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File name:	Target-ERID # for Domino.txt
Version:	1.0
Document Type:	RPF Record
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Document Details:

Title:	ERID-102790 1) THE APLICATION OF ECORSK.9 TO THE PAJARITO CANYON WATERSHED AT THE LOS ALAMOS NATIONAL LABORATORY LA-14374
ERID Number.StartPage:	ERID-102790
Office of Record:	WES-DO
Date Received:	09/09/2008
Official Use Only:	N
Page Count:	23
Record Type:	Letter
Document Date:	09/01/2008
To:(Addressees - Organization) *(separate multiple values with semicolons)*	N/A
From:(Senders - Organization) *(separate multiple values with semicolons)*	GIL GONZALES, RANDALL RYTI, PATRICIA GALLEGOS, KATHRYN BENNETT
Other Document Number(s): *(separate multiple values with semicolons)*	LA-14374
TA: *separate multiple values with semicolons)*	
PRS Number(s): *(separate multiple values with semicolons)*	
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The Application of ECORSK.9 to the Pajarito Canyon Watershed at the Los Alamos National Laboratory

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Edited by Hector Hinojosa, Group IRM-CAS.

Front cover: Mexican spotted owls within Los Alamos National Laboratory boundaries. Photo by David C. Keller.

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National Nuclear Security Administration

LA-14374
Issued: September 2008

The Application of ECORSK.9 to the Pajarito Canyon Watershed at the Los Alamos National Laboratory

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CONTENTS

List of Figures

List of Tables

The Application of ECORSK.9 to the Pajarito Canyon Watershed at the Los Alamos National Laboratory

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ABSTRACT

The Water Stewardship Program at the Los Alamos National Laboratory conducts investigations in various watersheds of potential impacts to biota from legacy contaminants that are dispersed in the environment. ECORSK.9 is a FORTRAN95 model used as one line of evidence for assessing risk to animals from chemicals of potential ecological concern (COPECs). We applied the model to two federally listed threatened and endangered (T&E) species—the Mexican spotted owl (*Strix occidentalis lucida*) and southwestern willow flycatcher (*Empidonax traillii extimus*)—in the Pajarito watershed where habitat exists that is suitable for nesting by the two species. The results of the model application are used to enhance the spatial and temporal coverage of risk screening and empirical studies that are conducted concurrently. We compiled contaminant data from canyons and non-canyons sources so that an understanding of the potential for adverse effects across a large-encompassing study area could be evaluated. ECORSK.9 assesses potential effects to terrestrial animals over large spatial areas on the basis of the U.S. Environmental Protection Agency Quotient Method. Estimates of animal exposure over a gridded area are compared with assumed health effects levels to generate hazard quotients (HQs) and hazard indices (HIs). Mean total HIs, HI distributions, COPEC-specific HQs, and contour maps are presented. The mean total HI helps us to begin to evaluate potential adverse effects to the animals from contaminants and leads us into examining COPEC- and location-specific results. Adjusted mean total HIs for the two receptors were as follows: Mexican spotted owl—0.1 (n = 1,000); and southwestern willow flycatcher—2.3 (n = 132). On average no appreciable impact is expected to Mexican spotted owls nor to southwestern willow flycatchers. While some moderately high HIs and HQs were generated for the flycatcher, examination of the detailed model results showed that, by and large, those HIs were the result of interpolating contaminant values into areas where no sampling has occurred. T&E species warrant protection of each individual in the population and, although there were a few HIs in the range of 10–100 for the owl and several in that range for the flycatcher, many factors that result in biasing HIs and HQs upwards may have resulted in significant overestimates of potential adverse effects. This is largely a function of modeling risk over large areas and applying conservatism at several levels in the development of model input parameters. When the ECORSK.9 modeling process involves large areas of land and data interpolation is used for areas not yet sampled, HIs and HQs of potential adverse effect are significantly biased upwards. Nevertheless, it is important to demonstrate for purposes of environmental stewardship the degree of potential risk to T&E species that might exist under conservative assumption of contaminant distribution, even when examination of uncertainties lowers substantially the level of concern.

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INTRODUCTION

The Pajarito watershed (Figure 1) includes Pajarito, Twomile, and Threemile canyons and their tributaries. Pajarito Canyon has been the subject of a biota investigation as described in the Pajarito Canyon Biota Investigation Work Plan (LANL 2006a). ECORSK.9 is a model written in FORTRAN95 computer code that has been applied for the biota investigation as one of many lines of evidence for evaluating potential adverse ecological effects from chemicals of potential ecological concern (COPECs) in soil and sediment. ECORSK.9 assesses potential effects in general to terrestrial animals over large spatial areas on the basis of the U.S. Environmental Protection Agency (EPA) Quotient Method (EPAQM). Estimates of animal exposure over a gridded area are compared with health effects levels collected from literature to generate hazard quotients (HQs) and hazard indices (HIs). ECORSK.9 integrates biological, ecological, and toxicological information using geographic information system (GIS) interfaces so that model input and output are spatially explicit on the grid system basis.

BACKGROUND

Ecological risk screenings and other risk-related information have indicated the need to perform additional studies in the Pajarito watershed (LANL 2006a). Assessments by Los Alamos National Laboratory's (LANL's) Water Stewardship Program of ecological effects from legacy COPECs at LANL were undertaken to assist in making remediation decisions and to develop plans for future environmental monitoring. Diverse terrestrial and aquatic biological communities in the Pajarito watershed are potentially exposed to contaminated soil, sediment, surface water, and shallow alluvial groundwater. With dispersed chemical (inorganic and organic) and radioactive contamination in the LANL-related environment, understanding potential risk to wildlife that is presented by these COPECs is an important ecological quality issue.

ECORSK.9 has been previously applied to the biota investigation in Mortandad Canyon (Gonzales et al. 2006), and ECORSK.7 was applied to the biota investigation in Los Alamos and Pueblo canyons (Gonzales et al. 2004). Application of the ECORSK.9 model helps to integrate screening level assessments into broader spatial contexts. A screening level assessment of the Pajarito watershed is documented in the work plan (LANL 2006a), which evaluated affected media—soil, sediments, and water—in canyon bottoms. Other screening assessments have been performed on source areas of contamination known as solid waste management units (SWMUs) in relation to the Resource Conservation and Recovery Act. The application of ECORSK.9 to the Pajarito watershed, used collectively with field studies, helps to test model assumptions and model results enhance spatial and temporal coverage of field measures. The operations strategy, documentation of code, mathematical models used, and previous applications of ECORSK have been documented in numerous reports (Gallegos et al. 1997a, b; Gonzales et al. 1998a, b; 2002; 2004).

While ECORSK.7 simulated receptor nest distribution by computationally adjusting the output data (HIs and HQs), ECORSK.9 assigns nest location (x, y or row, column values) according to predetermined weighted distributions that are associated with real receptor habitat preference data. This method of weighting the physical distribution of nest sites (or focal points) comprises the difference between ECORSK.7 and ECORSK.9.

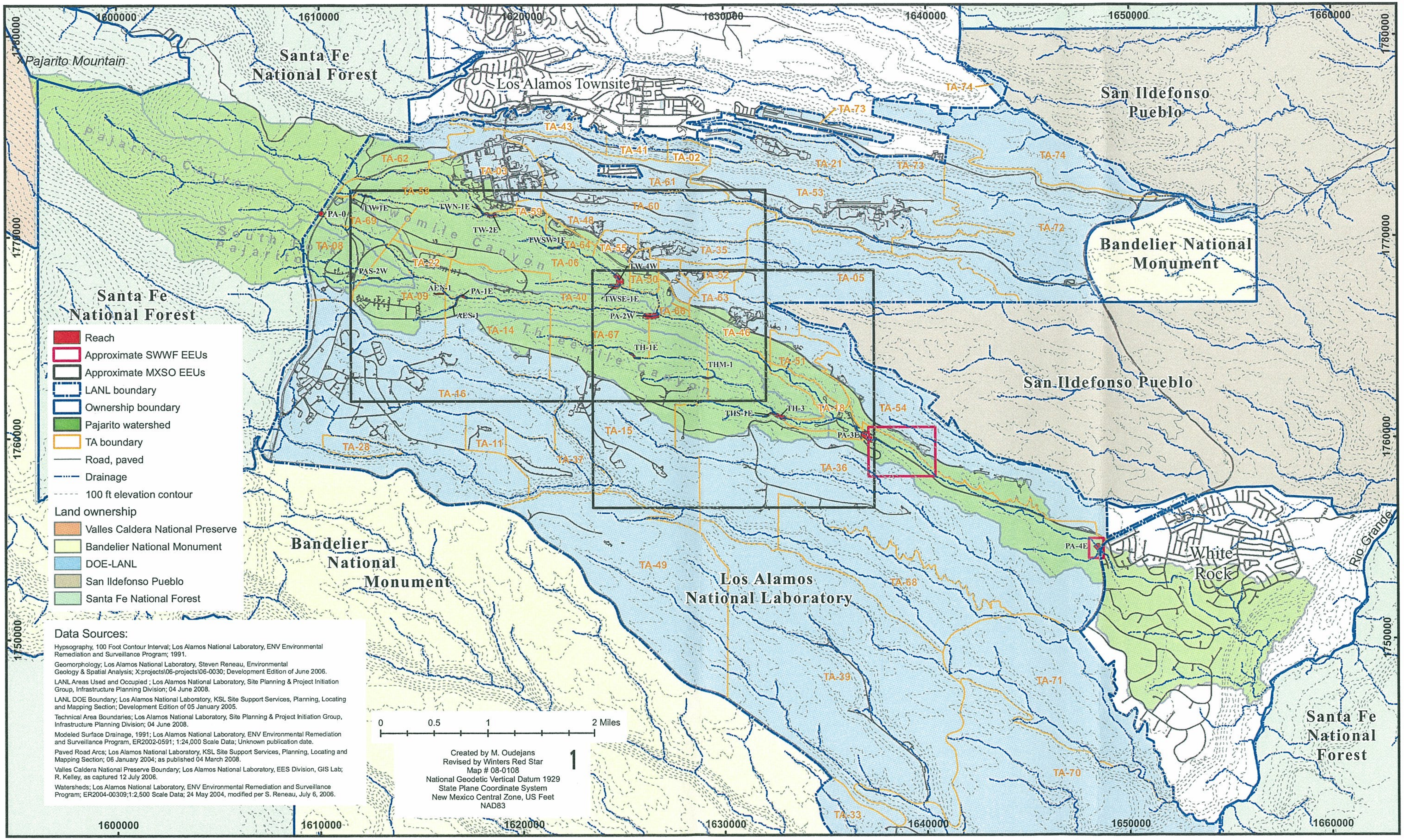

Figure 1. General study area and ecological exposure units (EEUs) for the southwestern willow flycatcher (SWWF) and Mexican spotted owl (MXSO) in the Pajarito watershed.

METHODS

Receptors

The receptors evaluated using ECORSK.9 were federally listed threatened and endangered (T&E) species—Mexican spotted owl (*Strix occidentalis lucida*) and southwestern willow flycatcher (*Empidonax traillii extimus*)—because there is viable habitat for these species in the Pajarito watershed and because T&E species warrant special protection.

The Mexican spotted owl nests in other canyons at LANL in habitat similar to that found in the Pajarito watershed. Habitat suitability for the owl in the forested areas within the LANL area was originally evaluated in the late 1990s and owl habitat was re-delineated in 2006 (Hathcock and Haarmann 2008). The owl is a top carnivore, consuming mostly rodents such as woodrats (*Neotoma* spp.), field mice, and voles (*Microtus* spp. and *Sorex* spp.), and its diet has been measured locally indicating measurable proportions of birds and insects. Since ECORSK.9 considers fraction of diet as soil and uses food-chain transfer factors, potential bio-concentration of COPECs is estimated. Home ranges (HRs) for Mexican spotted owls vary significantly by region. Local experts believe HRs in this area of the Rocky Mountains to be less than those published for the Pacific Northwest. ECORSK.9 uses a body-weight-based allometric equation from Peters (1993) to calculate a foraging HR of 4.1 km^2. This value is used by the model in the foraging process, discussed later. The owl has been a subject of numerous modeling evaluations and risk-related studies at LANL.

Within LANL, suitable habitat for the southwestern willow flycatcher is largely in the wetlands of Pajarito Canyon where willows (*Salix* spp.) and other riparian plants occur. The flycatcher is an insectivore, foraging within and above plant canopies, often catching insects while flying. Feeding on insects associated with aquatic communities, the flycatcher can be affected by potential COPEC pathways originating in wetlands and riparian areas that exist in the Pajarito watershed. The HR of the flycatcher fluctuates significantly, varying around nesting season, and pre- and post-nesting movements can be quite large. Mean HR during nesting has been measured by Cardinal (2005) at 3,800 m^2, and pre-nesting movement of the flycatcher can range up to 0.654 km^2 (654,000 m^2). The grid cells used in modeling using ECORSK.9 are 900 km^2. A HR of 3,800 m^2 was used as the base modeling scenario in ECORSK.9 and a comparison was made to a larger HR of 0.654 km^2.

ECORSK.9 Organization and Operations

A summary of the general organization of ECORSK.9 in relation to GIS information and input and output files is shown in Figure 2. ECORSK.9 integrates several different kinds of GIS information, COPEC data, and biological, ecological, and toxicological information.

