## 2.5 Lewis's Woodpecker in Burned Forests

We developed and evaluated habitat suitability index (HSI) models for nesting Lewis's woodpeckers with nest location data collected following wildfire in dry conifer forests of Idaho and Oregon, U.S.A. (table 2.5.1; Cross *et al.* In Review). Lewis's woodpeckers favor nesting in burned forests dominated by ponderosa pine (*Pinus ponderosa*), with open canopies containing moderately high snag densities. To quantify these habitat associations, we developed models using remotely sensed variables describing burn severity, canopy cover, and topography (table 2.5.2; Cross *et al*. In Review).

**Table 2.5.1**—Summary of sampling at four wildfire locations Idaho (ID) and Oregon (OR), USA where we trained and validated habitat suitability models for nesting Lewis's Woodpeckers (LEWO).

| | Timing | | *n* | |
|---|---|---|---|---|
| Wildfire Location | Ignition | Sampling | nest | non-nest* |
| Foothills, ID | 1992 | 1994–1996 | 202 | 52 |
| Star Gulch, ID | 1994 | 1995–1998 | 50 | 82 |
| Toolbox, OR | 2002 | 2004–2007 | 47 | 499 |
| Canyon Creek, OR | 2015 | 2016–2018 | 49 | 112 |

*Non-nest sites represented a random sample drawn from within survey units for nest searching.

**Table 2.5.2**—Descriptions of environmental variables used to develop habitat models for nesting Lewis's woodpeckers in burned forests of the Idaho and Oregon. Local-scale variables quantified conditions at the nest site (3×3 cells; 0.81 ha; 2 ac), while landscape-scale variables quantified conditions approximating home range size inclusive of most woodpecker species (1 km radius circle; 0.62 mi = 314 ha; 776 ac). Descriptive statistics (mean [SD]) are reported across all study locations where the model was developed at nest sites and available sites representing the area surveyed.

| Variable (abbreviation) | Description | Nest | Non-Nest |
|---|---|---|---|
| Local burn severity (LocΔNBR) | Median index of delta normalized burn ratio (ΔNBR) using Landsat TM satellite imagery for a 0.81 ha (2 ac) moving window | 490.88 [188.45] | 351.66 [201.04] |
| Landscape open canopy cover (LndCCop) | Percentage of 314 ha (776 ac) moving window with >0 – ≤10% canopy cover recorded before fire (%) | 31.18 [15.92] | 17.63 [14.90] |
| Landscape low canopy cover (LndCClo) | Percentage of 314 ha (776 ac) moving window with >10 – ≤40% canopy cover recorded before fire (%) | 30.92 [10.72] | 31.63 [11.27] |

We developed models across four wildfire locations—Foothills, ID, Star Gulch, ID, Toolbox, OR, and Canyon Creek, OR—and validated models at individual locations testing with predictive performance. We modeled relationships at nest and available sites using weighted logistic regression (WLR) and measured predictive performance using RPI (Resource Selection Function Plot Index, Wiens et al. 2008). We selected the top model base on greatest minimum

RPI measured across all four individual validation locations. The final model provided by the ArcGIS tool describes positive relationships with local burn severity and with open (0–10%) and low (10–40%) landscape (314 ha; 776 ac) canopy cover (table 2.4.3). Model HSIs designate suitable nesting habitat.

**Table 2.5.3**—Selected habitat model developed to inform habitat mapping for Lewis's woodpecker following wildfire in Idaho and Oregon, U.S.A. Performance criteria used for model selection was RPI (resource selection function plot index; Wiens *et al.* 2008), a measure based on predictive performance at individual wildfire locations. We selected the model with the greatest minimum RPI.

| Model coefficients | Min RPI | Mean RPI (SD) |
|---|---|---|
| Intercept (-3.180) + LocΔNBR (0.004) + LandCCop (0.016) + LandCClo (0.029) | 0.696 | 0.872 (0.141) |

**3.5 Lewis's Woodpecker Burned Forest Model Applicability**

The HSI model for Lewis's woodpecker in burned forests included in the FIRE-BIRD toolbox was developed from nest locations at two wildfire locations in Idaho (Foothills, 1992; Star Gulch, 1994) and two in Oregon (Toolbox, 2002; Canyon Creek, 2015). These wildfires burned areas consisting largely of lower-elevation dry conifer forest dominated by ponderosa pine (table 2.5.1). The final model exclusively quantifies relative indices of nesting habitat suitability for Lewis's woodpecker.

