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

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Front cover: Sandia Wetland in Sandia Canyon at the Los Alamos National Laboratory.

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Gil Gonzales

Randall Ryti

Patricia Gallegos

Anthony Gallegos

Kathryn Bennett

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

Gil Gonzales[1], Randall Ryti[2], Patricia Gallegos[2], Anthony Gallegos[2], and Kathryn Bennett[3]

ABSTRACT

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 species—the Mexican spotted owl (*Strix occidentalis lucida*) and southwestern willow flycatcher (*Empidonax traillii extimus*)—in the Sandia Canyon 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 soil and sediment contaminant data from canyons and non-canyons sources so that the potential for adverse effects across the 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. Model results agreed very well with soil and sediment screening results that considered birds as receptors. 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 0.11 (n = 907) for the Mexican spotted owl and 18.2 (n = 30) for the southwestern willow flycatcher. These values are interpreted as, on average, no appreciable impact to the owl and substantial potential for impact to the flycatcher. Considering the distribution of HIs, and without consideration of conservatisms built into model parameters, the model predicts a substantial potential for impacts to the southwestern willow flycatcher at half of the 30 hypothetical nest sites in Sandia Canyon and a small potential for impact at another 11 nest sites. There is a small potential for impact to owls at a very small percentage of the 907 hypothetical nest sites in core habitat in Sandia Canyon.

[1]Ecology and Air Quality Group, Los Alamos National Laboratory, P.O. Box 1663, MS J978, Los Alamos, NM 87545; [2]Neptune and Company, Inc., 1505 15th Street, Los Alamos, NM 87544; [3]Environmental Data and Analysis Group, Los Alamos National Laboratory, P.O. Box 1663, MS J978, Los Alamos, NM 87545.

INTRODUCTION

Sandia Canyon extends east-southeast from Los Alamos National Laboratory (LANL) Technical Area 3 to the Rio Grande for a distance of approximately 10 miles and occupying approximately 5.5 mi^2 (LANL 2007). The upper canyon contains a perennial stream that is supplied from effluent discharges from LANL's Sanitary Wastewater Consolidation System and from cooling tower discharges. A large wetland occupies the upper canyon. The stream in the middle and lower parts of the canyon is mainly ephemeral, flowing in response to precipitation events. The headwaters of Sandia Canyon are highly developed and include large areas of pavement and buildings, enhancing storm water runoff.

The canyon is rich in biological diversity as the result of several terrestrial habitats, the consistent supply of water to a portion of it, and aquatic habitats including a wetland located in the upper canyon. The wetland consists of a large cattail marsh of roughly six acres. The terrestrial habitats include mixed conifer, riparian areas, piñon-juniper woodlands, and grass and shrub areas (LANL 2007). In addition to wetlands, the aquatic habitats include perennial, intermittent, and ephemeral reaches. The suitability of habitat in Sandia Canyon to various threatened, endangered, and sensitive species was first generally assessed in 1994; and then in 1997 and 1998 suitability to the Mexican spotted owl (*Strix occidentalis lucida*) and southwestern willow flycatcher (*Empidonax traillii extimus*) was more thoroughly evaluated (LANL 1998). Figure 1 shows a small patch of habitat (about 30 grid cells or 0.03 km^2) in Sandia Canyon that is considered of moderate suitability to the flycatcher and a moderately large area (about 907 grid cells or 0.8 km^2) that is considered of high suitability ("core habitat") to the owl. Neither species has ever been observed nesting or residing in Sandia Canyon.

Solid waste management units (SWMUs) or areas of concern (AOCs) on adjacent mesas and in the canyon have introduced organic and inorganic chemicals into Sandia Canyon during the past 50 years (LANL 1999). Metals, polychlorinated biphenyls (PCBs), and pesticides are a few contaminants of concern (LANL 2007). Numerous studies on biota, contamination, and their interaction have been conducted previously and are summarized in the Sandia Canyon Biota Investigation Work Plan (LANL 2007).

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) that reside in soil and sediment (LANL 2007). ECORSK.9 assesses potential effects in general to terrestrial animals over large spatial areas on the basis of the U.S. Environmental Protection Agency 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.

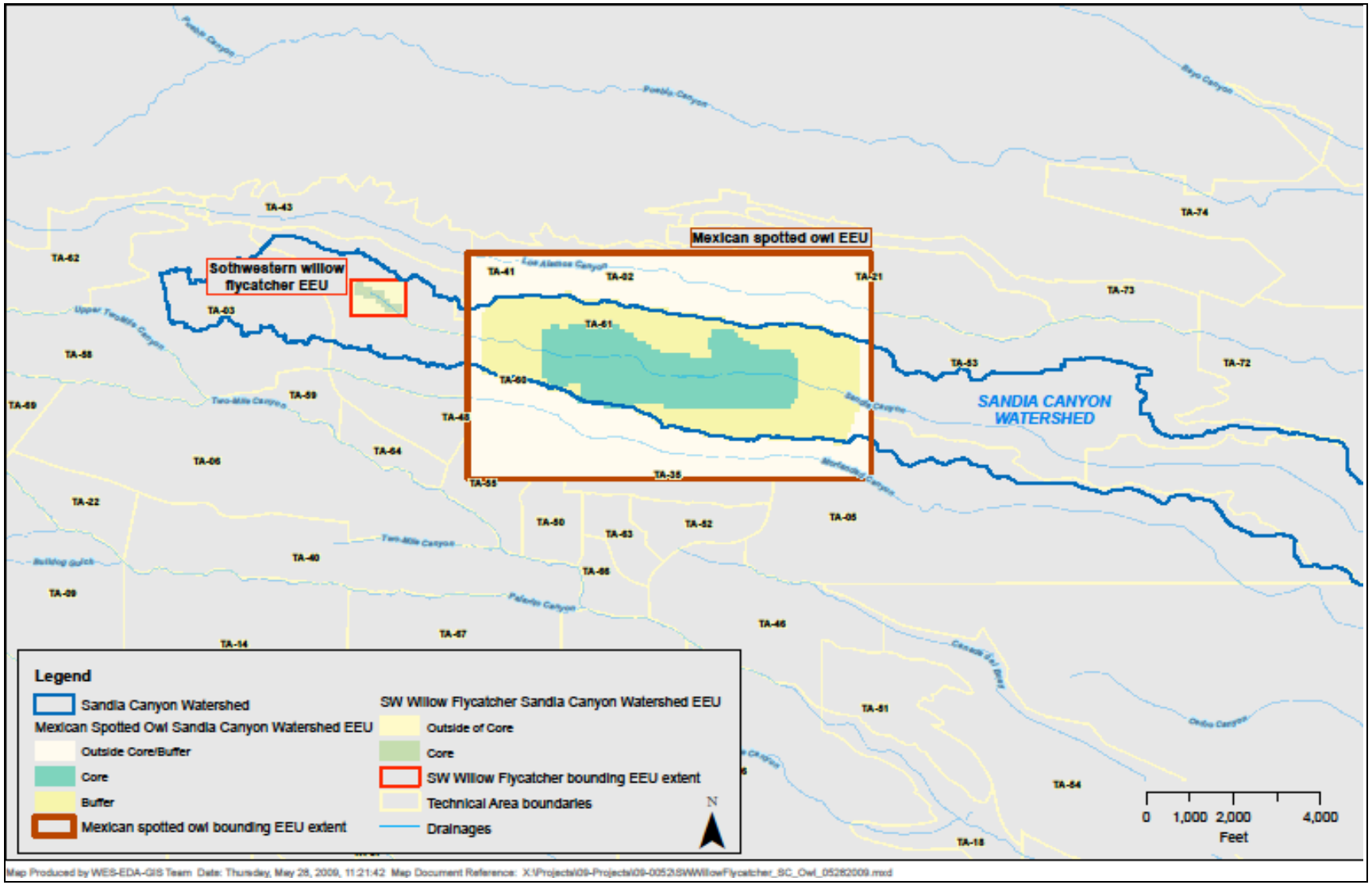

Figure 1. Study area—Sandia Canyon watershed within LANL and ecological exposure units (EEUs) for the Mexican spotted owl and southwestern willow flycatcher.