The basic spatial unit used by ECORSK.9 is a 30- × 30-m grid that is assigned a unique grid cell identification (ID) value, which corresponds to a unique New Mexico State Plane Coordinate System 'x' and 'y' value. All environmental information, such as COPEC concentrations, are cataloged by location (grid cell ID) using this spatial system. We overlaid a grid with the 30- × 30-m units on the watershed. Some receptors, such as the owl, have nesting habitats that are discrete from the surrounding foraging areas (HRs), which together comprise ecological exposure units (EEUs) as defined in the ECORSK.9 model.

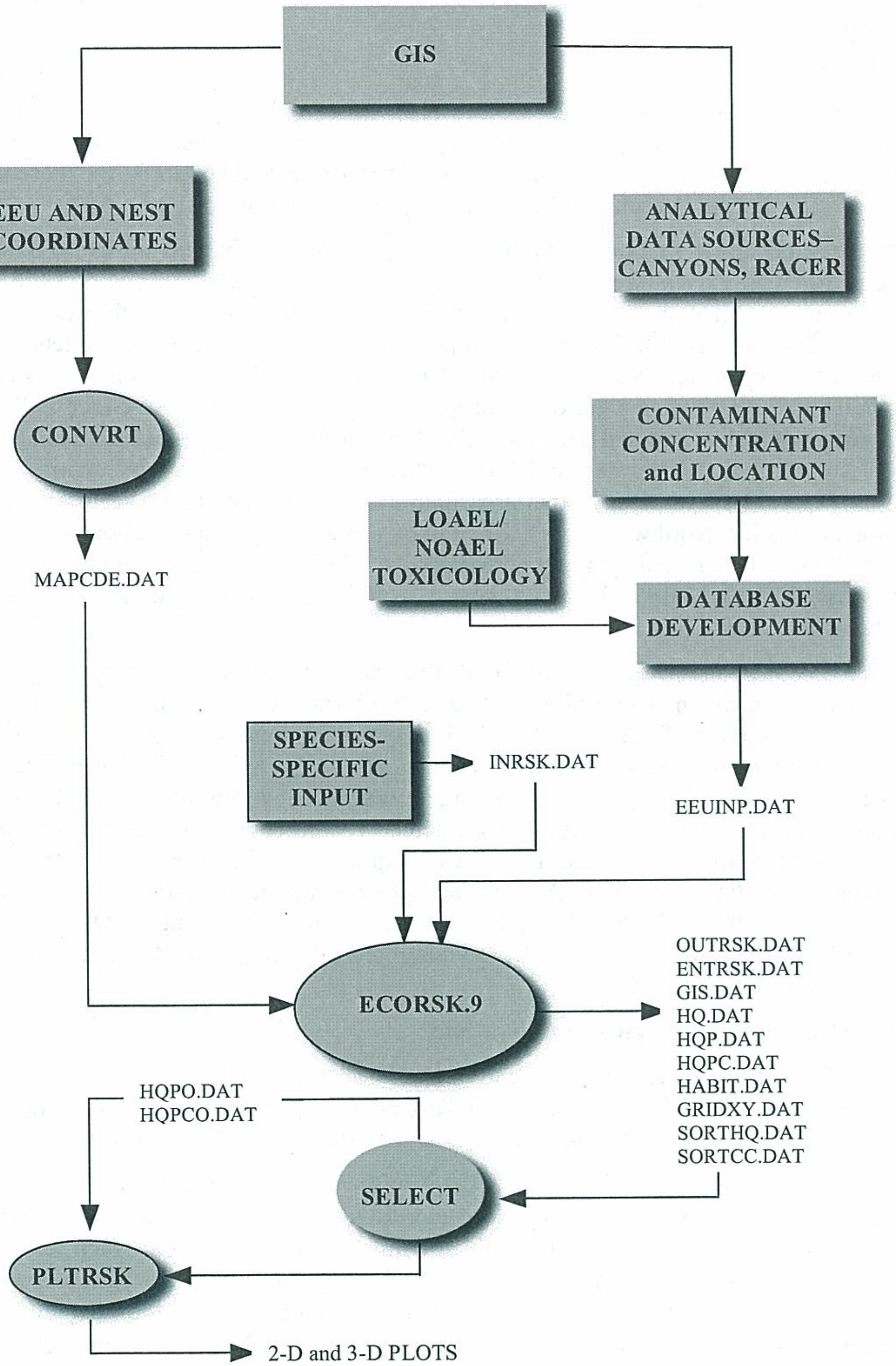

Figure 2. Schematic of strategy for integrating FORTRAN95 code with analytical data. (Note: LOAEL is "lowest observed adverse effects level;" NOAEL is "no observed adverse effects level").

Nest Site/Focal Point Designation. During ECORSK.9 operation, the model assigns nest sites (or focal points) within a nesting habitat based on user inputs (random or as specified) and differentiates the spatial components by the grid cell ID. Random nest site selection is based on Monte Carlo methods, or alternatively, nests can be specifically assigned to particular grid cells such as a grid cell occupied by a known contaminated area (SWMU or area of concern) and/or a grid cell known to contain an actual nest or other niche of an animal. In the current evaluation for the Pajarito watershed, all 132 grid cells that occupy nesting habitat of the flycatcher were selected for placement of a nest by the model. The distribution of nest/focal point locations can be unweighted throughout the EEU whereby each grid cell within a nesting habitat or EEU receives equal consideration, or distribution can be weighted on the basis of the natural distribution tendencies of the animal that are determined by habitat. At LANL, land cover types, including classes of animal habitat, have been determined from ground-verified aerial data. For the owl, 1,000 nest sites were randomly located in owl "core" habitat. Previous reports provide examples of how habitat preference (weighting) would interact with habitat occurrence for nest placement (Gallegos et al. 1997a, b; Gonzales et al. 1998a, b; 2002; 2004). The weightings also affect simulated foraging (or occupancy) as discussed later. Habitat suitability distributions for the two receptors are presented in the next subsection. In actuality, nests were not placed in map coded value 1 or 10 habitat (known as "buffer") for the owl and flycatcher; i.e., no nests were placed outside habitat designated as "core" in the LANL Habitat Management Plan (LANL 1998) for the owl nor outside the wetland for the flycatcher. With a spatial distribution of HIs, HI contours can then be applied to address population risk by geographical area.

Simulated Foraging Process

Beginning at any given nest site (grid cell), if the HR of an animal is larger than one grid cell, ECORSK.9 begins the selection of grid cells in a concentric fashion around the nest site and continues until the HR of an animal is reached. The model iterates this process for the specified number of nest sites/focal points for a receptor, e.g., 1,000 for the owl and 132 for the flycatcher. For each nest site, ECORSK.9 calculates HIs and HQs as discussed below.

Distance-Weighted Foraging. Only the Mexican spotted owl had a HR sufficiently large to apply an exponential function that is based on the central place foraging theory. The assumption can be made that the relative probability of foraging is inversely related to the radial distance from the animal's nest site, roosting area, or other focal point, and mathematically this can be expressed through the use of an exponential function:

$$O_i = A_i/\sum A_i \, ENH_i \; Exp(-R_i/R_c),$$

where

O_i = occupancy factor for any grid cell (i) of an EEU,
A_i = surface area, km^2, of the i^{th} grid within the HR of a given animal,
ENH_i = enhancement factor,
R_i = radial distance, m, of the i^{th} grid from the grid center containing the nest site, and
R_c = a scaling constant, m, for a given species.

A scaling constant of 350 m was estimated from Johnson (1993) for the Mexican spotted owl. Application of this function results in almost 75% of the foraging within 1 km of a nest site.

Distance-weighted foraging was used only for the owl. Scaling constants for non-avian species with large HRs can be obtained in a similar manner.

Habitat-Weighted Foraging. The relative density or abundance data mentioned previously in discussion of nest site selection also can affect the foraging process during calculation of HQs and HIs if this option is selected. From field data collected at LANL, absolute measures of density or abundance were converted to the relative values shown in Table 1. The GIS computer software ARC/INFO was used to integrate land cover and topography with species distribution data across the study area. Relative values are associated with the integer values that are used as map codes by ECORSK.9 to give every grid cell an identifier that is associated with a particular weighting (relative value) when the model is executed. HI/HQ output data are populated using the density/abundance data such that, for example, it is assumed that 100 owls will forage in grid cells occupied by "core" habitat for every 10 owls that forage in grid cells with "buffer" habitat. Distribution of the Mexican spotted owl for foraging was based on the suitability of three generalized habitats to be consistent with methods used for protecting the owl as described in the Habitat Management Plan (LANL 1998). Habitats are designated as core area, buffer area, or extraneous and the relative difference in weighting is 100, 10, and 1, respectively. Table 1a shows the number of grid cells that fall into each relative habitat type for the Mexican spotted owl in the Pajarito watershed. While the buffer and extraneous weightings are arbitrary, core habitat was determined using a topographic model that was modified to include other factors (such as land cover type) that influence habitat suitability. Potential nesting/roosting zones (core habitat) were based on work performed by Johnson (1993) in which he developed a topographic model to rate the physical potential of habitat for breeding spotted owls. Topographic data of the U.S. Geological Survey provided the input for modeling the potential habitat. Historical owl locations were extracted from a New Mexico Department of Game and Fish database prepared by the New Mexico Natural Heritage Program. The model was developed by examination of topographic characteristics of owl locations and random locations to find a scalar function of topography that quantitatively separated inhabited areas from random locations. The database included 1,383 records of historical reports and U.S. Forest Service inventory and monitoring daytime follow-up field work through 1991. See Johnson (1993) for more detail on the methodology for identifying potential owl nesting habitat. As previously mentioned, for our modeling efforts, areas of the watershed outside of core habitat were excluded from nest site selection.

Habitat for the southwestern willow flycatcher in the study area was arbitrarily graded on a relative basis into suitability categories like those of the Mexican spotted owl. The flycatcher is found in riparian areas in association with willows, arrowweed (*Pluchea* spp.), buttonbush (*Cephalanthus* spp.), tamarisk (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia* L.), cattails (*Typha* spp.), and some other riparian vegetation, often with a scattered overstory of cottonwood (*Populus* spp.; NMDGF 2006). The flycatcher breeds in riparian habitats—along rivers, streams, and wetlands. Although occurring widely in New Mexico during migration, willow flycatchers are confined to riparian woodlands in the breeding season (NMDGF 2006). There is a small wetland/riparian area in Pajarito Canyon that is capable of supporting flycatcher nests and foraging needs (Keller 2004). The wetland is small and the riparian habitat is of moderate quality. Its total area occupies only 132 grid cells. Habitat in the watershed was assigned either a 1 or 10 to represent relative suitability of occurrence. This means that the likelihood that the wetland habitat in Pajarito Canyon could support flycatchers is assumed to be 10 times greater than that of the remainder of the watershed. Migrating flycatchers have been identified in the

Pajarito wetlands but no nesting flycatchers have ever been observed since monitoring began in the late 1990s. Table 1b shows the number of grid cells that fall into each of two relative habitat types for the southwestern willow flycatcher in the Pajarito watershed.

Table 1a. Number of Grid Cells in Each Relative Habitat Type for the Mexican Spotted Owl in the Pajarito Watershed

Land Type	Relative Preference (Weighting)	Assigned Map Code Integer Values	No. Grid Cells in Study Area	No. Grid Cells With Sample Value Data
Outside Core and Buffer, Within Watershed	1.0	1	76,641	2,894
Buffer Zone	10.0	10	6,448	281
Core Area/Habitat	100.0	100	4,314	289

Table 1b. Relative Importance Values and Weighting of Land Cover Types for the Southwestern Willow Flycatcher in the Pajarito Watershed

Land Type	Relative Preference (Weighting)	Assigned Map Code Integer Values	No. Grid Cells in Study Area	No. Grid Cells With Sample Value Data
Pajarito Watershed Outside Wetlands ("Buffer Habitat")	1.0	1	17,698	393
Wetlands ("Core Habitat")	10.0	10	132	54

THE EPAQM

The EPAQM, or some variation of it, has been widely used in screening level and more sophisticated ecological risk assessments. The HQ is a ratio between exposure and an effect level (as represented by a toxicity reference value [TRV]), which can be used as a potential indicator of effects. The HI is defined as the sum of HQ values for all COPECs. An HQ or HI greater than 1.0 is an indication of the potential for adverse ecological effects.

The following equations are simplified versions of how the HQ and HI are calculated and are discussed in the Ecological Risk Assessment Guidance for Superfund (USEPA 1997):

$$HQ_{ij} = \frac{exposure\ level}{effect\ level\ (or TRV)} \quad \text{and} \quad HI_i = \sum_{j=1}^{n} HQ_{ij} \ ,$$

where

HQ_{ij} = hazard quotient for receptor i to COPEC j (unitless),

exposure level = exposure dose received by the animal receptor (units are mg of COPEC per kg body weight of the exposed animal per day or mg/kg/day),
effect level = effect level (represented by TRV) for exposure to COPEC j for receptor i (mg/kg/day),
and HI_i = hazard index for receptor i for n (all) COPECs (unitless).