As with other post-fire models, nest locations were surveyed within 5 years of wildfire. Survey units at all four locations were subjected to selective-cut salvage logging. The only location where salvage logging occurred throughout the survey period (Foothills, ID) was where we saw the lowest predictive performance for the model incorporated in the tool (RPI = 0.696). The Foothills location consisted of patchy habitat among nest sites and non-nest sites and was unique due to its adjacency to expansive sagebrush habitat (at other locations, forest surrounded nest sites and non-nest sites). This natural patchiness, which existed prior to openings created by wildfire coupled with salvage logging throughout the study area, may have disrupted the correspondence between pre-fire canopy cover and post-fire snag density. At other locations, logging extent and intensity was limited but varied. Therefore, we caution against applying our model to areas like Foothills characterized before fire by extensive non-forest openings and/or extensive salvage logging (see Appendix C in Cross *et al.* In Review for summary of canopy cover at Foothills), and we suggest that you compare descriptive statistics for your project area with those at our model-development locations to avoid application in landscapes where conditions differ substantially from the characteristics where models were developed (see table 2.5.2).

To avoid over-fitting models to conditions at individual locations, models excluded logging variables. Models nevertheless showed predictive ability among locations, suggesting that logging was not extensive enough to negate model applicability. However, logging extent/intensity exceeding the four wildfire locations could compromise the accuracy of the remotely sensed data upon which our model depended. We expect that our model is most useful

for informing management planning in post-fire dry conifer forests prior to the occurrence of salvage logging.

We expect some limits to model applicability. Limited representation of burned locations ($n = 4$) across the species' range restricts information for quantifying relationships with other potentially important habitat components. For example, open and low landscape canopy cover varied in availability across the four wildfire locations. Furthermore, model predictability improved when using field-collected variables related to nest tree size and snag density. Most importantly, models are most applicable in dry conifer forest. This is the forest type where we developed the models, like other post-fire models; therefore, we offer an application mask that excludes areas not including dry conifer forest types (based on LANDFIRE vegetation classifications).

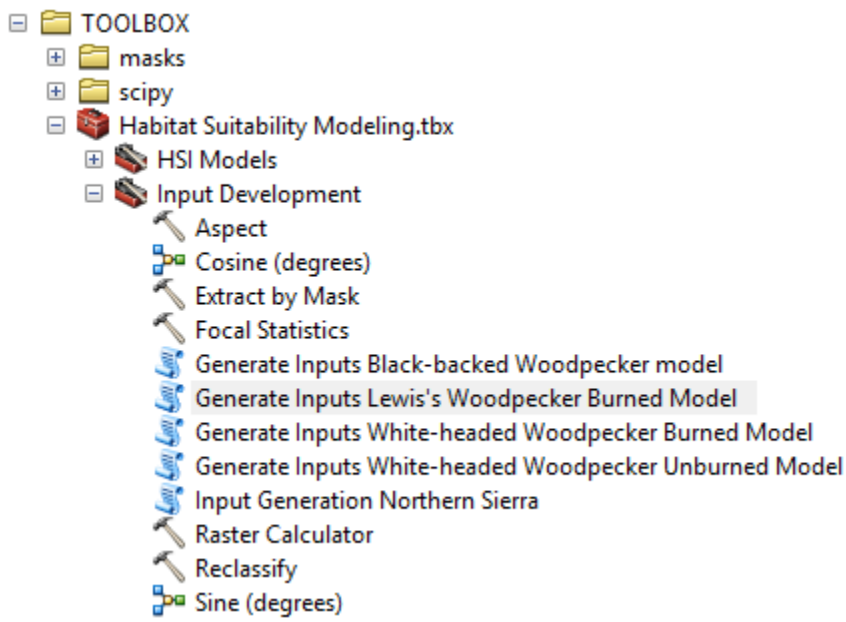
### 4.5 Lewis's Woodpecker Instructions for Burned Forests

