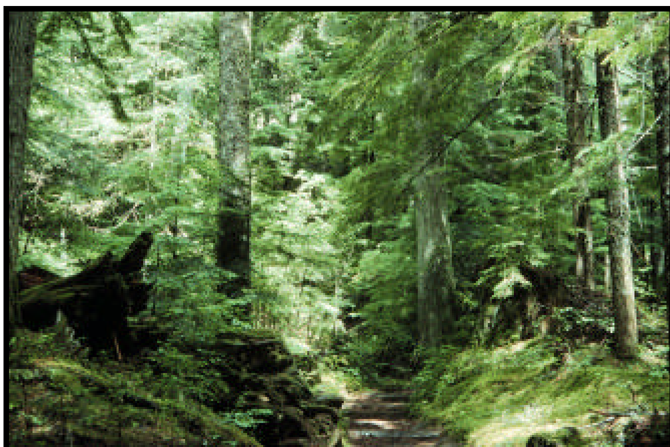
Assessment of Fisher Habitat in Washington State

Tier 1 and Tier 2 Final Report



Washington Department of FISH and WILDLIFE

Assessment of Fisher Habitat in Washington State

Tier 1 Refinement and Tier 2 Final Report

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and

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Executive Summary

This document reviews activities involved with the assessment of habitat for the possible reintroduction of fishers (*Martes pennanti*) to Washington State. It details the refinement of previous Tier 1 analyses that used Interagency Vegetation Mapping Project (IVMP) data to model 'suitable habitat', which only included denning and resting habitat. Although fishers use other types of habitat, den and rest sites are the most important life requisites for a fisher population. This report also describes the analyses conducted for the Tier 2 effort that further defines suitable habitat for fishers.

The Fisher Science Team recommended that certain aspects of the Tier 1 effort be refined to possibly improve results that would be used as a base for Tier 2 activities. There was an overestimation of suitable habitat within the East Cascades using 10 inches and greater Quadratic Mean Diameter (QMD) in the habitat model. The alternative of using 20 inch and greater QMD in the habitat model for the East Cascades resulted in a very sparse distribution of suitable habitat, so late seral forests were interpreted from year 2000 Landsat 7 data. Also, fixed upper elevation boundaries in the Cascades in particular were not be sensitive to ecological variations throughout this mountain range. The upper limit of the silver fir (*Abies amabilis*) zone was chosen as the elevation boundary for suitable fisher habitat, and this improved ecological sensitivity throughout the study area, especially for the southern Cascades. Furthermore, the 1000 km^2 and 1500 km^2 'moving window' areas representing the approximate area of a small fisher population resulted in too much generalization of the concentration areas of suitable habitat. A concentration area analysis using an average fisher home range window of 25 km^2 demonstrated a greater sensitivity to local distributions of suitable habitat. Overall, these refinements improved the overall characterization of suitable habitat analyzed in the Tier 1 effort.

About 31% of the extent of home ranges of female and male fishers in a southern Oregon population was identified as suitable habitat. This information was used to generate concentration areas in Washington that represented suitable habitat concentrations of less than 31%, or greater than or equal to 31%. Interestingly, this population did not use large and contiguous areas of suitable habitat north of its observed location. The largest concentration area in the Olympics had twice the combined area of the three largest concentration areas in the Cascades. The West Cascades had numerous concentration areas, but most of these were relatively small and linear in shape. However, investigation of the North Cascades indicated that corridors of mid and late seral forest appear to exist between currently identified concentration and connectivity areas if you reduce the importance of the silver fir zone boundary.

The potential for movement of fishers between patches of suitable habitat is an important factor to consider, so an analysis was conducted that demonstrated the connectivity between the patches of suitable habitat throughout the study area. The largest connectivity area in the Olympics had twice the combined area of the three largest connectivity areas in the Cascades. The concentration and connectivity areas have a synergistic effect in helping to identify potential fisher reintroduction sites.

The Fisher Science Team reviewed the results from the refinement of the Tier 1 analyses and formed a concensus to concentrate on the Olympics during the Tier 2 analysis, as this region contained the greatest amount and the most contiguous extent of suitable habitat.

It was important to validate the results of the IVMP model to provide a greater confidence in its value for identifying focus areas of fisher habitat. There was a 62% agreement overall between the IVMP suitable habitat and the Olympic National Forest (ONF) and Olympic National Park (ONP) late seral model data for the Olympics. Significant areas of disagreement between the models were investigated by analyzing the same areas within orthophotos. Overall, the IVMP model seemed conservative in identifying late seral forests throughout most of the ONP and ONF except for the western side. The models complimented one another in many areas based on orthophoto review, and this suggests that substantially more suitable habitat exists over what was indicated by just the IVMP model results.

There was a 68% agreement between the IVMP suitable habitat and the Mount Baker-Snoqualmie National Forest late seral model data, and an 81% agreement between the IVMP model and the Gifford-Pinchot National Forest (GPNF) late seral model. However, nearly 62% of this agreement within the GPNF was for areas where late seral forests were considered absent in both models. The differences between late seral forest models in the Cascades were not investigated using orthophotos.

The results of the various late seral model analyses helped to identify 'focus areas' within the Olympics that have the most optimal size, shape, and density of suitable habitat to possibly establish a reintroduced fisher population. However, the Fisher Science Team identified the need to describe the habitat quality of these areas to assure they could satisfy other life requisites of a population. Current Vegetation Survey (CVS) plot data for the ONF and Pacific Meridian Resources (PMR) plot data for the ONP were used to assess the habitat quality on these federal properties that contained most of the focus areas. Three definitions of old growth forests were used to determine if the selected plots that corresponded with the IVMP suitable habitat had characteristics of old growth forests that are important for fishers. This comparison indicates that the CVS and PMR plots possess forest component characteristics that are similar to old growth, but may not match these definitions in every respect. The IVMP suitable habitat model was developed to identify late seral forests, which includes both old growth and mature forests.

The Cascades are considered by members of the Fisher Science Team and the Northwest Ecosystem Alliance to be important as a corridor for connectivity of fisher populations throughout the North American Cascade Range. Local corridors between concentration areas in the North and South Cascades could be investigated further by using orthophotos and/or field visits to determine their viability to fishers. Additional analyses using stereo pairs of color orthophotos or field visits could identify more detailed 'core areas' of fisher habitat in the Olympics that would have the optimal forest conditions to support and maintain a fisher population. Additional information on how fishers move from one area of suitable habitat to another would be beneficial in more accurately modeling the connectivity between suitable habitat. Also, it is important to have a more sophisticated model for determining how many fishers a given focus or core area could support, and this level of modeling is currently being pursued at the Washington Department of Fish and Wildlife using a software program called PATCH.

Table of Contents

List of Maps

List of Tables

Introduction

The potential for reintroduction of fishers (*Martes pennanti*) into Washington State is being investigated through a partnership between the Northwest Ecosystem Alliance (NWEA) and the Washington State Department of Fish and Wildlife (WDFW). A Fisher Science Team was assembled that provides scientific direction in designing and conducting a study to assess the feasibility of this reintroduction. The Olympic Peninsula and the Cascades were identified as regions within Washington State where it was deemed important to assess suitable habitat for fishers.

The analysis of suitable habitat was to be completed in two tiers of investigation: Tier 1 would evaluate suitable habitat throughout the study area and identify several coarse scale areas that might support a viable population of fishers; and Tier 2 would identify 'focus areas' within these larger expanses of landscape that would be optimal for successful fisher reintroductions, and characterize the forest conditions within these areas.

The Interagency Vegetation Mapping Project (IVMP) data had been selected as the most current and appropriate data for identifying suitable habitat throughout western Washington. Therefore, the study area was defined by the extent of the IVMP data for the Olympics, West Cascades, and East Cascades.

Tier 1 Fisher Habitat Refinements

The results from the Tier 1 analysis (Weir 2002) provided good direction for the Tier 2 analyses. However, there were some analysis refinements that the Fisher Science Team agreed were important to investigate before the Tier 2 analyses should begin:

QMD Refinement

Data for Quadratic Mean Diameter (QMD) for the East Cascades were only available in the categories of 10-19.9 inches and 20 inches or greater. The initial Tier 1 analysis used 10 inch and greater to define suitable habitat in the data model. Weir (2002) suggested there was probably a significant overestimation of suitable habitat within the East Cascades because these QMD values were used in the habitat model.

The IVMP data used in the Tier 1 analysis contained information on the amount of vegetative cover, conifer cover, and QMD, which is a partial indication of forest structure. These data were used to model suitable habitat based on thresholds within each data type (Table 1). The IVMP literature states that QMD values were not determined for any area with less than 70% vegetative cover and less than 40% conifer cover. This fact could have eliminated some forest areas from being considered as suitable habitat. However, review of orthophotos showed that most of these areas were at high elevations and contained sparse vegetation.

Table 1. IVMP and elevation thresholds used to determine suitable fisher habitat for the initial Tier 1 analysis.

Habitat Criteria	*Suitable*[1]
Vegetative Cover	40%
Conifer Cover	30%
Quadratic Mean Diameter	
Olympics, West Cascades	20in
East Cascades	10in
Elevation	
Olympics	>3500ft
West Cascades	>4000ft
East Cascades	>5000ft

[1] An area was considered suitable only if it met all thresholds.

The overestimation of suitable habitat from using a threshold 10 inch or greater QMD in the East Cascades prompted the use of the 20 inch or greater category available in the IVMP data. The model results using the 20 inch minimum QMD showed a very sparse distribution of suitable habitat, much less than was actually thought to exist in the East Cascades (Map 1). Other data sources that covered this geographic extent such as the Combo100 data were investigated as a surrogate to the suspect IVMP data. The Combo100 data appeared to overestimate late seral forests relative to the adjoining suitable habitat from the West Cascades IVMP data (Map 2).

Therefore, a decision was made to interpret these forest conditions from year 2000 Landsat 7 Enhanced Thematic Mapper (ETM) data. Color images were developed using ETM bands 4, 5, and 1 for a red, green, and blue composite image, respectively, and a contrast table was applied to enhance the identification of late seral forests (Map 3). Portions of six Landsat scenes were needed to cover the extent of the East Cascades IVMP data. This image interpretation process resulted in an amount and distribution of late seral forests that seemed reasonable, and it transitioned well to the adjoining suitable habitat from the West Cascades IVMP data (Map 4).

Elevation Refinement

The elevational extent of suitable habitat is restricted in part by the amount of deep snow that accumulates at higher elevations, as well as the existence of suitable forest conditions at these higher elevations. The upper elevation boundary of suitable habitat can vary throughout the study area because of environmental and landscape variation, especially between the northern and southern portions of the Cascade Range within Washington State. Upper elevation boundaries fixed at 3500 feet for the Olympics, 4000 feet for the

West Cascades, and 5000 feet for the East Cascades were used in the initial Tier 1 analysis.

It would be beneficial to identify an elevation boundary based more on ecological considerations rather than the fixed elevation boundaries decided upon for the initial Tier 1 analysis. Ecological modeling of the upper limit of the silver fir (*Abies amabilis*) zone was recommended by the Fisher Science Team as an appropriate upper boundary for suitable fisher habitat (Henderson, USDA, Forest Service, unpublished data). This ecologically based boundary varies in elevation, relates to snow depth and forest structure, and intuitively seems more reasonable given the variation in ecological conditions, especially from the northern to southern extent of the Cascade Range. Therefore, the habitat model would consider any habitat type to be unsuitable above the upper limit of the silver fir zone. The habitat model process incorporating this new ecological boundary identified suitable habitat areas higher than 4000 and 5000 feet within the South Cascades that were not previously identified because of the fixed elevation boundaries. However, some suitable habitat areas in the North Cascades were now eliminated because they occurred above the silver fir zone boundary. Identification of suitable habitat did not change significantly in the Olympics with the use of this new boundary.

Concentration Area Refinement

A gradient of percent suitable habitat was determined by using a 'moving window' analysis where the window represented an area supporting a small population of fishers that included at least 15 females. The 1000 km^2 and 1500 km^2 moving windows used in the initial Tier 1 analyses processed non-habitat data, data above established elevation boundaries, and areas outside the study boundaries. Furthermore, these windows moved in one-third increments of their width across the data for developing mean patch size and suitable habitat area. This increment may have caused the process to be less sensitive to more local variation in suitable habitat. The results tended to indicate this method caused too much generalization of suitable habitat concentrations across the landscape relative to the distribution of suitable habitat.

This moving window process that was used to identify a gradient of percent suitable habitat had characteristics that could be refined to possibly improve results. It was decided that every data point would be analyzed relative to the surrounding data within that instance of the window as it moved through the entire data file. However, this analysis would only occur when the window center point fell on valid data, which was suitable habitat or less suitable forested conditions, and not areas of rock, ice, or snow, or areas above the silver fir zone.

