Appendix T – Northern Spotted Owl

Forecasting Habitat Change, and Northern Spotted Owl Population Responses, in Washington, Oregon and California

The U.S. Fish and Wildlife Service used HexSim (Schumaker 2011)—a spatially explicit, individual-based, population model—to help inform its decisions on northern spotted owl recovery and the delineation of northern spotted owl critical habitat. The U.S. Fish and Wildlife Service described the development and parameterization of its HexSim model in USDI FWS 2011 (pp. Appendix C) and USDI FWS 2012.

Early in its planning process, the BLM sought the advice of federal experts familiar with the applications of HexSim and other population models to inform management decisions. Based on its review, the BLM chose to use the northern spotted owl HexSim model developed by the U.S. Fish and Wildlife Service to inform its decisions on northern spotted owl recovery and the delineation of northern spotted owl critical habitat (USDI FWS 2011, pp. Appendix C, and USDI FWS 2012). The BLM did this because:

- Federal experts familiar with similar models had found HexSim to be as reliable as those models while requiring less calibration and time to operate.
- The U.S. Fish and Wildlife Service had developed its HexSim model through a peer-reviewed process and with the advice and assistance of northern spotted owl experts from throughout the northern spotted owl's range.
- The range-wide scale of the U.S. Fish and Wildlife Service HexSim model suited the BLM's analytical needs.
- The BLM was one of the cooperators that had advised the U.S. Fish and Wildlife Service during the development of its HexSim model and, thus, already was familiar with its operation and applications.
- The BLM determined that it could use the U.S. Fish and Wildlife Service's model, fully parameterized, to meet its specific planning needs with considerable savings in cost and time.
- The U.S. Fish and Wildlife Service already was familiar with the development and applications of its model. Since the U.S. Fish and Wildlife Service would advise the BLM during the development of the RMP, and the U.S. Fish and Wildlife Service eventually would render a biological opinion on the Proposed RMP, the BLM determined that the U.S. Fish and Wildlife Service's HexSim model would best suit its requirements for evaluating the potential effects of the alternatives and the Proposed RMP on northern spotted owl populations.

The BLM did not modify any of the population parameters in the U.S. Fish and Wildlife Service's HexSim model. The only difference between the U.S. Fish and Wildlife Service's use of its HexSim model and the BLM's use was that the BLM recalibrated the time step that corresponded to the year 2013.

The U.S. Fish and Wildlife Service calibrated its HexSim model to run with northern spotted owl relative habitat suitability surfaces (i.e., digitized geospatial datasets used for computer analyses), which it derived using 1996 and 2006 Gradient Nearest Neighbor (GNN) data developed by the U.S. Forest Service (Ohmann and Gregory 2002). Relative habitat suitability values range from 0 to 100, with higher numbers signifying better habitat value. The values themselves are derived from a variety of biotic and abiotic variables, such as the amount of forest canopy cover, mean tree diameter, and degree and direction of terrain slope. To create its relative habitat suitability surfaces, the U.S. Fish and Wildlife Service used MaxEnt (Phillips *et al*. 2006) to compare variables present on broad landscapes with those associated with known northern spotted owls nest sites.

Concurrent with the U.S. Fish and Wildlife Service process, the U.S. Forest Service created a separate set of northern spotted owl relative habitat suitability surfaces to evaluate implementation of the Northwest Forest Plan (Davis *et al*. 2011). The U.S. Forest Service based its surfaces on a unique set of MaxEnt models that it also derived using 1996 and 2006 GNN data (Davis *et al*. 2011, pp. 27–28).[46] Differences between the two processes included:

- The two agencies used different variable scales to create their MaxEnt models. The U.S. Forest Service variables were specific to 30 × 30-m pixels (Davis *et al*. 2011, p. 28), whereas the U.S. Fish and Wildlife Service variables were at the scale of 200 ha (USDI FWS 2012, p. 84).
- The two agencies trained their MaxEnt models to geographically different modeling regions (Davis *et al*. 2011, p. 35 and USDI FWS 2011, p. C-13).
- Whereas the U.S. Forest Service trained its MaxEnt models primarily on discrete variable values, which could change independently (Davis *et al*. 2011, p. 99), the U.S. Fish and Wildlife Service trained its MaxEnt models on a combination of discrete and compositional variables. Compositional variables are combinations of discrete variables, all of which must be present (USDI FWS 2012, p. C-38).
- The U.S. Forest Service used LandTrendr to examine changes in forest stand conditions from 1996 to 2006 from timber harvest, insects and disease, and wildfire (Davis *et al*. 2011, pp. 28, 29, 121–125).

Before the BLM northern spotted owl modeling process began, the BLM decided to use Woodstock for its planning process to forecast changes in forest stand growth and timber yield variables on the decision area (i.e., the BLM-administered lands in the planning area) (see the Vegetation Modeling Section in Chapter 3). Therefore, for the northern spotted owl modeling, the BLM created relative habitat suitability surfaces for the decision area that changed each decade for five decades (see Chapter 3, Northern Spotted Owl), using Woodstock variable outputs. In addition, to generate credible range-wide simulations of northern spotted owl demographic responses to the alternatives and the Proposed RMP using HexSim, the BLM:

- Created relative habitat suitability surfaces for all 'other lands' (i.e., lands other than BLM-administered lands in the planning area) within the northern spotted owl's range so that simulated northern spotted owls could move across planning area boundaries and respond to habitat conditions on all land ownerships inside and outside the planning area, and;
- Forecasted changes to those surfaces from forest ingrowth, timber harvest, and wildfire at the same decadal increments as its Woodstock model, something not done by either the U.S. Forest Service or U.S. Fish and Wildlife Service.

Thus, to simulate habitat conditions on the decision area, the BLM could not use the U.S. Forest Service or U.S. Fish and Wildlife Service relative habitat suitability surfaces, because the BLM needed to vary the relative habitat suitability surfaces according to each of the alternatives and the Proposed RMP and over time, using variables derived from Woodstock.

[46] Both the U.S. Fish and Wildlife Service and U.S. Forest Service trained their MaxEnt models using 1996 GNN data because the intent was to develop models that predicted the relative habitat suitability for northern spotted owls when competitive interactions with barred owl still were relatively uncommon. For this purpose, 1996 GNN data are better than 2006 and 2012 GNN data because, when associated with northern spotted owl nesting-roosting location data, they better represent the association between habitat conditions and northern spotted owl occupancy before later displacements of northern spotted owls by barred owls. Once the models were trained, both agencies projected their models to 2006 GNN data, the most recent data available. Hence, throughout the remainder of Section S-A, when the BLM refers to U.S. Fish and Wildlife Service 2006 GNN MaxEnt models or U.S. Forest Service 2006 GNN MaxEnt models it always means models developed with 1996 GNN data and applied to 2006 data.

To simulate habitat conditions on other lands within the northern spotted owl's range, the BLM originally hoped to build upon the relative habitat suitability surfaces developed by the U.S. Forest Service because:

- The similarity of scale between the BLM Woodstock variables and the U.S. Forest Service GNN variables potentially made it easier for the BLM to merge its relative habitat suitability surfaces for BLM-administered lands with those generated by the U.S. Forest Service for other lands;
- Since Woodstock generates individual variable values, instead of compositional variable values, the BLM could more-directly compare its MaxEnt models to those created by the U.S. Forest Service, and;
- Woodstock could generate the same variable values used by the U.S. Forest Service to create its relative habitat suitability surfaces, which potentially made the BLM and U.S. Forest Service surfaces more compatible.

In addition, the BLM initially hoped that unpublished U.S. Forest Service LandTrendr results could help it forecast habitat changes on other lands.

Therefore, the BLM programmed Woodstock to generate the same variables used by the U.S. Forest Service GNN MaxEnt models (see Davis *et al*. 2011, p. 99) and, using those variables, planned to apply the U.S. Forest Service's MaxEnt models to the decision area. The BLM initially hoped that there would be sufficient compatibility between the relative habitat suitability surfaces generated from the Woodstock and GNN datasets so that the BLM could use the Woodstock variable outputs for the decision area and the GNN variable outputs for all other lands. If the two sets of variable outputs were insufficiently compatible, the BLM could add a stand age variable to the Woodstock outputs to correlate the two relative habitat suitability surfaces.

Unfortunately, as described below under Model 1, the BLM found that the U.S. Forest Service MaxEnt models would not work in this way. Subsequently, the BLM went through an iterative process (described under models 1–13) to identify and account for design differences between the U.S. Forest Service and U.S. Fish and Wildlife Service GNN MaxEnt models so that the BLM could use the HexSim model developed by the U.S. Fish and Wildlife Service —with little or no recalibration—with relative habitat suitability surfaces that utilized both Woodstock data for the decision area and GNN data for other lands.

A. Developing MaxEnt Models for the Decision Area

Objectives and Selection Criteria

Since the BLM initially sought to use the U.S. Forest Service's GNN MaxEnt models, it first evaluated whether doing so was reasonable for its planning purposes. The BLM used three model assessment criteria to evaluate the utility of the U.S. Forest Service, and subsequently other, MaxEnt models:

1) Whether the current-year relative habitat suitability surface generated by the MaxEnt models had a strong correlation[47] with that generated by the U.S. Fish and Wildlife Service's MaxEnt models. The U.S. Fish and Wildlife Service calibrated its northern spotted owl HexSim model to its own relative habitat suitability surface. If the new relative habitat suitability surfaces were strongly correlated to the U.S. Fish and Wildlife Service's surface, the BLM could use the U.S. Fish and Wildlife Service's HexSim model with the new surfaces with relatively little recalibration of the HexSim model. However, if they were not strongly correlated, a long and detailed recalibration of the HexSim model would be needed. The BLM preferred to avoid a lengthy recalibration.

[47] Strong correlation: The BLM, knowing the substantive differences between the origins of the Woodstock and GNN datasets, did not choose an *a priori* minimum correlation coefficient. Instead, the BLM sought for the highest correlation coefficient it could achieve with the available datasets, and then determined if the coefficient were sufficiently strong to allow the BLM to proceed with its analyses.

2) Whether the relative habitat suitability models applied to BLM-administered lands performed similarly[48] to those applied to non-BLM-administered lands. The spatial scale for evaluating the effects of alternatives and the Proposed RMP on the northern spotted owl population was to occur over the entire geographic range of the northern spotted owl, within modeling regions, and at smaller scales. Hence, the BLM needed the models to perform similarly on the decision area and all other lands within the northern spotted owl's range.
3) Relative habitat suitability surfaces developed for the decision area had to be derived from the forest growth and timber yield variables generated by Woodstock, the most accurate data for those lands.

To determine if criterion 2 were met, the BLM evaluated how its models worked under the No Timber Harvest reference analysis by evaluating the portions of the decision area that occurred in various relative habitat suitability value bins and strength-of-selection bins (see Model 8, below, the first model so evaluated, for more information). This was a heuristic evaluation of the 'reasonableness' of the model(s) applied to decadal changes according to the No Timber Harvest reference analysis. The BLM forecasted changes at decadal intervals for 50 years. If the model(s) worked well, there would be a steady decrease in the portion of BLM-administered lands in low relative habitat suitability value bins and increases in the proportion of that land in higher relative habitat suitability value bins. This evaluation was heuristic because the BLM knew the general trajectory that would be seen if the model(s) worked reasonably well, even though it did not know the specific extent of that change.

Here, the BLM describes its process to develop relative habitat suitability surfaces that met its three assessment criteria. **Figure T-1** outlines the process.

[48] In this context, models 'performed similarly' in terms of their relative progressions, over time, through relative habitat suitability bins and strength-of-selection bins. See Model 8, below, the first model so evaluated, for descriptions of these analyses.

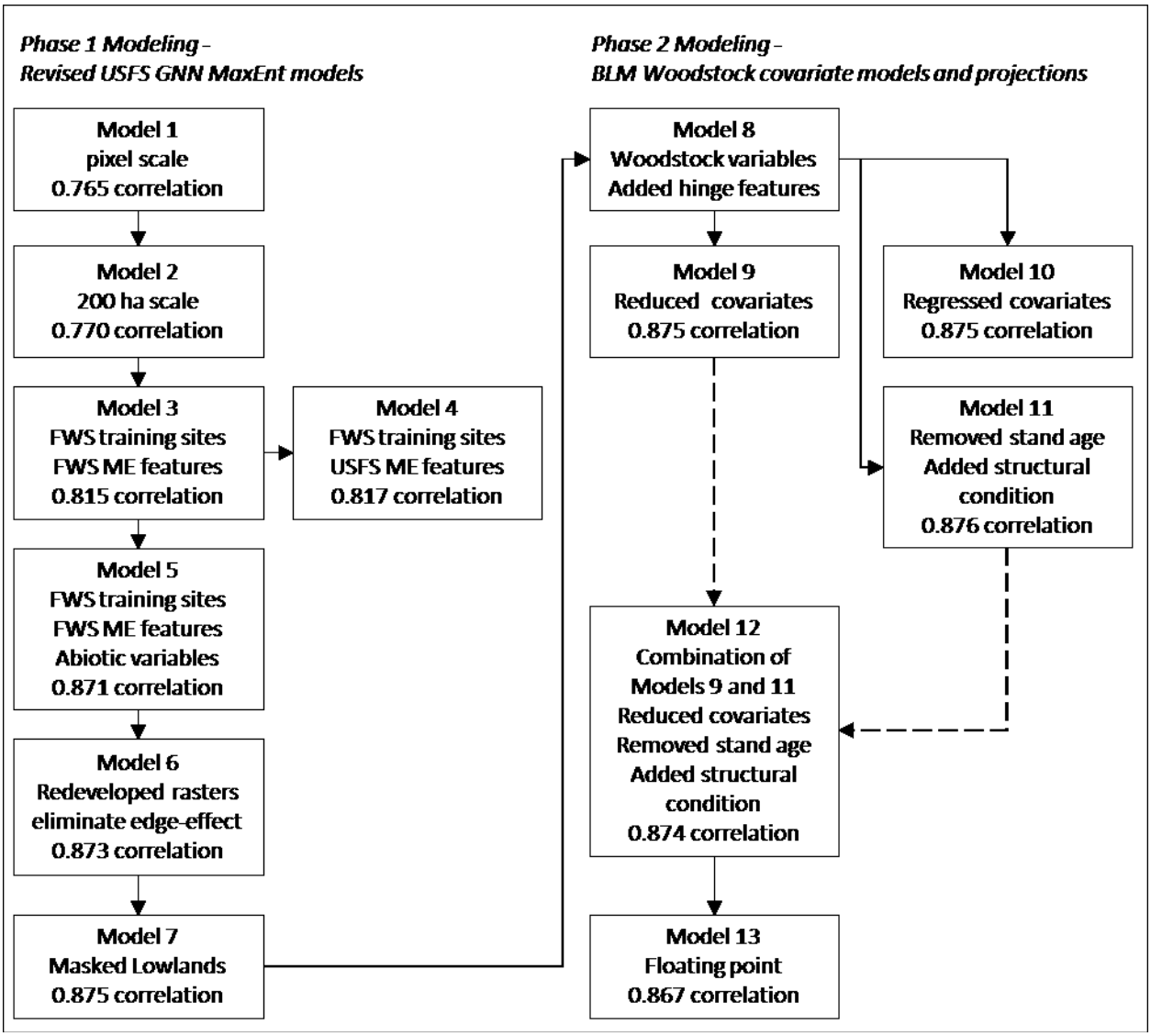


Figure T-1. Flowchart of the BLM MaxEnt modeling sequence
Note: ME refers to MaxEnt

Model 1

The BLM first conducted range-wide comparisons of the U.S. Forest Service (Davis *et al*. 2011) and U.S. Fish and Wildlife Service (USDI FWS 2011, pp. Appendix C) relative habitat suitability surfaces. The BLM overlaid the geographic range of the northern spotted owl with a grid of 86.6-ha hexagons—the grid used by the U.S. Fish and Wildlife Service's HexSim model (USDI FWS 2012, p. 24)—and compared the relative habitat suitability values of both sets of models in each hexagon. As shown in **Figure T-2** the two sets of models produced dissimilar results; the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models estimated more of the landscape to be in the lowest (relative habitat suitability values 0–10) and highest (values greater than 40) bins, whereas the USDA FS 2006 GNN MaxEnt models estimated more of the landscape to be in the middle (values 11–40) bins. These results were not unexpected because, as described above, the U.S. Forest Service and U.S. Fish and Wildlife Service calculated relative habitat suitability values at different scales.

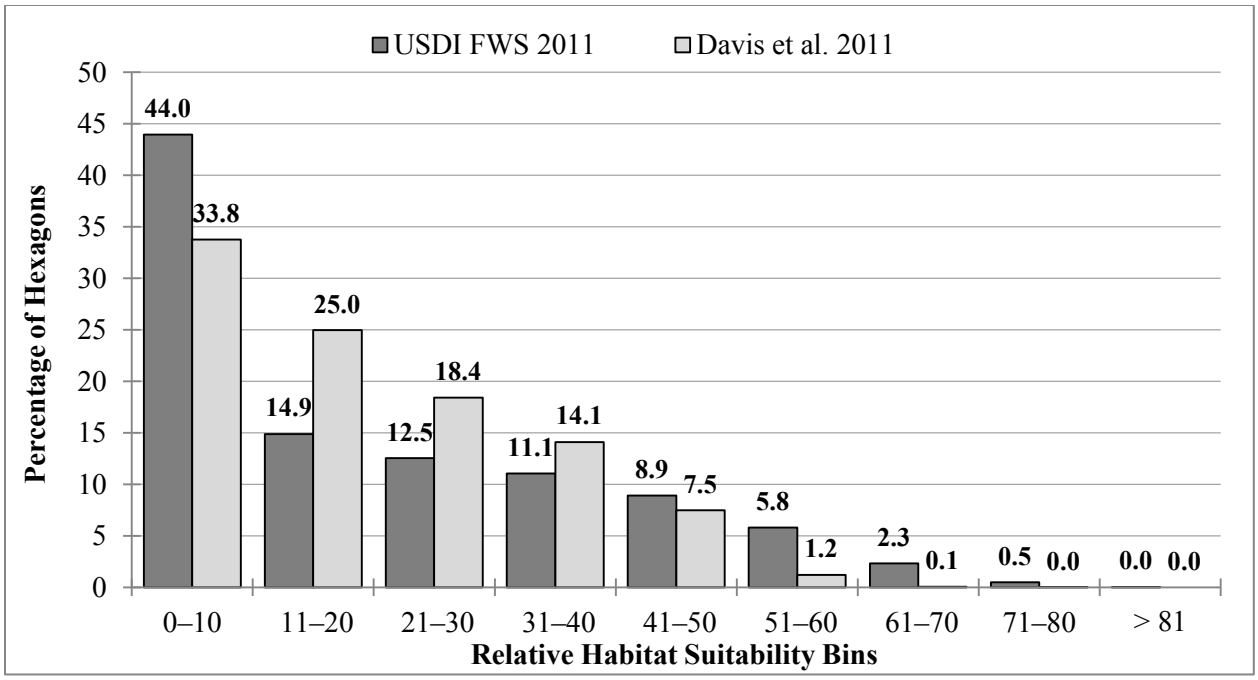


Figure T-2. Distribution of hexagons relative habitat suitability scores among various bins from 2006 GNN MaxEnt models developed by the U.S. Fish and Wildlife Service and the U.S. Forest Service
Source: USDI FWS 2011, pp. Appendix C; Davis *et al*. 2011

The correlation (Pearson r) between hexagon relative habitat suitability values for the two sets of models was 0.765. The BLM sought a stronger relationship as well as greater similarity in the distribution of relative habitat suitability scores. The BLM determined that the U.S. Forest Service 2006 GNN MaxEnt models failed assessment criterion 1.

Model 2

The Model 1 results suggested the influence of an artifact-of-scale; i.e., the correlation would have been stronger if the two sets of MaxEnt models had been calculated at the same scale. Therefore, the BLM ran the comparison again at the 200-ha scale used by the U.S. Fish and Wildlife Service because the GNN data in part were derived from satellite imagery, the spatial accuracy of which increases with scale. Stated another way, although the GNN variable data reasonably describe forest conditions on a landscape, they are less accurate at the 30 × 30 m pixel scale used by the U.S. Forest Service (see Ohmann and Gregory 2002 and http://www.fs.fed.us/wwetac/projects/ohmann.html). The BLM chose the 200-ha scale, because the BLM intended to use its relative habitat suitability surfaces with the U.S. Fish and Wildlife Service's HexSim model, in which simulated northern spotted owls 'select' habitat from a relative habitat suitability surface, and the scale at which northern spotted owls are known to strongly select habitat is the 200-ha (i.e., ~ 500-acre) core use area (see Chapter 3, Northern Spotted Owl).

MaxEnt examines a variety of variables associated with known northern spotted owl nest locations and identifies those variables and combinations of variables, and the relative importance of each variable/combination, that best discriminate between occupied and available locations. The U.S. Forest Service (Davis *et al*. 2011) divided the northern spotted owl range into six modeling regions and used MaxEnt to identify and weigh the best variables/combinations in each region, creating a unique MaxEnt model for each region. To alter the scale of the U.S. Forest Service relative habitat suitability surface, the BLM ran MaxEnt on the same modeling regions defined by the U.S. Forest Service, using the U.S. Forest Service 1996 GNN MaxEnt model for each region, but at the 200-ha scale. In other words, the BLM

created a new set of MaxEnt models (Model 2) by running MaxEnt, with the region-specific models developed by the U.S. Forest Service, to calculate new relative habitat suitability values for each 30 × 30-m pixel based on the mean of the values of each variable within the 200-ha circle around each pixel.

The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt model and the Model 2 estimated relative habitat suitability for hexagons was 0.770. To meet assessment criterion 1, the BLM sought a stronger relationship.

Model 3

Keeping in mind that the U.S. Forest Service (Davis *et al*. 2011) and the U.S. Fish and Wildlife Service (USDI FWS 2011) developed their MaxEnt models for different purposes, the BLM addressed another difference between the two model sets. The U.S. Forest Service MaxEnt models used northern spotted owl nest and pair roost sites from the demographic study areas supplemented by a random subset of northern spotted owl pair sites from the 10-year monitoring report training data set (Davis and Lint 2005) that were outside of the study area boundaries and spaced no nearer to each other than the mean nearest neighbor distance for that modeling region (Ray Davis, U.S. Forest Service, personal communication via e-mail to Eric Greenquist, October 21, 2014). In contrast, the U.S. Fish and Wildlife Service MaxEnt models considered a subset of all known sites (USDI FWS 2011, p. C-21). Because northern spotted owl *known* nest sites tend to occur at greater densities in better habitat, and in areas that received more survey, when MaxEnt considers all sites, it calculates formulas that can be biased by the similarity of the variables around proximal sites. To help control for this, the U.S. Forest Service and U.S. Fish and Wildlife Service used different approaches to limit the number of known sites MaxEnt could consider (i.e., aware of biased datasets, the agencies took different steps to reduce the bias). For Model 3, and all subsequent models, the BLM used the same northern spotted owl locations used by the U.S. Fish and Wildlife Service.