The principal output generated by the application tool for Lewis's woodpecker in burned forests is a 30-meter resolution raster layer with HSI values ranging from 0 to 1 (i.e., least to most suitable for nesting). The study area must have been burned by large enough wildfires (~1,000-acres in the western United States) for the necessary input data to be retrievable. As with all ArcGIS tools, you can choose among various file extensions indicating format for output layers, of which we recommend ".tif" or ".img" formats for flexibility in file naming (the more restrictive default ArcGrid file naming leaves off a filename extension). Additional data processing steps will be required if you do not have access to the Forest Service T-drive. We provide "optional" data processing instructions for such cases in step I.C (below).

I. Retrieve and compile data layers. In this step you will process remotely sensed data to compile the variables listed in table 2.5.2. Pathnames for data files cannot have spaces, so when saving the data layers, ensure that no parent folders in the file pathnames have spaces. For example, "C:\GIS\DATA\lewiss woodpecker\cancov.tif" is an invalid path name. Change the name of the "lewiss woodpecker" folder, to "lewiss_woodpecker" or "LEWO" (for example).
   A. Follow instructions in steps I.A.1–5 in subsection 4.1 Black-Backed Woodpecker Instructions for the Inland Northwest (above) to retrieve MTBS burn severity data for the wildfire relevant to your project. As noted in step I.A.5, the fire perimeter polygon shapefile will end in "…burn_bndy.shp", and the burn severity raster will end in "…dnbr.tif" (hereafter "burn_bndy.shp" and "dnbr.tif", respectively).
   B. Compile the three input variables needed for model application (table 2.5.2) using the associated input generation tool described here. **Note: This input generation tool can be operated only within the Forest Service Citrix environment or from an environment with access to the Forest Service T drive. If neither of these conditions is met, follow step I.C (below) for input compilation.** This tool requires input of burn severity ("dnbr.tif") and burn perimeter ("burn_bndy.shp") files (retrieved in step I.A, above), which it combines with default pre-fire canopy cover data to compile inputs. The default canopy cover data represent 2012 gradient nearest neighbor (GNN) data from LEMMA (2018). These data may represent pre-fire canopy cover for wildfires that burned in 2012 or later in the states of CA, OR, and WA unless additional disturbance occurred between recording default imagery (after 2011 but before 2012 fire seasons) and the wildfire of interest. We have observed default imagery poorly representing pre-fire canopy cover at

some locations for reasons unknown, so you should carefully inspect default canopy cover data to verify they make sense and are reasonably accurate. In cases where default canopy cover data are adequate, continue with steps I.B.1–6 (below) to compile input layers. **For wildfires that occurred outside the states of CA, OR, and WA, before 2012, or for which default imagery are unlikely to accurately represent canopy coverage immediately before wildfire (e.g., due to additional disturbance in the interceding period), uncheck the "Use Standard Canopy Cover" option, then follow steps in I.C (below) to use data from an alternate source.**

1. From ArcCatalog, navigate to the TOOLBOX → Habitat Suitability Modeling.tbx → Input Development, and open the "Generate Inputs Lewis's Woodpecker Burned Model" tool.