If the gradient of percent suitable habitat is grouped into ranges of percentages, 'concentration areas' are formed that aid in visualizing the grouping of suitable habitat within a given area. The habitat model process that used these new conditions for the 1000 km^2 window produced results for the Olympics that were not significantly different from the initial Tier 1 process (Map 5). The extremely large area of data encompassed by 1000 km^2 was apparently generalizing the results regardless of how the analysis window was moved across the data, or whether it processed valid or non-valid data. Incorporating suitable habitat derived from Landsat data and new elevation boundaries in the habitat model resulted in a significantly different configuration of concentration areas in the Cascades. Overall, the 1000 km^2 concentration areas identified seemed to over-generalize or inaccurately represent the available suitable habitat within a local area. A new habitat model process was not conducted for the 1500 km^2 analysis window because of the unsatisfactory representation of concentration areas based on the 1000 km^2 window.

Additional Tier 1 Analyses

Home Range Analysis

Data was obtained for the bounding extent of home ranges of a population of female and male fishers from a southern Oregon study area (Aubry and Raley 2002). The females' home ranges existed within the West Cascades, and the IVMP data for this area was used to determine suitable habitat using the same model thresholds as were applied for the West Cascades IVMP data for Washington State (Map 6). The result was that suitable habitat constituted about 31% of the nearly 900 km^2 extent of the females' home ranges.

The majority of the males' home ranges resided in the West Cascades, and encompassed all of the females' home ranges. However, a portion of the males' home ranges also extended to the east Cascades. QMD data was not available for the East Cascades of Oregon, so the same model parameters were applied only to the extent of the males' home ranges in the West Cascades. A similar result of 31% suitable habitat was obtained from analyzing the extent of the males' home ranges that included about 40% more area than the females' home ranges.

The shape of the females' and males' home range extent was fairly circular in the West Cascades, and maintained this shape with the addition of the males' range in the East Cascades. Most of the suitable habitat identified by the model occurred in northern and eastern portions of the West Cascades home range areas, and a more sparse distribution of suitable habitat elsewhere. This observation suggests the fishers were using areas of unsuitable habitat, for at least travel behavior, and this may be confirmed in part by nearly all of this population's area having greater than 30% conifer cover, which would provide good travel protection.

Members of the Fisher Science Team suggested at the end of this habitat assessment project that it would be interesting to investigate the landscape 50 km outward from the area of this fisher population. Nearly 44% of the landscape extending 50 km to the north was suitable habitat based on the IVMP model (Map 7). IVMP datasets were not available for areas mostly east or west of this fisher population extent. The landscape extending to the south and somewhat west of this population boundary had only about 14% suitable habitat, and these areas may have a suitable habitat density that is too low to support fishers. Further investigation would be required to determine why this fisher population chose to reside in a suitable habitat configuration that seemed inferior to those suitable habitat areas to the north.

Home Range Based Concentration Areas

The over-generalization or inaccurate representation of suitable habitat using a moving window of 1000 km^2 indicated a different window area was required to improve the identification of 'focus areas' that would help determine 'core sites' for fisher reintroduction in future efforts. Weir (2002) pointed out a moving window analysis at the home range scale would be beneficial in determining which areas could support a viable fisher population. This analysis approach was investigated to determine if a gradient of percent suitable habitat could be obtained that was more representative of suitable habitat relating to an average home range for a fisher.

Aubry and Raley (2002) studied fishers in the southern Cascades of Oregon, and found the average home range of a single female was about 25 km^2. Although the ecological conditions of southern Oregon are different than the Olympics and the North Cascades of Washington State, this information was deemed appropriate to use to better represent concentration areas of suitable habitat. The results from the moving window analysis using an area of 25 km^2 (Map 8) demonstrated a greater sensitivity to local distributions of suitable habitat compared to the 1000 km^2 analysis. The gradient of percent suitable habitat based on a 25 km^2 home range area could now be grouped into percentage categories relating to the information obtained from the home range analysis. Concentration areas were generated that represented concentrations of either 31% and greater, or less than 31% suitable habitat (Map 9).

A focus area derived from the concentration areas should have certain characteristics that are optimal for fishers. The area should be large enough to establish and maintain a small fisher population. Ideally, the concentration area should have a low perimeter to area ratio to avoid linear areas that could be impacted by external forces, such as timber harvests that could fragment the area. Also, a high percentage of suitable habitat within a concentration area will improve the viability of a resident fisher population. Overall, the Olympics had focus areas that were the most optimal based on these considerations compared to those in the Cascades.

A significant result is that the largest concentration area in the Olympics has twice the combined area of the three largest concentration areas in the Cascades (Table 2 and Map 9). Also, areas in the Olympics had low perimeter to area ratios, and exceeded 60% suitable habitat concentrations within portions of the western Olympics. The West Cascades had numerous concentration areas, but most of these were relatively small, more linear in shape, contained lower percentages of suitable habitat overall, and were fairly widely separated from one another (Map 9). The East Cascades had very few concentration areas, and these were similar in characteristics to those in the West Cascades.

Table 2. Comparison of the three largest concentration areas in each major region.

Concentration Area	**Olympics**(km^2)	**Cascades**(km^2)
Largest	2020	854
2^{nd} Largest	386	397
3^{rd} Largest	81	300

The largest concentration area in the Olympics could include 80, 25 km^2 fisher home ranges that did not overlap, whereas the largest concentration area in the Cascades could include 24 home ranges. This provides an estimate of population capacity that might be overestimated because the entire concentration area would probably not be utilized by all of these fishers.

Connectivity Analysis

The moving window analysis provided a good indication of the concentration of suitable habitat within an average home range of 25 km^2. However, the potential for movement of fishers between patches of suitable habitat is also an important factor to consider. An analysis was conducted for the Olympics and Cascades that demonstrated the potential connectivity between patches of suitable habitat. Fisher Science Team members were consulted for information on how fishers move from one suitable habitat patch to another through unsuitable habitat areas. Conservatively, it was decided that fishers would only traverse an area of non-habitat that was less than 200 meters. Also, patches of suitable habitat that were 10 hectares or less were considered too small an area for fishers to use as a ‘bridge’ between other suitable habitat patches. These small patches were eliminated, and the remaining patches were buffered out 100 meters so that adjacent patches would connect with one another within 200 meters. This process generated areas that represented connectivity corridors where fishers could potentially move between suitable habitat patches (Map 10).

A significant result is that the largest connectivity area in the Olympics had twice the combined area of the three largest connectivity areas in the Cascades (Table 3 and Map 10). The largest connectivity area in the Olympics could include 100, 25 km^2 fisher home ranges that did not overlap, whereas the largest connectivity area in the Cascades could include 34 home ranges. Similar to the concentration areas, this provides an estimate of population capacity that might be overestimated because the entire area of connectivity may not be utilized by the fishers.

Table 3. Comparison of the three largest connectivity areas in each major region.

Connectivity Area	**Olympics**(km^2)	**Cascades**(km^2)
Largest	2506	615
2nd Largest	910	345
3rd Largest	182	270

Overall, it is prudent to identify focus areas where reintroduced fishers do not have to make extended daily movements to sustain themselves, or extensive dispersal movements to sustain a population. The concentration areas based on home range, and the connectivity areas can be used in concert to help define these focus areas for fishers.

Cascade Concentration Area Corridors

Members of the Fisher Science Team expressed the importance of eventually establishing a fisher population in the Cascades of Washington State. However, concentration and connectivity areas in the West Cascades were fairly widely separated from one another, and this seemingly limits the value of the Cascades to fisher reintroduction at this time. However, larger contiguous concentration and connectivity areas would have occurred if there had been corridors of enough suitable habitat between these existing areas.

A region in the North Cascades was investigated to determine if the model parameters caused these corridors to be unidentified in the initial results. A primary factor in these corridors not occurring was that many of these potential corridors were above the silver fir zone boundary, and thus these areas were not considered in the suitable habitat model (Map 11). Habitat above the silver fir zone consisted of rock/ice/snow or sparsely vegetated areas, but forested conditions also existed, as determined by reviewing orthophotos and the IVMP data (Map 12). Also, small portions of corridors were possibly missed because these portions of suitable habitat were bordered by enough area above the silver fir zone that they did not qualify for being 31% or greater suitable habitat in the moving window analysis.

Corridors of mid and late seral forest conditions appear to exist between currently identified concentration and connectivity areas in the North Cascades, especially if you reduce the importance of the silver fir zone boundary. The silver fir zone boundary does not exclude as much higher elevation forest habitat in the South Cascades, and therefore fewer corridors were undetected between these currently identified concentration and connectivity areas. A few corridors in the South Cascades connecting areas between the East and West Cascades may have been missed because of the limitation of the silver fir zone.

Tier 1 Review and Recommendation

The Fisher Science Team and NWEA reviewed the Tier 1 results, and the overall consensus was to concentrate on the Olympics for the Tier 2 analyses because this region contained potential focus areas with the greatest amount and most contiguous extent of suitable habitat, as well as having the highest densities of suitable habitat. The habitat characteristics of the Cascades would be investigated further as resources would permit, as this region is still considered important for connectivity between fisher populations within the North American Cascade Range.

Tier 2 Fisher Habitat Assessment

Suitable Habitat Model Validation

The IVMP data and Tier 1 model were used to identify suitable habitat, and provided the basis for the concentration and connectivity results derived from the suitable habitat. The accuracy assessment conducted by IVMP personnel for the Olympics and West Cascades indicates a significant amount of error could exist within the 40-69% range for conifer and vegetative cover, and there could have been substantial commission for 20 inch and greater QMD (Browning et al. 2002). Suitable habitat for the East Cascades was developed from interpreting Landsat ETM data for which no accuracy assessment was conducted for this region. Overall, it was deemed important to validate the results of the IVMP model to provide greater confidence in its use for identifying focus areas of fisher habitat.

Olympics Validation

Data representing suitable spotted owl (*Strix occidentalis*) and marbled murrelet (*Brachyramphus marmoratus*) habitat was obtained from the USFS for the Olympic National Forest (ONF). These data represented late seral forests, and were developed by modeling the relationships between stand seral stage, fire history, wind damage, and stand management. No seral stage data was available for the Olympic National Park (ONP), so a model was developed from Pacific Meridian Resources (PMR) forest data to identify late seral conditions. The model used all tree species greater in height than shrubs, crown closure of 41-100%, and single-storied and multi-storied structures with diameter at breast height (DBH) of 21 inches or greater. Only the suitable habitat within the boundaries of the ONP and the ONF could be compared with the late seral model data for these federal properties. It is difficult to analyze models developed from such disparate data sources, but it could provide insight into the suitable habitat derived from the IVMP model.

There was a 62% agreement overall between the IVMP suitable habitat and the ONF and ONP late seral model data for the Olympics (Map 13). Visual review of this analysis result show there were differences in agreement between the models depending on the general area within the Olympics. These differences were investigated further by separating the Olympics into three units corresponding somewhat with the distribution of concentration areas in the Olympics (Maps 14,15,16). The results indicate there is a greater amount of agreement between models in the western unit and the eastern/southern unit, and less for the northern/Elwah drainage unit (Table 4). Similar amounts of commission and omission error occurred for each unit, and this fact suggests that each model varied in how it identified late seral forest conditions.

Table 4. Comparison of percent area between the IVMP model and the combined ONF/ONP model for suitable habitat.

	Olympics Subarea		
	North/Elwah	**West**	**East/South**
Agree (habitat)	24.9	43.2	26.8
Agree (no habitat)	23.1	24.4	35.5
Total Agree	48.0	67.6	62.3
Commission[1]	27.7	16.3	16.4
Omission[1]	24.3	16.1	21.3

[1] Commission and omission are determined relative to the IVMP suitable habitat.

The amount of disagreement between models in various areas around the Olympics prompted an investigation of the differences with the aid of orthophotos. Areas where the disagreement between models seemed more pronounced were compared with the same areas within the orthophotos. The western portion of the ONF and ONP demonstrated the greatest amount of agreement between models. A cursory review of orthophotos from this area indicated the IVMP model was somewhat conservative in identifying late seral forests throughout this region. There were no areas of considerable disagreement between the models in this western portion area, except for a few locations within some of the major drainages.

In the Elwah drainage it was determined that the IVMP model underestimated the amount of late seral forest. In most of the other major drainages within the ONP, late seral forests were underestimated on south facing aspects by the ONP model, whereas the IVMP model underestimated these forests on north facing aspects. Review of the PMR data layers indicated there were DBH classes smaller than 20 inches on south facing aspects compared to north facing aspects, and this fact caused many of these areas to be ignored as late seral forests. However, interpretation of the orthophotos indicated there were similar forest conditions on both aspects.

There were numerous areas in the eastern and southern portion of the ONF that demonstrated differences between the models. It appears that after reviewing the orthophotos, the IVMP model underestimated late seral forests in many areas. However, there were some areas where the IVMP model seemed to overestimate late seral forests, especially along the eastern boundary of the ONF. Overall, the IVMP model seemed to underestimate late seral forests in the eastern and southern portion of the ONF.

The IVMP model seemed conservative in identifying late seral forests throughout most of the ONP and ONF except for the western side. A majority of this conservatism was attributed to an intermittent identification of late seral forests within a local area ('salt and pepper' look) instead of more contiguous areas within a local area as observed on the orthophotos. The ONP and ONF models seemed to accurately identify late seral forests in those areas where the IVMP data was conservative in identifying late seral forests. In many areas the converse situation also existed where the IVMP data identified late seral forests where the ONP and ONF models were conservative. These observations were not investigated further, but differences in the data used in these models, and the model parameters used in each may have caused these conditions to occur.