The BLM also used the same MaxEnt feature sets used by the U.S. Fish and Wildlife Service. Features, in MaxEnt, refer to the functional forms or shapes of relationships evaluated in MaxEnt. The BLM did this to determine if it could use variables used by the U.S. Forest Service (albeit, at the different scale) and that the BLM could estimate with Woodstock, while, at the same time, minimizing other differences between the U.S. Forest Service and the U.S. Fish and Wildlife Service models so that the differences in the respective relative habitat suitability surfaces would not be a function of the differences in either training location or MaxEnt specifications (e.g., the features used).

The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 3 estimated relative habitat suitability for hexagons was 0.815, an improvement from previous models. Although the BLM determined that this correlation coefficient was sufficiently strong to meet assessment criterion 1, it sought a stronger relationship.[49]

Model 4

Model 4 was identical to Model 3 except that the BLM returned to the MaxEnt features used by the U.S. Forest Service (Davis *et al*. 2011). The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 4 estimated relative habitat suitability for hexagons was 0.817, nearly identical to that of Model 3, indicating that models 3 and 4 were nearly identical in their predictive capabilities.

[49] Although the BLM did not set an *a priori* correlation coefficient to evaluate model assessment criterion 1, statisticians commonly consider a Pearson r coefficient above 8.0 to be strong or very strong (e.g., Dancey and Reidy 2004).

Model 5

Model 5 was identical to Model 3 except that the BLM added the abiotic variables elevation, curvature, and relative slope position index (USDI FWS 2011, p. C-25 and Table C9). The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 5 estimated relative habitat suitability for hexagons increased to 0.871. The BLM determined that this correlation coefficient met criterion 1, but it evaluated whether a stronger relationship was possible.

Model 6

Model 6 was identical to Model 5 except that the BLM redeveloped the variable rasters to match the methods used by the U.S. Fish and Wildlife Service (USDI FWS 2011, p. C-60). The BLM generated GNN variable rasters using buffered U.S. Forest Service modeling regions to eliminate edge effect. Because variable values reflect the mean of all values within a 200-ha circle, the MaxEnt model for a modeling region can be influenced by the lack of data beyond the regional boundary (i.e., up to 800 m beyond the boundary, the area potentially within the radius of a 200-ha circle). Buffering the modeling region caused MaxEnt to clip data at the regional boundary and calculate mean values from only variable values within the region.

The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 6 estimated relative habitat suitability for hexagons was 0.873. The BLM evaluated whether a stronger relationship was possible.

Model 7

Model 7 was identical to Model 6 except that the BLM masked those portions of western Oregon, such as the Willamette Valley and Puget Lowlands that, due to limited habitat, support few, if any, northern spotted owls. This forced MaxEnt to consider more subtle associations between northern spotted owl sites and the habitat variables associated with those sites. In the BLM MaxEnt analyses, masked areas became unavailable to be included in the random subset of available locations to which MaxEnt compared locations occupied by northern spotted owls. Masking these areas resulted in MaxEnt formulas based on forests in which northern spotted owls occurred compared to other, available, forested areas rather than to the broader array of habitat types, some of which were unoccupied by northern spotted owls. This eliminated major areas of non-potential habitat from the models.

The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 7 estimated relative habitat suitability for hexagons was 0.875.

Through the development of Model 7, the BLM had worked to refine the compatibility of the BLM regional MaxEnt models with those used by the U.S. Fish and Wildlife Service in its HexSim model. As stated earlier, the BLM saw the opportunity to use the unpublished U.S. Forest Service (Davis *et al*. 2011) LandTrendr data to help it forecast changes in relative habitat suitability values on other lands within the northern spotted owl range (lands other than BLM-administered lands in the planning area), and the BLM saw the opportunity to use the U.S. Fish and Wildlife Service's HexSim model to forecast northern spotted owl population responses. With a 0.875 correlation between the Model 7 relative habitat suitability surfaces and those developed by the U.S. Fish and Wildlife Service (both of which used 2006 GNN data), the BLM was confident of its reconciliation.

Model 8

Beginning with Model 8, the BLM replaced the 2006 GNN variable values for the decision area with those produced by Woodstock for 2013. Because the BLM, at this stage, was developing relative habitat suitability surfaces for its administered lands within the planning area, the BLM also begin limiting this, and subsequent models, to the three western Oregon modeling regions defined by the U.S. Forest Service: the Oregon Coast Range, Oregon and California Cascades, and Oregon and California Klamath modeling regions (Davis *et al*. 2011, p. 35). Finally, the BLM added the hinge feature to MaxEnt, adding this feature to the threshold, quadratic and linear features the BLM had added to Model 3. Adding the hinge feature allowed MaxEnt to consider more subtle associations between variables, an attempt to improve its predictive capability.

With these changes, the BLM began an iterative modeling process to—

1. Project the current MaxEnt model for each of the three western Oregon modeling regions to the Woodstock variables (i.e., beginning with Model 8, apply the Model 8 MaxEnt formulas to the 2013 Woodstock-generated variable values for the decision area) by using the MaxEnt .lamdas files from the model developed with the 1996 GNN data;[50]
2. Evaluate the projected MaxEnt outputs by (a) relative habitat suitability bins and (b) strength-of-selection habitat class distributions[51] through the decadal time-series (2013-2063);
3. Refine the model variables (i.e., generate new models, beginning with Model 9), and;
4. Repeat steps 1 through 3 with each set of new and refined MaxEnt models until all three of the assessment criteria were met.

As further explanation, MaxEnt is a multivariate model; i.e., its predictions are influenced by both the state of individual variables and how each variable co-varies with the other model variables. The U.S. Fish and Wildlife Service (USDI FWS 2011) and U.S. Forest Service (Davis *et al*. 2011) MaxEnt models were projected to 2006 GNN data. In contrast, for the decision area, the BLM would use the variable values derived from Woodstock. Thus, the BLM began evaluating how the 2006 GNN- and 2013 Woodstock-derived variables co-varied.

Figure T-3 shows scatterplots of the relationship between each pair of the biotic variables from 2006 GNN data (left) and 2013 Woodstock data (right) for the decision area. The BLM did not evaluate abiotic variables because the sources of those variables are the same for both models. For the initial comparisons, the BLM evaluated 2006 GNN data (the most recent dataset available at the time) and Woodstock's estimates for 2013 conditions on the decision area. It is important to note that the GNN and Woodstock datasets were derived through substantively different processes, so the BLM anticipated substantive, albeit undefined, differences between the two datasets.

[50] To clarify: The BLM developed all of its MaxEnt models using 1996 GNN data, then projected those models to 2006 GNN, 2012 GNN and 2013 Woodstock data.

[51] Based on its modeling needs (see Chapter 3, Northern Spotted Owl), the BLM divided northern spotted owl habitat into categories based on strength-of-selection. This was similar to the process used by the U.S. Fish and Wildlife Service (USDI FWS 2011, pp. C-31 – C-39) but, in the BLM's case, the BLM used four categories: (1) 'strongly selected against,' (2) 'selected against,' (3) 'selected for,' and (4) 'strongly selected for.' For additional information, see **Sections C** of this appendix.

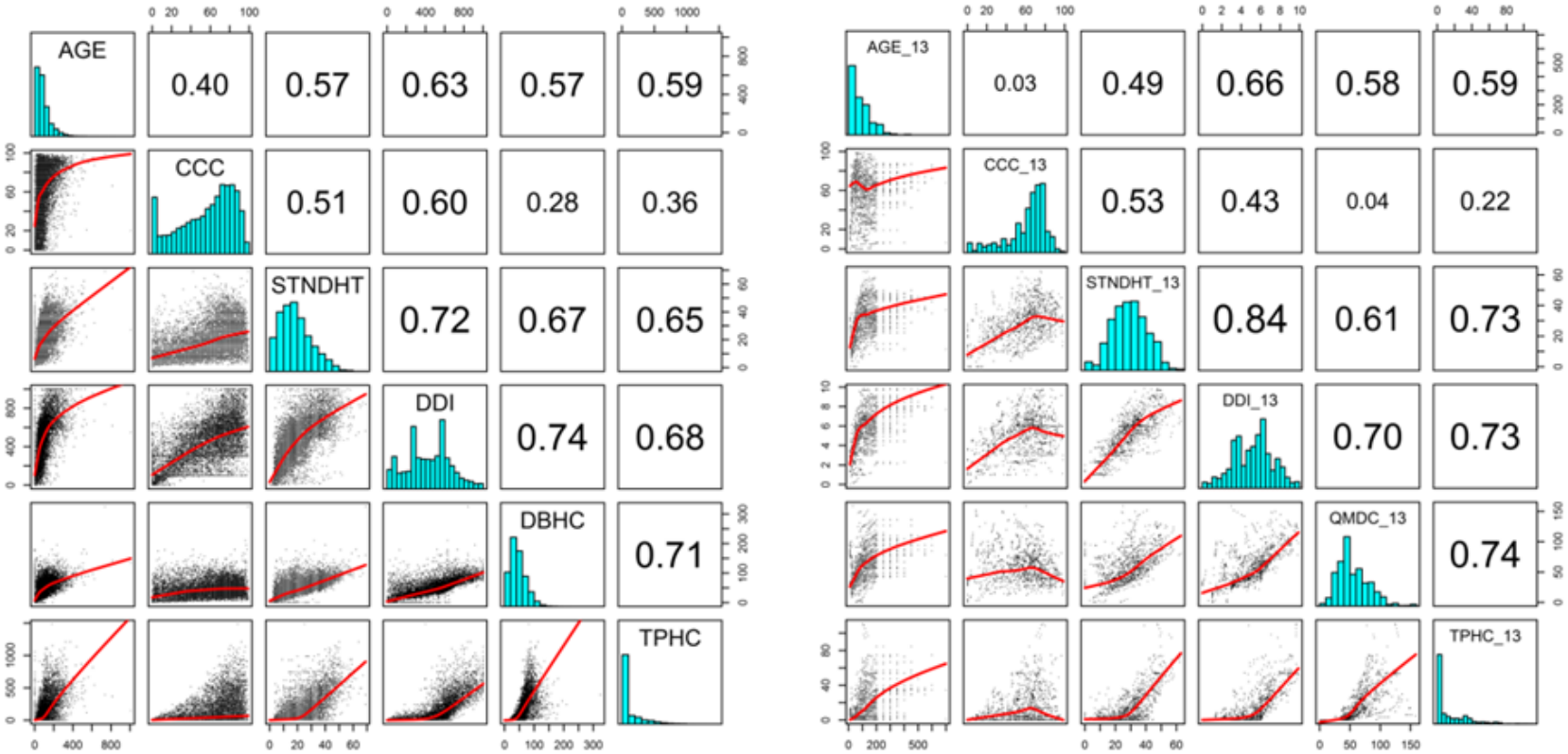


Figure T-3. Bivariate scatterplots for select 2006 GNN variables for the three western Oregon modeling regions (left) and 2013 Woodstock variables for the decision area (right)

Note: Both matrices display the XY scatter plots for each pair of variables, using a non-linear LOWESS smoother (locally-weighted scatterplot smoothing, a type of non-parametric regression) for the fitted line, in the lower left, the covariate histogram for each pair of variables across the diagonal, and the Pearson's correlation coefficient for each pair of variables in the upper right. Variable abbreviations are defined in the text, below, except DBHC, which refers to the mean trunk diameter of conifers, similar to quadratic mean trunk diameter of dominate and co-dominate conifers (QMDC_13).

The comparisons revealed very different relationships between stand age (AGE in **Figure T-3**) and canopy cover of all conifers (CCC), stand age and stand height (STNDHT), stand age and the number of large conifer trees per hectare (TPHC), canopy cover of all conifers and stand height, canopy cover of all conifers and stand diameter diversity index (DDI), canopy cover of all conifers and quadratic mean trunk diameter of conifers (QMDC), and canopy cover of all conifers and the number large conifer trees per hectare. Most disconcerting were the differences in the relationships of conifer canopy cover to stand height, diameter diversity index, mean conifer trunk diameter, and the number of large conifer trees per hectare. In all cases, Woodstock estimated that, as canopy cover increased beyond approximately 70 percent, each of these variables would decrease. In contrast, GNN represented these same relationships as increasing in all cases, though the rate of increase varied from slight (number of large conifer trees per hectare) to rapid (stand height and stand diameter diversity index).

In accordance with assessment criterion 2 the BLM also compared the models in terms of decadal progressions of relative habitat suitability. To this point, the correlations the BLM had calculated were between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the BLM 2006 GNN MaxEnt models at both modeling region and range-wide scales. For the BLM Woodstock models, the focus of the evaluation was the temporal trend in relative habitat suitability and habitat distributions. Given that the first projection of habitat change in the BLM's Woodstock model was the No Timber Harvest reference analysis, the BLM expected that the percentage of BLM-administered lands with low relative habitat suitability would decrease while the percentage in intermediate and higher relative habitat suitability would increase. The BLM based this expectation on its knowledge that northern spotted owls preferentially select areas with larger trees and more structural complexity and, as trees get older, they get larger, and such forests acquire more structural diversity. The BLM did not have a specific expectation on the exact quantity or percentage of BLM-administered lands in lower, intermediate, and high relative habitat suitability bins, only of the trends over time in each of those bins. The BLM's evaluations were meant to check on the trends.

However, as shown in **Figure T-4**, although the temporal trends in relative habitat suitability showed a reduction over time in the percentage of the landscape in the lowest relative habitat suitability categories and an increase in the highest relative habitat suitability category, the trend in the intermediate categories (40–50, 50–60, 60–70) were in the opposite direction than what was expected, particularity in the Oregon and California Cascades Modeling Region (**Figure T-4 B**).

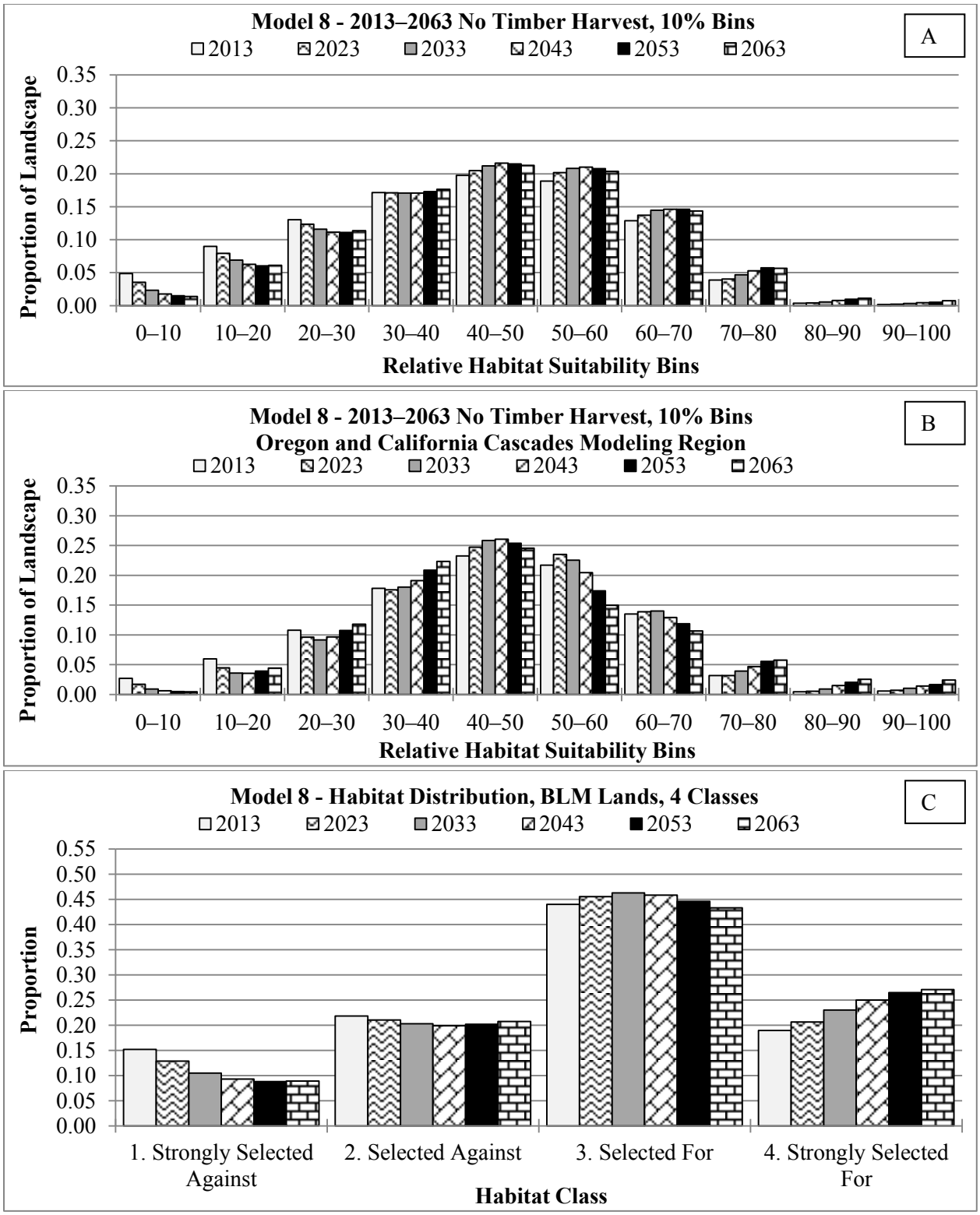


Figure T-4. No Timber Harvest: distribution of relative habitat suitability by decade for Model 8, on the decision area (A and C), and on BLM-administered lands in the Oregon and California Cascades Modeling Region (B)

Note: Histograms A and B show BLM-administered lands in each relative habitat suitability bin at the start of each of six decades. Histogram C shows BLM-administered lands in each strength-of-selection bin at the start of each of six decades.

In part, these trends in variable value with age and relative habitat suitability progression arose because the models generated from Woodstock variable data were not always indicative of how forests on BLM-administered lands develop. For example, an existing 140-year-old stand on BLM-administered lands does not exhibit the structural characteristics that an existing 40-year-old stand would be expected to exhibit in one-hundred years. The 40-year old stand might have received commercial thinning and other silvicultural practices that would result in different stand metrics when it eventually becomes 140 years old. Timber harvests before 1960 tended to be more extensive and intensive than later harvests, and subsequent regeneration commonly occurred through natural seeding. In contrast, timber harvests after 1960 more likely left legacy trees and riparian buffers, and the subsequent regeneration more commonly was the result of planting, fertilization, and thinning. Thus, younger stands on BLM-administered lands commonly exhibit some structural characteristics, such as canopy cover, that are greater than those of some older stands.

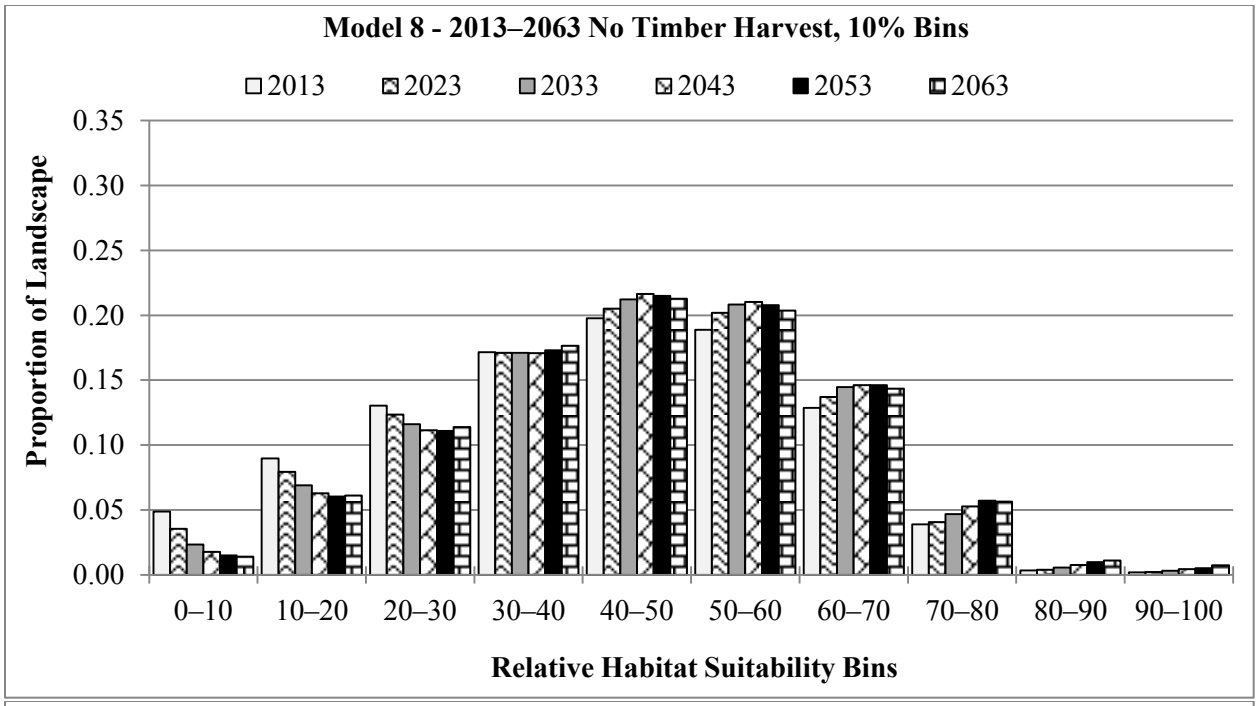
This analysis revealed that the BLM could not simply use Model 8 with the Woodstock-derived variable values. For example, as shown in **Figure T-3**, in the BLM 2013 Woodstock MaxEnt model, stand height was very influential. In the 2006 GNN data, stand height increased nearly linearly with stand age (**Figure T-3**, left matrix, STNDHT/AGE). In contrast, according to the 2013 Woodstock data, stand height increased rapidly with increasing age for young stands, but then the rate of increase decreased dramatically (**Figure T-3**, right matrix, STNDHT_13/AGE_13). The effect of these many differences was that, when the BLM used the Model 8 MaxEnt formulas (which were derived from 1996 GNN data) with the 2013 Woodstock variable values, relative habitat suitability decreased as stands got older, or, at least, their rate of increase was less than represented by the GNN data. Therefore, the BLM had to further modify the MaxEnt model to better reconcile how the 2013 Woodstock and 2006 GNN variables co-varied.

The BLM dealt with the appreciably different forms of relationships between the 2006 GNN and 2013 Woodstock variables by removing some of those variables, as described below. At this point, the BLM questioned whether it could meet model assessment criteria 2 and 3, especially given that age was an influential variable in the models. Additionally, similar to previous models, the BLM evaluated whether it could find stronger relationships between its newly developed models and the model developed by USDI FWS (2011).

