may be

necessary to ensure compliance with wetland regulations if LANL activities affect any of the outfalls supporting hydrophytic vegetation.

Gonzalez, T.C., T.S. Foxx, and J. Biggs. 1995. Analysis of Animal-Related Accidents in Los Alamos County. Report No. LA-UR-95-3950. Los Alamos National Laboratory. 8pp.

Since Los Alamos National Laboratory inception, a multitude of changes have occurred throughout Laboratory property that have included large-scale developments at various Technical Areas. These developments have resulted in seemingly significant alterations in the terrain and the general landscape of the Pajarito Plateau. Although not documented, this in turn has likely caused significant changes in land use by most groups of wildlife species, particularly those that have large seasonal and/or daily ranges, such as birds and large mammals. These changes have undoubtedly caused some species of wildlife, such as elk and deer, to alter their land use patterns by way of cutting off travel corridors to wintering areas, breeding habitat, foraging habitat, and bedding areas, as well as other necessary habitats. In this report, animal-related accidents from January 1990 to February 1995 were tabulated and analyzed to determine relationship to various parameters such as species, location, time of day, and season. Elk and Mule deer were by far the most common species involved in accidents.

Moeur, S., and D.A. Guthrie. 1984. The Effects of Clearing Fire-Killed Trees on Wildlife. In: Proceedings of La Mesa Fire Symposium, October 6-7, 1981. T.S. Foxx, ed. Pp. 135-144. Report No. LA-9236-NERP. Los Alamos National Laboratory.

Rapid recovery of the forest after a fire should be an important objective of forest management. Following a severe fire in the Jemez Mountains in north central New Mexico, two management approaches were instituted on adjacent burn sites. On Bandelier National Monument property, burned forest areas were heavily seeded from the air with a variety of grasses. This was the only action taken. However, on Los Alamos National Laboratory property, all dead trees were cut down and removed. The purpose of the study reported upon in this paper was to compare the effects of the two management policies on the flora and fauna of the sites. The results show that slight differences in vegetation and insect populations were found between the Bandelier and Laboratory sites, but these differences were not significant. No difference was found in mammal populations between the two sites. Bird populations differed, with greater populations of both resident and visiting species on the Bandelier site. This difference is thought to be due to the presence of nesting sites and perches provided by dead trees rather than to differences in food supply. The few trees left standing on the Laboratory site were used by birds and lessen the differences observed between the two sites. The effects of the two strategies of forest management thus have their greatest effect on bird populations. Effects of the Laboratory approach on vegetation are minor but could be minimized even more by restricting vehicular traffic in the process of wood removal (requiring cut wood to be carried to existing roads rather than allowing vehicles to drive to the cutting site). The effects on birds could be greatly reduced by leaving a certain percentage of dead trees standing, particularly large trees that were partially dead before the fire and that were used by hole-nesting species.

Myers, O.B. 1999. On Aggregating Species for Risk Assessment. Human and Ecological Risk Assessment 5: 559-574.

Different combinations of species characteristics such as dietary strategies and foraging tactics define unique pathways for material cycling and energy flow. Such clusters of species may also have similar functions in ecosystems because they use similar resources in similar ways. By using species characteristics to aggregate and define assessments, more ecologically relevant assessment endpoints can be defined.

Hansen, L.A., P.R. Fresquez, R.J. Robinson, J.D. Huchton, and T.S. Foxx. 1999. Medium-Sized Mammals around a Radioactive Liquid Waste Lagoon at Los Alamos National Laboratory: Uptake of Contaminants and Evaluation of Radio-Frequency Identification Technology. Report No. LA-13660-MS. Los Alamos National Laboratory. 29 pp.

Use of a radioactive waste lagoon by medium-sized mammals and levels of tritium, other selected radionuclides, and metals in biological tissues of the animals were documented at TA-53

*at Los Alamos National Laboratory during 1997 and 1998. Rock Squirrel (*Spermophilus variegatus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and bobcat (*Lynx rufus*) were captured both at TA-53 and at a control site in the Santa Fe National Forest. Captured animals were anesthetized and marked with radiofrequency identification (RFID) tags and/or ear tags. Urine and hair samples were collected and analyzed for tritium and metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and thallium). In addition, muscle and bone samples from two rock squirrels collected from each of TA-53, perimeter, and regional background sites were analyzed for tritium, ^{137}CS, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and total uranium. Animals at TA-53 were monitored entering and leaving the lagoon area using an RFID monitor to read identification numbers from the tags of marked animals and a separate camera system to photograph all animals passing through the monitor. Cottontail Rabbit (*Sylvilagus *spp), rock squirrel, and raccoon were the species most frequently photographed going through the RFID monitor. Male and female rock squirrels from the lagoon area had significantly higher tritium concentrations compared to rock squirrels from the control area. Metal concentrations were not significantly higher in rock squirrels from TA-53, although there was a trend toward increased levels of lead in some individuals. Muscle and bone samples from squirrels in the lagoon area appeared to have higher levels of tritium, total uranium, and ^{137}Cs than samples collected from perimeter and background locations. However, the committed effective dose equivalent estimated from the potential human consumption of the muscle and bone tissue from these rock squirrels did not suggest any human health risk. Indirect routes of tritium uptake, possibly through consumption of vegetation, are important for animals in the lagoon area.*

Swetnam, T.E., C.D. Allen, and J.L. Betancourt. 1999. Applied Historical Ecology: Using the Past to Manage for the Future.

This paper discusses the usefulness of historical data for ecosystem management. Some of Craig Allen's work on the Pajarito Plateau is used in the examples.

White, G.C. 1981. Biotelemetry Studies on Elk. Report No. LA-8529-NERP. Los Alamos National Laboratory. 24 pp.

The movements of Rocky Mountain elk in the eastern Jemez Mountains in north-central New Mexico were studied from 1978 to 1980. Thirty-six elk were trapped, marked, and released; and 30 of these animals were radio-collared. The June 1977 La Mesa fire created a wintering habitat that was used heavily by the radio-collared elk. The 10-year-old clear cuts on Cerro del Medio on the Baca Land and Cattle Company property were used for calving and nursing areas. In general, radio-collared elk used areas in an early successional state, and they did not use areas at the Los Alamos National Laboratory where there was human activity.

Wolters, G.L. 1996. Elk Effects on Bandelier National Monument Meadows and Grasslands. Proceedings of the Second La Mesa Fire Symposium. C.D. Allen, ed. Pp. 196-205.. Report No. RM-GTR-286. USDA Rocky Mountain Forest and Range Experiment Station.

This study was designed to quantify current vegetation composition and determine forage production, use, and preference by elk on a seasonal basis on two Bandelier National Monument habitat types – mesa grasslands and montane meadows. In 1993, the mesa grassland habitat, created by the 1977 La Mesa Fire, was dominated by sheep fesque and other grasses. Montane meadows were dominated by low to mid-seral introduced species such as Kentucky bluegrass, white clover, and common dandelion. Kentucky bluegrass provided over twice as much cover and total plant cover was about 40% greater on a portion of one meadow protected from grazing by elk for several years. The change in species composition and litter after a few years' protection from elk suggests that montane meadows may respond rapidly to reduced elk grazing pressure. Annual production averaged about 1600 and 1000 kg/ha on montane meadows and grassland sites, respectively. Utilization averaged about 50% on the meadows and only about 25% on the grasslands. Warm season grasses such as blue grama, little bluestem, spike muhly, and Arizona three-awn were the principal forage species consumed on grassland sites, while Kentucky bluegrass, beauty cinquefoil, and bedstraw were the most common species consumed on montane meadows.