The Wildlife Habitat Response Model: A Tool for Estimating Terrestrial Wildlife Habitat Responses to Fuel Treatments

Authors: David S. Pilliod,[1,2] Katharine Shick,[3] M. Elena Velasquez[4]

[1]Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, USDA Forest Service, P.O. Box 8089, Missoula, Montana 59807

[2]Department of Biological Sciences, College of Science and Mathematics, California Polytechnic State University, San Luis Obispo, CA 93407; Phone: (805) 756-2207; Email: dpilliod@calpoly.edu

[3]927 Cooper Street, Missoula, MT 59802
[4]202 W. Artemos Drive, Missoula, MT 59803

Abstract

This paper describes the Wildlife Habitat Response Model (WHRM), a web-based computer tool for evaluating potential effects of fuel reduction projects on terrestrial wildlife habitats in dry coniferous forests of the western United States. WHRM uses species-habitat associations to predict how fuel treatments may affect species habitat suitability. Users input the amount of change in forest floor components, down wood, standing dead wood, understory vegetation, and live trees based on fuel treatment objectives, desired future conditions, or predictions from forest stand development models. Using data gleaned from the scientific literature, WHRM identifies the habitat elements that are important for species in terms of reproduction, food acquisition, and shelter from predators and environmental extremes. Managers can then enter variations of proposed fuel management activities into the model to determine how alternatives may influence these habitat elements. The output of WHRM is strictly qualitative (for example, will management activity result in a positive, negative, or have no affect on habitat conditions for a species). The model output and background information can help managers compare alternatives and develop the environmental consequences components of NEPA-type assessments for fuel treatment activities.

Introduction

Managers face a difficult task in predicting the effects of fuel treatments on wildlife within the dry interior forests of the western United States. Few empirical studies are available from which to draw inferences and thus there is uncertainty and some concern about how sensitive wildlife species will respond to mechanical thinning, prescribed burning and their alternatives (Pilliod and others, in press). Anecdotal observations suggest that wildlife mortality during forest thinning and prescribed burning operations is minimal and inconsequential to populations of terrestrial species (Folk and Bales 1982; Komarek 1969). Populations are more likely to respond to the rapid changes and sometimes prolonged recovery in forest structure and composition that result from fuel management activities. When empirical studies on the effects of fuel treatments on wildlife habitats are unavailable, some predictions may still be possible by first identifying the habitat requirements of a species and then estimating how fuel management activities will alter the habitat elements that are important to a species' survival and reproduction. The Wildlife Habitat Response Model (WHRM) is a web-based predictive computer tool that was developed to meet this need.

WHRM is based on species-habitat relationships and organized similarly to an envirogram. Species-habitat relationships are descriptive mechanisms used by wildlife biologists and managers for linking species with the habitats in which they are associated. Typically organized in matrices and databases, species-habitat relationships can be general (for example, species-biome) or specific (for example, species-habitat element) and can have qualifiers on habitat usage such as resident, seasonal, occasional, breeding, foraging, and other descriptive terms. An envirogram is a graphic representation of causal relationships linking indirect to direct causes of species responses to the environment (Andrewartha and Birch 1984). Each causal pathway is listed under of one of four categories: mates, resources, predators, and mal-entities. These four categories represent the general habitat requirements of a species and can be described as those features or habitat elements that are needed for an animal to (1) find a mate, reproduce, and successfully rear offspring (for example, breeding sites, birthing areas, and nest sites), (2) acquire the nutrition necessary for survival and reproduction (for example, foraging habitat, forage, and habitat for prey which influences prey availability), (3) escape predation, and (4) seek shelter from environmental hazards (for example, daytime or nighttime temperatures, extreme weather events, seasonal climate fluctuations, and unpredictable disturbances such as drought, fire, or flooding).

The goal of this paper is to provide a user's guide to the Wildlife Habitat Response Model. In the following sections we describe the concept, inputs, outputs, utility, limitations, and assumptions of the model. In chapter XI of this document, we provide a case-study of how WHRM can be used for fuel treatment planning.

