



# Standard Guide for Estimating Wildlife Exposure Using Measures of Habitat Quality<sup>1</sup>

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## 1. Scope

1.1 Ecological Risk Assessments (EcoRAs) typically focus on valued wildlife populations. Regulatory authority for conducting EcoRAs derives from various federal laws [for example, Comprehensive Environmental Response, Compensation and Liability Act 1981, (CERCLA), Resource Conservation and Recovery Act (RCRA), and Federal Insecticide, Fungicide, and Rodenticide Act, (FIFRA)]. Certain procedures for conducting EcoRAs (**1-4**)<sup>2</sup> have been standardized [**E1689-95**(2003) Standard Guide for Developing Conceptual Site Models for Contaminated Sites; **E1848-96**(2003) Standard Guide for Selecting and Using Ecological Endpoints for Contaminated Sites; **E2020-99a** Standard Guide for Data and Information Options for Conducting an Ecological Risk Assessment at Contaminated Sites; **E2205/E2205M-02** Standard Guide for Risk-Based Corrective Action for Protection of Ecological resources; **E1739-95**(2002) Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites]. Specialized cases for reporting data have also been standardized [**E1849-96**(2002) Standard Guide for Fish and Wildlife Incident Monitoring and Reporting] as have sampling procedures to characterize vegetation [**E1923-97**(2003) Standard Guide for Sampling Terrestrial and Wetlands Vegetation].

1.2 Most states have enacted laws modeled after the federal acts and follow similar procedures. Typically, estimates of likely exposure levels to constituents of potential concern (CoPC) are compared to toxicity benchmark values or concentration-response profiles to establish the magnitude of risk posed by the CoPC and to inform risk managers considering potential mitigation/remediation options. The likelihood of exposure is influenced greatly by the foraging behavior and residence time of the animals of interest in the areas containing significant concentrations of the CoPC. Foraging behavior and residence time of the animals are related to landscape features

(vegetation and physiognomy) that comprise suitable habitat for the species. This guide presents a framework for incorporating habitat quality into the calculation of exposure levels for use in EcoRAs.

1.3 This guide is intended only as a framework for using measures of habitat quality in species specific habitat suitability models to assist with the calculation of exposure levels in EcoRA. Information from published Habitat Suitability Index (HSI) models (**5**) is used in this guide. The user should become familiar with the strengths and limitations of any particular HSI model used in order to characterize uncertainty in the exposure assessment (**5-7**). For species that do not have published habitat suitability models, the user may elect to develop broad categorical descriptions of habitat quality for use in estimating exposure.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

- E1689** Guide for Developing Conceptual Site Models for Contaminated Sites
- E1739** Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites
- E1848** Guide for Selecting and Using Ecological Endpoints for Contaminated Sites
- E1849** Guide for Fish and Wildlife Incident Monitoring and Reporting
- E1923** Guide for Sampling Terrestrial and Wetlands Vegetation (Withdrawn 2013)<sup>4</sup>
- E2020** Guide for Data and Information Options for Conducting an Ecological Risk Assessment at Contaminated Sites
- E2205/E2205M** Guide for Risk-Based Corrective Action for Protection of Ecological Resources

## 3. Terminology

3.1 The words “must,” “should,” “may,” “can,” and “might” have specific meanings in this guide. “Must” is used to express

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<sup>2</sup> The boldface numbers in parentheses refer to the list of references at the end of this standard.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>4</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

an absolute requirement, that is, to state that the test ought to be designed to satisfy the specified condition, unless the purpose of the test requires a different design. “Should” is used to state that the specified condition is recommended and ought to be met if possible. Although violation of one “should” is rarely a serious matter, violation of several will often render the results questionable. “May” is used to mean “is (are) allowed to,” “can” is used to mean “is (are) able to,” and “might” is used to mean “could be possible.” Thus, the distinction between “may” and “can” is preserved, and “might” is never used as a synonym for either “may” or “can.”

3.2 Consistent use of terminology is essential for any vegetation sampling effort. below is a list of terms that are used in this guide, as well as others that may be encountered commonly in the wildlife habitat quality literature. this list is not exhaustive.