The mean total HI is the arithmetic average of HIs for a specified total number of nest sites for a receptor—totaled across all COPECs. When the HQ for all COPECs is summed, the assumption is that they elicit similar effects. Although this also assumes that there are no synergistic effects, the summation of HQs likely errs to the side of overestimating effects. The more detailed calculation of HIs is discussed below.

Although HQs for all classes of COPECs (radionuclides, nonradionuclide metals, and organic chemicals) are summed into one HI, we discuss their derivation separately.

For nonradionuclides,

$$HI = Food \times (Soilf + BCF) / Bodwt \times \sum_{j=1}^{ncs} Occup_j \sum_{l=1}^{ncoc} Dc_{j,l} / TRV_l \ ,$$

where

HI = hazard index (cumulative HQ for all COPECs),
$Food$ = amount of food consumed by a given animal, kg/day,
$Soilf$ = fraction of diet comprised of soil,
BCF = bioconcentration factor (transfer factors from Ecorisk Database R2.2, LANL 2005), where the BCF is used in a manner that soil-to-receptor and food chain transfer of COPECs are included in the HI calculation;
$Occup_j$ = occupancy factor on the j^{th} contamination site,
$Dc_{j,l}$ = concentration of COPEC in soil (mg COPEC/kg soil) for the j^{th} contamination site (exposure dose) of the l^{th} COPEC,
TRV_l = consumed dose above which observable adverse effects may occur, mg-COPEC/kg-body weight-day of the l^{th} COPEC,
ncs = number of contaminated sites, and
$ncoc$ = number of COPECs in the j^{th} contamination site.

For radionuclides, effects levels (TRVs) have been back-calculated to concentrations in soil (ecological screening levels [ESLs], defined below) so the derivation of HIs for radionuclides is simplified as

$$HI = \sum_{j=1}^{ncs} Occup_j \sum_{l=1}^{ncoc} SC_{j,l} / (ESL_l \times ESL_{a_l}) \ ,$$

where

HI = hazard index (cumulative HQ for all COPECs),
$SC_{j,l}$ = soil concentration of COPEC, pCi-COPEC/kg-soil for the j^{th} contamination site of the l^{th} COPEC,
ESL_l = ecological screening level, pCi COPEC/kg soil of the l^{th} COPEC,
$ESLa_l$ = adjustment factor for ESL_l above for the l^{th} COPEC,
$Occup_j$ = occupancy factor on the j^{th} contamination site,

ncs = number of contamination sites, and
$ncoc$ = number of COPECs in the j^{th} contamination site.

The derivation of ESLs is described in Screening Level Ecological Risk Assessment (SLERA) Methods (LANL 2004), and ESLs were taken from LANL's Ecorisk Database 2.2 (LANL 2005).

A cumulative HQ across all COPECs, or HI, assumes that sublethal doses of various COPECs are additive in their effect, rather than synergistic, antagonistic, or independent. Although HQs for all classes of COPECs (radionuclides, nonradionuclide metals, and organic chemicals) are summed into an HI, the output files are such that HQs can be separated on any basis, such as radionuclides from nonradionuclides, and then summed into HIs by class of COPEC. The mathematical representations of this equation and any others used in the model are detailed in Gallegos and Gonzales (1999).

Approach

The ECORSK.9 model was designed to contribute to or comprise a Tier 2 level of assessment, which generally is more realistic than screening assessments. For example, for broad-ranging species, ECORSK.9 integrates large areas of contaminant information into HQs/HIs including areas outside of an artificial boundary if an animal's HR extends to those areas. This might include areas where little or no contamination or only background levels are present and these relatively low contaminant concentrations are integrated with relatively high concentrations. Actual animal distribution data are used where possible rather than assuming that an animal's distribution is restricted to a contaminated area.

Source Types

ECORSK.9 computes HIs and HQs for potential effects associated with three source types: unadjusted, background, and adjusted.

Unadjusted. This source type is a quantified total HI/HQ associated with anthropogenic and background levels of COPECs. Mathematically, unadjusted HIs are the sum of the contribution from "background" and "LANL-added" sources. Sample values are read into the model through the major input file *eeuinp.dat.* In un-sampled grid cells in canyon bottoms, concentrations were interpolated (predicted) from the nearest measured values; elsewhere, mean background concentrations were entered. When a sample value is less than the mean background concentration, the sample value is entered. Mean background concentrations are presented in McDonald et al. (2004). Background data exist for most inorganic chemicals and radionuclides, but not for organic chemicals. The unadjusted mean total HI is the arithmetic average of HIs for a specified total number of nest sites or focal points established by the model operator for each receptor. As mentioned previously, the HI for a given nest site is the sum of HQs for all COPECs within the HR of an animal.

Background. This source type is a quantified HI associated with "natural" (nonradionuclides) and "regional" (radionuclides) non-Laboratory sources of COPECs. The mean natural or regional background soil or sediment concentration is entered into the HQ formula. Natural is distinguished from regional because radionuclide background values exist from sources other than LANL (e.g., atmospheric fallout).

Adjusted. This source type is a quantified HI/HQ for potential effects associated with "LANL-added" concentrations of COPECs. Although regional sampling has shown that there are measurable concentrations of COPECs upslope and upwind of LANL, on a practical level we did not use a background value for organic COPECs, therefore, while all of the modeled effects associated with organic COPECs are ascribed to LANL sources, in reality some are from non-LANL sources.

Thus, mathematically,

Unadjusted HIs/HQs = LANL-added + background contributions,

and

Adjusted HIs/HQs ("LANL-added") = total – background contributions.

Much of our discussion of the results centers on Adjusted HQs and HIs because the Adjusted source type represents a contribution, of sorts, by LANL.

Detailed Model Output. Several different output files are generated by ECORSK.9, varying in the degree of summarization or breakout that is represented by a value. The mean total HI, a single value representing the mean of HIs for all nests or focal points and summed for all COPECs, is the most summarized value and is generated for each execution of ECORSK.9. For example, if 1,000 nest sites were selected for a given model execution (or run), then a single value, the mean total HI (in *outrsk.dat*), would be the mean of 1,000 HIs. Mean HIs can be used as a general indication of potential population-level effects for species not on T&E species lists and can indicate the level of effort that might be required to investigate area-specific and other more specific potential effects. The model also provides HI and HQ data on specific nest sites or focal points, useful for evaluating potential effects to individual threatened or endangered species that occupy specific nest sites or focal points. The distribution of HIs is output in *hq.dat* and in sorted order in *sorthq.dat*.

HIs assume that all classes of COPECs—organic, metal, and radiological—have common toxicological effects; however, detailed model breakouts by COPEC enable the user to sum HIs and HQs by any particular grouping of COPEC. The HI for one nest site (in a total of, say, 1,000) would result from the sum of the HQs for each COPEC for each grid cell in the HR. The 1,000 sets of HQs (summed within a HR) by COPEC are output in *hq.dat*. If there were 28 COPECs, then for each nest site there would be 28 HQs, one for each COPEC contributing to an HI. The HQs by COPEC by HI are in the model output *hqpc.dat*.

Contaminant Data

The Pajarito Canyon Biota Investigation Work Plan and related reports summarize the known nature and extent of contamination in the Pajarito watershed, and additional or new soil/sediment sampling that was planned for 2008 (LANL 2006a, b, 2007). Soil COPEC data sources for the application of ECORSK.9 to the Pajarito watershed included measured soil concentrations and interpolated soil concentrations. Sources of measured data included (1) LANL canyons data and (2) the RACER (Risk Analysis, Communication, Evaluation, and Reduction) database (RAC 2005). We note that we used the RACER database "as is" for the purposes of this report because it was not feasible to carefully track the pedigree and accuracy of the sample results in this database (it contains millions of records). Interpolated data, described below, consisted of estimated COPEC concentrations for channel and floodplain areas in canyon bottoms that have not been sampled but include areas of fluvial sediment deposits between sampled investigation reaches (e.g., Reneau et al. 2004). So, there were three data sources, or "sets," that served as input to ECORSK.9—(1) the canyons measured data set, (2) canyons interpolated data, and (3) a RACER data set. Using these three data sources results in a relatively spatially complete analysis compared to using one or two data sources. If, for a given grid cell, there existed multiple data sources, then the priority was as follows: (1) canyons measured, (2) canyons interpolated, (3) RACER; hence for a given grid cell a canyon's measured value took priority over an interpolated value, and an interpolated value took precedence over a RACER value.

Non-Detect Replacement Values. When an analytic result for a particular COPEC is zero ('0') it does not necessarily mean that the COPEC was not present. Rather it means that the COPEC was either not present or its concentration was below the level that could be quantified by the analytical technique. Replacement of non-detects (NDs) with the detection limit (DL) or some proportion of the DL is a commonly used technique and whether or not this method is practiced and the value used should depend on the particular objectives of an assessment (Gilbert 1987). The use of one-half the DL (½DL) is less conservative than using the DL and more conservative than using "0," although in many cases a COPEC may not be present or may only be present in trace amounts (in which case "0" would be the best approximation of actual conditions). Some measure of effect of using replacement values should be evaluated when interpreting results of an assessment. Many of the sample results in both the canyons database and the RACER data set were qualified as "not detected." For our modeling evaluation, radionuclide sample results were not censored and negative values were accepted, thus COPEC data included all reported radionuclide results.

As a simple sensitivity analysis, two scenarios were developed and executed in ECORSK.9 to assess the impact of NDs on model results:

- Scenario A (canyons and interpolated data only): Organic and inorganic non-radiological chemical NDs were replaced with a zero ('0'); and
- Scenario B: ND results for non-radiological COPECs were assigned the ½DL value, which is a common practice for environmental data analysis. Replacement of NDs occurred before calculating cell or reach average concentrations.

Much of our discussion of results is centered on Scenario A results because this scenario provides realism to balance other more protective parameters used in the conservative decisions that are made in the development and selection of model data input parameters. Data types and sources of data are described below.

Measured Canyons Contaminant Data. The canyons COPEC database was obtained from the Environmental Restoration Database. Some of these data are reported in the work plan for the Pajarito Canyon biota investigation (LANL 2006a) and other documents (e.g., LANL 2006b, 2007). These data will also be reported in the Pajarito Canyon investigation report. COPECs identified in the work plan and that have a TRV for the receptor are evaluated using ECORSK.9. There were 28 COPECs identified in the Pajarito Canyon Biota Investigation Work Plan (LANL 2006a).

Interpolation of Measured Contaminant Data. Based on our understanding of COPEC dispersion during floods (e.g., Reneau et al., 2004), we interpolated COPEC concentrations in canyon inter-reaches at grid cell locations that are usually down-slope from a measured concentration where trends were observed. Interpolated values were derived from all measured concentration data (both detected and ND). The interpolations were based on reach averages of measured canyons sediment samples and trends were evaluated with distance along the watershed measured to the Rio Grande. Prior reports, including the Los Alamos and Pueblo Canyons Investigation Report (LANL 2004) and the Mortandad Canyon Investigation Report (LANL 2006c), show that there are general spatial trends in the sediment data. For a single source and downgradient attenuation of a marker substance in canyon sediments, one useful interpolation model is $\log(concentration) = \alpha + \beta \cdot x$, where x is distance from the source and α and β are estimated from the measured data. We also evaluated a simple linear regression of concentration versus distance. The model with the larger coefficient of determination (r^2) was selected to interpolate the inter-reach concentrations. If there were no significant concentration trends and there was a sufficient frequency of detects then the average concentration of detects in the watershed was used as the estimate of the analyte concentration in non-measured canyon-bottom grid cells. For Pajarito Canyon and its tributaries, we substituted distance (kilometers) from the Rio Grande measured along the active channel. One factor affecting analyte concentrations is the input of sediments from an adjacent subwatershed, such as when Twomile or Threemile canyon empties into Pajarito Canyon. If the tributary canyon has low concentrations of the analyte, then concentrations can sharply decrease at the confluence. Concentrations can also sharply increase if higher concentrations exist in the tributary compared to the main canyon drainage. The trend plots were inspected for such discontinuities, and information on nature and sources of contamination from prior reports was also instructive in establishing interpolation models with a sound basis.

Sediment texture (particle size distribution) is another factor affecting concentrations of analytes. However, for these interpolations, variations in concentration based on texture were not evaluated. Instead it was assumed that texture does not vary sufficiently across the watershed to make a significant difference in the exposure concentrations for wildlife receptors or wildlife populations. We evaluated reach averages for spatial trends as reaches represent the most ecologically relevant spatial scale for wildlife receptors and populations. A summary of the interpolation models used for the canyons data are presented in Table 2. This table indicates if there was a linear trend and where consequently an interpolation model was used (two COPECs: silver and uranium-238), or if instead a subwatershed average was used for each COPEC. Trends were evaluated for COPECs that were detected with sufficient frequency (>2%) in the Pajarito watershed.