Description

The goal of our modeling effort was to produce a straightforward tool to help fuel planners and NEPA specialists (that is, non-biologists) to conceptualize and qualitatively predict how fuel reduction treatments might affect the habitats of terrestrial wildlife species living in dry, coniferous forest ecosystems of the western U.S. Hence, WHRM is intended for planning purposes and general assessments and is not intended to replace detailed population-level assessments of threatened, endangered, or sensitive species.

WHRM was designed to predict potential habitat suitability relative to pre-treatment conditions and can be used to compare the potential effects of different treatments on a species' habitat. Habitat suitability within a given area is based on the availability of habitat elements required for successful reproduction, food acquisition, predator avoidance, and shelter from environmental hazards and stresses.

In essence, WHRM packages a wildlife-habitat database into a user-friendly computer-based tool. WHRM first identifies the habitat requirements of a chosen species and then allows users to investigate how proposed fuel management activities and alternatives may influence the critical habitat needs of a species. The predicted response of a species to proposed habitat changes is based on species-habitat associations reported in the scientific literature for ponderosa pine (*Pinus ponderosa*) and dry-type Douglas-fir (*Pseudotsuga menseizii*), lodgepole pine (*Pinus contorta*) and mixed conifer forests in the western U.S. (see map and definition, pages xx-xx, this document). Therefore, WHRM predictions are specific to these forest types and may not apply to a species across its range. Furthermore, WHRM predictions are most appropriate within the stand being modeled. Predictions have no temporal scale, but users can produce time-specific predictions based on the values selected for changes or recovery in each habitat element. Predictions from forest stand development models, such as the Forest Vegetation Simulator with the Fire and Fuels Extension (FVS-FFE) can aid in predicting how various habitat elements may change over time.

Species-habitat associations used in this model were generated from an extensive search of over 450 peer-reviewed published articles on wildlife and wildlife habitats. In most cases, we used original data from papers published in scientific journals. For each paper, we recorded the location of the study, habitats investigated, whether the paper was a disturbance paper (in other words, describing habitat associations in a disturbed or recovering environment), species studied, the response variable used (for example, occurrence, abundance), a description of the habitat elements with which a species was significantly correlated (probability less than 0.05 or 0.10, depending on the usage in the paper), and the direction of the correlation. Habitat elements were then placed into standard categories (see table 1). If the habitat categories described in a paper and those used in WHRM did not match exactly, we used a liberal, inclusive approach. For example, if a paper reported snags in the size class 12 to 24 inches diameter-at-breast-height (d.b.h.), we used size classes 10 to 19 inches and 20 to 29 inches d.b.h. for WHRM. If size classes were not provided in a paper, we used a general category (for instance, snags (size not specified)). Based on information reported in a paper, we placed each habitat association described for a species into one of four categories: reproduction, non-consumptive foraging habitat, forage or prey habitat, and shelter from predators or environmental extremes. Some habitat associations fell into two or more categories depending on the life history of the animal. If not specified in a paper, we categorized remaining habitat associations based on field guides, species accounts, and other general references. Data from papers outside the target area were not included in WHRM unless no other information was available. Under such circumstances, we first included papers from similar forest types (for example, moist, coastal Douglas-fir) within the region and then other forest types (for example, spruce).

Table 1. List of habitat elements important for wildlife. Definitions of habitat elements adapted from O'Neil and others (2001). Units are not displayed because WHRM uses percent change from pre-treatment conditions and thus any units can be used.