### 3.3 Definitions of Terms Specific to This Standard:

3.3.1 *abundance*—the number of individuals of one taxon in an area; equivalent to the term density as used in botanical literature.

3.3.2 *basal area (BA)*—the cross-sectional area of a tree trunk at 1.4 m (4.5 ft) above ground. (See *diameter at breast height*.)

3.3.3 *biomass*—the mass of vegetation per unit area.

3.3.4 *canopy*—the uppermost layer, consisting of branches and leaves of trees and shrubs, in a forest or woodland.

3.3.5 *carrying capacity*—the theoretical density of organisms that can be supported in a specified ecological system.

3.3.6 *cover*—the area of ground covered by plants of one or more taxa.

3.3.7 *density*—the number of organisms in a specified area.

3.3.8 *diameter at breast height (DBH)*—the widest point of a tree trunk measured 1.4 m (4.5 ft) above the ground.

3.3.9 *foraging-range*—the area typically explored by an animal while it is feeding. (See *home-range*.)

3.3.10 *forb*—a non-graminoid (that is, broadleaf) herbaceous plant.

3.3.11 *geographic information system (GIS)*—an integrated spatial data base and mapping system in which geographical information can be used to produce digital maps, manipulate spatial data, and model spatial information. It allows the overlay of layers of information, such as habitats or plant ranges.

3.3.12 *global positioning system (GPS)*—a survey system in which a GPS unit is used to receive signals from satellites. Signals are then interpreted to provide information such as latitude and longitude or bearings for navigation, positioning, or mapping.

3.3.13 *graminoid*—a grass (Poaceae), sedge (Cyperaceae), or rush (Juncaceae).

3.3.14 *habitat*—the collection of biological, chemical, and physical features of a landscape that provide conditions for an organism to live and reproduce.

3.3.15 *habitat suitability index*—a calculated value that characterizes a specified landscape unit (for example, a polygon) in terms of the features and conditions that are favorable for a particular species. Values range between 0.0 (unsuitable) and 1.0 (ideal).

3.3.16 *herb*—a plant with one or more stems that die back to the ground each year; (that is, graminoids and forbs).

3.3.17 *home-range*—the area around an animal’s established home, which is traversed in normal activities. (See *foraging-range*.)

3.3.18 *physiognomy*—the surface features of an area.

3.3.19 *population*—a group of individuals of the same species occupying a habitat small enough to permit interbreeding.

3.3.20 *remote sensing*—the use of satellites or high-altitude photography to measure geographic patterns such as vegetation.

3.3.21 *shrub*—woody plant typically smaller than a tree when both are mature (typically with DBH < 10 cm), often with multiple main stems from the base. Should be defined specifically at start of project.

3.3.22 *tree*—woody plant with a single main stem from the base, typically > 2 to 3 m tall when mature (typically DBH > 10 cm). The operational definition should be stated explicitly for each project.

## 4. Habitat Approaches

4.1 Naturalists and wildlife managers have understood, at least in qualitative terms, the importance of critical habitat for various life history stages (for example, nesting sites, winter range, etc.). Animals are drawn to suitable physical structure and food availability, while avoiding areas of lower quality. The term habitat, though often used loosely as an indication of environmental quality, refers to the combination of physical and biological features preferred by a particular species. Habitat that is great for prairie chicken is unacceptable for barred owls. Different habitat preferences reflect evolution and adaptation of species separating from each other in “*n*-dimensional niche space” (8). There are differential area use rates by different species. Animals are drawn to particular features of the landscape for foraging, loafing, nesting/birthing, etc. Some species are attracted to disturbance zones and edges, but others avoid such areas.