BACKGROUND

Diverse terrestrial and aquatic biological communities in Sandia Canyon are potentially exposed to contaminated soil, sediment, surface water, and shallow alluvial groundwater. With dispersed contamination in the LANL-related environment, understanding potential risk to wildlife that is presented by these COPECs is an important ecological quality issue. Ecological risk screening by LANL consisted of comparing maximum concentrations of chemicals of potential concern (COPCs) in soil and sediment to ecological screening levels (ESLs) (LANL 2007). COPCs whose maximum concentrations exceeded ESLs were identified as COPECs. The soil/sediment comparison resulted in 16 inorganic and 10 organic COPECs.

ECORSK has been previously applied to the biota investigations in Pajarito Canyon (Gonzales et al. 2008), Mortandad Canyon (Gonzales et al. 2006), and 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. Application of ECORSK.9 to the Sandia Canyon 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; 2006; 2008).

METHODS

Receptors

The receptors evaluated using ECORSK.9 were federally listed threatened and endangered (T&E) species—Mexican spotted owl and southwestern willow flycatcher—because there is viable habitat for these species in Sandia Canyon 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 parts of Sandia Canyon. 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 small but measurable proportions of birds and insects (Bennett et al. 2006). 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. ECORSK.9 can use a body-weight-based allometric equation from Peters (1993) to calculate a foraging HR of 4.1 km^2 or, alternatively, a defined HR of any size can be entered into one of the input files. Local experts believe that HRs in this area of the Rocky Mountains to be less than those published for the Pacific Northwest (LANL 1998). The 4.1-km^2 foraging HR is so large that, used in Sandia Canyon, it extends to contaminated areas well outside of the watershed. This can detract from evaluating the influence of the particular watershed. As such, we compared model results using HRs of 4.1, 2.0, and 1.0 km^2.

Within LANL, suitable habitat for the southwestern willow flycatcher is largely in the wetlands of Sandia Canyon where willows (*Salix* spp.) and other riparian plants occur. But other canyons similar to Sandia have smaller patches of suitable habitat. 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 Sandia Canyon. 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 m^2. A HR of 3,800 m^2 was used for modeling the flycatcher.

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’ location (midpoint of grid cell). All environmental information, such as COPEC concentrations, are cataloged by location (grid cell ID) using this spatial system.

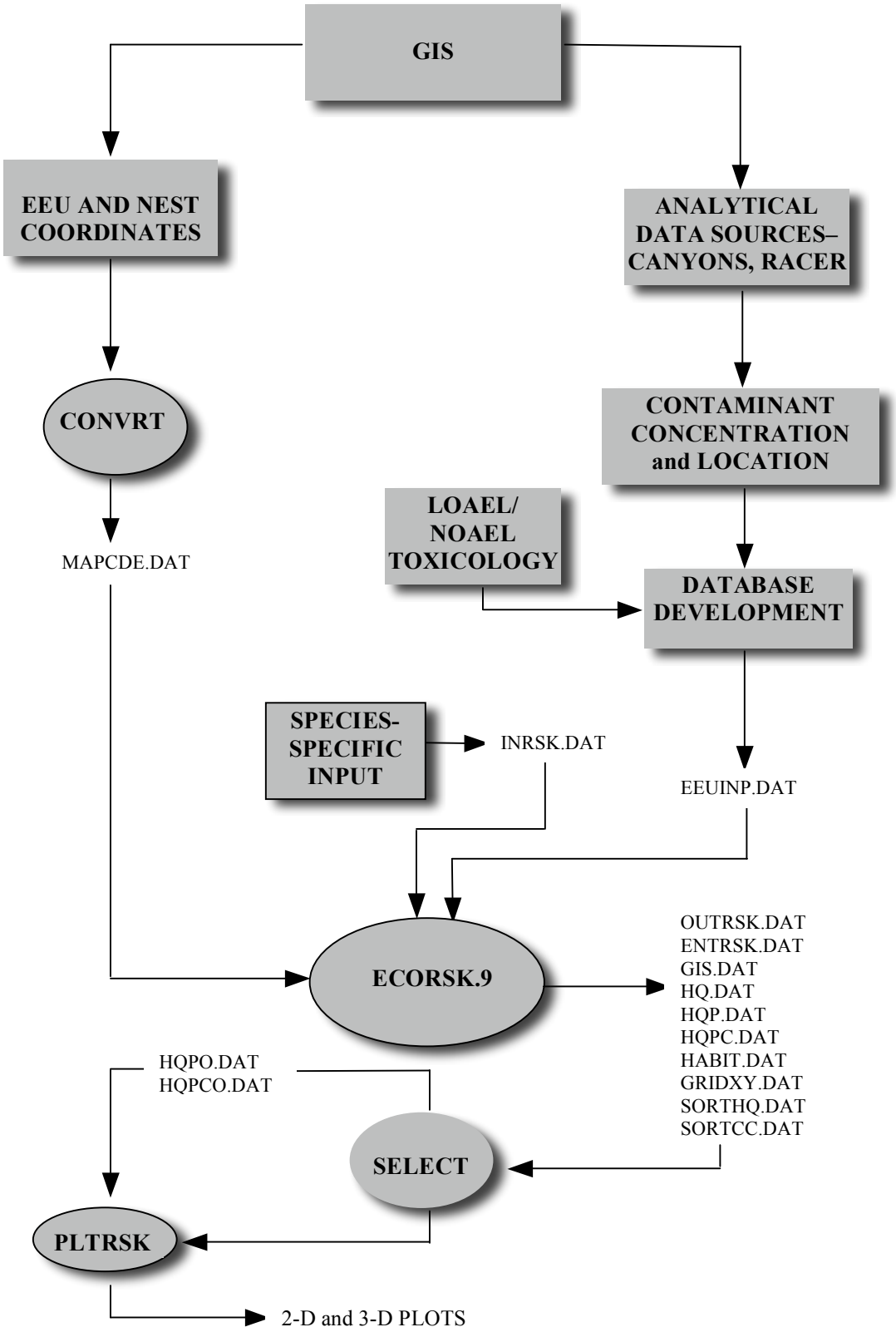

Figure 2. Schematic of strategy for integrating FORTRAN95 code with analytical data. (Note: LOAEL is lowest observed adverse effects level; NOAEL is no observed adverse effects level; RACER is Risk Analysis, Communication, Evaluation, Reduction).

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 EEUs as defined in the ECORSK.9 model.

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 or potential contaminated area (SWMU or AOC) and/or a grid cell known to contain an actual nest or other niche of an animal. In the current evaluation for Sandia Canyon, 907 grid cells that are occupied by core nesting habitat of the owl were selected for placement of a nest by the model and 30 grid cells that occupy suitable habitat for the flycatcher were selected for placement of a nest. 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. Since only core habitat was used for placement of owl nest sites and only one suitability habitat is present for the flycatcher, weighting of nest site distribution was unnecessary. 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).

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., 907 for the owl and 30 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:

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

where

O_i = occupancy factor for any grid cell (i) of an EEU,
A_i = surface area, km^2, of the ith grid within the HR of a given animal,
ENH_i = enhancement factor,
R_i = radial distance, m, of the ith 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 Sandia Canyon. 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 data through 1991. See Johnson (1993) for 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 Sandia Canyon that is capable of supporting flycatcher nests and foraging needs (Keller 2007). The wetland is small and the riparian habitat is of moderate quality. Its total area occupies only 30 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 Sandia Canyon could support flycatchers is assumed to be 10 times greater than that of the remainder of the watershed. No nesting flycatchers have ever been observed at LANL 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 Sandia Canyon.