A member of the Fisher Science Team suggested that suitable habitat characterized by mid to late seral forests might be important, as based on habitat conditions where fishers exist in British Columbia. It is possible that combining the IVMP, ONF, and ONP model results could provide a more liberal depiction of the landscape that might include mid-seral forests. Combining the habitat identified by each of these three models produced a distribution of habitat that is very similar to the connectivity analysis distribution (Map 17). The connectivity process incorporated a conservative distance of 200 meters for which a fisher would travel through non-habitat. The similar distributions of these two models suggests that the habitat within the 200 meter distances between the modeled suitable habitat, may contain mid-seral habitat that would be useful to fishers for other activities than just travel habitat.

Cascades Validation

Data identifying late seral forests was obtained from the USFS for the Mount Baker-Snoqualmie National Forest (MBSNF) and the Gifford-Pinchot National Forest (GPNF). Only suitable habitat within the boundaries of the MBNF and the GPNF could be compared with the data from these federal properties. These models were also developed from disparate data sources making it difficult to analyze model differences. However, it could again provide insight into the suitable habitat identified by the IVMP model.

There was a 68% agreement between the IVMP suitable habitat and the MBSNF late seral model data (Map 18 and Table 5). Visual review of this analysis result showed the models disagreed in certain portions of the major drainages. The IVMP model identified large contiguous areas of suitable habitat within these drainages that were omitted by the MBSNF model. However, the IVMP model did not identify smaller segments of suitable habitat within these drainages that were included by the MBSNF model. Similar amounts of commission and omission error occurred for these models, and this fact suggests that each model varied in how it identified late seral forest conditions.

Table 5. Comparison of percent area between the IVMP model and National Forest areas of the Cascades.

	MBSNF	**GPNF**
Agree (habitat)	38.0	16.6
Agree (no habitat)	30.4	52.3
Total Agree	68.4	68.9
Commission[1]	16.9	14.6
Omission[1]	14.7	16.5

[1] Commission and omission are determined relative to the IVMP suitable habitat.

Overall, there was nearly a 69% agreement between the IVMP suitable habitat and the GPNF late seral model data (Map 18 and Table 5). However, it is important to note that 52% of this agreement was for areas where late seral forests were considered absent in both models. Throughout the GPNF there appears to be a fairly even distribution of patches of late seral forest agreement, omission, and commission. Again, similar amounts of commission and omission error occurred for these models, and this fact suggests that each model varied in how it identified late seral forest conditions. The poor agreement of late seral forests areas for the GPNF supports this suggestion, and the specifics of how this model was developed could be pursued in the future.

Suitable Habitat Quality Assessment

The results of the various model analyses to this point have helped to identify focus areas within the Olympics that have the most optimal size, shape, and density of suitable habitat to possibly establish a reintroduced fisher population. However, the Fisher Science Team identified the need to describe the habitat quality of these areas to assure they could satisfy other life requisites of a population. Canopy closure and layering, and presence and quality of shrubs, den sites, and resting structures were suggested as habitat characteristics that should be assessed to determine habitat quality in these focus areas.

Ground Plot Data Selection

A search was conducted for forest characterization data that could either directly quantify these habitat variables, or be processed to provide at least an index for these habitat variables. Results of this search identified databases from the National Forest Inventory and Analysis (FIA), the Current Vegetation Survey (CVS), and PMR for the ONP. The geographic locations for the ground plot centers of FIA forest data could not be obtained due to these data being considered ‘sensitive’. Therefore, the FIA data was not pursued as a viable database for habitat quality assessment.

The CVS database contains forest metrics for one-hectare ground plots that were located every 6.8 miles on USFS wilderness lands, and every 1.7 miles on other USFS land. More detailed information on the CVS design and forest data collected can be obtained from Johnson (1998). Review of the forest variables collected in this database indicated it would be useful in determining habitat quality. However, the plot center locations are reported to have a location accuracy of about 200 meters (Brown, USDA Forest Service, personal communication), and this distance is four times the resolution of the IVMP data that was the basis for development of the focus areas. A visual review of the spatial relationship of the CVS plot centers to the suitable habitat resulted in the identification of only 23 plot centers that were located in and surrounded by at least 200 meters of suitable habitat. This method increased the possibility that the selected CVS plot areas were well within blocks of suitable habitat. Forest component characteristics from these 23 plots were used to assess habitat quality of the focus areas.

The PMR database contains forest metrics for one-hectare ground plots that were located along transects approximately 1.5 miles long that were positioned throughout the ONP, but not on a systematic grid similar to the CVS data. The database values for the snag variables of height and basal area seemed unreasonable, and personnel at the ONP could not explain the data sufficiently to warrant using these variables. Also, this database was limited in the forest component data obtained from the plots, but does provide some information about forest conditions within the ONP. The spatial relationship of the PMR plot centers to the suitable habitat was reviewed to obtain 27 plots that were selected using the same method employed for the CVS plots. Both the CVS and PMR plots were well distributed throughout the ONF and ONP, respectively.

Comparison to Old Growth Definitions

Three definitions of old growth forests that were summarized by Marcot et al. (1991) were used to determine if the selected plots that related to the IVMP suitable habitat had characteristics of old growth forests, which are considered important habitat for fishers (Table 6).

Table 6. Plot data means of habitat components compared to old growth definitions summarized by Marcot et al. (1991).

Habitat Component				**-----------Old Growth Definitions---------**		
		CVS	**PMR**	**DEF 1**[1]	**DEF 2**[2]	**DEF 3**[3]
Live Trees 32in	**Count(ha)**	17		20	12	25
	DBH(in)	45	31	>32	32	>40
	Age(yrs)	299	145[4]	>200		>200
Canopy: Trees 50-100ft	**Count(ha)**	14		Multi	Multi	Multi
	DBH(in)	20				
	Age(yrs)	133				
	Height(ft)	74				
Canopy: Trees >100ft	**Count(ha)**	21		Multi	Multi	Multi
	DBH(in)	33				
	Age(yrs)	231				
	Height(ft)	138				
Snags 20in	**Count(ha)**	11	20	10	5	>25
	DBH(in)	35		>20		>25
	Height(ft)	39		>15		>20
Logs 20in	**Count(ha)**	3		10		'Some'
	DBH(in)	30		24		>25
	Length(ft)	49		50		50
	Metric Tons		70	34	67	>45
Ground Cover 1ft	**Height(ft)**	3				
	Area(%)	30	39			

[1] Old Growth Definition Task Group, [2] Pacific Northwest Regional Guide, [3] Society of American Foresters
[4] Mean tree age was determined from the 40 'largest' trees.

Overall, the plots had a live tree component that could provide substantial forest structure to meet the habitat needs of fishers. Also, the plots had a snag component that was comparable or exceeded the definition for old growth forests. Although the average number of logs in the plots is lower than the definitions, the plots have a log component that could provide denning habitat for fishers. It is unknown what percentage of the PMR tonnage is contributed to logs, but it may be within the range of the old growth definitions because its relatively high value. The characteristics of each canopy layer investigated suggest that a multi-layered condition exists within these plots. Also, the PMR plot centers were intersected with the PMR canopy closure data, and this resulted in 24 of the 27 plots having a 70-100% canopy closure. Although this information was not derived from the plot database, it does provide some indication of the amount of canopy closure in the focus areas within the ONP.

Although there is no shrub component in the old growth definitions, this was considered an important component by the Fisher Science Team. The CVS plots have a ground cover that averaged about 3 feet in height and 30% areal coverage for all ground cover vegetation greater than 1 foot in height. Further investigation of the plot data would be required to determine shrub species alone, but it is assumed that vegetation greater than 1 foot in height could be considered shrub or shrub-like. Coverage of the forest floor of nearly a third in shrubs would be a substantial amount of cover for fishers, and provide cover for their prey as well. The PMR plots averaged 39% areal coverage for all ground cover, but unfortunately no data was available for height.

This comparison indicates that the CVS and PMR plots possess forest component characteristics that are similar to old growth, but may not match these definitions in every respect. It is important to remember that the IVMP suitable habitat model was developed to identify late seral forests, which includes old growth and mature forest seral stages. Marcot et al. (1991) define mature forests as having more than 50 trees per hectare that exceed 20 inches DBH or 80 years old. The CVS plots have an average of 38 trees per hectare and 238 years old for all trees 20 inches or greater DBH. Although the number of trees per hectare is somewhat lower than the definition for a mature forest, the average age of 238 years suggests these plots would represent mature forests.

Future Analysis Considerations

Members of the Fisher Science Team and personnel from NWEA indicated it was important to consider the Washington Cascades as a significant corridor for providing connectivity between populations of fishers in the North American Cascade Range. The analysis performed in the North Cascades suggests that corridors of forested conditions exist between currently identified concentration areas. These corridors could be investigated further by using orthophotos and/or field visits to determine their viability to fishers. Also, it is important to research the snow conditions of these corridors, as they were excluded from the concentration areas in part because they were above the silver fir zone. The South Cascades were not analyzed for possible corridors between concentration areas, but this region could also be investigated for potential improvement in the size and shape of the concentration areas.

The Olympics were analyzed to obtain focus areas that have forest landscape characteristics that reduce the need for extended daily movements of individual fishers, or extensive dispersal movements of a fisher population. The CVS and PMR plot data provided an indication that the suitable habitat in these focus areas exhibit mature and old growth forest characteristics. These focus areas could be analyzed with the use of stereo pairs of large-scale color orthophotos and/or field visits to further identify 'core areas' of landscape that would have the most optimal forest habitat conditions to support and maintain a fisher population. These activities seem warranted to provide reintroduced fishers the greatest opportunity to establish and maintain themselves in a new environment.

Connectivity between suitable habitat was investigated using a coarse model for potential fisher movement across non-habitat areas. Additional information on how fishers move across a landscape would be beneficial for more accurately modeling the connectivity between suitable habitat. Also, it is important to have a more sophisticated model for determining how many fishers a given focus or core area could support. This level of modeling is currently being pursued at WDFW, using a software program called PATCH developed by the Environmental Protection Agency.

Literature Cited

Aubry, K.B., Raley, C.M., 2002. Ecological characteristics of fishers in the southern Oregon Cascade Range. Final Progress Report: June 2002, on file at the USDA Forest Service, Pacific Northwest Research Station, Olympia, WA. 14pp.

Brown, R. 2003. Forest Inventory and Monitoring, USDA Forest Service, PO Box 3623, Portland, OR 97208. Personal communication.

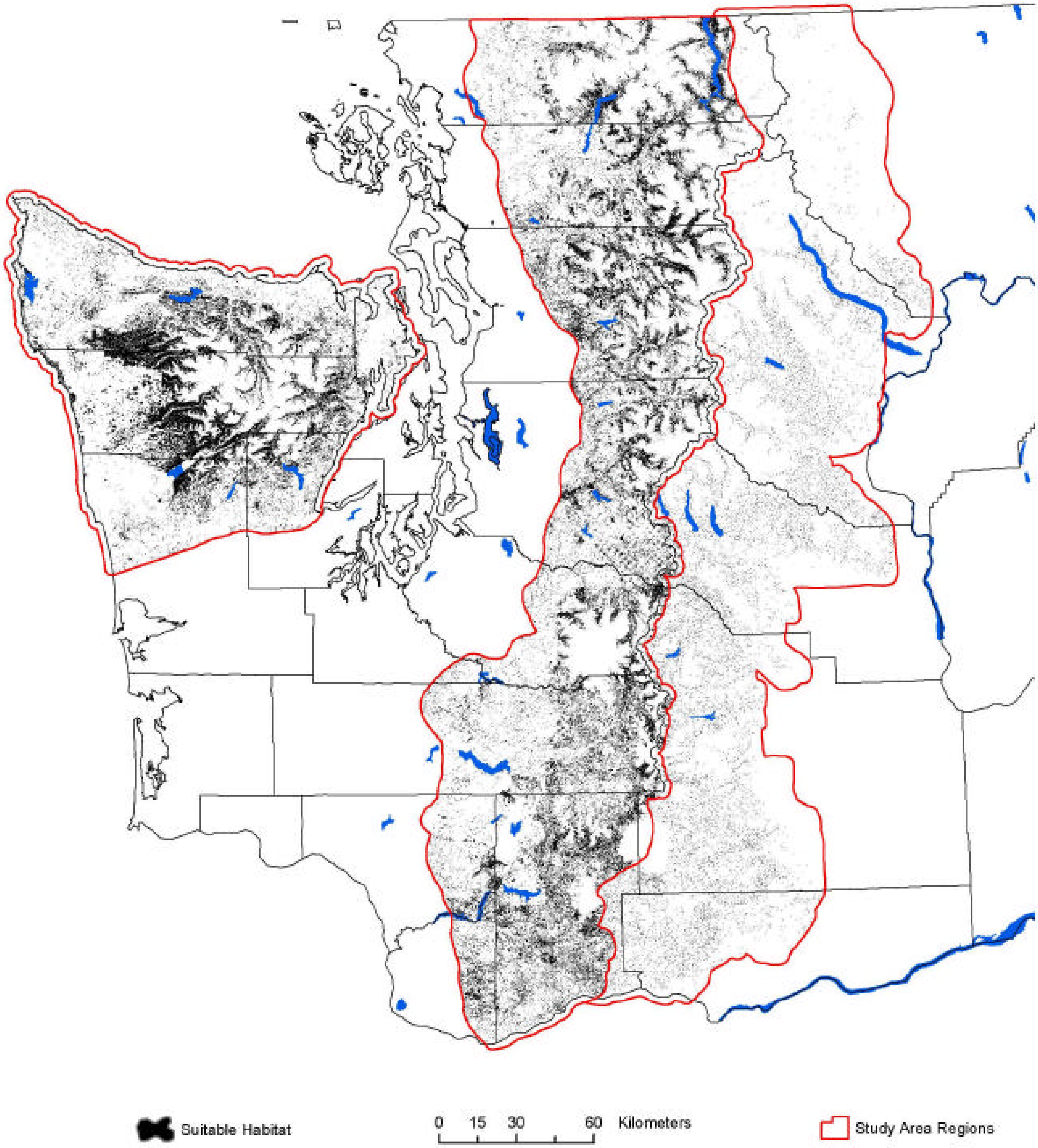
Browning, J., Kroll, K.C., Grob, C., Ducey, C., 2002. Accuracy Assessment Interagency Vegetation Mapping Project (IVMP) Olympic Province and Western Cascades Washington Province, Version 2.0, Titan Systems Corporation, 37pp.