Model 9

Model 9 was identical to Model 8 except that the BLM reduced the variable set of each modeling region based on its evaluation of differences in 2006 GNN and 2013 Woodstock variable distributions observed in the scatterplots and histograms generated by Model 8. The BLM removed those variables that strongly influenced a model's predictions and co-varied with other variables substantially differently within the 2006 GNN and 2013 Woodstock data. For the Oregon and California Klamath Region the BLM removed canopy cover of all conifers (CCC in **Figure T-3**) and the number of large conifer trees per hectare (TPHC); for the Oregon and California Cascades Region the BLM removed stand height (STNDHT) and the number of large conifer trees per hectare; and for the Oregon Coast Range Region the BLM removed stand height. Removing these variables allowed other variables to become more influential in the models. The reduced sets of variables produced what the BLM interpreted as a more reasonable distribution of changes in relative habitat suitability by decade, given the habitat change under the No Timber Harvest reference analysis.

Figure T-5 and **Figure T-6** compare the results of Models 9 and 8; Model 9 demonstrated a more-expected distribution of relative habitat suitability by decade.



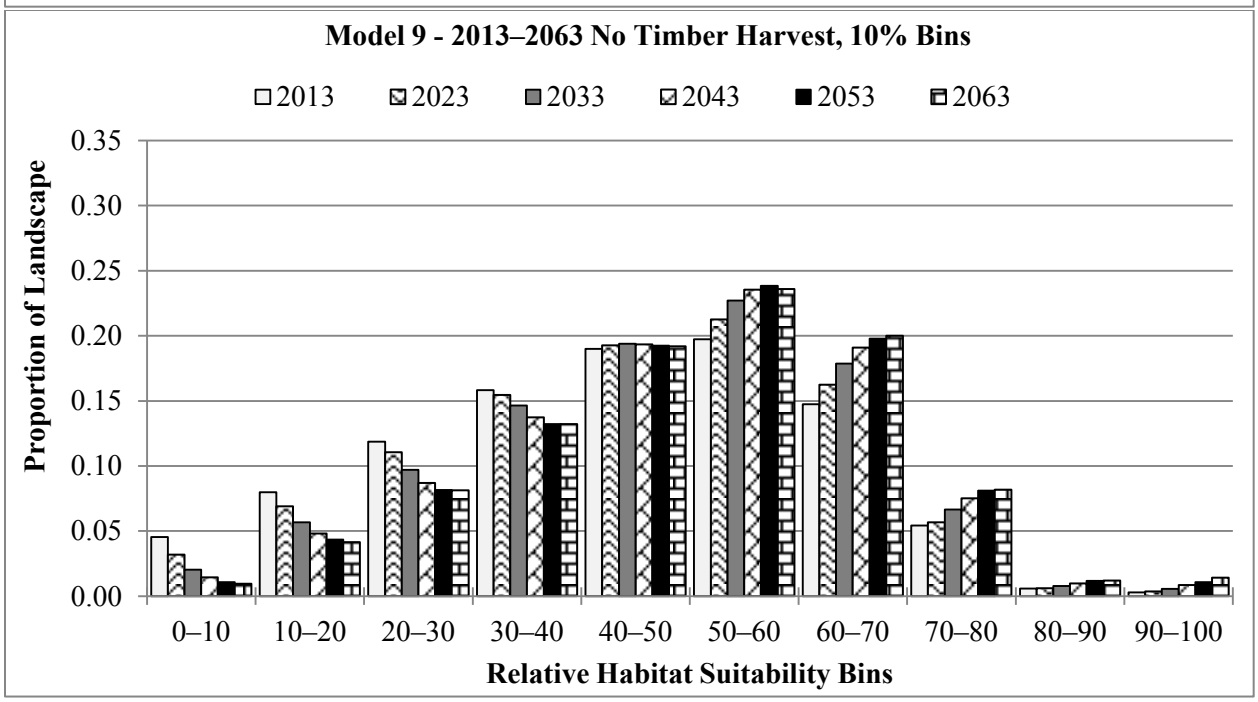


Figure T-5. No Timber Harvest: distributions of relative habitat suitability by decade for Model 8 (top) and Model 9 (bottom) on the decision area

Note: The histograms show the portion of BLM-administered lands in each relative habitat suitability bin at the beginning of each of six decades.

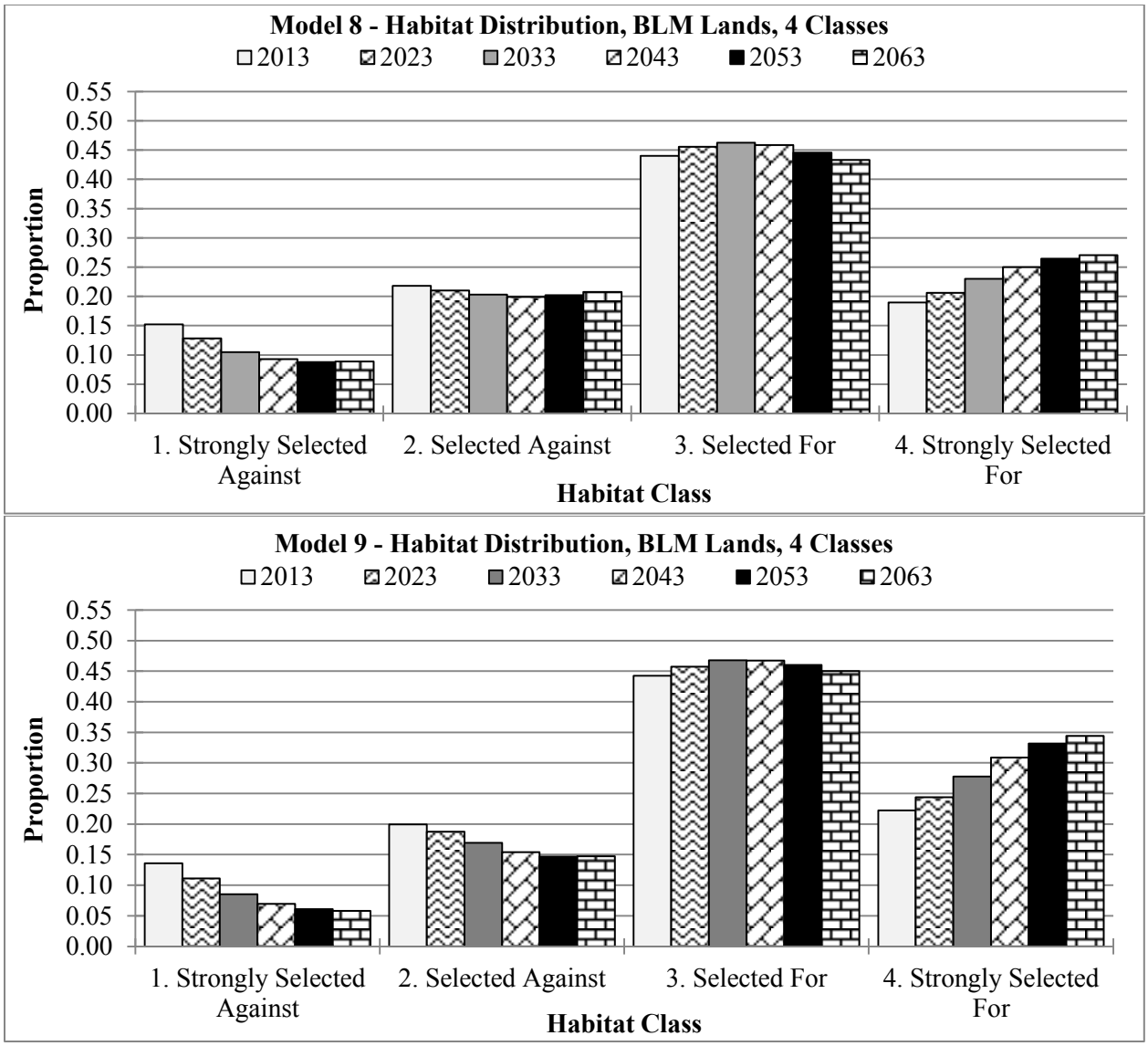


Figure T-6. No Timber Harvest: distribution of relative habitat suitability by decade for Model 8 (top) and Model 9 (bottom), on the decision area

Note: The histograms show the portion of BLM-administered lands in each strength-of-selection bin at the beginning of each of six decades.

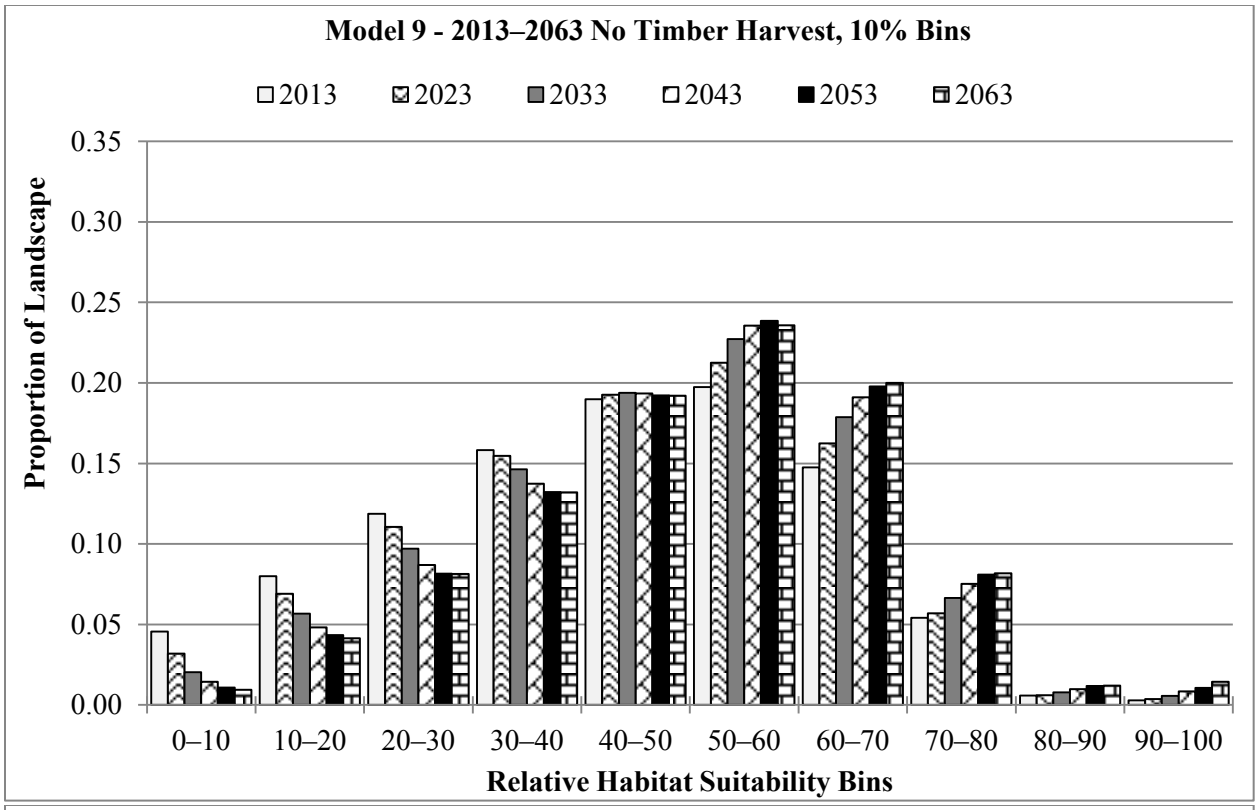
The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 9 estimated relative habitat suitability for hexagons was 0.875, identical to that of Model 7. Nonetheless, the lack of the expected increase in the selected-for habitat class in **Figure T-6** indicated the need for further refinement. The BLM still questioned whether it could meet model assessment criteria 2 and 3, given that age was an influential variable in the models.

Model 10

Model 10 was identical to Model 8 except that, for those modeling regions and for those variables that showed declines with age, the BLM created regression equations to predict each of those variables as a function of age. The regression equations that best fit the data always were logarithmic (threshold)

relationships and had the effect of smoothing the associations. The BLM did this because these variables appeared in the original 2006 GNN MaxEnt models, but, for the 2013 Woodstock representation of BLM-administered lands, they sometimes showed counter-intuitive relationships—such as mean tree diameter and stand height declining as stands aged—only to sometimes increase at older ages. In part, these relationships probably were an artifact of limited data; relatively few BLM inventory plots exist in forest stands with very old trees. The BLM developed these regression equations within each of the three western Oregon modeling regions. The BLM also removed canopy cover of all conifers from the set of modeling covariates, because the distribution relative to age, even when regressed, was highly inconsistent with GNN canopy cover distributions.

As shown in **Figure T-7**, when compared to Model 9, Model 10 generated a more-expected and logical trend in relative habitat suitability change over time. The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 10 estimated relative habitat suitability for hexagons again was 0.875. However, the BLM subsequently determined that Model 10 was not viable due to issues with the stand age variable.



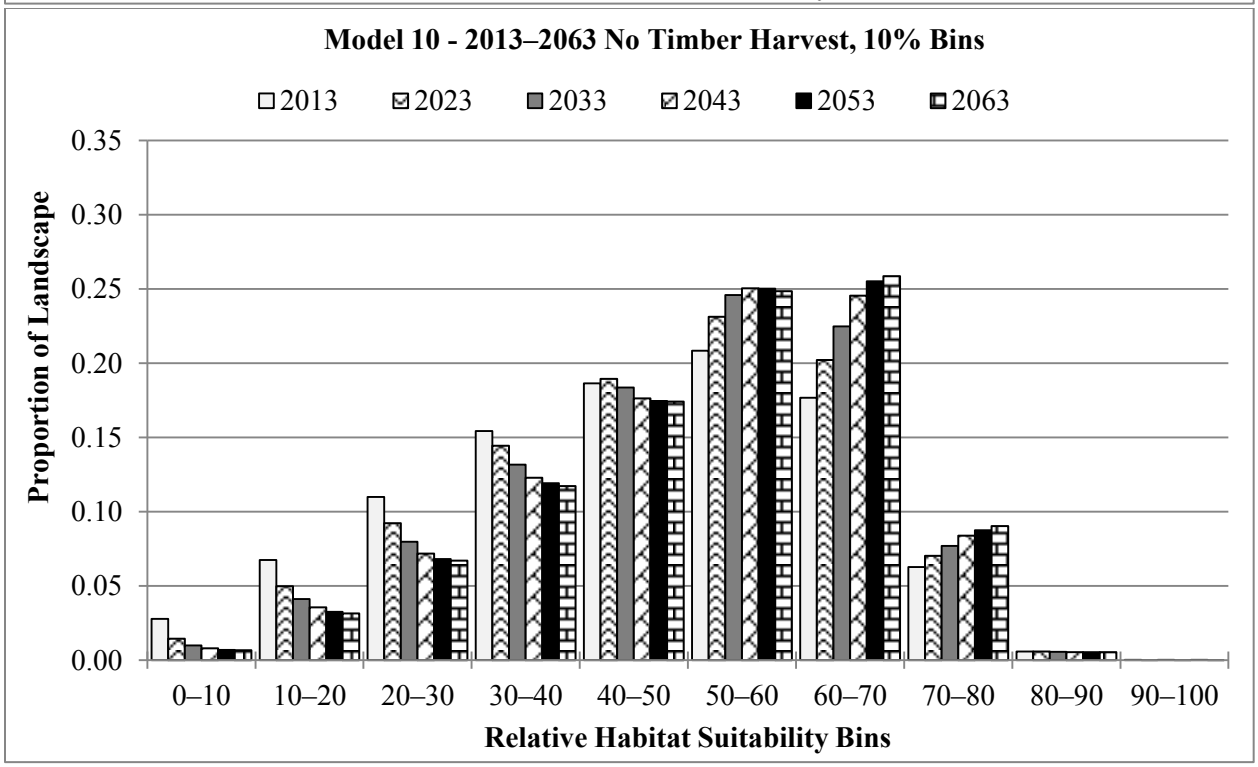


Figure T-7. No Timber Harvest: distributions of relative habitat suitability by decade for Model 9 (top) and Model 10 (bottom) on the decision area

Note: The histograms show the portion of BLM-administered lands in each relative habitat suitability bin at the beginning of each of six decades.

Woodstock, when it forecasts the treatment of a stand, does not threat stand age consistently. Instead, when Woodstock forecasts a treatment, it retains the original stand age or resets the stand age to 0, depending on the nature of the treatment (e.g., light thinning versus regeneration harvest). Thus, over time, forest stands of the same age value could have substantially different values for other variables. Since the BLM was creating relative habitat suitability surfaces for different decadal time steps, it could not rely on stand age as a variable. For this reason, Model 10 was not viable.

Model 11

Model 11 was identical to Model 8 (using non-regressed covariates) except that the BLM removed age as a variable for the reason described under Model 10. Instead, the BLM added the Woodstock "structural condition" variable because structural condition is a GNN-defined categorical variable that also can be derived from Woodstock data. The GNN structural condition classes included: sparse, open, sapling/pole, small/medium tree, large tree, and large/giant tree.

The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 11 estimated relative habitat suitability for hexagons was 0.876, almost identical to that of Model 9. Nonetheless, as shown in **Figure T-8**, regarding model assessment criterion 2, the modified set of variables resulted in relative habitat suitability progressions that the BLM interpreted as less logical than expected.

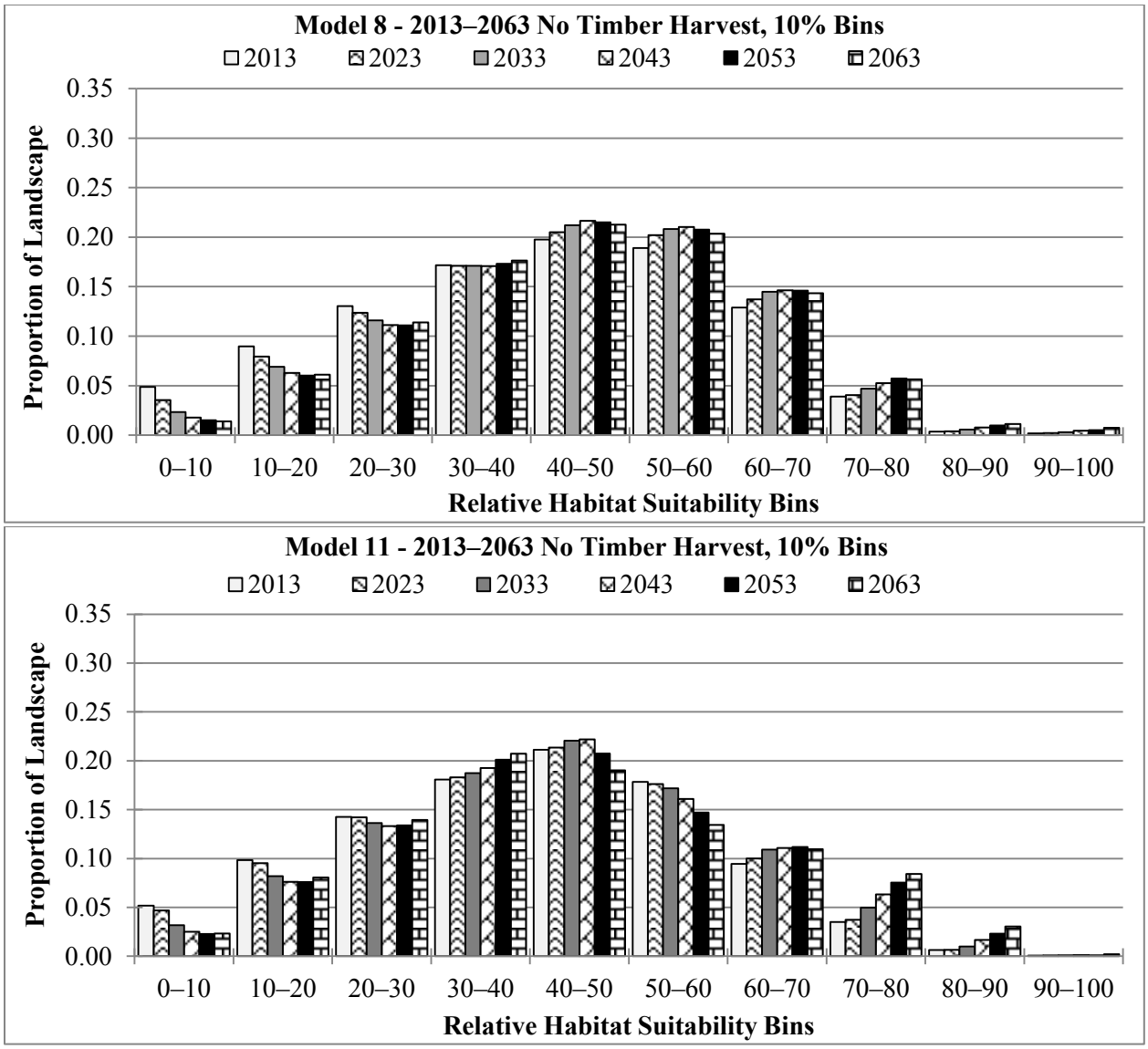


Figure T-8. No Timber Harvest: distributions of relative habitat suitability by decade for Model 8 (top) and Model 11 (bottom) on the decision area

Note: The histograms show the portion of BLM-administered lands in each relative habitat suitability bin at the beginning of each of six decades.

Model 12

Model 12 was a combination of the refinements implemented in models 9 and 11. The BLM used the same reduced set of variables used in Model 9, and removed age (because of the age-related issues described under Model 10) and added structural condition as it had in Model 11.

Figure T-9 and **Figure T-10** compare the decadal relative habitat suitability progressions under Models 9 and 12. Although Model 9 had generated the best previous distribution, it also included stand age as a variable, which Woodstock did not treat in a consistent manner. Model 12 was the best set of revised variables the BLM was able to develop. The Model 12 relative habitat suitability progressions were very similar to those for Model 9 in terms of showing the expected progression of relative habitat suitability by

decade, but also showed slightly lower relative habitat suitability values overall (as seen in the higher suitability bins).