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

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	9,164	2,894
Buffer Zone	10.0	10	1,328	281
Core Area/Habitat	100.0	100	907	289

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

Land Type	Relative Preference (Weighting)	Assigned Map Code Integer Values	No. Grid Cells in Study Area	No. Grid Cells With Sample Value Data
Sandia Canyon Outside Wetlands ("Buffer Habitat")	1.0	1	87	5
Wetlands ("Core Habitat")	10.0	10	30	30

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), [Note: The source of TRVs is LANL's ECORISK database (LANL 2008).]

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 R2.3 (LANL 2008), 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 jth contamination site,
$Dc_{j,l}$ = concentration of COPEC in soil (mg COPEC/kg soil) for the jth contamination site (exposure dose) of the lth COPEC,
TRV_l = consumed dose above which observable adverse effects may occur, mg-COPEC/kg-body weight-day of the lth COPEC,
ncs = number of contaminated sites, and
ncoc = number of COPECs in the jth contamination site.

For radionuclides, effects levels (TRVs) have been back-calculated to concentrations in soil (ESLs, defined below) using LANL's ECORISK database (LANL 2008), 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 jth contamination site of the lth COPEC,
ESL_l = ecological screening level, pCi COPEC/kg soil of the lth COPEC,
$ESLa_l$ = adjustment factor for ESL_l above for the lth COPEC,
$Occup_j$ = occupancy factor on the jth contamination site,
ncs = number of contamination sites, and
ncoc = number of COPECs in the jth 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 2.3 (LANL 2008).

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. (2003). 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 some radionuclides) and "regional" (fallout radionuclides) non-LANL 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 fallout radionuclides have non-LANL anthropogenic sources.

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 concentration 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 potential contribution 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 T&E 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 radionuclide—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 907) would result from the sum of the HQs for each COPEC for each grid cell in the HR. The 907 sets of HQs (summed within a HR) by COPEC are output in *hq.dat*. If there were 24 COPECs, then for each nest site there would be 24 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 Work Plan for Sandia Canyon and Cañada del Buey (LANL 1999) summarizes the known nature and extent of contamination in Sandia Canyon prior to 1999, and additional soil and sediment sampling was conducted from 1998 to 2008. Soil COPEC data sources for the application of ECORSK.9 to Sandia Canyon 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 2008). The RACER database was used "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. 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 reported as "non-detected" 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:

- ND = 0—Organic and metal NDs were replaced with a zero ('0'); and
- ND = ½DL—Organic and metal NDs 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 the ND = 0 scenario results because this scenario provides realism to balance other more protective/conservative parameters used in the model. But ranges in data results are presented that represent upper end results. Data types and sources of data are described below.

Measured Canyons Contaminant Data. The canyons COPEC database was obtained from LANL's Sample Management Database. Some of these data are reported in the Sandia Canyon Biota Investigation Work Plan (LANL 2007). These data will also be reported in the Sandia Canyon investigation report. COPECs identified in the work plan and that have a TRV for a receptor are evaluated using ECORSK.9. There were 24 COPECs identified in the work plan for which a TRV was available or could be developed from literature toxicological data.

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 downslope from measured concentrations 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 assessments 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, a 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.

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 2a. This table indicates if there was a linear or loglinear trend and where consequently an interpolation model was used (19 COPECs), or if instead a subwatershed average was used (all other COPECs). Trends were evaluated for COPECs that were detected with sufficient frequency (>~5%) in Sandia Canyon. The models used for the interpolations are summarized in Table 2b.

Table 2a. Summary of Interpolations Used for Canyons Data

Suite	COPEC	Number of Samples (N), Detects (D), Non-detects (ND), and Detection Frequency				Notes
		N(D)	N(U)	D rate	Model developed	
Inorganic	Aluminum	220	0	100%	no	loglinear trend but all reach mean concentrations less than background mean
Inorganic	Arsenic	207	13	94.1%	yes*	S-1, S-2 >rest of watershed
Inorganic	Barium	220	0	100%	no	S-1S, S2 >rest of watershed but all reach mean concentrations less than background mean
Inorganic	Beryllium	187	27	87.4%	no	no trend
Inorganic	Cadmium	83	131	38.8%	yes	S-2 trend downstream
Inorganic	Chromium (total)	219	1	99.5%	yes	S-2 trend downstream
Inorganic	Chromium hexavalent ion	71	46	60.7%	yes	S-3 trend downstream
Inorganic	Copper	209	11	95.0%	yes	S-2 trend downstream
Inorganic	Cyanide (total)	71	43	62.3%	yes	S-1S, S-2 >rest of watershed
Inorganic	Iron	220	0	100%	no	S-1N trend downstream but all reach mean concentrations less than background mean
Inorganic	Lead	220	0	100%	yes	S-1N trend downstream
Inorganic	Manganese	214	0	100%	no	no trend
Inorganic	Mercury	152	58	72.4%	yes	S1-S trend downstream
Inorganic	Nickel	219	1	99.5%	no	no trend
Inorganic	Selenium	95	119	44.4%	yes	trend downstream
Inorganic	Silver	190	28	87.2%	yes	trend from S-2 downstream
Inorganic	Thallium	103	117	46.8%	no	no trend
Inorganic	Vanadium	220	0	100%	no	trend from S-2 downstream but all reach mean concentrations less than background mean
Inorganic	Zinc	210	0	100%	yes	trend from S-2 downstream
Organic-PAH**	Acenaphthene	2	146	1.4%	no	low detection rate; no models evaluated
Organic-PAH	Anthracene	32	116	21.6%	yes	detected in reaches S-1N, S-1S; no other trend
Organic-PAH	Benzo(a)anthracene	50	98	33.8%	yes	S-1 trend downstream
Organic-PAH	Benzo(b)fluoranthene	20	128	13.5%	yes	S-1 trend downstream
Organic-PAH	Benzo(g,h,i)perylene	26	122	17.6%	yes	S-1 trend downstream
Organic-PAH	Indeno(1,2,3-cd)pyrene	2	146	1.4%	no	low detection rate; no models evaluated
Organic-PAH	Naphthalene	3	145	2.0%	no	low detection rate; no models evaluated
Organic-PAH	Phenanthrene	59	89	39.9%	yes	S-1S trend downstream

Organic-PCB	Aroclor-1242	4	233	1.7%	no	low detection rate no models evaluated
Organic-PCB	Aroclor-1248	5	232	2.1%	no	low detection rate no models evaluated
Organic-PCB	Aroclor-1254	112	126	47.1%	yes	trend from S-2 downstream
Organic-PCB	Aroclor-1260	178	60	74.8%	yes	trend from S-1S downstream
Organic-PCB	TEC Bird	0	0	100%	no	1 reach only
Organic-Pesticide	Dieldrin	2	155	1.3%	no	low detection rate no models evaluated
Organic-SVOC	Bis(2-ethylhexyl)phthalate	26	112	18.8%	yes	S-1, S-2 >rest of watershed
Organic-SVOC	Di-n-Butyl Phthalate	4	134	2.9%	no	low detection rate no models evaluated
Organic-VOC	Acetone	6	104	5.5%	no	low detection rate no models evaluated

*'Yes' indicates a trend, therefore, an interpolation model was used. 'No' indicates no trend and no interpolation.
**PAH = polycylic aromatic hydrocarbons; PCB = polychlorinated biphenyls; SVOC = semivolatile organic compounds; VOC = volatile organic compounds
S-1N, S-1S, S-2, and S-3 are sediment investigation reaches