Table 2. Summary of Interpolations Used for Canyons Data

Suite	COPEC	Units	Number of Samples (N), Detects (D), Non-detects (ND), and Detection Frequency				Subwatershed (SWS) Mean Concentration			Interpolation Models and Notes**
			N	D	ND	D freq	PA*	TH*	TW*	
Inorganic	Aluminum	mg/kg	349	349	0	100.0%	9913	9358	7178	No
Inorganic	Antimony	mg/kg	256	63	193	24.6%	0.086	0.123	0.137	No
Inorganic	Arsenic	mg/kg	349	345	4	98.9%	3.122	2.611	2.592	No, high in reach AW-1 only
Inorganic	Barium	mg/kg	349	349	0	100.0%	144	90.4	86.7	No, high in reach AW-1 only
Inorganic	Cadmium	mg/kg	349	214	135	61.3%	0.423	0.116	0.137	Yes, SWS average of detects
Inorganic	Chromium	mg/kg	349	346	3	99.1%	9.1	6.6	6.1	Yes, SWS average
Inorganic	Copper	mg/kg	349	345	4	98.9%	9.8	10.3	7.2	Yes, SWS average
Inorganic	Cyanide (Total)	mg/kg	289	108	181	37.4%	0.183	0.109	0.209	Yes, SWS average of detects
Inorganic	Iron	mg/kg	349	349	0	100.0%	11538	11053	9768	No
Inorganic	Lead	mg/kg	349	349	0	100.0%	15.3	13.6	14.0	Yes, SWS average
Inorganic	Manganese	mg/kg	349	349	0	100.0%	447	326	356	Yes, SWS average
Inorganic	Nickel	mg/kg	349	348	1	99.7%	7.45	4.36	4.68	Yes, SWS average
Inorganic	Selenium	mg/kg	349	99	250	28.4%	0.272	0.088	0.228	Yes, SWS average of detects
Inorganic	Silver	mg/kg	349	267	82	76.5%	5.43	0.095	0.398	Yes, trends in PA watershed
Inorganic	Vanadium	mg/kg	349	347	2	99.4%	19.8	14.4	14.1	Yes, SWS average
Inorganic	Zinc	mg/kg	349	348	1	99.7%	40.7	38.5	37.7	Yes, SWS average
Organic-HE*	Amino-4,6-dinitrotoluene[2-]	mg/kg	307	2	305	0.7%	0.003	0.000	0.001	No
Organic-HE	Dinitrotoluene[2,4-]	mg/kg	339	2	337	0.6%	0.000	0.000	0.006	No
Organic-HE	Dinitrotoluene[2,6-]	mg/kg	339	1	338	0.3%	0.000	0.005	0.000	No
Organic-HE	Tetryl	mg/kg	287	5	282	1.7%	0.065	0.008	0.002	No
Organic-PAH*	Acenaphthene	mg/kg	365	22	343	6.0%	0.005	0.000	0.200	No, high in reach TWN-1E only
Organic-PAH	Anthracene	mg/kg	365	48	317	13.2%	0.007	0.000	0.206	No, high in reach TWN-1E only
Organic-PAH	Benzo(a)anthracene	mg/kg	365	72	293	19.7%	0.022	0.000	0.286	No, high in reach TWN-1E only
Organic-PAH	Benzo(a)pyrene	mg/kg	365	65	300	17.8%	0.025	0.000	0.202	No, high in reach TWN-1E only
Organic-PAH	Benzo(b)fluoranthene	mg/kg	364	27	337	7.4%	0.015	0.000	0.036	No
Organic-PAH	Benzo(g,h,i)perylene	mg/kg	365	40	325	11.0%	0.009	0.000	0.017	No
Organic-PAH	Chrysene	mg/kg	365	87	278	23.8%	0.024	0.000	0.211	No, high in reach TWN-1E only
Organic-PAH	Fluoranthene	mg/kg	365	120	245	32.9%	0.069	0.002	0.674	No, high in reach TWN-1E only
Organic-PAH	Fluorene	mg/kg	365	24	341	6.6%	0.006	0.000	0.178	No, high in reach TWN-1E only

Suite	COPEC	Units	Number of Samples (N), Detects (D), Non-detects (ND), and Detection Frequency				Subwatershed (SWS) Mean Concentration			Interpolation Models and Notes**
			N	D	ND	D freq	PA*	TH*	TW*	
Organic-PAH	Indeno(1,2,3-cd)pyrene	mg/kg	365	8	357	2.2%	0.002	0.000	0.004	No
Organic-PAH	Methylnaphthalene[2-]	mg/kg	329	23	306	7.0%	0.005	0.000	0.002	No
Organic-PAH	Naphthalene	mg/kg	365	7	358	1.9%	0.005	0.000	0.274	No, high in reach TWN-1E only
Organic-PAH	Phenanthrene	mg/kg	365	116	249	31.8%	0.063	0.001	0.823	No, high in reach TWN-1E only
Organic-PAH	Pyrene	mg/kg	365	151	214	41.4%	0.071	0.002	0.654	No, high in reach TWN-1E only
Organic-PCB*	Aroclor-1248	mg/kg	318	13	305	4.1%	0.000	0.000	0.010	Yes, SWS average of detects
Organic-PCB	Aroclor-1254	mg/kg	318	79	239	24.8%	0.019	0.002	0.014	Yes, SWS average of detects
Organic-PCB	Aroclor-1260	mg/kg	318	92	226	28.9%	0.009	0.001	0.011	Yes, SWS average of detects
Organic-Pesticide	BHC[gamma-]	mg/kg	277	1	276	0.4%	0.000	0.000	0.000	No
Organic-Pesticide	DDE[4,4'-]	mg/kg	277	29	248	10.5%	0.000	0.000	0.000	Yes, SWS average of detects
Organic-Pesticide	DDT[4,4'-]	mg/kg	277	18	259	6.5%	0.001	0.000	0.000	Yes, SWS average of detects
Organic-Pesticide	Dieldrin	mg/kg	277	1	276	0.4%	0.000	0.000	0.000	No
Organic-SVOC*	Benzoic Acid	mg/kg	329	14	315	4.3%	0.046	0.044	0.017	No
Organic-SVOC	Bis(2-ethylhexyl)phthalate	mg/kg	329	13	316	4.0%	0.004	0.024	0.007	No
Organic-SVOC	Di-n-butylphthalate	mg/kg	329	5	324	1.5%	0.008	0.000	0.000	No
Organic-SVOC	Phenol	mg/kg	329	3	326	0.9%	0.016	0.000	0.000	No
Organic-VOC*	Acetone	mg/kg	282	27	255	9.6%	0.003	0.000	0.001	No
Radionuclide	Thorium-232	pCi/g	152	152	0	100.0%	1.256	1.383	1.161	No
Radionuclide	Uranium-238	pCi/g	295	295	0	100.0%	1.130	6.899	1.037	Yes, trends in TH watershed

* PA = Pajarito Canyon; TH = Threemile Canyon; TW = Twomile Canyon; HE = high explosives; PAH = polyaromatic hydrocarbons; PCB = polychlorinated biphenyls; SVOC = semivolatile organic compounds; VOC = volatile organic compounds

** 'Yes' indicates a trend, therefore, an interpolation model was used. 'No' indicates no trend and no interpolation.

Summary of COPEC Data

This section describes the derivation of the primary model input data used for model executions.

EEUINP.DAT Summary Data. Table 3 contains the summary statistics for the environmental data along with the TRVs and bioconcentration factors (BCFs) used to create the major input file (*eeuinp.dat*) to ECORSK.9 for the owl and the flycatcher. Tables 3a and 3b differentiate Scenarios A (ND = 0) and B (ND = ½DL) for the owl and Tables 3c and 3d differentiate Scenarios A and B for the flycatcher. The COPEC sample value summary statistics (average, maximum, minimum) as well as a corresponding background value are listed for each analyte. The tables also contain the TRV and weighted BCFs associated with a particular COPEC for the receptor of concern. The term TRV is used generically and can refer to a level of a COPEC in food such as a NOAEL (in units of mg/kg/d) or a level in soil such as an ESL (in units of pCi/g). TRVs were adopted from LANL's Ecorisk Database Release 2.2 (LANL 2005) and the tiered TRV development process is discussed in LANL's SLERA Methods document (LANL 2004).

Nonradionuclide TRVs. All the nonradionuclide TRVs are from the LANL Ecorisk Database Release 2.2 (LANL 2005) and were developed using a tiered TRV development process implemented in 2003. Descriptions of TRV selection criteria can be found in the SLERA Methods document (LANL 2004). Full documentation of the derivation of each TRV can be found in the Ecorisk Database (LANL 2005).

Radionuclide TRVs. The TRVs for radionuclides are ESLs. ESLs for the owl and flycatcher were calculated using ESL models for their feeding guilds that are available in the Ecorisk Database Release 2.2 (LANL 2005). The ESL for the flycatcher is based on the violet-green swallow (*Tachycineta thalassina*) model (insectivore). Further information on these models can be found in the SLERA Methods document (LANL 2004). Receptor-specific information such as life span, body weight, food intake, and dietary component fractions and associated BCFs were used to calculate owl and flycatcher radionuclide ESLs. See Table 4 for the parameters used. Some site-specific data were also derived and used. As the default, ECORSK.9 can calculate many of the parameters from various allometric equations when site-specific data are not available.

Table 3a. Summary of Data Input to ECORSK.9 for the Mexican Spotted Owl, Scenario A

COPEC Group	COPEC	Average of Sample Value[a]	Maximum of Sample Value[a]	Minimum of Sample Value[a]	Count of Sample Value	Average Sediment Background[a]	TRV[b]		BCF[c]
INORG	Arsenic	1.50E+00	1.07E+02	0.00E+00	1576	1.84E+00	2.24E+00	h	2.86E-02
INORG	Barium	2.01E+02	2.02E+04	0.00E+00	1006	6.04E+01	7.35E+01	d	1.09E-02
INORG	Cadmium	2.01E-01	1.39E+02	0.00E+00	3183	9.30E-02	1.47E+00	i	1.72E+00
INORG	Chromium (total)	1.44E+01	1.32E+03	0.00E+00	1560	5.62E+00	7.70E+01	e	1.98E-02
INORG	Copper	2.47E+01	5.46E+03	0.00E+00	1526	4.57E+00	2.98E+00	d	8.01E-02
INORG	Cyanide (total)	1.03E-01	3.46E+00	0.00E+00	1277	2.95E-01	4.00E-02	g	3.51E-01
INORG	Lead	2.74E+01	6.01E+03	0.00E+00	1416	9.25E+00	1.63E+00	h	2.70E-02
INORG	Manganese	3.60E+02	8.67E+03	0.00E+00	1444	2.90E+02	5.81E+02	e	7.29E-03
INORG	Nickel	4.41E+00	3.32E+02	0.00E+00	2380	4.98E+00	2.19E+01	d	9.61E-02
INORG	Selenium	2.44E-01	3.36E+01	0.00E+00	3134	1.00E-01	4.40E-01	f	1.28E-01
INORG	Silver	4.54E-01	1.07E+02	0.00E+00	3094	6.60E-02	5.44E+00	e	2.49E-01
INORG	Vanadium	1.28E+01	7.51E+01	0.00E+00	1513	1.04E+01	3.44E-01	h	5.12E-03
INORG	Zinc	5.63E+01	7.20E+03	0.00E+00	1256	3.39E+01	3.77E+01	d	6.74E-01
ORG	Acetone	2.19E-02	3.58E+00	0.00E+00	1045	0.00E+00	2.01E+02	e	4.21E-01
ORG	Aroclor-1248	1.21E-03	3.04E-01	0.00E+00	616	0.00E+00	1.00E-01	e	3.35E+00
ORG	Aroclor-1254	1.42E-02	2.19E+00	0.00E+00	1532	0.00E+00	1.00E-01	e	4.67E+00
ORG	Aroclor-1260	9.71E-03	2.20E+00	0.00E+00	1423	0.00E+00	2.15E+00	d	4.93E+00
ORG	BHC[gamma-]	1.36E-05	1.73E-03	0.00E+00	127	0.00E+00	5.60E-01	f	1.34E+00
ORG	Bis(2-ethylhexyl)phthalate	2.30E-01	1.60E+02	0.00E+00	2056	0.00E+00	1.10E+00	f	3.08E+02
ORG	DDE[4,4'-]	8.55E-04	1.25E-01	0.00E+00	1212	0.00E+00	8.60E-02	d	1.52E+01
ORG	DDT[4,4'-]	1.93E-03	3.00E-01	0.00E+00	1155	0.00E+00	1.68E+00	d	1.60E+01
ORG	Dieldrin	1.82E-04	4.00E-02	0.00E+00	766	0.00E+00	7.09E-02	h	6.99E+00
ORG	Di-n-Butyl Phthalate	2.52E-02	1.25E+01	0.00E+00	2071	0.00E+00	1.40E-01	e	9.42E+00
ORG	Methylnaphthalene[2-]	2.48E-02	3.87E+01	0.00E+00	2079	0.00E+00	1.60E+02	d, l	9.19E-01
ORG	Naphthalene	1.85E-02	1.07E+01	0.00E+00	2118	0.00E+00	1.60E+02	d	5.09E-01
RAD	Thorium-232	1.02E+00	1.27E+01	4.70E-03	126	1.43E+00	7.10E+03	j	0.00E+00
RAD	Uranium-238	1.24E+01	1.42E+02	-2.06E+00	274	1.22E+00	4.20E+03	j	0.00E+00