Forest Component	Habitat Elements	Definition
Forest Floor	Bare Mineral Soil Exposure	The inorganic soil layer beneath the humus. This HE is usually expressed as percent exposure in a given area representative of the stand. Although not generally considered a wildlife HE, bare mineral soil represents a lack of duff and litter cover (1-(duff+litter cover)) and therefore is indicative of poor habitat quality for some species and increased erosion potential.
	Duff Cover	The matted layer of organic debris beneath the litter layer. Decomposition is more advanced than in litter layer; intergrades with uppermost humus layer of soil. This HE is usually expressed as percent cover of a given area representative of the stand. Duff depth can also be important for wildlife habitat, but is not included.
Understory Vegetation	Grass Cover	The amount of ground cover composed of grasses. This HE is usually expressed as percent cover of a given area representative of the stand.
	Forb/Herbaceous Cover	The cover of understory, non-woody vegetation layer beneath the shrub layer that includes forbs, mosses, and ferns. This HE is usually expressed as percent cover of a given area representative of the stand.
	Shrub Cover	A measure of shrub density and usually visually estimated as a vertical projection of shrub crown diameter onto the ground. Shrubs are further sub-divided into short shrubs (0-18" tall) and tall shrubs (>18" tall). Tall shrubs are usually considered ladder fuels whereas short shrubs are not. If shrub height is not specified in a study, it is listed under "shrub cover (all size classes)". Shrub species and number of shrub canopy layers are important for wildlife habitat, but are not specified.

Forest Component	Habitat Elements	Definition
Down Wood	Litter Cover	The upper layer of loose, organic (primarily vegetative) debris on the forest floor. Decomposition may have begun, but components still recognizable. This HE is usually expressed as percent cover of a given area representative of the stand. WHRM does not specify litter depth, but this can influence wildlife use.
	Down Wood	Includes downed logs, branches, and rootwads. This HE is usually expressed in tons per acre and described as downed woody debris (DWD). DWD is subdivided in size classes based on maximum diameter: 0-3” (considered fine woody debris, FWD and includes 1, 10 and 100 hour fuels) and >3” (considered coarse woody debris, CWD and includes all 1000 hour fuels). WHRM subdivides CWD in size classes 4-6”, 7-12”, and >12”. If a study does not specify size classes, then it is listed under "down wood (all size classes). The WHRM does not specify decay class, but this can be important for wildlife use.
Standing Dead Wood	Snags	Standing dead wood can be grouped (listed as "snags (all size classes)") or separated into size classes measured in diameter at breast height (dbh) or at 4.5 feet above the ground. WHRM groups snags into the following size classes: 0-4.9" dbh, 5-9" dbh, 10-19" dbh, 20-29" dbh, and 30+" dbh. Snags are usually expressed in snags per acre. Stumps can be considered short snags. WHRM does not specify decay class, but this can be important for wildlife use.
Live Trees	Crown Base Height	The height from the ground to the base of the live overstory tree canopy. This HE is usually expressed as a linear measure, such as feet or meters.
	Tree Canopy Cover	The cover of the coniferous and deciduous living tree canopy projected vertically to the ground. This HE is usually expressed as a percentage.
	Trees	Living trees are usually described as a density (trees per acre or TPA). All coniferous trees are grouped together (listed as "trees (all species and size classes)") or grouped by size classes measured as dbh (see snags). WHRM also lists aspen trees and "other trees", which are usually site specific such as Gambel Oaks.