4.2 Habitat Suitability Index (HSI) Models have been developed for many species of interest. Characterization of habitat for certain species was formalized by the U.S. Fish and Wildlife Service in the 1990s (9). Currently, more than 160 HSI models have been published, though usage is limited for quantitative predictions of population densities (6). Rand and Newman (10) describe the applicability of HSI models for EcoRA in general terms, but provide no examples of its use and do not give specific details to integrate habitat information with exposure assessment or risk characterization. Freshman and Menzie (11) describe two approaches to take into account spatial differences in contaminant concentrations with respect to foraging activities and the proportion of each population

likely to be exposed to the contaminants. Their approach does not incorporate HSI models formally, but does demonstrate the fundamental concepts for such use. Hope (12-14), Wickwire et al. (15), Linkov et al. (16, 17) and Linkov and Grebenkov (18) have used placeholder habitat values to illustrate the effect of habitat on cumulative exposure levels. Kapustka et al. (5, 19) and Linkov et al. (20) have described procedures to use HSIs as the habitat quality parameter for use in estimating exposure levels. The U.S. EPA Office of Solid Waste conducted an exploratory program in which they characterized vegetation types and physical features within a 2-km radius of more than 200 chemically contaminated sites. The focus was on using habitat characteristics to modify estimates of risk. Landscape relationships were used to incorporate ecological dynamics into risk assessments by another group within the U.S. EPA. The Program to Assist in Tracking Critical Habitat (PATCH) model used a GIS platform that allows user input in defining polygons and their characteristics (21); [www.epa.gov/wed/pages/models.htm](http://www.epa.gov/wed/pages/models.htm)). This program has been incorporated into HexSim(22). The Army Risk Assessment Modeling System (ARAMS) ([www.wes.army.mil/el/arams/arams.html](http://www.wes.army.mil/el/arams/arams.html)) developed modules that use habitat quality assessments to improve the realism of exposure assessments. Loos et al. (23) developed a receptor-oriented cumulative exposure model (Eco-SpaCE) for wildlife species that includes relevant ecological processes such as spatial habitat variation, food web relations, predation, and life history characteristics. Johnson et al. (24) found that a spatially explicit exposure model based on the general procedures outlined in this Standard provided good agreement with field observations and therefore produced more accurate risk estimates than conventional deterministic approaches. Loos et al. (25) provided a comparative review of approaches used to model exposures experienced by humans and wildlife. Wick-

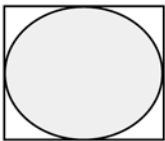
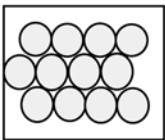
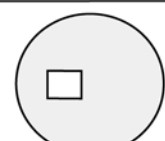
wire et al. (26) discussed the rationale for using spatially explicit exposure models and also describe some of the impediments that may be deterring a broader use of such approaches.

## 5. Identifying Scenarios where Habitat Value can be Important in EcoRAs

5.1 Heterogeneous landscapes coupled with heterogeneous distribution of contaminants introduce great uncertainty in exposure estimates for any species (Fig. 1). In such situations, the relative size of the site to the home range of the species does not matter. Two other cases occur in which habitat modifications of exposure estimates would reduce uncertainty; one in which contaminant distribution is heterogeneous and home range is small relative to the area of the site, the other in which habitat is heterogeneous and the home range is very large relative to the contaminated area. The combination of homogeneous habitat and homogeneous contaminant distribution precludes using habitat conditions as a modifier of exposure regardless of the home range to site area relationship. Homogeneous contaminant distribution also makes habitat conditions moot for species with home ranges equal to or less than the site. Finally, with homogeneous habitat conditions, exposure estimates for species having home ranges equal to or larger than the contaminated area would not be improved.

## 6. Significance and Use

6.1 Explicit consideration of landscape features to characterize the quality of habitat for assessment species can enhance the ecological relevance of an EcoRA. This can help avoid assessing exposure in areas in which a wildlife species would be absent because of a lack of habitat or to bound exposure estimates in areas with low habitat quality. The measure of

| Spatial relationship habitat agent                                                  | homogeneous homogeneous | homogeneous heterogeneous | heterogeneous heterogeneous | heterogeneous homogeneous |
|-------------------------------------------------------------------------------------|-------------------------|---------------------------|-----------------------------|---------------------------|
|  | O                       | O                         | +                           | O                         |
|  | O                       | +                         | +                           | O                         |
|  | O                       | O                         | +                           | +                         |

Cases where habitat characterization may be useful in reducing uncertainty of exposure estimates (+) and cases where habitat considerations may be moot (O). Adapted from Kapustka et al., 2001, (5).

FIG. 1 Contingency Table Illustrating Relationships of Home Range (Circle) Relative to Site Size (Square)