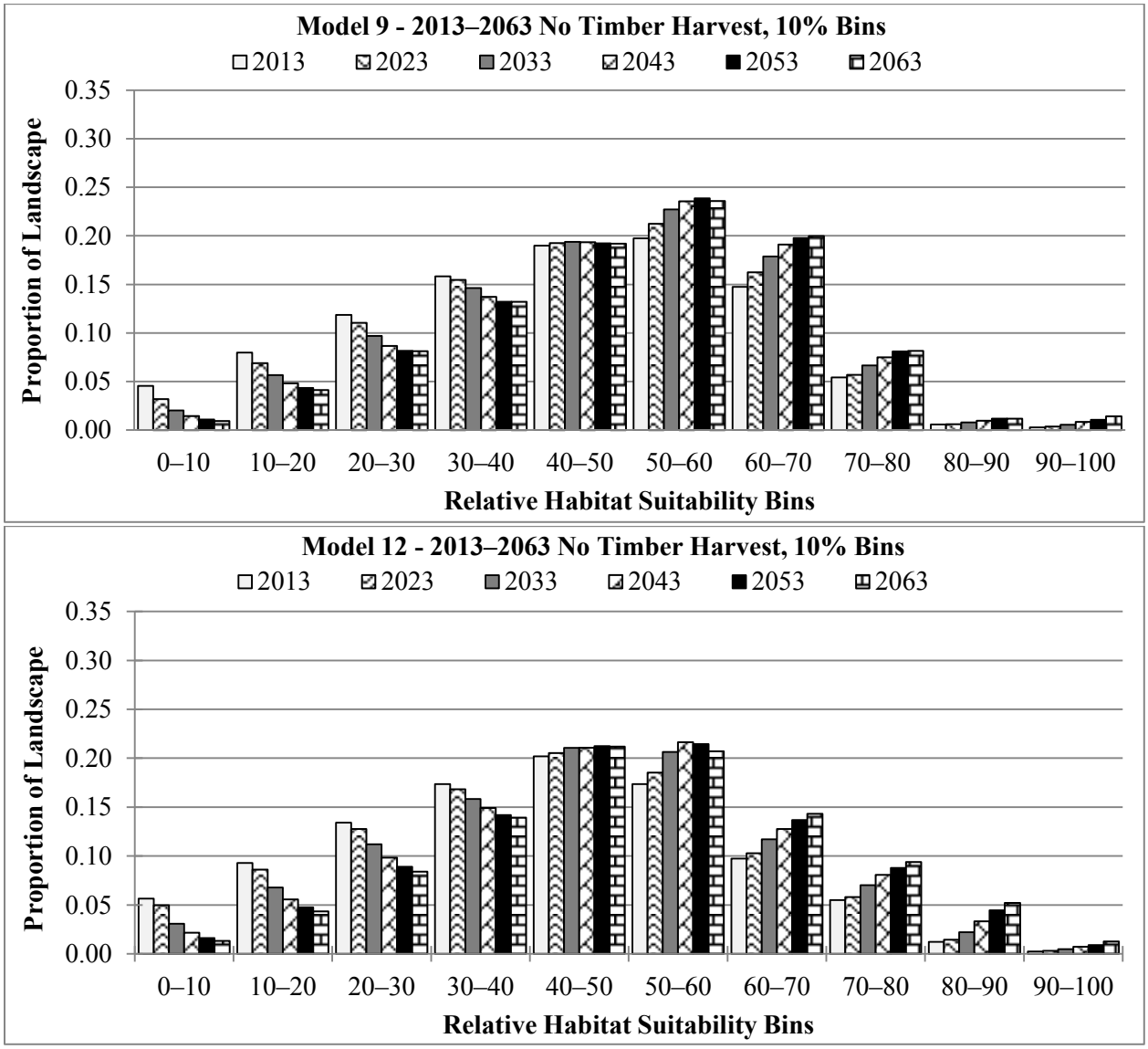


Figure T-9. No Timber Harvest: distributions of relative habitat suitability by decade for Model 9 (top) and Model 12 (bottom) on the decision area

Note: The histograms show the portion of BLM-administered lands in each relative habitat suitability bin at the beginning of each of six decades.

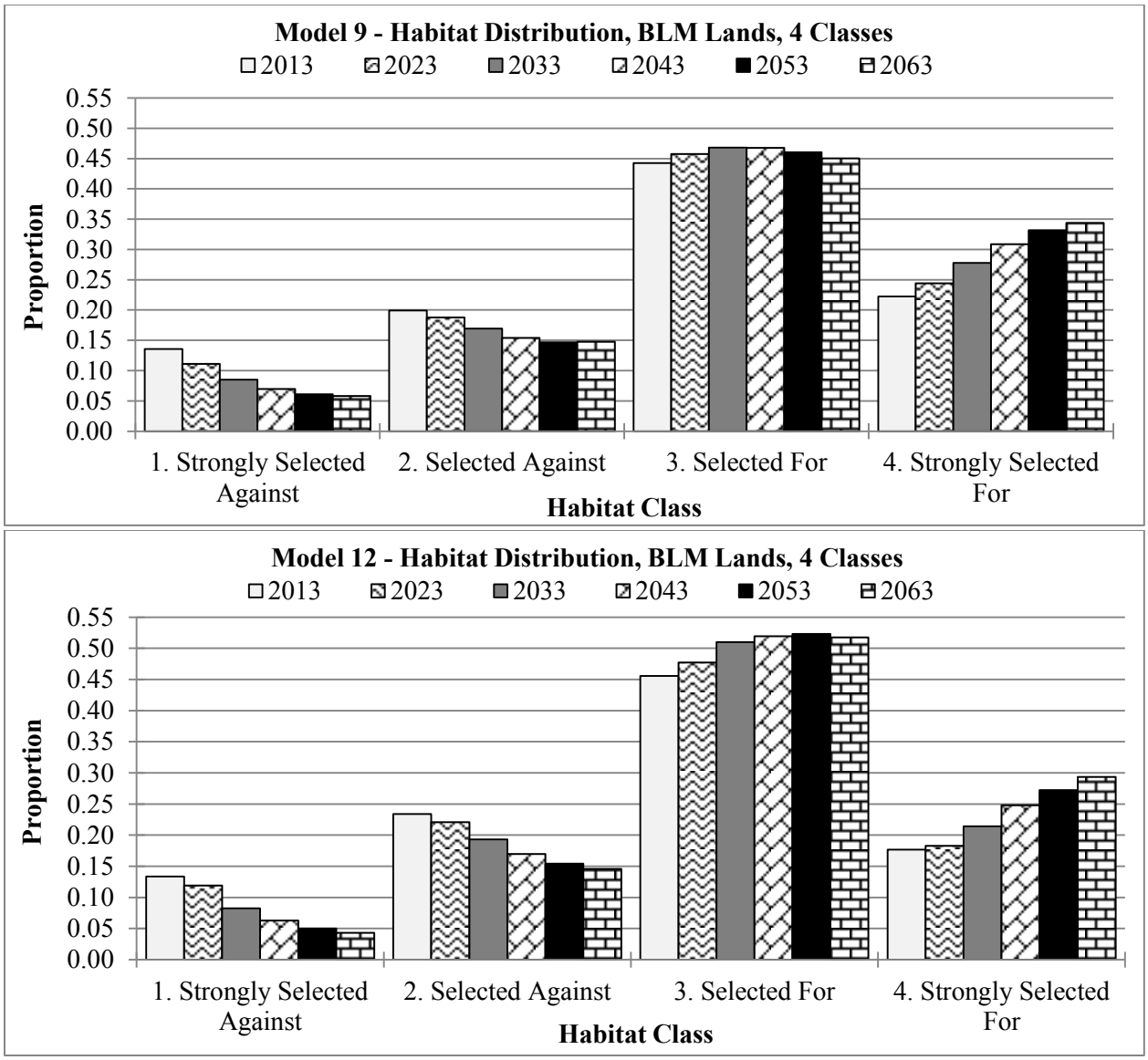


Figure T-10. No Timber Harvest: distribution of relative habitat suitability by decade for Model 9 (top) and Model 12 (bottom) on the decision area

Note: The histograms show the portion of BLM-administered lands in each strength-of-selection bin at the beginning of each of six decades.

The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 12 estimated relative habitat suitability for hexagons was 0.874. Based on this correlation coefficient and the progressions shown in **Figure T-9** and **Figure T-10**, the BLM determined that Model 12 fulfilled its three model assessment criteria.

Model 13

Model 13 became the final BLM model. It was identical to Model 12, except that the BLM used floating point values, rather than integer values, to conform GNN covariate values to Woodstock output precision (i.e., to better reconcile the data going into the 2006 GNN and 2013 Woodstock models). Floating point values include decimals; integers are whole numbers.

The correlation between the U.S. Fish and Wildlife Service 2006 GNN MaxEnt models and the Model 13 estimated relative habitat suitability for hexagons was 0.867. For the three western Oregon modeling regions, this set of models included eleven variables for each of the modeling regions. **Table T-1** shows the variables and their relative contributions. As described below, the BLM determined that Model 13 fulfilled its three model assessment criteria. The BLM's earlier attempts to fine-tune models so as to increase the correlation between its newly-developed models and those of the USDI FWS (2011) were reasonable but, by this point, the BLM recognized that hexagon correlations of 0.860 to 0.870 were as strong as it likely would get, given inherent differences in the sources of the 2006 GNN and 2013 Woodstock variables.[52]

Table T-1. Model 13 variables and percent contributions by modeling region

Covariate	Covariate Description	KLAMT	ORCAS	ORCOA
ccc	Canopy cover of all conifers		0.45	1.0213
curv	Topographic curvature	5.0242	3.122	2.3622
dbhc	Basal-area weighted mean diameter of all live conifers	1.0851	11.3159	0.2664
ddi	Diameter diversity index	5.5428	40.1345	12.9418
elev	Elevation	1.1043	4.1592	2.6962
evghwd	Evergreen hardwood composition type	2.4068	4.1657	7.8237
oak	Oak composition type	6.6165	0.8094	
pine	Pine composition type	2.0507	13.552	6.4613
rpi	Relative position index (% slope position in 200 ha window)	29.631	12.8439	9.5835
stndht	Stand height, computed as average of heights of all dominant and co-dominant trees	44.6563		
struccond	Structural condition (lumping of Johnson and O'Neil's (2001) SIZECL and COVCL	0.3544	4.4098	0.2031
subalp	Sub-alpine composition type	1.528	5.0377	1.6429
tphc	Density of all live conifers ≥ 75 cm DBH			54.9975

Note: Missing values indicate that the BLM did not use the variable for the modeling region. The modeling regions are the Oregon and California Klamath (KLAMT), the Oregon and California Cascades (ORCAS), and Oregon Coast Range (ORCOA), described by Davis *et al*. (2011).

Before accepting Model 13, the BLM compared the Model 13 distribution of hexagons among relative habitat suitability bins with that of the U.S. Fish and Wildlife Service (USDI FWS 2011) 2006 GNN MaxEnt model for: (1) the decision area within the three western Oregon modeling regions and (2) all lands within those regions. To do this, the BLM "updated" the U.S. Fish and Wildlife Service relative habitat suitability surfaces by projecting the U.S. Fish and Wildlife Service's MaxEnt models, which the U.S. Fish and Wildlife Service had trained on 1996 GNN data (see footnote on p. 1), to newly-available 2012 GNN data (http://lemma.forestry.oregonstate.edu/data/structure-maps). (For brevity, these new models hereafter are referred to as the U.S. Fish and Wildlife Service 2012 GNN MaxEnt models, even though the BLM created them.) The BLM did this to reduce the temporal differences between the 2006 GNN and the 2013 Woodstock datasets.

[52] GNN variables are derived from vegetation measurements from regional networks of field plots and Landsat imagery data to characterize forest vegetation across a region; see Ohmann and Gregory (2002). Woodstock variables are derived from BLM Forest Operations Inventory (forest stand exam) data and U.S. Forest Service/BLM Current Vegetation Survey (https://www.fbo.gov/index?s=opportunity&mode=form&id=bed33e38414e6986bc3dbada90bde22a&tab=core&_cview=1) data.

The BLM evaluated relative habitat suitability distributions among eight relative habitat suitability bins (the largest bin being greater than 70, because so little of the landscape existed above that value). Thus, for the three modeling regions and eight bins, there were 24 modeling region by bin comparisons for the two sets of models. As shown in **Figure T-11**, the largest absolute value of difference was 5 percentage points and the smallest difference was 0 percentage points. Of the 24 comparisons, the most frequent difference was an absolute value of 1 percentage point (nine times), followed by 5 percentage points and 4 percentage points (four times each), 2 percentage points and 0 percentage points (three times each), and 3 percentage points (one time). Thus, the two sets of models predicted similar amounts of the landscape (all lands within each modeling region or only BLM-administered lands within each modeling region) within each of the relative habitat suitability bins.

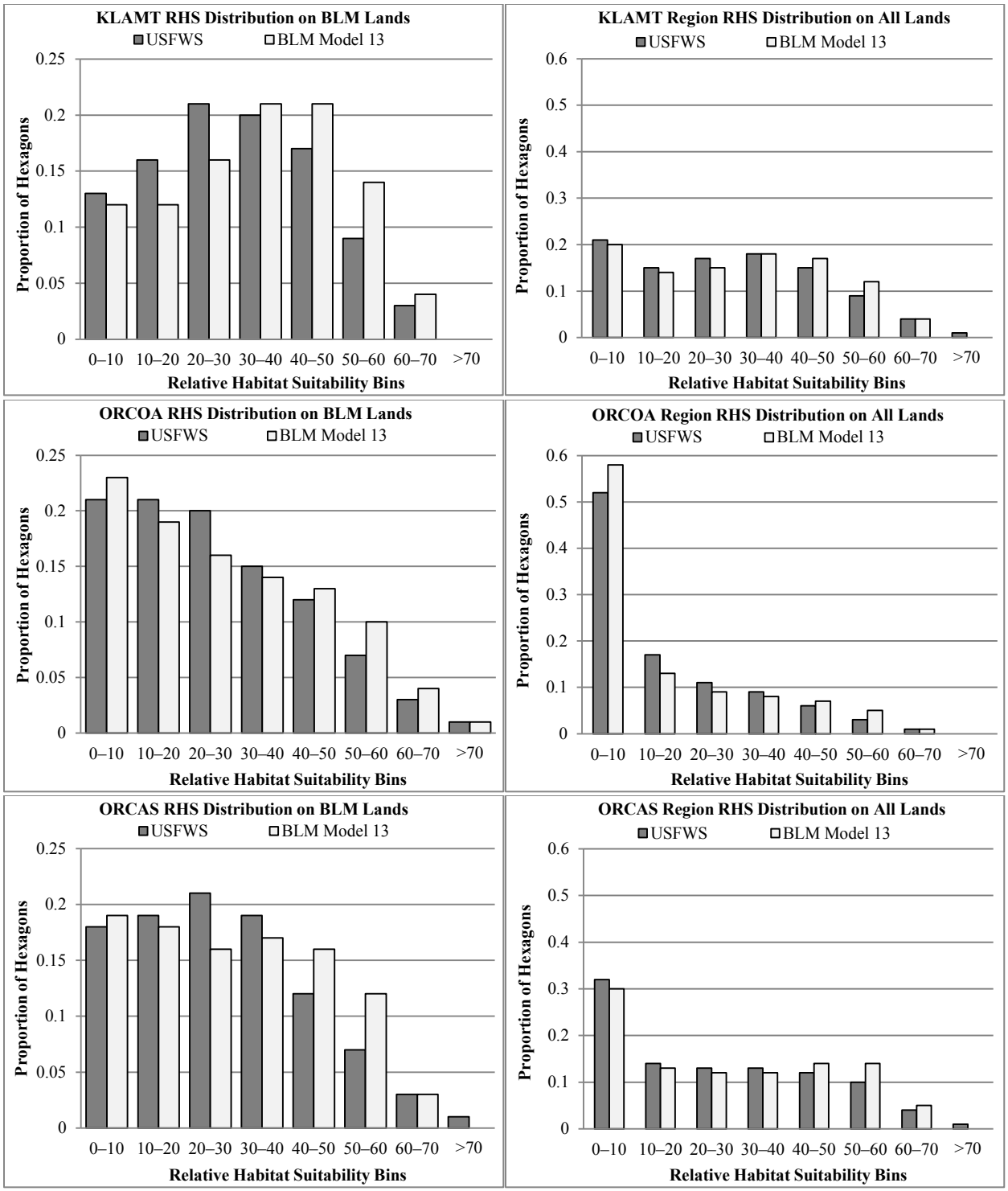


Figure T-11. Comparisons of the distribution of relative habitat suitability at the hexagon scale, on BLM-administered lands (left column), and all lands (right column), in the Oregon and California Klamath, Oregon Coast Range and the Oregon and California Cascades modeling regions (described by Davis *et al*. 2011)

Note: The U.S. Fish and Wildlife Service relative habitat suitability surfaces are based on the U.S. Fish and Wildlife Service 2012 GNN MaxEnt model. The BLM surfaces are based on the BLM 2013 Woodstock Model 13.

As shown in **Figure T-12**, the BLM also found, when mapped, a strong similarity in the spatial distribution of relative habitat suitability values between the two sets of models. Most differences were minor rather than one model predicting very high suitability for an area while the other model predicted very low suitability for that area.

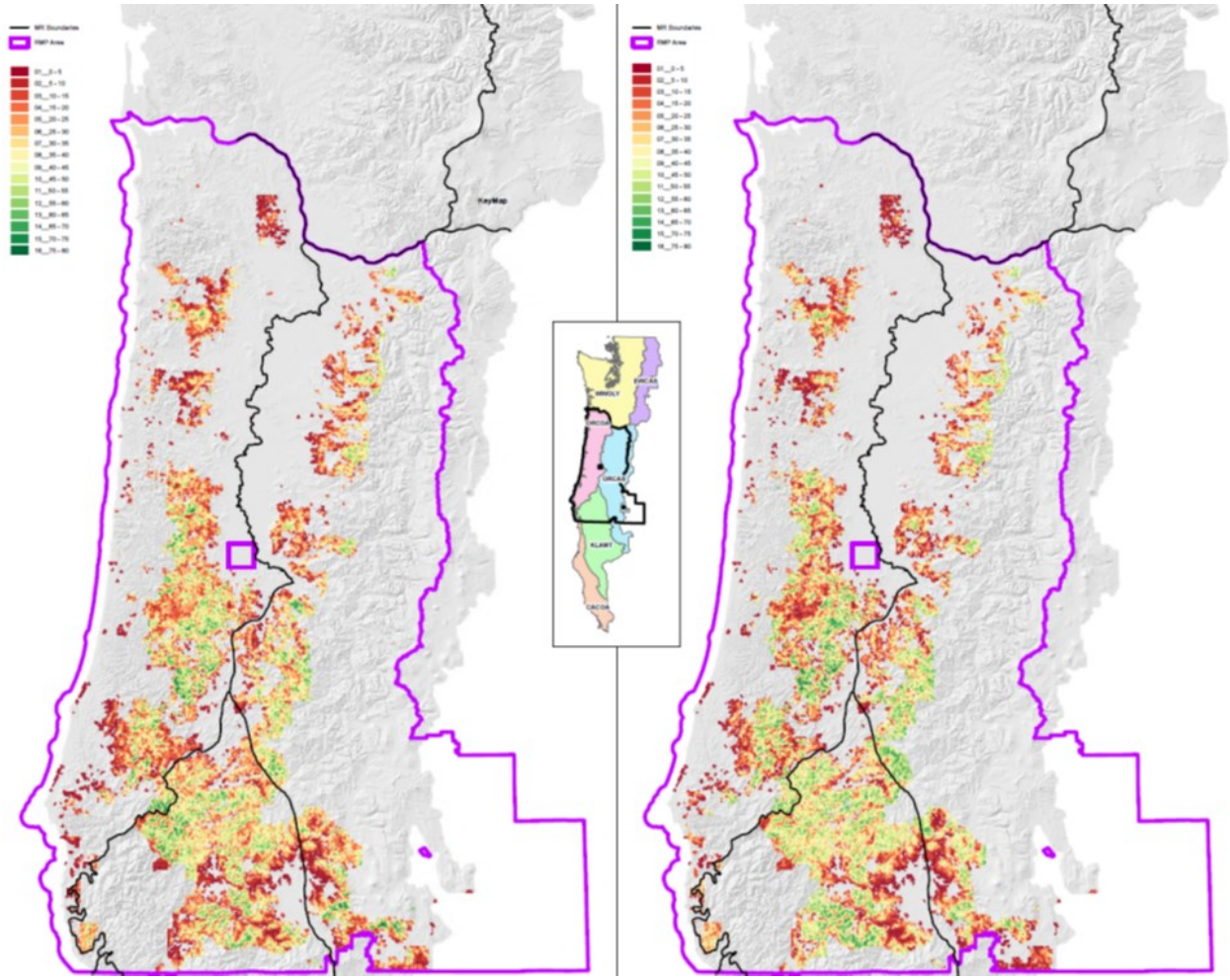


Figure T-12. Spatial distribution of relative habitat suitability for the U.S. Fish and Wildlife Service 2012 GNN MaxEnt model (left) and the BLM 2013 Woodstock Model 13 (right)
Note: Greener areas represent higher relative habitat suitability whereas redder colors represent lower relative habitat suitability.

Also, before accepting Model 13, the BLM examined the distribution of the northern spotted owl known sites used to train Model 13 (training sites) with those known sites withheld from model development (test sites) as described in the description of Model 3. There were 2,465 training sites in the northern spotted owl range (of which 490 occurred on the decision area) and 925 test sites in the northern spotted owl range (of which 164 occurred on BLM-administered lands).

Figure T-13 compares the range-wide distributions of training sites among relative habitat suitability bins for the U.S. Fish and Wildlife Service 1996 GNN MaxEnt models and the BLM 1996 GNN Model 13,[53] The distributions are similar. **Figure T-14** makes the same comparison of the test sites. The distributions

[53] As explained in the footnote on page 1, the U.S. Fish and Wildlife Service used 1996 GNN data to train its MaxEnt models. The BLM developed Model 13 using the same data for the comparison.

are not as similar as for the training sites, which are expected because the models were trained on the training sites. Nonetheless, the two distributions in **Figure T-14** follow similar trends.