INORG = inorganic chemical; ORG = organic chemical; RAD = radionuclide.
[a]Units for INORG and ORG values are mg/kg soil while units for RAD values are pCi/g soil.
[b]Units for INORG and ORG TRVs are mg COPEC/kg body wt of receptor/day; i.e., "mg/kg/d." Units for RAD TRVs are pCi/g soil.
[c]Units for INORG and ORG BCFs are mg analyte/kg dry food per mg analyte/kg dry soil. Units for RAD BCFs are pCi analyte/g fresh food per pCi analyte/g dry soil.
[d]LANL-derived geometric mean (GMM) TRV.
[e]LANL-derived critical study (CS) TRV.
[f]Oak Ridge National Laboratory TRV.
[g]LANL value based on secondary data TRV.
[h]EPA ecological soil screening level (EcoSSL) CS TRV
[i]EPA EcoSSL GMM TRV
[j]LANL ESL model for diet of sediment invertebrates
[k]Not available
[l]Napthalene toxicity data used as a surrogate

Table 3b. Summary of Data Input to ECORSK.9 for the Mexican Spotted Owl, Scenario B

COPEC Group	COPEC	Average of Sample Value[a]	Maximum of Sample Value[a]	Minimum of Sample Value[a]	Count of Sample Value	Average Sediment Background[a]	TRV[b]		BCF[c]
INORG	Arsenic	4.21E+00	1.07E+02	5.50E-02	1.58E+03	1.84E+00	2.24E+00	h	2.86E-02
INORG	Barium	2.03E+02	2.02E+04	5.00E-02	1.01E+03	6.04E+01	7.35E+01	d	1.09E-02
INORG	Cadmium	4.46E-01	1.39E+02	5.00E-03	3.18E+03	9.30E-02	1.47E+00	i	1.72E+00
INORG	Chromium (total)	1.47E+01	1.32E+03	4.50E-02	1.56E+03	5.62E+00	7.70E+01	e	1.98E-02
INORG	Copper	2.50E+01	5.46E+03	4.00E-02	1.53E+03	4.57E+00	2.98E+00	d	8.01E-02
INORG	Cyanide (total)	2.38E-01	3.46E+00	2.50E-06	1.28E+03	2.95E-01	4.00E-02	g	3.51E-01
INORG	Lead	2.76E+01	6.01E+03	6.00E-02	1.42E+03	9.25E+00	1.63E+00	h	2.70E-02
INORG	Manganese	3.61E+02	8.67E+03	6.39E-04	1.44E+03	2.90E+02	5.81E+02	e	7.29E-03
INORG	Nickel	5.47E+00	3.32E+02	6.50E-02	2.38E+03	4.98E+00	2.19E+01	d	9.61E-02
INORG	Selenium	7.29E+00	4.33E+03	4.00E-02	3.13E+03	1.00E-01	4.40E-01	f	1.28E-01
INORG	Silver	7.31E-01	1.07E+02	1.30E-05	3.09E+03	6.60E-02	5.44E+00	e	2.49E-01
INORG	Vanadium	1.34E+01	7.51E+01	1.90E-01	1.51E+03	1.04E+01	3.44E-01	h	5.12E-03
INORG	Zinc	5.63E+01	7.20E+03	2.46E-05	1.26E+03	3.39E+01	3.77E+01	d	6.74E-01
ORG	Acetone	3.61E-02	5.50E+00	2.50E-05	1.05E+03	0.00E+00	2.01E+02	e	4.21E-01
ORG	Aroclor-1248	3.67E-03	3.04E-01	9.69E-05	6.16E+02	0.00E+00	1.00E-01	e	3.35E+00
ORG	Aroclor-1254	3.61E-02	2.20E+00	1.03E-03	1.53E+03	0.00E+00	1.00E-01	e	4.67E+00
ORG	Aroclor-1260	3.19E-02	2.20E+00	1.05E-03	1.42E+03	0.00E+00	2.15E+00	d	4.93E+00
ORG	BHC[gamma-]	2.30E-03	8.55E-03	3.36E-04	1.27E+02	0.00E+00	5.60E-01	f	1.34E+00
ORG	Bis(2-ethylhexyl)phthalate	5.75E-01	1.60E+02	1.50E-04	2.06E+03	0.00E+00	1.10E+00	f	3.08E+02
ORG	DDE[4,4'-]	8.12E-02	1.67E+01	3.20E-04	1.21E+03	0.00E+00	8.60E-02	d	1.52E+01
ORG	DDT[4,4'-]	8.62E-02	1.67E+01	3.36E-04	1.16E+03	0.00E+00	1.68E+00	d	1.60E+01
ORG	Dieldrin	1.28E-01	1.67E+01	3.30E-04	7.66E+02	0.00E+00	7.09E-02	h	6.99E+00
ORG	Di-n-Butyl Phthalate	4.35E-01	3.35E+01	1.50E-04	2.07E+03	0.00E+00	1.40E-01	e	9.42E+00
ORG	Methylnaphthalene[2-]	3.67E-01	3.87E+01	1.50E-05	2.08E+03	0.00E+00	1.60E+02	d	9.19E-01
ORG	Naphthalene	3.35E-01	3.35E+01	1.50E-05	2.12E+03	0.00E+00	1.60E+02	d, l	5.09E-01
RAD	Thorium-232	1.02E+00	1.27E+01	4.70E-03	1.26E+02	1.43E+00	7.10E+03	j	0.00E+00
RAD	Uranium-238	1.24E+01	1.42E+02	-2.06E+00	2.74E+02	1.22E+00	4.20E+03	j	0.00E+00

Table 3c. Summary of Data Input to ECORSK.9 for the Southwestern Willow Flycatcher, Scenario A

COPEC Group	COPEC	Average of Sample Value[a]	Maximum of Sample Value[a]	Minimum of Sample Value[a]	Count of Sample Value	Average Sediment Background[a]	TRV[b]		BCF[c]
INORG	Arsenic	5.61E-01	7.50E+00	0.00E+00	137	1.84E+00	2.24E+00	h	2.36E-01
INORG	Barium	6.87E+01	5.54E+02	0.00E+00	83	6.04E+01	7.35E+01	d	9.10E-02
INORG	Cadmium	2.77E-01	8.80E-01	0.00E+00	436	9.30E-02	1.47E+00	i	1.43E+01
INORG	Chromium (total)	7.72E+00	2.31E+01	0.00E+00	346	5.62E+00	7.70E+01	e	1.61E-01
INORG	Copper	8.08E+00	3.12E+01	0.00E+00	345	4.57E+00	2.98E+00	d	6.36E-01
INORG	Cyanide (total)	1.76E-01	1.62E+00	0.00E+00	315	2.95E-01	4.00E-02	g	1.00E+00
INORG	Lead	1.52E+01	4.09E+01	0.00E+00	299	9.25E+00	1.63E+00	h	2.25E-01
INORG	Manganese	4.40E+02	1.78E+03	0.00E+00	311	2.90E+02	5.81E+02	e	6.05E-02
INORG	Nickel	5.79E+00	4.81E+01	0.00E+00	385	4.98E+00	2.19E+01	d	7.78E-01
INORG	Selenium	2.26E-01	1.62E+00	0.00E+00	426	1.00E-01	4.40E-01	f	9.90E-01
INORG	Silver	9.22E-01	1.66E+01	0.00E+00	433	6.60E-02	5.44E+00	e	2.05E+00
INORG	Vanadium	1.58E+01	5.39E+01	0.00E+00	358	1.04E+01	3.44E-01	h	4.20E-02
INORG	Zinc	4.09E+01	1.07E+02	1.35E+01	289	3.39E+01	3.77E+01	d	3.78E+00
ORG	Acetone	4.69E-01	1.76E+01	0.00E+00	42	0.00E+00	2.01E+02	e	3.16E+00
ORG	Aroclor-1248	9.08E-05	9.69E-05	0.00E+00	272	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1254	1.41E-02	1.88E-02	0.00E+00	344	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1260	7.23E-03	2.27E-02	0.00E+00	345	0.00E+00	2.15E+00	d	6.80E+00
ORG	BHC[gamma-]	0.00E+00	0.00E+00	0.00E+00	17	0.00E+00	5.60E-01	f	7.36E+00
ORG	Bis(2-ethylhexyl)phthalate	1.20E-02	3.33E-01	0.00E+00	89	0.00E+00	1.10E+00	f	1.54E+02
ORG	DDE[4,4'-]	4.11E-04	6.32E-03	0.00E+00	337	0.00E+00	8.60E-02	d	1.22E+01
ORG	DDT[4,4'-]	5.47E-04	6.50E-03	0.00E+00	337	0.00E+00	1.68E+00	d	1.56E+01
ORG	Dieldrin	6.31E-06	5.23E-04	0.00E+00	83	0.00E+00	7.09E-02	h	1.67E+01
ORG	Di-n-Butyl Phthalate	2.70E-03	1.45E-01	0.00E+00	90	0.00E+00	1.40E-01	e	3.56E+01
ORG	Methylnaphthalene[2-]	0.00E+00	0.00E+00	0.00E+00	90	0.00E+00	1.60E+02	d, l	4.81E+00
ORG	Naphthalene	7.25E-02	6.50E+00	0.00E+00	90	0.00E+00	1.60E+02	d	2.52E+00
RAD	Thorium-232	1.12E+00	1.80E+00	1.10E-01	20	1.43E+00	2.80E+01	j	0.00E+00
RAD	Uranium-238	1.26E+00	2.31E+00	3.83E-01	17	1.22E+00	7.70E+02	j	0.00E+00

Table 3d. Summary of Data Input to ECORSK.9 for the Southwestern Willow Flycatcher, Scenario B

COPEC Group	COPEC	Average of Sample Value[a]	Maximum of Sample Value[a]	Minimum of Sample Value[a]	Count of Sample Value	Average Sediment Background[a]	TRV[b]		BCF[c]
INORG	Arsenic	1.15E+00	7.50E+00	2.15E-01	137	1.84E+00	2.24E+00	h	2.36E-01
INORG	Barium	7.44E+01	5.54E+02	4.25E+00	83	6.04E+01	7.35E+01	d	9.10E-02
INORG	Cadmium	3.65E-01	1.50E+00	5.00E-03	436	9.30E-02	1.47E+00	i	1.43E+01
INORG	Chromium (total)	7.99E+00	2.31E+01	3.70E-01	346	5.62E+00	7.70E+01	e	1.61E-01
INORG	Copper	8.30E+00	3.12E+01	2.85E-01	345	4.57E+00	2.98E+00	d	6.36E-01
INORG	Cyanide (total)	1.98E-01	1.62E+00	1.00E-01	315	2.95E-01	4.00E-02	g	1.00E+00
INORG	Lead	1.52E+01	4.09E+01	3.50E+00	299	9.25E+00	1.63E+00	h	2.25E-01
INORG	Manganese	4.40E+02	1.78E+03	4.66E+01	311	2.90E+02	5.81E+02	e	6.05E-02
INORG	Nickel	6.30E+00	4.81E+01	3.25E-01	385	4.98E+00	2.19E+01	d	7.78E-01
INORG	Selenium	3.62E-01	2.00E+00	4.00E-02	426	1.00E-01	4.40E-01	f	9.90E-01
INORG	Silver	1.03E+00	1.66E+01	1.00E-02	433	6.60E-02	5.44E+00	e	2.05E+00
INORG	Vanadium	1.63E+01	5.39E+01	7.50E-01	358	1.04E+01	3.44E-01	h	4.20E-02
INORG	Zinc	4.09E+01	1.07E+02	1.35E+01	289	3.39E+01	3.77E+01	d	3.78E+00
ORG	Acetone	4.76E-01	1.76E+01	2.55E-03	42	0.00E+00	2.01E+02	e	3.16E+00
ORG	Aroclor-1248	9.10E-04	4.26E-02	9.69E-05	272	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1254	1.73E-02	4.26E-02	1.70E-03	344	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1260	1.04E-02	4.26E-02	1.70E-03	345	0.00E+00	2.15E+00	d	6.80E+00
ORG	BHC[gamma-]	2.61E-03	4.38E-03	1.03E-03	17	0.00E+00	5.60E-01	f	7.36E+00
ORG	Bis(2-ethylhexyl)phthalate	2.35E-01	3.47E+00	3.00E-02	89	0.00E+00	1.10E+00	f	1.54E+02
ORG	DDE[4,4'-]	5.55E-03	3.70E-01	4.66E-04	337	0.00E+00	8.60E-02	d	1.22E+01
ORG	DDT[4,4'-]	5.75E-03	3.70E-01	6.78E-04	337	0.00E+00	1.68E+00	d	1.56E+01
ORG	Dieldrin	2.12E-02	3.70E-01	6.78E-04	83	0.00E+00	7.09E-02	h	1.67E+01
ORG	Di-n-Butyl Phthalate	2.38E-01	3.47E+00	8.50E-02	90	0.00E+00	1.40E-01	e	3.56E+01
ORG	Methylnaphthalene[2-]	1.95E-01	3.47E+00	1.33E-02	90	0.00E+00	1.60E+02	d, l	4.81E+00
ORG	Naphthalene	2.39E-01	7.72E+00	2.60E-03	90	0.00E+00	1.60E+02	d	2.52E+00
RAD	Thorium-232	1.12E+00	1.80E+00	1.10E-01	20	1.43E+00	2.80E+01	j	0.00E+00
RAD	Uranium-238	1.26E+00	2.31E+00	3.83E-01	17	1.22E+00	7.70E+02	j	0.00E+00

Table 4. Parameters Used in Radionuclide ESL Models

Parameter	Receptor	
	Owl	Flycatcher
Life span (d)	7,300	1,460
Body weight (kg)	0.6	0.012
Food intake (kg dwt/d)	0.019	0.003
Fraction plant diet	0	0
Fraction invertebrate diet	0.12	1
Fraction of flesh in diet	0.88	0
Fraction of soil in diet	0.05	0.05
Home Range (km^2)	4.1	3.8E-03–1.4*
Exponential foraging function	$e^{-r/350}$	N/A

*Source: Cardinal (2005). HR was varied for model executions—3,800 m^2 and 0.654 km^2. Only HIs using 3,800 m^2 are reported in table format in the results section.

