APPLYING AN ECOSYSTEM DIVERSITY FRAMEWORK FOR CONSERVATION PLANNING IN NORTHERN IDAHO

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INTRODUCTION

The Idaho Department of Lands (IDL) is preparing a Conservation Plan (Conservation Plan) for its forestlands in the panhandle of northern Idaho. Development of the Conservation Plan will address all state endowment lands north of the Pend Oreille River and Lake Pend Oreille. The purpose of the Conservation Plan is to demonstrate IDL's contribution to maintaining biodiversity associated with its forest management. IDL is especially interested in providing conservation benefits for 9 species that are either listed species, or species of concern in northern Idaho, and include Flammulated Owl, Boreal Owl, Great Gray Owl, Northern Goshawk, Black-backed Woodpecker, Boreal Chickadee, Woodland Caribou, Fisher, and Canada Lynx. While state lands are managed to produce a maximum long-term financial return to public schools and other endowments, this Conservation Plan addresses the need to maintain and benefit these species within the planning area. The desired Conservation Plan will be designed to identify reasonable stewardship actions for selected listed species and other species of concern, while allowing continued forestry activities that meet IDL management objectives.

The IDL is interested in addressing development of a Conservation Plan based not only on the needs of the specifically identified species, but also based on providing native ecosystem diversity within the northern Idaho planning landscape. Providing native ecosystem diversity for a Conservation Plan involves identifying an adequate level of representation of the various native ecosystems to meet the objectives of the Conservation Plan. This project developed a description and quantification of native ecosystem diversity for forest ecosystems in the Idaho Panhandle, and quantified what would be needed to provide a level of representation of these ecosystems. One way of ensuring an appropriate level of representation of native ecosystem diversity is to evaluate the response of species identified for inclusion in the Conservation Plan to future landscape conditions. For this project, an evaluation tool termed habitat-based species viability analysis (Roloff and Haufler 1997, 2002) was used that is based on linking population status to the quality and quantity of home ranges of selected species. This approach included the analysis of past, existing, and projected future habitat conditions for the species of interest.

OBJECTIVES

The primary objectives of this project were two-fold: 1) develop a framework for northern Idaho that identified and described native ecosystem diversity for terrestrial systems and that served as a coarse filter for the planning region, and 2) conduct species assessments of the coarse filter to evaluate its effectiveness as the foundation for a multi-species Conservation Plan.

PURPOSE

This project identified, inventoried, and collated the available existing data for the planning area that was needed to complete a Conservation Plan, and developed a classification and characterization of this information relative to historical, existing, and future ecosystem diversity for terrestrial systems of the northern Idaho planning region.

This document:

1. Describes the conservation strategy selected by IDL to serve as the foundation for the described Conservation Plan on their lands in northern Idaho,
2. Describes the coarse filter or native ecosystem diversity for forest ecosystems of the northern Idaho landscape,
3. Presents the results of an assessment of existing data to determine the status of today's ecosystem diversity for forest ecosystems,
4. Describes and quantifies the cumulative impacts of post-European settlement on the native ecosystem diversity of forest ecosystems in northern Idaho,
5. Identifies Idaho Department of Lands restoration or maintenance goals for future forest ecosystem diversity within the northern Idaho landscape,
6. Evaluates the effectiveness of IDL restoration and management efforts in providing for the habitat needs of the 9 identified species using a habitat–based species viability approach for this evaluation, and
7. Discusses the results of the species assessment and its application to management of IDL lands in northern Idaho.

THE CONSERVATION STRATEGY

Conservation strategies refer to the framework and the underlying basis and assumptions used in planning to maintain or restore ecosystem and biological diversity to an identified area. A wide range of strategies exist, each with advantages and disadvantages (Haufler 1999a;1999b). Some are narrowly focused, only striving to address a subset of biological diversity, while others are broadly focused, striving to address biological diversity within a defined area at all four of its levels (landscape, ecosystem, species, and genetic). Selection of a strategy is dependent on the unique objectives of an individual planning effort. To achieve the objectives identified by the IDL for the planning area, a combined coarse filter/fine filter strategy was selected. The following section provides a brief overview of coarse filter and fine filter strategies, and provides a discussion of how they are used. Following this overview, the selected strategy will be described and discussed relative to addressing the objectives of this project.

OVERVIEW OF CONSERVATION STRATEGIES

Coarse filter and fine filters are terms that have been widely used to describe conservation strategies. Coarse filter strategies focus on providing an appropriate mix of ecosystems or ecological communities across a planning landscape, while fine filter strategies focus on providing for the needs of individual or multiple species within a landscape (The Nature Conservancy 1982, Marcot et al. 1994, Schwartz 1999, Haufler 1999a). While many conservation planning efforts blend the two strategies, there is a fundamental difference in whether the primary basis of a strategy is focused on ecosystems or species. Each type of strategy is based on various assumptions as to how it can provide for biodiversity conservation (Haufler 1999a).

Coarse Filter Strategies

Coarse filter strategies have the goal of maintaining enough diversity of ecosystems or ecological communities to maintain the ecological integrity of these ecosystems and to provide for the habitat needs of all species and their genetic diversity inherent to a landscape. A key to the success of a coarse filter strategy is to use an appropriate classification of ecosystem diversity that is applied at an appropriate scale (Schwartz 1999, Mayer and Cameron 2003) to address the specific conservation objectives identified for an area. Few efforts have considered the appropriateness of the classification system used and more frequently use whatever classification happens to be available for an area. Numerous authors have discussed the importance of ensuring that appropriate types and amounts of ecosystems are identified and represented within a planning region (Pressey 1998, Schwartz 1999, Shaffer and Stein 2000, Lambeck and Hobbs 2002, Groves 2003, Roloff et al. 2009). Both biological and physical factors should be determined when identifying ecosystem diversity and various authors (Haufler et al. 1996, Haufler et al. 1999, Poiani et al. 2000b, de Blois et al. 2002, Groves 2003, Saxon 2003) have identified the importance of understanding both the role of physical factors that create different types of ecological sites within a planning landscape, and the biological response, or how ecosystems change over time following disturbance across these different ecological sites.

Another important consideration of coarse filter strategies is that the composition and structure of communities identified to represent ecosystems must be appropriate for that specific ecosystem. For example, if a particular area possesses a large amount of exotic species that may exceed an appropriate threshold level, then this area should not be considered representative of the targeted ecosystem conditions. Few coarse filter strategies have addressed more than landscape level measures of different existing vegetation types. However, tests of coarse filter strategies have shown that they can be effective for biological diversity conservation (Nichols et al. 1998, Wessels et al. 1999, Ben Wu and Smeins 2000, Kintsch and Urban 2002, Oliver et al. 2004).

Haufler (1999a, 1999b, 2000) discussed strategies for biological diversity conservation and identified several types of coarse filter strategies. One type of strategy, termed the historical reference approach or historical range of variability-based approach (Haufler 1999a), has been proposed or utilized in various planning efforts. This approach is based on the premise that the ecosystem diversity that occurred in an area over the past hundreds to several thousand years defined biodiversity at the ecosystem and landscape levels, and also provided the habitat that supported the species and genetic diversity of a landscape (Poiani et al. 2000a, Haufler et al. 2002). This approach has as a primary objective the maintenance of all historically occurring ecosystems at some level of representation. The historical reference approach strives to understand, characterize, and quantify the historical ecosystem diversity that occurred within a planning area, and then attempts to maintain suitable representation of these ecosystems within that area factoring in the historical reference at both landscape and ecosystem levels (Haufler et al. 2002). The goal is not to return a landscape to historical conditions, but to use this understanding as a baseline or reference for providing representation of ecosystems at both the landscape and ecosystem levels. Use of this approach requires the development of information on historical ecosystem diversity (Morgan et al. 1994, Landres et al. 1999). This approach generally focuses on understanding how natural disturbances and processes combined with different ecological sites within a planning area produced the dynamics of historical or native ecosystem diversity. The approach then uses this information to determine how the extent and distribution of historical ecosystems have been changed by recent human activities (i.e., post Euro-American settlement).

Fine Filter Strategies

Fine filter strategies have a primary focus on planning for single or multiple species. Related topics in many publications describe such measures as species richness or species diversity, and the use of hotspots for identifying conservation areas (Flather et al. 2009). A majority of the recent publications on fine filter strategies have been focused on reserve planning, and use species as a basis for identifying the most appropriate places to locate reserves.

Fine filter strategies have the advantage of having a legal basis for their use in conservation planning in the United States and other countries through provisions of endangered species legislation (Schwartz 1999). Proponents who favor fine filter strategies over coarse filter strategies argue that species are the fundamental parts of ecosystems, and that using coarse filter analyses to represent species needs is inaccurate and inadequate (Noon et al. 2003, Cushman et al. 2008), although most of the examples of problems with coarse filters have not evaluated the appropriateness of the coarse filter being critiqued, as discussed above.

A primary concern with fine filter strategies is that the number of species occurring in any area is so large that they cannot all be accounted for in a fine filter approach. Attempts to simplify this complexity through the use of surrogates have many problems associated with them (Groves 2003). Numerous publications point out the difficulty and limitations of using species groupings as surrogates for conservation planning (Flather et al. 1997, Niemi et al. 1997, Brockway et al. 1998, Pearson and Carroll 1998, van Jaarsveld et al. 1998, Carroll et al. 2001, Fleishman et al. 2001, Fleishman et al. 2002, Lawler et al. 2003, Su et al. 2004). Further, most fine filter strategies fail to consider the landscape and ecosystem levels of biodiversity, so their ability to represent all levels of biodiversity is limited.

Combination Strategies

Today, many conservation planning initiatives use a combination of strategies to address their objectives. Many coarse filter approaches combine in some way with fine filter approaches. The Nature Conservancy approach (Groves 2003) combined a rarity focus in identifying both fine and coarse filter elements for representation in reserves. Haufler (1999a; 2000) and Haufler et al. (1996a) used a coarse filter approach based on an historical reference, but then suggested that this be checked using indicator species selected to test the effectiveness of the coarse filter. Noon et al. (2009) recommended using a combination of coarse and fine filter strategies as the most effective currently available method of resource planning.

Combination approaches have the capability of addressing many of the concerns identified with individual strategies. The goal of any specific initiative should be to develop a comprehensive and cohesive conservation planning approach, and to carefully review the approach to identify any holes in coverage where elements of biodiversity might not be sufficiently addressed. As noted by many including Haufler et al. (2002) and Groves (Groves 2003), much is unknown about conservation planning, so monitoring and adaptive management designs are important considerations.

SELECTED STRATEGY

A strategy was selected that provides a strong scientific foundation for conservation of all biological diversity as well as the flexibility to consider forest management objectives in the overall effort. The historical reference coarse-filter strategy combined with a species assessment evaluates ecosystem integrity and biological diversity relative to what has occurred historically at a specific site or location. For this purpose, historical is typically considered a time-period of less than 1000 years prior to European settlement. This time frame presents a realistic view of vegetation conditions and disturbance regimes that influenced native species still present today, while also providing the best available physical evidence to support assumptions and models to predict historical conditions. There is a strong scientific foundation for using an historical reference for defining ecosystem integrity and biological diversity (Morgan et al. 1994, Swetnam et al. 1999). It was the complex array and dynamic distribution of ecosystems across the planning landscape that shaped and sustained the biological diversity of the region. Most of the wildlife present in northern Idaho today is the product of historical ecosystems that have existed for thousands of years. Understanding the types, distribution and dynamics of these ecosystems is fundamental to understanding and managing northern Idaho's wildlife.

The success of a coarse-filter approach will largely depend on properly applying the coarse filter, in this case, the conditions appropriate to the historical reference approach. This means using a reference to historical disturbance patterns and ecosystem distributions to assist in evaluating desired sizes and distributions within the landscape. The focus should be on providing representation of historical ecosystems in appropriate amounts, sizes, and distributions based on reference to these ecosystems under historical disturbance regimes. Decisions would not be made based on the needs of individual species. Striving to maximize conditions for multiple species within a planning landscape will quickly lead to conflicting needs of species with different habitat requirements, making planning based on the needs of multiple species problematic (Gutzwiller 2002). The use of the coarse filter approach provides a feasible way of properly addressing landscape planning.

The resulting landscape conditions can be checked for the likelihood of continued persistence of selected species using assessment tools such as habitat-based species viability models (Roloff and Haufler 1997, 2002). To address any concerns with distribution of ecosystems with lower levels of representation, dispersal models (e.g., With 1999, 2002) can also be used. Species assessments provide a check on the assumptions and proper functioning of the coarse filter. If a species that had a high probability of persistence under historical conditions was found to not have an acceptable probability of persistence under the planned conditions, then the coarse filter standards may need to be reevaluated and modified. However, if conditions for the species selected for the assessment are shown to provide an acceptable likelihood of persistence, then the coarse filter is supported in its function to address the maintenance of biological diversity and ecosystem integrity.

Combining a coarse-filter and fine filter strategy has several advantages. First, the coarse filter provides a sound scientific foundation for identifying and quantifying the cumulative effects of post-settlement activities on species and their habitat (fine filter). Second, it is more time and cost effective to manage for desired ecosystem conditions than to manage for an ever-increasing number of endangered, threatened, or declining species scattered across the landscape. Third, a coarse filter provides the mechanism to make sense of conflicting habitat demands in a single landscape for multiple species of concern. Finally, for many species, little information on their distribution and specific habitat needs is available at this time. By applying the coarse filter strategy, we are increasing the likelihood that the habitat needs of these species will be addressed with the restoration or maintenance of historically-occurring ecosystems.

The IDL has selected a combined coarse filter and fine filter strategy to support the objectives and requirement of the Conservation Plan process. A description of native ecosystem diversity that is based on historical references for plant community compositions, structures, and dynamic processes will represent the coarse filter component of this strategy. The selected strategy is described in greater detail in The Wildlife Society Technical Review 02-1, "Performance Measures for Ecosystem Management and Ecological Sustainability" (Haufler et al. 2002).

APPLYING THE STRATEGY

Biological diversity is often assessed at four levels: 1) landscape, 2) ecosystem (also referred to as the community level), 3) species, and 4) genetic (Noss 1996). The combination of a coarse filter and fine filter strategy provides the mechanism to address these four levels of biological organization. The coarse filter addresses the landscape and ecosystem levels while the fine filter addresses the species level. Genetic analyses can be a component of the fine filter, and may also provide insights into landscape and ecosystem level functionality. The primary emphasis for the purpose of this project, however, is on the landscape, ecosystem, and species levels. Genetic levels could be incorporated at future times to address specific questions such as connectivity for a particular species' population.

THE PLANNING LANDSCAPE

The delineation of the planning landscape is an important initial consideration relative to applying the coarse filter/fine filter conservation strategy at the appropriate scale and ensuring that the diversity of ecosystems and their inherent variation is adequately represented. Haufler et al (1996) recommended defining the planning landscape on the basis of 4 primary criteria:

1. Similar biogeoclimatic conditions that influence ecological site potential,
2. Similar historical disturbance regimes that influence vegetation structures and species compositions,
3. Adequate size to provide a sufficient range of habitat conditions to assure population maintenance of the majority of native species that historically occurred in the planning landscape, and
4. Recognition of maximum size and operational boundaries to avoid practical operational limitations in terms of data management, implementation, and number of cooperating landowners.

Figure 1. The delineated landscape for the development of an ecosystem diversity framework for northern Idaho.

Two ecoregional classifications were used to evaluate biogeoclimatic condition influencing site potential; the first being Bailey's ecoregional classification at the Section level (Nesser et al. 1997) and the second being Major Land Resource Areas (NRCS 2006). The first classification, Bailey's ecoregional classification, indicated that IDL lands in the planning area lie within two Sections of the Bailey's classification: Section M333A, Okanagan Highlands and Section 333B, Flathead Valley. These Sections have similar landscape characteristics including low mountains, hills, and glaciated mountains that formed in quartzite, siltite, argillite, and granitic rocks. Wide valley bottoms formed in alluvium, glacial outwash, and lacustrine sediments. Thick layers of volcanic ash form the surface of most soils in the area. Elevation ranges from 1400 to 7700 feet. Mean annual precipitation ranges from 15 to 70 inches with as much as 70 percent falling as snow. The second classification, Major Land Resource Areas (MLRA), also encompassed 2 MLRA's for IDL lands within the planning area: Northern Rocky Mountain MLRA and Northern Rocky Mountain Valley MLRA. MLRA's are delineated based on soil and landscape characteristics, vegetation, and climate. The combined consideration of both classification systems supported the delineation of the northern Idaho panhandle as an appropriate planning area considering the biogeoclimatic conditions and historical disturbance regimes influencing ecological site potential. In addition, to address the concern for possible operational limitations of data management and implementation, as well as maintaining a reasonable number of cooperating landowners, the Idaho state boundary was deemed a useful boundary for the north, east, and west sides of the planning area. The southern planning area boundary was delineated using state Highways 2 and 200, as commonly used boundaries for mapping efforts, and which was also closely correlated to the southern boundary of Bailey's ecoregions at the sub-section level. The resulting planning landscape represents approximately 1.5 million acres (Figure 1).

Ownership patterns within the planning landscape are presented in Figure 2. Federal agencies are the primary landowners in the planning area representing 52% of the total acres. The U.S. Forest Service is the primary federal agency representing 98% of the federal ownership. The Bureau of Land Management and U.S. Fish and Wildlife Service are also represented but with a relatively minor amount at 1.5% and <1%, respectively, of federal ownership. The State of Idaho represents 14% of the overall land base while other private ownership represents 34% of the remaining ownership. Open water in the form of lakes and reservoirs represents 2% of the land base in the planning area.

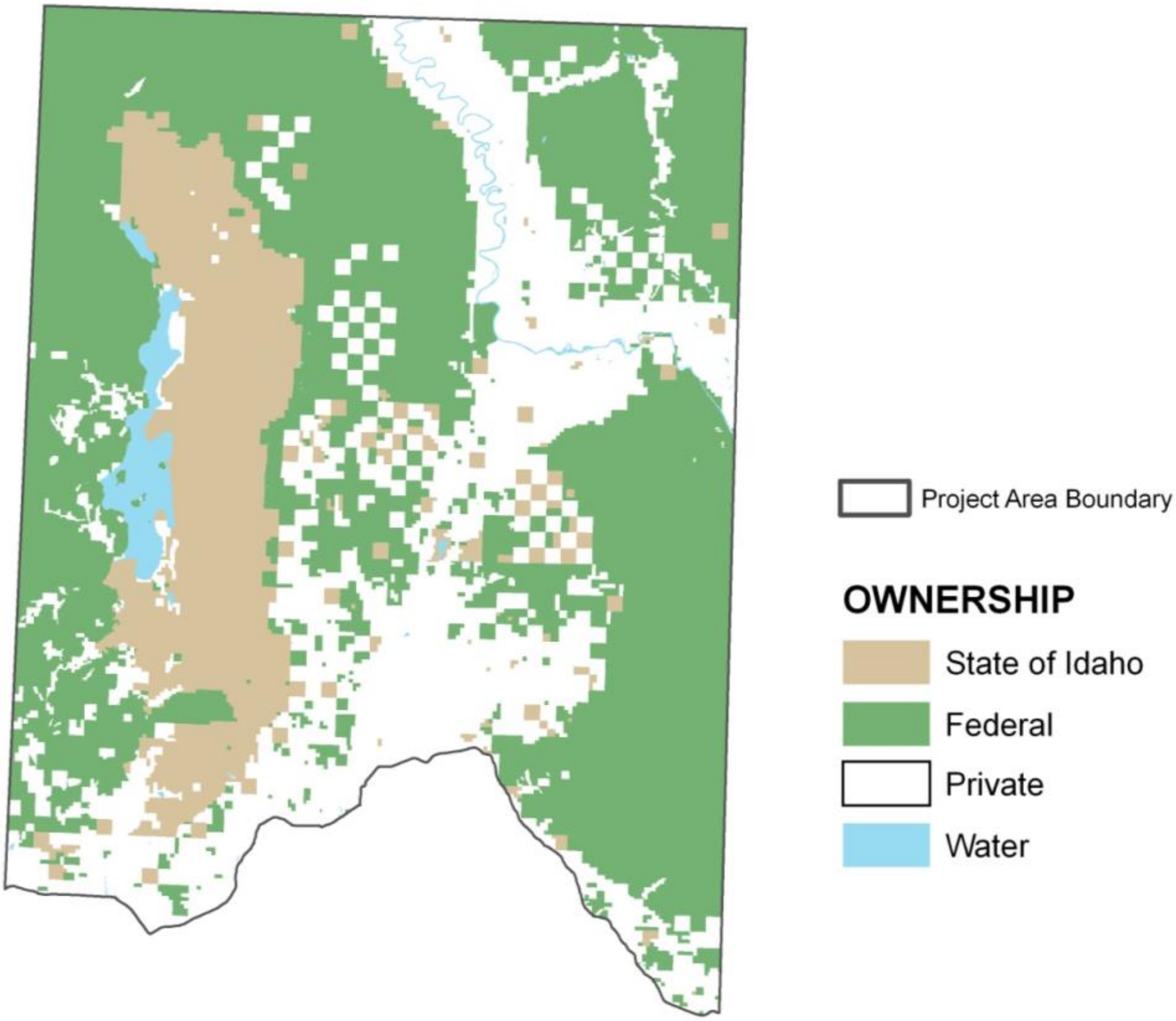

Figure 2. Ownership patterns within the northern Idaho planning region.

THE COARSE FILTER

NATIVE ECOSYSTEM DIVERSITY

Terrestrial ecosystems of the northern Idaho region, as stated previously, are the combination of communities of living organisms with the physical environment in which they live. To characterize native ecosystem diversity for this assessment, a combination of the two primary drivers of ecosystem diversity was used: ecological sites and disturbance states. Ecological sites represent the physical environment component of an ecosystem and disturbance states represent the vegetation communities that can occur on an ecological site in response to natural disturbance regimes. The following sections describe the native terrestrial ecosystem diversity that occurred within the planning region relative to these two primary drivers, disturbance states and ecological sites.

Ecosystems and Ecosystem Diversity

What is meant by ecosystems or ecosystem diversity? An ecosystem is the combination of the community of living organisms with the physical environment in which they live. Each ecosystem can thus be described as the assemblage of species that typically occurs together on a particular type of ecological site as a result of past disturbance events. These disturbance events could be either natural disturbances in describing native ecosystem diversity, or human disturbances over the past 100 years that have created new species assemblages that did not occur historically. The range of ecosystems, (ecosystem diversity) occurring across a landscape and available as habitat for native plants and animals was historically the result of the different types of ecological sites within the landscape and the natural disturbance processes (e.g., fire, windthrow, grazing, etc.) that typically occurred within that landscape. Ecosystem diversity is often described by the range of vegetation types (plant communities) occurring in an area. Such characterizations typically have only looked at the plant communities present, and often have ignored the underlying site differences and often have not provided an understanding of the transitional dynamics and causative factors that produced the observed ecosystem diversity. The historical reference coarse filter determines these additional relationships, and breaks out the influences of underlying sites, natural disturbance processes, and more recent human modifications to ecosystem diversity. It should be noted that while a classification of ecosystems reveals how they are clearly distinct from each other, the distributions of many ecosystems have less clearly defined edges in the transition from one ecosystem type to another within a landscape. However, in order to describe and quantify the amounts of each ecosystem for assessment and management purposes, it is necessary to map a line between ecosystems while recognizing that these transitions may not be as clearly discernable in the landscape.

Natural Disturbance and the Historical Reference

Prior to Euro-American settlement, natural disturbance processes such as fire were a primary influence on the ecosystem diversity that occurred in northern Idaho (Smith and Fischer 197). Native Americans interacted with and influenced ecosystem diversity for thousands of years, but typically in ways that used naturally occurring disturbance processes to benefit their subsistence strategies, such as using fire to create better wildlife habitat for hunted species or maintaining travel corridors in more open conditions (Williams 2005). The influences of natural disturbance processes and Native Americans on historical ecosystem diversity are incorporated in what is known as the historical reference.

Historical references are utilized in ecosystem assessments to help identify, describe, and quantify the native ecosystem diversity that occurred in a region (Blocker et al 2001). For the purpose of this project, an historical reference is defined as the ecosystem diversity that resulted from natural disturbance (i.e., fire, grazing, etc.) and pre-European human-influenced disturbance (American Indian influences) that created the dynamic conditions that plant and animal species were dependent upon. Natural disturbance regimes are the patterns of frequency and intensity that can be quantified using ecological evidence. For example, fire regimes are frequently described relative to frequency of occurrence and relative intensity.

Another term frequently used in relation to historical reference is the historical range of variability. Historical range of variability is an important concept because it emphasizes that many ecosystems varied in amounts, compositions, and structures due to variations in climate and stochastic events that influenced natural disturbance regimes (Aplet and Keeton 1999, Blocker et al. 2001, Hillis et al. 2001). Historical references are usually confined to a period less than 1000 years prior to Euro-American settlement, as these reflect the habitat conditions most relevant to the species that are present today (Morgan et al. 1994). Furthermore, native ecosystems were not static during any defined reference period. Species distributions were changing, disturbance regimes were changing, and species themselves were adjusting to these changes through behavioral and genetic alterations. However, developing an understanding of the ecosystem diversity that occurred during an identified timeframe prior to Euro-American settlement provides critical reference information for defining and quantifying a baseline of what should be considered “natural” or “native” for an area. In the following paragraphs, the primary disturbances that influenced ecosystem diversity within the northern Idaho planning area are described.

An important factor in identifying the potential range of conditions or disturbance states that occurred on a landscape is an understanding of the influence of historical disturbance regimes on vegetation structure, species composition, and spatial distribution (Haufler et al. 1999). Some of the more common disturbance regimes within North America include fire, insects, disease, hurricanes, blow downs, grazing, and flooding. Within any given landscape, several different historical disturbance regimes may have operated to influence vegetation in this manner. Relative to forested ecosystems of the northern Idaho landscape, fire was the primary disturbance agent directly influencing large-scale changes in forest species composition, structure, and spatial distribution. While insects and disease were and continue to be important disturbance agents as well, their activities often contribute to the occurrence and severity of fire as the end result. Consequently, the ultimate driving force of large-scale disturbance and vegetation change within northern Idaho was predominately fire.

European-induced changes and/or impacts have functionally suppressed, eliminated or changed many of the historical disturbance regimes throughout North America. The result has been changes to many native ecosystems and their corresponding biodiversity. In the northern Idaho landscape, the primary influence in this regard has been the reduction in the role of fire for nearly 100 years. Fire suppression programs have had profound effects on many ecological communities, ecosystem processes, and the biodiversity dependent on the fire-maintained historical condition. Understanding and quantifying these changes is critical to the success of biodiversity conservation.

Based on historical accounts (Arno 1980, Gruell 1983, Wellner 1970) and recent studies (Agee 1993, Brown 1974, Smith and Fischer 1997), the northern Idaho forested landscape was influenced by three primary fire regimes: non-lethal, lethal, and mixed severity. The non-lethal fire regime is predominantly characterized by relatively frequent, low to moderate intensity fires that burn along the surface of the ground and remain within the forest understory, thereby being relatively non-lethal to the overstory trees. Non-lethal fires can be expected to result in less than a 30% canopy cover loss (S. Barrett, 2002, unpublished data). The frequency of these fires influences both the species composition and vegetation structure within these forests. Fire tolerant species such as ponderosa pine and western larch become dominant in the overstory and bunchgrasses become dominant in the understory. The potential for destructive wildfire, insect, or disease events are low. Stand history studies in fire-influenced forest ecosystems have demonstrated that stands occurring within the non-lethal fire regime had relatively predictable species composition and vegetative structure (Smith and Fischer 1997). They were also less likely to move through a typical successional progression of age classes. Instead, fire maintained a multi-age stand, characterized by saplings to old growth trees with relatively low numbers of trees per acre, but with a preponderance of larger trees in the stand.

The lethal fire regime was characterized by infrequent, high-intensity fire that consumed both the forest understory and overstory as it moved across the landscape. Lethal fire regimes result in a short-term, stand replacing effect on forest conditions, in contrast to the persistent, yet less obvious effects of the non-lethal fire regime. The lethal fire regime typically resulted in a greater than 80% kill to the mature canopy layer (S. Barrett, unpublished data). The result of this impact is to set the stand back to an early structural stage and release plant species stimulated by severe fire events. The stand then proceeds along an undisturbed successional trajectory for many years, depending on the ecological site.

The mixed severity fire regime also frequently occurred in landscapes with both non-lethal and lethal fire regimes and where these two fire regimes intermingle due to topographic influences. That is, depending on site conditions or position on the landscape, both non-lethal and lethal fires could occur within a mosaic of diverse stand conditions. The mixed fire regime typically results in a 30 to 80% kill rate of the mature canopy layer. This is typically common through the transitional portion of the environmental gradient where the low elevation, drier sites are dominated by non-lethal fire regimes and higher elevation, moister sites are dominated by the lethal fire regime. Consequently, where a transitional site occurs primarily adjacent to the dry, low elevation types, it is predominantly influenced by a non-lethal fire regime with pockets of lethal fire influences. Where it occurs primarily adjacent to the moist, high elevation types, it is predominantly influenced by a lethal fire regime with pockets of non-lethal fire influences. The width of the mixed-severity zone within the landscape is further influenced by the characteristics of the slopes in this zone. In areas where the zone is characterized by steep slopes, the width of the zone is relatively narrow, whereas in areas where the zone is characterized by benches and more gradual topography, the zone is wider and more influential.

Ecological Sites

Understanding the role of historical disturbances and their influences on species compositions, stand structures, and ecosystem functions, requires a classification of ecological site conditions. Typically this type of classification delineates the differences in abiotic conditions such as climate, soils, aspect, elevation, moisture, etc., that influence the disturbance patterns and plant communities that can occur on that site. Habitat typing (Daubenmire 1968) is one type of ecological site classification and has been the most well developed and widely used ecological classification system for forest ecosystems in the

Intermountain Region. Habitat typing classifies an ecological site on the basis of its end point in plant succession without disturbances (Pfister et al. 1977). Specifically, it uses the floristic composition of both the overstory and understory plant community to differentiate environmental factors that affect species growth, competition, reproduction, and consequently, community development. While habitat typing is based on floristic evaluation, it reflects and differentiates the influences of both biotic and abiotic factors.