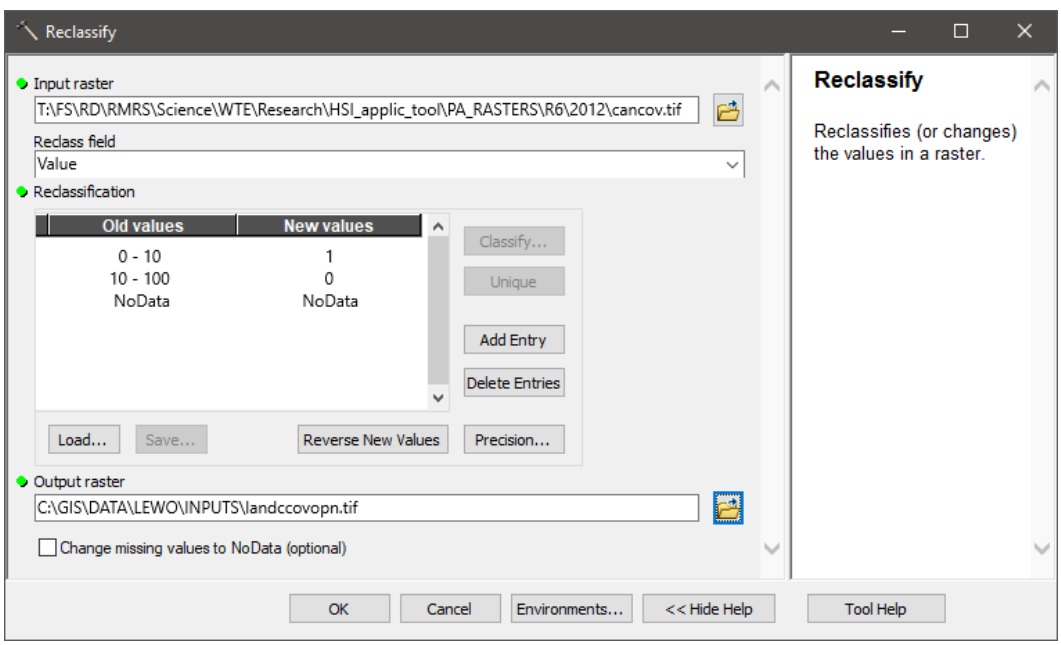

*Screenshot of the filepath for the Input Development tools*

2. Identify or create a folder where you want model inputs to be stored. Under "Workspace", navigate to this folder. Then click "Add".
3. For "Burn Severity", use "dnbr.tif" downloaded from MTBS (see step I.A, above). You can either navigate from outside the tool interface and drag and drop "dnbr.tif" or navigate from the "dNBR" box and click "Add".
4. For "Burn Perimeter", navigate to "burn_bndy.shp" downloaded from MTBS (I.A). You can either navigate from outside the tool interface and drag and drop the burn_bndy.shp into the "Fire Perimeter" box or navigate from within the tool and click "Add".
5. Click OK (all outputs will be stored in the INPUTS folder in your workspace).
6. Close this dialog when completed successfully.

C. *Optional* – Steps for compiling input layers ("LndCCop" and "LndCClo") from alternate data sources are described here. **These instructions are for users who lack access to the Forest Service T drive or if default canopy cover layers do not cover project areas.** These steps assume you have obtained three layers for your project area: (1) a "dnbr.tif" file describing burn severity (see step I.A, above), (2) a "burn_bndy.shp" file delineating

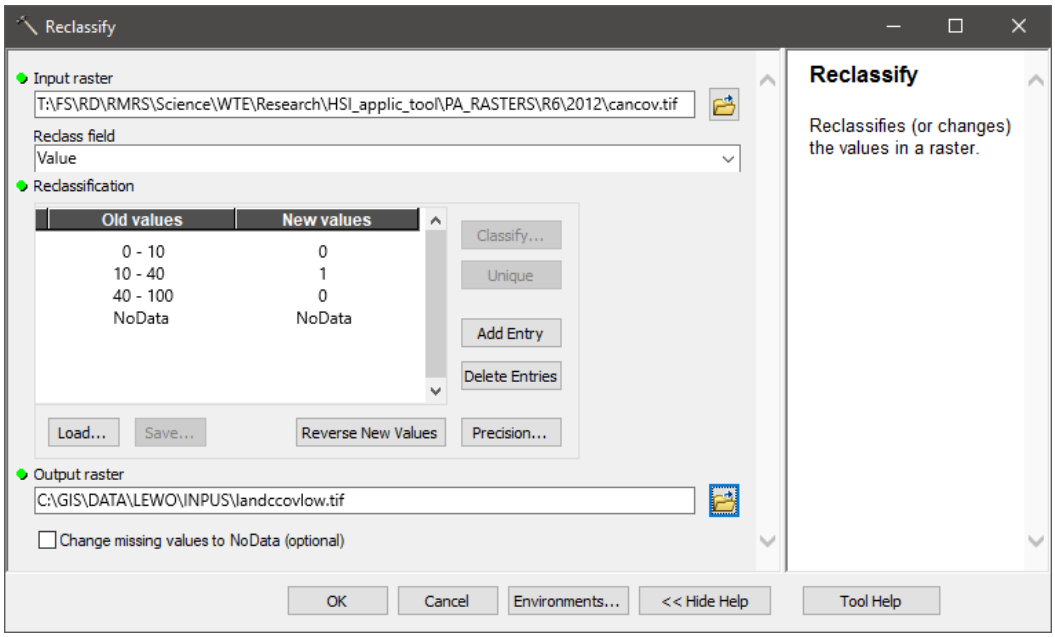
the fire perimeter (see step I.A, above), (3) a 30 m pixel raster layer that provides continuous canopy cover (percent). Raster layers (1, 3) should cover all areas inside and ≥ 1 km outside burn_bndy.shp. If coverage does not meet this criterion, layers should cover all areas within and ≥ 1 km outside study units relevant to management planning or decisions, in which case you should use a shapefile describing study unit boundaries in place of burn_bndy.shp in step I.C.5 (below). Note: We suggest following the file naming directions below to more easily keep track of files referenced in these instructions.