Henderson, J. 2003. USDA Forest Service, Portland, OR, Unpublished data on ecological zones, Personal communication.

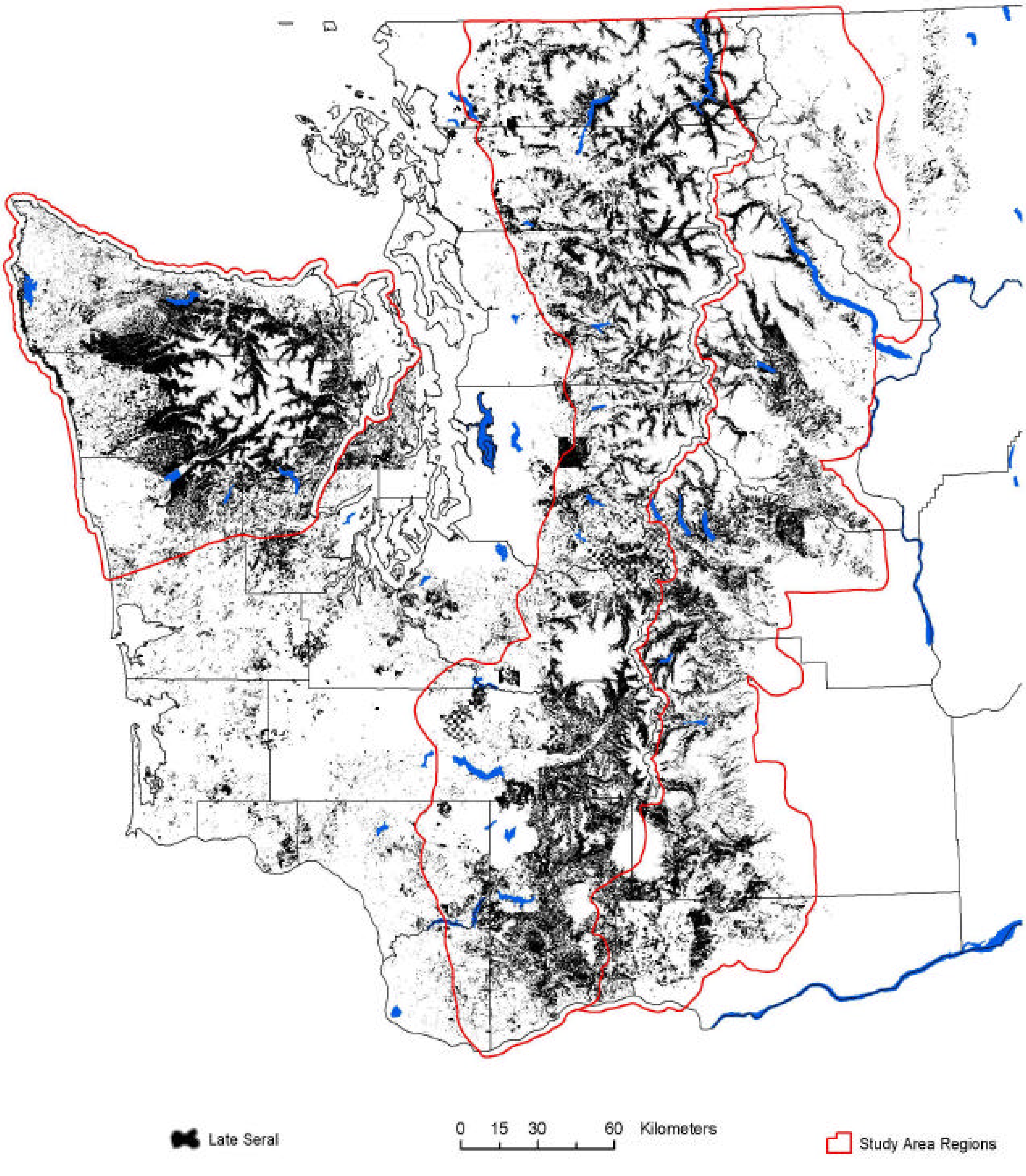
Johnson, M.D. 1998. Region 6 Inventory and Monitoring System: Field Procedures for the Current Vegetation Survey. Version 2.02b. USDA Forest Service, Portland, OR. 152pp.

Marcot, B.G., Holthausen, R.S., Teply, J., Carrier, W.D., 1991. Old-growth inventories: status, definitions, and visions for the future. In:Wildlife and Vegetation of Unmanaged Douglas-Fir Forests. USDA General Technical Report PNW-GTR-285, pp. 47-60.

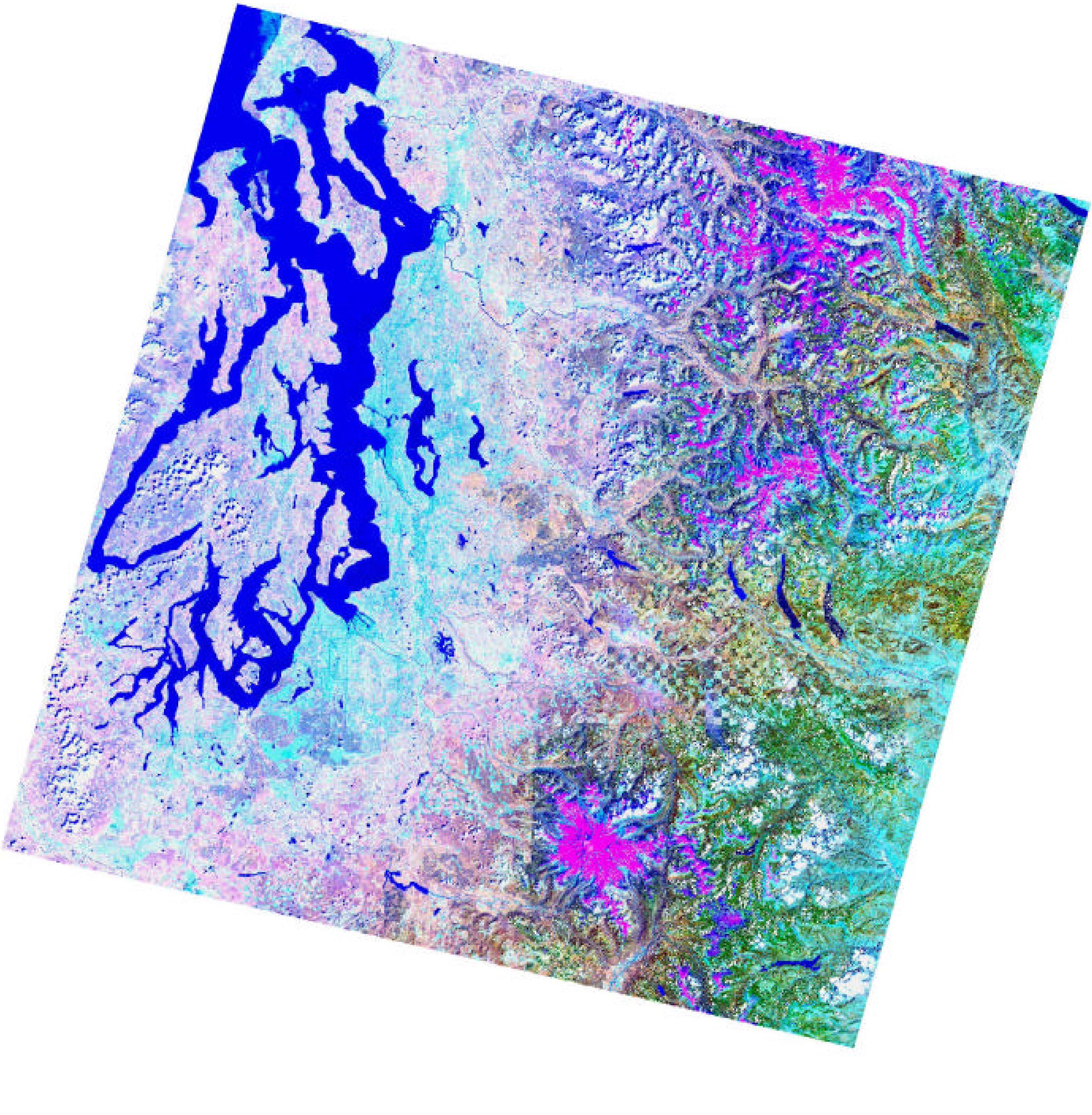
Weir, R.P. 2002. Fisher habitat feasibility assessment for Washington State – Tier 1 final report. Montera Environmental Inc., Salmon Arm, British Columbia, Canada, 17pp.



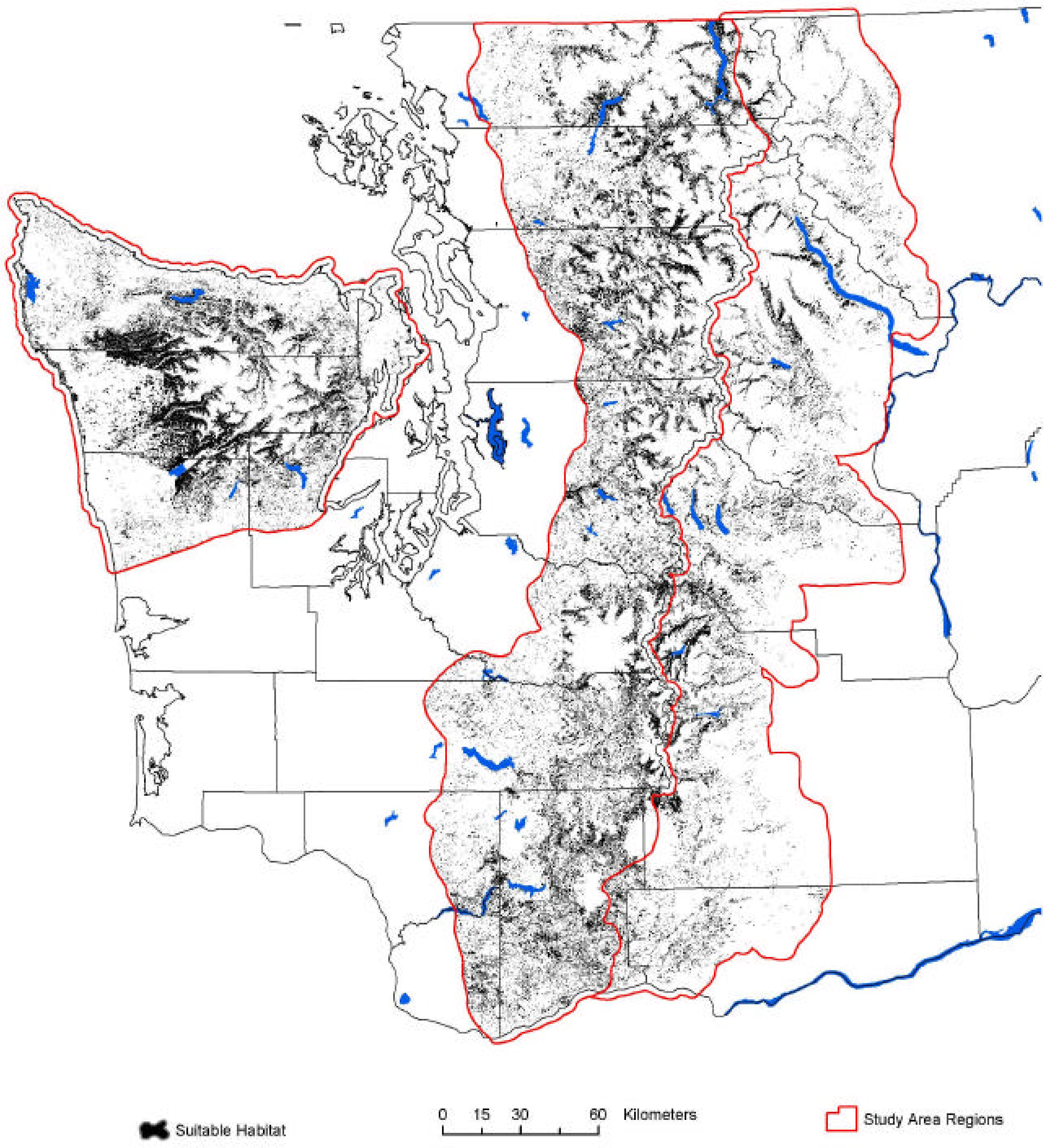
Map 1. Suitable habitat derived from 20 inch and greater QMD in the East Cascades.