List of COPECs Without TRVs. Sensitivity analyses performed in the 1990s using ECORSK.4 (Gallegos et al. 1997a) showed that of the many parameters used by the model, variation of the TRV and BCF parameters can have a substantial effect on HIs and HQs. While uncertainty exists in the state of the art of toxic effects of COPECs on nonhuman biota, LANL's method of TRV derivation has resulted in fewer COPECs without TRVs. Table 5 lists the COPECs without TRVs for the birds. These COPECs were not included in the ECORSK.9 input files (*eeuinp.dat*) for the bird receptors.

Table 5. COPECs Without TRVs for the Bird Receptors

COPEC Group	COPEC	COPEC Group	COPEC
INORG	Aluminum	ORG	Chrysene
INORG	Antimony	ORG	Dinitrotoluene[2,4-]
INORG	Iron	ORG	Dinitrotoluene[2,6-]
ORG	Acenaphthene	ORG	Fluoranthene
ORG	Amino-4,6-dinitrotoluene[2-]	ORG	Fluorene
ORG	Anthracene	ORG	Indeno(1,2,3-cd)pyrene
ORG	Benzo(a)anthracene	ORG	Phenanthrene
ORG	Benzo(a)pyrene	ORG	Phenol
ORG	Benzo(b)fluoranthene	ORG	Pyrene
ORG	Benzo(g,h,i)perylene	ORG	Tetryl
ORG	Benzoic acid		

INORG = inorganic chemical; ORG = organic chemical; RAD = radionuclide

RESULTS AND DISCUSSION

Mean Total HI

Table 6 presents mean total HIs and dominant COPECs for the owl and flycatcher. The criterion used by the environmental restoration program for retaining a COPEC in screening evaluations is an HQ of 0.3 for non T&E species. In Table 6 we listed any COPEC with an HQ≥0.1 because of the application of this model to T&E species. Results for Scenarios A and B are separated. Presentation of mean HIs for the two T&E species is not meant to imply that the risk management objectives are to protect these species at the population level, allowing the sacrifice of some portion of the population. Rather all individual T&E animals in a population require protection. The mean total HI is the arithmetic average of the total number of HIs whereby each HI represents a nest site or focal point and its corresponding HR over which the animal theoretically fed. The HI as used here helps us to evaluate the relative potential for adverse effects to the animals from contaminants and leads us into examining COPEC- and location-specific results. Upon examination of the more detailed results, concerns about potential adverse effects may diminish or may be completely eliminated (e.g., where inferred risk is strongly affected by interpolated data and/or the treatment of NDs).

Mexican Spotted Owl. The Adjusted mean total HI for the owl under Scenarios A and B was 0.16 (n = 1,000) and 0.42 (n = 1,000), respectively. These values generally indicate that no appreciable impact is expected to the owl.

Southwestern Willow Flycatcher. The Adjusted mean total HI for the flycatcher for Scenarios A and B was 2.3 (n = 132) and 6.6 (n = 132), respectively. These values generally indicate that there is a small potential for impact to the flycatcher.

Sensitivity Analysis. The effect of replacing NDs with ½DL instead of "0" was to increase the mean total HI between 163% and 187%. Using the pre-nesting HR of 0.654 km^2 in Scenario B resulted in a negligible (0.07) increase in the mean total HI. Use of a higher food intake rate (8.38E-03 kg dry wt/day) (compared with 3.27E-03 kg dry wt/day) for the flycatcher in Scenario B increased the mean total HI substantially—by 11.4. Placing flycatcher nests in buffer habitat in addition to core habitat in Scenario A reduced the mean total HI moderately—by 2.0.

Table 6. Mean Total HIs and Dominant COPECs for Mexican Spotted Owl and Southwestern Willow Flycatcher Using ECORSK.9

Scenario A. Organic Chemical Non-Detects = 0		
Risk Source	**Mean Total HI***	**Dominant COPEC Mean HQs**
Mexican spotted owl		
Unadjusted	0.16	None≥0.1
Background	0.06	None≥0.1
Adjusted	0.10	None≥0.1
Southwestern willow flycatcher		
Unadjusted	5.5	Cyanide (1.2), V (1.0), Zn (0.83), Cd (0.75), Pb (0.52), Cu (0.45)
Background	3.2	Cyanide (1.0), Zn (0.71), V (0.58), Pb (0.32), Cu (0.22), Cd (0.19)
Adjusted	2.3	Cd (0.58), V (0.46), Aroclor-1254 (0.23), Cu (0.22), Pb (0.19), cyanide (0.16)

Scenario B. Organic and Inorganic Chemical Non-Detects = ½DL in Reaches With Detections		
Risk Source	**Mean Total HI***	**Dominant COPEC Mean HQs**
Mexican spotted owl		
Unadjusted	0.52	BEHP (0.32), DNBP (0.08)
Background	0.10	None≥0.1
Adjusted	0.42	BEHP (0.42), DNBP (0.10)
Southwestern willow flycatcher		
Unadjusted	10.4	DNBP (3.1), BEHP (1.7), cyanide (1.2), V (1.0), Zn (0.83), Cd (0.76), Pb (0.52), Cu (0.45), Aroclor-1254 (0.26), Se (0.14)
Background	3.8	Cyanide (1.0), Zn (0.71), V (0.58), Pb (0.32), Cu (0.22), Cd (0.19)
Adjusted	6.6	DNBP (3.1), BEHP (1.7), Cd (0.58), V (0.46), Aroclor-1254 (0.26), Cu (0.23), Pb (0.29), cyanide (0.16), Zn (0.12)

* Value is an arithmetic mean of total observations/nest sites (n = 1,000 for owl; n = 132 for flycatcher).

HI Frequency Distributions

Table 7 shows HI frequency distributions in grid cells with modeled nests for the two receptors. When NDs were assumed to be zero ('0') (Scenario A) there were no HIs>1.0 for the owl compared with Scenario B (ND = ½DL) resulting in 4 HQs>10 and 160 HQs between 1 and 10.

For the flycatcher, Scenario A resulted in 91 of 132 (69%) HQs between 1.0 and 10 and Scenario B resulted in 26 HIs (20%) between 10 and 100 and 69 HIs (52%) between 1.0 and 10.

Table 7. HI Frequency Distributions for Scenarios A and B. Values are number of nest sites with a mean total HI in the noted HI ranges.

HI Range	Mexican Spotted Owl		Flycatcher	
	ND = 0 (A)	ND = ½DL (B)	ND = 0 (A)	ND = ½DL (A)
≥100	0	0	0	0
10–100	0	4	0	26
1–10	0	160	91	69
<1	1,000	836	41	37
Total	1,000	1,000	132	132

Dominant COPECs

Mexican Spotted Owl. Scenario A (NDs = 0) for the owl produced no COPEC-specific Adjusted mean total HQs≥0.1. Of the 1,000 modeled nest sites, the five highest Scenario A Adjusted HIs for the owl ranged from 0.53–0.58. The dominant COPEC contributor to these five HIs, and the only COPEC with an HQ≥0.3, was aluminum (Al). Looking at the range of 1,000 HQs for Al, the number of repeated values is low, so it appears to be a relatively real contributor, however, the pH conditions that are necessary to make Al available to biota are not present in the Pajarito watershed (LANL 2005, USEPA 2003). [Note: A large number of repeated HQs or HIs can be an indication that, for any string of HQs or HIs, they might have been based on repeated sample values that are the same, which indicates that they were largely derived by interpolating data or replacing NDs with a real value. Table 8a shows that relatively low percentages of COPEC sample values used for the owl were comprised of interpolated values.]

In the scenario where NDs were replaced by the ½DL value (Scenario B), only bis(ethylhexyl)phthalate (BEHP) and di-n-butyl phthalate (DNBP) had mean total HQs≥0.3 for the owl. Since BEHP and DNBP had mean total HQs near zero for Scenario A, we can say that almost all contribution for these two constituents in Scenario B was the result of using ½DL for NDs and this does not represent a realistic exposure or the potential for adverse effects. Neither BEHP nor DNBP were detected frequently in the canyons data and no pattern was noted in these detections that would warrant interpolating values for these analytes.

Southwestern Willow Flycatcher. The Scenario A COPECs dominating the contribution to the Adjusted HIs for the flycatcher generally were cadmium (Cd) (0.58) and vanadium (V) (0.46). Other contributors (HQs 0.1–0.3) were Aroclor-1254, copper (Cu), lead (Pb), and cyanide. These values are consistent with the results obtained when soil and sediment contaminant screening completed for the robin (*Turdus* spp.) and swallow in the Pajarito Canyon Biota Investigation Work Plan (LANL 2006a).

For the flycatcher, COPECs with Adjusted mean total HQs≥0.3 were DNBP, BEHP, Cd, and V. Other contributors (HQ≥0.1) were Aroclor-1254, Cu, Pb, cyanide, and zinc (Zn). In the screening of surface water conducted for the Pajarito Canyon Biota Investigation Work Plan, Cu, Pb, V, and Zn had HQs>3. Cyanide, Cu, Pb, and Zn exceeded surface water standards (LANL 2006a). While we used ECORSK.9 to examine contaminant pathways leading from soil and sediment, not water, there is some relationship in that many of the insects that would be consumed by flycatchers if they did occur in the watershed would be those that emerge from the aquatic habitat of the Pajarito wetland.

Many of the Adjusted HIs in both Scenarios A and B for the flycatcher were repeat values. There can be two sources of repeated HI values—replacement contaminant values whereby a ND is replaced by, in this case, ½DL, and interpolated contaminant values. Since the repeat HIs were found in Scenario A (and B) and Scenario A has no replacement values other than '0,' we conclude that the source of the repeated values were interpolated values. Flycatcher habitat occurs in an area where relatively little sampling of soil and sediment for the presence of contaminants has been completed, therefore much of the data set for that area was populated with data through the interpolation process. Table 8b shows the percentage of the sample values made up by interpolated values for the flycatcher data set. The COPECs with a zero ("0") in the last column were not subjected to interpolation because either there were no detections or the number of detections was low. Ignoring those COPECs for which interpolation was not performed, the range of sample values that were made up by interpolated values, in percent of total, was 58–94. Interpolated values may be relatively high compared to conservative effects levels, so sets of HIs based largely on interpolated contaminant values may be artificially biased upwards.

Cadmium (mean total HQ = 0.58) consistently surfaced as a dominant contributor to HIs in the ECORSK.9 modeling results. It was not an issue in the screening evaluation for swallow but it was for robin ((LANL 2006a). Many of the Cd sample values were interpolated and might not be representative of realistic exposure. Vanadium also had a mean total Adjusted HQ>0.3 but many (71%) of its sample values were also interpolated. The range of sample value concentrations of Cd and V were not greatly different from background.

Cadmium (mean total HQ = 0.58) consistently surfaced as a dominant contributor to HIs in the ECORSK.9 modeling results but it was not an issue in the screening evaluation. Many (58%) of the Cd sample values were interpolated and might not be an accurate representation of reality. Vanadium also had a mean total Adjusted HQ>0.3 but many (71%) of its sample values were also interpolated.

Of the 132 modeled nest sites, the five highest Scenario A Adjusted HIs for the flycatcher ranged from 3.9–9.6. The dominant COPEC contributors to these five HIs with HQs≥0.3 generally were cyanide, Al, Se, and Cu. In the contour plot of HIs in Figure 3a, the red area at the extreme east end of the EEU reflects five high cyanide HQs. The five cyanide values appear to be realistic as they are not ND replacement values, they do not appear to be interpolated values, and background does not comprise a portion of Adjusted source types. However, the cyanide TRV is artificially low because an uncertainty factor of 100 was applied (lowered) for converting an acute effects level to a chronic effects level. As mentioned in the discussion of the owl in the subsection above, Al can be ruled out as a concern because it is not available for absorption by biota under the soil and sediment chemistry conditions that exist in the Pajarito watershed (LANL 2005, USEPA 2003). The areass of high Se and Cu HQs are in the same grid cells as the high cyanide HQs. Aside from the five grid cells discussed in this paragraph, the full range of HQs for the COPECs discussed in this paragraph were largely based on interpolated values; i.e., 81% of the sample values for cyanide were interpolated, Se (60%), and Cu (74%).