1. Identify or create a folder named "INPUTS" in your workspace. Place intermediate and final layers generated from steps I.C.2–6 (below) in this folder. The remainder of these steps will refer to this folder as the INPUTS folder.
2. Classify your continuous canopy cover layer (see step I.B above; hereafter, "cancov.tif") to generate "LndCCop.tif" layer.
   a. Open the Reclassify tool (TOOLBOX → Habitat Suitability Modeling.tbx → Input Development → Reclassify).
   b. Designate "cancov.tif" as the "Input Raster". Adjust the "Reclassification" table to match the image below to generate two classes: value = 1 for cancov < 10 and value = 0 for cancov > 10.




*Dialog box for the Reclassify tool for the open canopy cover layer*

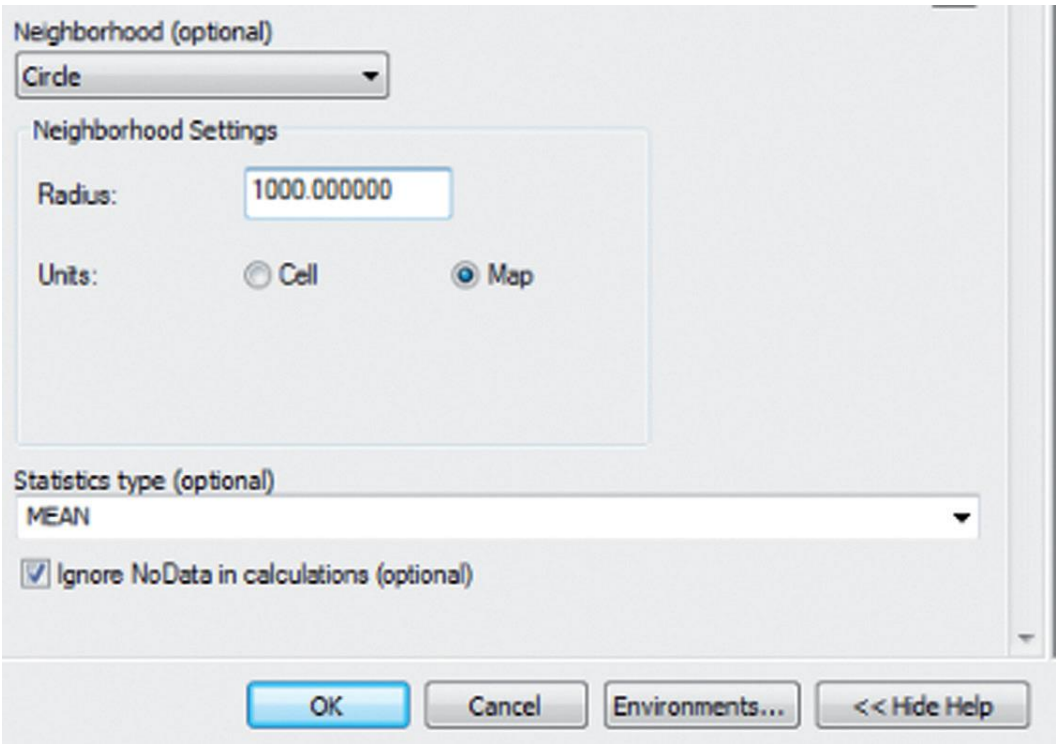
   c. Browse to your INPUTS folder and name the output file "LndCCop.tif". Click OK.
3. Classify your continuous canopy cover layer (see step I.B above; hereafter, "cancov.tif") to generate "LndCClo.tif" layer.
   a. Open the Reclassify tool (TOOLBOX → Habitat Suitability Modeling.tbx → Input Development → Reclassify).
   b. Designate "cancov.tif" as the "Input Raster". Adjust the "Reclassification" table to match the image below to generate three classes: value = 0 for cancov < 10, value = 1 for cancov > 10 & < 40 and value = 0 for cancov > 40.