Table 2b. Summary of Interpolation Models Used for Canyons Data

COPEC	Distance from Rio Grande where model applies		Loglinear model	Intercept	Slope
	Minimum (km)	Maximum (km)			
Anthracene	0.2	3.3	Yes	-0.772	-2.53
Aroclor-1254	0.2	12.7	Yes	-1.67	-0.331
Aroclor-1260	0.2	12.7	Yes	-0.893	-0.356
Arsenic	0.2	15.7	Yes	1.21	-0.0994
Benzo(a)anthracene	0.2	9.4	Yes	-0.767	-0.695
Benzo(b)fluoranthene	0.2	3.3	Yes	-0.212	-1.72
Benzo(g,h,i)perylene	0.2	3.3	Yes	-1.36	-1.52
Bis(2-ethylhexyl)phthalate	0.2	1.8	No	0.21*	0
Cadmium	0.2	12.7	Yes	-1.01	-0.308
Chromium (total)	0.2	15.7	Yes	5.71	-0.326
Chromium hexavalent ion	0.2	15.7	No	0.602	-0.0355
Copper	0.2	15.7	Yes	2.96	-0.137
Cyanide (total)	0.2	9.4	Yes	0.250	-0.344
Lead	0.2	15.7	Yes	3.44	-0.111
Mercury	0.2	15.7	Yes	-1.15	-0.321
Phenanthrene	0.2	9.4	Yes	-0.197	-0.742
Selenium	0.2	14	No	1.355	-0.095
Silver	0.2	15.7	Yes	1.89	-0.333
Zinc	0.2	15.7	Yes	4.85	-0.119

*watershed average

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 summarize contaminant data for the ND = 0 (Fig. 3a) and ND = ½DL (Fig. 3b) cases for the owl and Tables 3c and 3d are the same type of data for the flycatcher. The COPEC sample value summary statistics (average, maximum, minimum) as well as a corresponding average background concentration 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 2.3 (LANL 2008) 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 2.3 (LANL 2008) and were developed using a tiered TRV development process. 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 2008).

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 2.3 (LANL 2008). 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. The source of most of the parameters is LANL's ECORISK database (LANL 2008). 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, ND = 0

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 (As)	1.79E+00	1.07E+02	0	850	1.84E+00	2.24E+00	h	2.86E-02
INORG	Barium (Ba)	5.30E+01	2.40E+02	0	302	6.04E+01	7.35E+01	d	1.09E-02
INORG	Cadmium (Cd)	9.49E-02	3.31E+00	0	1,354	9.30E-02	1.47E+00	i	1.72E+00
INORG	Chromium (Cr) (total)	8.12E+01	1.41E+03	0	630	5.62E+00	7.70E+01	e	1.98E-02
INORG	Chromium hexavalent ion	4.92E-01	2.63E+00	0	354	0.00E+00	1.10E+01	e	7.43E-03
INORG	Copper (Cu)	2.23E+01	1.50E+03	0	654	4.57E+00	4.05E+00	h	8.01E-02
INORG	Cyanide (total)	5.47E-01	3.80E+00	0	338	2.95E-01	4.00E-02	g	7.07E-01
INORG	Lead (Pb)	1.92E+01	1.37E+02	0	606	9.25E+00	1.63E+00	h	2.70E-02
INORG	Manganese (Mn)	2.71E+02	1.06E+03	0	352	2.90E+02	1.79E+02	i	7.29E-03
INORG	Mercury (Hg)	8.63E-02	6.90E+00	0	1,012	1.20E-02	1.90E-02	e,k	1.04E+00
INORG	Nickel (Ni)	3.40E+00	2.46E+02	0	636	4.98E+00	6.71E+00	i	9.61E-02
INORG	Selenium (Se)	3.76E-01	1.81E+01	0	1,298	1.00E-01	2.90E-01	h	1.28E-01
INORG	Silver (Ag)	8.12E-01	3.27E+01	0	1,300	6.60E-02	2.02E+00	h	2.49E-01
INORG	Thallium (Tl)	4.44E-02	6.10E-01	0	862	7.30E-01	3.50E-01	j	1.43E-01
INORG	Vanadium (V)	8.94E+00	3.95E+01	0	276	1.04E+01	3.44E-01	h	5.12E-03
INORG	Zinc (Zn)	8.14E+01	3.78E+02	0	500	3.39E+01	6.61E+01	i	6.74E-01
ORG	Acetone	4.10E-02	1.23E+00	0	392	0.00E+00	2.01E+02	e	4.21E-01
ORG	Aroclor-1242	0.00E+00	0.00E+00	0	42	0.00E+00	1.00E-01	e	1.43E+00
ORG	Aroclor-1248	0.00E+00	0.00E+00	0	42	0.00E+00	1.00E-01	e	3.35E+00
ORG	Aroclor-1254	3.56E-02	1.03E+00	0	936	0.00E+00	1.00E-01	e	4.67E+00
ORG	Aroclor-1260	7.16E-02	8.94E-01	0	828	0.00E+00	2.15E+00	d	4.93E+00
ORG	Bis(2-ethylhexyl)phthalate (BEHP)	4.03E-01	1.60E+02	0	972	0.00E+00	1.10E+00	f	3.08E+02
ORG	Dieldrin	0.00E+00	0.00E+00	0	40	0.00E+00	7.09E-02	h	6.99E+00
ORG	Di-n-Butyl Phthalate (DNBP)	2.04E-02	1.80E+00	0	898	0.00E+00	1.40E-01	e	9.42E+00
ORG	Naphthalene	3.84E-03	4.45E-01	0	920	0.00E+00	1.50E+01	e	5.09E-01

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.

Table 3b. Summary of Data Input to ECORSK.9 for the Mexican Spotted Owl, ND = ½DL

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	4.19E+00	1.07E+02	1.00E-01	425	1.84E+00	2.24E+00	h	2.86E-02
INORG	Barium	5.31E+01	2.40E+02	5.00E-02	151	6.04E+01	7.35E+01	d	1.09E-02
INORG	Cadmium	4.05E-01	5.00E+00	5.00E-03	677	9.30E-02	1.47E+00	i	1.72E+00
INORG	Chromium (total)	8.20E+01	1.41E+03	4.41E-01	315	5.62E+00	7.70E+01	e	1.98E-02
INORG	Chromium hexavalent ion	5.12E-01	2.63E+00	6.04E-02	177	0.00E+00	1.10E+01	e	7.43E-03
INORG	Copper	2.30E+01	1.50E+03	2.25E-01	327	4.57E+00	4.05E+00	h	8.01E-02
INORG	Cyanide (total)	5.56E-01	3.84E+00	8.14E-02	169	2.95E-01	4.00E-02	g	7.07E-01
INORG	Lead	1.93E+01	1.37E+02	1.24E+00	303	9.25E+00	1.63E+00	h	2.70E-02
INORG	Manganese	2.71E+02	1.06E+03	8.00E+00	176	2.90E+02	1.79E+02	i	7.29E-03
INORG	Mercury	4.46E-01	9.41E+00	9.00E-04	506	1.20E-02	1.90E-02	e,k	1.04E+00
INORG	Nickel	4.93E+00	2.46E+02	7.00E-01	318	4.98E+00	6.71E+00	i	9.61E-02
INORG	Selenium	1.96E+00	3.29E+01	5.00E-02	649	1.00E-01	2.90E-01	h	1.28E-01
INORG	Silver	1.02E+00	3.27E+01	1.48E-02	650	6.60E-02	2.02E+00	h	2.49E-01
INORG	Thallium	2.29E+00	3.29E+01	2.00E-06	431	7.30E-01	3.50E-01	j	1.43E-01
INORG	Vanadium	9.07E+00	3.95E+01	4.90E-01	138	1.04E+01	3.44E-01	h	5.12E-03
INORG	Zinc	8.15E+01	3.78E+02	5.00E+00	250	3.39E+01	6.61E+01	i	6.74E-01
ORG	Acetone	4.66E-02	1.23E+00	2.50E-03	196	0.00E+00	2.01E+02	e	4.21E-01
ORG	Aroclor-1242	3.13E-02	1.10E-01	7.01E-03	21	0.00E+00	1.00E-01	e	1.43E+00
ORG	Aroclor-1248	3.13E-02	1.10E-01	7.01E-03	21	0.00E+00	1.00E-01	e	3.35E+00
ORG	Aroclor-1254	5.61E-02	1.03E+00	1.05E-03	468	0.00E+00	1.00E-01	e	4.67E+00
ORG	Aroclor-1260	9.44E-02	8.94E-01	1.05E-03	414	0.00E+00	2.15E+00	d	4.93E+00
ORG	Bis(2-ethylhexyl)phthalate	7.02E-01	1.60E+02	1.80E-02	486	0.00E+00	1.10E+00	f	3.08E+02
ORG	Dieldrin	6.19E-03	1.38E-02	7.40E-04	20	0.00E+00	7.09E-02	h	6.99E+00
ORG	Di-n-Butyl Phthalate	4.09E-01	1.65E+01	1.95E-02	449	0.00E+00	1.40E-01	e	9.42E+00
ORG	Naphthalene	2.97E-01	1.65E+01	2.50E-03	460	0.00E+00	1.50E+01	e	5.09E-01