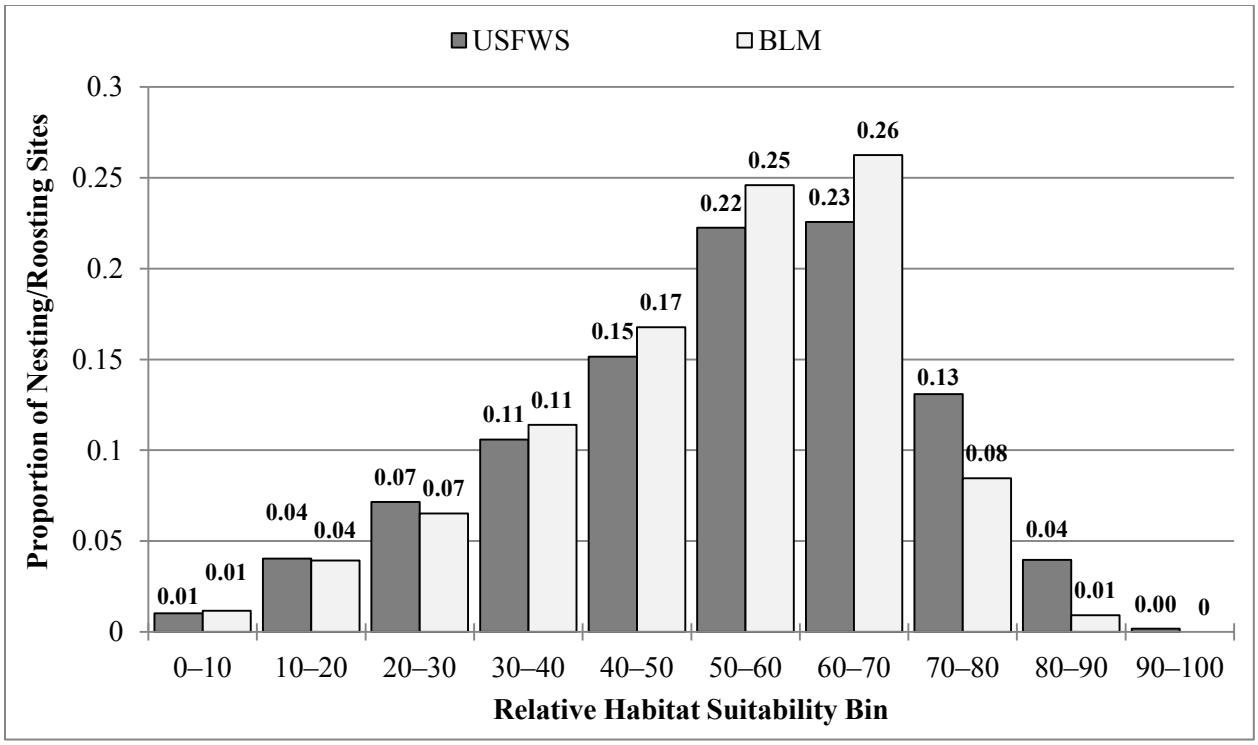


Figure T-13. Rangewide distribution of relative habitat suitability values among training northern spotted owl sites for the U.S. Fish and Wildlife Service 1996 GNN MaxEnt model and BLM's 1996 GNN Model 13

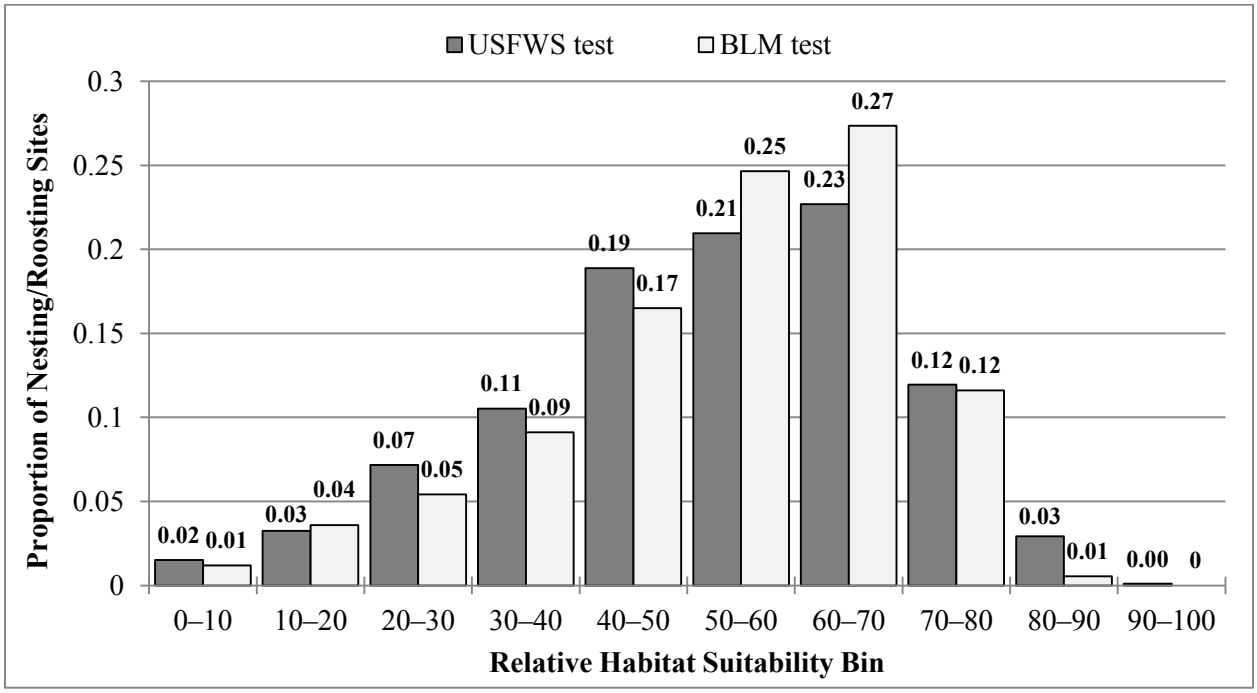


Figure T-14. Rangewide distribution of relative habitat suitability values among test northern spotted owl sites for the U.S. Fish and Wildlife Service 1996 GNN MaxEnt model and BLM's 1996 GNN Model 13

The BLM made similar comparisons for the decision area, this time using the U.S. Fish and Wildlife Service 2012 GNN MaxEnt models and the BLM 2013 Woodstock Model 13. **Figure T-15** shows the distributions for training sites on the decision area; **Figure T-16** shows the distributions for test sites on the same lands. As expected, the distributions are less similar than the range-wide distributions shown in **Figure T-13** and **Figure T-14** because of the smaller numbers of sites associated with the decision area and because of substantive differences in the origins of the 2012 GNN and 2013 Woodstock data. Because the Woodstock variables were derived from forest stand exam and Current Vegetation Survey plot data (i.e., on-the-ground examination and measurement), the BLM is confident of the accuracy of the Woodstock variables for the decision area. Nonetheless, **Figure T-13** to **Figure T-16** suggest that Model 13, as used by the BLM, inflates relative habitat suitability values. As explained below, this almost certainly is an artifact of truncating Model 13 to BLM-administered lands.

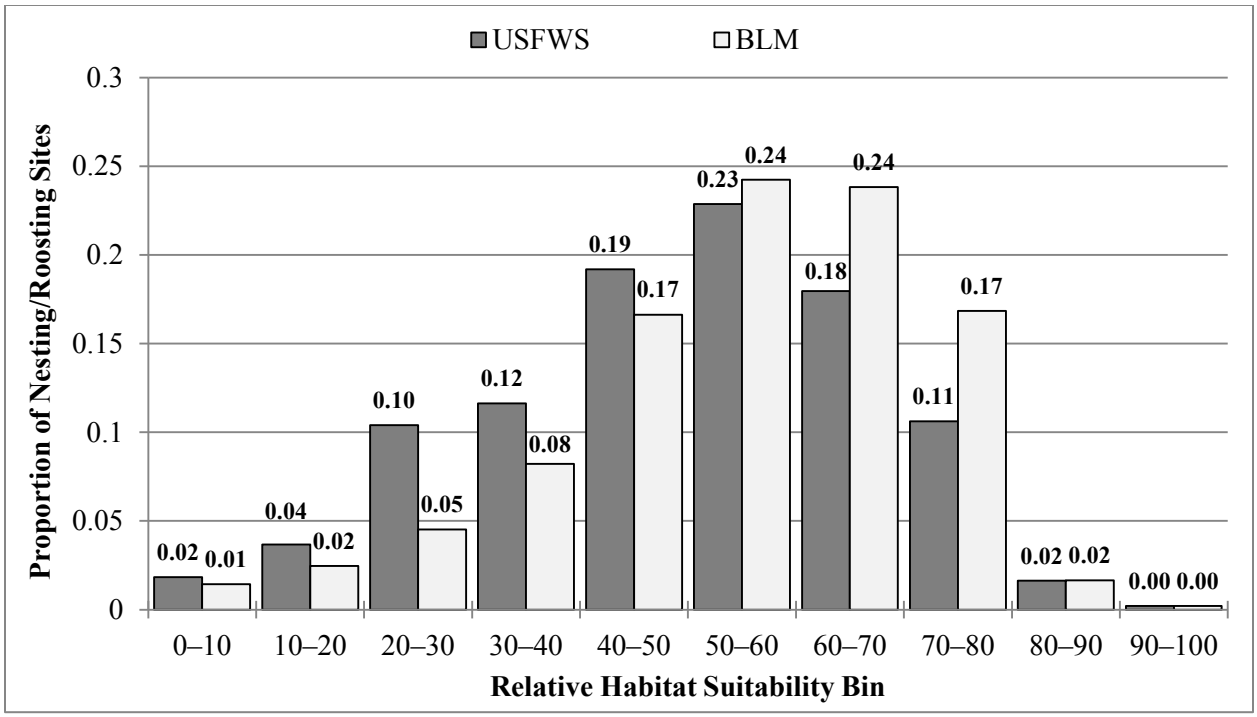


Figure T-15. Distribution of relative habitat suitability values among training northern spotted owl sites on the decision area for the U.S. Fish and Wildlife Service 2012 GNN MaxEnt model and BLM's 2013 Woodstock Model 13

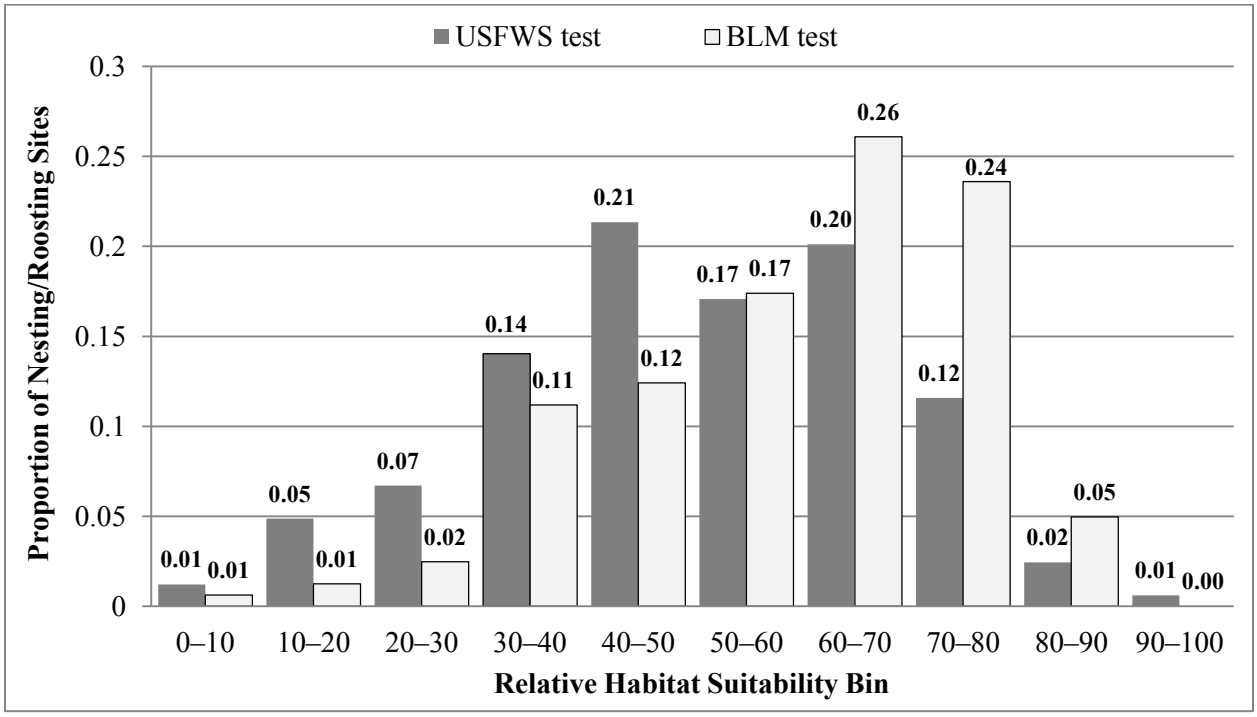


Figure T-16. Distribution of relative habitat suitability values among test northern spotted owl sites on the decision area for the U.S. Fish and Wildlife Service 2012 GNN MaxEnt model and BLM's 2013 Woodstock Model 13

As described above, MaxEnt calculates relative habitat suitability based on variable values within a 200-ha circle. GNN data, used in the U.S. Fish and Wildlife Service MaxEnt models, were available for all lands within the northern spotted owl range. However, the BLM developed Woodstock data only for the decision area. The BLM uses Woodstock data, because it is the most accurate data for BLM-administered lands. However, an artifact arises when the BLM applies Model 13 to BLM-administered lands that abut other lands (i.e., lands within 800 m of BLM-administered lands, which is the radius of a 200-ha circle). In this case, the BLM could use Model 13 to calculate relative habitat suitability values for 2013 based on 2013 Woodstock data for BLM-administered lands and 2012 GNN data for other lands. However, the BLM cannot do this for subsequent decades, because there are no reliable data on how individual GNN values vary and co-vary over time. As described below, the BLM simulated changes in relative habitat suitability values on other lands by developing a 2012 relative habitat suitability surface for each modeling region, and then changing relative habitat suitability values according to the calculated effects of ingrowth, wildfire, and timber harvest on those values at decadal increments. However, the BLM could not do the same for the underlying GNN variable values used to calculate relative habitat suitability. Stated another way, Woodstock generates new variable values for BLM-administered lands at decadal increments. However, after 2012, there are no comparable GNN values available for other lands abutting BLM-administered lands. Thus, after 2013, Model 13 must calculate relative habitat suitability values for BLM-administered lands using only Woodstock data. Since forest conditions on BLM-administered lands commonly support northern spotted owls better than those on adjacent lands, which frequently are industrial timber lands, the BLM method appears to inflate relative habitat suitability values on its own administered lands. This is not a weakness of Model 13. Instead, it is an artifact of data limitations for other lands within 800 m of the decision area. After publishing the Draft RMP/EIS, the BLM further refined its relative habitat suitability forecasts (see **Sections A** and **D** of this appendix).

B. Forecasting Change in Relative Habitat Suitability on Other Lands in Washington, Oregon and California for the Draft RMP/EIS

The BLM forecasted changes in relative habitat suitability from ingrowth, large (1,000+-acre) wildfires, and timber harvests for all lands within the U.S. portion of the northern spotted owl range. Modifications in forest structure and composition at decadal increments on the decision area were incorporated in the Woodstock models and reflected in the BLM's Model 13 relative habitat suitability surfaces. The BLM based its forecasted magnitudes of change on all other lands on differences between the U.S. Fish and Wildlife Service 1996 and U.S. Fish and Wildlife Service 2006 GNN-based relative habitat suitability surfaces. That is, BLM assumed that the decadal change in relative habitat suitability from 1996 to 2006 would be realized during subsequent decades.

To estimate rates-of-change from forest ingrowth in decadal increments, the BLM calculated the mean difference between 1996 and 2006 for each integer relative habitat suitability value (i.e., the analysis determined the mean value in 2006 for all pixels with the same value in 1996). The BLM generated rates-of-change statistics separately for each physiographic province and, within each province, further stratified by Congressionally Reserved lands (e.g., designated Wilderness Areas), Federal reserved lands (e.g., the Late-Successional Reserve under the Northwest Forest Plan), Federal non-reserved lands (e.g., Matrix lands under the Northwest Forest Plan), and non-Federal lands. The BLM excluded pixels from the analysis within Monitoring Trends in Burn Severity (http://www.mtbs.gov/) fire perimeters and unpublished U.S. Forest Service LandTrendr harvest patches (see Davis *et al*. 2011) to minimize the influence of other agents of change on the ingrowth rates.

Initially, the BLM included only pixels showing positive or no change between 1996 and 2006 in the calculations. The BLM did this because negative change does not reflect forest ingrowth. The BLM used

those derived rates-of-change to generate projected decadal relative habitat suitability surfaces for other lands, combined with the decadal Woodstock projections for BLM-administered lands. However, after examining the results, the BLM determined that the rate of ingrowth for forests in the drier portion of the northern spotted owl's range (i.e., most of California, and the eastern Cascades of Washington and Oregon) appeared to exceed observed rates. After additional consideration and testing, the BLM truncated all negative changes to 0 and all positive changes to 10 because negative changes in relative habitat suitability were not indicative of ingrowth and, knowing how habitat develops, rates higher than 10 were unrealistic. Although relatively few values exceeded 10, they were sufficiently high to affect mean rates-of-change. The final results were sets of range-wide ingrowth forecasts for strata within each physiographic province.[54]

The BLM used results from Davis *et al*. (2014) to forecast changes in relative habitat suitability values following wildfires. The BLM applied changes only for moderate and high severity fires by habitat class, because Davis *et al*. (2014) determined that low severity fires have a negligible effect on northern spotted owl habitat. These findings are supported by Manley's (2014) descriptions of the effects of fire on northern spotted owls. The BLM modeled the spatial locations, extents, and severity of future wildfires using the same predicted wildfire dataset included in the Woodstock models, which extends over the non-BLM portions of the northern spotted owl's range (**Appendix D** – Modeling Large Stochastic Wildfires and Fire Severity Within the Range of the Northern Spotted Owl).

Expanding on the methods described by Davis *et al*. (2011, pp. 28–30), the BLM used the unpublished U.S. Forest Service LandTrendr change detection data to develop range-wide forecasts of decadal rates of negative change in relative habitat suitability values following timber harvests. To create potential timber harvest patches on other lands, the BLM segmented the U.S. Forest Service 2006 GNN-based relative habitat suitability model using eCognition Developer 8 (Trimble Navigation Ltd., Westminster, CO). The BLM parameterized the software's segmentation routine to iteratively group neighboring pixels with similar relative habitat suitability values into discrete patches until the mean patch size ± 1 SD within each physiographic province and strata most closely approximated those observed in the LandTrendr dataset between 1996 and 2006 (**Table T-2** and **Table T-3**). Segmenting the U.S. Forest Service 2006 GNN-based surface resulted in more realistic representations of harvest treatment patch shapes and dimensions than those created using the smoother, 200-ha-scale U.S. Fish and Wildlife Service relative habitat suitability surfaces.

[54] The BLM subsequently tested methods to refine its forecasts; see Section D of this appendix. Because the U.S. Forest Service LandTrendr analysis was based on a 200-ha scale relative habitat suitability surface—i.e., relative habitat suitability values are based on the means of variable values within 800 meters of each pixel, the radius of a 200-ha circle—any negative change in burn and timber harvest areas would affect the relative habitat suitability values within 800 m, and not just within the treatment or burn area. The BLM tested masking areas within 800 meters of burn and treatment areas, and recalculating relative habitat suitability change, and found that this eliminated much of the negative change the BLM had detected outside burn and harvest areas. However, the degree of change did not cause the BLM to replace its analyses for the Draft RMP/EIS. As described in **Section D** of this appendix, the BLM subsequently tested additional methods to refine its relative habitat suitability surfaces during its preparation of the Proposed RMP/Final EIS.

Table T-2. Metrics, calculated from data developed by Davis *et al*. (2011), used to forecast decadal (1996–2006) losses of northern spotted owl dispersal and nesting-roosting habitat from timber harvest on lands other than BLM-administered lands in the planning area

Physiographic Province	Dispersal Habitat in 1996 (Acres)	Dispersal Habitat Harvested (Acres)	Dispersal Habitat Harvested (Percent)	Nesting-Roosting Habitat in 1996 (Acres)	Nesting-Roosting Habitat Harvested (Acres)	Nesting-Roosting Habitat Harvested (Percent)	Habitat Harvested that was Nesting-Roosting (Percent)	10-Year Mean Loss of Habitat to Harvest	Mean Harvest Patch Size (Acres)	Stand Harvest Patch Size (Acres)
Federal Non-Reserved Lands†										
Washington										
Eastern Cascades	128,810	1,208	1%	207,310	1,819	1%	60%	1.0%	20	10
Olympic Peninsula	39,038	128	-	37,275	47	-	27%	0.2%	19	9
Western Cascades	143,116	404	-	288,691	1,025	-	72%	0.3%	19	8
Western Lowlands	11	-	-	-	-	-	-	-	-	-
Oregon										
Coast Range	34,732	265	1%	34,722	135	-	34%	0.6%	21	11
Eastern Cascades	109,494	1,725	2%	145,704	1,756	1%	50%	1.4%	23	13
Klamath	111,577	628	1%	135,992	737	1%	54%	0.6%	18	7
Western Cascades	478,515	3,972	1%	844,548	6,669	1%	63%	0.9%	19	9
Willamette Valley	4	-	-	-	-	-	-	-	-	-
California										
Cascades	110,507	1,386	1%	63,151	1,858	3%	57%	2.1%	33	23
Coast Range	25,543	12	-	11,191	-	-	0%	-	12	-
Klamath	576,849	2,482	-	657,433	1,845	-	43%	0.4%	17	7
Federal Reserved Lands*										
Washington										
Eastern Cascades	139,270	606	-	268,674	1,618	1%	73%	0.8%	17	8
Olympic Peninsula	89,086	73	-	277,151	308	-	81%	0.1%	16	5
Western Cascades	182,939	234	-	486,969	443	-	65%	0.1%	18	7
Oregon										
Coast Range	118,696	598	1%	266,301	1,103	-	65%	0.5%	20	9
Eastern Cascades	73,898	397	1%	159,868	347	-	47%	0.4%	19	8
Klamath	218,679	103	-	210,418	232	-	69%	0.1%	20	10
Western Cascades	264,104	328	-	740,398	487	-	60%	0.1%	18	7
California										
Cascades	67,741	267	-	85,839	239	-	47%	0.3%	22	15
Coast Range	30,071	31	-	25,486	22	-	42%	0.1%	13	3
Klamath	335,682	536	-	579,128	526	-	50%	0.1%	16	5

Physiographic Province	Dispersal Habitat in 1996 (Acres)	Dispersal Habitat Harvested (Acres)	Dispersal Habitat Harvested (Percent)	Nesting-Roosting Habitat in 1996 (Acres)	Nesting-Roosting Habitat Harvested (Acres)	Nesting-Roosting Habitat Harvested (Percent)	Habitat Harvested that was Nesting-Roosting (Percent)	10-Year Mean Loss of Habitat to Harvest	Mean Harvest Patch Size (Acres)	Stand Harvest Patch Size (Acres)
Non-Federal Lands										
Washington										
Eastern Cascades	319,729	18,536	6%	362,291	24,540	7%	57%	6.3%	30	20
Olympic Peninsula	275,885	33,068	12%	192,741	23,153	12%	41%	12.0%	41	27
Western Cascades	212,118	23,573	11%	120,707	11,207	9%	32%	10.2%	39	27
Western Lowlands	524,668	73,413	14%	149,848	19,729	13%	21%	13.6%	40	27
Oregon										
Coast Range	659,641	104,393	16%	483,985	106,584	22%	51%	18.9%	44	30
Eastern Cascades	132,149	15,728	12%	114,531	11,061	10%	41%	10.8%	37	25
Klamath	300,416	26,920	9%	244,411	23,492	10%	47%	9.3%	33	22
Western Cascades	411,318	63,999	16%	260,687	45,250	17%	41%	16.5%	46	33
Willamette Valley	50,477	3,220	6%	37,962	3,553	9%	52%	7.9%	22	12
California										
Cascades	184,094	9,049	5%	109,434	6,310	6%	41%	5.3%	20	9
Coast Range	1,189,363	41,598	3%	967,484	36,891	4%	47%	3.7%	20	9
Klamath	382,099	10,094	3%	353,724	10,157	3%	50%	2.8%	19	8
Non-Federal Land Totals by State‡										
Washington	1,332,399	148,590	11%	825,587	78,629	10%	35%	10.3%	38	26
Oregon	1,554,001	214,260	14%	1,141,576	189,940	17%	47%	15.2%	42	30
California	1,755,556	60,741	3%	1,430,642	53,358	4%	47%	3.6%	20	9

* Congressionally Reserved and the decision area not included
† The decision area not included
‡ Mean harvest patch sizes on non-Federal lands by state are NOT averages of the above physiographic province averages

Table T-3. Changes, calculated from data developed by Davis *et al*. (2011), in relative habitat suitability values from timber harvests occurring in northern spotted owl habitat between 1996 and 2006 by physiographic province and Northwest Forest Plan land use allocation

Physiographic Province	Federal Reserved Lands*			Federal Non-Reserved Lands†			Non-Federal Lands		
	Selected Against	Selected For	Strongly Selected For	Selected Against	Selected For	Strongly Selected For	Selected Against	Selected For	Strongly Selected For
Washington									
Eastern Cascades	-2	-2	-	-2	-4	-2	-3	-6	-10
Olympic Peninsula	4	3	-	5	-8	4	-7	-12	-13
Western Cascades	4	2	4	3	-1	-1	-9	-15	-19
Western Lowlands	-	-	-	-	-	-	-7	-12	-16
Oregon									
Coast Range	2	-2	-	-3	1	1	-5	-10	-13
Eastern Cascades	1	1	-4	-	-1	-2	-3	-7	-16
Klamath	-1	1	-10	-	-1	-	-3	-5	-4
Western Cascades	-	-2	-5	1	-	-1	-7	-9	-6
Willamette Valley	-	-	-	-	-	-	-6	-7	-27
California									
Cascades	4	-6	-4	-5	-13	-13	-3	-7	-13
Coast Range	-2	-3	-	-2	-	-	1	1	-1
Klamath	0	1	-1	-1	-	1	-1	-1	-3

* Congressionally Reserved and the decision area not included
† The decision area not included

Starting with the 2012 relative habitat suitability surface (i.e., the surface the BLM created using 2012 GNN data with the U.S. Fish and Wildlife Service 1996 GNN MaxEnt models), the BLM forecasted changes on other lands from ingrowth, wildfire, and timber treatments before advancing in decadal increments for five decades (2013–2063). Modeling each decade in sequence was necessary because estimating change in future decadal intervals depended on adjusted values from the previous decade.