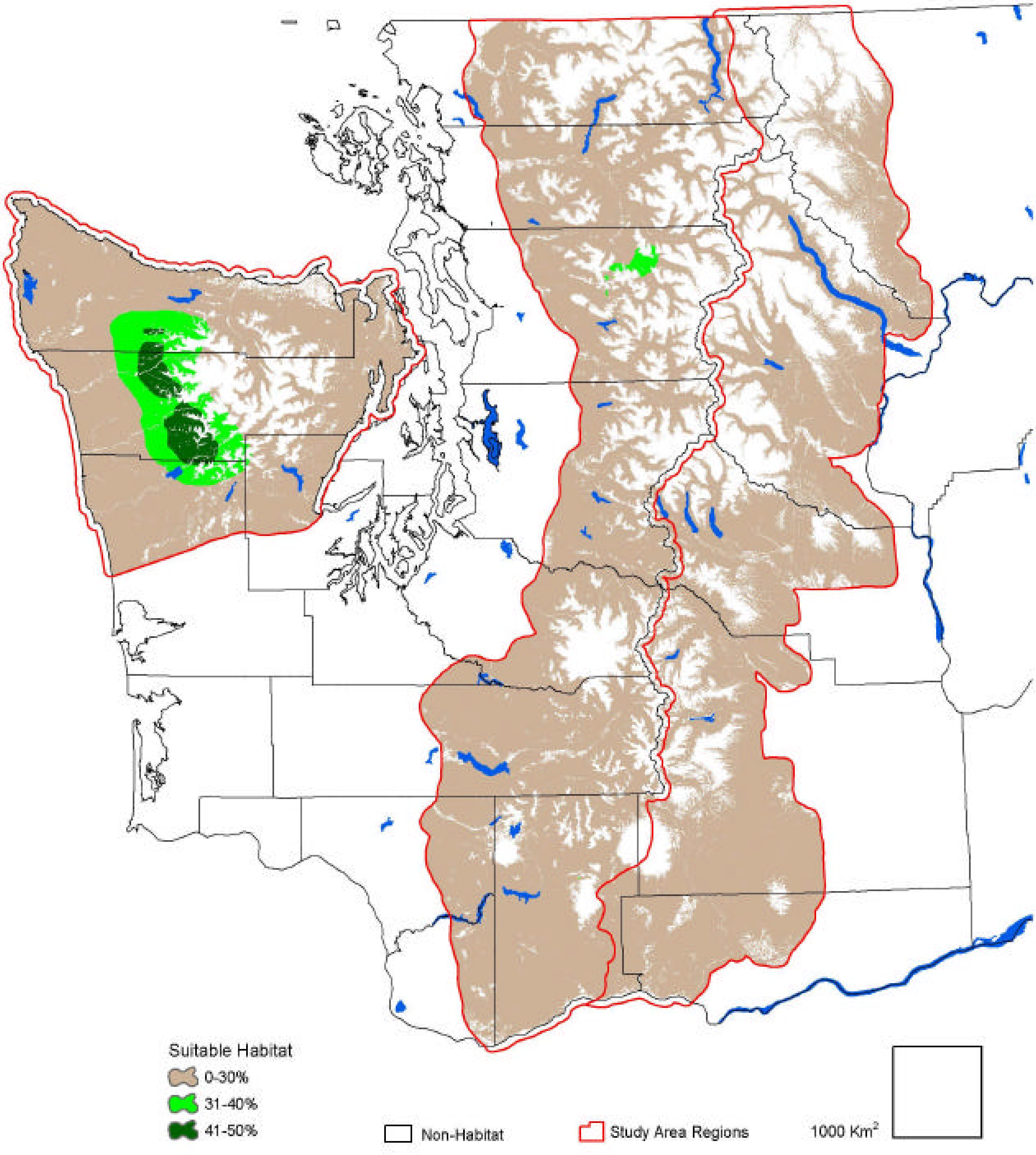
Map 2. Distribution of the Combo100 late seral data.



Map 3. Example of a Landsat scene with contrast table applied to detect late seral forests.

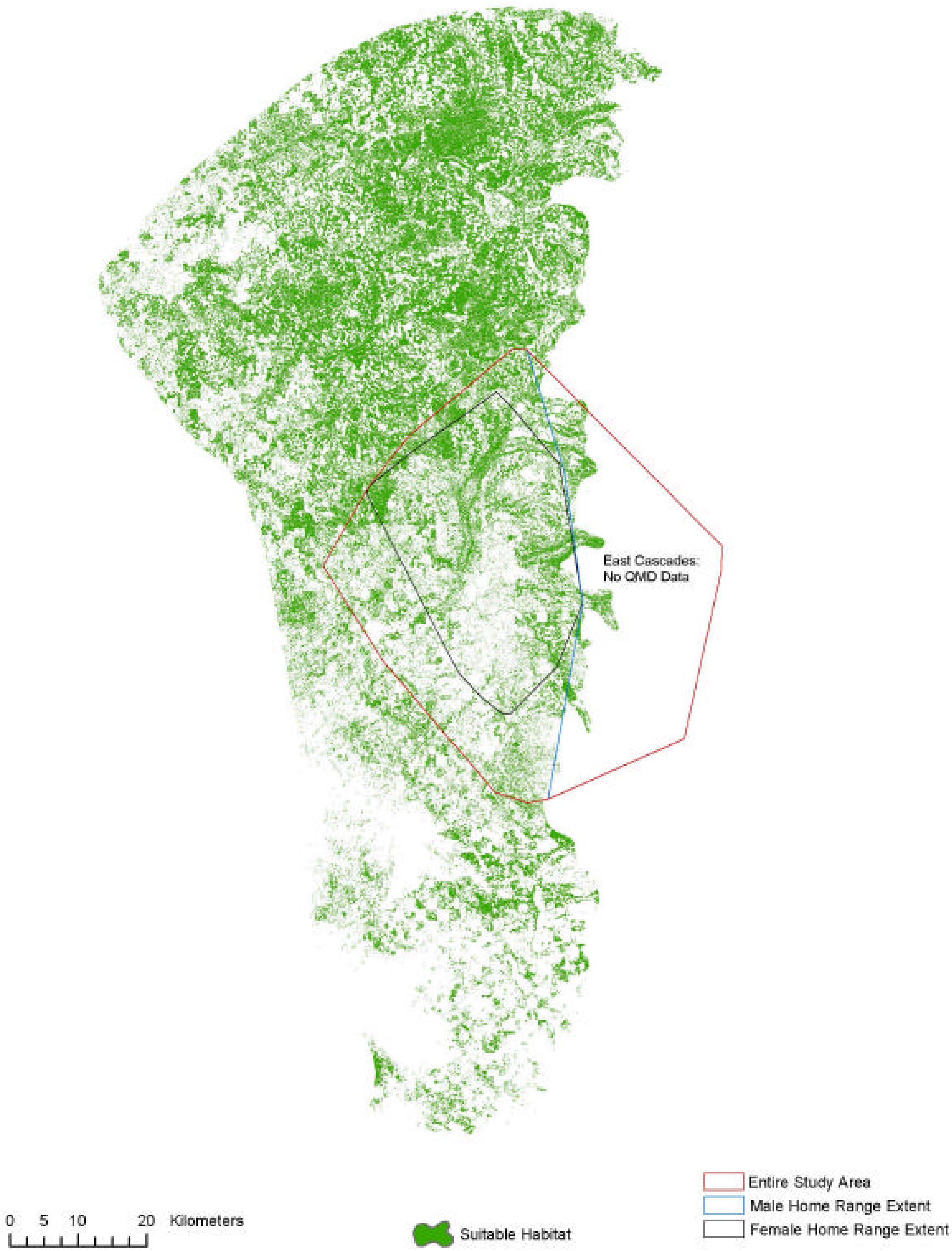


Map 4. Distribution of suitable habitat derived from IVMP data and Landsat data.

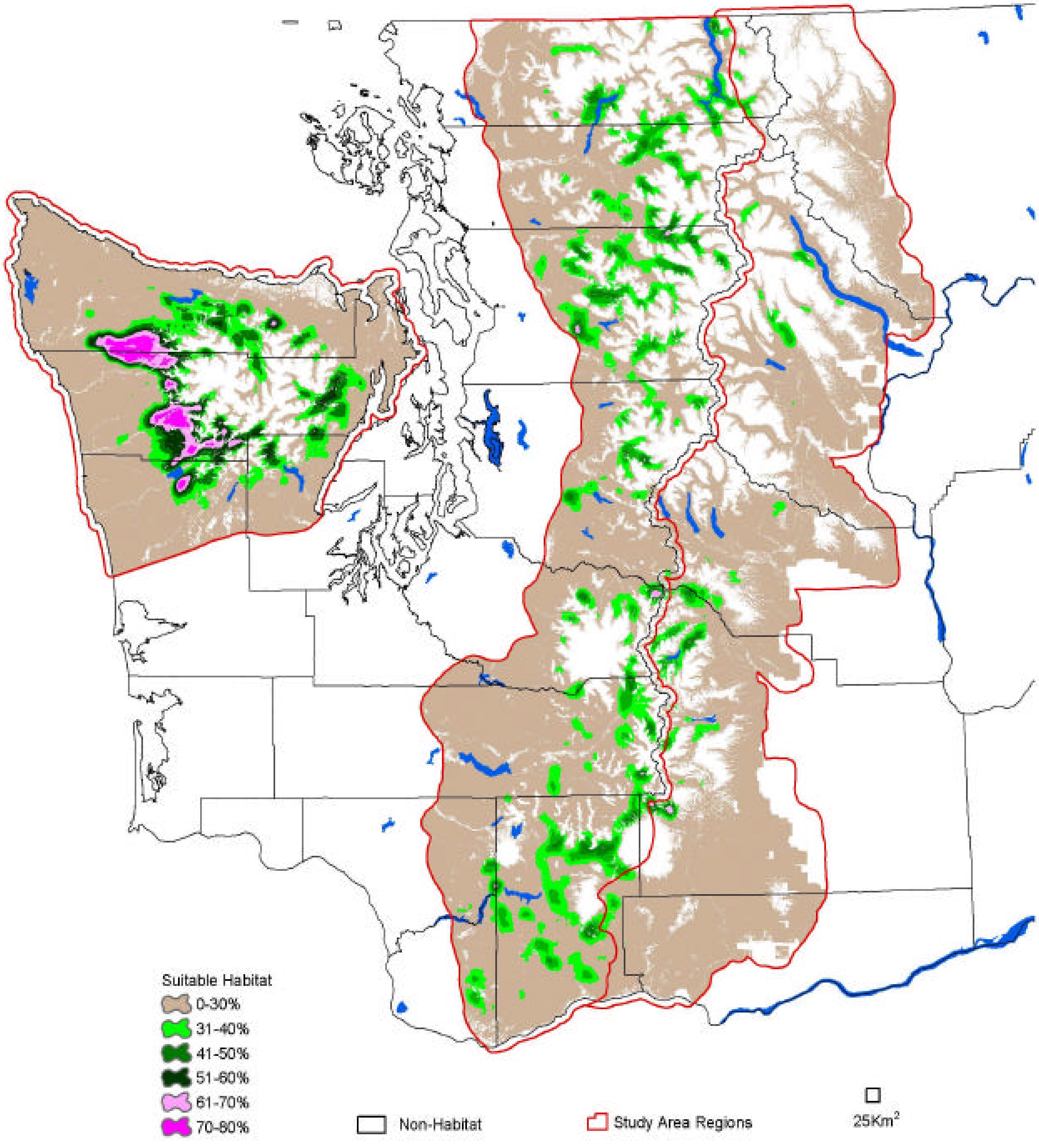


Map 5. 1000km^2 moving window analysis results based on a fisher population area.