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]EPA Region VI screening value
[k]Not available

Table 3c. Summary of Data Input to ECORSK.9 for the Southwestern Willow Flycatcher, ND = 0

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	3.43E+00	1.10E+01	0.00E+00	70	1.84E+00	2.24E+00	h	2.36E-01
INORG	Barium	8.18E+01	1.95E+02	0.00E+00	28	6.04E+01	7.35E+01	d	9.10E-02
INORG	Cadmium	4.59E-01	3.31E+00	0.00E+00	70	9.30E-02	1.47E+00	i	1.43E+01
INORG	Chromium (total)	2.70E+02	1.41E+03	2.30E+00	70	5.62E+00	7.70E+01	e	1.61E-01
INORG	Chromium hexavalent ion	4.22E-01	7.15E-01	0.00E+00	68	0.00E+00	1.10E+01	e	6.00E-02
INORG	Copper	2.27E+01	1.06E+02	0.00E+00	70	4.57E+00	4.05E+00	h	6.36E-01
INORG	Cyanide (total)	1.16E+00	3.80E+00	0.00E+00	68	2.95E-01	4.00E-02	g	1.00E+00
INORG	Lead	2.62E+01	4.83E+01	4.30E+00	68	9.25E+00	1.63E+00	h	2.25E-01
INORG	Manganese	1.92E+02	3.85E+02	8.20E+01	26	2.90E+02	1.79E+02	i	6.05E-02
INORG	Mercury	3.18E-01	1.22E+00	0.00E+00	68	1.20E-02	1.90E-02	e,k	3.93E+00
INORG	Nickel	1.02E+01	3.33E+01	0.00E+00	28	4.98E+00	6.71E+00	i	7.78E-01
INORG	Selenium	1.06E+00	3.99E+00	0.00E+00	70	1.00E-01	2.90E-01	h	9.90E-01
INORG	Silver	6.30E+00	3.27E+01	0.00E+00	70	6.60E-02	2.02E+00	h	2.05E+00
INORG	Thallium	1.45E-01	5.13E-01	0.00E+00	28	7.30E-01	3.50E-01	j	1.00E+00
INORG	Vanadium	1.68E+01	3.95E+01	0.00E+00	28	1.04E+01	3.44E-01	h	4.20E-02
INORG	Zinc	1.40E+02	3.78E+02	3.60E+01	68	3.39E+01	6.61E+01	i	3.78E+00
ORG	Acetone	2.19E-02	1.04E-01	0.00E+00	24	0.00E+00	2.01E+02	e	3.16E+00
ORG	Aroclor-1242	1.31E-02	1.83E-01	0.00E+00	28	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1248	0.00E+00	0.00E+00	0.00E+00	28	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1254	1.99E-01	1.43E+00	0.00E+00	70	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1260	3.20E-01	1.05E+00	0.00E+00	70	0.00E+00	2.15E+00	d	6.80E+00
ORG	Bis(2-ethylhexyl)phthalate	1.98E-01	5.94E-01	0.00E+00	68	0.00E+00	1.10E+00	f	1.54E+02
ORG	Dieldrin	4.63E-03	3.70E-02	0.00E+00	16	0.00E+00	7.09E-02	h	1.67E+01
ORG	Di-n-Butyl Phthalate	1.89E-03	2.65E-02	0.00E+00	28	0.00E+00	1.40E-01	e	3.56E+01
ORG	Naphthalene	0.00E+00	0.00E+00	0.00E+00	28	0.00E+00	1.50E+01	e	2.52E+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]EPA Region VI screening value
[k]Not available

Table 3d. Summary of Data Input to ECORSK.9 for the Southwestern Willow Flycatcher, ND = ½DL

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	3.47E+00	1.10E+01	2.80E-01	35	1.84E+00	2.24E+00	h	2.36E-01
INORG	Barium	8.29E+01	1.95E+02	1.55E+01	14	6.04E+01	7.35E+01	d	9.10E-02
INORG	Cadmium	5.12E-01	3.31E+00	1.75E-01	35	9.30E-02	1.47E+00	i	1.43E+01
INORG	Chromium (total)	2.70E+02	1.41E+03	2.30E+00	35	5.62E+00	7.70E+01	e	1.61E-01
INORG	Chromium hexavalent ion	4.50E-01	8.39E-01	7.00E-02	34	0.00E+00	1.10E+01	e	6.00E-02
INORG	Copper	2.32E+01	1.06E+02	1.75E+00	35	4.57E+00	4.05E+00	h	6.36E-01
INORG	Cyanide (total)	1.16E+00	3.84E+00	1.55E-01	34	2.95E-01	4.00E-02	g	1.00E+00
INORG	Lead	2.62E+01	4.83E+01	4.30E+00	34	9.25E+00	1.63E+00	h	2.25E-01
INORG	Manganese	1.92E+02	3.85E+02	8.20E+01	13	2.90E+02	1.79E+02	i	6.05E-02
INORG	Mercury	3.23E-01	1.23E+00	4.17E-02	34	1.20E-02	1.90E-02	e,k	3.93E+00
INORG	Nickel	1.03E+01	3.33E+01	8.00E-01	14	4.98E+00	6.71E+00	i	7.78E-01
INORG	Selenium	1.35E+00	4.24E+00	1.20E-01	35	1.00E-01	2.90E-01	h	9.90E-01
INORG	Silver	6.39E+00	3.27E+01	3.85E-01	35	6.60E-02	2.02E+00	h	2.05E+00
INORG	Thallium	2.63E-01	7.09E-01	1.23E-01	14	7.30E-01	3.50E-01	j	1.00E+00
INORG	Vanadium	1.70E+01	3.95E+01	2.55E+00	14	1.04E+01	3.44E-01	h	4.20E-02
INORG	Zinc	1.40E+02	3.78E+02	3.60E+01	34	3.39E+01	6.61E+01	i	3.78E+00
ORG	Acetone	2.90E-02	1.06E-01	2.69E-03	12	0.00E+00	2.01E+02	e	3.16E+00
ORG	Aroclor-1242	6.38E-02	2.00E-01	1.37E-02	14	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1248	5.17E-02	1.10E-01	1.37E-02	14	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1254	2.16E-01	1.43E+00	2.75E-02	35	0.00E+00	1.00E-01	e	6.80E+00
ORG	Aroclor-1260	3.32E-01	1.05E+00	6.79E-02	35	0.00E+00	2.15E+00	d	6.80E+00
ORG	Bis(2-ethylhexyl)phthalate	2.61E-01	5.97E-01	4.39E-02	34	0.00E+00	1.10E+00	f	1.54E+02
ORG	Dieldrin	1.71E-02	3.70E-02	1.40E-03	8	0.00E+00	7.09E-02	h	1.67E+01
ORG	Di-n-Butyl Phthalate	5.35E-01	1.27E+00	1.75E-01	14	0.00E+00	1.40E-01	e	3.56E+01
ORG	Naphthalene	1.64E-01	9.18E-01	1.16E-02	14	0.00E+00	1.50E+01	e	2.52E+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]EPA Region VI screening value
[k]Not available

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 about toxic effects of many COPECs on nonhuman biota, LANL's method of TRV derivation has resulted in a small list of COPECs without TRVs. Table 5 lists the COPECs without TRVs for birds. These COPECs were not included in the ECORSK.9 input files (*eeuinp.dat*) for the bird receptors.