At the beginning of each decade, the BLM applied the rates-of-change in relative habitat suitability value from ingrowth and categorized the results into the four habitat suitability classes using the previously derived strength-of-selection class breaks: strongly-selected-against, selected-against, selected-for, and strongly-selected-for. Next, the BLM adjusted pixel values within the wildfire perimeters predicted to occur within the decade depending on the fire severity and corresponding relative habitat suitability class. The BLM categorized the resulting continuous surface into habitat classes a second time before adding the effects of timber harvests. Finally, the BLM calculated the median habitat class within each candidate harvest treatment patch (i.e., the results of the image segmentations described above), and randomly selected treatment patches in each province and strata until the area harvested approached, but did not exceed, the total decadal treatment area calculated from the LandTrendr data. The BLM then repeated the process for the next and subsequent decades.

The BLM applied the following four selection criteria when selecting timber harvest patches for the purpose of forecasting change in relative habitat suitability on lands other than BLM-administered lands:

- All modeled harvest patches had to exceed 10 acres in size because the BLM anticipated smaller timber harvests would be commercially inviable.
- The BLM did not allow the selection of patches that were more than 500 m from a road because of anticipated limitations to commercial access.

- Patches classified as 'strongly-selected-against' were not considered because such stands generally would be too young for commercial timber harvest.
- The BLM did not allow a patch to be selected for treatment twice during the 50-year forecast period. Once selected, the rates of change from harvest were applied to the relative habitat suitability values within each patch. After harvesting a patch, the BLM allowed ingrowth within modeled harvests to progress uninterrupted for the remainder of the planning horizon.

The BLM applied changes in relative habitat suitability to all lands before updating the pixel values on the decision area with the results from Model 13 for the same decade.

The BLM created only one set of decadal relative habitat suitability surfaces for non-BLM-administered lands across the northern spotted owl's range. The BLM used this single set of surfaces for all evaluations of the alternatives, the Proposed RMP, and the No Timber Harvest reference analysis (i.e., only the relative habitat surfaces for the decision area changed by alternative or the Proposed RMP). The BLM used this final set of relative habitat suitability surfaces, one for each decade between 2013 and 2063, for the HexSim population dynamics models.

C. Additional Notes on the BLM's Northern Spotted Owl Modeling and Analyses for the Draft RMP/EIS

Sections A and B appeared in Appendix S of the Draft RMP/EIS (USDI BLM 2015). However, the BLM did not intend those narratives to be sufficient to allow someone to duplicate BLM processes, only to help reviewers better understand the BLM's analytical processes so they could better interpret results. The BLM recorded the steps of its processes in its administrative record.

The BLM requested review of Appendix S of the Draft RMP/EIS by Drs. Bruce Marcot and Peter Singleton of the U.S. Forest Service—experts on northern spotted owl biology and modeling. The following section provides additional explanation of the BLM processes through responses to the comments of Drs. Bruce Marcot and Peter Singleton.

Relative Habitat Suitability Surfaces

Comment: As it explained in its development of models 1–13, the BLM worked to achieve a strong correlation between its relative habitat suitability surfaces and those prepared by the FWS on the apparent assumption that the FWS's surfaces were a near-perfect representation of northern spotted owl habitat. However, the BLM's process likely compounded the error inherent in FWS's surfaces with the error inherent in the BLM's process.

BLM response: The BLM did not assume that the U.S. Fish and Wildlife Service's relative habitat suitability surfaces represented a near-perfect representation of northern spotted owl habitat. Instead, the BLM reviewed the U.S. Fish and Wildlife Service's data and methods for surface development and determined that those surfaces (actually, the MaxEnt models developed by the U.S. Fish and Wildlife Service to create its surfaces, which the BLM then applied to 2012 GNN data to generate updated surfaces) most likely were the most credible range-wide northern spotted owl surfaces available. Second, as described above in this appendix, the BLM derived its MaxEnt models independently of the U.S. Fish and Wildlife Service's MaxEnt models, and then examined the degree of fit between the relative habitat suitability surfaces derived from the two sets of models to help ensure that HexSim would work with the merged surfaces. As described under Model 8, the BLM determined that it could not use stand age as a variable in its MaxEnt models because Woodstock calculates stand age differently over time based on simulated stand treatment. Since stand age typically is an important variable in the modeling of northern spotted owl habitat, the BLM compared the results of its MaxEnt models against those of the most-similar

and credible models available for the same land base. Although the relative habitat suitability surfaces developed by the U.S. Fish and Wildlife Service contain inherent uncertainty, the BLM used a rational process to refine and test its models. However, it did not tailor its models to generate surfaces similar to the U.S. Fish and Wildlife Service's surface.

That said, at the time the BLM prepared its northern spotted owl relative habitat suitability surfaces, only two comparable range-wide surfaces existed: one produced by the U.S. Fish and Wildlife Service (USDI FWS 2011, pp. Appendix C) and one by the U.S. Forest Service (Davis *et al.* 2011). Since preparation of the Draft RMP/EIS, the U.S. Forest Service updated its surfaces using 2012 GNN data (Davis *et al*. 2015). **Table T-4** compares the acres of northern spotted owl nesting-roosting habitat on federal lands as calculated by the U.S. Forest Service using 2012 GNN data (Davis *et al*. 2015, Table 6) and by the BLM using 2013 Woodstock data for the decision area and 2012 GNN data (U.S. Fish and Wildlife Service 1996 GNN MaxEnt models applied to 2012 GNN data) for other Federal lands. Even though these acres were calculated using different datasets, MaxEnt models and analytical scales, the estimates are similar.

Table T-4. A comparison of the estimated acres of northern spotted owl nesting-roosting habitat on Federal lands as calculated by the U.S. Forest Service and the BLM

Physiographic Province	U.S. Forest Service (Acres)	BLM (Acres)
Washington		
Olympic Peninsula	737,600	972,223
Western Lowlands	12,900	6,278
Western Cascades	1,169,500	1,238,477
Eastern Cascades	779,400	753,264
Washington Totals	**2,699,400**	**2,970,242**
Oregon		
Coast Range	506,200	867,550
Willamette Valley	7,500	8,194
Western Cascades	2,371,400	2,112,585
Klamath	932,100	828,637
Eastern Cascades	339,600	508,885
Oregon Totals	**4,156,800**	**4,325,851**
California		
Coast Range	123,800	103,130
Klamath	1,764,700	1,606,645
Cascades	209,300	142,265
California Totals	**2,097,800**	**1,852,040**

Comment: Developing relative habitat suitability surfaces that combine GNN and BLM Woodstock data compounds the uncertainty inherent in both datasets, making the surfaces, and the BLM analyses that use those surfaces, less reliable.

BLM response: The GNN/CVS data are the most reliable range-wide data available for other (non-BLM-administered) lands in the northern spotted owl's range. As described in this appendix, the BLM used the GNN-derived relative habitat suitability surfaces developed by the U.S. Fish and Wildlife Service (USDI FWS 2011, pp. C-16 – C-43) for all lands within the northern spotted owl range except BLM-

administered lands in the planning area. (Again, the BLM used the U.S. Fish and Wildlife Service 1996 GNN MaxEnt models but applied them to 2012 GNN data, so the BLM did not actually use the U.S. Fish and Wildlife Service's relative habitat suitability surfaces, only its MaxEnt models.)

The Woodstock (BLM data) variable values, which are derived from BLM field operations inventory and CVS plot data, are the most reliable data available for the decision area. Since the BLM used GNN- or Woodstock-derived relative habitat suitability surfaces appropriate to land base, and ensured, at multiple steps, that those surfaces were compatible, the uncertainty inherent in the GNN data does not compound the uncertainty inherent in the Woodstock data. Even though there is uncertainty inherent in the merged surfaces, because the surfaces are based on the best data available for each land base, the merged surfaces likely are more reliable than those derived from only GNN data.

Because biases or uncertainties in the underlying GNN/Woodstock layers and subsequent relative habitat suitability surfaces are used for comparing all alternatives and the Proposed RMP, and because BLM interprets the HexSim model results as relative among alternatives and the Proposed RMP, any over- or under-estimation of northern spotted owl habitat changes or population responses that may exist would exist for all alternatives and the Proposed RMP and would not influence the relative difference(s) among alternatives and the Proposed RMP. The BLM acknowledges that the uncertainty inherent in its relative habitat suitability surfaces compounds the uncertainty inherent in modeling that relies on those surfaces. However, that compounding effect is inherent in all modeling.

Comment: MaxEnt, which the BLM used to create relative habitat suitability surfaces for its administered lands, is prone to over-fitting the data, especially when too many variables are used.

BLM response: The BLM did not employ the full range of fitting features available in MaxEnt. The BLM MaxEnt models relied on 11 covariates specific to each of the western Oregon modeling regions (**Table T-1**). In addition, as described under Model 13, the BLM tested its MaxEnt models with data that had not been used to train the models to help ensure that the models did not over-fit the data.

Comment: How did the BLM use strength-of-selection thresholds to classify northern spotted owl habitat?

BLM response: Based on its modeling needs (see Chapter 3, Northern Spotted Owl), the BLM divided northern spotted owl habitat into categories based on strength-of-selection. This was similar to the process used by the U.S. Fish and Wildlife Service (USDI FWS 2011, pp. C-31 – C-39) but, in the BLM's case, the BLM used four categories: (1) strongly selected against, (2) selected against, (3) selected for, and (4) strongly selected for.

To summarize strength-of-selection: If the relative habitat suitability values greater than 45 represent 10 percent of a modeling region, and 50 percent of the northern spotted owl nests in that region are in areas with relative habitat suitability greater than 45, the strength-of-selection value would be 5.0 (50 percent of the nests divided by 10 percent of the area, which means that the area was used for nesting five times more than would be expected based on its availability). Similarly, if 50 percent of the landscape is in areas with relative habitat suitability less than 15, and 10 percent of the nests in that region are in areas with relative habitat suitability less than 15, the strength-of-selection would be -5.0 (10 percent of the nest sites divided by 50 percent of the area—and multiplied by -1—because the percent of nest sites is less than the percent of the area), which means the area was used five times less than would be expected based on its availability).

The BLM created strength-of-selection curves separately for each modeling region. These strength-of-selection-defined categories provided a relatively simple and consistent way to track changes in the amount of area containing habitats of differing value to northern spotted owls; with value being defined

by the owls' relative attraction or avoidance. The BLM then classified northern spotted owl habitat according to strength-of-selection curves following a process used by the U.S. Forest Service (Davis *et al*. 2011:36-40) but with its own relative habitat suitability surfaces. Examining the results for each modeling region, the BLM found that strength-of-selection curves between -2.75 and 2.75 were relatively flat in each modeling region, and then deviated sharply downward (below -2.75) or upward (above 2.75) beyond those values. Therefore, values below -2.75 were strongly selected against, values -2.75 – 0 were selected against, values 0 – 2.75 were selected for and values greater than 2.75 were strongly selected for.

Among the modeling regions, the 'strongly selected for' category accounted for 3.48 – 12.1 percent of the landscape and 15.4 – 72.0 percent of the known northern spotted owl sites; combining it with the 'selected for' category accounted for 18.7 – 35.4 percent of the landscape and 78.4 – 89.9 percent of the known northern spotted owl sites. Range-wide, 28.6 percent of the landscape was categorized as either 'selected for' or 'strongly selected for' and 83.8 percent of the known owl sites occurred on that landscape. Conversely, ~72 percent of the area was 'selected against' or 'strongly selected against' and contained ~17 percent of the known owl sites. Therefore, although the BLM could have chosen other values to define categories, the values it chose have real meaning for how northern spotted owls select habitat.

The BLM determined that the 'selected against' category in western Oregon described habitat that the BLM previously had classified as habitat used only for northern spotted owl dispersal. As described above (**Table T-4**), the BLM also determined that "selected for" and "strongly selected for" were reliable predictors of nesting-roosting habitat. Given that northern spotted owls show strongest selection for nesting and roosting habitat, less strong selection for foraging habitat, and still weaker selection for dispersal habitat, the BLM determined that the "strongly selected for," "selected for" and "selected against" categories, combined, were a reasonable description of habitats that supported dispersing northern spotted owls.

In **Table T-4**, the BLM compared the acres of nesting-roosting habitat on Federal lands derived by the U.S. Forest Service (Davis *et al.* 2015) and the BLM using their separate models and data sets. In **Table T-5**, the BLM compares the acres of northern spotted owl dispersal habitat on all lands in western Oregon (the BLM evaluated dispersal capability and flux only in western Oregon) as calculated by the U.S. Forest Service (Davis *et al*. 2015, Table 12) from 2012 GNN data, and by the BLM using 2013 Woodstock data for BLM-administered lands and 2012 GNN data for other lands. Even though the two agencies used different datasets and MaxEnt models, the results are similar. And, again, the BLM is confident that its 2013 data for BLM-administered lands in western Oregon are more reliable than the 2012 GNN data for those same lands.

Table T-5. A comparison of the estimated acres of northern spotted owl dispersal habitat on all lands in western Oregon as calculated by the U.S. Forest Service and by the BLM

Oregon Physiographic Province	Acres from Davis *et al*. 2015, Table 12	Acres calculated by the BLM
Coast Range	2,589,300	1,961,636
Western Cascades	4,082,000	3,728,991
Klamath	1,918,100	1,960,445
Eastern Cascades	1,307,700	1,035,568
Totals	**9,897,100**	**8,686,640**

<u>Comment</u>: The BLM should plot response curves for the range of potential values for each MaxEnt model covariate, with other covariates fixed at the mean for each habitat suitability class, to evaluate the

efficacy of the MaxEnt models for capturing plausible changes in habitat suitability in response to changes in forest structure from forest growth or management activities.

BLM response: The U.S. Fish and Wildlife Service also was asked to provide response curves but purposefully did not. Although relative habitat suitability values are intended to predict the relative suitability of an area (based on conditions within 800 meters of the focal pixel), the individual variable values are not meant to reflect all factors that influence northern spotted owls. Thus, the U.S. Fish and Wildlife Service sought a model with good predictive abilities and that was robust and well calibrated. In this, it succeeded. Since the BLM's models are highly correlated with the U.S. Fish and Wildlife Service's models, as verified by the BLM, they should have similar attributes. The BLM is confident that its models have good predictive ability and are robust because they predicted both the original data and independent data well.

HexSim

Comment: The BLM did not perform a sensitivity analysis to determine which covariate values most influence its HexSim results.

BLM response: The BLM relied on the sensitivity analyses performed by the U.S. Fish and Wildlife Service during the development of its model (USDI FWS 2012, pp. 13–17).The BLM did not modify any of the population parameters in the U.S. Fish and Wildlife Service's HexSim model. The only difference between the U.S. Fish and Wildlife Service's use of its HexSim model and the BLM's use was that the BLM updated northern spotted owl survival and reproduction rates, and barred owl encounter rates, according to the results of the 2016 northern spotted owl meta-analysis (provided by Dr. Katie Dugger, Oregon State University, the principal author of the meta-analysis; Dugger *et al*. 2016) and recommendations by the U.S. Fish and Wildlife Service, and recalibrated the simulation start time to the year 2013.

Comment: The BLM approach for simulating competitive interactions between barred owls and northern spotted owls misrepresents the ecological mechanism that contributes to spotted owls being displaced from sites, which many experts believe is interference competition. If interference competition and competitive displacement are the mechanisms, which contribute to spotted owl site abandonment, then total habitat carrying capacity becomes extremely important because much of that habitat is occupied by barred owls. If that is the case, then relatively small changes in habitat amount could produce disproportionate changes in northern spotted owl numbers. That relationship is currently masked within the BLM HexSim model because encounters with barred owls are represented as a random predation effect that has the potential to suppress the northern spotted owl population well below habitat carrying capacity.

BLM response: Northern spotted owl survival, as used in the U.S. Fish and Wildlife Service's HexSim model, and subsequently by the BLM, was derived from Forsman *et al*. 2011 (USDI FWS 2011, pp. C-59, C-68 and C-69, and 2012, pp. 10, 13) and, for preparation of the Proposed RMP/Final EIS, from the 2016 meta-analysis (Dugger *et al*. 2016). Although survival, as it is used in the model, might not reflect the ecological processes, such as interference competition, that cause northern spotted owls to react to barred owls in specific ways, it is based on scientific research.

As explained in the Northern Spotted Owl section of Chapter 3, BLM simulations indicate that, within the range of the alternatives and the Proposed RMP examined by the BLM, limited carrying capacity is not a basis for BLM decision-making because there are no substantive differences in the northern spotted owl responses among alternatives and the Proposed RMP. In addition, all alternatives and the Proposed RMP show essentially identical northern spotted owl responses as would occur under the BLM's No Timber Harvest reference analysis.

Neither the U.S. Fish and Wildlife Service nor the BLM have suggested that barred owl effects are random predation effects and not competition effects. The northern spotted owl HexSim model used by both the U.S. Fish and Wildlife Service and BLM simply assumes that, if a barred owl is present in a northern spotted owl's territory, survivorship of the spotted owl would decrease according to observed rates and probabilities. Neither agency assumed that this decrease was due to predation, starvation, competition or any other specific mechanism. The encounters with barred owls in the HexSim model are represented only as reductions in survival; scientists have not identified a specific mechanism. Among potential causes, displacement from nest sites (competition for nest sites), direct predation of spotted owls by barred owls (predation), and competition for food are ideas that have varying levels of support in the scientific community, and it is likely that more than one mechanism occurs.

When barred owl encounters are treated like predation effects, there may be little or no response to changes in habitat availability. The U.S. Fish and Wildlife Service found this to be the case when barred owl encounter rates exceeded 0.5. However, with barred owl encounter rates at 0.25 or 0.0, the U.S. Fish and Wildlife Service found a relatively strong effect of habitat on northern spotted owl populations. Those results are logical regardless of whether the actual mechanism is predation, competition or some combination.

Comment: On page 774 of the Draft RMP/EIS, the BLM notes that there is relatively broad consensus among northern spotted owl experts that competition with barred owls is a primary contributor to northern spotted owl population declines, and the BLM cites Dugger et al. (2011) and Wiens et al. (2014) regarding the importance of habitat conservation in the face of competition with barred owls. Unfortunately, the HexSim modeling in the BLM analysis does not capture that competitive displacement mechanism. This is a particularly difficult problem because representing spatial displacement of northern spotted owls by barred owls requires spatially explicit predictions of barred owl occupancy, and such information is probably not available for most of the range. One approach for addressing this problem would be to run HexSim scenarios both with and without additive mortality from barred owl interactions and interpret the outputs from model runs without barred owl impacts as estimates of total owl habitat carrying capacity, then compare carrying capacity across management alternatives with the understanding that the carrying capacity is in reality likely to be split between spotted owls and barred owls due to the displacement pressures of barred owls on spotted owl populations. Even using the modified barred owl encounter rates is likely to reduce the sensitivity of the HexSim model to changes in habitat amount and distribution.

<u>BLM response</u>: The suggestion that northern spotted owl population responses to the alternatives and the Proposed RMP are "likely to be split" between the effects of habitat and barred owl encounters is too suppositional for BLM decision-making processes. Furthermore, the National Environmental Policy Act requires the BLM to examine reasonably foreseeable northern spotted owl responses to its alternatives and the Proposed RMP. The BLM saw no value in determining if spotted owls would respond better under one alternative than another in the absence of barred owls when such absence was not reasonably foreseeable, even if the U.S. Fish and Wildlife Service were to implement a control program. That said, the BLM discussed the reasonableness of reduced barred owl encounter rates with the U.S. Fish and Wildlife Service. The BLM recognizes that both habitat and barred owls have impacts on northern spotted owl populations.

D. How the BLM Refined its Relative Habitat Suitability Surfaces between the Draft RMP/EIS and the Proposed RMP/Final EIS

As explained in Appendix S of the Draft RMP/EIS (USDI BLM 2015), the BLM developed, through separate processes, northern spotted owl relative habitat suitability surfaces for (1) the decision area (using BLM Woodstock covariates) and (2) all lands in the United States' portion of the northern spotted owl range (using GNN covariates). The BLM then deleted those portions of the range-wide surfaces that pertained to the decision area and replaced them with the surfaces it developed specifically for those lands. Here, the BLM describes how it further refined its relative habitat suitability surfaces since publication of the Draft RMP/EIS.

All Lands in the United States' Portion of the Northern Spotted Owl's Range

For the Draft RMP/EIS, the BLM forecasted decadal changes in relative habitat suitability over time from three causes: large (at least 1,000-acre) wildfires, timber harvest and forest ingrowth (USDI BLM 2015, pp. 1480–1485).

- To forecast large wildfires, the BLM developed the method described in Appendix D of the Draft RMP/EIS.
- To forecast timber harvest, the BLM used unpublished LandTrendr data developed by the U.S. Forest Service for 1996–2006 (Davis *et al*. 2011, pp. 28–30) and projected changes calculated from 1996–2006, specific to modeling region and land classification, into the future at decadal increments.
- To forecast forest ingrowth, the BLM initially masked out (1) 1996–2006 wildfire burn patches, (2) 1996–2006 calculated timber harvest units (based on the 1996–2006 LandTrendr data) and (3) lands within 800 meters of those areas (because the BLM relative habitat suitability values of each pixel are based on the means of covariate values within 800 meters of the pixel; see USDI BLM 2015, pp. 1480–1481). In theory, masking out these lands would eliminate all lands that experienced, or were influenced by, habitat losses during 1996–2006, leaving only those lands that had experienced positive or neutral changes (i.e., forest ingrowth) during that period.