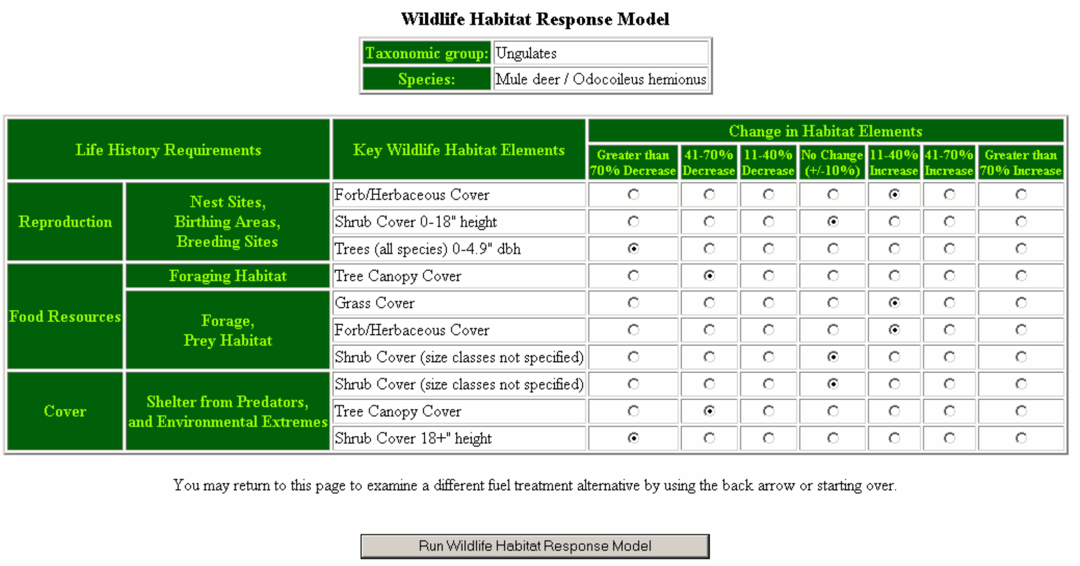
Mechanics

Inputs

Step 1: Select a species and fuel treatment

The first step to running WHRM is to specify a species. Only one species can be modeled at a time. WHRM provides a drop-down list of species occurring in dry interior forest types of the western U.S. for which there is sufficient life history information to predict responses to habitat alterations.

After selecting the species and fuel treatment type, click on the button *Display Habitat Associations*. WHRM uses your species selection to display the habitat elements (see definitions in table 1) that are considered important habitat requirements for the life history of the species in terms of reproduction, food acquisition, and shelter/cover (figure 1). Some habitat elements will be listed under more than one life history requirement category.



Wildlife Habitat Response Model

Taxonomic group:	Ungulates
Species:	Mule deer / Odocoileus hemionus

Life History Requirements		Key Wildlife Habitat Elements	Change in Habitat Elements						
			Greater than 70% Decrease	41-70% Decrease	11-40% Decrease	No Change (+/-10%)	11-40% Increase	41-70% Increase	Greater than 70% Increase
Reproduction	Nest Sites, Birthing Areas, Breeding Sites	Forb/Herbaceous Cover	○	○	○	○	●	○	○
		Shrub Cover 0-18" height	○	○	○	●	○	○	○
		Trees (all species) 0-4.9" dbh	●	○	○	○	○	○	○
Food Resources	Foraging Habitat	Tree Canopy Cover	○	●	○	○	○	○	○
	Forage, Prey Habitat	Grass Cover	○	○	○	○	●	○	○
		Forb/Herbaceous Cover	○	○	○	○	●	○	○
		Shrub Cover (size classes not specified)	○	○	○	●	○	○	○
Cover	Shelter from Predators, and Environmental Extremes	Shrub Cover (size classes not specified)	○	○	○	●	○	○	○
		Tree Canopy Cover	○	●	○	○	○	○	○
		Shrub Cover 18+" height	●	○	○	○	○	○	○

You may return to this page to examine a different fuel treatment alternative by using the back arrow or starting over.

Figure 1. Example of habitat element input fields. User decides the relative change in each habitat element based on treatment objectives, desired future conditions, or values derived from computer simulation models.

Step 2: Indicate change in habitat elements

The second step of WHRM requires inputs on how a planned fuel treatment will alter the specific habitat elements that are associated with a species. The user specifies the magnitude and direction of change in each habitat element based on one or a combination of the following sources: (1) fuel treatment objectives, (2) desired future conditions, or (3) simulated results using computer models such as FVS-FFE with the WHRM compute variable (see appendix A) and the Understory Response Model for shrubs, forbs, and grasses (Sutherland and Miller, this volume).