Table 5. COPECs Without TRVs for Bird Receptors

COPEC Group	COPEC	Analyte Code
INORG	Aluminum*	AL
INORG	Beryllium	BE
INORG	Iron	FE
INORG	Mercury	HG
ORG	Acenaphthene	83-32-9
ORG	Anthracene	120-12-7
ORG	Benzo(a)anthracene	56-55-3
ORG	Benzo(b)fluoranthene	205-99-2
ORG	Benzo(g,h,i)perylene	191-24-2
ORG	Indeno(1,2,3-cd)pyrene	193-39-5
ORG	Phenanthrene	85-01-8
ORG	TEC Bird	TEC Bird

INORG = inorganic chemical; ORG = organic chemical; RAD = radionuclide; TEC = toxicity equivalent concentration for PCB congeners.
*Aluminum is not toxic at near-neutral soil pH values (USEPA 2003)

RESULTS AND DISCUSSION

Mean Total HI

Table 6 presents mean total HIs and dominant COPECs for the owl and flycatcher. For both receptors the ND = 0 option was selected to be the base scenario to which other variations are compared and, for the owl, the base scenario includes restricting foraging to the watershed.

Mexican Spotted Owl. The adjusted mean total HI for the owl for the ND = 0 scenario was 0.11 (n = 907) and for the ND = ½DL scenario was 0.36 (n = 907). These values generally indicate that no appreciable impact is expected to the owl. Placing nest sites in buffer habitat as well as core habitat increased the adjusted mean total HI to 0.16 and 0.29 for the ND = 0 and ND = ½DL scenarios, respectively. This increase likely occurred because, by placing nest sites in buffer habitat, HRs surrounding some of those nest sites envelope SWMUs and AOCs that are north and south of Sandia Canyon. While the use of larger HRs (2.0 and 4.1 km^2) also increased the mean total HI somewhat, they still were ≤0.5 and interpretation of those results would deviate largely from the focus on the Sandia Canyon watershed.

Southwestern Willow Flycatcher. The adjusted mean total HI for the flycatcher for the ND = 0 scenario was 18.2 (n = 30) and for the ND = ½DL scenario was 43.5 (n = 30). These values generally indicate that there is a moderate potential for impact to the flycatcher. Unadjusted mean total HIs were only a little higher than adjusted mean total HIs, indicating that background contributions were relatively low.

HI Frequency Distributions

Table 7 shows HI frequency distributions for the two receptors. For the owl, when NDs were assumed to be equal to zero there was one HI between 10 and 100 and there were 17 HIs between 1.0 and 10.0. The distribution changed some for the ND = ½DL scenario, whereby there were three HIs between 10 and 100 and there were 92 HIs between 1.0 and 10.0. When foraging was restricted to the Sandia Canyon area, there were no HIs between 10.0 and 100.0 and the number of HIs between 1.0 and 10.0 reduced to eight. More elevated HIs when foraging was not restricted probably resulted from several SWMUs north of Los Alamos Canyon and many SWMUs south of Mortandad Canyon being included in HI calculation using a very large HR for the owl. The restricted HR scenario is more insightful to the risk posed by this watershed.

For the flycatcher, 15 of 30 (50%) HIs were between 10 and 100 and 11 of 30 were between 1 and 10. When NDs were replaced with ½DL, 17 HIs were between 10 and 100 and nine were between 1 and 10. This absolute quantity of HIs in the 10–100 HI bin was previously seen in Pajarito Canyon, but never has there been such a large fraction of elevated HIs.

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

Scenario: ND = 0, HR Restricted.		
Risk Source	**Mean Total HI***	**Dominant COPEC Mean HQs**
Mexican spotted owl		
Unadjusted	0.36	None ≥0.3
Background	0.24	None ≥0.3
Adjusted	0.11	None ≥0.3
Southwestern willow flycatcher**		
Unadjusted	25.5	Hg (11.8), cyanide (5.8), BEHP (5.1), Aroclor-1254 (2.7), Zn (1.3), Ag (1.2), Pb (0.8), Cd (0.8), Cu (0.8), Se (0.7), V (0.3)
Background	7.3	Hg (0.4), cyanide (1.5), Zn (0.4), Pb (0.3)
Adjusted	18.2	Hg (11.4), BEHP (5.1), cyanide (4.3), Aroclor-1254 (2.7), Ag (1.2), Zn (0.9), Se (0.7), Cd (0.7), Cu (0.6), Pb (0.5)

Scenario: ND = ½DL in Reaches With Detections, HR Restricted.		
Risk Source	**Mean Total HI***	**Dominant COPEC Mean HQs**
Mexican spotted owl		
Unadjusted	0.41	None ≥0.3
Background	0.24	None ≥0.3
Adjusted	0.17	None ≥0.3
Southwestern willow flycatcher**		
Unadjusted	35.9	Hg (12.1), DNBP (11.1), BEHP (7.5), cyanide (5.8), Aroclor-1254 (2.9), Ag (1.3), Zn (1.3), Cd (0.9), Se (0.9), Pb (0.8), Cu (0.8), V (0.3), Aroclor-1242 (0.3).
Background	4.3	Cyanide (1.5), Hg (0.5), Zn (0.4), Pb (0.3)
Adjusted	31.6	Hg (11.6), DNBP (11.1), BEHP (7.5), cyanide (4.3), Aroclor-1254 (2.9), Ag (1.2), Zn (0.9), Se (0.8), Cd (0.7), Cu (0.6), Pb (0.5), Aroclor-1242 (0.3).

*Value is an arithmetic mean of total observations/nest sites (n = 907 for owl; n = 30 for flycatcher).
**Flycatcher mean total HI data are based on scenarios in which foraging was restricted to Sandia Canyon.

Table 7. HI Frequency Distributions for ND = 0 and ND = ½DL Scenarios. Values are number of nest sites with a mean total HI in the noted HI ranges.

HI Range	Mexican Spotted Owl*		Southwestern Willow Flycatcher**	
	ND = 0	ND = ½DL	ND = 0	ND = ½DL
≥100	0	0	0	0
10–100	1	3	15	17
1–10	17	92	11	9
<1	889	812	4	4
Total	907	907	30	30

*Based on nest placement in core habitat only.
**Flycatcher data based on scenario in which foraging was restricted to Sandia Canyon.

Dominant COPECs

COPECs with adjusted mean total HQs ≥0.3 are listed in Table 6. COPEC-specific results are important especially for grid cells with mean total HIs ≥1.0. Examination of the more detailed results helps to qualify the results of concern.

Mexican Spotted Owl. The Mexican spotted owl had no COPEC-specific adjusted mean total HQs ≥0.3. Of the 907 modeled nest sites, the ND = 0 adjusted HIs >1.0 for the owl ranged from 1.2–15.9. The dominant COPEC contributors to these nest sites were BEHP, DNBP, Aroclor-1248, and Hg. BEHP and DNBP had a sufficient number of detections (302 and 104, respectively) to hypothesize that the modeling results could be real and they have in the past surfaced as contributors to elevated HIs, but the phthalates (BEHP and DNBP) were not carried forward from the screening as COPECs for Sandia Canyon because similar levels exist in Pajarito Canyon and likely do not have LANL sources (LANL 2007). Aroclors had HQs greater than 50 in the Sandia biota plan screening assessment (LANL 2007) and sources of PCBs into Sandia Canyon are well documented (LANL 1999).

Southwestern Willow Flycatcher. For the flycatcher, Hg dominated the contribution to the adjusted mean total HI for both ND = 0 (HQ = 11.4) and ND = ½DL (HQ = 11.6) scenarios. This result is consistent with Hg being noted as a potential ecological risk driver in the Sandia Canyon biota plan; the maximum HQ in soil screening was 429 and the maximum HQ in sediment screening was 309 (LANL 2007). The model-generated HQs for Sandia Canyon exceeded those calculated for Pajarito Canyon (Gonzales et al. 2008). High concentrations of Hg have been previously measured in SWMUs adjacent to Sandia Canyon (LANL 1999); and in the more recent screening, birds were included as one of the animal guilds for both soil and sediment (LANL 2007).