The BLM verified the reliability of its wildfire methodology through expert review and continued to use it for the Proposed RMP/Final EIS. The BLM also determined that its use of LandTrendr was the most reliable method for forecasting timber harvest. However, to forecast forest ingrowth, the BLM found that, even after it had masked out the lands described above, the remaining lands still exhibited substantial habitat loss during 1996–2006 (i.e., the LandTrendr analysis did not account for much of the observed habitat loss that occurred during that period). Because the BLM needed to forecast changes in relative habitat suitability values from forest ingrowth, and habitat losses during 1996–2006 clearly did not result from ingrowth, the BLM compensated by changing all negative changes in relative habitat suitability values on unmasked lands during 1996–2006 to 0. In addition, because the BLM felt that positive changes in relative habitat suitability values during 1996–2006 greater than 10 were unrealistic, based on how northern spotted owl habitat is known to develop, the BLM truncated change values greater than 10 to 10. However, even though the BLM determined analytically that the resulting forecasts in forest ingrowth realistically followed observed forest structural progressions, it felt that its estimates of forest ingrowth in some areas, primarily in northern California, were optimistic and could be improved.

Following publication of the Draft RMP/EIS, the BLM experimented with dropping the 1996–2006 LandTrendr analysis. Instead, the BLM used GNN data to estimate changes (both positive and negative) from all causes other than large wildfires. Since the 2012 GNN data now were available, the BLM estimated such changes during 1996–2012 by:

- Masking out the decision area, because the BLM was estimating temporal changes in relative habitat suitability on other lands in this process;
- Masking out 1996–2012 wildfire burn patches of at least 1,000 acres, because the BLM would forecast habitat changes from large wildfires using its wildfire model;
- Masking out all lands within 800 meters of the BLM-administered lands and the 1996–2012 large wildfire patches.
- Calculating the observed mean change in each relative habitat suitability value during 1996–2012 for the remaining lands (i.e., for all 30 × 30-m pixels with the same relative habitat suitability value in 1996, calculating the mean change in that value between 1996 and 2012); and
- Dividing the mean rate-of-change for each relative habitat suitability value by 1.6 to prorate the 16-year (1996–2012) change to a decadal change (e.g., a mean change in relative habitat suitability value during 1996–2012 of +16 was prorated to +10; a mean change of -16 was prorated to -10).

The BLM calculated such mean changes by land division (i.e., for each physiographic province and, within each province, for Congressionally Reserved lands, all other Federal reserved lands, Federal non-reserved lands, and non-Federal lands). Since there are 12 physiographic provinces within the northern spotted owl's range, the BLM calculated 48 sets of mean changes in relative habitat suitability values.

Because the GNN data were derived from Landsat imagery, the BLM still was concerned that calculated mean changes (both positive and negative) for some relative habitat suitability values could be unrealistic given how forest structure develops. Although satellite imagery is reliable at the landscape scale, it is less reliable at the scale of a 200-ha circle (which has a radius of 800 m), the scale at which the BLM calculated relative habitat suitability values. Thus, the BLM anticipated that the values of some individual pixels could change to such a degree that they would bias the mean change for certain pixel values (e.g., a positive change that exceeds the rate at which forest stands are known to develop). This especially would be likely for relative habitat suitability values that were uncommon on the landscape in 1996.

To address this, the BLM compared, for each land division, decadal rates of change for all data and for subsets of data within 1.0, 1.5 and 2.0 standard deviations from the mean change for each relative habitat suitability value. The BLM found no appreciable differences between any of the resulting data sets, i.e., no evidence that one dataset projected habitat change more accurately than the other datasets. Therefore, the BLM chose to use the full dataset for each land division.

Table T-6 shows, for each physiographic province, forecasts of northern spotted owl habitat change during 2013–2063 on non-Federal lands using different methods. Habitat is classified by strength-of-selection, with 'selected for' and 'strongly selected for' corresponding to northern spotted owl nesting-roosting habitat, and these two classes plus 'selected against' corresponding to northern spotted owl dispersal habitat. Column 1 shows the forecasts that the BLM developed for the Draft RMP/EIS. Column 2 shows the forecasts according to the full 1996–2012 GNN datasets described in the previous paragraph.

Table T-6. A comparison of decadal rates of change in relative habitat suitability value on non-Federal lands from large wildfires, timber harvest and forest ingrowth, by strength-of-selection category and physiographic province, using four methods described in the text

Physiographic Province	Strength-of-Selection Class	1	2	3	4
Oregon Coast Range	Strongly Selected Against	-12.29%	25.04%	-10.55%	-10.74%
	Selected Against	63.46%	-76.17%	58.22%	59.20%
	Selected For	3.56%	-99.43%	-4.43%	-5.09%
	Strongly Selected For	-31.30%	-97.46%	-33.36%	-30.35%
Oregon Eastern Cascades	Strongly Selected Against	-60.02%	-78.70%	-45.31%	-56.83%
	Selected Against	45.81%	170.10%	37.22%	24.64%
	Selected For	126.66%	47.75%	97.81%	144.29%
	Strongly Selected For	49.63%	-59.68%	25.50%	60.72%
Oregon Klamath	Strongly Selected Against	-21.69%	1.34%	-10.39%	-13.53%
	Selected Against	31.99%	9.71%	23.47%	8.46%
	Selected For	31.53%	4.39%	8.39%	43.55%
	Strongly Selected For	82.08%	-85.47%	23.03%	24.36%
Oregon Western Cascades	Strongly Selected Against	-22.98%	34.72%	-6.75%	-6.62%
	Selected Against	69.89%	-89.10%	29.41%	28.99%
	Selected For	42.91%	-96.96%	-3.31%	-4.11%
	Strongly Selected For	47.27%	-98.79%	-6.29%	-3.05%
California Cascades	Strongly Selected Against	-29.12%	-35.58%	-14.78%	-21.78%
	Selected Against	51.60%	147.96%	19.78%	28.56%
	Selected For	62.70%	-44.34%	44.03%	54.01%
	Strongly Selected For	59.34%	-100.00%	27.89%	100.62%
California Coast Range	Strongly Selected Against	-50.55%	-81.80%	-26.80%	-48.05%
	Selected Against	-5.61%	-25.23%	-1.35%	-7.84%
	Selected For	10.15%	36.55%	7.08%	31.98%
	Strongly Selected For	114.60%	176.84%	51.87%	57.35%
California Klamath	Strongly Selected Against	-41.91%	-41.00%	-28.23%	-41.42%
	Selected Against	-15.98%	-0.56%	-14.50%	0.96%
	Selected For	36.88%	61.08%	39.05%	17.84%
	Strongly Selected For	97.68%	-12.72%	39.76%	96.46%
Washington Eastern Cascades	Strongly Selected Against	-21.66%	0.26%	-20.77%	-21.08%
	Selected Against	26.13%	66.58%	41.42%	24.98%
	Selected For	41.69%	-69.28%	25.84%	44.19%
	Strongly Selected For	45.30%	-97.29%	12.86%	36.73%
Washington Western Lowlands	Strongly Selected Against	-6.75%	10.56%	-5.92%	-5.86%
	Selected Against	74.88%	-100.00%	65.36%	63.91%
	Selected For	9.98%	-100.00%	9.98%	13.19%
	Strongly Selected For	26.60%	-100.00%	29.64%	47.83%
Washington Olympic Peninsula	Strongly Selected Against	-16.48%	24.65%	-14.82%	-15.08%
	Selected Against	63.15%	-43.84%	56.59%	49.07%
	Selected For	-3.57%	-99.79%	5.44%	25.85%
	Strongly Selected For	29.10%	-100.00%	-8.14%	-10.01%
Washington Western Cascades	Strongly Selected Against	-5.24%	9.31%	-4.81%	-4.73%
	Selected Against	51.10%	-37.64%	47.10%	45.98%
	Selected For	0.29%	-88.08%	0.26%	0.45%
	Strongly Selected For	-2.62%	-99.78%	-3.34%	-2.16%

Regarding the method reflected in **Table T-6**, Column 2, in the Oregon Coast Range and Oregon Western Cascades provinces, the two largest provinces in the decision area, unfiltered rates of change during 1996–2012 resulted in forecasted losses of 97–99 percent of selected-for and strongly-selected-for habitat during the next 50 years. (Not shown in **Table T-6**, the forecast for the Oregon Coast Range Province also showed a 43 percent loss in these classes during 2013–2023.) However, although these forecasts reflect observed rates of non-Federal timber harvests that began in the early to mid-1990s and extended to the 2008 recession (Gale *et al*. 2012, pp. 3–11), they cannot continue at this rate in the future and, thus, are not reliable for making 50-year forecasts. Stated another way: to lose 97–99 percent of such habitat on non-Federal lands during the next 50 years, it would have to be harvested from steep slopes, fragile soils, riparian areas, private house lots, State parks and other areas not reasonably subject to timber harvest, or burned on unprecedented numbers of acres by unprecedented levels of high-intensity wildfire (Gale *et al*. 2012). Thus, the BLM determined that habitat changes that occurred on non-Federal lands during 1996–2012, although real, were not indicative of future change, because they cannot continue at that rate and, therefore, could not be used in their raw form to forecast future change.

Given these results, the BLM returned to the method it used for the Draft RMP/EIS, with the following revisions:

- To forecast forest ingrowth, the BLM tested limiting positive changes in relative habitat suitability values to 1.0, 1.5 and 2.0 standard deviations from the mean instead of simply +10.
- To forecast timber harvest, the BLM replaced the 2006 LandTrendr analysis with the newly-available 2012 LandTrendr analysis.

The results of these changes are shown in columns 3 and 4 of **Table T-6**; Column 3 is based on limiting forest ingrowth rates to 1 standard deviation from the mean; Column 4 is based on limiting ingrowth rates to 2 standard deviations from the mean. Because columns 1–4 include the effects of forest ingrowth, timber harvest and wildfire on non-Federal lands, the forecasted change values are directly comparable.

Comparing the values in columns 1, 3 and 4 of **Table T-6**, the BLM determined that the values in columns 3 and 4 likely were more reliable forecasts of habitat change on non-Federal lands given past harvest rates and the fact that both sets of values reflected sustainable rates of timber harvest. In addition, the values in Column 3 were more conservative than the values in Column 4. After conferring with experts who were familiar with the original data and how forests develop in western Oregon (Craig Ducey, BLM, Jeffrey Dunk, Humboldt State University, Betsy Glenn, U.S. Fish and Wildlife Service, and David LaPlante, Natural Resource Geospatial, pers. com. to Eric Greenquist, various dates during 2015) , the BLM determined that the more-conservative Column 3 values, in terms of northern spotted owl habitat change on non-Federal lands, were the most realistic forecasts it could make from the available data.

In summary, the BLM determined analytically that the 1996–2012 GNN data, the most accurate data for non-BLM-administered lands in the range of the northern spotted owl, could not be used in their raw form to forecast habitat changes on those lands during 2013–2063, because observed rates of habitat loss on non-Federal lands during 1996–2012 were not indicative of future change. As described above, this finding by the BLM accords well with the findings of Gale *et al*. (2012). Therefore, the BLM explored methods to filter the GNN data to generate forecasts that better accord with projections of timber harvest on non-Federal lands at rates that could continue into the future. In refining its methods, the BLM chose the more conservative of its reliable forecasts: the forecast that showed the largest habitat losses on non-Federal lands that could still continue into the future. To be clear, the BLM does not intend its forecasts of range-wide habitat changes to be precise and accurate predictions of future habitat conditions. Instead, they are intended only as reasonable and credible approximations of future habitat conditions in each province and land classification that can be used to compare northern spotted owl habitat and population responses to the different alternatives and the Proposed RMP.

The Decision Area

For the Draft RMP/EIS, the BLM used only the covariate values derived by Woodstock to calculate relative habitat suitability values for BLM-administered lands. This was problematic because, normally, the relative habitat suitability value of each 30 × 30-m pixel is calculated from the means of the covariate values within 800 meters of the pixel. However, for the years 2023, 2033, 2043, 2053 and 2063 no GNN covariate values existed for lands that were within 800 meters of BLM-administered lands. Although the BLM can forecast decadal changes in relative habitat suitability values for other lands, as described above, it cannot forecast decadal changes in the GNN covariate values that are used to calculate relative habitat suitability values. Since Woodstock derives future covariate values only for BLM-administered lands, there existed no future covariate values for other lands within 800 meters of BLM-administered lands that the BLM could use to calculate relative habitat suitability values on BLM-administered lands for the years 2023, 2033, 2043, 2053, and 2063.

For the Draft RMP/EIS, the BLM used only Woodstock-derived covariate values to calculate relative habitat suitability on BLM-administered lands, effectively ignoring the influence of other lands within 800 meters of BLM-administered lands. The only option the BLM had to ignoring the influences of other lands within 800 meters of BLM-administered lands was to assume that habitat conditions on those other lands would remain static over time (i.e., calculate decadal relative habitat suitability values for BLM-administered lands using the decadal Woodstock covariate values for BLM-administered lands and the 2012 GNN covariate values for other lands within 800 meters of BLM-administered lands). The BLM chose to ignore the influence of other lands, because it determined that the effects of ignoring the other lands were negligible where BLM-administered lands abutted reserves on other Federal lands. However, where BLM-administered lands abutted non-Federal lands, especially private industrial timberlands, and to a lesser extent, Federal non-reserved lands, the BLM determined that its process tended to overestimate the relative habitat suitability of the BLM-administered lands.

With its more-conservative forecasts of habitat changes on other lands within the range of the northern spotted owl, as described above, the BLM determined that the latter of the two options described above—use the decadal Woodstock covariate values for BLM-administered lands and the 2012 GNN covariate values for other lands within 800 meters of BLM-administered lands—was likely more realistic than using only the decadal Woodstock covariates to calculate relative habitat suitability values for BLM-administered lands. The BLM tested modeling relative habitat suitability values on BLM-administered lands in two ways:

1. Non-weighted covariate values

- The BLM identified BLM-administered lands within 800 meters of Congressionally Reserved lands and other Federal reserves (e.g., the Late-Successional Reserve on U.S. Forest Service lands). On those BLM-administered lands, the BLM calculated relative habitat suitability values using only the Woodstock covariates within 800 meters of each pixel to account for the likelihood that habitat development on BLM-administered lands would best represent habitat development on the adjacent reserved lands.
- On all other BLM-administered lands, the BLM calculated relative habitat suitability values using the decadal Woodstock covariates for the BLM-administered lands within 800 meters of each pixel and the 2012 GNN covariate values within 800 meters of each pixel.

2. Weighted covariate values

- The BLM masked Congressionally Reserved lands and other Federal reserves within 800 meters of BLM-administered lands and excluded the GNN covariate values for those lands from its analysis.

- Within the 800 meters circle around each pixel, the BLM calculated the area of (1) BLM-administered lands plus Congressionally Reserved lands and other Federal reserves, and (2) Federal non-reserved lands and non-Federal lands.
- The BLM then weighted the decadal Woodstock covariate values and 2012 GNN covariate values within 800 meters of each pixel according to the area of each of the two land classifications; i.e., the BLM weighted the decadal Woodstock covariate values according to the portion of the 800 meters circle represented by BLM-administered lands, Congressionally Reserved lands and other Federal reserves, and the 2012 GNN covariate values according to the portion represented by Federal non-reserved lands and non-Federal lands.

The BLM found no substantive difference between the two methods in its habitat forecasts for BLM-administered lands over time. Therefore, the BLM chose not to weigh the covariate values, because that was the analytically simpler and quicker of the two methods.

E. Developing and Calibrating the BLM HexSim Model

As described above, the BLM determined that the HexSim model developed by the U.S. Fish and Wildlife Service to inform its decisions on northern spotted owl recovery and critical habitat (USDI FWS 2011, pp. Appendix C, and USDI FWS 2012), with specific changes, could help the BLM meet its planning needs. Therefore, the BLM took the U.S. Fish and Wildlife Service's northern spotted owl HexSim model, fully parameterized, and modified it as necessary. The BLM made the following changes:

- The BLM developed different range-wide relative habitat suitability surfaces that reflected spatially-explicit estimates of how forest stands would respond over time to forest ingrowth, timber harvest and wildfire on all lands, and also to forest restoration treatments (such as thinning consistent with Late-Successional Reserve or Riparian Reserve management direction) on the decision area.
- Although the BLM altered relative habitat suitability values by decade on all lands, as described above, the BLM did not otherwise augment or suppress those values. In effect, unlike some U.S. Fish and Wildlife Service simulations that limited northern spotted owl nesting to potential critical habitat units, the BLM always allowed simulated northern spotted owls to move, forage, and establish nest territories on all lands according to local relative habitat suitability values.
- Because the BLM required both stochastic and non-stochastic simulations of northern spotted owl response for the reasons described in Chapter 3 (Northern Spotted Owl, Issue 4), the BLM completed 500 replicate simulations of each alternative. In contrast, after its Phase 1 modeling, the U.S. Fish and Wildlife Service used only stochastic simulations, with 100 replicates per alternative (USDI FWS 2012, p. 29).
- Although the BLM calibrated the BLM model using the same method used by the U.S. Fish and Wildlife Service (USDI FWS 2011, pp. C-71 – C-74), the BLM calibration, described below, yielded unique numbers and locations of female northern spotted owls to begin each of the replicate simulations.
- The BLM used observed barred owl encounter rates (for the Draft RMP: Forsman *et al*. 2011, pp. Appendix B, and USDI FWS 2011, p. C-66 and Table C-25; for the Proposed RMP/Final EIS: the 2016 meta-analysis data provided by Dr. Dugger and as recommended by the U.S. Fish and Wildlife Service) for reasons described in Chapter 3 (Northern Spotted Owl Issue 4).
- Also for reasons described in Chapter 3 (Northern Spotted Owl Issue 4), the BLM simulated 50 years (2013–2063) with relative habitat suitability values changing every 10 years according to the BLM forecasts, and then held habitat values constant for an additional 50 years.

Calibration for the Draft RMP/EIS

The northern spotted owl HexSim model developed by the U.S. Fish and Wildlife Service (USDI FWS 2011, Schumaker *et al*. 2014) is an individual-based, spatially explicit, population simulation model. The U.S. Fish and Wildlife Service parameterized the model based on empirically derived estimates of age-

specific survival, fecundity, territory and home-range size, and dispersal (USDI FWS 2011 and Schumaker *et al*. 2014). The U.S. Fish and Wildlife Service used its relative habitat suitability surface in HexSim to represent resource quality (higher values were of greater quality than lower values). Each of the eleven modeling regions (USDI FWS 2011, p. C-13) had different resource targets for northern spotted owls, and resource targets varied in relation to home range size (larger targets in areas with larger home ranges). For home range size variation, many empirical studies existed and the U.S. Fish and Wildlife Service used them to guide its decisions in the development of HexSim (USDI FWS 2011, pp. Appendix C, and Schumaker *et al*. 2014). However, other than variation in home range size, no empirical information existed to guide specific decisions on resource targets. Because resource targets—as represented by relative habitat suitability—are not real, on-the-ground quantities, they can have no empirical basis; they only can be associated with on-the-ground resources. Thus, the authors of the U.S. Fish and Wildlife Service's northern spotted owl HexSim models varied resource targets until resulting simulated population sizes were similar to empirically estimated populations of northern spotted owls (USDI FWS 2011, pp. Appendix C, and Schumaker *et al*. 2014). This model calibration happened by 'tuning' (i.e., varying) resource targets by modeling region. The U.S. Fish and Wildlife Service (USDI FWS 2011, pp. Appendix C) also calibrated its HexSim model for dispersal such that simulated northern spotted owls that dispersed did so in a way that resulted in similar dispersal distance profiles to those estimated from empirical studies. For this portion of the calibration, the U.S. Fish and Wildlife Service tuned the model by varying the attraction/repulsion of various habitats (relative habitat suitability values) as well as the maximum number of 86.6-ha hexagons a dispersing owl could move through while attempting to find a territory (USDI FWS 2011, Schumaker *et al*. 2014).

The BLM initially intended to use the 2012 GNN version of Model 13 for other lands within the northern spotted owl's range. However, as the BLM evaluated how Model 13 would be used for HexSim population dynamics modeling, it evaluated a range of factors that, instead, suggested using the U.S. Fish and Wildlife Service MaxEnt model projected to newly available 2012 GNN variables for other lands:

- The U.S. Fish and Wildlife Service HexSim model had been developed to work with and calibrated to the U.S. Fish and Wildlife Service 2006 GNN MaxEnt relative habitat suitability model, and had been demonstrated to be well-calibrated to those data (USDI FWS 2011, pp. Appendix C).
- The BLM's 2006 GNN version of Model 13 demonstrated a high degree of correlation to the U.S. Fish and Wildlife Service 2006 GNN model (correlation coefficient of 0.867).
- The decision area accounts for about 4 percent of lands in the northern spotted owl's range. As such, relative habitat suitability values on BLM-administered lands would likely have a proportionally small effect on overall population response.
- The U.S. Fish and Wildlife Service initially calibrated its HexSim model by adjusting model parameters (i.e., resource targets) separately for each of its eleven modeling regions. The decision area is constrained to four of those regions. This meant that, by using the U.S. Fish and Wildlife Service 2006 GNN MaxEnt relative habitat suitability surface, five of the eleven modeling regions would require no recalibration at all. And, because of the high degree of correlation between the U.S. Fish and Wildlife Service's model and Model 13, the other modeling regions probably would require only minor recalibration.

Given these conditions, the BLM determined that using the U.S. Fish and Wildlife Service 2012 GNN model for other lands was reasonable and would require less calibration and re-development of HexSim than would be required using the BLM 2012 GNN Model 13 relative habitat suitability surfaces for those lands.

The U.S. Forest Service released its 2012 GNN data at about the same time the BLM reached this phase in the project; up to this point, the latest release of these data was for 2006. To create the new 2012 version of the U.S. Fish and Wildlife Service MaxEnt model, the BLM generated a full set of model

variable surfaces from the 2012 GNN data, using the same GNN attributes and methods used by U.S. Fish and Wildlife Service to generate the original 1996 and 2006 covariate rasters (USDI FWS 2011, Appendix C). The BLM then projected the original U.S. Fish and Wildlife Service 1996 MaxEnt model to the 2012 covariate rasters separately for each of the eleven U.S. Fish and Wildlife Service modeling regions and merged them into a single, seamless, range-wide relative habitat suitability surface.

To derive the relative habitat suitability surface needed to calibrate HexSim, the BLM then replaced the pixels in the U.S. Fish and Wildlife Service 2012 GNN model for the decision area with data from the final BLM 2013 Woodstock Model 13 raster.

Because the BLM created new MaxEnt surfaces for the decision area, the BLM sought to evaluate whether the 'default settings' of HexSim, as used by the U.S. Fish and Wildlife Service, would work well for the BLM, or whether further calibration (fine tuning) was needed before running population simulations. In its calibration/tuning of the northern spotted owl HexSim model, the U.S. Fish and Wildlife Service (USDI FWS 2011, pp. Appendix C) found that time-step 50 represented a reasonable approximation of the present (at the time the U.S. Fish and Wildlife Service did its work). The only differences between the data feeding into the northern spotted owl HexSim models by the U.S. Fish and Wildlife Service and this effort by the BLM were that:

- The U.S. Fish and Wildlife Service and the BLM used different MaxEnt relative habitat suitability surfaces for the decision area, and;
- The relative habitat suitability surface for the decision area was estimated for 2013. The BLM projected the U.S. Fish and Wildlife Service 1996 GNN MaxEnt models using GNN data from 2012 (as opposed to 2006, as used by the U.S. Fish and Wildlife Service) for other lands.