*Dialog box for the Reclassify tool for the low canopy cover layer*

c. Browse to your INPUTS folder and name the output file "LndCClo.tif". Click OK.

4. Apply the "Focal Statistics" to both "LndCCop.tif" and "LndCClo.tif" (from previous step, I.C.3) and further process with "Raster Calculator" to generate layers describing percent area burned or open.
   a. Open the Focal Statistics tool (TOOLBOX → Habitat Suitability Modeling.tbx → Input Development → Focal Statistics).
   b. Designate "LndCCop.tif" as the "Input Raster".
   c. Apply the "Circle" neighborhood with "Radius" set to "1000" and "Units" set to "Map" with "Statistics type (optional)" set to "Mean" and select "Ignore NoData in calculations (optional)". Name the resulting layer "LndCCop_prp.tif".
   d. Run the Focal Statistics tool again (Repeat steps I.C.4.a–c), this time designating "LndCClo.tif" as the "Input Raster" (see below screenshot). Name the resulting layer "LndCClo_prp.tif".



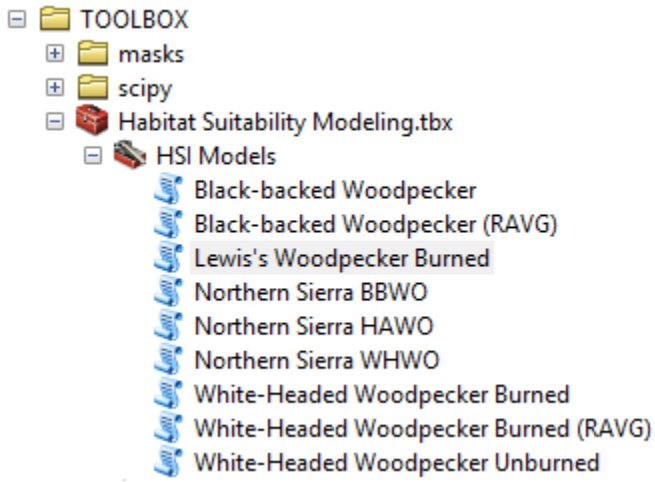

*Dialog box for neighborhood and statistics type*

e. For each layer generated in the last step ("LndCCop_prp.tif" and "LndCClo_prp.tif"), apply the Raster Calculator tool again (TOOLBOX → Habitat Suitability Modeling.tbx → Input Development → Raster Calculator) to rescale to percentages, that is, multiply "LndCCop_prp.tif" and "LndCClo_prp.tif" by 100. Designates the INPUTS folder as the output location and name the output files "LndCCop_premask.tif" and "LndCClo_premask.tif", respectively.

5. Clip percent area layers to the fire perimeter to produce final input layers. Open TOOLBOX → Habitat Suitability Modeling.tbx → Input Development → Extract by Mask. Successively designate layers generated in the prior step (see preceding step I.C.4; "LndCCop_premask.tif" and "LndCClo_premask.tif") as Input layers and "burn_bndy.shp" as the mask. Designate the INPUTS folder as the output location and name the output files "LndCCop.tif" and "LndCClo.tif". For "LndCClo.tif", set the snapping layer (Under "Environments… → Processing Extent → Snap Raster" at the bottom of the "Extract by Mask" window) to "LndCCop.tif" to ensure both layers are snapped together.
6. To remain organized and ensure input layers can be easily located in the future, delete all intermediate layers (cancov.tif, LndCCop_prp.tif, LndCClo_prp.tif, LndCCop_premask.tif, and LndCClo_premask.tif) or move them to another appropriate location (e.g., a subfolder named "intermediates" in your INPUTS folder in your workspace).