The change in habitat elements is a categorical measure of the proportional change in a habitat element relative to pre-treatment conditions (figure 1). As such, habitat elements that are low in abundance will show exaggerated proportional response with small increases or decreases in abundance. For example, if there are only 2 trees in the 20 to 29 cm d.b.h. size class in your stand and one of them dies during a burn, then that mortality will result in a 50% decrease in abundance of that size class of trees. This may or may not be biologically meaningful, depending on the species of interest. Therefore, users need to be aware of the absolute abundance of various habitat elements and make careful decisions when determining the proportional change in habitat elements that are rare in a stand. We recommend selecting "no change" for habitat elements that are at very low abundance in the stand, unless these are absolutely critical to a particular wildlife species.

Step 3: Run model

After the expected change in each habitat element has been selected, click on the button *Run Wildlife Habitat Response Model*. Based on these inputs, WHRM generates a qualitative prediction of changes in the suitability of each habitat element listed (highly positive, moderately positive, slightly positive, neutral, slightly negative, moderately negative, or highly negative) and immediately generates a weighted average habitat suitability (see table 4) for each of the five life history requirements. WHRM generates the habitat element suitability response prediction by multiplying the value given to the relative magnitude of change expected in a given habitat element (table 2) by the expected association of that habitat element with a given species (table 3). For example, in figure 2 under cover, WHRM multiplied the values -1 and 1 to generate a value of –1 (which equates with a slightly negative effect, table 4), because mule deer (*Odocoileus hemionus*) are positively associated (value of 1) with shrub cover for shelter and escape habitat from predators and shrub cover decreased by 11-40% (value of –1) in this treatment. Predicted habitat suitability changes are then averaged within life history requirements weighted by the "confidence" in the habitat association. "Confidence" was quantified as the number of studies demonstrating a given association. Weighted average habitat suitability changes were placed into categories described in table 4.

Table 2. Ordinal values used to quantify the change in habitat elements associated with fuel treatments.

Change in Habitat Element	Value Used in Computation
Decrease more than 70%	-3
Decrease 41-70%	-2
Decrease 11-40%	-1
No change (+/- 10%)	0
Increase 11-40%	1
Increase 41-70%	2
Increase more than 70%	3

Table 3. Values used to quantify the association of a species with a habitat element. Relationships were estimated from correlative studies with response variables including probabilities of occurrence, indices of abundance (number observed or densities), and population estimation.

Slope of a line representing the relationship between a species and a habitat element	Value Used in Computation
Negative	-1
Neutral	0
Positive	1

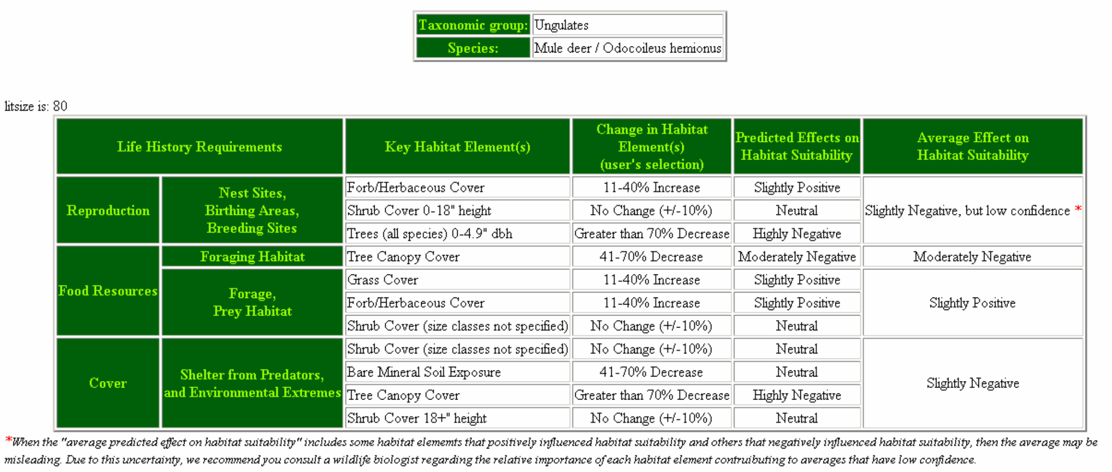
Table 4. Values used to depict species habitat responses to planned fuel treatments.