Table 8a. Proportion of Sample Results Detected, Non-detected, and Interpolated for Mexican Spotted Owl

COPEC Group	COPEC	No. (Count) Detected	No. (Count) Non-Detected	Total	Percent of Total Non-Detected	**Percent of Total Interpolated Values**
INORG	Arsenic	986	590	1,576	37	0
INORG	Barium	886	120	1,006	12	0
INORG	Cadmium	1,546	1,637	3,183	51	15
INORG	Chromium (total)	1,396	164	1,560	11	30
INORG	Copper	1,300	226	1,526	15	31
INORG	Cyanide (total)	757	520	1,277	41	37
INORG	Lead	1,367	49	1,416	3	33
INORG	Manganese	1,440	4	1,444	0	32
INORG	Nickel	1,643	737	2,380	31	20
INORG	Selenium	1,259	1,875	3,134	60	15
INORG	Silver	1,503	1,591	3,094	51	15
INORG	Vanadium	1,294	219	1,513	14	31
INORG	Zinc	1,250	6	1,256	0	37
ORG	Acetone	330	715	1,045	68	0
ORG	Aroclor-1248	477	139	616	23	76
ORG	Aroclor-1254	652	880	1,532	57	31
ORG	Aroclor-1260	689	734	1,423	52	33
ORG	BHC[gamma-]	1	126	127	99	0
ORG	Bis(2-ethylhexyl)phthalate	510	1,546	2,056	75	0
ORG	DDE[4,4'-]	575	637	1,212	53	39
ORG	DDT[4,4'-]	594	561	1,155	49	41
ORG	Dieldrin	36	730	766	95	0
ORG	Di-n-Butyl Phthalate	187	1,884	2,071	91	0
ORG	Methylnaphthalene[2-]	102	1,977	2,079	95	0
ORG	Naphthalene	128	1,990	2,118	94	0
RAD	Thorium-232	126	0	126	100	0
RAD	Uranium-238	274	0	274	100	0

INORG = inorganic chemical; ORG = organic chemical; RAD = radionuclide

Table 8b. Proportion of Sample Results Detected, Non-detected, and Interpolated for Southwestern Willow Flycatcher

COPEC Group	COPEC	No. (Count) Detected	No. (Count) Non-Detected	Total	Percent of Total Non-Detected	Percent of Total Interpolated Values
INORG	Arsenic	41	96	137	70	0
INORG	Barium	51	32	83	39	0
INORG	Cadmium	294	142	436	33	58
INORG	Chromium (total)	317	29	346	8	74
INORG	Copper	298	47	345	14	74
INORG	Cyanide (total)	274	41	315	13	81
INORG	Lead	298	1	299	0	85
INORG	Manganese	310	1	311	0	82
INORG	Nickel	299	86	385	22	66
INORG	Selenium	300	126	426	30	60
INORG	Silver	293	140	433	32	59
INORG	Vanadium	302	56	358	16	71
INORG	Zinc	289	0	289	100	88
ORG	Acetone	9	33	42	79	0
ORG	Aroclor-1248	255	17	272	6	94
ORG	Aroclor-1254	264	80	344	23	74
ORG	Aroclor-1260	265	80	345	23	74
ORG	BHC[gamma-]	0	17	17	0	0
ORG	Bis(2-ethylhexyl)phthalate	11	78	89	88	0
ORG	DDE[4,4'-]	262	75	337	22	76
ORG	DDT[4,4'-]	257	80	337	24	76
ORG	Dieldrin	1	82	83	99	0
ORG	Di-n-Butyl Phthalate	6	84	90	93	0
ORG	Methylnaphthalene[2-]	0	90	90	0	0
ORG	Naphthalene	3	87	90	97	0
RAD	Thorium-232	20	0	20	100	0
RAD	Uranium-238	17	0	17	100	0

INORG = inorganic chemical; ORG = organic chemical; RAD = radionuclide

Table 9 identifies decisions that were made regarding the selection of parameters and how they might have impacted the results. A sensitivity analysis of the effect of parameter variation on ECORSK results conducted on the American peregrine falcon (*Falco peregrinus*) in 1997 established that TRV and BCF selection most impact HI and HQ results (Gallegos et al. 1997b). Since the time of assessments on T&E species in the late 1990s, LANL has developed a rigorous process (discussed in Methods) for the selection of TRVs and BCFs. The TRV database currently is reflective of the large majority of available primary and secondary literature on animal toxicological data; however, TRVs are sometimes still conservative as the result of selection criteria and how uncertainties, such as LOAEL to NOAEL extrapolation, are dealt with. BCFs have increased for some COPECs. For some areas where the flycatcher was modeled, the replacement of NDs with ½DL values dominated contribution to HIs and HQs.

Table 9. Parameter and Assumption Selections for ECORSK.9 Modeling and Subjective Binning of Effects of Parameters on Model Results

Conservative (overestimate potential for adverse effects)	Realistic	Nonconservative (underestimate potential for adverse effects)
In some reaches (~western one-third of watershed), sampling on which HIs and HQs are based is biased to areas known or suspected of having elevated concentrations.		
Non-detects replaced with the ½DL, which is an overestimate of the DLs for some samples and analytes.		
	Grid cells where no soil/sediment sampling occurred are populated with interpolated data, as appropriate	
COPEC concentrations measured at sampling points assumed for entire 30- by 30-m area of a grid cell, when in fact, sometimes, the contaminated area is less than the 900-m^2 grid cell.		
HIs assume all COPECs have same biological effect, therefore treated as additive.		
CS TRVs	GMM TRVs	HQs not calculated for COPECs for which TRVs not available.
Assumed bioavailability of COPECs = 100%.		
	Average, not maximum, COPEC concentrations in soil and sediment used.	
Percent of dietary food intake as soil = 5 for owl and flycatcher.		
Effects levels decreased by a factor of 10 for each major uncertainty in TRVs or ESLs up to a maximum of 100 factor adjustment; e.g., LOAEL to NOAEL extrapolation results in decreasing an effect level by a factor of 10, which in effect increases an HI or HQ by 10.		
Used BCFs developed for the ESLs; these are intended to be upper bounds of contaminant uptake.		

Risk by Geographic Area: HI Contours

Figures 3 and 4 are contour plots of HIs for Scenarios A and B each for the Mexican spotted owl and southwestern willow flycatcher. Contours of HIs are normally useful for demarcating general areas of risk, however, such a large proportion of the data set was artificially generated that the contour plots need to be reviewed with this in mind. We consider the ND = 0 (Scenario A) plots to convey the most information about spatial changes in risk across the landscape because the corresponding data sets have fewer artificial values.

Figure 3a is a contour plot of the Scenario A HIs for the owl. Keep in mind that in the scale depicting ranges of HIs in this contour plot, none of the HIs for this scenario exceeded 1.0. Figure 1 shows the relationship of the owl EEUs—one in Pajarito-Twomile canyons and one in Threemile Canyon—to subwatershed reaches. The Pajarito-Twomile canyons EEU overlaps reaches AEN-1, AES-1, PA-1E, TWSE-1E, TW-4W, and PA-2W. The Threemile Canyon EEU overlaps reaches THM-1, THS-1E, and Th-3. The elevated (>0.3) HIs on the extreme west end of the owl EEU is in Pajarito-Twomile canyons habitat and is in the vicinity of reach AEN-1. The HIs in that area are largely reflective of the high HQ contributions by Al. This area of elevated HIs then distends along the southern edge of the owl habitat in an easterly direction and, albeit still low HIs in an absolute sense, the HIs that comprise the data set for this owl scenario are not repeating values, therefore appear to be real. This distended area of red also is largely reflective of contributions by Al and dissects reach AES-1.

In Scenario B for the owl (Figure 3b), the area of relatively highest HIs shifted from the western end of the Pajarito-Twomile habitat to the eastern end of the Threemile habitat. An examination of the data indicates that there was a relatively higher percentage of NDs on the eastern end of the Threemile habitat and replacement of the NDs with the ½DL values caused the shift, but the visual patterns remained generally the same.

Figure 4a is a contour plot of the Scenario A HIs for the flycatcher. Figure 1 shows that there are two distinct flycatcher EEUs that we'll refer to as the western habitat and the eastern habitat. The western habitat is in the vicinity of reach PA-3E and the eastern habitat coincides with reach PA-4E. The elevated (>3.0) HIs on the extreme east end of the eastern flycatcher habitat is in the vicinity of reach PA-4E and the HIs in that area are reflective of the high HQ contributions by cyanide, Al, Se, and Cu. There are also elevated (>3.0) HIs at the western end of the western habitat, but the facts that the pattern follows the contour of the channel streambed and an examination of the data indicate that this elevated patch is largely associated with interpolated values of COPECs.

In Scenario B for the flycatcher (Figure 4b), the contour patterns remained the same. Comparing Scenario A contours with Scenario B contours, the conversion of the mid-level ("yellow") bin in Scenario A to the high-level ("red") bin in Scenario B is reflective of the fact that the ½DL values for COPECs increased many COPEC concentrations by roughly one to three orders of magnitude.

Contour Plot 3a

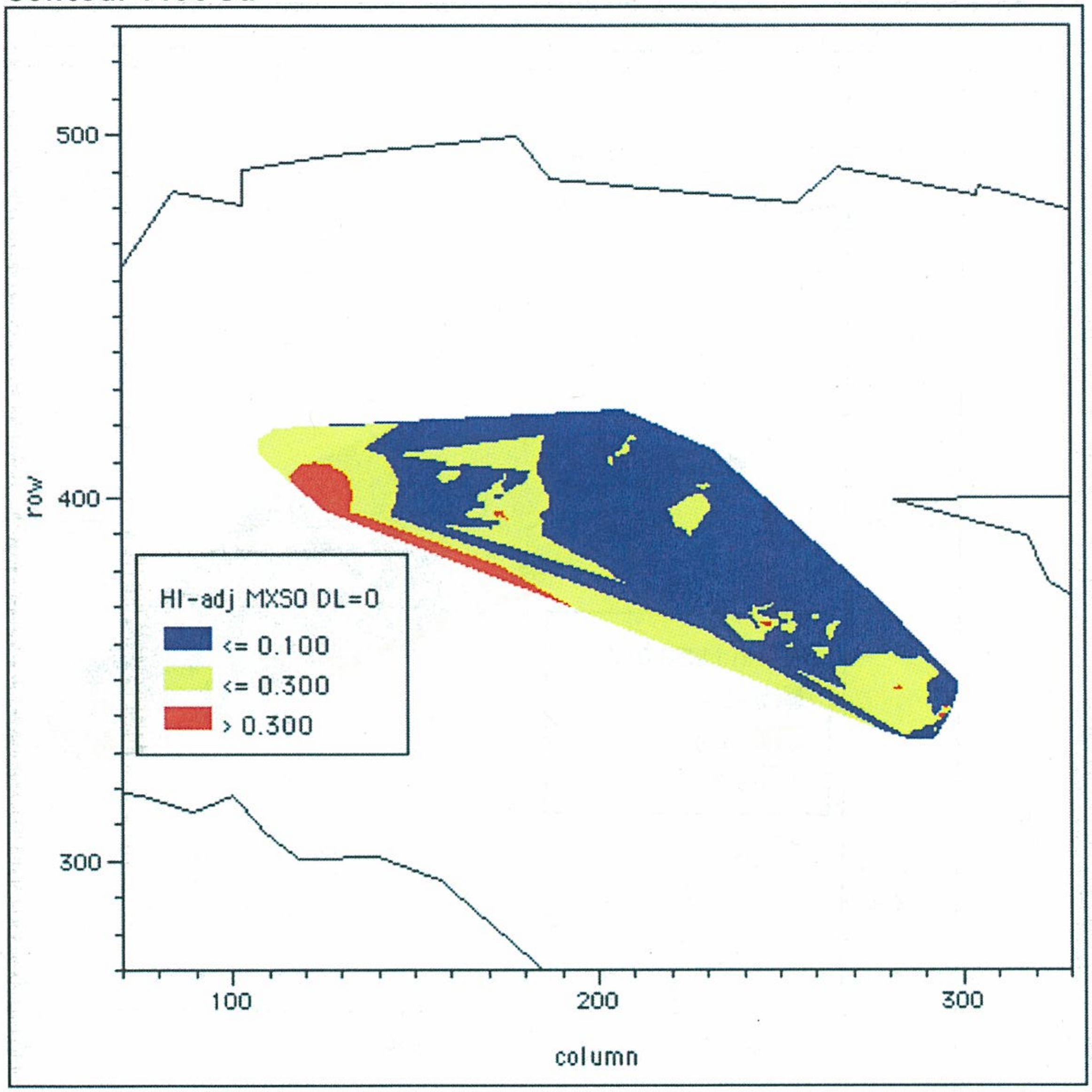

Figure 3a. Contour plot of Scenario A (ND = 0) Adjusted mean total HIs for the Mexican spotted owl in the Pajarito watershed (black lines indicate LANL boundary).