DNBP had an elevated mean total HQ for the ND = ½DL scenario, but was absent in the ND = 0 scenario and there were only two detections in the data set (Table 8b), so this does not appear to be a real contributor. BEHP was a noticeable contributor to elevated HIs. BEHP and DNBP have in the past been identified as contributors to elevated HIs, but phthalates do not

generally have recognized LANL sources. Further assessment of phthalates is not warranted, which was the same disposition in the Pajarito Canyon investigations (Gonzales et al. 2008).

Cyanide had adjusted mean total HQs of 4.3 for both scenarios and also had been identified as large contributors in soil and sediment screening. ECORSK.9 generated HQs greater than 10 for cyanide as did the soil and sediment screening, except that the soil screening in the Sandia Canyon biota plan had HQs for cyanide and Zn greater than 100 (LANL 2007).

In addition to Hg, several other metals (Zn, Ag, Pb, and Cd) had high HQs generated by both ECORSK.9 and as the result of the soil and sediment screening.

Lastly, significant concentrations of PCBs in Sandia Canyon, including in the wetland, are well documented (e.g., LANL 1999, 2007), so elevated Aroclor HQs generated by both the model and the screening were expected.

Risk by Geographic Area

Mexican Spotted Owl. Figure 3a and 3b are contour plots of adjusted HIs for the owl whereby NDs were unaltered (3a) and NDs were replaced with ½DL (3b). Replacing NDs had little effect on the HI distribution. These plots show that the nest site locations with elevated HIs are not common and are isolated to a small part of the potential spotted owl habitat. Figure 4 shows the distribution of Adjusted HIs for 907 nest sites placed in core owl habitat and the scenario was ND = 0, HR = 1.0. No strong groupings are apparent, but in the eastern half of the owl habitat the influence appears to be AOCs or SWMUs in nearby reaches. The single HI in the 10–100 range is close to the Technical Area 60 SWMUs. When larger HRs were used, the influence of SWMUs on distant mesa tops was quite apparent.

Southwestern Willow Flycatcher. The habitat for the flycatcher in Sandia Canyon was too small to evaluate spatial patterns in HI distribution. Generally there were lower HIs in the western end of the flycatcher habitat shown in Figure 1 and higher HIs in the eastern end.

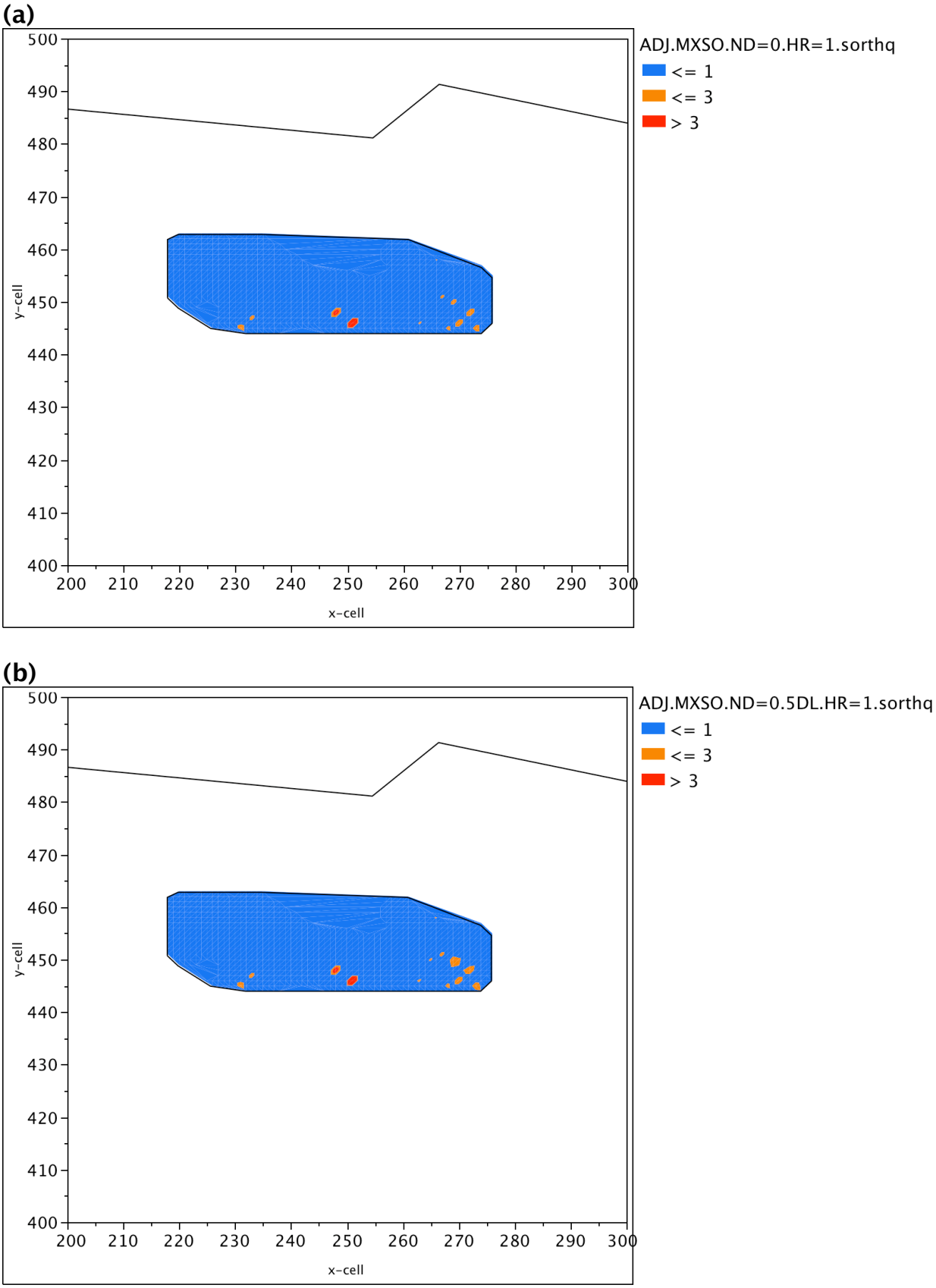

Figure 3. Contour plot of 907 adjusted HIs for the Mexican spotted owl whereby (a) NDs were unaltered and (b) NDs were replaced by ½DL.