Value Range	Description
-3.0 to -2.1	Highly Negative
-2.0 to -1.1	Moderately Negative
-1.0 to -0.26	Slightly Negative
-0.25 to 0.25	Minimal to None
0.26 to 1.0	Slightly Positive
1.1 to 2.0	Moderately Positive
2.1 to 3.0	Highly Positive

Averaging across each life history requirement provides an estimate of change in habitat suitability for reproduction, foraging habitat, prey habitat or forage availability, and shelter/cover. The average may not always be a meaningful summary and we recommend looking at how the change in each habitat element influences a species' habitat and discuss these with a wildlife biologist. There will be cases where, within one life history requirement (for example, foraging habitat), the change in some habitat elements results in a positive influence on habitat suitability whereas the change in other habitat elements results in a negative influence. When this occurs, WHRM flags the output with a cautionary statement suggesting that users carefully evaluate the individual habitat elements and/or discuss them with a trained biologist to decide which habitat elements are most important given the existing conditions within the stand and surrounding landscape.

Outputs

The output of WHRM is a table showing the habitat requirements of a given species, how the modeled fuel treatment will change the key habitat elements for that species, and the change in habitat suitability relative to those habitat changes. For example, figure 2 shows an output for the mule deer. In this treatment, the removal of smaller trees and subsequent increase in grass and forbs resulted in increased forage for mule deer despite the negative effects of shrub removal.



Taxonomic group:	Ungulates
Species:	Mule deer / Odocoileus hemionus

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Life History Requirements		**Key Habitat Element(s)**	**Change in Habitat Element(s) (user's selection)**	**Predicted Effects on Habitat Suitability**	**Average Effect on Habitat Suitability**
Reproduction	**Nest Sites, Birthing Areas, Breeding Sites**	Forb/Herbaceous Cover	11-40% Increase	Slightly Positive	Slightly Negative, but low confidence *
		Shrub Cover 0-18" height	No Change (+/-10%)	Neutral	
		Trees (all species) 0-4.9" dbh	Greater than 70% Decrease	Highly Negative	
Food Resources	**Foraging Habitat**	Tree Canopy Cover	41-70% Decrease	Moderately Negative	Moderately Negative
	Forage, Prey Habitat	Grass Cover	11-40% Increase	Slightly Positive	Slightly Positive
		Forb/Herbaceous Cover	11-40% Increase	Slightly Positive	
		Shrub Cover (size classes not specified)	No Change (+/-10%)	Neutral	
Cover	**Shelter from Predators, and Environmental Extremes**	Shrub Cover (size classes not specified)	No Change (+/-10%)	Neutral	Slightly Negative
		Bare Mineral Soil Exposure	41-70% Decrease	Neutral	
		Tree Canopy Cover	Greater than 70% Decrease	Highly Negative	
		Shrub Cover 18+" height	No Change (+/-10%)	Neutral	

**When the "average predicted effect on habitat suitability" includes some habitat elememts that positively influenced habitat suitability and others that negatively influenced habitat suitability, then the average may be misleading. Due to this uncertainty, we recommend you consult a wildlife biologist regarding the relative importance of each habitat element contruibuting to averages that have low confidence.*

Figure 2. Example of the output generated by the Wildlife Habitat Response Model. The output is read left to right.