For the northern Idaho planning area, 9 habitat type groupings or classes were identified based on their potential vegetation communities. These habitat type classes grouped individual habitat types developed by Cooper et al. (1991) with similar habitat types combined on the basis of site potentials, influence of historical disturbance patterns, and comparable ecological functions. This allows for a more efficient and operational way of understanding the ecological complexity of the landscape by reducing the number of potential habitat types from approximately 50 types to the 9 habitat type classes identified for this project. While finer scale classification of all 50 types is possible, delineation and analysis of the 9 habitat type classes was deemed to capture the range of variability in site conditions in sufficient detail to maintain the diverse ecosystem diversity of the landscape in a functionally feasible manner.

The 9 forested habitat type classes also reflect the moisture and elevation gradients that exist in the northern Idaho landscape. These environmental gradients of hot to cold and dry to moist conditions illustrate, in general, where you will find different ecological sites occurring in the landscape and gives some sense of which ecological sites might be adjacent to one another. However, the riparian habitat type classes are the exception and may be intermingled with various upland habitat type classes. Generally speaking, the Moderate, Wet Western Red Cedar habitat type class (a riparian habitat type class) will be associated with the low to moderate elevation zone and the Cool, Wet Subalpine Fir/Mountain Hemlock habitat type class (the second riparian habitat type class) will be associated with the moderate to high elevation zone or where frost pockets occur at lower elevations.

In the following sections, each of the 9 forested habitat type classes will be discussed in terms of their distribution, species compositions and historical structures as influenced by historical disturbance regimes. Much of this information was summarized and adapted from the Forest Habitat Types of Northern Idaho: A Second Approximation (Cooper et al. 1991), Vegetation Response Unit Characterizations and Target Landscape Prescriptions (USFS 1999), and Fire Ecology of the Forest Habitat Types of Northern Idaho (Smith and Fischer 1997) unless otherwise noted.

Hot, Dry Ponderosa Pine/Xeric Douglas-fir
(Hot, Dry PIPO/PSME)

Distribution: This group of habitat types represents the warmest, driest extreme of forest environments wherever ponderosa pine is found. Typically, they represent lower timberline conditions where forested and non-forested sites are intermixed due to the limitations of soil moisture and soil depth, which are the controlling influences for tree growth and reproduction on these sites. Elevations range from 2,000 to 5,400 feet. Associated geology is quite variable and includes steep, rocky sites to glacially scoured ridge tops and ridge noses to moderately deep glacial till, with drumlins and moraines, to shallow and moderately deep residual soils. The Hot, Dry Ponderosa Pine/Xeric Douglas-fir habitat type class is a relatively minor ecological site within the planning region, making up approximately 0.7% of the forested acres.

Potential Dominant Species: Open stands of large ponderosa pine are the characteristic tree cover. At the upper elevations or more moist sites within this class, scattered Douglas-fir may be associated with the pine. Canopy cover is often less than 30% and seldom exceeds 50%. The undergrowth vegetation is characterized by grasses (Idaho fescue, bluebunch wheatgrass, elk sedge and pinegrass) and occasional patches or stringers of shrubs (snowberry and ceanothus).

Historical Disturbance: These sites are severely limited in their tree-stocking capability and frequently maintain a savannah appearance even when fully stocked. Before Euro-American settlement interrupted the normal fire cycle, the majority of these stands were likely in a savannah condition dominated by ponderosa pine and grassy understories with occasional patches of low shrubs. Historically, these sites were primarily influenced by non-lethal (i.e., <30% overstory killed trees) fires on an average of every 5 to 25 years. Average densities ranged from 5 to 20 overstory trees per acre. Historical patch sizes were characterized by small openings of less than 5 acres, within 20 to 200 acre stands of low-density trees. Low-intensity non-lethal fires would result in few fire-sensitive shrubs, low fuel accumulations, and few tree seedlings and small saplings.

Occasionally, when fire did not occur in a stand for greater than 40 years, mixed-severity conditions could occur. These conditions were typically characterized by large ponderosa pine and a small proportion of Douglas-fir in the overstory with higher than average densities of seedlings, saplings, and poles in the understory. When fire did return to these stands, the greater densities of ladder fuels could lead to >30% but less than 80% overstory killed trees. Mixed-severity conditions were more likely to occur on protected and moister sites within this habitat type class. Lethal fire conditions (>80% overstory killed trees) rarely, if ever occurred within this habitat type class.

Since the early 1900s, attempts to exclude fire have lengthened fire return intervals. Tree seedlings, small saplings, and fire-sensitive shrubs, such as spirea and snowberry, have become more common and thereby have increased understory fuel loadings. When fires do occur today, they are often of mixed-severity and lethal types and result in conditions that were less common or rare, historically.

Warm, Dry Ponderosa Pine/Douglas-fir/Grand Fir (Warm, Dry PIPO/PSME/ABGR)

Distribution: This group of habitat types supports the ponderosa pine/Douglas-fir/grand fir forests of northern Idaho. It is characteristic of the warm, mild environments of low- to mid-elevation forests but may extend upward to about 5,800 feet on dry, southerly aspects. These sites are typically well drained and vary from fairly deep glacial till associated with drumlins and moraines, to shallow and moderately deep residual soils. Soils are characterized by silt loam top soils with gravelly loam to sandy silt loam sub-soils. The Warm, Dry Ponderosa Pine/Douglas-fir/Grand Fir habitat type class makes up approximately 15.1% of the forested acres in the planning area.

Potential Dominant Species: The ponderosa pine habitat types are characterized by ponderosa pine as the tree component. The Douglas-fir habitat types are characterized by mixed stands of Douglas-fir and ponderosa pine but at lower elevations, Douglas-fir may be absent. On the grand fir habitat types, ponderosa pine, Douglas-fir and western larch are major seral species with small amounts of lodgepole pine, or Engelmann spruce present, as well. In unlogged stands, ponderosa pine or western larch are usually the larger, older components with Douglas-fir ranging from sapling to mature trees. The undergrowth, if undisturbed, supports mainly rhizomatous shrub and graminoids such as common snowberry, mallow, ninebark, pinegrass, or elk sedge. Following a disturbance such as fire or logging, a wide variety of other shrubs, herbs, and grasses may be present.

Historical Disturbance: Historically, these sites were primarily influenced by frequent non-lethal underburns that excluded most Douglas-fir and grand fir and killed many small ponderosa pines, western larch, and lodgepole pine. In addition, a smaller percentage of the sites were influenced by a mixed-severity fire regime probably due to inclusions of moister micro-sites or their position on the landscape relative to moister habitat type classes. Estimates of the average fire return interval range from 15 to 45 years. The non-lethal fires burned extensively throughout the low- to mid-elevation forests, being extinguished only by fall rains or lack of fuel due to previous fires. Under this burning regime, the stands remained open and park-like, consisting of mostly ponderosa pine, western larch and Douglas-fir in a variety of age classes. Stand density ranged from about 15 to 30 overstory trees per acre. Trees often occurred in clumps, with irregular shaped openings between the relatively low densities of trees. The potential for destructive wildfire, insect, or disease events was low. Due to their different responses to understory burning, it is likely that shrub cover was less and grass cover was greater than under present conditions. Those stands influenced by the mixed-severity fire regime were likely dominated by the more open, non-lethal stand conditions but contained pockets and patches of denser fire-intolerant species that were vulnerable to crown fires if weather conditions allowed more severe fire occurrences.

Since Euro-American settlement, fires have become less frequent and stand conditions have changed dramatically, particularly in unmanaged stands. Here, the historical stand of widely spaced ponderosa pine and western larch is often still evident in the overstory of un-harvested stands as an older stand component. Between the large pines and larches, many smaller Douglas-firs and grand firs have become established since the last underburn, which likely occurred in the late 1800s to early 1900s. Stand densities have increased dramatically on many sites, creating stressful conditions throughout the tree layer. Now the potential for destructive wildfire, bark beetle, spruce budworm, Douglas-fir tussock moth, dwarf mistletoe, and root rot events is quite high.

Moderate Warm, Moist Western Red Cedar/Western Hemlock/Grand Fir
(Mod. Warm THPL/TSHE/ABGR)

Distribution: This group of habitat types occupies the warmer spectrum of the moderate sites within the mid-elevation forest zone. It ranges in elevation from 2,000 to 6,400 feet with moderate to high precipitation. These sites are considered some of the most productive for the region and are moderately widespread in the landscape. These sites are particularly influenced by the moderating effects of the inland maritime climate. Landforms that have been affected by continental glaciation and volcanic ash (loess) deposits are dominant features of these habitat types. The Moderate Warm, Moist Western Red Cedar/Western Hemlock/Grand Fir habitat type class makes up approximately 44.3% of the forested acres in the planning area.

Potential Dominant Species: Western hemlock, western red cedar, and grand fir are the dominant late seral species on these ecological sites. Where these species occur together, western hemlock can dominate over both red cedar and grand fir, as it reproduces successfully in late succession. However, red cedar can maintain itself in the canopy as it is long-lived, shade intolerant, and reproduces vegetatively. Red cedar reproduces successfully over grand fir where they occur together. Grand fir habitat types are relatively rare in this landscape. Where grand fir is successful, it is usually due to the site being at the limits of the ecological and geographical requirements of western red cedar and western hemlock. Western white pine, Douglas-fir and western larch are often dominants or co-dominants in seral stands. Lodgepole pine and birch are minor components in seral stands.

Historical Disturbance: Historical disturbance regimes typically produced a diversity of stand structures and species composition from primarily mixed severity and lethal fire regimes. Mixed severity fire intervals ranged from 43-164 years and generally produced more heterogeneous structures and within-stand structural diversity than long-interval fire regimes. Non-lethal fires were rare, but where they occurred they had mean fire return intervals ranging from 26-39 years. Fire regimes within this habitat type class are heavily influenced by topographic position. Warmer, drier sites within these types exhibited stand conditions that were more open, with greater vertical structure as trees survived the shorter-interval, more moderate-severity fires. Western larch and Douglas-fir, and to a lesser extent, western white pine were common dominants under these conditions. Moister, cooler sites were influenced by long-interval fire regimes ranging from 97 to 312 years in occurrence and were characterized by more even-aged stands. Lethal fires resulted in burn patch sizes averaging 100-300 acres whereas mixed severity fires occurred over less extensive areas.

With the advent of fire suppression activities over the last 100 years, these stands are losing their diversity and becoming more homogeneous in species composition and structure, reducing their value for some wildlife species and making them more susceptible to insect outbreaks and stand destroying wildfire.

Moderate Cool, Moist Western Red Cedar/Western Hemlock/Grand Fir (Mod. Cool THPL/TSHE/ABGR)

Distribution: This group of habitat types occupies the cooler spectrum of the moderate sites within the mid-elevation forest zone. It ranges in elevation from 2,000 to 6,400 feet with moderate to high precipitation. Like the similar Moderate Warm, Moist sites, these sites are considered some of the most productive in the region and are moderately widespread in the northern half of the ecoregion. They are also influenced by the moderating effects of the inland maritime climate. Landforms that have been affected by continental glaciation and volcanic ash (loess) deposits are dominant features of these ecological sites. The Moderate Cool, Moist Western Red Cedar/Western Hemlock/Grand Fir habitat type class makes up approximately 12.4% of the forested acres in the planning area.

Potential Dominant Species: Western hemlock and western red cedar are the dominant late successional species on these ecological sites. Where these species occur together, western hemlock can dominate over red cedar as it reproduces successfully in late succession. However, red cedar can maintain itself in the canopy as it is long-lived, shade intolerant, and reproduces vegetatively. Western white pine, Douglas-fir and western larch are often dominants or co-dominants in seral stands, and occasionally Engelmann spruce will also be dominant. Lodgepole pine and birch are minor components in seral stands. Grand fir and subalpine fir can occur as minor seral or minor climax species.

Historical Disturbance: Historical disturbance regimes typically produced a diversity of stand structures and species composition from primarily mixed severity and non-lethal fires. Mixed severity fire intervals ranged from 65-164 years and generally produced more heterogeneous structures and within-stand structural diversity than long-interval fire regimes. Fire regimes within these ecological sites are heavily influenced by topographic position. Warmer, drier sites within these types exhibited stand conditions that were more open, with greater vertical structure as trees survived the short-interval, more moderate-severity fires. Western larch and Douglas-fir, and to a lesser extent, western white pine, were common dominants under these conditions. Moister, cooler sites were influenced by long-interval fire regimes ranging from 126 to 290 years in occurrence and are characterized by more even-aged stands of combined seral and late successional species. Lethal fires resulted in burn patch sizes averaging 100-300 acres whereas mixed severity fires occurred over less extensive areas of 100 acres or less.

With fire suppression activities over the last 100 years, these stands are losing their diversity and becoming more homogeneous in species composition and structure, making them more susceptible to insect outbreaks and stand destroying wildfire.

Cool, Dry Subalpine Fir/Mountain Hemlock
(Cool, Dry ABLA/TSME)

Distribution: This group of habitat types occurs throughout much of the planning region. They are found at elevations between 3,900 and 7,600 feet and represent the dry extremes of the subalpine fir and mountain hemlock zones. At their lower limits, these sites occur mainly on steep, northerly or easterly aspects but shift to southerly and westerly aspects at their upper limits. Sites at the lower limits are often controlled by cold air drainage and are strongly interfingered with Douglas-fir sites. Soil parent materials are mainly granitics but also include quartz, monzonite, rhyolite, and metasediments. The Cool, Dry Subalpine Fir/Mountain Hemlock habitat type class makes up approximately 4.6% of the forested acres in the planning area.

Potential Dominant Species: In early structural stages, lodgepole pine may be the dominant species or lodgepole pine mixed with Douglas-fir and Engelmann spruce. At the cool, moist extremes, lodgepole pine and Engelmann spruce may appear in varying amounts but seldom dominate. At late structural stages, subalpine fir and mountain hemlock are the dominant tree species. Dense shrub layers are common, reflecting the relatively warm nature of these sites. Grouse whortleberry and blue huckleberry are typically widespread on all sites. Sitka alder and mountain ash are common in late-seral stands, while serviceberry and Scouler willow are common components of mid-seral shrub layers. Ceanothus and pinegrass can develop high coverages on severely burned sites in early seral stages. The pinegrass can persist indefinitely on many of these sites, often dominating the herb layer.

Historical Disturbance: The historical fire regime consisted of sites predominantly influenced by lethal fires ranging from 100 to 500 years. Mixed-severity conditions, while not as common as uniformly lethal conditions, also occurred depending on the site conditions with evidence of non-lethal fire regimes ranging from 30 to 71 years intermixed with the longer lethal regimes. Non-lethal fire conditions can occur under several circumstances on these sites such as mild summers or burning periods, along the edges of lethal burns, and on sheltered or moist locations within severe burns. A mixture of non-lethal and lethal fire patterns can create a mosaic of seral stages at the landscape level. Cyclic bark beetle attacks on dense patches of Douglas-fir, lodgepole pine, and Engelmann spruce can contribute further to this mosaic. Lethal fire conditions often were characterized by even-aged lodgepole pine with a scattered relic overstory of western larch or some stands may be mixed with Douglas-fir or subalpine fir. Mixed-severity conditions were characterized by a diversity of structures and species compositions including lodgepole pine, subalpine fir, Engelmann spruce, Douglas-fir, and western larch. Historical patch size ranged from 50 to 300 acres on mixed-severity sites and 5,000 to 100,000 on lethal sites.

While less impacted than the lower elevation sites, fire suppression activities on these sites have resulted in the loss of their mosaic patterns and diverse structures; contributing to more uniform conditions at the landscape level. Unless managed to maintain landscape diversity, these sites will increase their risk of extensive, stand-destroying fire and bark beetle epidemics, providing less opportunities for a diversity of conditions at the landscape level.

Cool, Moist Subalpine Fir/Mountain Hemlock
(Cool, Moist ABLA/TSME)

Distribution: This group of habitat types ranges in elevation from about 5,000 to 6,500 feet but may follow cold air drainages as low as 3,300 feet. These sites are typically found on mid- to upper slopes but may also be found within alluvial fans and stream floodplains. Soils are variable and range from loess overlaying glacial tills and lacustrine sediments, to alluvial and outwash deposits on terraces. The Cool, Moist Subalpine Fir/Mountain Hemlock habitat type class makes up approximately 9.3% of the forested acres in the planning area.

Potential Dominant Species: Various mixtures of lodgepole pine, western larch, Douglas-fir, and Engelmann spruce comprise the seral tree layers. Any one of these tree species may be dominant, depending on frequency of fire disturbance and local site conditions. All-aged stands of Engelmann spruce, western white pine, and subalpine fir were more common in protected mature stands. Seral shrub layers may be tall and dense, consisting largely of Sitka alder. Lesser amounts of mountain maple, mountain ash, and serviceberry may be present. In late seral stages, menziesia dominates some sites, but usually lower-growing shrubs, such as blue huckleberry and Utah honeysuckle are more common.

Historical Disturbance: Historically, these sites experienced both lethal and mixed-severity fire regimes. Mixed-severity fire regimes were less prevalent than lethal. Estimates of fire frequency range from 38 to 120 years on mixed-severity sites and 120 to 300 years on lethal sites. Generally, ignitions occurred on adjacent drier sites, and the fire was wind-driven onto these sites. Fire patterns could be small and patchy (100 acres or less) on mixed-severity sites or uniform and extensive (5,000 to 100,000 acres) on lethal sites, depending on the burning conditions. Sites influenced by predominantly mixed severity fires resulted in large gaps in the canopy and a mosaic of structures within the stand. The presence of western larch in the canopy is a good indicator of mixed-severity fires on these sites. Lethal fires create a mosaic of even-aged single or two storied structures that may be characterized by the presence of both early seral and late seral species, and in some instances dense stands of lodgepole pine.

Cold Subalpine Fir/Whitebark Pine
(Cold ABLA/PIAL)

Distribution: This group of habitat types is common at mid to upper elevations of the subalpine fir zone. They represent cold, dry subalpine sites and range upwards to 7,800 feet in elevation but are also common down to about 4,500 feet in cold frost-pocket areas. At the lower elevations, these sites usually occur in the dry gentle terrain formed by glacial outwash in broad valleys. Soils are derived mainly from granitics but also include a broad array of other parent materials. The Cold Subalpine Fir/Whitebark Pine habitat type class makes up approximately 3.0% of the forested acres in the planning area

Potential Dominant Species: At the upper elevations of this group, whitebark pine may be present in minor amounts, however in recent years its distribution has decreased as a result of mountain pine beetle and whitepine blister rust. In the moister areas, minor amounts of Engelmann spruce are common. At the cold, dry extremes, which are transitional to non-forested systems, lodgepole pine is the only tree present and is considered to be the climax species. Elsewhere, subalpine fir usually appears in varying amounts as the climax indicator species. Alpine larch occurs on rockslides and talus. Mountain hemlock habitat types are similar to subalpine fir types except for the addition of mountain hemlock as a major climax component. Douglas-fir, western larch, and western white pine rarely occur on these ecological sites. Shrub layers are usually sparse and consist mainly of low-growing huckleberries, such as dwarf huckleberry and whortleberry. The sparse low shrub layer reflects the cool temperatures and short growing seasons inherent to these sites.

Historical Disturbance: Stand conditions were predominantly influenced by mixed-severity and lethal fire regimes as well as mountain pine beetle attacks. Mountain pine beetle attacks often contributed conditions favorable to a lethal fire event. Mixed-severity fire intervals ranged from 35 to 300+ years, while lethal fire regimes occurred about every 200+ years. The result of the mixed-severity and lethal fire regimes contributed a mosaic of forest structures ranging from relatively open stands with clustered and shrub-like trees to uneven- and even-aged conditions. Historical patch sizes ranged from 200 to 30,000 acres with an average patch size of 2,400 acres. Fires crept through these stands wherever fine fuels would carry a flame and then flared up wherever fuel concentrated on the denser patches of larger trees, usually those greater than eight inches in diameter. When these trees were killed, the beetle population often subsided until another group of trees grew into the vulnerable size class (Amman 1977). Beetle events also occurred exclusive of fire events. An outbreak would result in dead trees that soon fell and provided an opening for more regeneration. In this manner, a mosaic of tree sizes and densities were maintained, which helped reduce stand uniformity and the widespread destruction from lethal fires and bark beetle epidemics.

Moderate, Wet Western Red Cedar
(Mod., Wet THPL)

Distribution: This group of habitat types occurs throughout the lower elevations, mostly between 1,500 and 4,900 feet in elevation. These sites are normally found in bottoms having a seasonally high water table and cold air drainage. Landforms tend to be lower benches, valley bottoms, toe slopes, and lower stream terraces. These sites are relatively small and narrow due to the nature of these landforms and are often classified as riparian zones. Soils are typically quartzite and alluvial mixtures. Soil textures are fairly coarse and often high in gravel content and permeability. Soil moisture is generally greater during summer months due to high water tables. The Moderate, Wet Western Red Cedar habitat type class makes up approximately 2.6% of the forested acres in the planning area.

Potential Dominant Species: Western red cedar and western hemlock are the major seral and late successional tree species on these highly productive sites. Engelmann spruce occurs occasionally as a seral species on colder, higher elevation sites, whereas grand fir occurs occasionally as a seral species on warmer, low elevation sites. Microsites exhibiting better drainage may occasionally support western white pine. Dense shrubs are common on these productive sites and ferns are conspicuous in the understory.

Historical Disturbance: The Moderate, Wet Western Red Cedar habitat type class is commonly characterized by large trees and lush undergrowth in a late successional condition. During moist and moderate years, the likelihood of extensive wildfires is uncommon on these sites due to the low flammability of surface fuels and duff. These sites may even serve as fire breaks for adjacent habitat type classes under average or above average precipitation conditions. Most forests on these sites persist for many centuries without severe fire. However, during severe drought years, the likelihood of lethal fire is especially great in the narrow stringers that characterize this habitat type class. Under drought conditions, these sites may even support isolated pockets of mixed-severity wildfire. Most researchers have estimated an average fire return interval of >200 years for lethal fire conditions on these sites. For the less common mixed severity fire condition, fire return intervals are estimated between 24 to 200 years.

Cool, Wet Subalpine Fir/Mountain Hemlock
(Cool, Wet ABLA/TSME)

Distribution: This group of habitat types occurs at mid- to high elevations, mostly between 3,300 and 7,100 feet in elevation, depending on the lower penetration of the cool air drainage. Landforms are typically characterized by subirrigated alluvial stream terraces, toe-slopes with seeps, or valley bottoms of compacted till. These sites are frequently relatively small and narrow due to the nature of these landforms and are often classified as riparian zones. Soils are typically characterized by parent materials of alluvium and may have a restrictive clay plan layer. In all cases, these sites are characterized by the presence of a seasonally high water table. The Cool, Wet Subalpine Fir/Mountain Hemlock habitat type class makes up approximately 0.4% of the forested acres in the planning area.

Potential Dominant Species: The saturated soils and cool microclimate of these sites limit the establishment of tree species. Subalpine fir and Mountain hemlock are the primary late successional species. Lodgepole pine and Engelmann spruce are the primary seral species with spruce also frequently persisting as a late successional component as well. Western larch and Douglas-fir can occur on better drained sites.

Historical Disturbance: Information on the role of wildfire within the Cool, Wet Subalpine Fir/Mountain Hemlock habitat type classes is sparse. Barrett (2002, unpublished data) conducted fire scar sampling on several of these sites in northern Idaho and found that 100% of the samples indicated a lethal fire regime and a mean fire return interval of >180 years. These sites are expected to be difficult to burn except during extremely dry conditions, however, during severe drought conditions, the narrow width of these sites may make them more vulnerable to fires that move in from adjacent slopes.

Other Habitat Types or Landscape Features

In addition to the primarily forested habitat types of the northern Idaho planning region, additional riparian and wetland habitat types occur that may be characterized by coniferous and deciduous forests or woodlands, as well as shrub and emergent cover types. These habitat types represent approximately 2.0% of the planning area but are likely underestimated relative to historical conditions due to land use practices that may have altered surface water drainage and storage patterns as well as reduced beaver populations and beaver pond acreage within the landscape.

Mapping Ecological Sites

The ability to map ecological sites in a geographic information system (GIS) is critical to the assessment and quantification of ecosystem diversity within the planning landscape. Ecological sites are considered a permanent feature of a landscape as they are based on site potential which does not change outside of a primary successional event where new substrate is deposited, so once ecological sites are mapped, these locations are considered fixed in the landscape. Climate change is not expected to change most site characteristics so that site differences would still be present, but it may, over time, influence the expected plant communities and disturbance regimes associated with an ecological site.

An existing map of ecological sites was not available for the entire planning area. To address this need, a GIS model was developed to predict ecological site locations from existing digitally mapped information. The ecological site/habitat type class predictive model incorporated multiple levels of information to help classify the planning area for the 9 forested habitat type classes identified for this landscape. This information included:

- Development of a wetness grid for the landscape using 30m DEM's. Essentially this grid identifies how surface water will flow and pool across the landscape (from the DEM's) and results in a grid of data points ranging from very dry to very wet sites.
- A GIS layer of elevation breaks was developed from the 30m DEM's. The classification resulted in a layer of 10 elevation breaks for the planning area.
- A GIS layer of aspect breaks was developed from the 30m DEM's. The classification resulted in a layer of 5 aspect breaks (N, E, S, W, Flat) for the planning area.
- These three GIS layers were combined to form the final layer for classification of habitat type classes.
- The Idaho Department of Lands Priest Lake habitat type layer was then used to help "train" the model for identification of habitat type classes.
- National Wetland Inventory (USFWS) GIS layers and SSURGO soil layers (USGS) were overlayed with the ecological site layer to help identify wetland and riparian ecological sites.
- US Forest Service VMAP polygons for rock and sparse vegetation were overlayed with the ecological site layer to better refine the habitat type class model results.

While the results of the habitat type model have not been quantitatively evaluated, we were encouraged by ability of the GIS map to explain the Priest Lake habitat type layer. The wetness grid in particular showed particular overlap with the habitat type layer's polygons even without the inclusion of elevation and aspect. We attempted to obtain additional habitat type data for the planning area to 'test' the results but were unable to locate a source with reasonable confidence in their data.

There are known limitations with the habitat type class GIS layer that includes the following:

- The wetness model was unable to calculate the required topology in some instances due to incomplete coverage beyond the DEM's border. This was primarily a problem along the Canadian border.
- The use of elevation breaks was reasonably effective for differentiating transitional zones for habitat type classes. However, in some areas it was clear that additional factors were influencing these transitional zones by several hundred feet or more.
- We were unable to test the results of the habitat type model beyond the Priest Lake habitat type layer due to lack of additional habitat type data.

The ecological site layer resulting from the GIS modeling effort is presented in Figure 3. As stated previously, because ecological sites are considered a permanent feature of the landscape, it is reasonable to assume that the ecological sites mapped today are the same as those present before European settlement. With the development of the mapped ecological site layer, the number of acres representing each habitat type class in the landscape was quantified. The number of acres representing each ecological site (habitat type class) identified for the entire planning landscape and by primary landowner, is presented in Table 1.

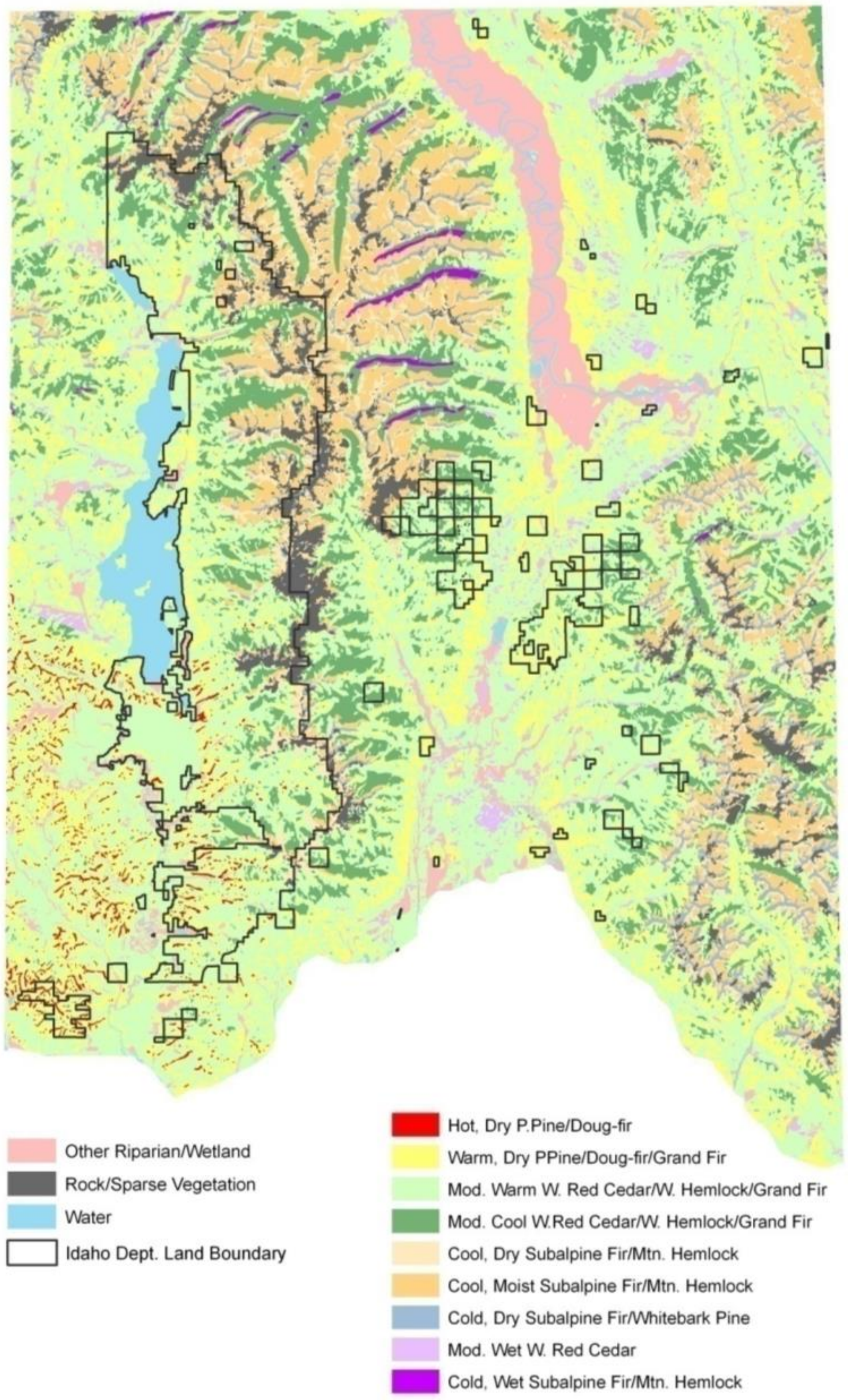

Figure 3. Habitat type classes and other land features identified and mapped for the northern Idaho planning region.