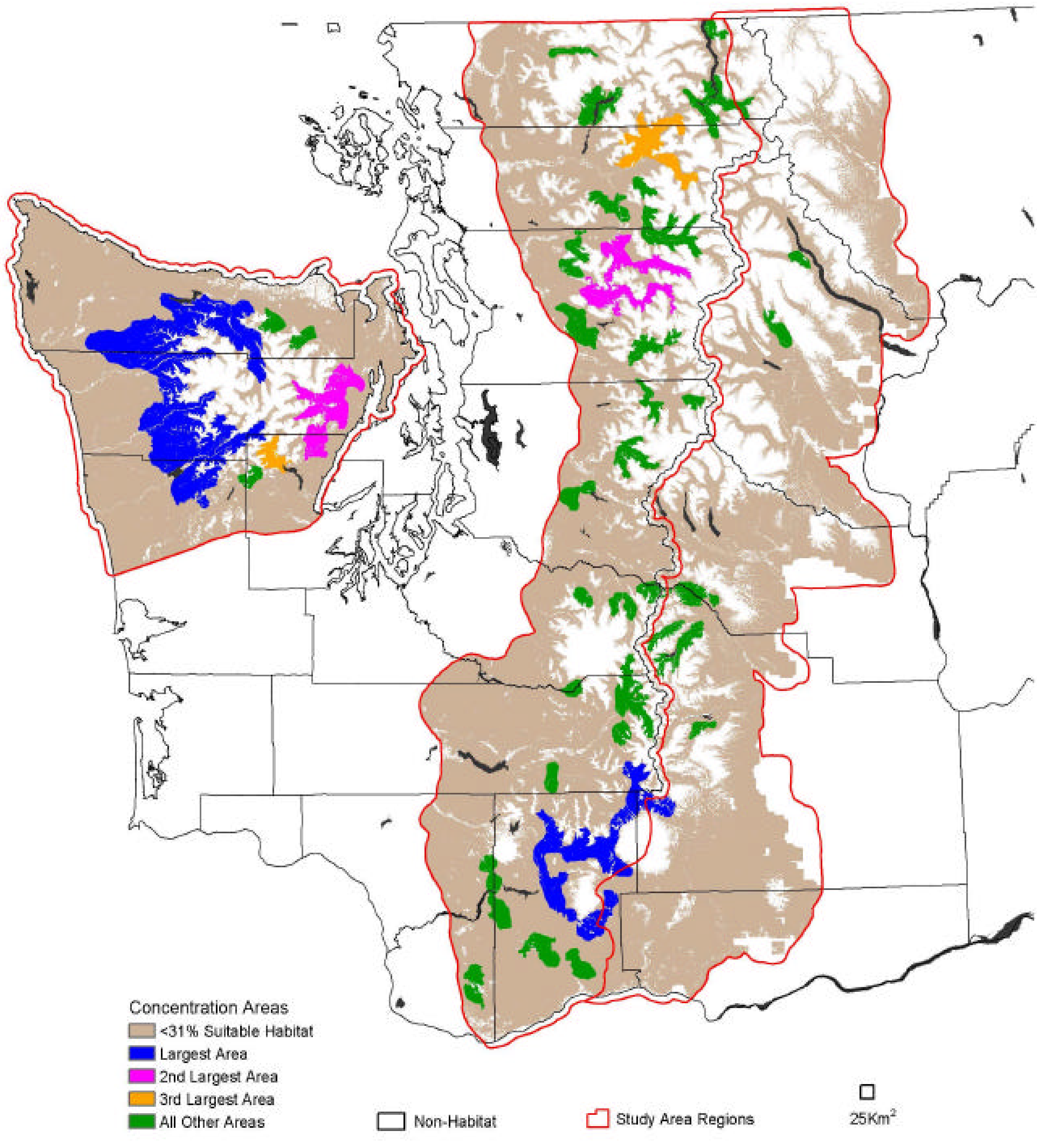
Map 6. Distribution of suitable habitat in the West Cascades of the southern Oregon study area.



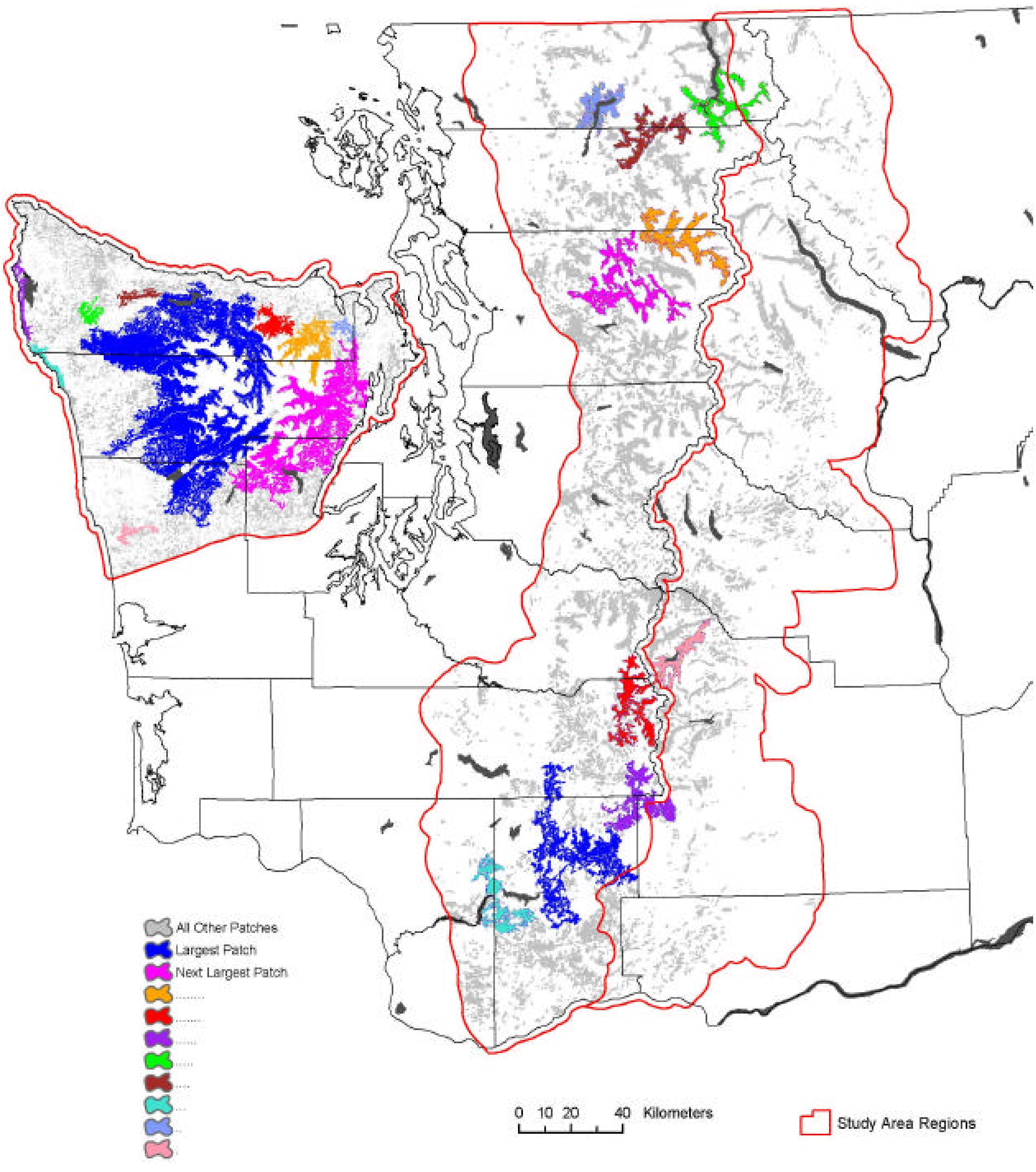
Map 7. Distribution of suitable habitat within a 50km buffer of the southern Oregon study area for the West Cascades IVMP data.



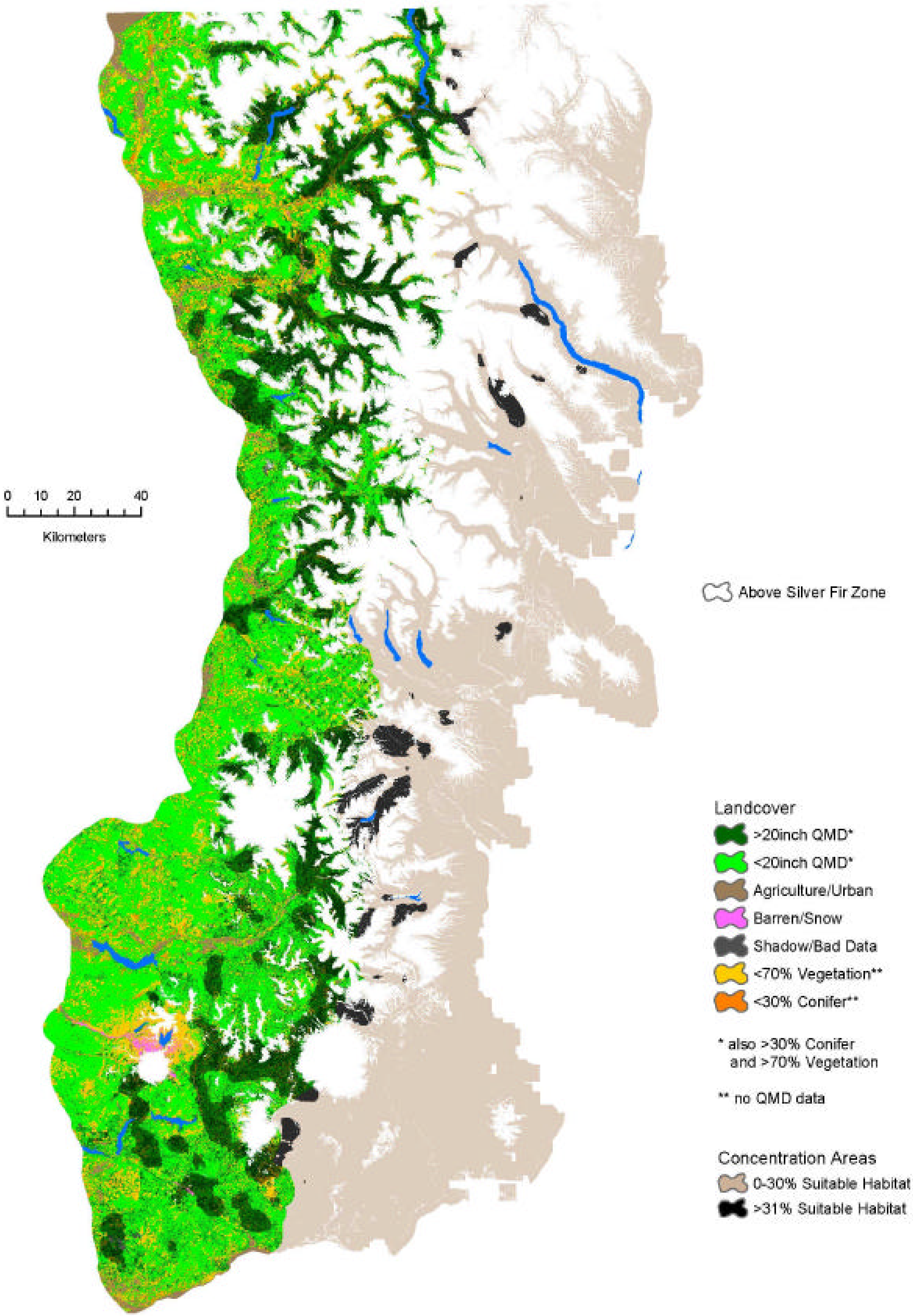
Map 8. Moving window analysis results based on a 25km^2 home range area.