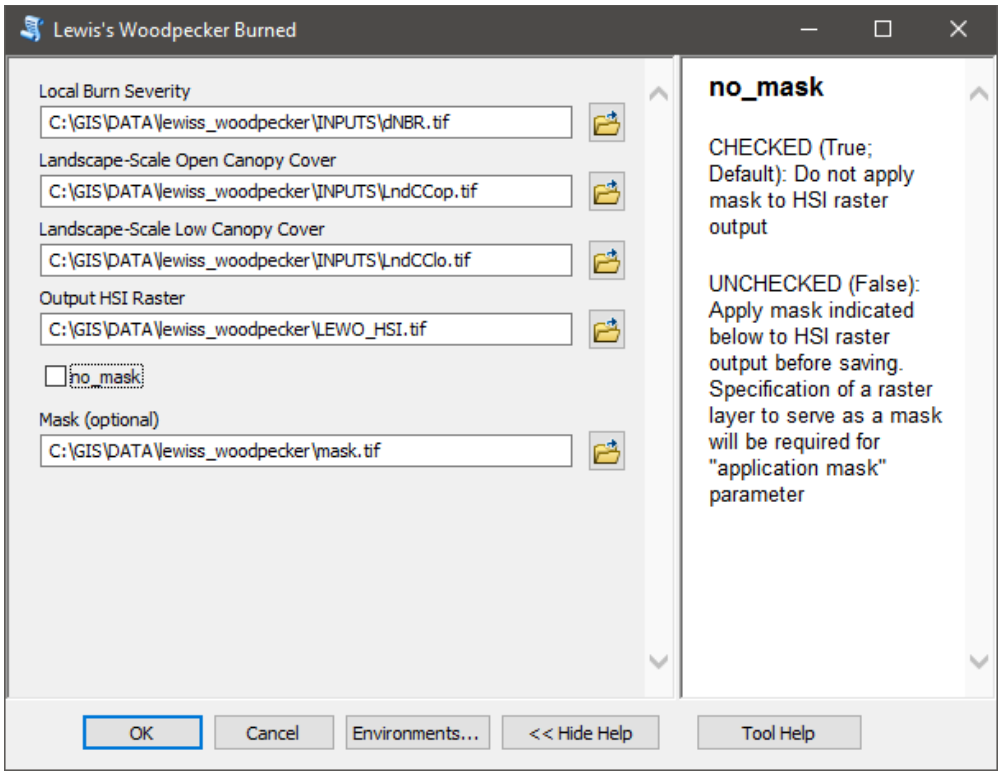
II. Run model application tool.

A. From ArcCatalog, navigate to "TOOLBOX → Habitat Suitability Modeling.tbx → HSI Models" and open the "Lewis's Woodpecker Burned" tool.




*Screenshot of the filepath for the HSI models tools*

B. For "Local Burn Severity", "Landscape-Scale Open Canopy Cover" and "Landscape-Scale Low Canopy Cover" use "LocdNBR.tif", "LndCCop.tif", and "LndCClo.tif" input rasters, respectively (see steps under I.A–C, above). Either navigate to the INPUTS folder from outside the tool dialog box and drag and drop each input layer or navigate from within the dialog box and click "Add" to designate each layer.
C. For "Output Raster", designate an appropriate location and filename for the output raster. Click the button with the folder icon to the right, locate your workspace, and create a meaningful name, such as "LEWO_burned_HSI.tif". Again, you can specify alternate file formats for rasters, but we recommend ".img" or ".tif" because these allow longer filenames than the default ArcGrid format (which omits a filename extension).
D. Select masking option. You must either check the "no mask" box or provide a raster layer to serve as a mask for the final HSI output layer. If neither is done, the tool will produce an error. Any raster layer can function as a mask, whereby pixels in the mask layer with NODATA will indicate which values to be dropped (i.e., converted to NODATA) in the final HSI output. We provide a potential mask at TOOLBOX → masks → LEWO → dcfmask.img. This mask covers all areas characterized as dry conifer forest where GNN data are available (Washington, Oregon, and northern California). Alternatively, you may provide a comparable mask that covers your project area or check the "no mask" box, bearing in mind limitations to model applicability previously described (see 3.5 Lewis's Woodpecker Burned Forest Model Applicability). With a mask selected, the input window for this tool will resemble the screenshot below.