Table 1. Approximate number of acres by primary landowner group for each forested habitat type class (HTC) (yellow), riparian forested habitat type class (purple), and other land cover types (other riparian, water, and rock/sparsely vegetated) of the northern Idaho planning landscape. The total number of acres in each habitat type class or landcover type represents the estimated historical acres for each ecological site.

	HOT, DRY PIPO/PSME	WARM PIPO/ PSME/ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/PIAL	MOD, WET THPL	COOL, WET ABLA/TSME	OTHER RIPARIAN	WATER	ROCK/ SPARSE VEG	TOTAL
IDAHO DEPARTMENT OF LANDS													
acres	3117	35,773	110,863	35,553	12,121	19,986	4,568	442	38	3,467	704	16,101	242,733
% HTC*	29.6%	15.3%	16.2%	18.5%	17.1%	13.9%	9.7%	1.7%	0.6%	11.2%	1.9%	25.6%	14.0%
U.S. FOREST SERVICE													
acres	5567	111,817	284,600	119,333	49,075	108,103	36,364	6,417	5,549	5,484	1,691	32,254	766,254
% HTC	52.9%	47.8%	41.5%	62.2%	69.0%	75.4%	77.4%	24.2%	88.9%	17.8%	4.6%	51.4%	52.0%
PRIVATE													
acres	1,842	86,357	290,229	36,992	9,877	15,257	6,024	19,606	658	21,889	34,507	14,428	537,666
% HTC	17.5%	36.9%	42.3%	19.3%	13.9%	10.6%	12.8%	74.1%	10.5%	71.0%	93.5%	23.0%	34.0%
TOTAL ACRES	**10,526**	**233,947**	**685,692**	**191,878**	**71,073**	**143,346**	**46,956**	**26,465**	**6,245**	**30,840**	**36,902**	**62,783**	**1,546,653**
% All Acres	**0.7%**	**15.1%**	**44.3%**	**12.4%**	**4.6%**	**9.3%**	**3.0%**	**2.6%**	**0.4%**	**2.0%**	**2.4%**	**4.1%**	

PIPO = Ponderosa pine
PSME = Douglas-fir
ABGR = Grand fir
THPL – Western red cedar
TSHE = Western hemlock
ABLA = Subalpine fir
TSME = Mountain hemlock
PIAL = Whitebark pine

Disturbance States/Structural Stages

While ecological sites (habitat type classes) help describe the gradient of environmental differences affecting vegetation, they do not provide a classification of disturbance states or structural stages occurring on these sites (Steele and Geier-Hayes 1992). Historical disturbance states/structural stages are the result of the influence of natural disturbance on species compositions and stand structures. The distribution of native wildlife species across a landscape is influenced by a number of variables but vegetation structure is often considered a primary indicator of habitat quality and suitability for many species. Understanding the landscape in terms of these disturbance states is important for the maintenance of ecosystem function as well as meeting overall biodiversity objectives.

To describe the disturbance states based on the historical fire regimes for the northern Idaho landscape, 9 vegetation structural stages were identified. As discussed previously, two disturbance pathways within each ecological site are identified for a non-lethal fire regime and a mixed severity/lethal fire regime. The mixed severity fire regime was combined with the lethal fire regime, as it usually exhibits more horizontal and structural diversity more closely resembling the lethal fire regime. Each of the 9 structural stages was further differentiated on the basis of the dominant tree structure in a stand. Figure 4 presents these 9 structural stages and their tree characteristics, expressed as a range of diameter at breast height (DBH). An additional tenth stage is identified as "very old conditions" and includes those stands exhibiting old structure (>300 years since last disturbance) and relatively undisturbed conditions, as frequently characterized by additional stand features such as snags, down wood, etc. However, information on classifying these "very old conditions" were not available for this effort but future stand inventories should strive to obtain the appropriate stand information to allow classification to this structural stage in the future.

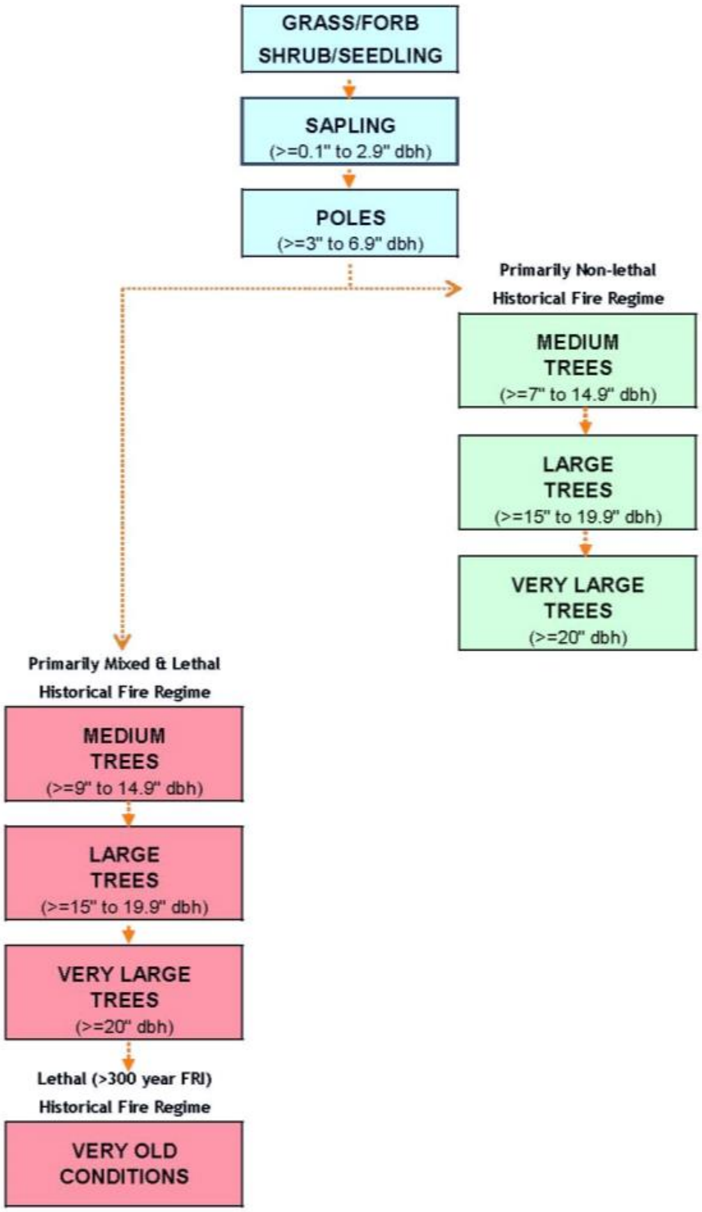

Figure 4. The disturbance states or vegetation structural stages, expressed as a range of diameters at breast height (dbh), developed for the northern Idaho landscape.

There are currently many different vegetation classification systems to describe successional or structural stages in use by federal agencies, state agencies, and corporate landowners. As one might expect there is considerable variation in both the definition of a stage and the rules used to classify stands according to a stage. For the most part, existing classification systems were developed to describe and assist with management of the timber resource. Consequently, they do not describe forest structure with an emphasis on ecologically significant variables that reflect historical stand conditions or their importance to or potential use by wildlife. To support the objectives of the coarse filter, two primary guidelines were used in the development of a classification system to describe a disturbance state/structural stage:

1. Place more emphasis on the important features of a stand relative to historical conditions and disturbance regimes, as well as biodiversity drivers such as tallest trees in the stand, and less emphasis on sheer numbers of trees or dominant basal area by stage.
2. Discern meaningful forest structure from actual stand inventoried data, where available.

Consequently, the breaks to define these structural stages were developed with the objective of identifying forest structures influencing the distribution of biological diversity within the landscape. These stages were defined using our best approximation of structural conditions that may influence use and habitat preference by wildlife. As additional information becomes available to improve this understanding, the structural stages may be adjusted accordingly.

Ecosystem Diversity Matrix

While the diversity of ecosystems occurring across each ecological site can be described individually, a tool for displaying all of the native ecosystem diversity in a landscape has been developed and is referred to as the ecosystem diversity matrix (EDM) (Haufler et al. 1996, 2000, 2002). For the purposes of the conservation strategy, the EDM represents the coarse filter. For terrestrial ecosystems, the columns of the EDM identify the terrestrial ecological sites occurring in the planning region that exhibit the physical differences in soils, moisture, etc., that in turn influence the potential for a plant community to occur on that site (Figure 5). The rows of the EDM represent the disturbance states/structural stages as they relate to vegetation communities that can occur on an ecological site due to the influences of historical (both natural and as influenced by American Indians) disturbance regimes. The intersection of ecological sites (i.e., column) with the disturbance state (i.e., rows) can be described by the resulting vegetation community (i.e., cell) that characterizes that particular condition, and is considered a potentially occurring native ecosystem.

Each of the vegetation communities within a column correspond to the disturbance states discussed previously. All of the vegetation communities within the entire EDM represent the range of conditions or native ecosystem diversity that can occur in the planning area for terrestrial ecosystems. The amount of each vegetation community can vary over time and this variation is often referred to as the historical range of variability, as discussed in a previous section. The EDM framework is a particularly useful tool for quantifying, assessing, and displaying the cumulative impacts or changes in a landscape relative to historical or native ecosystem diversity.

Figure 6 represents the fully developed EDM or the coarse filter for native ecosystem diversity of the northern Idaho planning region.

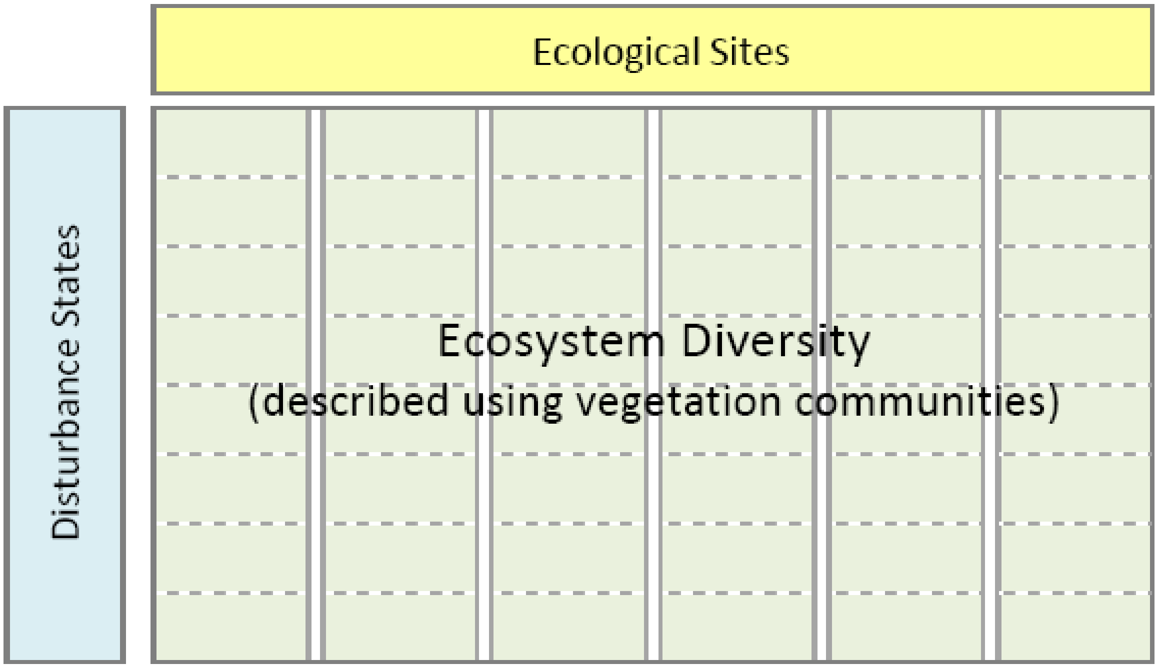

Figure 5. The ecosystem diversity framework that represents the conservation planning tool called the "ecosystem diversity matrix".

Modeling the Historical Reference

The development of a coarse filter based on the historical reference, provides the framework to quantify the historical range of variability (HRV) for each ecosystem diversity class. Estimating historical amounts relative to the disturbance categories of the EDM requires an understanding of plant community responses within each ecological site to historical disturbance regimes. In many landscapes of the Intermountain Region, dendrochronology studies have helped forest ecologists understand and reconstruct the influence of historical fire on vegetation structure and species composition relative to different ecological sites. This information can then be used to evaluate and check the results of landscape models to ensure that the best available information and science is applied to reconstruct plant community response to historical disturbance processes.

Historical range of variability was modeled for terrestrial ecosystems in the northern Idaho planning region using the spatially explicit landscape model SIMPPLLE (SIMulating Patterns and Processes at Landscape scales)(Chew et al. 2004). Although SIMPPLLE has a variety of potential applications, SIMPPLLE was specifically used to derive the historical range of variability (HRV) for each terrestrial ecosystem. SIMPPLLE is a spatially explicit vegetation dynamics management tool that provides the user with the ability to simulate vegetative changes across a defined landscape as influenced by disturbance events. It identifies a range of conditions for forest ecosystems that can result from the interaction between landscape elements, climate, and disturbance processes. SIMPPLLE tracks the location of each ecological site and uses stochastic probabilities to assign disturbance events and weather patterns and then further tracks the response by key plant species and vegetation structural stage. The parameters for disturbance and plant species response included in the model are based on

Figure 6. The ecosystem diversity framework (a.k.a. Ecosystem Diversity Matrix) or coarse filter for the northern Idaho planning landscape.

ECOSYSTEM DIVERSITY MATRIX - NORTHERN IDAHO REGION

HABITAT TYPE CLASSES

	Upland Forested Systems														Riparian Forested Systems			
Disturbance States/Structural	**Hot, Dry Ponderosa Pine/ Xeric Douglas-fir**		**Warm, Dry P. Pine/ Douglas-fir/Grand Fir**		**Mod. Warm W. Red Cedar/ W. Hemlock/Grand Fir**		**Mod. Cool W. Red Cedar/ W. Hemlock/Grand Fir**		**Cool, Dry Subalpine Fir/ Mountain Hemlock**		**Cool, Moist Subalpine Fir/ Mountain Hemlock**		**Cold Subalpine Fir/ Whitebark Pine**		**Moderate, Wet Western Redcedar**		**Cool, Wet Subalpine Fir/ Mountain Hemlock**	
	Potential Dominant Spp.	Acres	Potential Dominant Spp.	Acres	Potential Dominant Spp.	Acres	Potential Dominant Spp.	Acres	Potential Dominant Spp.	Acres	Potential Dominant Spp.	Acres	Potential Dominant Spp.	Acres	Potential Dominant Spp.	Acres	Potential Dominant Spp.	Acres
GRASS/ FORB/ SHRUB/ SEEDLING	*Ponderosa pine*		*Ponderosa pine Lodgepole pine*		*Douglas-fir Western White Pine Western Larch Lodgepole pine*		*Douglas-fir Western White Pine Western Larch Lodgepole pine*		*Douglas-fir Subalpine fir Lodgepole pine*		*Douglas-fir Subalpine fir Lodgepole pine*		*Whitebark pine Lodgepole pine*		*Engelmann spruce Subalpine fir Western red cedar Western hemlock*		*Lodgepole Pine Engelmann spruce Subalpine fir*	
SAPLING (>=0.1 to 2.9 dbh)	*Ponderosa pine Douglas-fir*		*Ponderosa pine Western larch Lodgepole pine*		*Douglas-fir Ponderosa pine Western larch Western white pine Lodgepole pine*		*Douglas-fir Western larch Lodgepole pine Western white pine*		*Douglas-fir Lodgepole pine Engelmann spruce Subalpine fir Trembling aspen*		*Lodgepole pine Engelmann spruce Western larch Subalpine fir Douglas fir*		*Whitebark pine Lodgepole pine Subalpine fir*		*Western white pine Subalpine fir Western red cedar Engelmann spruce Western hemlock*		*Lodgepole pine Engelmann spruce Subalpine fir*	
POLES (>=3 to 6.9 dbh)	*Ponderosa pine Douglas-fir*		*Ponderosa pine Western larch Lodgepole pine Douglas-fir*		*Douglas-fir Ponderosa pine Western larch Western white pine*		*Douglas-fir Western larch Engelmann spruce Western white pine Lodgepole pine*		*Douglas-fir Lodgepole pine Engelmann spruce Subalpine fir Trembling aspen*		*Lodgepole pine Engelmann spruce Western larch Subalpine fir*		*Whitebark pine Lodgepole pine Subalpine fir*		*Western white pine Subalpine fir Western red cedar Engelmann spruce Western hemlock*		*Lodgepole pine Engelmann spruce Subalpine fir*	
Predominantly Non-lethal Historical Fire Regime	**Non-lethal**		**Non-lethal**		**Non-lethal**		**Non-lethal**		**Non-lethal**		**Non-lethal**		**Non-lethal**		**Non-lethal**		**Non-lethal**	
MEDIUM TREES (>=7 to 14.9 dbh)	*Ponderosa pine*		*Ponderosa pine Western larch*		*Ponderosa pine Western larch Douglas-fir Lodgepole pine*		*Paper birch Western larch Western white pine Lodgepole pine*		*Lodgepole pine Douglas-fir*		*Western larch Lodgepole pine*		*Alpine larch Whitebark pine Lodgepole pine*					
LARGE TREES (>=15 to 19.9 dbh)	*Ponderosa pine*		*Ponderosa pine Western larch*		*Ponderosa pine Western larch Douglas-fir Lodgepole pine*		*Paper birch Western larch Western white pine Lodgepole pine*		*Lodgepole pine Douglas-fir*		*Western larch Lodgepole pine*		*Alpine larch Whitebark pine Lodgepole pine*					
VERY LARGE TREES (>=20 dbh)	*Ponderosa pine*		*Ponderosa pine Western larch*		*Ponderosa pine Western larch Douglas-fir Western white pine*		*Western larch Western white pine*		*Lodgepole pine Douglas-fir*		*Western larch Lodgepole pine*		*Whitebark pine Alpine larch*					
Predominantly Mixed & Lethal Historical Fire Regime	**Mixed Severity**		**Mixed Severity**		**Mixed Severity & Lethal**		**Mixed Severity & Lethal**		**Mixed Severity & Lethal**		**Mixed Severity & Lethal**		**Mixed Severity & Lethal**		**Mixed Severity & Lethal**		**Lethal**	
MEDIUM TREES (>=9 to 14.9 dbh)	*Ponderosa pine Douglas-fir*		*Ponderosa pine Douglas-fir Western larch Lodgepole pine*		*Douglas-fir Western larch Ponderosa pine Western white pine Western hemlock*		*Douglas-fir Western red cedar Lodgepole pine Western white pine Western hemlock*		*Douglas-fir Subalpine fir Lodgepole pine Engelmann spruce*		*Western larch Douglas-fir Western white pine Lodgepole pine*		*Whitebark pine Lodgepole pine Alpine larch*		*Western white pine Western red cedar Grand fir Engelmann spruce Western hemlock*		*Lodgepole pine Engelmann spruce Subalpine fir Mountain hemlock*	
LARGE TREES (>=15 to 19.9 dbh)	*Ponderosa pine Douglas-fir*		*Ponderosa pine Douglas-fir Western larch Grand fir*		*Douglas-fir Western white pine Western larch*		*Douglas-fir Western larch Western red cedar Western white pine Engelmann spruce Western hemlock*		*Douglas-fir Subalpine fir Engelmann spruce*		*Western larch Douglas-fir Western white pine Engelmann spruce*		*Whitebark pine Alpine larch Subalpine fir Engelmann spruce*		*Western white pine Western red cedar Grand fir Engelmann spruce Western hemlock*		*Lodgepole pine Engelmann spruce Subalpine fir Mountain hemlock*	
VERY LARGE TREES (>=20 dbh)	*Ponderosa pine Douglas-fir*		*Ponderosa pine Douglas-fir Western larch Grand fir*		*Grand fir Douglas fir Western white pine Western larch*		*Western hemlock Grand fir Western red cedar Western larch Western white pine Subalpine fir*		*Douglas-fir Subalpine fir Engelmann spruce*		*Western larch Douglas-fir Engelmann spruce Subalpine fir*		*Subalpine fir Engelmann spruce Whitebark pine Alpine larch*		*Western white pine Western red cedar Grand fir Engelmann spruce Western hemlock*		*Subalpine fir Engelmann spruce Mountain hemlock*	
Lethal (>300 year FRI) Historical Fire Regime																		
VERY OLD CONDITIONS	*Ponderosa pine Douglas-fir*		*Douglas-fir Grand fir*		*Grand fir Western red cedar Western hemlock*		*Grand fir Western red cedar Western hemlock Engelmann spruce*		*Subalpine fir Engelmann spruce*		*Subalpine fir Engelmann spruce*		*Subalpine fir Whitebark pine Alpine larch*		*Western red cedar*		*Subalpine fir Mountain hemlock*	
OTHER																		
Total Acres =	**10,526**		**233,947**		**685,692**		**191,878**		**71,073**		**143,346**		**46,956**		**26,465**		**6,245**	
HABITAT TYPES	130. PIPO/AGSP 140. PIPO/FEID 170. PIPO/SYAL 210. PSME/AGSP 220. PSME/FEID		190. PIPO/PHMA 250. PSME/VACA 260. PSME/PHMA 310. PSME/SYAL 320. PSME/CARU 330.PSME/CAGE 340. PSME/SPBE 505. ABGR/SPBE 506. ABGR/PHMA		510. ABGR/XETE 515. ABGR/VAGL 520. ABGR/CLUN 530. THPL/CLUN 570. TSHE/CLUN 590. ABGR/LIBO		516. ABGR/ASCA 529. ABGR/SETR 545. THPL/ASCA 575. TSHE/ASCA 555. THPL/GYDR 565. TSHE/GYDR		640. ABLA/VACA 690 ABLA/XETE 660. ABLA/LIBO 710. TSME/XETE 730. ABLA/VASC 920. PICO/VACA c.t. 940. PICO/VASC c.t. 925. PICO/XETE c.t.		579. TSHE/MEFE 620. ABLA/CLUN 670. ABLA/MEFE 685. TSME/CLUN 680. TSME/MEFE 720. ABLA/VAGL		830. ABLA/LUHI 850. PIAL-ABLA 860. LALY-ABLA 840. TSME/LUHI		540. THPL/ATFI 550. THPL/OPHO 560. THPL/ADPE		610. ABLA/OPHO 630. ABLA/GATR 650. ABLA/CACA 635. ABLA/STAM 675. TSME/STAM	

Fire Return Interval (FRI)**
Non-lethal <= 40 year
Mixed Severity >40 but < 100 year
Lethal = > 100 year

Fire Severity**
Non-lethal = <30% overstory kill
Mixed Severity = >30% but <80% overstory kill
Lethal = > 80% overstory kill

References:

Ecosystem Diversity Matrix concept described in:
1) Haufler, J.B. et al. 2002. Performance measures for ecosystem management and ecological sustainability. The Wildlife Society Technical Review 02-1, 2002.
2) Haufler, J.B. et al. 1996. Using a coarse-filter approach with a species assessment for ecosystem management. Wildl. Soc. Bull. 24(2):200-208.
3) Haufler, J.B. et al. 1994. An ecological framework for planning for forest health. J. Sustainable Forestry. 2(3/4):307-316

Habitat Type Classes derived from:
1) Vegetation response unit characterizations and target landscape prescriptions 1999. Kootenai National Forest, U.S. Dept. of Agric., U.S. Forest Service, Northern Region.
2) Cooper, S.V., K.E. Neiman, and D.W. Roberts. 1991. Forest habitat types of Northern Idaho: A second approximation. USDA For. Serv., GTR-INT-236.

Fire regime information derived from:
1) Smith, J.K. and W.C. Fischer. Fire ecology of the forest habitat types of Northern Idaho. INT-GTR-363. U.S. Dept. of Agric., U.S. Forest Service.
2) Vegetation response unit characterizations and target landscape prescriptions 1999. Kootenai National Forest, U.S. Dept. of Agric., U.S. Forest Service, Northern Region.
3) S. Barrett. 2002. Fire regimes database for U.S. For. Serv. Reg. 1.

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the best available scientific literature, expert opinions, and existing data. For the northern Idaho landscape, SIMPPLLE was used to simulate plant community dynamics as influenced by fire, the primary natural disturbance event, climate, and landscape elements (e.g., ecological site and elevation). HRV was characterized using the average, minimum, and maximum number of acres that each terrestrial ecosystem occupied in simulations. Results of the SIMPPLLE simulation for the northern Idaho planning landscape provide an estimate of the historical range of variability for each ecosystem diversity class identified in the EDM. The following sections provide a brief description of the model parameters and assumptions used in the SIMPPLLE simulations for the planning area.

Model Landscape

The model landscape was created for the northern Idaho planning area in ArcGIS. Each modeled area was delineated into 10 acre pixels and each pixel was identified as a specific vegetation unit based on its habitat type class and by its disturbance state, which was based on its vegetation composition. Landscape features that were static components in each simulated area included habitat type class, aquatic areas, and riparian areas. The starting point was developed for the planning landscape using general vegetation descriptions extrapolated to ecological sites based on studies of historical stand conditions.

Plant Dynamics

On a decade-by-decade basis, the response of key plant species to climate (i.e., precipitation and temperature) and disturbance (i.e., fire) were followed and subsequently was given an ecosystem classification within each habitat type class. We performed 500 year simulations in each area and summarized the historical range of variability for each ecosystem in the landscape. Supporting information relative to plant species response to climate and disturbance was based on expert opinion and scientific literature.

Fire

The probability of fire occurring in the simulated areas and the resulting acres of non-lethal, mixed severity, and lethal regimes was validated using dendrochronology/fire regime data for the region (S. Barrett 2002, unpublished data). However, it should be noted that the ability to differentiate between the mixed severity regime and the lethal fire regime within habitat type classes where both occur, is not possible at this time using the SIMPPLLE model results. The probability of fire occurrence is also influenced by climate and a known limitation of the model is the inability to vary climate on an annual basis. Climate information is provided on a decade-by-decade basis and may result in less variable fire extremes over the long-term. Fire spread probabilities were also influenced by adjacent stand conditions and fixed landscape features, such as aquatic/riparian areas that may provide natural fire breaks within the landscape.

Simulations

Three simulations, each representing 500 years, were performed in SIMPPLLE for the planning area. In each of the simulations, the weather patterns were varied but within the range of weather patterns recorded for the region. Fire starts were also stochastically selected, resulting in variations designed to simulate historical variations over time. Following the simulations, the data were combined and results were summarized (Table 2) using the Ecosystem Diversity Matrix framework described previously. Due to the complexity of mapping all of the reference conditions (habitat type class x disturbance state) characterized in the EDM, Figure 7 represents a map of the SIMPPLLE modeling results using mean HRV for disturbance states/structural stages only.

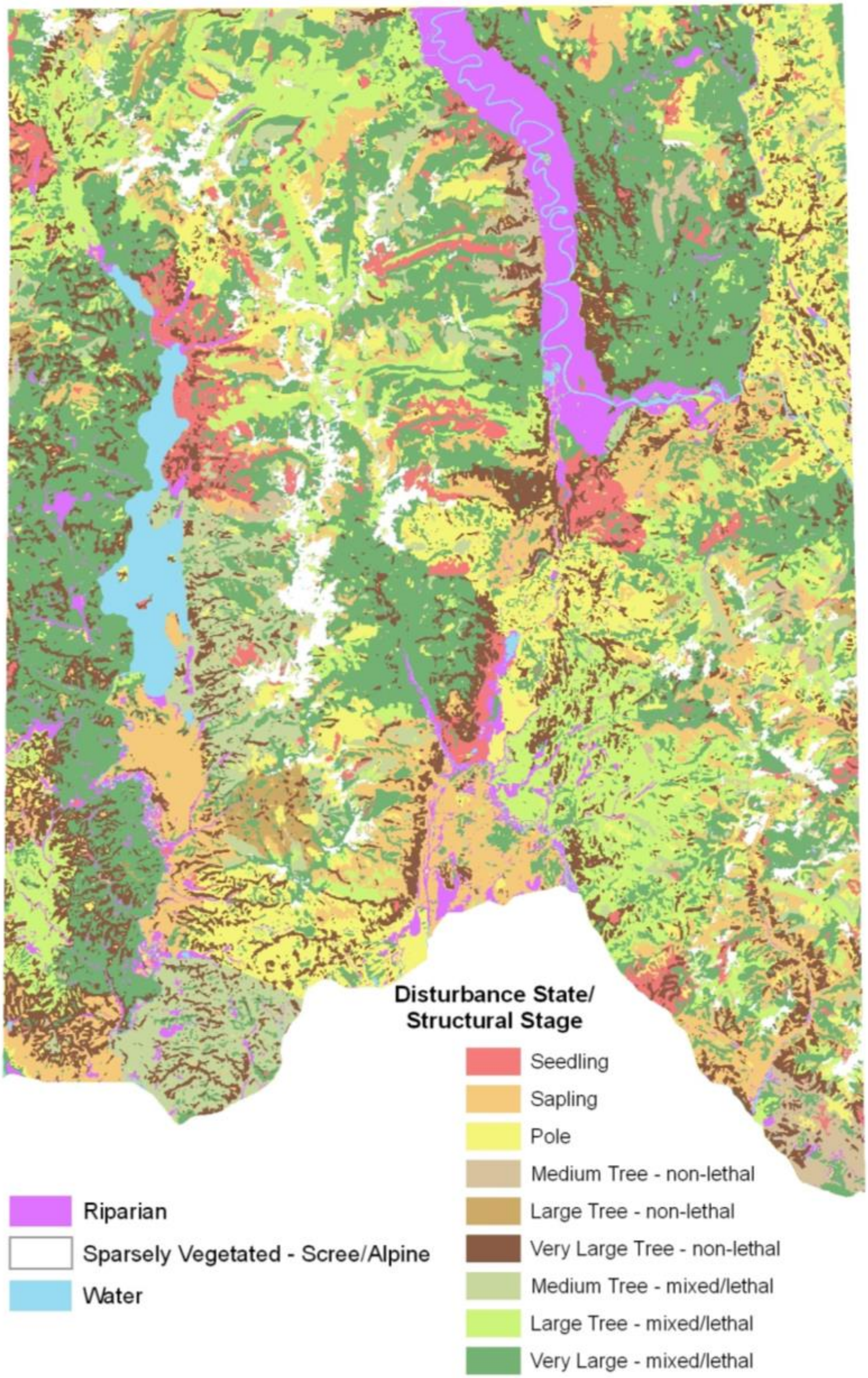


Figure 7. The mapped results of the SIMPPLLE modeling effort for mean historical range of variability using Disturbance State/Structural Stage, in the northern Idaho planning region.