The background information used to build the model for each species is provided in text format and can be accessed by clicking on the *View Background Information* button that is displayed immediately after the final output table. This includes a description on general distribution, habitat preferences, diet, predators, home range sizes, responses to disturbance, general sources of information used, specific sources of information used in the model, and summaries of selected scientific publications. The summaries describe the information gleaned from each publication that we considered relevant to WHRM and may not match the overall conclusions of the paper or even original objectives. The table and text in each output can be cut and pasted into a planning document.

Table 5. Underlying assumptions in the Wildlife Habitat Response Model.

Assumptions of the Wildlife Habitat Response Model

1. Habitat associations reported in the literature are correct.
2. Habitat associations are linear and mostly one to one.
3. Abundance or probability of occurrence are correlated with habitat suitability

Interpretation and Assumptions

WHRM is most appropriately used to assist managers in decisions about how fuel treatments can be applied such that habitat elements for wildlife species of interest are protected or enhanced. By organizing species-habitat associations by reproduction, food acquisition, and shelter, WHRM enables users to see what part of an animal's life history may be most affected by a fuel treatment. The information in WHRM output also can be used by wildlife biologists to identify information gaps and help direct future research. As is the case with all models, the quality of the prediction is only as good as the data available to run the model and information on some species is limited. As new or revised information on species-habitat associations becomes available, the simple structure of WHRM programming should enable easy and frequent updates.

The primary assumption behind WHRM is that habitat associations reported in the literature are correct (Table 5). One of the potential problems with such an assumption is that most correlative information reported in field studies is untested. Correlative studies generally use an exploratory hindcasting approach to explain patterns observed in species occurrence and abundance at a specific place and period of time. Given that most of these correlations have never been validated with novel datasets, there is certain risk in using them to make general predictions about species responses to habitat change because environmental, demographic, and ecological conditions may vary considerably among locations or over time (see additional discussion in Morrison and others 1992). Although we cannot account for these variable or unmeasured factors, the user can reduce the uncertainty of their predictions by only applying WHRM to make predictions in appropriate forest types and by checking the background information used to build the model for each species.

The second assumption of WHRM is that habitat associations are linear and essentially one to one. In other words, a 11-40% increase in a positively associated habitat element results in a 11-40% increase in habitat suitability. Assumptions that all responses are linear can be misleading. For instance, some species may prefer intermediate levels of canopy closure, avoiding closed canopy and open forests. We did not address non-linear relationships in this version of the model. If a species selected intermediate levels of a habitat element, we generally did not include it in the models. Instead, this information was described under "General Habitat Associations" in the Background Information output.

The third assumption of WHRM is that species abundance or probability of occurrence is correlated with habitat suitability. For the most part, the habitat associations in WHRM are based on a species' abundance in relation to a habitat element. However, high abundance does not necessarily mean high quality habitat, especially when considering altered habitats (Van Horne 1983). Estimates of vital rate parameters (for instance, fecundity, survival, dispersal) are needed to make a true assessment of habitat quality or potential source and sink habitats. However, these more complicated modeling procedures are only possible with fairly extensive field data on local populations and thus are generally beyond the scope of most fuel plans and NEPA assessments.

Limitations

The accuracy of the WHRM predictions will vary depending on the species examined. WHRM will likely work best for species that are closely associated with forest structure and composition or have very specific habitat needs (for example, trees of a specific diameter for nesting). WHRM may provide meaningful information for some but not all habitats of species that use very different habitats seasonally (for example, elk), use multiple habitats for different life history traits (for example, lynx denning in continuous mature forest but hunting along edges), or are extremely far-ranging (for example, grizzly bears). Habitat generalists and species not closely associated with forest structure and composition will likely not respond to fuel treatments (Pilliod and others, in press) and in such cases, WHRM may not provide much useful information. There are several factors that can influence predictions of habitat suitability. The following paragraphs discuss these factors and limitations to WHRM.