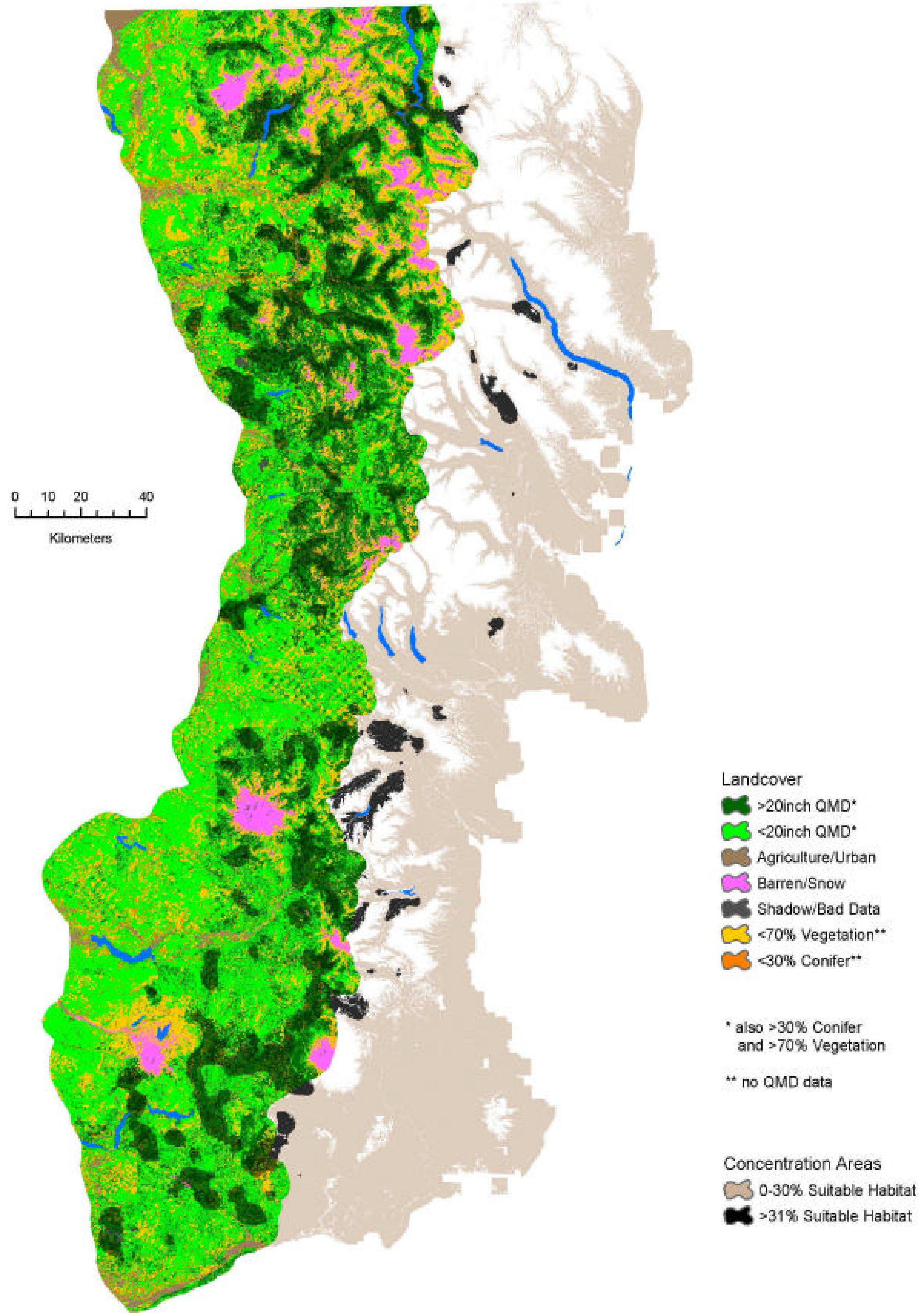
Map 9. Concentration areas based on suitable habitat percentage in the southern Oregon study area.



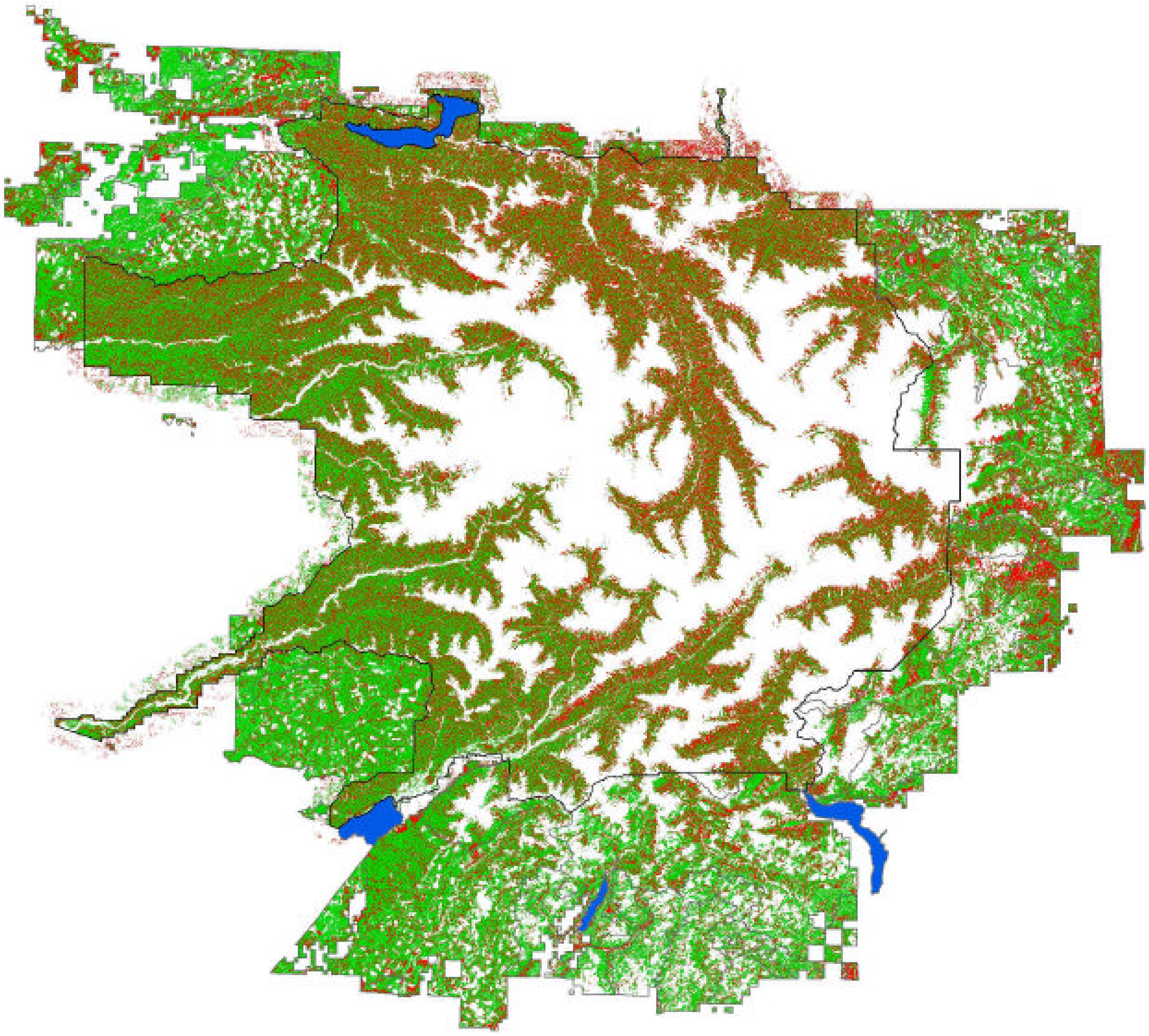
Map 10. Connectivity area results derived from modeling fisher movement between suitable habitat.



Map 11. Potenital corridors between concentration areas in the Cascades with silver fir zone mask.



Map 12. Potenital corridors between concentration areas in the Cascades without silver zone.