Table 2. The results of the SIMPPLLE modeling effort to quantify the Historical Range of Variability (expressed as the mean and the minimum and maximum values) for the northern Idaho planning region, using the Ecosystem Diversity Matrix framework. See figure 4 for a description of the disturbance state/structural stage(s). (NL = non-lethal fire regime and L = mixed-severity/lethal fire regime)

Disturbance State/ Successional Stage		HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	**mean**	0.02	0.2	6.5	4.3	4.1	4.1	5.2	1.2	0.8
	min-max	(0 - 0.1)	(0 - 0.5)	(4.7 - 7.8)	(3.5 - 5.8)	(3.3 - 5.6)	(3.3 - 5.1)	(3.4 - 7.4)	(0.9 - 1.9)	(0.5 - 1.7)
SAPLING	**mean**	0.05	0.3	17.6	12.3	11.5	12.0	15.0	3.6	2.5
	min-max	(0 - 0.1)	(0 - 0.6)	(15.9 - 19.9)	(9.4 - 15.6)	(6.3 - 16.1)	(9.6 - 15.8)	(10.4 - 21.1)	(2.7 - 5.5)	(1.1 - 4.5)
POLE	**mean**	0.05	0.7	17.0	11..8	10.8	11.5	14.2	3.5	2.4
	min-max	(0 - 0.1)	(0 - 1.5)	(14.0 - 19.0)	(9.0 - 15.4)	(5.6 - 15.6)	(9.0 - 15.2)	(8.5 - 20.7)	(2.6 - 5.0)	(1.1 - 4.1)
MEDIUM-NL	**mean**	0.03	0.7	2.9	2.1	2.3	1.6	1.7	0.4	0.2
	min-max	(0 - 0.1)	(0 - 1.5)	(0.4 - 5.5)	(0.5 - 3.9)	(0.1 - 4.5)	(0.3 - 3.5)	(0.2 - 3.3)	(0.1 - 1.4)	(0 - 0.7)
LARGE-NL	**mean**	0.05	0.2	1.6	0.7	1.2	0.5	1.2	0.1	0.0
	min-max	(0 - 0.3)	(0 - 0.7)	(0 - 3.4)	(0 - 1.9)	(0 - 4.6)	(0 - 1.4)	(0 - 6.4)	(0 - 0.3)	(0 - 0.2)
VERY LARGE-NL	**mean**	87.3	69.8	0.5	0.10	0.3	0.0	0.6	0.0	0.0
	min-max	(82.7 - 91.9)	(62.7 - 75.3)	(0 - 1.8)	(0 - 0.7)	(0 - 1.3)	(0 - 0.4)	(0 - 3.6)	(0 - 0)	(0 - 0)
MEDIUM-L	**mean**	0.02	0.4	8.6	11.1	6.9	8.1	13.2	2.6	2.0
	min-max	(0 - 0.1)	(0 - 1.3)	(4.1 - 11.2)	(6.9 - 29.0)	(1.9 - 11.4)	(1.8 - 11.7)	(6.1 - 27.6)	(0.7 - 4.0)	(0.7 - 3.7)
LARGE-L	**mean**	0.03	0.4	15.6	18.9	19.2	21.0	19.9	15.5	14.9
	min-max	(0 - 0.1)	(0 - 1.6)	(6.9 - 42.6)	(7.4 - 49.3)	(6.9 - 52.4)	(10.2 - 52.4)	(9.1 - 49.3)	(3.3 - 65.4)	(2.2 - 63.2)
VERY LARGE-L	**mean**	12.4	27.2	29.8	38.7	43.7	41.1	29.1	73.1	77.1
	min-max	(1.9 - 17.1)	(5.3 - 33.8)	(14.1 - 35.2)	(1.2 - 51.2)	(19.7 - 57.1)	(17.0 - 51.3)	(1.9 - 45.6)	(25.9 - 85.4)	(25.2 - 92.1)

TODAY'S ECOSYSTEM DIVERSITY

Native ecosystems and habitats have and continue to be directly and indirectly altered by human actions. Although American Indians interacted and influenced ecosystems for thousands of years, these influences are incorporated in an historical reference. It is the extent of human influence over the last 150 years that is of greatest conservation concern to native ecosystem diversity in the northern Idaho planning region. Land conversion to agriculture and urban uses such as towns and roads are the most obvious impacts. However, there are also less obvious, yet in some instances more pervasive, human-induced changes as well. The implications of a century of alterations to and interruptions of natural disturbance regimes in the northern Idaho region have only recently become understood. Recent studies have shown that the suppression, alteration, or cessation of natural disturbance has gradually changed ecosystem processes and ultimately the composition, structure, and function of many ecosystems (Fitzgerald 2005, Keeling et al. 2006, Arno 1980, Arno et al. 1999). Developing a clear understanding of the ecosystem conditions present within the planning area today is a necessary first step toward identifying and quantifying cumulative changes to native terrestrial ecosystem diversity.

Assessing Today's Conditions

As stated previously, the ecosystem diversity matrix is a conservation planning tool that can be used to quantify historical, current, and future ecosystem diversity within a planning area. To quantify today's ecosystem diversity requires two essential layers of mapped information maintained in a geographic information system (GIS): 1) the ecological site layer (habitat type classes), and 2) the disturbance state/structural stage layer. By overlaying the habitat type class layer with the vegetation structural stage layer, the resulting union of the mapped polygons creates the ecosystem diversity layer (Figure 8) identified in the ecosystem diversity matrix framework. The total number of acres of each ecosystem (each cell of the EDM) can then be summed across the landscape. Further, the ecosystem diversity layer can then be overlaid with a GIS layer of land ownership and acres summed by landowner as well. This process is used to quantify ecosystem diversity as it is represented on the landscape today.

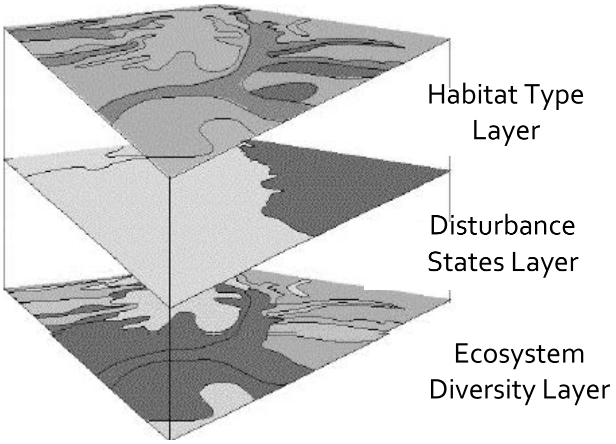


Figure 8. Combining the ecological site GIS layer with the disturbance state GIS layer results in the ecosystem diversity class GIS layer.

As previously discussed, the habitat type class layer was modeled for the landscape and mapped in a GIS. To develop the disturbance state/structural stage GIS layer for current conditions, forest stand inventory data referenced to a GIS layer was used where available. Decision rules were developed to use the forest inventory data to characterize a stand's structure and species composition relative to the disturbance states/structural stages identified for the coarse filter. Where stand inventory data were not available, classified satellite imagery data were used, however, the accuracy of these data is greatly reduced. The specific methods and data sources used in the development of the disturbance state/structural stage layer are presented in Appendix A. Figure 9 represents a map identifying the disturbance states/structural stages occurring on the landscape today, as developed using the best available inventory and classified satellite imagery data as well as the methods described in Appendix A.

Figure 10 and Table 3 identify the decision rules used to determine the disturbance state/structural stage for each inventoried forest stand. Figure 10 describes the decision rules used to identify a stand relative to the 6 stand structures (seedling, sapling, pole, medium, large, and very large). Table 3 identifies the fire pathway (i.e., non-lethal vs. mixed severity/lethal fire regime) best represented by stand conditions. As discussed previously, the non-lethal vs. mixed severity/lethal fire pathways of the ecosystem diversity matrix represent very different forest conditions in terms of species composition and structure. Specifically, the non-lethal fire regime is a fire maintained system that has predictable effects on species composition and tree density. Using information obtained from recent studies on historical stand structures and species composition, as well as historical accounts of stand conditions, a set of decision rules were developed to determine whether each current stand represents the historical fire-maintained conditions. Inventory data were evaluated against these rules to determine the appropriate fire regime. One complicating factor for the mixed-fire regime is that typical stand inventory methods are based on stand averaging for desired stand variables. The patchy and diverse structural nature of mixed-severity stands, are difficult to ascertain using existing inventory methods. For this reason, it is difficult to identify and quantify small patches of mixed-severity influenced stand conditions from the lethal severity stand conditions. The possible implications of this deficiency are discussed in later sections. Those stands that did not meet the non-lethal criteria or the mixed-severity/lethal criteria (e.g., managed stands that left low densities of late-successional species as seed trees) are classified as “other” conditions for purposes of the coarse filter.

The ecosystem diversity class GIS layer resulting from the combination of ecological sites with disturbance states provides a link to the spatial distribution of ecosystems across the landscape. This allows the valuation of many ecosystem functions, including the potential spatial distribution of biodiversity. Characterizing each ecosystem diversity class by appropriate habitat components will also allow an assessment of habitat quantity and quality for any species of concern or management interest. This is also the mechanism by which the coarse filter can be checked using an individual species assessment. This process is described in greater detail in Roloff and Haufler (1997, 2002) and Haufler et al. (1999), and is the focus of the fine filter assessment of this project.

Ecosystem Diversity Class

The results of overlaying existing vegetation structural conditions with the habitat type information allow the quantification of each ecosystem (cell) within the EDM framework (Table 4). In addition, Table 5 summarizes the number of acres for each ecosystem by primary landowner.

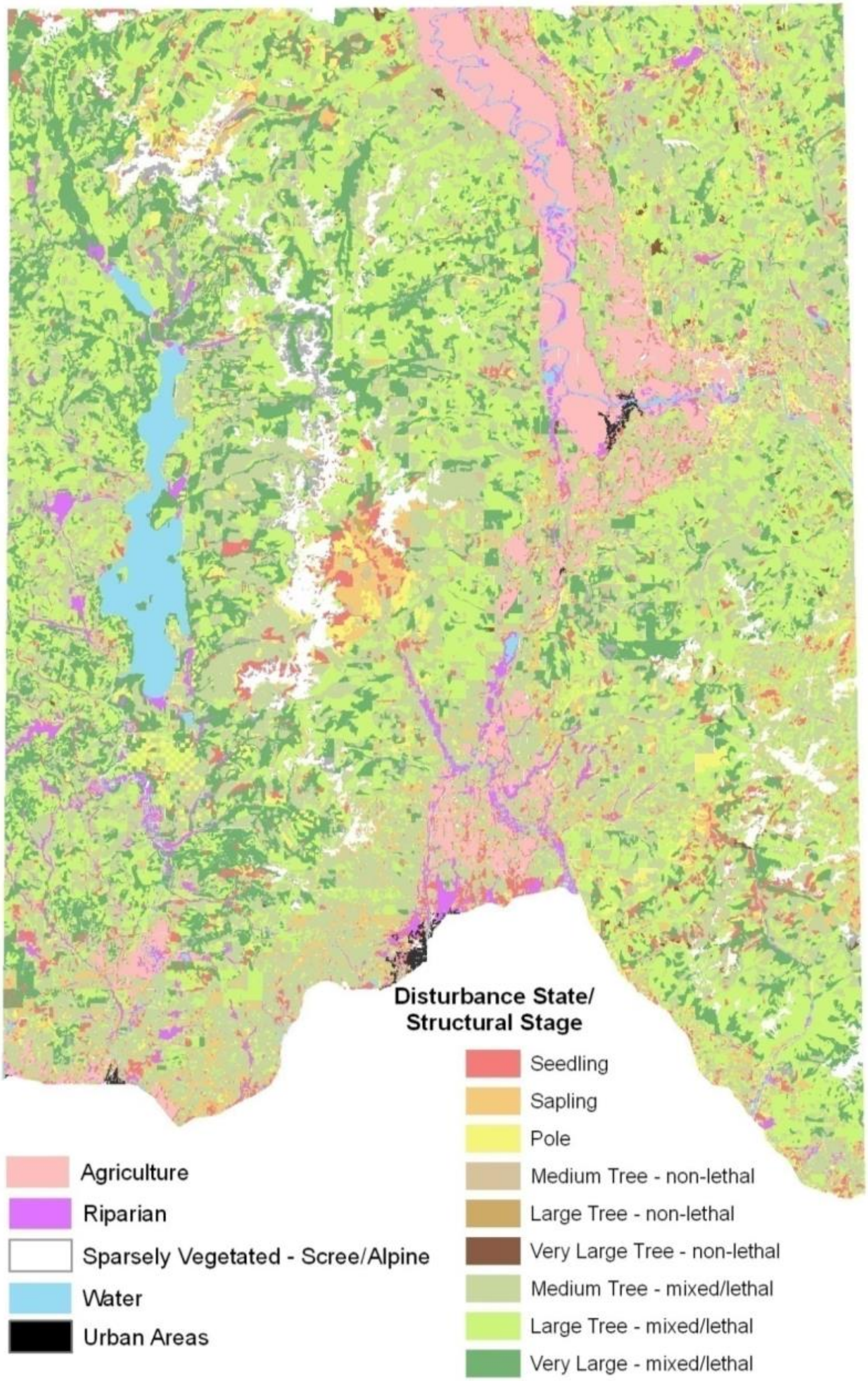


Figure 9. The results of a landscape assessment to determine the disturbance state/structural stage for the northern Idaho planning region, using both inventory data and classified satellite imagery data (see text and Appendix A for description of methods).

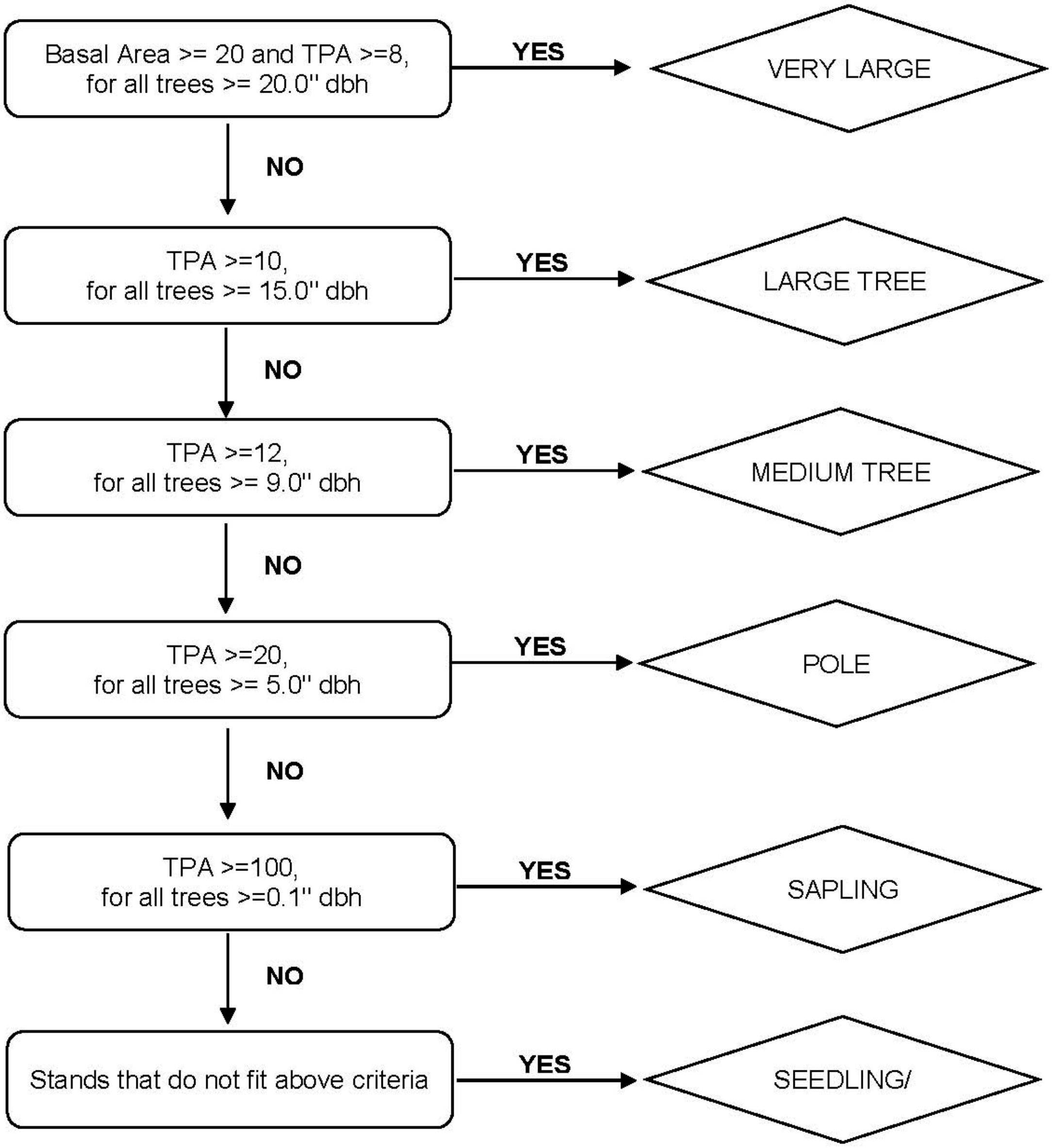


Figure 10. Decision rules for determining disturbance state/structural stage using common stand data variables (dbh = diameter at breast height, TPA = trees per acre). See figure 4 for a description of the disturbance state/structural stage(s) (i.e., Very Large, Large Tree, etc.)

Table 3. Rule set for determining non-lethal and mixed severity/lethal fire regimes for specific habitat type classes of the northern Idaho ecosystem diversity matrix. Non-historical conditions also occur and are termed "Other" conditions; other conditions are usually the result of land use conversion (i.e., urban, agriculture, roads, etc.) or forest harvest practices that result in non-historic stand conditions. Overstory trees per acre (TPA) include trees >=6" dbh.

HABITAT TYPE CLASS	**HISTORICAL FIRE REGIMES**	
	NON-LETHAL	**MIXED SEVERITY/LETHAL**
Hot, Dry P.Pine/Douglas-fir	>=10 and <=30 overstory TPA and species composition dominated by historically dominant seral species	>30 overstory TPA
Warm, Dry P.Pine/Douglas-fir/ Grand Fir	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA
Mod. Warm W. Red Cedar/ W. Hemlock/Grand Fir	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA
Mod. Cool W. Red Cedar/ W. Hemlock/Grand Fir	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA
Cool, Dry Subalpine Fir/ Mountain Hemlock	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA
Cool, Moist Subalpine Fir/ Mountain Hemlock	>=10 and <=60 overstory TPA and species composition dominated by historically dominant seral species	>60 overstory TPA
Cold Subalpine Fir/Whitebark Pine	>=10 and <=50 overstory TPA and species composition dominated by historically dominant seral species	>50 overstory TPA
Mod. Wet W. Red Cedar	>=10 and <=60 overstory TPA and species composition dominated by historically dominant seral species	>60 overstory TPA
Cool, Wet Subalpine Fir/ Mountain Hemlock	>=10 and <=60 overstory TPA and species composition dominated by historically dominant seral species	>60 overstory TPA

Table 4. Summary of the number of acres representing today's ecosystem diversity for all landowners of the northern Idaho planning area. See figure 4 for a description of the disturbance state/structural stage(s). (NL = non-lethal fire regime and L = mixed-severity/lethal fire regime).

Disturbance State/ Successional stage	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	947	11,826	55,938	4,424	2,568	3,718	3,008	4,727	13
SAPLING	447	11,469	35,320	5,322	2,753	4,257	802	1,898	10
POLE	302	7,488	29,599	8,148	2,084	4,280	1,427	783	623
MEDIUM-NL	166	5,371	18,059	2,946	555	1,075	522	968	93
LARGE-NL	29	1,249	2,219	1,048	708	390	219	27	0
VERY LARGE-NL	0	587	770	402	14	388	28	7	0
MEDIUM-L	3,030	69,650	199,746	45,031	16,230	18,343	12,263	8,287	667
LARGE-L	3,001	73,370	179,933	64,411	31,261	62,738	18,469	3,374	1,655
VERY LARGE-L	1,869	29,266	85,845	42,960	7,668	23,106	3,717	1,455	1,980
OTHER CONDITIONS	734	23,651	78,081	17,186	7,233	25,073	6,502	4,936	1,265
TOTAL ALL ACRES	10,526	233,947	685,512	191,878	71,073	143,346	46,956	26,465	6,246

Table 5. Summary of the number of acres representing today's ecosystem diversity by primary landowner.
NL= non-lethal and L= mixed severity/lethal fire regimes; na=not available; "OTHER" Conditions described in text

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
IDAHO DEPARTMENT OF LANDS - IDL STAND DATA									
SEEDLING	291	1886	4333	842	351	484	188	12	11
SAPLING	12	396	1009	133	258	94	26	5	0
POLE	228	970	6410	2088	206	342	48	6	0
MEDIUM-NL	0	207	1203	267	22	147	0	13	0
LARGE-NL	0	0	0	0	0	0	0	0	0
VERY LARGE-NL	0	85	7	0	0	0	0	0	0
MEDIUM-L	743	5158	24626	10771	1256	1506	297	70	9
LARGE-L	635	10798	26217	6533	5591	6108	1567	77	0
VERY LARGE-L	957	9702	32060	10528	1485	3780	455	147	18
OTHER	251	6571	14818	4391	2952	7525	1987	112	0
Total IDL	3,117	35,773	110,683	35,553	12,121	19,986	4,568	442	38
U.S. FOREST SERVICE - TMRS DATA									
SEEDLING	594	4,821	8,994	2,947	1,965	2,749	2,545	53	0
SAPLING	41	1,504	5,814	3,316	1,163	2,774	399	492	0
POLE	31	1,296	9,860	5,039	1,304	3,584	987	113	613
MEDIUM-NL	28	1,588	6,528	2,209	442	776	460	350	92
LARGE-NL	16	950	1,787	1,022	679	357	156	14	0
VERY LARGE-NL	0	502	763	402	14	388	28	7	0
MEDIUM-L	1,227	21,160	61,509	21,556	10,588	11,521	9,333	1,772	494
LARGE-L	2,270	50,520	121,026	44,735	23,393	51,595	15,168	2,241	1,402
VERY LARGE-L	911	17,296	48,004	28,927	5,883	18,614	2,981	1,241	1,804
OTHER	449	12,180	20,315	9,180	3,644	15,745	4,307	134	1,144
Total USFS	5,567	111,817	284,600	119,333	49,075	108,103	36,364	6,417	5,549
OTHER PRIVATE LANDS - VMAP REMOTE SENSING DATA and FOREST CAPITAL PARTNERS STAND DATA									
SEEDLING	62	5,140	42,611	635	252	482	275	4,662	2
SAPLING	394	9,568	28,497	1,873	1,333	1,383	377	1,401	10
POLE	43	5,222	13,329	1,021	574	353	392	665	10
MEDIUM-NL	138	3,576	10,328	470	90	152	62	606	1
LARGE-NL	13	299	433	26	29	33	63	13	0
VERY LARGE-NL	0	0	0	0	0	0	0	0	0
MEDIUM-L	1,060	43,332	113,612	12,704	4,386	5,309	2,633	6,445	164
LARGE-L	96	12,052	32,690	13,143	2,277	5,030	1,734	1,056	253
VERY LARGE-L	2	2268	5781	3505	300	712	281	68	158
OTHER	34	4900	42948	3615	637	1803	208	4690	59
Total VMAP & FCP	1842	86357	290229	36992	9877	15257	6024	19606	658
TOTAL ALL ACRES	**10526**	**233947**	**685512**	**191878**	**71073**	**143346**	**46956**	**26465**	**6245**

CUMULATIVE CHANGES TO NATIVE ECOSYSTEM DIVERSITY

There are two primary types of native ecosystem conversion or alteration that occur within the northern Idaho planning region and contribute to the cumulative changes to native ecosystem diversity observed in the landscape today. These two primary conversions or alterations include: 1) the direct conversion of terrestrial ecosystems to some other land use; and 2) the indirect alteration of terrestrial ecosystems through suppression of natural disturbance processes or alteration of species compositions, structures, or functions resulting from human activities. The primary causative agents for direct conversion of terrestrial ecosystems within the planning area include urban areas, roads, and agriculture. The primary causative agents for indirect alteration of terrestrial ecosystems include timber harvests, efforts to suppress wild fire across the landscape, and the accidental or intentional introduction of non-native species that can have negative impacts on native species and ecosystems.

Conversion of Terrestrial Ecosystems

Overall land conversion that can be documented with remote sensing within forested ecosystems of the northern Idaho planning area is relatively low at 50,544 acres or 3.6% of the total acres. Table 6 identifies a breakdown of the acres converted by habitat type and type of conversion including roads, areas developed for housing, and agriculture.

The Moderate, Warm Western Red Cedar, Western Hemlock, Grand fir habitat type class has received the highest amount of conversion at 6%, with 80% of this conversion occurring as agriculture. The remaining 8 habitat type classes have all received ecosystem conversion at rates less than 2%. The majority of the acres converted within the planning area have resulted from agriculture at 78% of the acres converted, followed distantly by roads at 18%, and housing development at 4% of the total converted acres. Conversion estimates for roads were roughly based on a 4 m wide average surface impact.

Indirect Alteration of Forested Ecosystems

While the direct conversion of ecosystem conditions is relatively low at 3.6%, the number of acres present today that represent native ecosystem conditions is much lower. Currently, lands within the northern Idaho planning area are predominantly used for timber production, recreation, and agriculture. It is important to note that while the EDM framework characterizes native ecosystem diversity relative to the natural disturbance processes of non-lethal and mixed-severity/lethal fire regimes, the conditions present on the landscape today are, for the most part, no longer influenced by the non-lethal fire regime and the extent and distribution of mixed-severity and lethal fires have been reduced. However, to evaluate the cumulative impacts of Euro-American settlement, today's conditions were assessed relative to structural and species compositions that most closely resemble native ecosystem conditions as influenced by natural disturbance processes. Ecosystems present today that are relatively similar in structure and species compositions to those present historically, are assumed for the purposes of this assessment, to provide similar habitat benefits to the wildlife species they historically supported.

Indirect alteration of forested ecosystems in northern Idaho, have resulted from three primary human-influences: 1) the introduction of exotic disease, 2) the suppression of fire in the landscape, and 3) past timber management activities. Historically western white pine was a significant component of the moist, fertile ecological sites of the northern Idaho planning region. It varied in composition from 15 to 80 percent of the forest canopy (Harvey et al. 2008). Over the past century, white pine blister rust, an introduced disease, has had a devastating effect on the occurrence of western white pine throughout its former range in North America. Western white pine composition within northern Idaho forests today is now estimated to be less than 5% of what existed at the turn of the 20th century (Neuenschwander et al. 1999). In addition to white pine blister rust, much of the indirect alteration of forested ecosystems has occurred as a result of the reduction of fire in the landscape which has produced profound effects on ecosystem conditions relative to historical conditions. However, in some instances, timber management objectives have also altered species compositions and structures to no longer resemble historical conditions. This has most commonly occurred as shelterwood cuts where mature late successional species may be left in low densities to re-seed the stand. Table 7 summarizes these acres by structural stage and habitat type class, where data were available to identify these non-historical conditions (i.e., USFS, IDL, and Forest Capital Partners stand inventory data). Acres identified as unknown were not classified by the landowner.

Changes to the northern Idaho landscape resulting from fire suppression activities and past timber management activities that still resemble native ecosystem conditions in terms of species composition and structure, are summarized in Table 8. This table provides an estimate of the percentage of each natural disturbance state/structural stage remaining today compared to the mean historical range of variability. The results presented in Table 8 demonstrate that the percentage of the landscape that is still similar to native ecosystem conditions (i.e., has similar structure and species compositions) has increased or decreased depending on the disturbance state/structural stage. The most concerning change has been to the 'Very large' – non-lethal disturbance state, where historically it comprised 12.6% of the landscape and has been reduced to only 0.2% of the landscape today. The 'Very Large' – mixed-severity/lethal disturbance state/structural stage has been reduced by greater than 50% of its historical amounts. Sapling and pole stages have been reduced to roughly 30% of their historical amounts. Nearly 12% of the landscape no longer exhibits conditions similar to historical conditions (i.e., 'other' conditions).

Table 6. Summary of the number of acres converted to urban and agricultural uses for each forested habitat type class within the northern Idaho planning region.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
CONVERTED ACRES									
Roads	47	1097	5845	1178	118	339	49	221	63
Housing	0	69	1980	0	0	0	0	127	0
Agriculture	142	3083	31890	33	0	0	0	4263	0
TOTAL ACRES	**189**	**4249**	**39715**	**1211**	**118**	**339**	**49**	**4611**	**63**
% of HABITAT TYPE CLASS	**2**	**2**	**6**	**<1**	**<1**	**<1**	**<1**	**2**	**1**

Table 7. Summary of the number of acres by habitat type class that are currently forested but do not represent historical conditions (see text for description of 'other' category).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
FORESTED BUT DOES NOT REPRESENT HISTORICAL CONDITIONS									
Medium Tree	294	9912	24690	10339	2752	7963	2496	234	195
Large Tree	106	2759	5883	2086	855	7813	863	83	380
Very Large Tree	145	4780	7793	3550	965	4872	1063	8	627
UNKNOWN	0	1951	0	0	2543	4086	2031	0	0
TOTAL ALL ACRES	**545**	**19402**	**38366**	**15975**	**7115**	**24734**	**6453**	**325**	**1202**

Table 8. The percentage of each disturbance state/structural stage present today compared to the mean historical range of variability for the northern Idaho planning area.