*Dialog box for the masking option for the Lewis's woodpecker HSI model.*

E. Click on OK to run the model. A series of progress bars will flash. If necessary, close the "Results" window once "succeeded" is displayed. To view the model output, navigate to the output file (e.g., "LEWO_HSI.tif") and select the preview pane tab.

### 5.1.A Guidelines for Lewis's Woodpecker Postfire Habitat Models

**Table 5.1.4**–Number of nests and observed nest densities where habitat suitability models were developed for nesting Lewis's woodpeckers in the Pacific Northwest by suitability class. Habitat suitability index (HSI) bins define suitability classes. All surveys were conducted within 5 years following wildfire. Density and percent nest values in parentheses are 95% confidence intervals generated by bootstrapping ($n$ = 243, 600 m × 600 m grids replicated 10000 times). Area surveyed = as the proportion of sites representing the surveyed area in each suitability class multiplied by the total area surveyed at each location. Expected percent nest values assume observed densities and equal area surveyed in each suitability category.

| | **Values by habitat suitability (HSI) class** | | |
|---|---|---|---|
| **Summary quantity** | **Low** | **Moderate** | **High** |
| HSI bins | 0.00–0.30 | 0.30–0.58 | 0.58–1.00 |
| No. nests | 23 | 148 | 146 |
| Area surveyed (ha) | 6,153 | 11,294 | 7,085 |
| Area surveyed (ac) | 15,204 | 27,907 | 17,507 |
| Density (nests per ha) | 41 | 114 | 245 |
| Expected % nests | 10 | 29 | 61 |

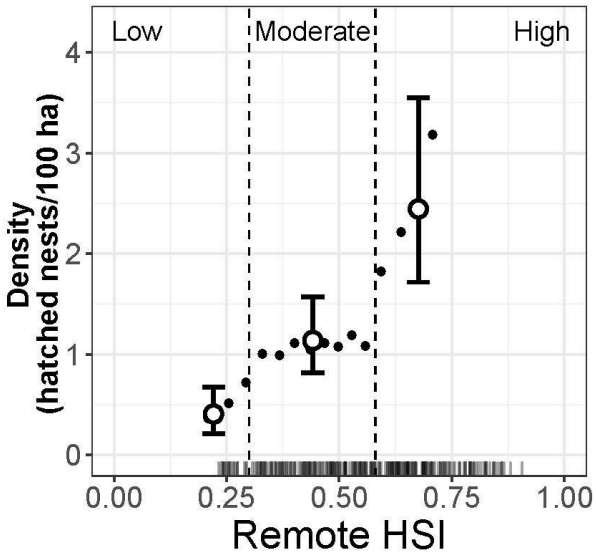



**Figure 5.1.4**—Densities of hatched nests for Lewis's woodpeckers along an HSI gradient in burned forest. Low, moderate, and high suitability classes are differentiated by two HSI thresholds placed at natural breaks in densities for equal-area moving-window bins in this figure (small dots) and the distribution of nest site HSIs (rug bars). Open circles and error bars are density estimates and bootstrapped 95% confidence intervals for each of the three habitat suitability classes.

**How to Cite**

If you use the Lewis's woodpecker burned forests tool, please cite the following literature:

Cross, T.B., Latif, Q.S., Dudley, J.G., Saab, V.A. In Review. Lewis's woodpecker nesting habitat suitability: predictive models for application within burned forests. In Review 2020, *Biological Conservation*. **Issue:Page-Page**. doi:

Latif, Quresh S.; Saab, Victoria A.; Haas, Jessica R.; Dudley, Jonathan G. 2018. FIRE-BIRD: A GIS-based toolset for applying habitat suitability models to inform land management planning. Gen. Tech. Rep. RMRS-GTR-391. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 74 p.