The reliability of WHRM predictions may be strongly influenced by climate patterns such as drought (Fulé and others 2002), post-treatment weather such as intense rainstorms (Robichaud, unpublished data), forest type, landscape physiognomy, subtleties of fuel treatment activities, and other factors. Overall, our confidence in suggested patterns decreases with time since treatment. For example, shrubs are likely to decrease considerably (for example, more than 40%) 1 year after broadcast burning, but then fully recover within 5-10 years depending on the type shrub and level of mortality (Sutherland and Miller, this volume). However, this assumes shrubs are top-killed only and are free from herbivory. Shrubs requiring seed regeneration will take longer and herbivory from large ungulates, like mule deer and Rocky Mountain elk (*Cervus elaphus*), can slow recovery rates of understory shrubs following thinning and/or prescribed burning (Huffman and Moore 2003, 2004).

Another limitation to consider is the scale or extent of predictions. This issue has two facets. First, with the popularity of landscape-level analysis and ecosystem approaches to wildlife management, it may be tempting to use WHRM for purposes beyond its intent and scope. WHRM is intended to be a stand-level predictive tool and should not be extrapolated to broader spatial scales. Second, many of the species included in WHRM do not use one stand for all of their habitat needs. Therefore, WHRM predictions may be less informative for a species that has a large home range and can simply avoid unfavorable habitat conditions without cost. We draw attention to this issue by comparing the size of the proposed treatment area with the typical home range size for a species and provide this information in the output. Hence, the predicted model results only apply for conditions within the stand being altered. Surrounding stand conditions and larger landscape characteristics may ameliorate or exacerbate the predicted results.

Finally, WHRM does not produce quantitative predictions of population responses to fuel treatments nor does it provide a measure of prediction confidence. If a fuel treatment may pose a significant risk to the habitats of a species of concern, we recommend using more specific modeling approaches such as various habitat suitability models or risk assessment tools such as population viability models (for examples, see Roloff and others 2001). Keep in mind, however, that these more complex models require at least some information on habitat patch location, quantity, and quality, and/or information on population sizes, age structures, and vital rates to estimate parameters that are meaningful. This level of information is rarely available for most species and locations.

Despite these limitations, species-habitat matrices are generally considered favorable relative to other habitat-based wildlife modeling approaches because of their practical application, simple model structure, and generality and communicability of model output (table 1 in Roloff and others 2001). WHRM is intended to be easy to understand and use for non-biologists, and yet provide meaningful general predictions about the potential environmental consequences of fuel treatments. As fuel reduction planning is stream-lined and more projects are rapidly moved through the review process, WHRM provides a tool to help managers quickly assess the potential effects of specific fuel treatments on wildlife habitats.

Acknowledgements

The programming for this model was developed by Elena Velasquez. Thanks to Stephanie Rebain for providing the coding for the FVS compute variable. We thank many scientists and managers for reviewing model content and 3 anonymous reviewers that provided helpful comments on earlier versions of this user’s guide.

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Appendix A. Instructions for using FVS-FFE to generate WHRM input data in the proper format.

1. Set the time scale for the simulation to be at least 12 years with 1 year cycles. So if the inventory date is 2004, you should run the simulation from 2004 to 2016 with one year cycles. In this case, 2004 would be for your initial conditions. The treatments would be done in 2005. The 2006 values would be 1-year post treatment. The 2010 values would be 5 years post treatment. And the 2015 values would be 10 years post treatment. If your inventory date is 1990, you can still do the simulation from 2004 to 2016. FVS is will grow the trees up to 2004. Normally, it is not recommended to run FVS on 1-year cycles, but acceptable for 12 years, but not much longer.

2. To get the desired variables, the WHRMCompVar.kcp file needs to be inserted into the run. This is done by going to the Edit Simulation window. You insert it into a simulation by clicking on "Insert from file" and selecting WHRMCompVar.kcp.

3. Make sure the Fire and Fuels Extension to FVS is actually used. This simply means making sure that an FFE keyword, such as FuelOut, is included in the run.

4. If any treatments are being simulated, add the appropriate keywords.

5. Lastly, you need to add the Compute 1 post processor into the simulation.