Model Relationships

Agree

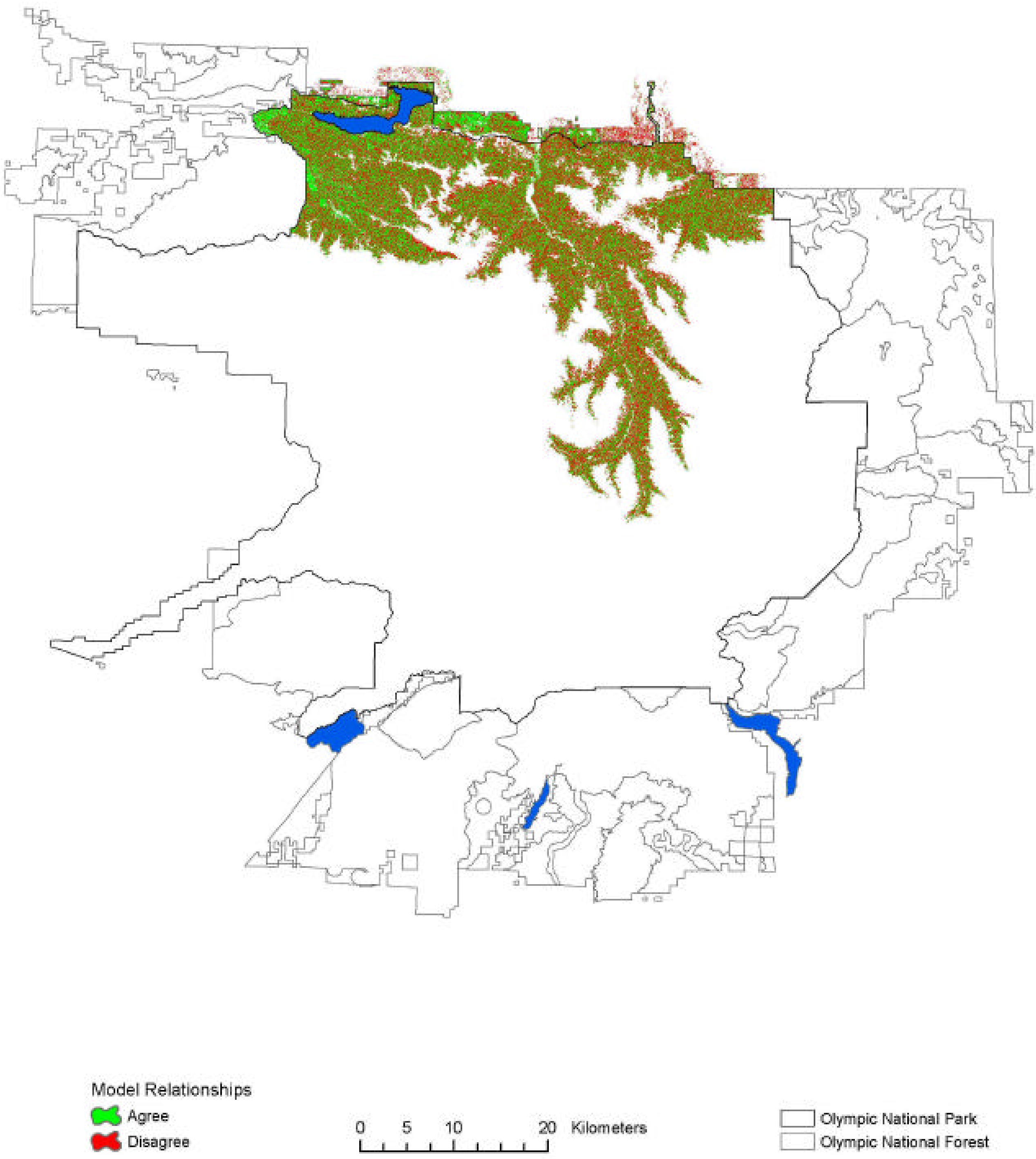
Disagree

0 5 10 20 Kilometers

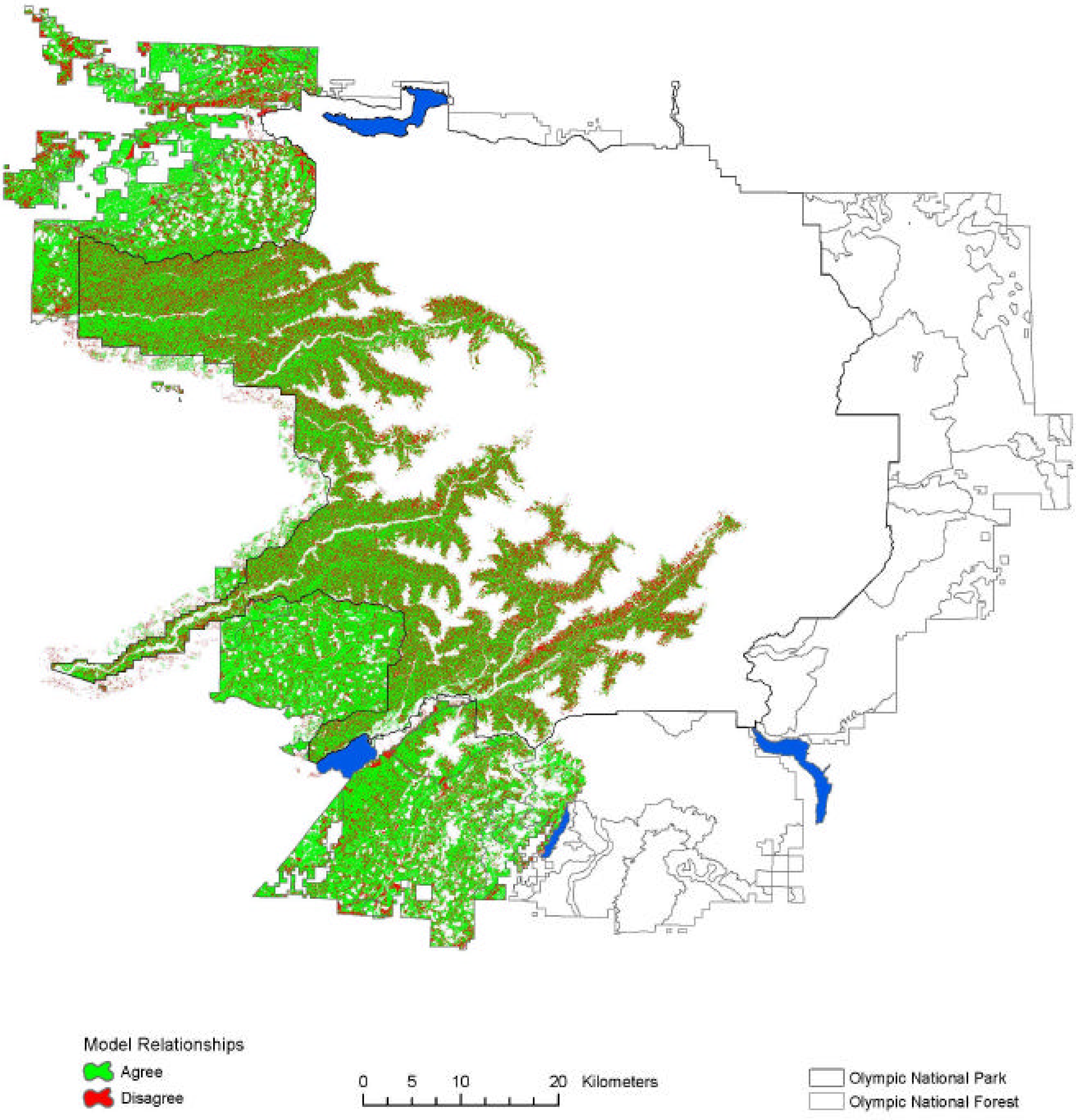
Olympic National Park

Olympic National Forest

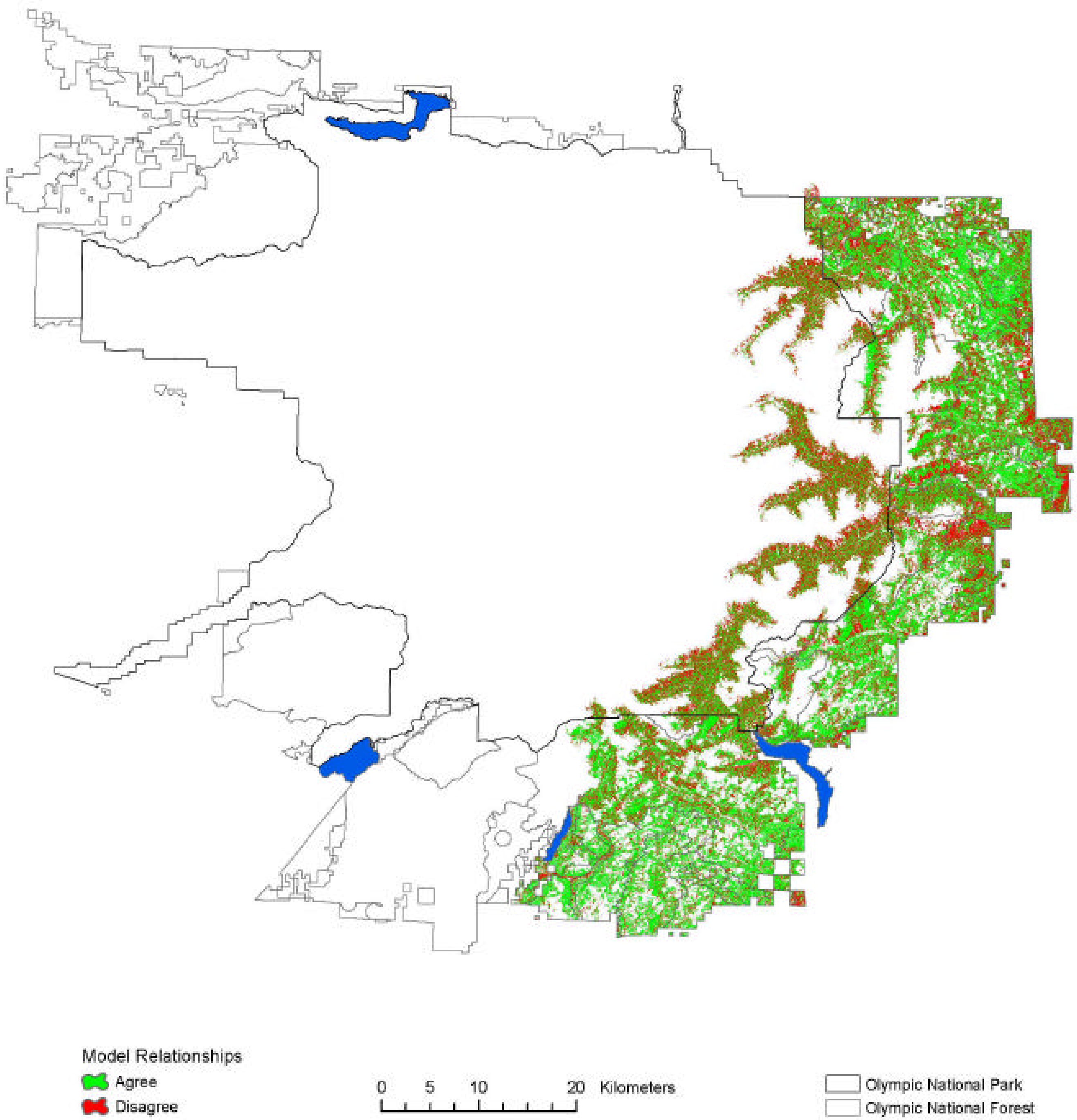
Map 13. Comparison between IVMP suitable habitat and ONF/ONP late seral model data.



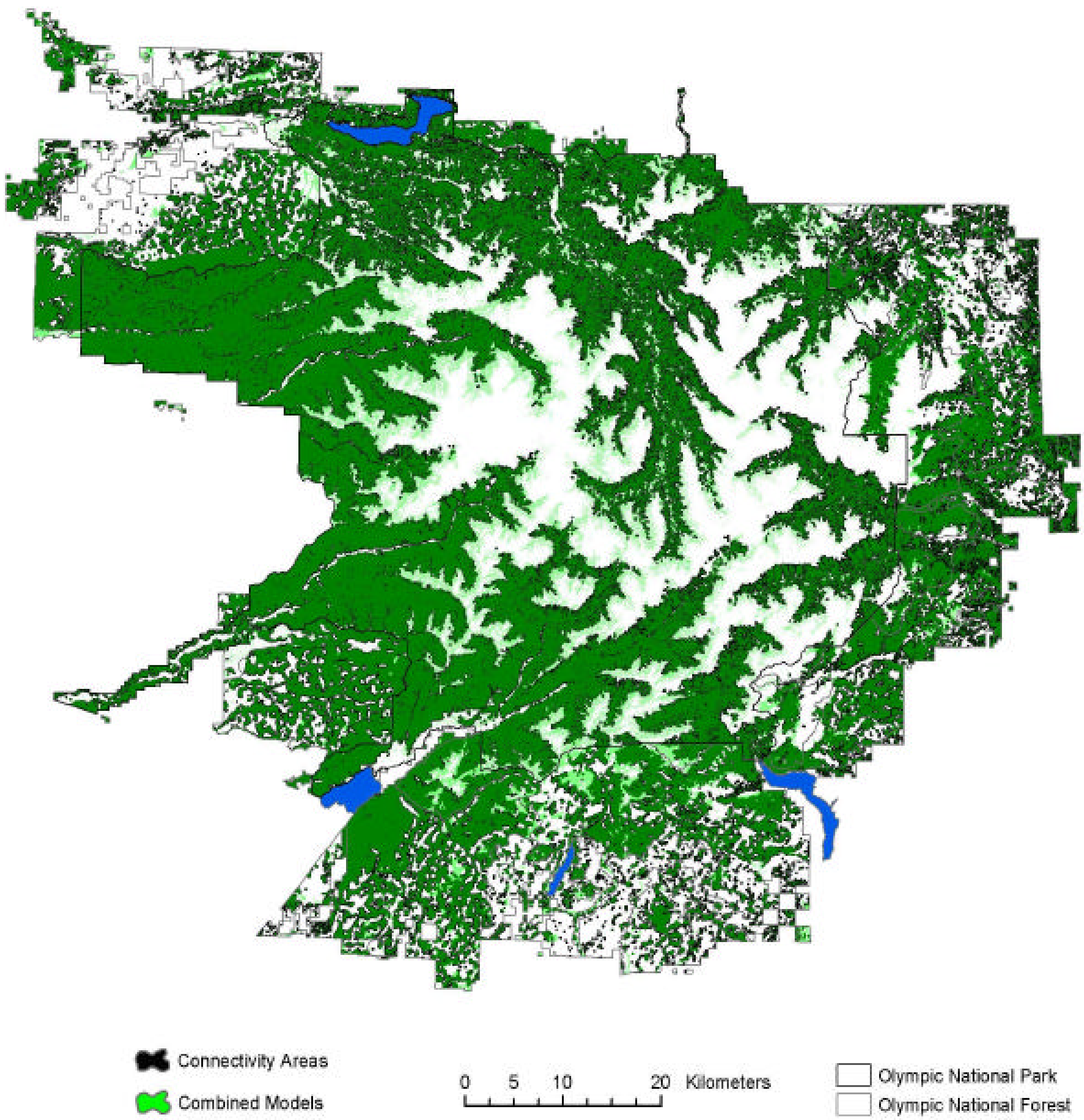
Map 14. North/Elwah subarea comparison between IVMP suitable habitat and ONF/ONP late seral model data.



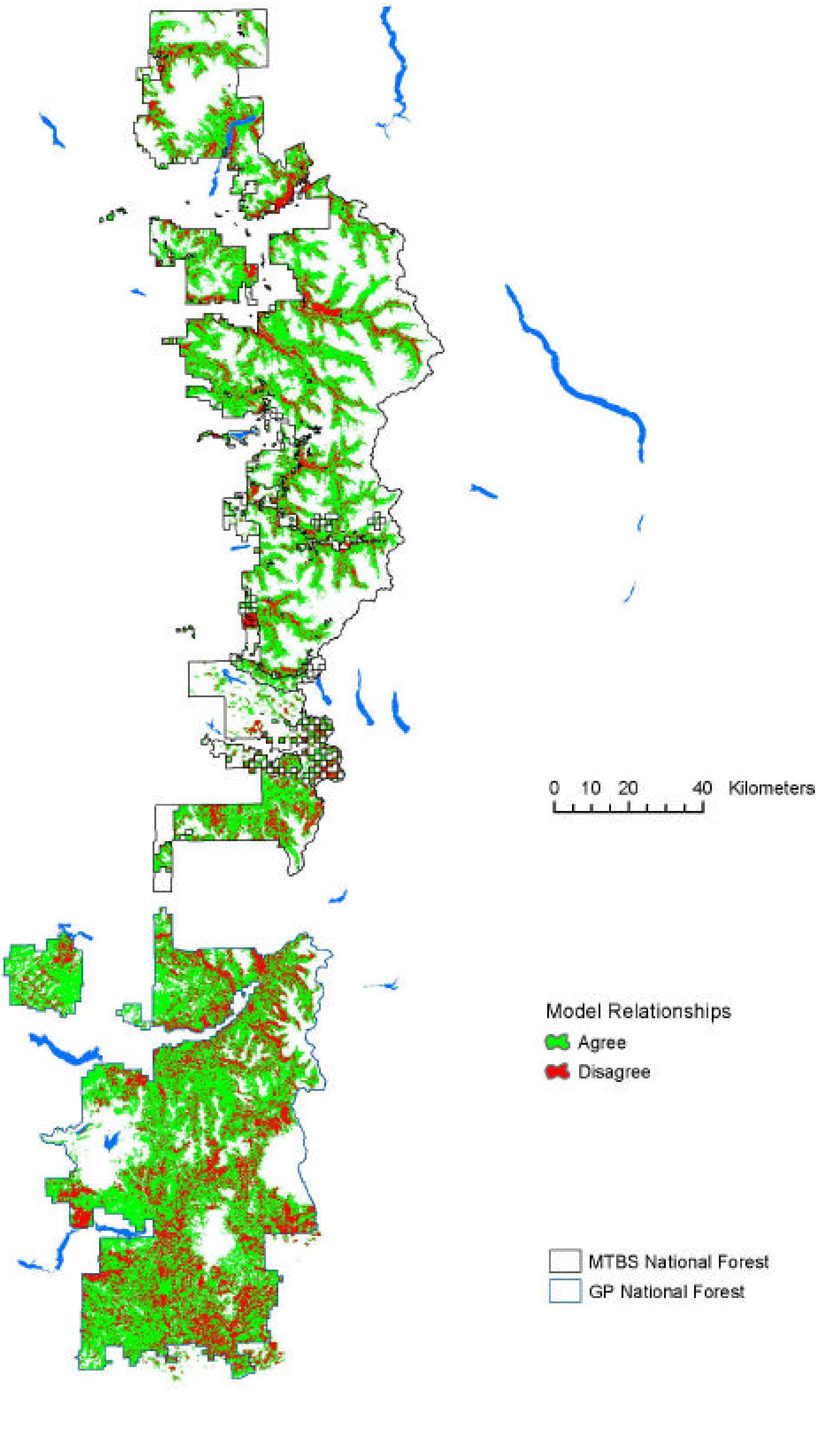
Map 15. West subarea comparison between IVMP suitable habitat and ONF/ONP late seral model data.



Map 16. East/South subarea comparison between IVMP suitable habitat and ONF/ONP late seral model data.



Map 17. Comparison between the connectivity areas and the combined late seral models.



Map 18. Comparison between IVMP suitable habitat and MBSNF/GPNF late seral model data.