Disturbance States/ Structural stages	% of Landscape Mean HRV	 Today's Conditions
Seedling	4.6	6.2
Sapling	12.6	4.4
Pole	12.1	3.9
Non-Lethal fire regime		
Medium	2.1	2.1
Large	1.1	0.4
Very Large	12.6	0.2
Mixed-severity/Lethal fire regime		
Medium	7.4	26.4
Large	14.3	30.9
Very Large	33.2	14.0
"Other" conditions	-	11.6

Cumulative Impacts

The ecosystem diversity matrix framework can be used to evaluate cumulative impacts within the landscape. Using the results of the existing conditions assessment and the historical range of variability modeling effort, we can quantify the cumulative impacts on historical ecosystem diversity using different percentages of representation of historical conditions. To illustrate this we arbitrarily selected 3 levels of representation to demonstrate this calculation for the planning region:

1) greater than 30% of the maximum historical range of variability,
2) between 10 and 30% of the maximum historical range of variability, and
3) less than 10% of the maximum historical range of variability.

The methods used in this calculation are demonstrated as follows:

> For each ecosystem diversity class (cell in the EDM), calculate the number of acres representing the maximum HRV value by multiplying the total number of acres for each habitat type class (column of the EDM) by the maximum HRV percent. See the following subset of the EDM as an example of the methodology used in this calculation.

Non-Lethal Fire Regime	Hot, Dry Ponderosa Pine/ Xeric Douglas-fir	Warm, Dry P. Pine/ Douglas-fir/Grand Fir
LARGE TREES (>=15 to 19.9 dbh)	**MIN-MAX (0% to 0.3%)** (0.003 x 10,526) **= 32 acres**	**MIN-MAX (0% to 0.7%)** (0.007 x 233,947) **= 1,638 acres**
VERY LARGE TREES (>=20 dbh)	**MIN-MAX (82.7% to 91.9%)** (0.919 x 10,526) **= 9,673 acres**	**MIN-MAX (62.7% to 75.3%)** (0.753 x 233,947) **= 176,162 acres**
TOTAL ACRES	**10,526**	**233,947**

Multiply the maximum number of HRV acres for each ecosystem diversity class by 30% and also by 10%. We then compare these numbers to the amounts of existing conditions for each ecosystem diversity class. We apply a color coding to the cell to indicate how existing conditions compare to historical ecosystem diversity. A green colored cell indicates that the number of today's acres represents 30% or more of the maximum historical conditions for that ecosystem diversity class. An orange colored cell indicates the number of today's acres represents 10 to 30% of the maximum historical conditions for that ecosystem diversity class. A red colored cell indicates the number of today's acres represents less than 10% of the maximum historical conditions for that ecosystem diversity class. See the following subset of the EDM as an example of this calculation and color coding relative to the amount of representation existing today within the planning area.

	Hot, Dry Ponderosa Pine/ Xeric Douglas-fir	Warm, Dry P. Pine/ Douglas-fir/Grand Fir
LARGE TREES (>=15 to 19.9 dbh)	(30% = 0.3 x 32 ac. = 9.6 ac.) (10% = 0.1 x 32 ac. = 3.2 ac.) **Existing = 29 acres**	(30% = 0.3 x 1,638 ac. = 491 ac.) (10% = 0.1 x 1,638 ac. = 164 ac.) **Existing = 1249 acres**
VERY LARGE TREES (>=20 dbh)	(30% = 0.3 x 9,673 ac. = 2,902 ac.) (10% = 0.1 x 9,673 ac. = 967 ac.) **Existing = 0 Acres**	(30% = 0.3 x 176,162 ac. = 52,849 ac.) (10% = 0.1 x 176,162 ac. = 17,616 ac.) **Existing = 587 acres**
TOTAL ACRES	**10,526**	**233,947**

The results of the cumulative impacts assessment for the entire northern Idaho planning landscape are presented in Table 9. Cumulative impacts can also be assessed relative to existing landownership as well. The cumulative impacts for Idaho Department of Lands and U.S. Forest Service lands are also provided in Table 9.

Table 9. Cumulative impacts of vegetation changes for all landowners within the planning region and for Idaho Department of Lands and U.S. Forest Service ownership, relative to historical conditions. The numbers identify the acres in a disturbance state/structural stage existing on the landscape today. Cells highlighted green indicate present conditions that represent = >30% of conditions that occurred historically, orange represents 10 to 30%, and red represents =<10% of. (*NL= non-lethal fire regime, L = mixed-severity/lethal fire regime)

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
ALL LANDOWNERS									
SEEDLING	930	11722	55759	4386	2568	3703	3008	4727	13
SAPLING	442	11534	35597	5435	2658	4209	800	1897	10
POLE	305	7534	29565	8162	2083	4293	1427	783	623
MEDIUM-NL	166	5369	18005	2917	555	928	522	967	93
LARGE-NL	29	1249	2219	1048	708	390	219	27	0
VERY LARGE-NL	0	587	769	402	14	388	28	7	0
MEDIUM-L	3034	70209	198470	45037	16393	18546	12279	8291	667
LARGE-L	2973	74681	181069	64395	31219	62763	18459	3369	1655
VERY LARGE-L	1978	29026	84325	42969	7669	23100	3717	1460	1980
IDAHO DEPARTMENT OF LANDS									
SEEDLING	274	1762	4155	804	351	469	188	12	11
SAPLING	7	462	1286	246	163	45	24	4	0
POLE	231	1016	6376	2103	206	355	48	6	0
MEDIUM-NL	0	205	1149	238	22	0	0	11	0
LARGE-NL	0	0	0	0	0	0	0	0	0
VERY LARGE-NL	0	85	6	0	0	0	0	0	0
MEDIUM-L	747	5124	23943	10777	1419	1709	314	74	9
LARGE-L	607	11127	28335	6517	5550	6133	1557	72	0
VERY LARGE-L	1066	9462	30540	10538	1486	3775	455	151	18
U.S. FOREST SERVICE									
SEEDLING	594	4,821	8,994	2,947	1,965	2,749	2,545	53	0
SAPLING	41	1,504	5,814	3,316	1,163	2,774	399	492	0
POLE	31	1,296	9,860	5,039	1,304	3,584	987	113	613
MEDIUM-NL	28	1,588	6,528	2,209	442	776	460	350	92
LARGE-NL	16	950	1,787	1,022	679	357	156	14	0
VERY LARGE-NL	0	502	763	402	14	388	28	7	0
MEDIUM-L	1,227	21,160	61,509	21,556	10,588	11,521	9,333	1,772	494
LARGE-L	2,270	50,520	121,026	44,735	23,393	51,595	15,168	2,241	1,402
VERY LARGE-L	911	17,296	48,004	28,927	5,883	18,614	2,981	1,241	1,804

REPRESENTATION OF NATIVE ECOSYSTEM DIVERSITY

Using an appropriate classification system and accompanying analyses, the coarse filter strategy should function to identify appropriate objectives for conserving ecosystem diversity within the northern Idaho planning landscape. However, the ecosystem representation that is sufficient to meet these objectives still remains a question. It is important to understand that the objectives for using a coarse-filter strategy based on the historical range of variability are not to return all of the northern Idaho planning landscape to an "historical" condition. This strategy focuses on providing sufficient amounts of functionally similar ecosystems represented across the landscape in order to maintain and benefit native species in northern Idaho. Providing an adequate level of representation under an historical range of variability-based approach requires an estimate of the threshold level to "represent" each ecological community that occurred under historical disturbance regimes. This threshold level identifies the minimum amount of all ecological communities needed to maintain biological diversity and ecosystem integrity within an acceptable level of risk. Scientific analysis can define and quantify the degree of risk associated with various levels of ecological representation so that appropriate policies and plans can be developed.

Quantifying risk has many complexities that must be factored into its determination. The first and primary complexity is the recognition that our understanding of many ecological relationships still remains relatively poor and therefore problematic. These uncertainties require that the question of adequacy, that is "how much is enough," revolve around a discussion of the acceptable level of risk to ecosystem diversity and species persistence. Science based approaches strive to gather knowledge that eliminate these uncertainties. Although, the true answer will never be completely known, a science-based approach can place probabilities of risk on possible outcomes of alternatives.

Habitat loss is acknowledged as one of the greatest threats to biological diversity at the species level (Ehrlich and Ehrlich 1981, Noss et al. 1995). Habitat loss and its effects on biological diversity can be viewed as having four aspects associated with it. First is the actual loss or conversion of habitat from conditions that support a species to new land uses that support unfavorable conditions that do not support a species. A second cause of habitat loss, alteration of disturbance processes, is often more difficult to recognize and quantify, but this form of habitat loss can result in changes in ecosystem structure, function, or composition (Noss et al. 1995, Franklin et al. 1981). Such alterations can severely reduce the habitat quality of an ecosystem for a particular species. The third aspect of habitat loss is the reduction in the size of the remaining patches that may not provide enough in one patch to support a species. The fourth aspect of habitat loss is that of shifting populations from being a single population within the landscape to being a metapopulation consisting of many independent populations that only interact with occasional dispersal of individuals. These newly created metapopulations, or existing metapopulations within the landscape, might be influenced by habitat loss to the point that interruption of demographic or genetic support to the metapopulation occurs (Hanski and Gilpin 1997), resulting in the subsequent loss of the entire population.

The long-term persistence of biodiversity and ecosystem integrity requires that forest management provide suitable conditions for a high likelihood of maintaining these ecological components. The conditions that enhance this likelihood are often in contrast to the production of economic or social goods and demands. Therefore, objectives for ecological sustainability must strive to define conditions that provide an acceptable likelihood of the long-term persistence of biodiversity and ecosystem integrity. Selecting an acceptable probability of persistence is a value judgment, as some would forgo economic or social benefits for a higher probability of maintaining ecological objectives while others would accept a lower probability in exchange for increased goods or services. However, the application of appropriate approaches, methods, and information to meet ecological objectives can reduce the range of conditions under consideration, allowing for better integration with the socio-economic objectives. Of importance to this decision-making process is information that helps address the question of how much is enough for representation of ecological conditions.

The assumption of the historical reference approach, and a critical point to the discussion of representation, is that if all of the ecosystems that occurred under historical disturbance regimes are sufficiently represented across the planning landscape at all times, then these ecosystems will provide the ecological conditions that can support the full complement of biological diversity and ecosystem integrity for that planning landscape. The obvious question then becomes what is a sufficient level (amount) of ecosystem representation that will meet biological diversity and ecosystem integrity objectives for the planning landscape. This question sounds straight forward, but quickly becomes complicated when applied to real landscapes. Complexities include identifying an appropriate classification of historically occurring ecosystems and the need to identify when a particular ecosystem meets the requirements for representation. These complexities were the focus of the development of the coarse filter, with the results presented in the preceding sections. Identifying specific amounts to address adequate ecological representation is the next step in applying the conservation strategy and a final question concerns the spatial distributions of representative ecosystems.

Goals for Representation

Numerous publications and organizations have attempted to address the question of how much is enough in reference to ecological representation. However, this is a very complex question and one that lacks good empirical information. Most of the goals set by conservation organizations have been based on modeling approaches, many of which have used very simplistic assumptions and relationships. For example, Tear et al. (2005) discussed the challenges of the question of "How much is enough?" They discussed how one planning initiative of The Nature Conservancy for the Southern Rocky Mountains reported by Neely et al. (2001) set a goal of 30% representation of all native ecosystem types and communities. The primary basis for this determination went back to a publication by MacArthur and Wilson (1967) that depicted a relationship between size of an area and species present called the species-area curve, further modified by theories on island biogeography. Based on this mathematical curve, it was estimated that at a 30% level of representation a loss of approximately 12-25% of the species in the ecoregion could be expected over time. But is this a reasonable expectation based on good interpretation of known science? The origins of the species-area curve go back to early ecological literature such as Gleason (1922), with more detailed discussions by Goodall (1952), Hopkins (1955) and Grieg-Smith (1964). The premise of these works was that as one sampled increasingly larger areas, more species (plant species were the primary focus) would be found. The more diverse the plant community, the greater the effect of the species-area curve, meaning larger areas needed to be sampled to include an equal percentage of the total species present. MacArthur and Wilson (1967) applied this concept to islands, and found that larger islands supported a greater number of species based on a number of reasons including probability of local extinction due to the small size of the area. The projections of Neely et al. (2001) were based on these types of theoretical models. Theoretical models provide insights for understanding how the effects of habitat loss may operate, and can be used in hypothesis generation. However, their relevancy to real landscapes has been questioned (Wiens 1997, Haila 1999, With and King 1999). Haila (1999) discussed how theoretical models that assume 100% habitat and then model loss from this level are unrealistic. Models that only discriminate between habitat and non-habitat are also unrealistic. Similarly, use of the island biogeography perspective of habitat fragmentation (With 1999) has drawn criticism. Use of species-area relationships drawn from island biogeography theory for setting representation goals has been questioned (Hanski and Simberloff 1997, Wiens 1997, Bunnel 1999) as the relevancy of real islands as models for terrestrial landscapes is unrealistically simplistic. Habitat patches in terrestrial systems are not surrounded by water, but by habitat of varying quality (Noss 1996, Monkkonen and Reunanen 1999). In addition, habitat patches in most landscapes change over time, allowing for temporal connectivity not available to true islands (Camp et al. 1997, Wiens 1997, Monkkonen and Reunanen 1999). Wiens (1997:45) stated, "In landscape ecology, the "matrix" is itself spatially structured, and spatial relationships play an active role in determining the dynamics within the "patches" of interest." Bunnel (1999) compared species distributions and movement capabilities in forested landscapes and concluded that there was little evidence in forests of the Pacific Northwest that vertebrates perceive old forest stands as discrete patches. He felt that connectivity of patches could be important, but that the needed amount of interchange is unknown. Further, he stressed the importance of the matrix conditions to understanding connectivity concerns. The complexities of patch sizes, shapes, surrounding habitat conditions, and the historical relationship of these factors all make a simple application of species-area relationships problematic (Connor et al. 2000).

Generally, empirical studies that have documented effects of habitat loss on species persistence that considered landscape and ecosystem levels and direct and indirect impacts have not been conducted. At very high levels of ecosystem or habitat loss, effects on species are clearly shown, such as species in peril associated with the long-leaf pine ecosystems of the Southeastern U.S. with an estimated 98% reduction in functional ecosystems (Noss et al. 1995). Some good empirical work has been conducted on the Florida scrub jay (*Aphelocoma coerulescens*) examining losses of habitat and likely persistence of this species. Breininger et al. (1999) reported that increasing the quality of the habitat for the Florida scrub-jay was more critical to its survival than restoring more "habitat", supporting the need for consideration of both landscape and ecosystem levels of analysis when addressing the goals of representation. Generally, there is agreement that habitat losses exceeding 90% are undesirable, even though a high percentage of our native ecosystems have well under this level of representation. A recent grassland conservation plan for prairie grouse (Vodehnal and Haufler 2008) endorsed by the Association of Fish and Wildlife Agencies set conservation goals ranging from 10-20% representation of native grassland diversity, even though these are unlikely to be obtained in much of the Great Plains planning area. South Dakota's Wildlife Action Plan (SDGF&P 2006) focuses on providing at least 10% representation of historically-occurring ecosystems in that state to provide for species of greatest conservation need.

The results of the cumulative impact assessment for northern Idaho have identified some native ecosystem conditions that have been significantly reduced on the landscape today, when compared to historical conditions. To address these losses, Idaho Department of Lands has identified a goal of 20% representation of all native ecosystem diversity for forested systems occurring on their lands in northern Idaho. This level of representation, if also similarly supported by other agencies or land owners in the planning area, exceeds most representation goals set by agencies for broad scale conservation efforts. If Idaho Department of Lands provides this level of representation on its lands, it will be contributing its proportional share to regional representation needs. While the adequacy of this level of representation for maintaining all species diversity in the long term can't be conclusively documented, it is a very reasonable goal in light of the detailed analysis supporting this goal at both landscape and ecosystem levels. Further, the adequacy of this goal on the species being included in the proposed habitat conservation plan has been further assessed (see below), further justifying this as an appropriate level of representation.

The number of acres needed to maintain 20% representation on IDL lands are presented by ecological site and disturbance state in Table 10. Figure 10 represents the mapped disturbance states/structural stages for today's conditions and the 20% representation of historical conditions on IDL lands only. If the U.S. Forest Service and other private landowners within the project area were to also support the goal of maintaining 20% representation, the benefits to species of concern would be that much greater. Table 10 also identifies the number of acres required for the U.S. Forest Service and other private landowners to maintain 20% representation of native ecosystem diversity by ecological site and disturbance state. Table 11 identifies the number of acres of each native ecosystem that will need to be re-established or restored, to reach the goal of 20% representation for IDL, U.S. Forest Service, and other private landowners. Figure 11 represents the mapped disturbance states/structural stages for today's conditions plus the 20% representation of historical conditions on all lands within the northern Idaho planning region.

In addition, all ecological sites that historically were influenced by the mixed-severity fire regime should be evaluated to ensure that at least 20% of these historical amounts and conditions are represented on the landscape in the future, as this cannot currently be verified through the evaluation of existing stand data alone.

Table 10. The number of acres required to maintain 20% representation of native ecosystem diversity for forested systems of the northern Idaho region, by landowner categories.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
IDAHO DEPARTMENT OF LANDS									
SEEDLING	1	71	1769	426	121	240	64	2	0
SAPLING	1	143	4423	1136	386	640	192	5	0
POLE	1	143	4202	1065	362	440	192	4	0
MEDIUM-NL	1	71	1327	284	97	200	27	2	0
LARGE-NL	1	71	663	142	24	200	55	0	0
VERY LARGE-NL	573	5348	442	50	10	40	37	0	0
MEDIUM-L	1	93	2433	2058	290	440	256	4	0
LARGE-L	1	114	3538	3478	1256	2079	448	57	5
VERY LARGE-L	106	2424	7740	3620	1232	2279	420	75	7
US FOREST SERVICE									
SEEDLING	1	222	4550	1432	491	1307	509	26	22
SAPLING	1	445	11376	3819	1570	3485	1527	77	56
POLE	1	445	10707	3580	1472	2396	1527	64	44
MEDIUM-NL	1	222	3413	955	393	1089	218	26	11
LARGE-NL	2	222	1706	477	98	1089	436	4	2
VERY LARGE-NL	1024	16682	1138	167	39	218	291	0	0
MEDIUM-L	1	289	6257	6922	1178	2396	2036	51	44
LARGE-L	1	356	9101	11695	5103	11327	3564	834	699
VERY LARGE-L	189	7562	19908	12173	5005	12416	3346	1091	1021
OTHER PRIVATE LANDS									
SEEDLING	0	167	4074	445	100	185	86	60	3
SAPLING	0	334	10185	1186	321	492	257	180	7
POLE	0	334	9676	1112	301	338	257	150	5
MEDIUM-NL	0	167	3056	297	80	154	37	60	1
LARGE-NL	1	167	1528	148	20	154	74	9	0
VERY LARGE-NL	333	12525	1019	52	8	31	49	0	0
MEDIUM-L	0	217	5602	2150	241	338	343	120	5
LARGE-L	0	267	8148	3633	1043	1600	601	1952	83
VERY LARGE-L	61	5678	17825	3782	1023	1754	564	2552	121
TOTAL	**2303**	**54779**	**155807**	**66284**	**22262**	**47325**	**17414**	**7405**	**2139**

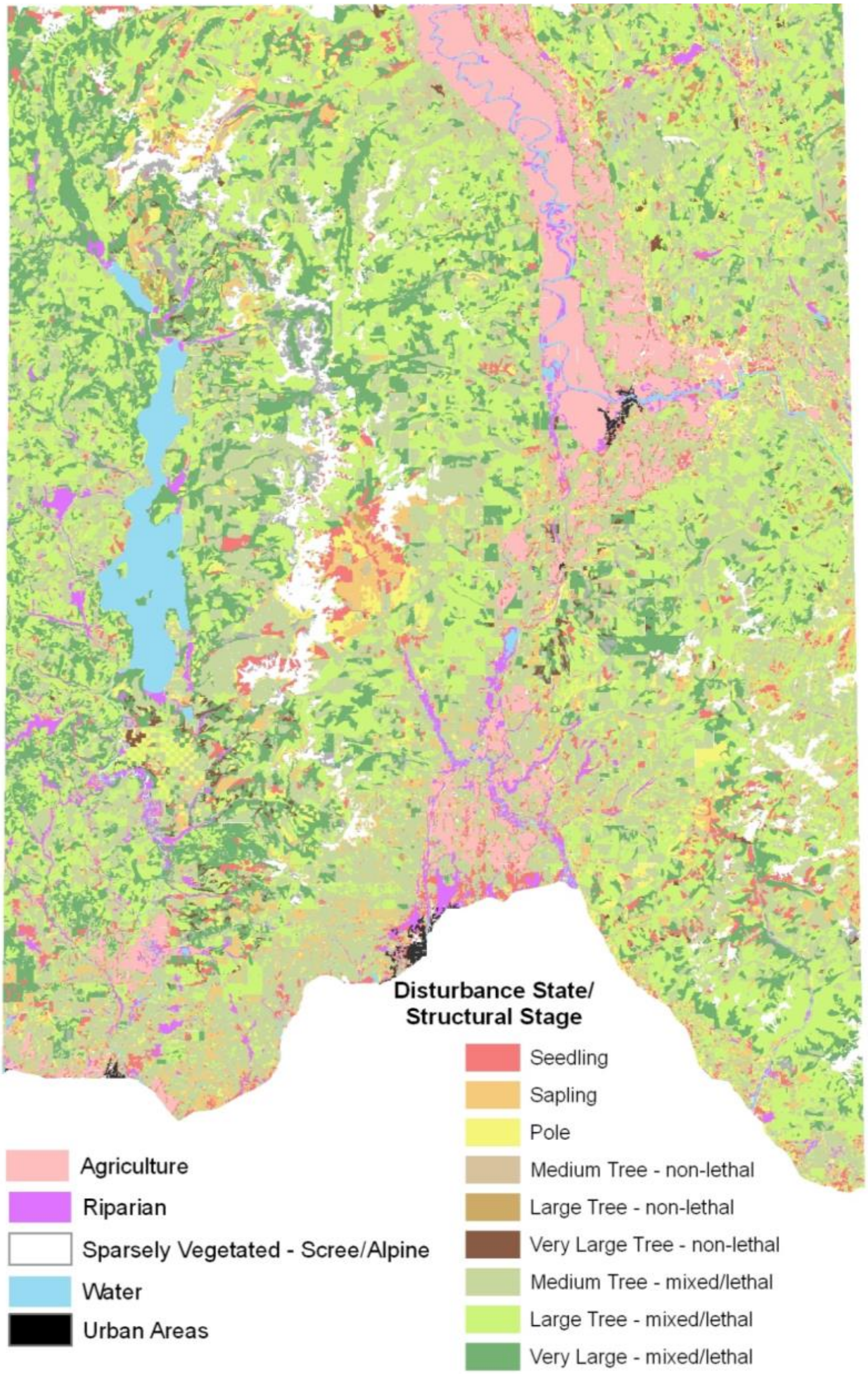


Figure 10. A map of disturbance state/structural stage representing today's conditions and proposed 20% representation of historical conditions on Idaho Department of Lands ownership, within the northern Idaho planning region.

Table 11. The number of acres of each native ecosystem that require restoration measures to reach the goal of 20% representation, by landowner category.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
IDAHO DEPARTMENT OF LANDS									
SEEDLING									
SAPLING			3137	890	224	595	168		
POLE					157	84	144		
MEDIUM-NL			178	46	74	200	27		
LARGE-NL		71	664	142	24	200	55		
VERY LARGE-NL	573	5263	436	50		40	37		
MEDIUM-L									
LARGE-L									
VERY LARGE-L			5660*	2669*	956*	1741*	330*	65*	7
US FOREST SERVICE									
SEEDLING									
SAPLING			5562	503	407	711	1129		56
POLE			947		168	313	540		
MEDIUM-NL						733			
LARGE-NL							280		
VERY LARGE-NL	1024	16180	374				263		
MEDIUM-L									
LARGE-L									
VERY LARGE-L			14558*	8902*	3882*	9486*	2633*	947*	1021
OTHER PRIVATE LANDS									
SEEDLING									
SAPLING									
POLE				91					
MEDIUM-NL									
LARGE-NL			1095	122		121			
VERY LARGE-NL	333	12525	1018	52			49		
MEDIUM-L									
LARGE-L								895	
VERY LARGE-L	60	3410	13035*	2765*	794*	1340*	444*	2552	121
TOTAL	**1990**	**37449**	**46664**	**16232**	**6686**	**15564**	**6099**	**4459**	**1205**

* Sufficient acreage currently exists in the very large tree-L categories for most habitat type classes, however, the designated number of acres should be allowed to develop old growth characteristics.

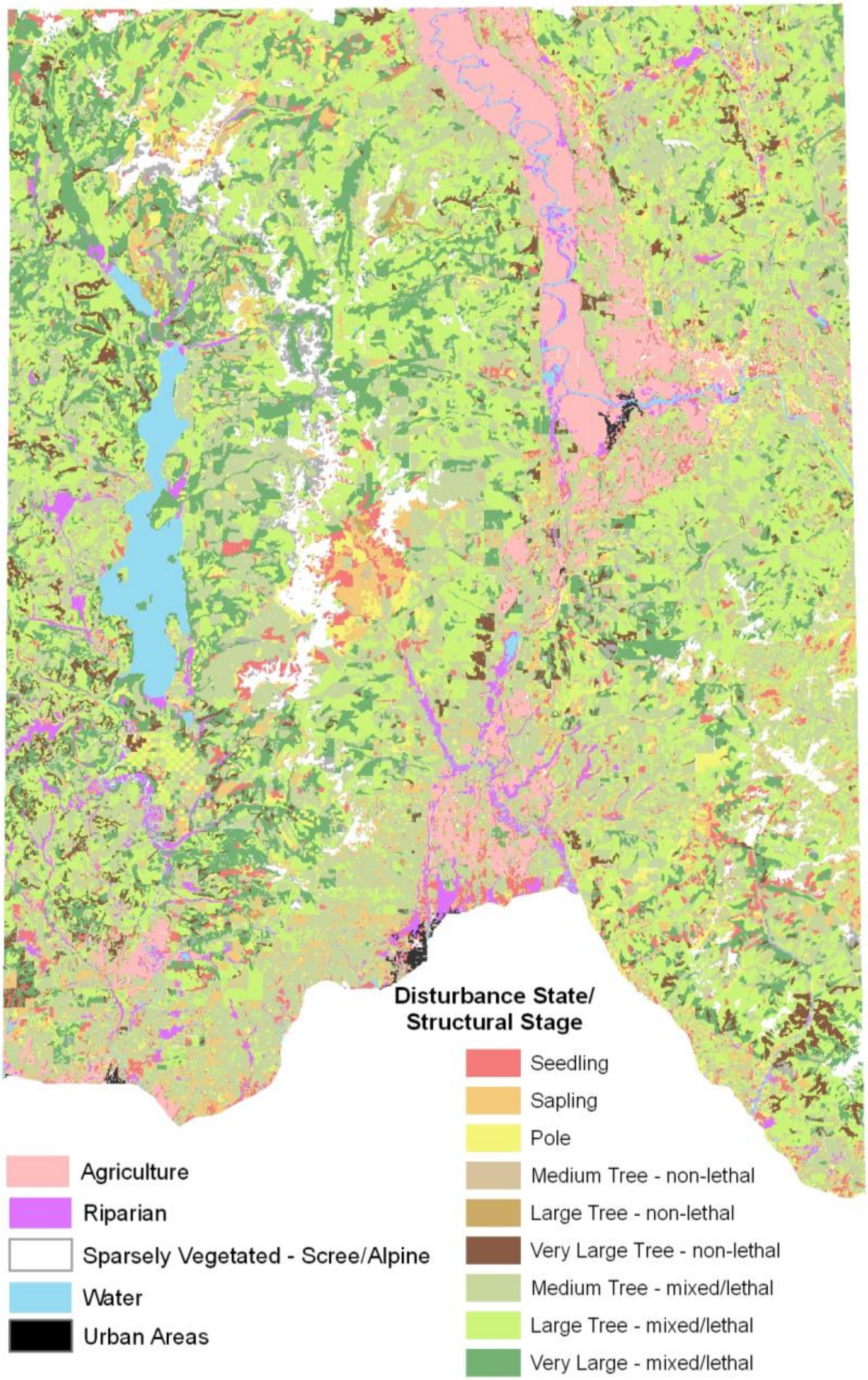


Figure 11. A map of disturbance states/structural stages representing today's conditions and proposed 20% representation of historical conditions on all lands within the northern Idaho planning region.

Target Conditions for Restoration

Forest restoration in the northern Idaho planning region should be based on our best understanding of how natural disturbance regimes historically influenced species composition and forest structure on different ecological sites (i.e., habitat type classes) (Fitzgerald 2005, Hillis et al. 2001, Blocker et al. 2001). These conditions are sometimes referred to as "reference conditions", as they represent conditions that existed before forest structure and functions were altered by Euro-American settlement. While it is generally accepted that recreating the exact conditions which occurred historically is no longer possible, due primarily to the past century of human impacts (e.g., invasive weeds, exotic disease/insects, fire suppression, etc.) and to the possible future impacts from climate change, the goal of restoration should be to simulate the *major* characteristics of the historically-occurring forests, particularly relative to species composition and structures, as well as stand and landscape-level patterns (i.e., patchiness, stand sizes, etc.) to the maximum extent feasible with current forest management practices. Stated more simply, understanding the range of conditions that once occurred on an ecological site and how they functioned is an important tool in deciding future restoration goals and management strategies.

The following sections and tables provide information on the major forest characteristics that should be targeted to achieve restoration goals within the northern Idaho planning region. The following list provides a brief description of the forest variables that are used to describe these major characteristics. The primary information sources used in the development of the following sections and tables include USFS (1999) and Green et al. (1992). Other references are noted as appropriate.

Disturbance State/Structural stage – To describe the influence of natural disturbance on species compositions and stand structures in the planning region, 9 vegetation structural stages were identified. See previous sections of this document for a more detailed description of disturbance state/structural stage and their classification.

Fire Regime – Represents the predominant natural fire regime historically influencing forest stand conditions. Three fire regime classes – non-lethal, mixed-severity, and lethal - are described for the forest ecosystems of the planning region. Fire regime influences on structure and species compositions are typically not evident until mid to late-seral conditions (medium tree or larger) occur. See previous sections for a description of these fire regimes and their influences on forest structure.