Thus, this new 'base' relative habitat suitability surfaces used by the BLM used the identical MaxEnt models for all lands except BLM-administered lands in the planning area, and, for those lands, the BLM developed a new MaxEnt model (Model 13). Since the correlation between the relative habitat suitability surfaces developed by the U.S. Fish and Wildlife Service and Model 13 was so high, the BLM anticipated that its HexSim model would require minor, or no, recalibration.

The BLM began recalibration by using the U.S. Fish and Wildlife Service default HexSim settings, and evaluated population estimates for the same eight demographic study areas for which the U.S. Fish and Wildlife Service had data (USDI FWS 2011, pp. C-71 – C-75). The BLM ran 20 replicates of HexSim (without environmental stochasticity; see Northern Spotted Owl, Chapter 3) for 70 time-steps. Replicates refer to the number of distinct simulations that are run. Because HexSim is not a deterministic model, several replicates are needed to get an estimate of mean responses (i.e., different replicates will almost always vary in their specific population responses). The BLM chose 70 time-steps because it initially wanted to evaluate whether, using default settings, simulated demographic study area population sizes were more/less similar to empirically-estimated populations before, during, or after time-step 50: the time-step that the U.S. Fish and Wildlife Service (USDI FWS 2011, pp. C-71 – C-75) found to be a good approximation of 'now.' The BLM used the mean population among the 20 replicates to estimate simulated population size. For the eight demographic study areas, the BLM used the mean of the three years with the largest population to estimate population size (USDI FWS 2011, pp. C-71 – C-75).

Using default parameters in the northern spotted owl HexSim model, the BLM found that mean population size of territorial owls on the eight demographic study areas at time-step 59 corresponded most closely with the empirical population estimates. For the demographic study areas, empirical estimates of populations ranged from 30 to 130, with the total population on the eight study areas being 756. At time-step 59, mean simulated estimates of populations ranged from 32 to 145, with a total population of 763. The pairwise percent differences between empirical and simulated populations on each of the study areas varied from 0.54 percent to 41.75 percent, with a mean percentage difference of 4.7 percent. Time-step 55

had the smallest mean percent difference (-2.3 percent) but the estimate of total population size on the eight study areas was 6 percent higher than the empirical estimates. In contrast, the time-step 59 estimated total population size on the eight study areas was 0.95 percent larger than the empirical estimate. **Figure T-17** compares empirical and time-step 59 population estimates in each of the study areas.

Because the default parameters worked well, the BLM did not further attempt to fine-tune any parameter settings and used the default settings. The only difference between the U.S. Fish and Wildlife Service's (USDI FWS 2011) and BLM's use of the spotted owl HexSim model was that the U.S. Fish and Wildlife Service used time-step 50 to represent the current year and the BLM used time-step 59.

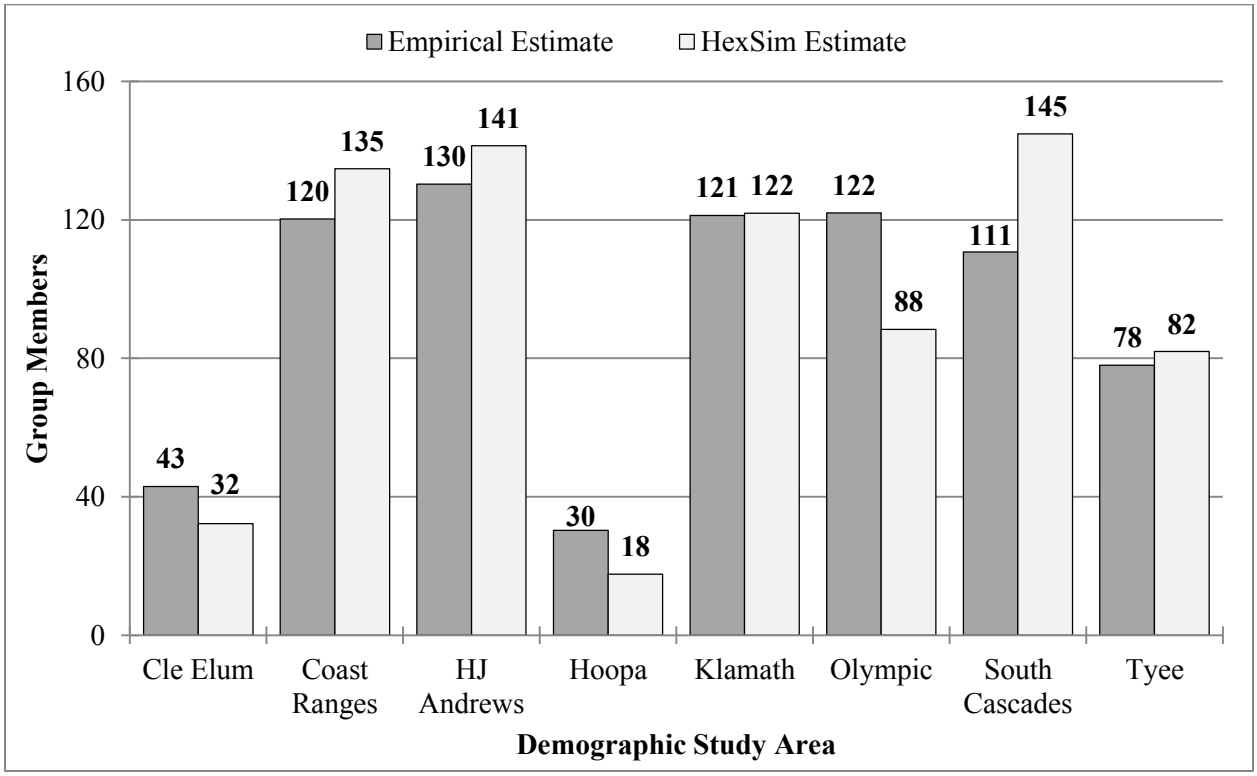


Figure T-17. Comparison of the mean of estimates of territorial northern spotted owls on eight demographic study areas estimated in the field (empirical estimates, n = mean of three highest years between 1996 and 2006) and estimated using the BLM northern spotted owl HexSim model (mean from 20 replicates of HexSim at time-step 59)

Additional Calibration for the Proposed RMP/Final EIS

The northern spotted owl HexSim model that the BLM used for its Draft RMP/EIS was essentially identical to that used by the U.S. Fish and Wildlife Service to inform its decisions on northern spotted owl recovery and the delineation of northern spotted owl critical habitat. The U.S. Fish and Wildlife Service model relied heavily on demographic parameters from the 2011 northern spotted owl meta-analysis (Forsman *et al*. 2011). Since publication of the Draft RMP/EIS, Dr. Katie Dugger, Oregon State University, the principal author of the 2016 northern spotted owl meta-analysis (Dugger *et al*. 2016), provided the BLM with five additional years of (not-yet-published) meta-analysis results on northern spotted owl adult fecundity and survival, and barred owl encounter rates.

Fecundity

Dr. Dugger provided meta-analysis results for the eight northern spotted owl demographic study areas on Federal land that are used to monitor the Northwest Forest Plan. Fecundity data were stratified among three northern spotted owl age classes: 1-year olds (S1), 2-year olds (S2), and greater than or equal to 3-year olds (adults). The northern spotted owl HexSim model that the BLM used for the Draft RMP/EIS , which relied on fecundity data from Forsman *et al*. 2011, assumed mean fecundity values of 0.070, 0.202, and 0.330 for S1, S2, and adults, respectively. Mean (un-weighted) fecundity values among the eight demographic study areas from the 2016 meta-analysis were 0.068, 0.215, and 0.326 for S1, S2, and adults, respectively. Since these values for each age class were nearly identical, the BLM did not change fecundity values in its HexSim model for the Proposed RMP/Final EIS.

Survival

The U.S. Fish and Wildlife Service used data from Forsman *et al*. 2011 (p. 32, Table 12) to stratify survival rates among S1, S2, and adult owls. The authors of the 2016 meta-analysis did not use the same analytic approach used by Forsman *et al*. (2011). Forsman *et al*. based their estimates of age-specific survival on model averaging. In contrast, for the 2016 meta-analysis, Dugger *et al*. (2016) based their results on the best random effects model for each demographic study area. In addition, Dugger *et al*. estimated only adult survival whereas Forsman *et al*. estimated survival for each age class. As with the fecundity data, Dugger *et al*. provided estimates of adult survival for the eight Federal land demographic study areas.

For each of the eight demographic study areas, the BLM estimated mean annual survival from the 2016 meta-analysis and compared them to the model-averaged rates estimated by Forsman *et al*. (2011) for the same demographic study areas. For the eight demographic study areas, the estimates by Forsman et al. were larger for three demographic study areas, smaller for three demographic study areas, and identical for two demographic study areas. The average difference between the Dugger *et al*. and Forsman *et al*. estimates was 0.0039 (range -0.003 to 0.025). The grand mean of estimates according to Dugger *et al*. and Forsman *et al*. were 0.8502 and 0.8463, respectively.

The BLM did not change survival values in its HexSim model for the Proposed RMP/Final EIS, because (1) estimates of adult survival by Dugger *et al*. and Forsman *et al*. 2011 were so similar, (2) both sets of authors used different approaches to calculate survival, and (3) Dugger *et al*. did not calculate survival for all age classes.

Barred Owl Encounter Rates

Dr. Dugger provided updated estimates of barred owl encounter rates (the proportion of northern spotted owl territories on which surveyors detected barred owls) for each of the eight Federal land demographic study areas. She provided the estimates for each year since the studies began (or when barred owls first were recorded) through 2013. For the eight demographic study areas, the highest barred owl encounter rates occurred in 2013 for four demographic study areas. Seven of the eight demographic study areas show very strong linear time trends in barred owl encounter rates.

For each demographic study area, the BLM compared the mean barred owl encounter rate for the years 2007–2009 and 2011–2013. The mean percent change for all demographic study areas between these two means was 24.04 percent (range 8.37–83.33). Mean change for 2008–2013 was 36.87 percent, and for 2009–2013 was 26.48 percent. Slopes of individual demographic study area linear regressions (barred owl encounter rate × time) averaged 0.02 (range 0.004–0.041). Thus, the barred owl encounter rates, on average, increased by about 2 percent per year in the eight demographic study areas from approximately 1990-2013.

In the U.S. Fish and Wildlife Service's HexSim model, the U.S. Fish and Wildlife Service based barred owl encounter rates on demographic study area data provided by Forsman *et al*. (2011). Some demographic study areas are completely within one of the U.S. Fish and Wildlife Service's modeling regions, whereas other demographic study areas straddle multiple modeling regions, and some modeling regions have no demographic study area. Thus, the U.S. Fish and Wildlife Service used a combination of empirical data and professional judgment to ascribe barred owl encounter rates to each of the eleven U.S. Fish and Wildlife Service modeling regions.

For those demographic study areas within a single discrete modeling region, the BLM used the 2013 barred owl encounter rate from the demographic study area. For those modeling regions where it was less clear, the BLM applied the 26.48 percent increase (i.e., the average observed rate of change for all demographic study areas during 2009–2013) to the rates used by U.S. Fish and Wildlife Service in its HexSim model. Forsman *et al*. (2011) presented data on barred owl encounter rates through 2008. Thus, the BLM determined that using the average percentage increase on demographic study areas from 2009 to 2013, as the inflation factor was warranted. **Table T-7** compares the barred owl encounter rates used by the BLM for the Draft RMP/EIS and the Proposed RMP/Final EIS.

Table T-7. Barred owl encounter rates used by the BLM for the Draft RMP/EIS and Proposed RMP/Final EIS

Modeling Region	Estimated Barred Owl Encounter Rates Used for the Draft RMP	Estimated Barred Owl Encounter Rates Used for the Proposed RMP/Final EIS
North Coast and Olympics*	0.505	0.515
East Cascades-North	0.296	0.374
West Cascades-North	0.320	0.405
West Cascades-Central	0.325	0.411
Oregon Coast*	0.710	0.831
West Cascades-South*	0.364	0.442
Inner California Coast Range	0.213	0.269
East Cascades-South*	0.180	0.228
Klamath-Siskiyou-East*	0.245	0.411
Klamath-Siskiyou-West*	0.315	0.398
Redwood Coast	0.205	0.259

* Modeling regions entirely or partially in the planning area

Mean barred owl encounter rates for the eleven modeling regions are 0.334 (Draft RMP/EIS) and 0.413 (Proposed RMP/Final EIS). Among the eight demographic study areas, Dugger *et al*. (2016) calculated a mean barred owl encounter rate in 2013 of 0.449.

Hypothetical Barred Owl Control Areas

For the Draft RMP/EIS, the BLM evaluated northern spotted owl population responses to all alternatives, and to the No Timber Harvest reference analysis, using the observed estimated barred owl encounter rates shown in Table 3-263 of the Draft RMP/EIS (USDI BLM 2015, p. 778). The BLM also evaluated Alternative C and the No Timber Harvest reference analysis using modified barred owl encounter rates developed by the U.S. Fish and Wildlife Service, also shown in **Table 3-263**. The BLM did the supplemental analyses to evaluate the degree to which BLM land use allocations could affect northern spotted owl population responses if the U.S. Fish and Wildlife Service implemented a barred owl control program.

As shown on pp. 783–804 of the Draft RMP/EIS, the BLM determined that northern spotted owl population responses to all of the alternatives, and to the No Timber Harvest reference analysis, were virtually identical because they primarily were determined by the observed estimated barred owl encounter rates (i.e., the degree of observed competitive interactions between northern spotted owls and barred owls). Since observed estimated barred owl encounter rates from the 2016 meta-analysis increased in all modeling regions (**Table T-7**), the BLM determined that it would learn nothing more by using the increased rates for the Proposed RMP/Final EIS.

Instead, the BLM simulated northern spotted owl population responses under Alternative C, the Proposed RMP, and the No Timber Harvest reference analysis using modified barred owl encounter rates in simulated barred owl control areas and observed estimated barred owl encounter rates (**Table T-7**, Column 3) in the remainder of each modeling region. The BLM did this to simulate range-wide northern spotted owl population responses under each scenario if the U.S. Fish and Wildlife Service were to implement a barred owl control program. Applying the modified barred owl encounter rates only in control areas more realistically simulates the true effects of a barred owl control program. This was a refinement to how the BLM simulated a barred owl control program for the Draft RMP/EIS, in which the BLM applied the modified barred owl encounter rate specific to each modeling region to all lands in the modeling region.

The BLM delineated hypothetical barred owl control areas and modified barred owl encounter rates with assistance from Jeffrey Dunk, Humboldt State University, David LaPlante, Natural Resource Geospatial, and Betsy Glenn, U.S. Fish and Wildlife Service, who helped the BLM develop its analytical assumptions. The BLM began with the assumptions that barred owl control would occur—

- Throughout the northern spotted owl's range;
- On approximately 10 percent of the forested landscape in each modeling region;
- In the Late-Successional Reserve on Federal lands, on State lands, and in northern spotted owl critical habitat on Federal and State lands;
- In aggregations of the best northern spotted owl habitat; and
- Within one mile of an improved road.

To delineate hypothetical control areas, the BLM segregated all lands in each modeling region into 20 resource bins according to relative habitat suitability value (those pixels with a relative habitat suitability value of 96 or higher were placed in Bin 1; those with values 91–95 were placed in Bin 2, etc.). The BLM then confined its analysis to those bins with relative habitat suitability values of 35 or higher (i.e., nesting-roosting habitat in 13 resource bins).

The BLM delineated the Late-Successional Reserve on Federal lands, State lands, and northern spotted owl critical habitat on Federal and State lands into five distance bins based on their distance from an improved road (i.e., those lands within 0.25 mile, 0.50 mile, 0.75 mile, and 1.0 mile of an improved road, and beyond 1.0 mile of an improved road). The BLM then confined its analysis to those bins within 1.0 mile of an improved road (i.e., 4 distance bins).[55]

This generated a digital map of Federal and State lands segregated into 52 bins (13 resource bins × 4 distance bins) based on relative habitat suitability value and distance to an improved road. That is, the 30 × 30-m pixels with highest habitat suitability values and lands nearest roads were placed in lower-numbered bins, respectively, and the BLM multiplied the two bin values for each pixel to rank the pixels, with the lowest multiples receiving the highest rank. The BLM then used the zonation model developed

[55] The BLM used a Fibonacci sequence where 0.25- and 0.5-mile bands equaled 1, 0.7-mile bands equaled 2, and 1.0-mile bands equaled 3.

by the U.S. Fish and Wildlife Service (USDI FWS 2011, pp. Appendix C, and USDI FWS 2012) to aggregate Federal and State lands into barred owl control areas based on relative habitat suitability value and nearness to an improved road until 10 percent of the forested landscape in each modeling region had been delineated. This process led to the highest value habitat areas within appropriate land allocation categories and closest to a road being included in the 'target area' first, followed by successively lower value habitats down to a value of 35 and greater distances out to 1.0 mile.

However, in the North Coast and Olympics and West Cascades-North modeling regions, zonation delineated only 4.8 percent of the forested landscape in each modeling region, due primarily to the acres of roadless lands, such as in Olympic National Park. The BLM conferred with the U.S. Fish and Wildlife Service, which recommended that the BLM expand the control areas in other modeling regions until it achieved a range-wide total of 10 percent (Betsy Glenn, U.S. Fish and Wildlife Service, pers. com. to Eric Greenquist, September 11, 2015). The U.S. Fish and Wildlife Service made this recommendation because the added acres mostly would occur in regions with the largest northern spotted owl populations, which is how the U.S. Fish and Wildlife Service most likely would design a control program. **Figure T-18** shows the hypothetical control areas delineated by zonation.

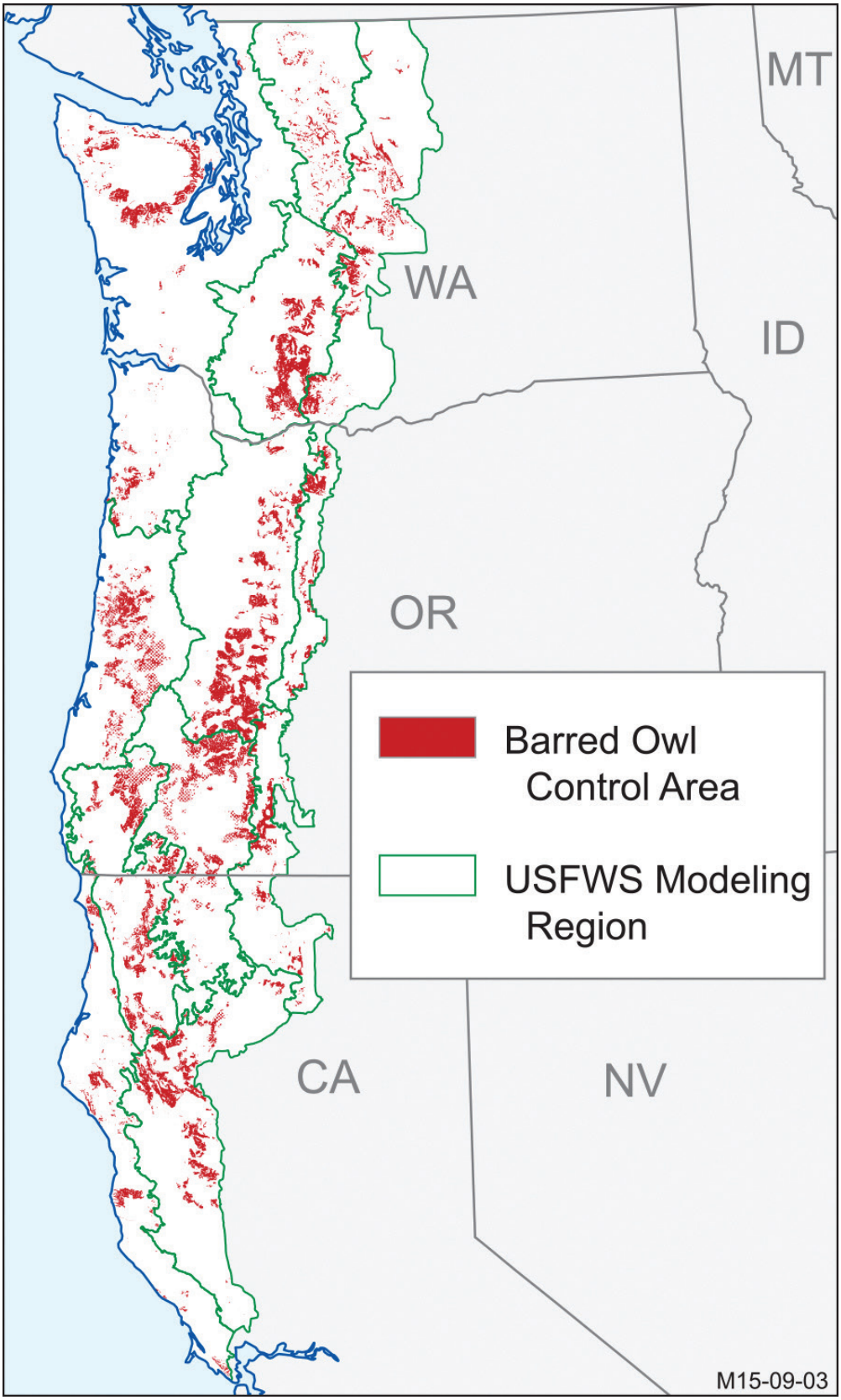


Figure T-18. Hypothetical barred owl control areas in the United States' portion of the northern spotted owl's range

Modified Barred Owl Encounter Rates

As the BLM explained on pp. 778–780 of the Draft RMP/EIS, when simulating northern spotted owl responses to a barred owl control program, the BLM used the estimated observed barred owl encounter rates (Table 3-263, p. 778 of the Draft RMP/EIS) during the first decade (2013–2023) and the modified barred owl encounter rates (same table) during 2023–2063. In two modeling regions with the highest estimated observed encounter rates, the BLM phased in the modified rates over the first two decades (2013–2033) (USDI BLM 2015, p. 779).

However, with the delineation of hypothetical control areas for the Proposed RMP/Final EIS, the BLM, based on the recommendation of the U.S. Fish and Wildlife Service (Betsy Glenn, U.S. Fish and Wildlife Service, personal communication to Eric Greenquist, September 1, 2015), used the observed estimated barred owl encounter rates shown in the third column of **Table T-7** but, beginning with the second decade (i.e., during 2023–2063), reduced the barred owl encounter rate in each of the hypothetical control areas to 0.15 to simulate the effects of a targeted barred owl control program (i.e., the BLM continued to use the observed estimated encounter rates outside the hypothetical control areas).

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