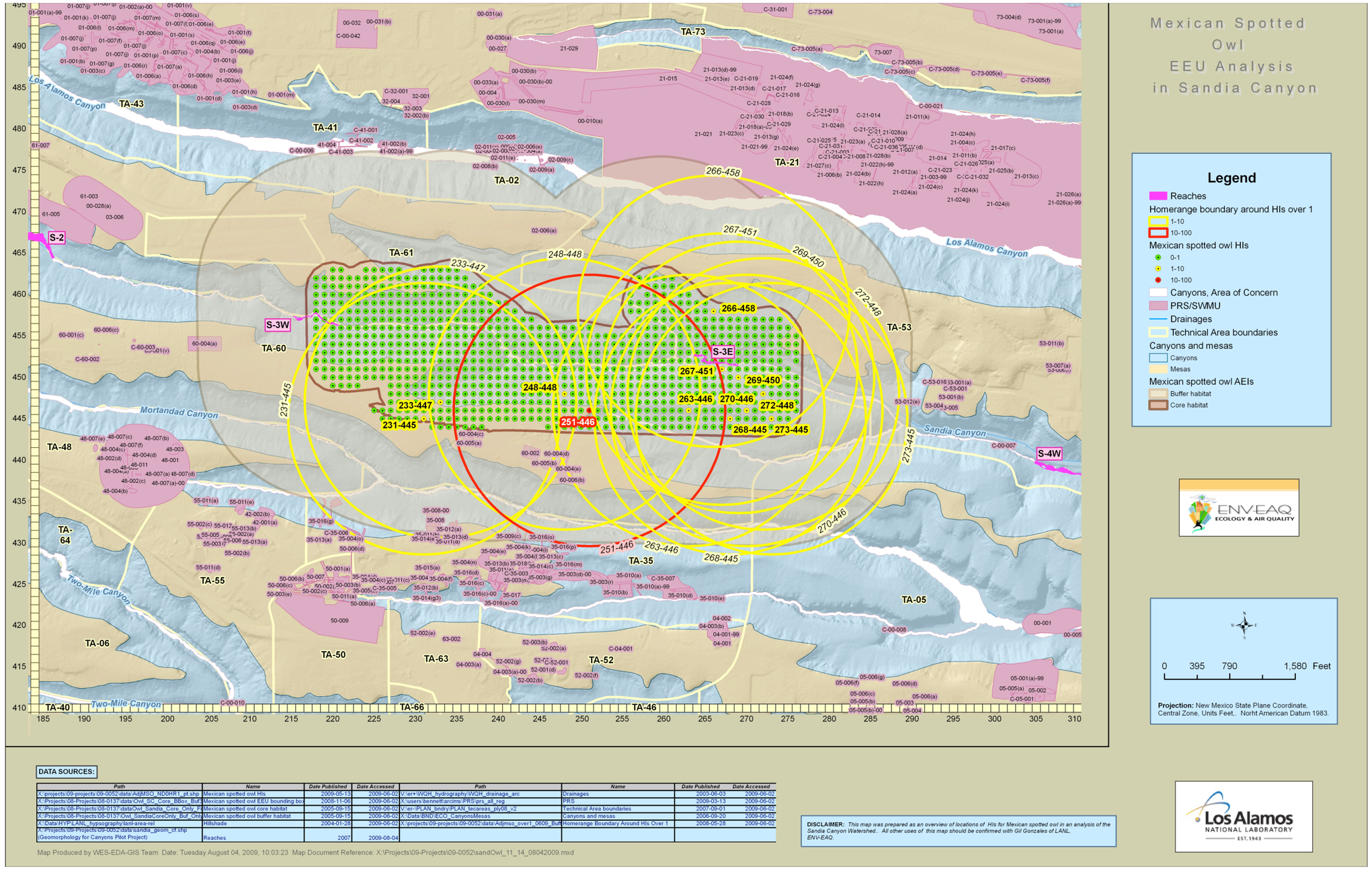

Figure 4. Distribution of 907 adjusted HIs for the Mexican spotted owl in hypothetical nest site locations in core habitat in Sandia Canyon. (Note: PRS is potential release site; AEI is Area of Environmental Interest)

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

COPEC Group	COPEC	Number (Count) Detected	Number (Count) Non-Detected	Total	Percent of Total Non-Detected	Percent of Total Comprised of Interpolated Values
INORG	Arsenic	662	188	850	22	35
INORG	Barium	298	4	302	1.3	0
INORG	Cadmium	756	598	1,354	44	22
INORG	Chromium (total)	536	94	630	15	47
INORG	Chromium hexavalent ion	340	14	354	4.0	87
INORG	Copper	564	90	654	14	45
INORG	Cyanide (total)	330	8	338	2.4	91
INORG	Lead	594	12	606	2.0	49
INORG	Manganese	350	2	352	0.6	0
INORG	Mercury	682	330	1,012	33	30
INORG	Nickel	432	204	636	32	0
INORG	Selenium	680	618	1,298	48	23
INORG	Silver	770	530	1,300	41	23
INORG	Thallium	400	462	862	54	0
INORG	Vanadium	266	10	276	3.6	0
INORG	Zinc	498	2	500	0.4	60
ORG	Acetone	156	236	392	60	0
ORG	Aroclor-1242	0	42	42	100	0
ORG	Aroclor-1248	0	42	42	100	0
ORG	Aroclor-1254	404	532	936	57	32
ORG	Aroclor-1260	424	404	828	49	36
ORG	Bis(2-ethylhexyl)phthalate	302	670	972	69	9
ORG	Dieldrin	0	40	40	100	0
ORG	Di-n-Butyl Phthalate	104	794	898	88	0
ORG	Naphthalene	48	872	920	95	0

INORG = inorganic chemical; ORG = organic chemical

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

COPEC Group	COPEC	Number (Count) Detected	Number (Count) Non-Detected	Total	Percent of Total Non-Detected	Percent of Total Comprised of Interpolated Values
INORG	Arsenic	68	2	70	2.9	60
INORG	Barium	26	2	28	7.1	0
INORG	Cadmium	62	8	70	11.4	60
INORG	Chromium (total)	70	0	70	0	60
INORG	Chromium hexavalent ion	66	2	68	2.9	65
INORG	Copper	68	2	70	2.9	60
INORG	Cyanide (total)	66	2	68	2.9	85
INORG	Lead	68	0	68	0	62
INORG	Manganese	26	0	26	0	0
INORG	Mercury	66	2	68	2.9	62
INORG	Nickel	26	2	28	7.1	0
INORG	Selenium	54	16	70	23	60
INORG	Silver	66	4	70	5.7	60
INORG	Thallium	18	10	28	36	0
INORG	Vanadium	26	2	28	7.1	0
INORG	Zinc	68	0	68	0	62
ORG	Acetone	10	14	24	58	0
ORG	Aroclor-1242	2	26	28	93	0
ORG	Aroclor-1248	0	28	28	100	0
ORG	Aroclor-1254	64	6	70	8.6	57
ORG	Aroclor-1260	64	6	70	8.6	57
ORG	Bis(2-ethylhexyl)phthalate	54	14	68	21	62
ORG	Dieldrin	2	14	16	88	0
ORG	Di-n-Butyl Phthalate	2	26	28	93	0
ORG	Naphthalene	0	28	28	100	0

INORG = inorganic chemical; ORG = organic chemical

Discussion

We first ran the model with a data set where NDs were replaced by ½DL, which is more conservative than replacing DLs with zero. Because this resulted in HIs and HQs above thresholds of concern (1.0), we ran the model with NDs replaced by zero to establish the low end of the range in HIs and HQs. Although HIs and HQs were higher using ½DLs, the HI frequency distribution didn't change for the owl and changed very little for the flycatcher. This result is different than from previous applications of the model and is an indication that at least this potential source of artificial inflation of HIs and HQs due to non-detected COPECs was not significant.

The HIs for the flycatcher were some of the highest ever generated in ECORSK modeling at LANL. One source of potential "artificial" inflation of HQs and HIs is interpolation of contaminant concentrations in grid cells where sampling has not occurred. Of the 26 non-zero adjusted HIs for the flycatcher, four pairs and one set of three values were repeats; i.e., the same exact value. The fact that the flycatcher results had some repeated HIs could be an indication that several of the grid cells within the small area of flycatcher EEU were comprised of similar interpolated data. In fact, for the flycatcher, the percent of the total count of sample values comprised by interpolated values for five of the top six dominant COPEC contributors—Hg, cyanide, BEHP, Aroclor-1254, and Ag—was 62%, 85%, 62%, 57%, and 60%, respectively (Table 8b). This suggests that a moderate amount of HI inflation occurred as a result of interpolating contaminant values.

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.

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 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.		

CONCLUSIONS

ECORSK.9 model results on the potential impacts of contaminants in Sandia Canyon to the Mexican spotted owl and southwestern willow flycatcher are in general agreement with soil and sediment screening that considered birds as receptors. Without consideration of conservatisms built into model parameters, the model predicts a substantial potential for impacts to the southwestern willow flycatcher at half of the 30 hypothetical nest sites in Sandia Canyon and a small potential for impact at another 11 nest sites. Generally this is a higher level of predicted impact than previously estimated in other areas including the Pajarito and Mortandad watersheds.

There is a small potential for impact to the Mexican spotted owl at a very small percentage of the 907 hypothetical nest sites in core habitat in Sandia Canyon. Generally there is a higher level of impact predicted to the owl than previously estimated for the Pajarito watershed. And, although less impact is predicted to owls in Sandia Canyon than in Mortandad Canyon, there was less artificial inflation of risk indices in the Sandia Canyon assessment.

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