Mean HRV – The mean historical range of variability (HRV) was modeled for terrestrial forest ecosystems in the northern Idaho planning region by habitat type class and disturbance state using the spatially explicit landscape model SIMPPLLE and further combined with fire regime information interpreted from Barrett (2001).

Dominant Tree Species – The dominant tree species as influenced by the interaction of the natural fire regimes and the habitat type class.

Description of Disturbance Influenced Conditions – The expected densities and in-stand conditions as influenced by the interaction of the natural fire regimes and habitat type; these conditions should be considered in combination with the Disturbance State/Structural stage classification.

Patch Size - Patch size refers to the continuous areas of similar forest structure. These areas often include multiple ecological sites of similar forest structure. Forest patch size and the resulting landscape pattern produced by historical disturbance events can provide insights for management decisions. Ecosystems that were primarily influenced by disturbances that operated consistently across large areas would produce less fragmented conditions than disturbances that varied in their size and intensity. Categorizations of fire regimes in the northern Idaho planning region help with this determination. Habitat type classes that were influenced primarily by short-interval, low intensity, non-lethal fires typically created stands with relatively consistent post-fire condition (Agee 1999). Non-lethal burns in these forest systems tended to be large, with only small widely spaced openings (Agee 1998, 1999). Other than these occasional small openings, stands maintained a relatively consistent composition and structure of fire resistant species with open canopies and herbaceous understory vegetation (Agee 1993, 1999). Patch sizes were a function of the habitat types that had similar understory fire regimes. Similarly, ecosystems that were influenced by infrequent, high intensity, lethal fire typically burned large percentages of these types (Romme and Despain 1989, Bessie and Johnson 1995), leaving only scattered patches in protected draws or other areas in an unburned condition (Agee 1999). Lethal fire regimes could leave up to 30% of the forest crown (Agee 1993), but typically triggered the initiation of a new even-aged stand. In landscapes with large expanses of these conditions, large tracts of similar structural conditions or disturbance states would have occurred. In between these two types of regimes are the mixed severity fire regimes. Patch size in under the mixed-severity regime would be variable in intensities and return intervals, and would create landscapes of a more mixed composition and structure (Agee 1999, Arno et al. 1999). Agee (1999) defined these fire regimes as maintaining a naturally fragmented forest. In addition, individual stand conditions were often more diverse under such mixed severity fire regimes (Arno et al. 1999).

The northern Idaho planning landscape is characterized by a relatively small proportion of the landscape that supported non-lethal fire regimes. The forests in northern Idaho were primarily influenced by mixed-severity fire regimes and lethal fire regimes. Agee (1999) characterized amounts of edge in these fire regimes, and identified low amounts of edge in non-lethal fire regimes, moderate amounts of edge in lethal fire regimes, and high amounts of edge in mixed-severity fire regimes. These amounts of edge are reflective of the amount of natural fragmentation that occurred in these systems from historical fire regimes and should be considered in all restoration efforts. For ecosystems that historically occurred in large patches, based on both the distribution of ecological sites across the landscape and fire patterns, management should strive to maintain some larger patches of these types. This will be a challenge based on the nature of current management practices, but larger sized patches should be incorporated into restoration plans, wherever feasible. Restoration plans should not prescribe one set size of prescriptions for a habitat type, but instead should include a range of appropriate sizes based on the best available information.

Hot, Dry Ponderosa Pine/Xeric Douglas-fir

Major characteristics – The major characteristics of reference conditions for the Hot, Dry Ponderosa Pine/Xeric Douglas-fir habitat type class are summarized in Table 12 by disturbance states/structural stages as described in previous sections. Management actions and treatment goals should target restoration of conditions as closely resembling these major characteristics as possible.

Historically, these sites were severely limited in their tree-growing capability and frequently maintained a savannah appearance even when fully stocked. The majority of these stands were influenced by a non-lethal fire regime that produced savannah conditions with a preponderance of ponderosa pine in the overstory and a grassy understory, with occasional patches of low shrubs. Non-lethal fires would result in few fire-sensitive shrubs, low fuel accumulations, and a few ponderosa pine seedlings and small saplings. Occasionally, mixed-severity fire conditions could occur. Where fire has been absent for a longer than average time, shrubs and seedlings continued to increase in the understory. Overstory conditions were still typically characterized by large ponderosa pine and a small proportion of Douglas-fir in the overstory but over time densities of seedlings, saplings, and poles continue to increase in the understory. When fire did return to these stands, the greater densities of ladder fuels could lead to a moderate level of overstory killed trees. Mixed-severity fire conditions were more likely to occur on protected and moister sites while lethal fire conditions very rarely occurred.

Restoration should target mean basal areas on this habitat type class ranging from 50 to 80 sq. ft. per acre and 8 to 20 trees per acre >= 21" dbh, where the very large tree structural stage is targeted. However, pockets of higher basal area (80 to 124 sq. ft. per acre) should be incorporated where moister site or protected conditions allow and the mixed-severity fire regime is more likely to occur. The probability of large (≥9" dbh) down woody material occurring within the very large tree structural stage should be low and average amounts of coarse woody debris (>3"dbh, standing dead and down woody) should range from 5 to 9 tons per acre. The understory conditions for this habitat type class should target restoration of bunchgrass species where non-lethal fire conditions prevailed, with patches of shrubs encouraged on moister site conditions or where mixed-severity fire was more likely to occur. It may be necessary to reseed with native species or remove invasive species prior to reseeding.

Additional recommendations:

- Management considerations should focus on what is left behind, rather than the more conventional focus on what is taken; snags and broken-topped trees should be considered desirable features.
- Reduce tree densities to basal areas more closely resembling historical conditions, while leaving enough trees to restore densities and diameter distributions where they are lacking.
- Ponderosa pine more naturally grows in a relatively clumped manner, often with interlocking crowns. Some wildlife species are particularly dependent on the combination of this vertical and horizontal structure. An even spacing of trees is not desirable across this habitat type class.
- Some openings should be maintained over time, especially where they occurred historically.
- Heavy to moderate slash will need to be removed to avoid unnatural wildfire intensities.
- Prescribed burning should be used where possible to reduce fuel loads, expose mineral soils, provide a nutrient flush for vegetation, reduce competition, and stimulate production of grasses and forbs. Maintenance burns will likely be necessary within 3 to 10 years of the initial prescribed burn to reintroduce periodic fire regime.
- Where prescribed burning is used, duff that may have accumulated around the base of remaining large trees may need to be raked away from the trees so that these trees won't be killed by the heat generated from the initial burn following a long period of fire exclusion and duff accumulation.

Table 12. Historical stand characteristics and target restoration conditions for the Hot, Dry Ponderosa Pine/Xeric Douglas-fir habitat type class.

Disturbance State[a]	**Fire Regime**	**Mean HRV**[b] **(%)**	**Dominant Tree Species**	**Description of Disturbance Influenced Conditions**	**Approximate Patch Size**[c]
Seedling		<1	na[d]	na	na
Sapling		<1			
Pole		<1			
Medium	Non-lethal	<1	Ponderosa pine, some Douglas-fir	Fairly contiguous, low density, all aged stand conditions (<30 tpa at >=6" dbh) interspersed with mostly small openings (usually <5 acres); single story conditions are dominant but multi-storied canopies also occur	20 to 200 ac.
Large		<1			
Very Large		87.3			
Medium	Mixed-severity	<1	Ponderosa pine, Douglas-fir	Moderate density, all-aged stand conditions (>=30 tpa at >=6" dbh) intermixed with non-lethal stand conditions (as described above); multi-story canopy	2 to 25 ac.
Large		<1			
Very Large		12.4			

[a] See text for a full description of "disturbance states" relative to tree sizes (dbh) and number of trees per acre
[b] HRV = Historical Range of Variability
[c] Patch size = may include contiguous similar habitat type classes
[d] na= not applicable, functionally did not occur as a "stand" (i.e., .10 acres)

Warm, Dry Ponderosa Pine/Douglas-fir/Grand Fir

Major characteristics – The major characteristics of the Warm, Dry Ponderosa Pine/Douglas-fir/Grand Fir habitat type class are summarized in Table 13 by disturbance states/structural stages as described in previous sections. Management actions and treatment goals should target restoration of conditions as closely resembling these major characteristics as possible.

Historically, these sites were primarily influenced by frequent non-lethal underburns that excluded most Douglas-fir and grand fir and killed many small ponderosa pines, western larch, and lodgepole pine. In addition, a smaller percentage of the sites were influenced by a mixed-severity fire regime probably due to inclusions of moister micro-sites or their position on the landscape relative to moister habitat type classes. Under the non-lethal fire regime, stands remained open and park-like, consisting of mostly ponderosa pine on the drier sites and ponderosa pine and western larch with smaller amounts of Douglas-fir on the moister sites. These stands also exhibited a variety of age classes. Trees often occurred in clumps, with irregular shaped openings between the relatively low densities of trees. Those stands influenced by the mixed-severity fire regime were likely characterized by western larch and ponderosa pine combined with denser fire-intolerant species that were vulnerable to crown fires if weather conditions allowed more severe fire occurrences. Lethal fire conditions very rarely occurred.

Restoration should target mean basal areas on this habitat type class ranging from 60 to 100 sq. ft. per acre and 19 to 27 trees per acre >= 21" dbh, where the very large tree structural stage is targeted. However, pockets of higher basal area (100 to 193 sq. ft. per acre) should be incorporated where moister site or protected conditions allow and the mixed-severity fire regime is more likely to occur. The probability of large (≥9" dbh) down woody material occurring within large to very large structural stages of the stand should be low to moderate and average amounts of coarse woody debris should range from 5 to 25 tons per acre.

The understory conditions should target restoration of mostly bunchgrass species where non-lethal fire conditions prevailed, with patches of shrubs encouraged on moister sites or where mixed-severity fire was more likely to occur. It may be necessary to reseed with native species and/or remove invasive species prior to reseeding.

Additional recommendations:

- Management considerations should focus on what is left behind, rather than the more conventional management focus on what is taken; snags and broken-topped trees should be considered desirable features of these forests.
- Reduce tree densities to basal areas more closely resembling historical conditions, while leaving enough trees to restore densities and diameter distributions where they are lacking.
- Ponderosa pine grows more naturally in a relatively clumped manner, often with interlocking crowns. Some wildlife species are particularly dependent on the combination of this vertical and horizontal structure. An even spacing of trees is not desirable across this habitat type class.
- Some openings should be maintained over time, especially where they occurred historically.
- Heavy to moderate slash will need to be removed to avoid unnatural wildfire intensities, and.
- Prescribed burning should be used where possible to reduce fuel loads, expose mineral soils, provide a nutrient flush for vegetation, reduce competition, and stimulate production of grasses and forbs. Maintenance burns will likely be necessary within 3 to 10 years of the initial prescribed burn to reintroduce periodic fire regime. As with the Ponderosa pine habitat type class, treatment of duff around remaining large trees may be necessary to protect these trees during initial burns.

Table 13. Historical stand characteristics and target restoration conditions for the Warm, Dry Ponderosa Pine/Douglas-fir/Grand fir habitat type class.

Disturbance State[a]	Fire Regime	Mean HRV[b](%)	Dominant Tree Species	Description of Disturbance Influenced Conditions	Approximate Patch Size[c]
Seedling		<1	na[d]	na	na
Sapling		<1			
Pole		<1			
Medium	Non-lethal	<1	Ponderosa pine, western larch, some Douglas-fir	Low density, all aged stand conditions (<50 tpa at >=6" dbh) interspersed with small openings (usually <5 acres)	20 to 200 ac.
Large		<1			
Very Large		69.8			
Medium	Mixed-severity	<1	Douglas-fir, ponderosa pine, western larch, grand fir, lodgepole pine	Moderate density stand conditions (>=50 tpa at >=6" dbh) intermixed with non-lethal stand conditions (as described above)	5 to 55 ac.
Large		<1			
Very Large		27.2			

[a] See text for a full description of "disturbance states" relative to tree sizes (dbh) and number of trees per acre

[b] HRV = Historical Range of Variability

[c] Patch size = may include contiguous similar habitat type classes

[d] na= not applicable, functionally did not occur as a "stand" (i.e., >10 acres)

Moderate Warm, Moist Western Red Cedar/Western Hemlock/Grand Fir

Major characteristics – The major characteristics of the Moderate Warm, Moist Western Red Cedar/Western Hemlock/Grand Fir habitat type class are summarized in Table 14 by disturbance states/structural stages as described in previous sections. Management actions and treatment goals should target restoration of conditions as closely resembling these major characteristics as possible.

Historical conditions were typically characterized by a diversity of stand structures and species composition from the occurrence of both mixed severity and lethal fire regimes. Mixed severity fire produced more heterogeneous structures and within-stand structural diversity than the lethal fire regime. Non-lethal fires were rare. Fire regimes within this habitat type class are heavily influenced by topographic position. Warmer, drier sites exhibited the mixed-severity stand conditions that were more open with large canopy gaps and greater vertical structure that included patches of even-aged conditions underneath the canopy of or intermixed with surviving groups or individual trees. Multiple-age classes were common as the mixed-severity regime would produce both understory burns but also would flare up and torch out the crown in other areas. The presence of large western larch and ponderosa pine in the overstory are a good indicator of the mixed- severity fire regime. Moister, cooler sites were influenced by the lethal fire regime and were characterized by a patchy distribution of more even-aged stands of combined seral and late successional species.

Average basal area on this habitat type class should range from 80 to 120 square feet per acre and 12 to 33 trees per acre ≥ 21" dbh, where the very large tree structural stage is targeted. Basal areas on the lower end of this range are more commonly associated with disturbance states influenced by the mixed-severity fire regime and basal areas on the higher end of this range are more commonly associated with disturbance states influenced by the lethal fire regime. The probability of large (≥9" dbh) down woody material occurring within large to very large structural stages should be moderate and the average amount of coarse woody debris should range from 10-20 tons per acre.

The understory conditions for this habitat type class should target restoration of native grass species and shrubs, as appropriate for the influence of the mixed-severity versus the lethal fire regimes.

Additional recommendations:

- Retain as much as possible of the surviving western white pine in current forests and provide openings for its regeneration.
- Particular emphasis should be placed on restoring mixed-severity conditions where they were likely to have occurred historically. The presence of large, scattered western larch, Douglas-fir, and/or western white pine in today's overstory, may indicate mixed-severity conditions that occurred historically. Where these large old trees occur, emphasis should be given to treatments that will help restore their diverse structures and species compositions, and for the short-term, protect them from future lethal fires in the surrounding stands.

Table 14. Historical stand characteristics and target restoration conditions for the Moderate Warm, Moist Western Red Cedar/Western Hemlock/Grand fir habitat type class.

Disturbance State[a]	Fire Regime	Mean HRV[b](%)	Dominant Tree Species	Description of Disturbance Influenced Conditions	Approximate Patch Size[c]
Seedling		4.3	Primarily Western white pine, Douglas-fir, western larch, ponderosa pine, lodgepole pine; some grand fir and Engelmann spruce	Dense, even-aged stand conditions	20 to 200 acres
Sapling		12.3			
Pole		11.8			
Medium	Non-lethal	2.1	Ponderosa pine, western larch, Douglas-fir	Low density stand conditions (<50 tpa at >=6" dbh) interspersed with small openings (usually <5 acres); all aged	<25 acres
Large		<1			
Very Large		<1			
Medium	Mixed-severity	3.0	Western white pine, Douglas-fir, western larch, western red cedar, grand fir, western hemlock	Mixed-severity: dense, multi-storied stand conditions (>=50 tpa at >=6" dbh) intermixed with non-lethal stand conditions (see above description) Lethal: dense, multistoried (drier sites) and single storied (moister sites) stand conditions	Mixed-severity: 5 to 50 acres Lethal: 20 to 200 acres
	Lethal	8.1			
Large	Mixed-severity	5.1			
	Lethal	13.8			
Very Large	Mixed-severity	10.4			
	Lethal	28.3			

[a] See text for a full description of "disturbance states" relative to tree sizes (dbh) and number of trees per acre

[b] HRV = Historical Range of Variability

[c] Patch size = may include contiguous similar habitat type classes

Moderate Cool, Moist Western Red Cedar/Western Hemlock/Grand Fir

Major characteristics – The major characteristics of the Moderate Cool, Moist Western Red Cedar/Western Hemlock/Grand Fir habitat type class are summarized in Table 15 by disturbance states/structural stages as described in previous sections. Management actions and treatment goals should target restoration of conditions as closely resembling these major characteristics as possible.

Historical disturbance regimes typically produced a diversity of stand structures and species composition from primarily mixed severity and non-lethal fires. Mixed severity fire produced more heterogeneous structures and within-stand structural diversity than long-interval fire regimes. Fire regimes within this habitat type class are heavily influenced by topographic position. Warmer, drier sites within these types exhibited stand conditions that were more open, with greater vertical structure as trees survived the mixed-severity fires. Western larch, Douglas-fir, and western white pine, were common dominants under these conditions. Moister, cooler sites were influenced by the lethal fire regime and are characterized by more even-aged stands of combined seral and late successional species.

Average basal area on this habitat type class should range from 120 to 200 square feet per acre and 12 to 53 trees per acre ≥ 21" dbh, where the very large tree structural stage is targeted. Basal areas on the lower end of this range are more commonly associated with disturbance states influenced by the mixed-severity fire regime and basal areas on the higher end of this range are more commonly associated with disturbance states influenced by the lethal fire regime. The probability of large (≥9" dbh) down woody material occurring within large to very large tree structural stages of the stand should be moderate to high and average amounts of coarse woody debris should range from 15-32 tons per acre.

The understory conditions for this habitat type class should target restoration of native grass species and shrubs, as appropriate for the influence of the mixed-severity versus the lethal fire regimes.

Additional recommendations:

- Retain as much as possible of the surviving western white pine in current forests and provide openings for its regeneration.
- Particular emphasis should be placed on restoring mixed-severity conditions where they were likely to have occurred historically. The presence of large, scattered western larch, Douglas-fir, and/or western white pine in today's overstory, may indicate mixed-severity conditions that occurred historically. Where these large old trees occur, emphasis should be given to treatments that will help restore their diverse structures and species compositions, and for the short-term, protect them from future lethal fires in the surrounding stands.

Table 15. Historical stand characteristics and target restoration conditions for the Moderate Cool, Moist Western Red Cedar/Western Hemlock/Grand fir habitat type class.

Disturbance State[a]	Fire Regime	Mean HRV[b](%)	Dominant Tree Species	Description of Disturbance Influenced Conditions	Approximate Patch Size[c]
Seedling		4.3	Primarily Western white pine, Douglas-fir, western larch; some grand fir, western red cedar, western hemlock	Dense, even-aged stand conditions	100 to 300 ac. or more
Sapling		12.3			
Pole		11.8			
Medium	Non-lethal	2.1	Western larch, some western white pine and Douglas-fir	Low density, all aged stand conditions (<50 tpa at >=6" dbh) interspersed with small openings (usually <5 acres)	<25 acres
Large		<1			
Very Large		<1			
Medium	Mixed-severity	3.0	Western white pine, Douglas-fir, western larch, western red cedar, grand fir, western hemlock, Engelmann spruce	Mixed-severity: dense, multi-storied stand conditions (>=50 tpa at >=6" dbh) intermixed with non-lethal stand conditions (see above description) Lethal: dense, multistoried (drier sites) and single storied (moister sites) stand conditions	Mixed-severity: 20 to 100 ac. Lethal: 100 to 300 ac.or more
	Lethal	8.1			
Large	Mixed-severity	5.1			
	Lethal	13.8			
Very Large	Mixed-severity	10.4			
	Lethal	28.3			

[a] See text for a full description of "disturbance states" relative to tree sizes (dbh) and number of trees per acre

[b] HRV = Historical Range of Variability

[c] Patch size = may include contiguous similar habitat type classes

Cool, Dry Subalpine Fir/Mountain Hemlock

Major characteristics – The major characteristics of the Cool, Dry Subalpine Fir/Mountain Hemlock habitat type class are summarized in Table 16 by disturbance states/structural stages as described in previous sections. Management actions and treatment goals should target restoration of conditions as closely resembling these major characteristics as possible.

The historical fire regime of this habitat type class consisted of both mixed-severity and lethal fires. Mixed-severity fire influenced sites, while not as common as lethal fire influenced sites, were more common on drier site conditions. The mixed-severity fire regime created a mosaic of seral stages at the landscape level. Cyclic bark beetle attacks on dense patches of Douglas-fir, lodgepole pine, and Engelmann spruce can contribute further to this mosaic. At mid-seral stages, lethal fire conditions often were characterized by even-aged lodgepole pine with a scattered relic overstory of western larch or some stands may be mixed with Douglas-fir or subalpine fir. Mixed-severity conditions were characterized by a diversity of structures and species compositions including large western larch, lodgepole pine, subalpine fir, Engelmann spruce, and Douglas-fir.

Average basal area on this habitat type class should range from 80 to 216 square feet per acre and 13 to 54 trees per acre ≥ 17" dbh, where large to very large tree structural stages are targeted. Basal areas on the lower end of this range are more commonly associated with disturbance states influenced by the mixed-severity fire regime and basal areas on the higher end of this range are more commonly associated with disturbance states influenced by the lethal fire regime. The probability of large (≥9" dbh) down woody material occurring within large to very large tree structural stages should be moderate to high and average amounts of coarse woody debris should range from 7-25 tons per acre.

The understory conditions for this habitat type class should target restoration of native grass species and shrubs, as appropriate for the influence of the mixed-severity versus the lethal fire regimes.

Additional recommendations:

- Retain as much as possible of the surviving western white pine in current forests and provide openings for its regeneration.
- Particular emphasis should be placed on restoring mixed-severity conditions where they were likely to have occurred historically. The presence of large, scattered western larch, Douglas-fir, and/or western white pine in today's overstory, may indicate mixed-severity conditions that occurred historically. Where these large old trees occur, emphasis should be given to treatments that will help restore their diverse structures and species compositions, and for the short-term, protect them from future lethal fires in the surrounding stands.
- Today, these stands are generally considered to be less structurally diverse and less diverse in terms of patch sizes and patch shapes at the landscape level, than what occurred historically. Future treatment should attempt to restore the historical mosaic of more diverse conditions.

Table 16. Historical stand characteristics and target restoration conditions for the Cool, Dry Subalpine fir/Mountain hemlock habitat type class

Disturbance State[a]	Fire Regime	Mean HRV[b] (%)	Dominant Tree Species	Description of Disturbance Influenced Conditions	Approximate Patch Size[c]
Seedling		4.1	Lodgepole pine, Douglas-fir, subalpine fir, Engelmann spruce	Dense, even-aged stand conditions	5,000 to 100,000 ac. or more
Sapling		10.5			
Pole		11.8			
Medium	Non-lethal	2.3	Western larch, Western white-pine, Douglas-fir, lodgepole pine	Low density, all aged stand conditions (<50 tpa at >=6" dbh) interspersed with small openings (usually <5 acres)	<100 ac.
Large		1.2			
Very Large		<1			
Medium	Mixed-severity	1.5	Douglas-fir, subalpine fir, Englemann spruce, mountain hemlock	Mixed-severity: dense, multi-storied stand conditions (>=50 tpa at >=6" dbh) intermixed with non-lethal stand conditions (see above description) Lethal: dense, mostly even-aged single-storied with some two storied stand conditions	Mixed-severity: <100 ac. Lethal: 5,000 to 100,000 ac. or more
	Lethal	5.4			
Large	Mixed-severity	4.3			
	Lethal	14.9			
Very Large	Mixed-severity	9.8			
	Lethal	33.9			

[a] See text for a full description of “disturbance states” relative to tree sizes (dbh) and number of trees per acre

[b] HRV = Historical Range of Variability

[c] Patch size = may include contiguous similar habitat type classes

Cool, Moist Subalpine Fir/Mountain Hemlock

Major characteristics – The major characteristics of the Cool, Moist Subalpine Fir/Mountain Hemlock habitat type class are summarized in Table 17 by disturbance states/structural stages as described in previous sections. Management actions and treatment goals should target restoration of conditions as closely resembling these major characteristics as possible.

Historically, these sites experienced both lethal and mixed-severity fire regimes. Moisture and temperature gradients create a complex influence on the fire regimes occurring on these sites. Fuels dry out slowly on average and under most conditions mixed severity fires burned small areas, in a patchy pattern, on drier portions of these sites. Under drought or low precipitation years, lethal fires may have burned very large areas but also in a patchy pattern. This site is also heavily influenced by the fire regimes influencing adjacent habitat type classes. Sites influenced by predominantly mixed severity fires resulted in large gaps in the canopy and a mosaic of structures within the stand. The presence of western larch in the canopy is a good indicator of mixed-severity fires on these sites. Lethal fires create a mosaic of even-aged single- or two-storied structures that may be characterized by the presence of both early seral and late seral species, and in some instances dense stands of lodgepole pine. Historically, fire regimes may have also been influenced by insect caused mortality.

Average basal area on this habitat type class should range from 80 to 120 square feet per acre and 34 to 51 trees per acre $\geq$ 17" dbh, where large to very large tree structural stages are targeted. Basal areas on the lower end of this range are more commonly associated with disturbance states influenced by the mixed-severity fire regime and basal areas on the higher end of this range are usually associated with disturbance states influenced by the lethal fire regime. The probability of large ($\geq$9" dbh) down woody material occurring within large to very large tree structural stages should be moderate to high and average amounts of coarse woody debris should range from 12-25 tons per acre.

The understory conditions for this habitat type class should target restoration of native grass species and shrubs, as appropriate for the influence of the mixed-severity versus the lethal fire regimes.

Additional recommendations:

- Retain as much as possible of the surviving western white pine in current forests and provide openings for its regeneration.
- Particular emphasis should be placed on restoring mixed-severity conditions where they were likely to have occurred historically. The presence of large, scattered western larch, Douglas-fir, and/or western white pine in today's overstory, may indicate mixed-severity conditions that occurred historically. Where these large old trees occur, emphasis should be given to treatments that will help restore their diverse structures and species compositions, and for the short-term, protect them from future lethal fires in the surrounding stands.
- Today, these stands are generally considered to be less structurally diverse and less diverse in terms of patch sizes and patch shapes at the landscape level, than what occurred historically. Future treatment should attempt to restore the historical mosaic of more diverse conditions.

Table 17. Historical stand characteristics and target restoration conditions for the Cool, Moist Subalpine fir/Mountain hemlock habitat type class.

Disturbance State[a]	Fire Regime	Mean HRV[b] (%)	Dominant Tree Species	Description of Disturbance Influenced Conditions	Approximate Patch Size[c]
Seedling		4.1	Western larch, Douglas-fir, western white pine, lodgepole, Engelmann spruce	Moderately dense, even-aged stand conditions	5,000 to 100,000 ac. or more
Sapling		12.0			
Pole		11.5			
Medium	Non-lethal	1.6	Western larch, Douglas-fir, western white pine, lodgepole	Low density, all aged stand conditions (<60 tpa at >=6" dbh) interspersed with small openings (usually <5 acres)	<100 ac.
Large		<1			
Very Large		<1			
Medium	Mixed-severity	1.9	Western larch, Douglas-fir, subalpine fir, Engelmann spruce, mountain hemlock, western hemlock	Mixed-severity: dense stand conditions (>=60 tpa at >=6" dbh) intermixed with non-lethal conditions (as described above) Lethal: even-aged, dense stand conditions (>=60 tpa at >=6" dbh)	Mixed-severity: 50 to 300 ac. Lethal: 5,000 to 100,000 ac. or more
	Lethal	6.2			
Large	Mixed-severity	4.9			
	Lethal	16.1			
Very Large	Mixed-severity	9.7			
	Lethal	31.4			

[a] See text for a full description of "disturbance states" relative to tree sizes (dbh) and number of trees per acre

[b] HRV = Historical Range of Variability

[c] Patch size = may include contiguous similar habitat type classes

Cold Subalpine Fir/Whitebark Pine

Major characteristics – The major characteristics of the Cold Subalpine Fir/Whitebark Pine habitat type class are summarized in Table 18 by disturbance states/structural stages as described in previous sections. Management actions and treatment goals should target restoration of conditions as closely resembling these major characteristics as possible.

Historically these sites exhibited highly variable fire return intervals and were characterized by small discontinuous fire that produced a complex mosaic of conditions. Fire regimes were both mixed-severity and lethal. Mixed-severity fire favors dominance by whitebark pine and lodgepole pine and reduces the occurrence of subalpine fir and Engelmann spruce. Lethal fire conditions are generally open, with both early and late-seral species growing in clusters. Crowns are frequently deformed and trees are stunted, particularly at the high elevation extremes of these sites.

Average basal area on this habitat type class should range from 100 to 223 square feet per acre and 32 to 81 trees per acre ≥ 13" dbh, where large to very large tree structural stages are targeted. Basal areas and number of trees per acre on the low end of these ranges are more commonly associated with disturbance states influenced by the non-lethal and mixed-severity fire regime and those on the higher end of these ranges are usually associated with disturbance states influenced by the lethal fire regime. The probability of large (≥9" dbh) down woody material occurring within large to very large tree structural stages should be moderate and the amount of coarse woody debris should average 7 to 15 tons per acre.

The understory conditions for this habitat type class should target restoration of native grass species and shrubs, as appropriate for the influence of the mixed-severity versus the lethal fire regimes.

Additional recommendations:

- Retain as much as possible of the surviving whitebark pine in current forests and provide openings for its regeneration.
- Planting of blister rust resistant whitebark pine may be necessary, where feasible.
- Maintaining a mosaic of relatively pure and mixed species stands would reflect the historical pattern of mixed-severity and lethal fire regimes.
- Prescribed fire of a patchy nature could be used to benefit the regeneration potential of seral species such as whitebark pine.
- All treatment activities should be very low impact due to the harsh, fragile nature of these sites.

Table 18. Historical stand characteristics and target restoration conditions for the Cold Subalpine fir/Whitebark pine habitat type class.