Contour Plot 3b

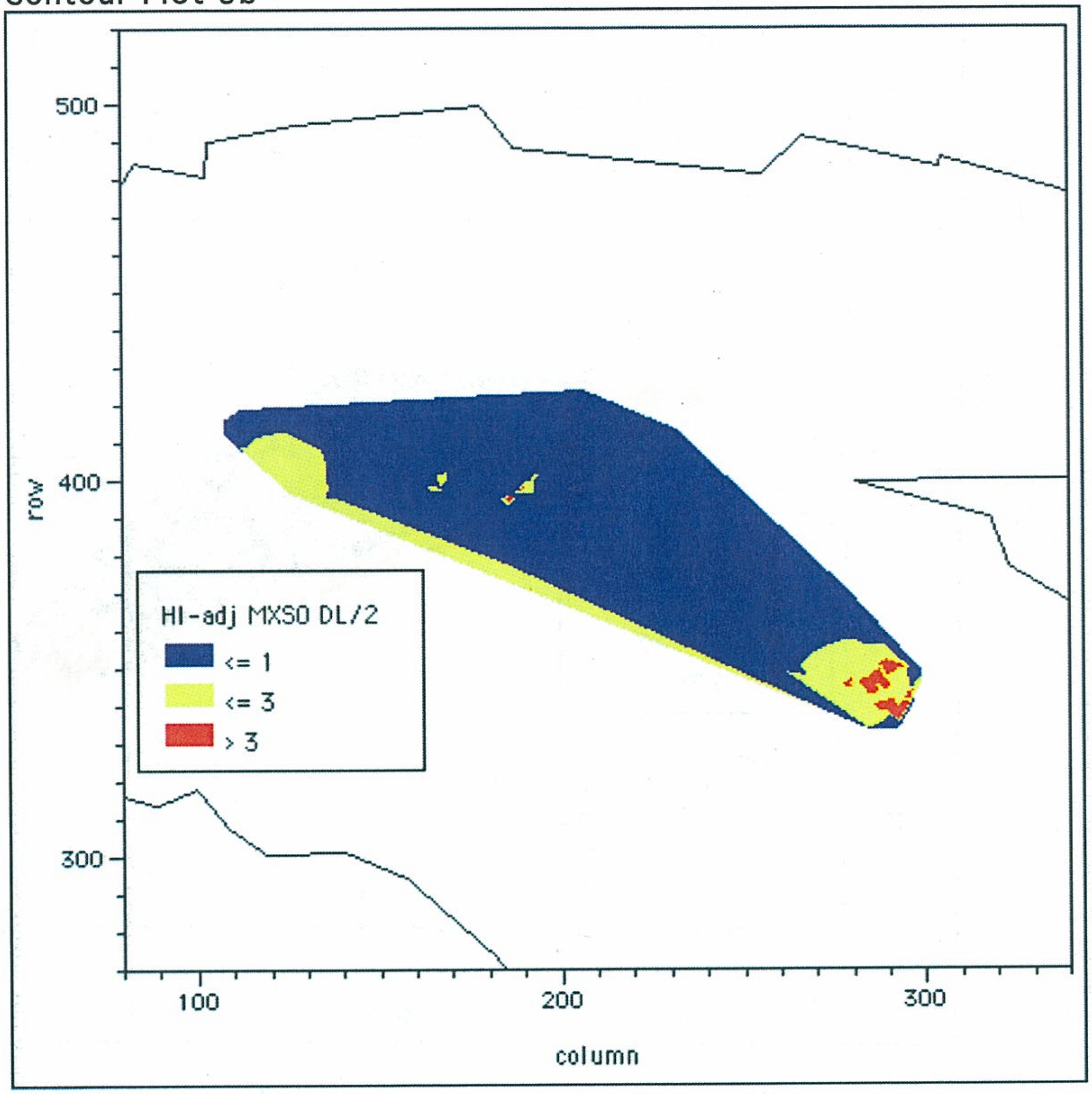

Figure 3b. Contour plot of Scenario B (ND = ½DL) Adjusted mean total HIs for the Mexican spotted owl in the Pajarito watershed (black lines indicate LANL boundary). [Note that the scale changed from Fig. 3a to 3b, therefore the color/HI relationship does not track from Fig. 3a to Fig. 3b.]

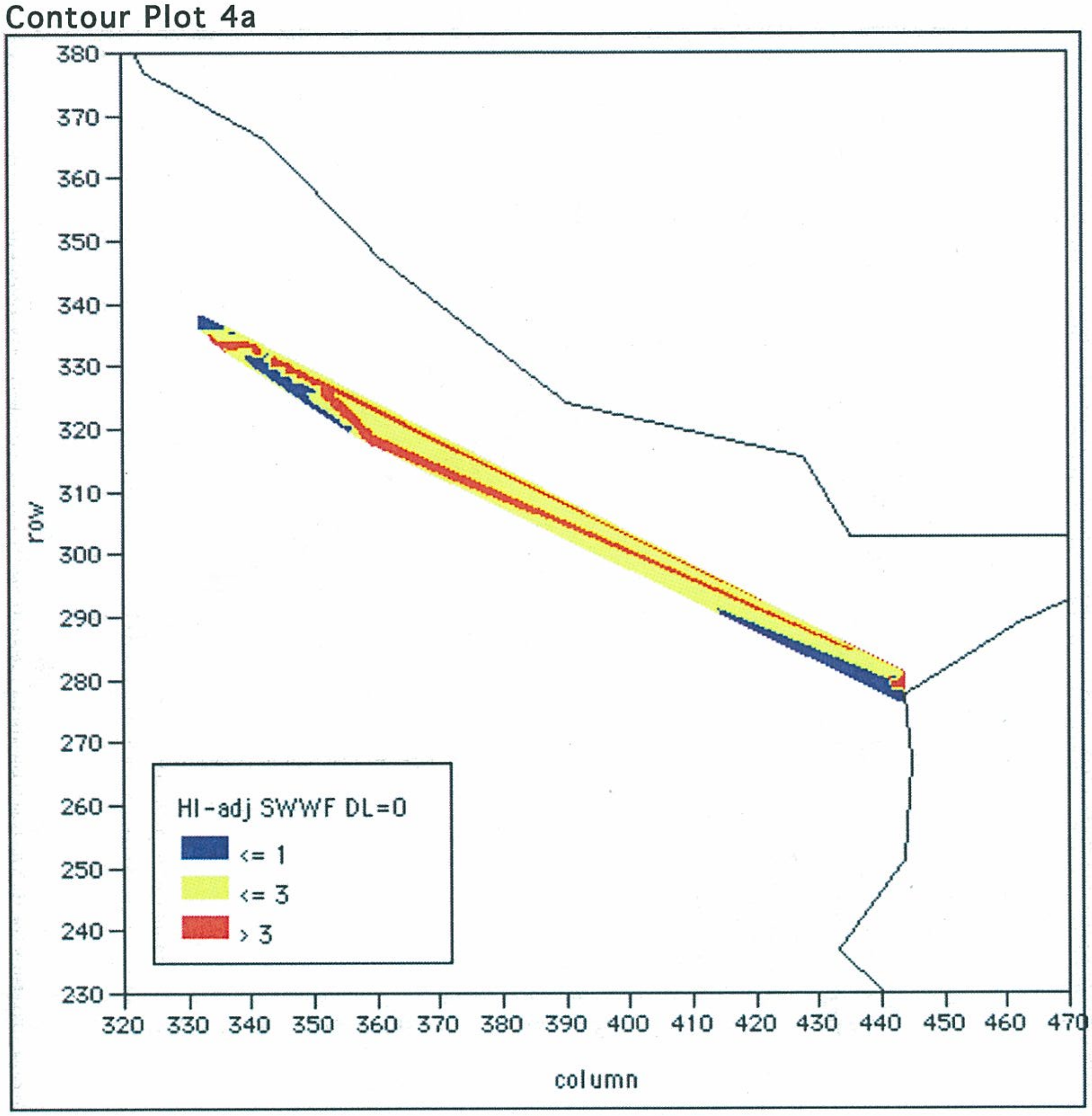

Figure 4a. Contour plot of Scenario A Adjusted mean total HIs for the southwestern willow flycatcher in the Pajarito watershed (black lines indicate LANL boundary).

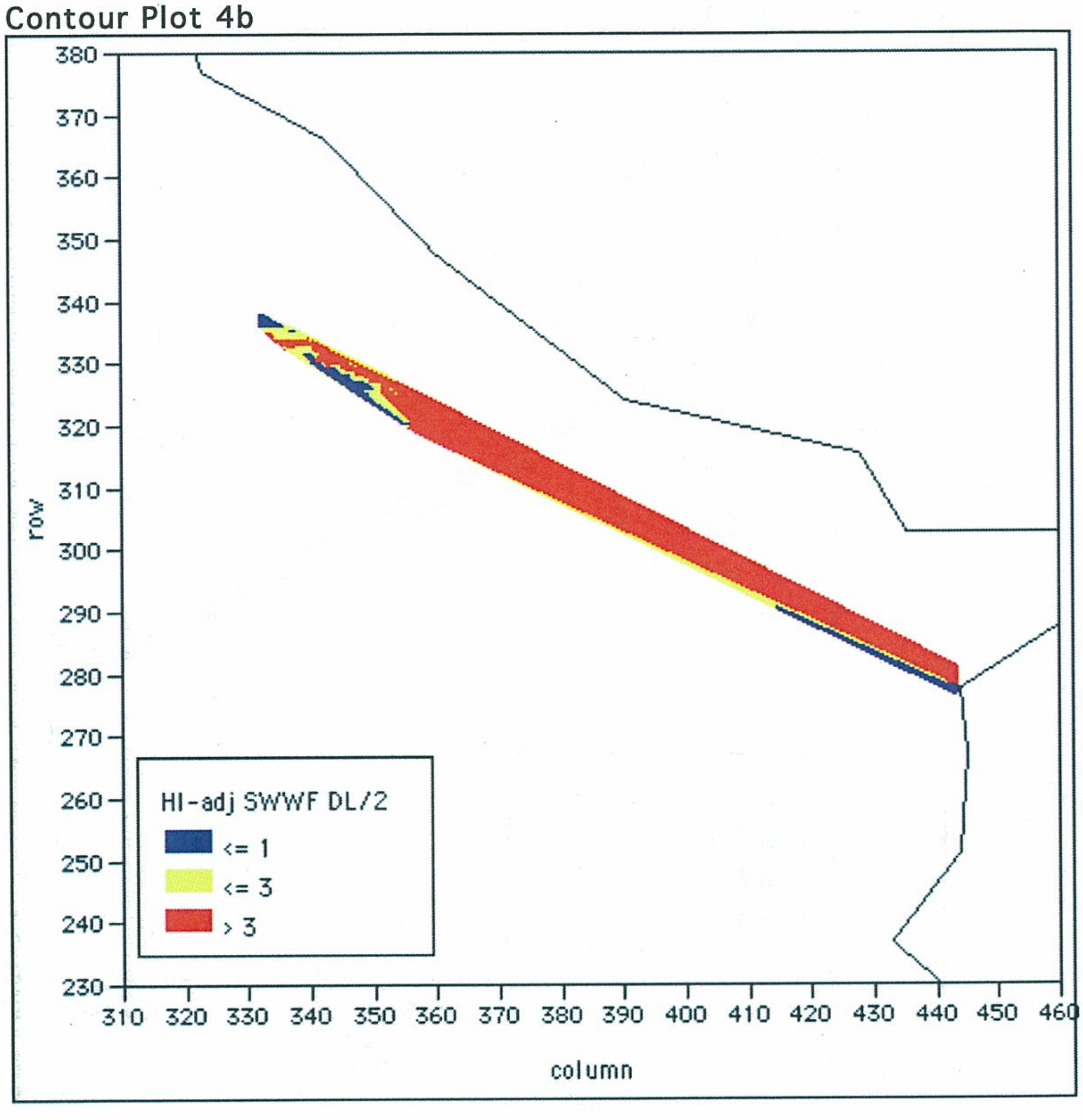

Figure 4b. Contour plot of Scenario B Adjusted mean total HIs for the southwestern willow flycatcher in the Pajarito watershed (black lines indicate LANL boundary).

CONCLUSIONS

Based on modeling the potential effects of COPECs in soil and sediment on the Mexican spotted owl and the southwestern willow flycatcher using ECORSK.9 we anticipate no appreciable impact to the owl nor the flycatcher. While some moderately high general indices of hazard were generated for the flycatcher, examination of the detailed model results showed that, by and large, those indices were the result of using interpolated values in areas where no sampling has occurred. These interpolated values may under- or overestimate exposures.

T&E species warrant protection of each individual in the population and, although there were a few HIs in the range of 10–100 for the owl and several in that range for the flycatcher both when NDs were replaced with the ½DL, many factors that result in biasing HIs and HQs upwards may have resulted in significant overestimates of potential adverse effects. This is largely a function of modeling risk over large areas and applying conservatism at several levels in the development of model input parameters. When the ECORSK.9 modeling process involves large areas of land and a vigorous method of populating grid cells with interpolated COPEC data is used, quotients and indices of potential for adverse effects can be significantly impacted. Nevertheless, it is important to demonstrate for purposes of environmental stewardship the degree of potential risk to T&E species that might exist when conservative assumptions about contaminant distribution are made even when examination of uncertainties lowers substantially the level of concern.

ACKNOWLEDGMENTS

The modeling task, one component of the Pajarito Canyon biota investigation, was supported by the Canyons Investigation Team of LANL's Water Stewardship Program. Steven Reneau of EES-9 did an extensive peer review of the report.

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