Disturbance State[a]	Fire Regime	Mean HRV[b](%)	Dominant Tree Species	Description of Disturbance Influenced Conditions	Approximate Patch Size[c]
Seedling		5.5	Whitebark pine, lodgepole pine, subalpine fir, mountain hemlock, Engelmann spruce	Even-aged, moderate density stand conditions with patchy openings	200 to 30,000 acres
Sapling		15.0			
Pole		14.2			
Medium	Non-lethal	1.7	Whtiebark pine; some lodgepole pine	Low density stand conditions (<50 tpa at >=6" dbh) interspersed with small openings (usually <5 acres); all aged	50 to 300 acres
Large		1.2			
Very Large		<1			
Medium	Mixed-severity	2.8	Whitebark pine, subalpine fir, mountain hemlock, Engelmann spruce, alpine larch; trees arefrequently stunted and shrublike due to severe conditions alpine larch	Mixed-severity: moderate density, multi-aged stand conditions (>=50 tpa at >=6" dbh) intermixed with non-lethal stand conditions (see description above) Lethal: multi-aged, relatively open stand conditions; trees frequently clustered	Mixed-severity: 50 to 300 ac. Lethal: 200 to 30,000 acres
	Lethal	10.4			
Large	Mixed-severity	4.2			
	Lethal	15.7			
Very Large	Mixed-severity	6.2			
	Lethal	22.9			

[a] See text for a full description of "disturbance states" relative to tree sizes (dbh) and number of trees per acre

[b] HRV = Historical Range of Variability

[c] Patch size = may include contiguous similar habitat type classes

Moderate, Wet Western Red Cedar

Major characteristics – The major characteristics of the Moderate, Wet Western Red Cedar habitat type class are summarized in Table 19 by disturbance states/structural stages as described in previous sections. Management actions and treatment goals should target restoration of conditions as closely resembling these major characteristics as possible.

Historically these valley bottom sites were frequently characterized by large trees and lush undergrowth in a late successional condition. In general the moist fuel beds and high humidity of these sites were a deterrent to non-lethal fires burning under normal or average conditions. Due to the lush undergrowth and ladder fuels, severe and widespread fires could occur during or following a summer of extreme drought. Under average moisture conditions, lethal fires that enter these stands from adjacent ecological sites, can decrease in intensity and become mixed-severity fires. Narrow valley bottoms or drier sites with this habitat type class are prone to more of a mixed-severity fire regime, whereas broader and wider valley bottoms or moister sites are prone to a lethal fire regime. Sites influenced by the lethal fire regime frequently have old growth characteristics of a fairly open canopy composed of large, evenly-spaced trees. However, dense conditions can also occur, creating a closed canopy with varying levels of understory plants. The mixed-severity fire regime, while less common in this habitat type class, can add to the species and structural diversity of these valley bottom forests.

Average basal area on this habitat type class should range from 268 to 330 square feet per acre and 23 to 37 trees per acre ≥ 25" dbh, where large to very large tree structural stages are targeted. The probability of large (≥9" dbh) down woody material occurring within large to very large tree structural stages should be low to high and average amounts of coarse woody debris should range from 15-32 tons per acre.

The understory conditions for this habitat type class should target restoration of native grass species and shrubs, as appropriate for disturbance states as influenced by the lethal fire regime.

Additional recommendations:

- Retain as much as possible of the surviving western white pine in current forests and provide openings for its regeneration.
- Particular care should be given to protecting the existing water tables and minimizing impacts to soils from compaction during any activities on these sites or adjacent sites.
- Restoration activities may require restoring normal site hydrology through removal of drainage mechanisms or levees/roads that may prevent normal hydrological flow to the site.

Table 19. Historical stand characteristics and target restoration conditions for the Moderate, Wet Western Red Cedar habitat type class.

Disturbance State[a]	Fire Regime	Mean HRV[b](%)	Dominant Tree Species	Description of Disturbance Influenced Conditions	Approximate Patch Size[c]
Seedling		1.2	Engelmann spruce, subalpine fir,western red cedar, western hemlock, and small amounts western white pine, western larch, Douglas-fir; with riparian shrubs and woody trees on wetter sites	Even-aged, dense stand conditions	Varies with size of valley bottom and adjacent habitat types
Sapling		3.6			
Pole		3.5			
Medium	Non-lethal	<1	na[d]	na	na
Large		<1			
Very Large		0			
Medium	Mixed-severity	<1	Western red cedar, western hemlock, grand fir, Engelmann spruce, western white pine, western larch	Mixed-severity: dense stand conditions (>=60 tpa at >=6" dbh) intermixed with patches of residual lower density, very large western larch in the overstory Lethal: multi-aged, multi-storied, dense stand conditions (>=60 tpa at >=6" dbh) with a shade tolerant understory	Varies with size of valley bottom and adjacent habitat types
	Lethal	2.0			
Large	Mixed-severity	3.9			
	Lethal	11.6			
Very Large	Mixed-severity	18.3			
	Lethal	54.8			

[a] See text for a full description of "disturbance states" relative to tree sizes (dbh) and number of trees per acre

[b] HRV = Historical Range of Variability

[c] Patch size = may include contiguous similar habitat type classes

[d] na = not applicable, functionally did not occur

Cool, Wet Subalpine Fir/Mountain Hemlock

Major characteristics – The major characteristics of the Cool, Wet Subalpine Fir/Mountain Hemlock habitat type class are summarized in Table 20 by disturbance states/structural stages as described in previous sections. Management actions and treatment goals should target restoration of conditions as closely resembling these major characteristics as possible.

Historically these valley bottom sites were frequently characterized by large trees and lush undergrowth in a late successional condition. In general the moist fuel beds and high humidity of these sites are a deterrent to non-lethal fires burning under normal or average conditions. Due to the lush undergrowth and ladder fuels, severe and widespread fires could occur during or following a summer of extreme drought. These sites frequently exhibit old growth characteristics of a fairly open canopy composed of large, evenly-spaced trees. However, dense conditions can also occur, creating a closed canopy with varying levels of understory plants.

Average basal area on this habitat type class should range from 80 to 229 square feet per acre and 42 to 51 trees per acre ≥ 13" dbh, where large to very large tree structural stages are targeted. The probability of large (≥9" dbh) down woody material occurring within large to very large tree structural stages should be moderate to high and average amounts of coarse woody debris should range from 12-25 tons per acre, depending on the individual habitat type.

The understory conditions for this habitat type class should target restoration of native grass species and shrubs, as appropriate for the lethal fire regime.

Additional recommendations:

- Particular care should be given to protecting the existing water tables and minimizing impacts to soils from compaction during any activities on these sites or adjacent sites.
- Restoration activities may require restoring normal site hydrology through removal of drainage mechanisms or levees/roads that may prevent normal hydrological flow to the site.

Table 20. Historical stand characteristics and target restoration conditions for the Cool, Wet Subalpine fir habitat type class.

Disturbance State[a]	Fire Regime	Mean HRV[b] (%)	Dominant Tree Species	Description of Disturbance Influenced Conditions	Approximate Patch Size[c]
Seedling		<1	Lodgepole pine, subalpine fir, Engelmann spruce; with riparian shrubs and woody trees on wetter sites	Dense stand conditions; even-aged	Varies with size of valley bottom and adjacent habitat types
Sapling		2.5			
Pole		2.4			
Medium	Non-lethal	<1	na[d]	na	na
Large		<1			
Very Large		0			
Medium	Lethal	2	Subalpine fir, mountain hemlock, Engelmann spruce, lodgepole pine	Multi-aged, dense stand conditions (>=60 tpa at >=6" dbh)	Varies with size of valley bottom and adjacent habitat types
Large		14.9			
Very Large		77.1			

[a] See text for a full description of "disturbance states" relative to tree sizes (dbh) and number of trees per acre

[b] HRV = Historical Range of Variability

[c] Patch size = may include contiguous similar habitat type classes

[d] na = not applicable, functionally did not occur

Additional Considerations

The following additional restoration considerations apply to all ecological sites.

- ### Patch Distributions

Distribution of ecosystems with low levels of representation, as discussed above, could be important for maintaining persistence of species favored by the habitat conditions provided by these ecosystems. However, in the Northern Rockies, historical landscapes contained a mosaic of ecosystems, both spatially and temporally, created by different abiotic patterns as well as disturbance effects. Species in these fire-dependent landscapes were adapted to relatively high levels of disturbance compared to other areas such as the coastal forests of Washington. In northern Idaho, these fire regimes were largely mixed severity and high severity. The mixed-severity regimes, in particular, produced a mosaic of landscape conditions. With matrix conditions in this landscape maintained in favorable conditions (e.g., forest), distributional concerns for species dispersal would be minimal (Bunnel 1999). It is unlikely that any species would develop problems associated with population discontinuities under these conditions. Exceptions could occur if major barriers to movements, such as a fenced highway bisecting the landscape, occurred. Potential population discontinuities could be checked using movement capability models for selected species applied to the actual landscape conditions.

- ### Invasive species

Treated sites should be monitored for multiple years to ensure that invasive species were not introduced or exacerbated during treatment. Existing invasive weed problems should be addressed prior to treatment or prescribed burning to reduce their potential for spread.

- ### Monitoring

Monitoring of treatments and their effects are needed to improve restoration planning and implementation, modify future treatments, and communicate progress toward restoration goals. The results of monitoring should be incorporated into restoration planning for future treatment through an adaptive management process. Grazing should not be allowed on sites that are in the process of being restored. Grazing on restored sites should be closely monitored to ensure understory species composition continues to represent historical conditions and diversity.

- ### Old growth forest conditions

Old growth has been defined in a number of ways, and the specifics of old growth varies for each ecological site and by type of fire regime. Stands in very large tree categories should be evaluated for old growth characteristics consistent with that ecological site and fire regime. Existing old growth conditions should be maintained and opportunities for establishing additional old growth conditions should be identified, wherever possible. For example, stands representing the very large tree-lethal fire category should be encouraged to develop old growth characteristics. These conditions could include higher levels of dead and down woody material, dominance of shade-tolerant species, larger and older trees, and similar characteristics. Green et al. (1992) developed descriptions of old growth conditions for the northern Idaho planning region that would be helpful in the identification of existing old growth as well as in restoration of future old growth conditions.

THE FINE FILTER

Maintaining or restoring an appropriate level of native ecosystem diversity throughout the northern Idaho planning area is the goal of the coarse filter. The assumption of this approach is that by providing representation of native ecosystem diversity, not only will ecosystem integrity be maintained, but the habitat needs and future persistence of all native species will also be provided. Adequate representation involves providing designated amounts of each native ecosystem as well as considering the sizes and distribution of the representation areas. Because the goal is to provide representation, not a return of the landscape to historical conditions, the selected level of representation should be assessed for its abilities to meet these needs by checking whether a species will have high probabilities of persistence into the future. Thus, the approach of providing representation of native ecosystems (coarse filter) combined with the assessment of the habitat needs of selected species of concern (fine filter) will check the adequacy of the coarse filter as the primary conservation strategy and form the basis for a conservation plan.

To check on the adequacy of the coarse filter, nine species of concern were selected for IDL lands in northern Idaho. The nine species of concern evaluated were:

1) Canada lynx
2) Selkirk Mountains Woodland Caribou
3) Fisher
4) Boreal Chickadee
5) Boreal Owl
6) Flammulated Owl
7) Black-Backed Woodpecker
8) Goshawk
9) Great Gray Owl

The nine species were selected from a list of 13 federally listed species and 22 state listed species that may occur on IDL's land base. The process for selection considered those species most likely to be influenced by forest management activities, with the following exclusions: grizzly bear and bald eagles which are already addressed through various plans and agreements that IDL has incorporated into its forest operations, and the gray wolf which occurs in the area, but its management needs are not as closely linked to forest management activities. In addition, plant species and wildlife or fish species associated with riparian/wetland and aquatic ecosystems were not included in this project.

Population persistence was evaluated for each of these nine species using a habitat-based species viability approach. These models and processes were developed and used to evaluate the adequacy of the coarse filter relative to the representation goal of 20% identified by Idaho Department of Lands for the northern Idaho planning landscape. The habitat-based species viability approach mapped and compared the quality of individual home ranges for the 9 selected species under historical, current, and proposed future conditions using methods described by (Roloff and Haufler 1997, Roloff and Haufler 2002). These results were then used to evaluate whether proposed levels of representation will be sufficient to provide an acceptable probability of viability for the focal species, thus serving as a check on the ecosystem diversity approach to biodiversity conservation and that forms the foundation for a habitat conservation plan.

SPECIES ASSESSMENTS

The habitat-based species viability assessment determines habitat quality for each species by developing a habitat potential map applied at the scale of the home range of the species. Each potential home range is "grown" in a GIS analysis by randomly selecting a starting point of a pixel with the highest habitat quality that has not already been incorporated into a home range, and building a new home range that is "grown" until it acquires an adequate amount of resources for a territory of the species to exist. Each identified home range is then evaluated for its resulting habitat quality based on how far each territory is spread out to obtain the required resources to survive and/or reproduce. Each identified home range is given a resulting value, and placed in a high, medium, low, or very low category. It is the number of high and medium quality home ranges that indicate the highest and next highest likelihood of persistence, followed by the number of low and very low quality home ranges. Low and very low quality home ranges and non-habitat are not expected to contribute substantially to long-term population persistence (Roloff and Haufler 2002).

Modeling Approach – Habitat-based Species Viability Models

A habitat model for each species was developed using relationships described in existing reported models as well as from information in the literature. For some species, good quantitative habitat information was available. For other species, quantitative information was lacking, and the relationship between vegetation features and habitat quality was estimated based on more general descriptions of habitat for the species. For each species, the HSI model was run using 4 different GIS base-layers that included:

1. The estimated mean historical range of variability for native ecosystem diversity (also referred to as historical conditions),
2. Existing ecosystem conditions (also referred to as current conditions),
3. Existing ecosystem conditions on both USFS and private lands combined with restoration of 20% of the historical ecosystem conditions on IDL lands only (also referred to as future conditions, IDL only), and
4. Existing ecosystem conditions combined with restoration of 20% of the historical ecosystem conditions on IDL lands and all other lands in the planning region, regardless of ownership (also referred to as future conditions, all lands).

In this manner, proposed forest restoration actions of IDL can be evaluated for future responses by the species included in the Conservation Plan. Each polygon in each of the 4 base-layers were assigned a "cell" call, where "cell" refers to the intersection of the habitat type class and disturbance state of the ecosystem diversity matrix.

Where available, Forest Inventory and Analysis (FIA) data were used to quantify vegetative characteristics for habitat variables of a given cell of the existing conditions matrix. This was done by calculating a HSI value for each habitat variable for each species of interest. There were 18 cells in the matrix that had a large enough sample size (n>6) of FIA plots to calculate standard deviation and standard error for each habitat variable. For most habitat variables measured in a standard fashion across all plots (i.e. trees per acre, diameter at breast height, and tree height) we calculated three values. These were the mean, the mean plus the standard deviation, and the mean minus the standard deviation. A small subset of habitat variables was sampled inconsistently or was not adequately captured with the standard FIA sampling protocol. These variables were snags per acre, canopy cover of boreal lichens, canopy cover of shrubs, deciduous trees per acre, deciduous tree diameter at breast height, and deciduous tree canopy cover. Due to the high degree of variation in these variables, the calculated values we used were the mean, the mean plus the standard error, and the mean minus the standard error. Using the calculated habitat values, we were able to generate HSI scores for each species of interest for each of the 18 cells.

For the remaining cells in the existing conditions matrix and all the cells in the historical conditions matrix, specific information on stand characteristics relative to habitat variables was not available. For this reason, we assigned HSI values based on existing literature and our best understanding of the vegetative characteristics of a cell relative to the habitat requirements of the target species. For cells that would have had a high degree of natural variation (such as stands with very large trees and a mixed severity fire regime) we assigned a range of three values to correspond with the process described above for cells with plot data. Each species specific description includes a table with these assigned values.

For each species, the next processing step was to give each of the 4 GIS base-layers an HSI score for each polygon, based on its cell call. Scores were assigned to polygons programmatically using a script written and executed in the database program Microsoft® Visual FoxPro® 9.0. For cells with a single HSI value, 100 percent of the acres got that value, but for cells with three HSI values the values were assigned with a 25/50/25 percent split. The mean value was assigned to 50 percent of the acres and minimum and maximum values (plus or minus the standard deviation) were assigned to 25 percent of the acres respectively. For the 2 GIS base-layers that combined both existing conditions with restoration of 20% of the historical condition, HSI scores were taken from both the existing conditions matrix and the historical conditions matrix, as appropriate. To prevent further fragmentation of the landscape under the combined conditions layers, HSI values were assigned at the stand polygon level. As a result, some cells with small acreages may not have an exact 25/50/25 percent split. For the historical model, polygons were based on habitat type classes, which in some instances could be quite large, so we used a grid with 100 acre cells to break the layer into manageable polygons of habitat type combined with disturbance states. This process allowed the larger habitat type polygons to be broken into smaller disturbance state polygons and enabled us to achieve a 25/50/25 percent split of acres within each cell for the historical modeling efforts.

Based on the species HSI values for each polygon, a habitat quality grid was developed in ESRI® Arcinfo 8.3 for each species. This grid displayed general habitat quality of the landscape for each species. Based on the scale of input data the grid cell size was 30 m. Using this grid, the next step in the habitat-based species viability process was to evaluate habitat quality as it is used by each species in identifying potential home ranges.

Home ranges for each species were modeled using the final HSI grids and the program HOMEGROWER. HOMEGROWER aggregates required elements into appropriate sized home ranges for each species within the planning landscape. Each species has minimum and maximum home range sizes that it will utilize. The quality of the habitat elements required by a species contained within a delineated home range determines the quality of that home range for the species. The quality of each potential home range delineated by HOMEGROWER is evaluated based on the amounts and distribution of the required habitat elements for the species occurring within each home range. This process has been described in publications by Roloff and Haufler (1997, 2002).

HOMEGROWER works by placing starting points, or seeds, throughout the landscape. The starting number of seeds varies by species, but enough are needed to insure that all high quality habitat areas are occupied. This is because the species viability component assigns high viability associated with higher quality home ranges, and lower viability with lower quality home ranges. If enough high quality home ranges followed by moderate quality home ranges occur, it doesn't matter if additional low quality home ranges also occur- the species should do well in the landscape. If only low quality home ranges exist for the species, then the viability of the species will have a much lower probability in the landscape. While exact probability estimates for each species in the landscape are not computed, comparisons of amounts of high, medium, and low quality home ranges can be compared among existing, future, and historical landscapes and allow for the determination of the likely response in terms of general viability potential of the species to management actions. This comparative approach to viability assessments, as opposed to efforts to directly estimate probabilities, has been recommended as the most supportable way of using viability assessments (Beissinger and Westphal 1998, Ralls et al. 2002, Samson 2002, Beissinger et al. 2009).

From each seed, HOMEGROWER builds home ranges by evaluating the cells around the seed and growing the home range into the cells of highest quality. The number of cells considered in each time step is called the growth window. The size of the growth window will vary due to the spatial scale at which each species uses the landscape. For species with potentially large home ranges, more cells are added in each time step or growth window. Cells are accumulated until the growth target, expressed as total HSI scores for that species has been met. HSI scores are tallied based on area X the habitat quality for each pixel that is added to the home range.

The target for each species is based on a multiplier of its allometric home range. Allometric home ranges are the estimated minimum area that a species could occur in based on its estimated metabolic requirements (Noon et al. 2009). For mammals, we assigned target values as 2x the allometric home range. For birds, with their higher metabolic rates and greater movement capabilities, we assigned target values as 5x the allometric home range.

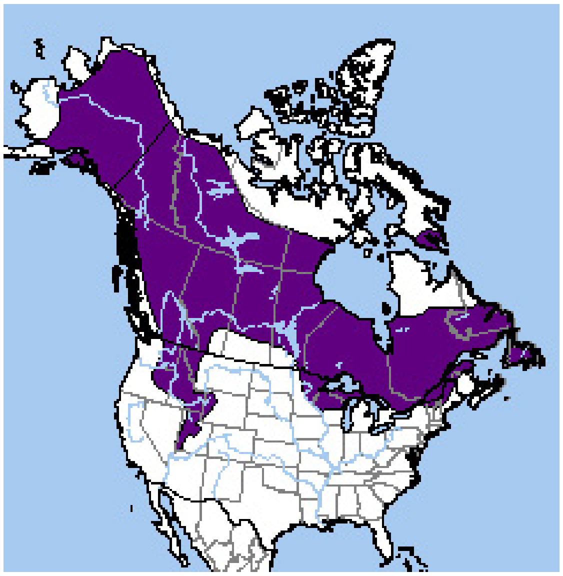
For example, if a bird had an allometric home range of 100 acres, its targeted home range requirements would be 500 acres- or 500 HSI units. This could be met with a home range of 500 acres if all units in that home range contributed 1.0 in HSI value, and would receive an overall home range quality of 1.0, and then be designated a high quality home range. However, this never actually occurs in the real world. Home ranges are typically comprised of patches of habitat for the species of varying quality. HOMEGROWER builds home ranges for a species by starting with a pixel of the highest quality in the landscape that has not already been included in another home range. It then grows by aggregating pixels of the next highest quality until it has acquired the HSI units desired for the species, in this case, 500 units. An upper threshold of size is set, beyond which HOMEGROWER ceases attempting to build a home range if the distances become too great to be utilized by the species. If in this example, HOMEGROWER identified a potential home range that took 900 acres to reach its target, it would be mapped as a home range, assigned an average HSI value of 0.56, and would be designated a medium quality home range. This process is repeated for the number of starting seeds identified for the species. If the number of seeds has quantified all of the high, medium, and low quality home ranges, then the number of initial seed is deemed sufficient to assess the landscape quality for that species.

This analysis produces a map of home ranges of varying quality distributed across the landscape for each species. High quality home ranges are assumed to have high rates of occupancy, support high reproductive rates, and have high survival rates, thus providing good demographic support of the population of the species (Roloff and Haufler 2002). Kroll and Haufler (2006) documented this to occur for occupancy rates and reproductive rates using empirical analysis of dusky flycatcher habitat in Idaho.

Because HOMEGROWER uses a random selection of the highest quality pixels available, it has a stochastic component. Therefore, we ran 3 separate iterations of HOMEGROWER for each species, and averaged the values generated for numbers of home ranges. There was very little difference among the three runs for any species, so we determined that additional runs were not warranted. Runs were conducted for the entire landscape based on existing conditions, future conditions, and historical conditions.

Model Descriptions and HOMEGROWER Results

Canada lynx (*Lynx canadensis*)



Current general range of the Canada lynx in North America (Patterson et al. 2005).

The Canada lynx is a medium-sized forest carnivore found in boreal, montane, and subalpine forest. They are morphologically adapted to forage successfully in acres with deep and persistent snow (Koehler and Aubry 1994). Winter foraging habitat has been identified as the most critical component dictating lynx population size and distribution (Miller et al. 2005). Ideal winter foraging habitat supports high numbers of snowshoe hares (*Lepus americanus*), the primary prey of the lynx (Ruggiero et al. 2000, Miller et al. 2005). Snowshoe hares are most abundant in early successional stands and late successional heterogeneous stands with high levels of horizontal cover (Koehler and Aubry 1994, Thomas et al. 1997, Ruggiero et al. 2000). Hare use reaches the highest levels when horizontal cover of above snow vegetation is ≥50% (Carreker 1985, Parker 1986). Dense cover provides the hares with critical food, cover, and thermal protection (Litvaitis et al. 1985, Hodges 2000). When horizontal cover drops below 10% the habitat is considered unsuitable (Thomas et al. 1997).

The second requisite component for Canada lynx is denning habitat. The most critical feature of ideal denning habitat is high densities of coarse woody debris (Koehler 1990, Mowat et al. 2000, Miller et al. 2005). The highest levels of coarse woody debris are typically found in late successional stands with low levels of disturbance (Miller et al. 2005). In north central Washington, four den sites were found in stands >200 years old with overstories composed of Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*) and high amounts of downed trees (Koehler 1990).

The final habitat component for Canada lynx is traveling cover. Lynx generally avoid open areas with <420 trees/ha (170 trees/ac) (Koehler and Brittell 1990), but have been shown to cross openings <100m (328 ft) in width (Koehler 1990, Koehler and Aubry 1994). Ideal traveling cover is >2m (6.56 ft) in height with >70% canopy cover and connects foraging and denning areas (Koehler and Brittell 1990, Miller et al. 2005). So, optimum Canada lynx habitat is a mosaic of early successional stands with high levels of horizontal cover for foraging, late successional stands with dense pockets of coarse woody debris for denning, and linkage areas with sufficient cover to provide security for travel between foraging and denning areas (Koehler and Aubry 1994).

The lynx model we used was based on the work of Roloff (unpublished) and consists of three main components. This model has been tested in a study conducted in Canada (Nylen-Nemetchek 1999) and found to predict actual lynx distributions with good accuracy, and has been used by the State of Washington to address lynx considerations for Forest Practices in northeast Washington. The first component of the model is the number of snowshoe hare home ranges (lynx winter foraging). This requires creating a habitat suitability index (HSI) for snowshoe hares (Carreker 1985). The snowshoe hare model uses total vertical and horizontal cover of vegetation (Figure 12) and total vertical (Figure 13) and horizontal cover (Figure 14) of food species to predict HSI values. It also uses understory (≤3m; 9.84 ft) cover type where an evergreen stand received an HSI of 100, a mixed stand received a 75, and a deciduous stand received a 50. The final snowshoe hare HSI is calculated by first taking the geometric mean of cover type and the mean of vertical browse and security cover. This value is then combined with the mean of horizontal browse and security cover using a geometric mean. At this point the HSI values for EDM cells without stand data were assigned (Table 21).

HOMEGROWER was used to predict the total number of snowshoe hare home ranges in the landscape. Hare home ranges with a mean HSI value ≥0.6 were assigned a rating of two and home ranges with a mean HSI value ≥0.25 but <0.6 were assigned a one. These scores were then summed within 860 ha (2125 ac) areas using a moving window of 97x97 cells. Areas with a score ≥90 where assigned an HSI of 1.0 and areas <90 were assigned HSI values using the equation: $y = 0.011x$ (where x = the score). This output served as the lynx winter foraging HSI grid.

The other component of the model is lynx denning habitat. This component consists of two parts; lynx denning and lynx summer foraging. For denning, vegetation types classified as forested with a mean stand diameter of 25 cm (9.84 in) providing ≥ 3.72 m^2/ha (16.2 ft^2/ac) of basal area on mesic sites and having >50% tree canopy cover were assigned an HSI of 0.75 and stands with canopy cover >75% were assigned an HSI value of 1.0. Lynx summer foraging was based on vertical security cover available for snowshoe hares (Figure 15). HSI values for EDM cells without stand data were assigned (Table 21). The geometric mean of the denning and summer foraging values was used to calculate the final lynx denning HSI grid.

The final lynx HSI grid was created by taking the geometric mean of the winter foraging and denning grids. This grid was then contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER (Figure 16). The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for an 8.5 kg (18.7 lb) female lynx is 860 ha (2125 ac) or 97x97 grid cells (Lindstedt et al. 1986).

Three iterations were run in HOMEGROWER. The target home range area was 2 times the allometric home range or 1720 ha (4250 ac). The number of seeds was 150,000 and the growth window was 25 cells. Figure 17 depicts home range quality for current conditions. The number of very low quality home ranges was not delineated.

The values used to create the Canada lynx HSI grid for historical conditions are presented in Table 22. Figure 18 is the grid used in HOMEGROWER for historical conditions. The same run parameters were used for both the current conditions and historical conditions model. Figure 19 depicts home range quality for historical conditions. The number of very low quality home ranges was not delineated.

The values used to create the Canada lynx HSI grids for future conditions were a combination of the values used for the current conditions and historical conditions. Areas modified to achieve reference conditions received historical conditions values and all other areas received current conditions values.

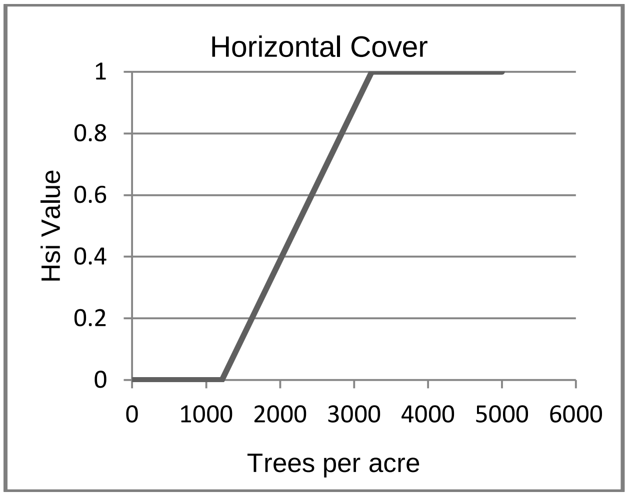


Figure 12. Relationship between trees per acres and HSI values for horizontal browse and security cover for snowshoe hare. The equation between 1215 and 3239 is *y=0.049x-60.01*.

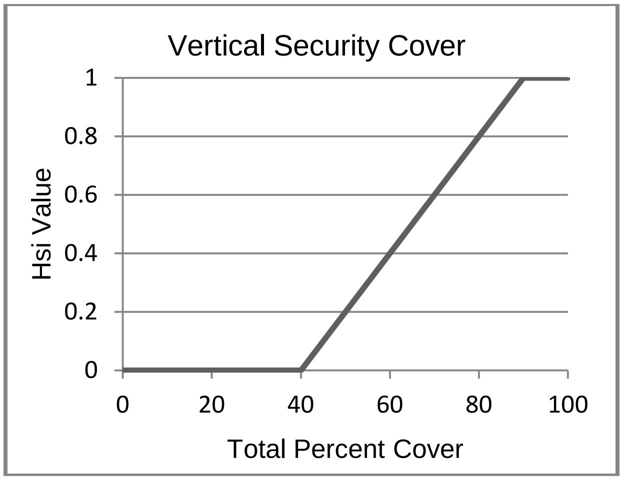


Figure 13. Relationship between tree and shrub canopy cover and HSI values for vertical security cover for snowshoe hare. The equation between 40 and 90 is *y=2x-80*.

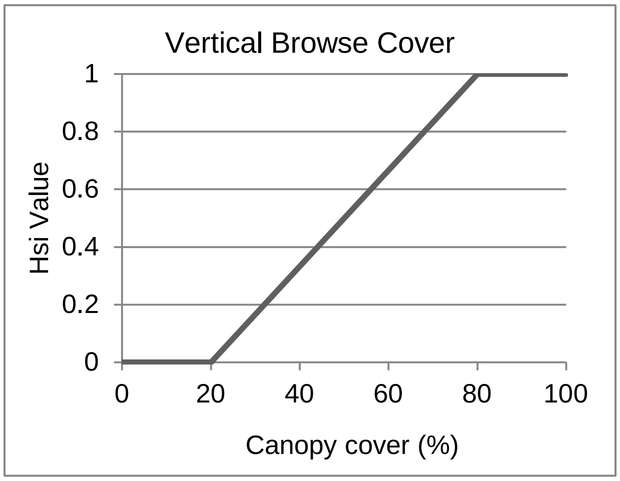


Figure 14. Relationship between canopy cover of browse species and HSI values for vertical browse cover for snowshoe hare. The equation between 20 and 80 is *y=1.666x-33.333*.

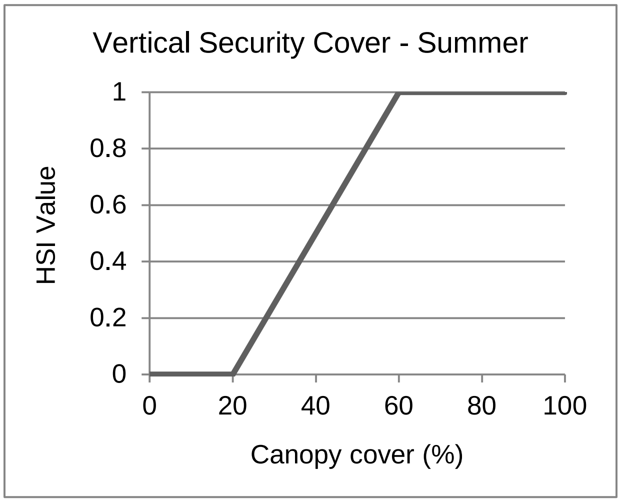


Figure 15. Relationship between summer canopy cover and HSI values for snowshoe hare vertical security cover. The equation between 20 and 60 is $y=0.025x-0.5$.

Figure 20 is the grid used in HOMEGROWER for future conditions applied only to IDL ownership and Figure 22 is the grid used in HOMEGROWER for future conditions applied to all ownerships. The same run parameters used for the current conditions model were also used for the future conditions models. Figure 21 depicts home range quality for future conditions applied only to IDL ownership and Figure 23 depicts home range quality for future conditions applied to all ownerships. The number of very low quality home ranges was not delineated. The mean numbers of Canada lynx home ranges of high, medium, and low quality resulting from the modeling effort are presented as follows for historical, current and future conditions.

	Historical Conditions	Current Conditions	Future Conditions (IDL)	Future Conditions (All Lands)
High (1.0-0.75)	0	0	0	0
Medium (<0.75-0.5)	47	19	18	24
Low (<0.5-0.25)	3	36	36	33

Run results were very similar between historical, current, and future conditions. This is likely the result of several factors. One, current patterns of human disturbance (particularly timber harvest) create good quality snowshoe hare habitat after stand regeneration has occurred. Also, the patchy ownership and thus differing management objectives creates a mosaic of young and old stands, somewhat mimicking the conditions created by historical fire regimes. Second, Canada lynx are at the southern fringe of their range in the planning landscape and the number and quality of home ranges in all the models clearly demonstrates the negative influence this has on potential population viability. Finally, the greatest changes in ecosystem conditions in the planning landscape has occurred in drier, low elevation habitat types that were not historically Canada lynx habitat.

Table 21. HSI values for snowshoe hare, lynx summer foraging, and lynx denning used in the current conditions model (* Where available, the mean and ± one standard deviation for each relevant habitat variable from FIA stand data was used to calculate three HSI scores).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
HSI Values for Snowshoe Hares									
SEEDLING	0	10	35	50	50	50	50	25	50
SAPLING	0	10	35	75	100	100	75	25	75
POLE	0	10	35	65	75	75	65	25	65
MEDIUM-NL	0	10	25	40	50	50	50	10	100
LARGE-NL	0	0	25	35	35	35	35	10	100
VERY LARGE-NL	0	0	10	30	30	30	30	0	0
MEDIUM-L	0-25-44*	30-43-54*	23-41-56*	20	23-39-53*	22-38-52*	20	10	10
LARGE-L	0	19-35-49*	17-38-54*	20-40-60	28-41-53*	22-39-54*	10-30-50	20-40-60	20-40-60
VERY LARGE-L	13-34-51*	23-40-54*	13-37-55*	13-36-53*	27-44-60*	25-42-57*	12-33-54*	29-44-58*	20-39-55*
HSI Values for Lynx Summer Foraging									
SEEDLING	0	10	35	50	50	50	50	25	50
SAPLING	0	10	35	75	100	100	75	25	75
POLE	0	10	35	65	75	75	65	25	65
MEDIUM-NL	0	10	25	40	50	50	50	10	100
LARGE-NL	0	0	25	35	35	35	35	10	100
VERY LARGE-NL	0	0	10	30	30	30	30	0	0
MEDIUM-L	0-0-3*	0-72-100*	0-51-100*	20	0-80-100*	0-88-100*	20	10	10
LARGE-L	0	0-4-45*	0-41-100*	20-40-60	0-54-100*	2-53-100*	10-30-50	20-40-60	20-40-60
VERY LARGE-L	0-0-30*	0-29-93*	0-29-100*	0-0-24*	0-56-100*	0-44-100*	0-50-100*	0-0-97*	0-0-7*
HSI Values for Lynx Denning									
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	10	10	10	10	10	10
POLE	0	0	0	10	10	10	10	10	10
MEDIUM-NL	0	0	0	10	40	40	50	50	100
LARGE-NL	0	0	0	20	35	35	40	50	100
VERY LARGE-NL	0	0	0	20	30	30	30	0	0
MEDIUM-L	0-0-0*	0-14-46*	0-38-81*	40	0-20-53*	0-14-44*	50	50	100
LARGE-L	0	25-57-90*	45-75-100*	45	0-38-78*	17-60-100*	40	50	100
VERY LARGE-L	0-0-0*	8-49-90*	35-72-100*	16-63-100*	0-38-79*	19-58-98*	0-38-77*	22-66-100*	0-43-88*

Table 22. HSI values for snowshoe hare, lynx denning, and summer foraging used in the historical conditions model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
HSI Values for Snowshoe Hare - Historical									
SEEDLING	0	10	35	50	50	50	50	25	50
SAPLING	0	10	35	75	100	100	75	25	75
POLE	0	10	35	65	75	75	65	25	65
MEDIUM-NL	0	10	25	40	50	50	50	10	100
LARGE-NL	0	0	25	35	35	35	35	10	100
VERY LARGE-NL	0	0	10	30	30	30	30	N/A	N/A
MEDIUM-L	0	10	10	20	20	20	20	10	10
LARGE-L	0	0	20-40-60	20-40-60	20-40-60	20-40-60	10-30-50	20-40-60	20-40-60
VERY LARGE-L	0	0	20-40-60	20-40-60	20-40-60	20-40-60	10-30-50	20-40-60	20-40-60
HSI Values for Canada Lynx Denning and Summer Foraging - Historical									
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	10	10	10	10	10	10
POLE	0	0	0	10	10	10	10	10	10
MEDIUM-NL	0	0	0	10	40	40	50	50	100
LARGE-NL	0	0	0	20	35	35	40	50	100
VERY LARGE-NL	0	0	0	20	30	30	30	N/A	N/A
MEDIUM-L	0	0	0	40	40	40	50	50	100
LARGE-L	0	10	10	45	45	45	40	50	100
VERY LARGE-L	0	10	50-75-100	50-75-100	50-75-100	50-75-100	50-75-100	50-75-100	100

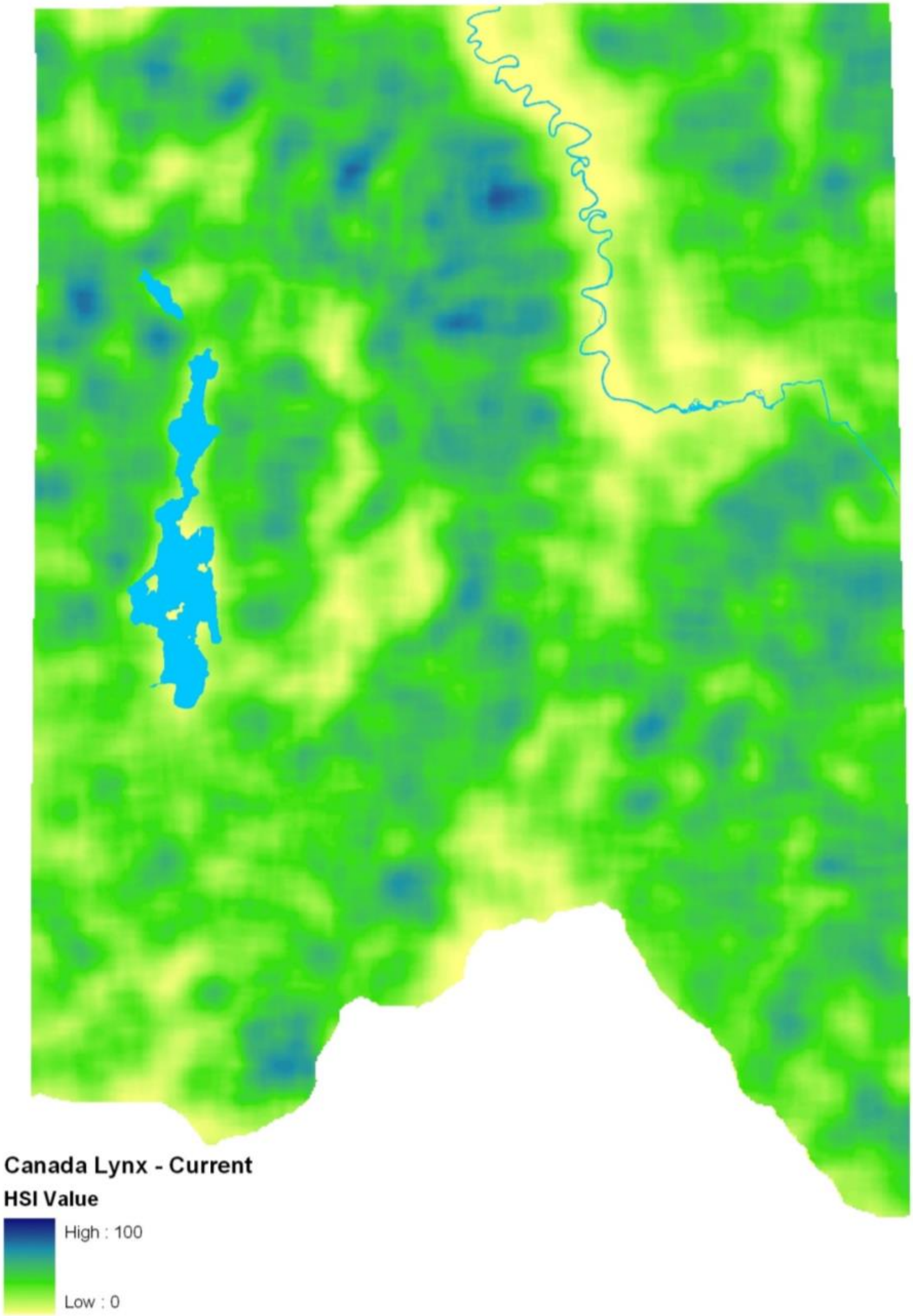


Figure 16. Current habitat suitability index for Canada lynx within the IDL planning landscape.

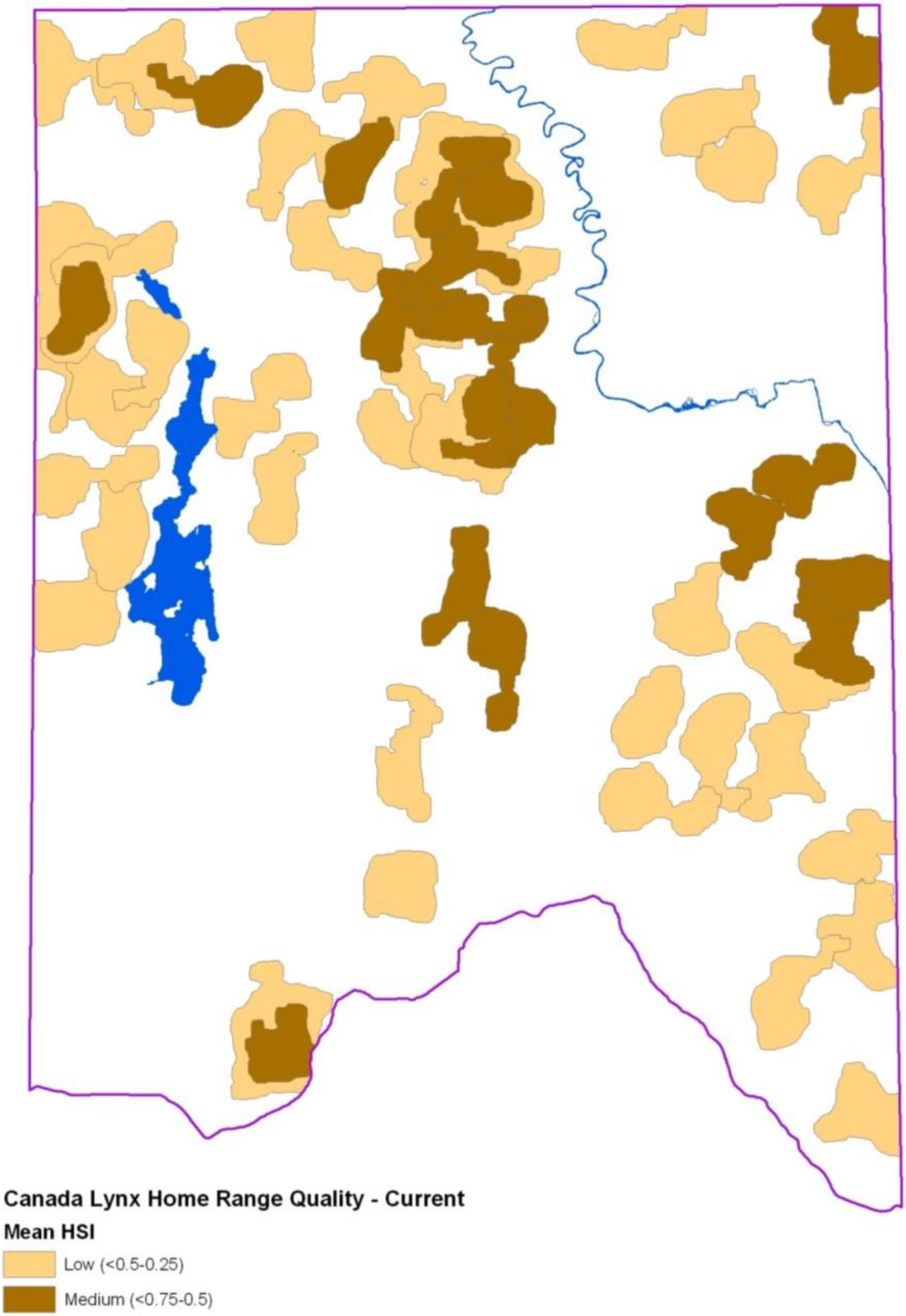


Figure 17. Current home range quality (mean HSI) for Canada lynx within the IDL planning landscape.

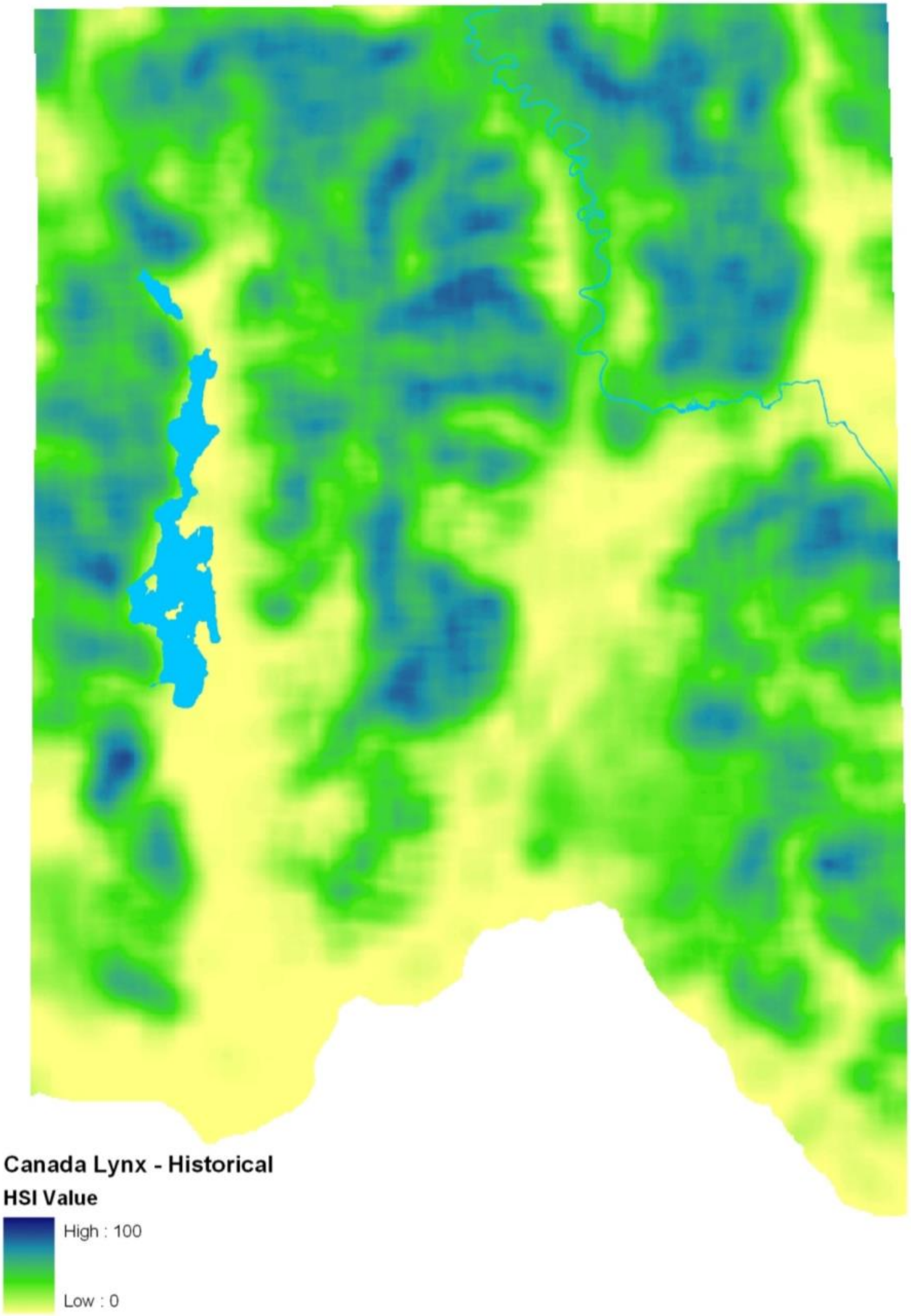


Figure 18. Historical habitat suitability index for Canada lynx within the IDL planning landscape.

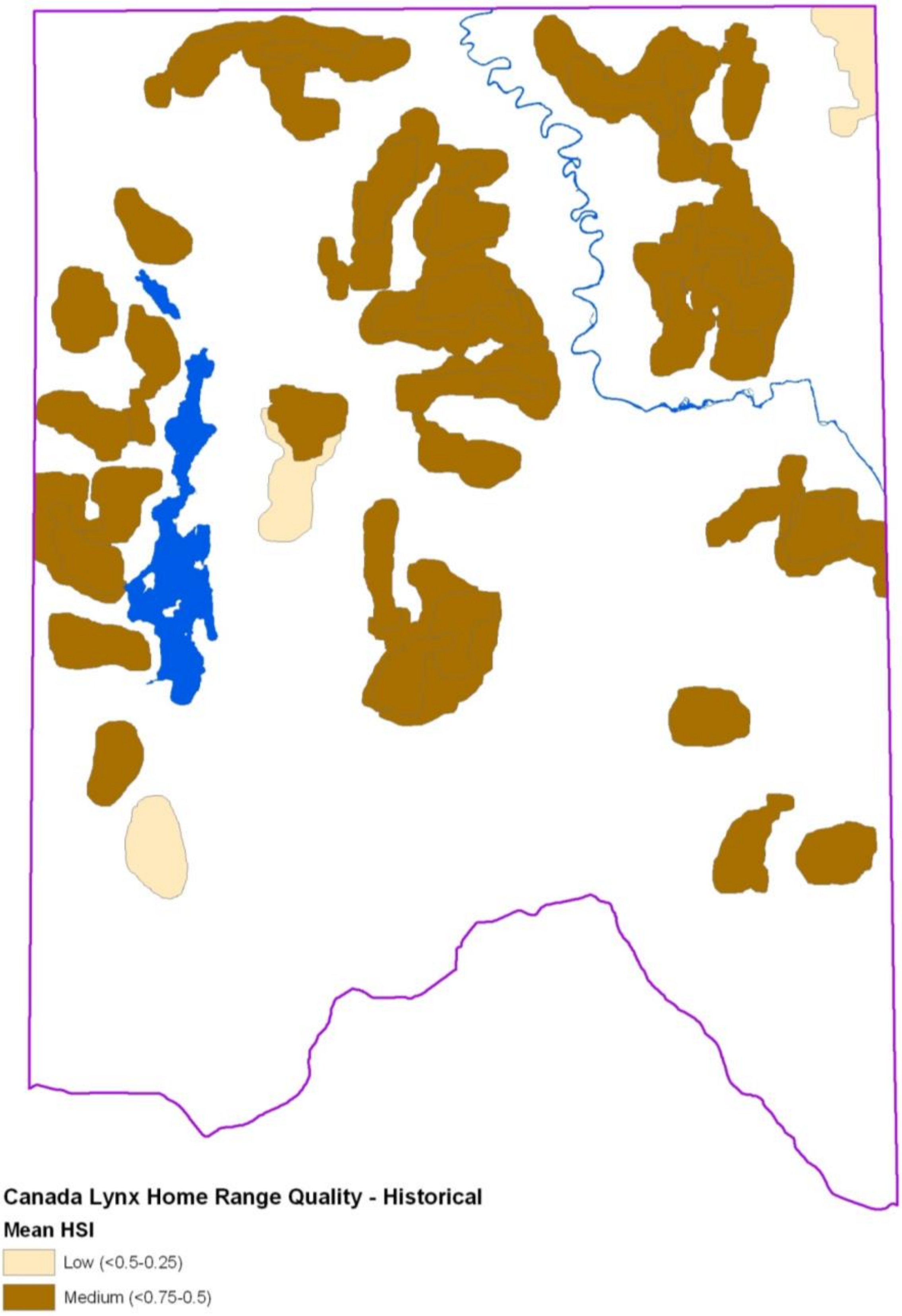


Figure 19. Historical home range quality (mean HSI) for Canada lynx within the IDL planning landscape.

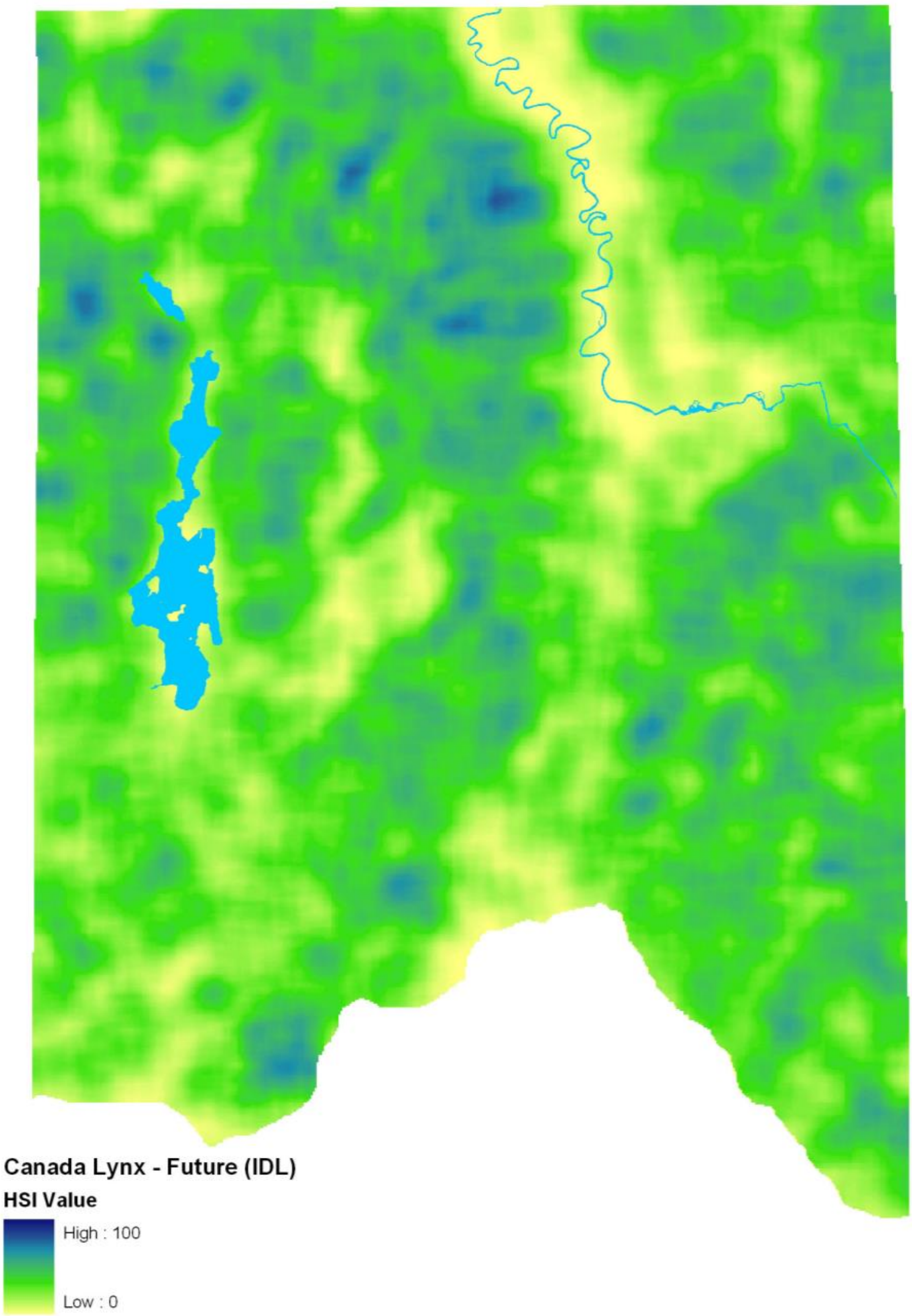


Figure 20. Future habitat suitability index for Canada lynx with 20% representation on IDL ownership only.

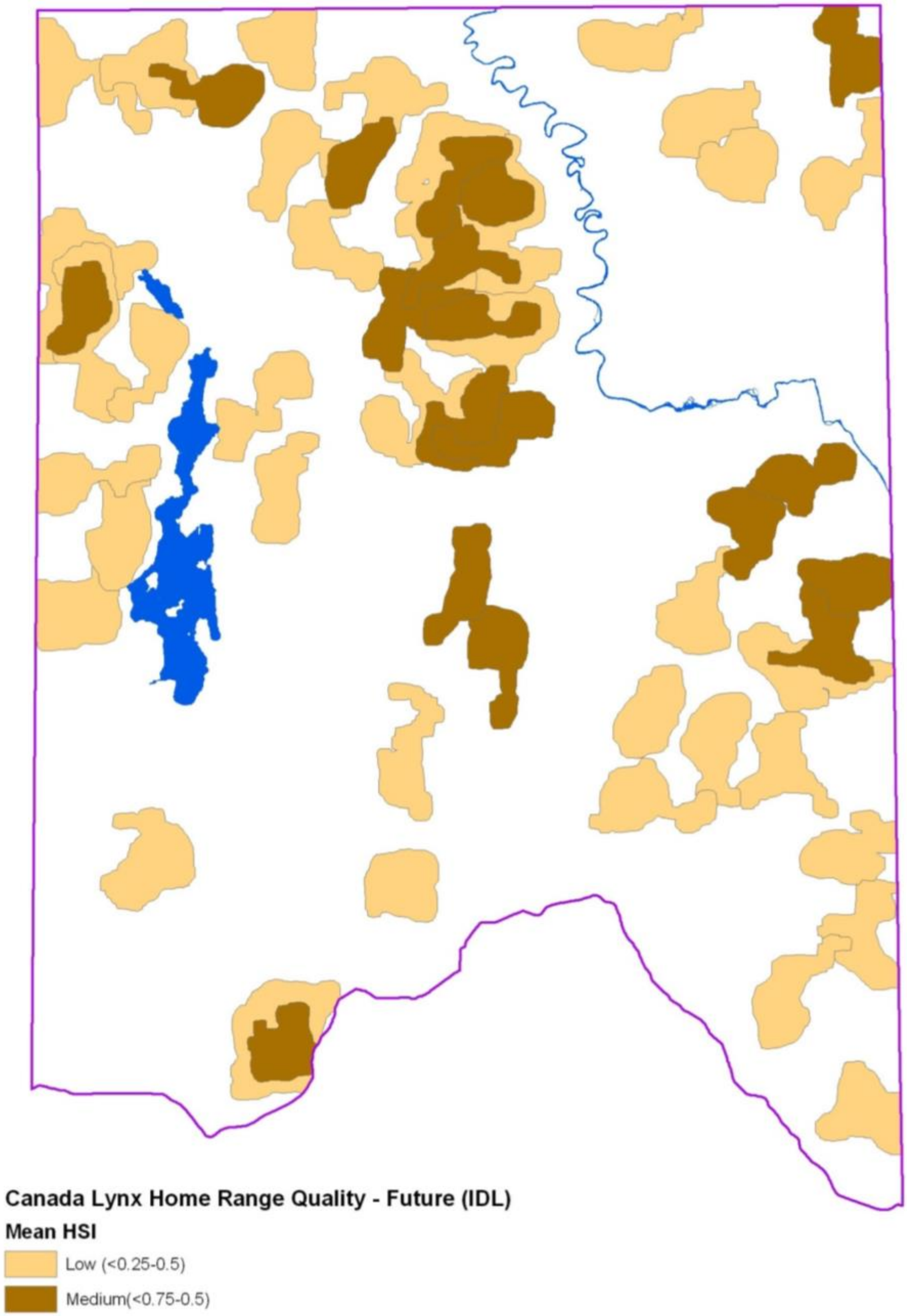


Figure 21. Future home range quality for Canada lynx with 20% representation on IDL ownership only.

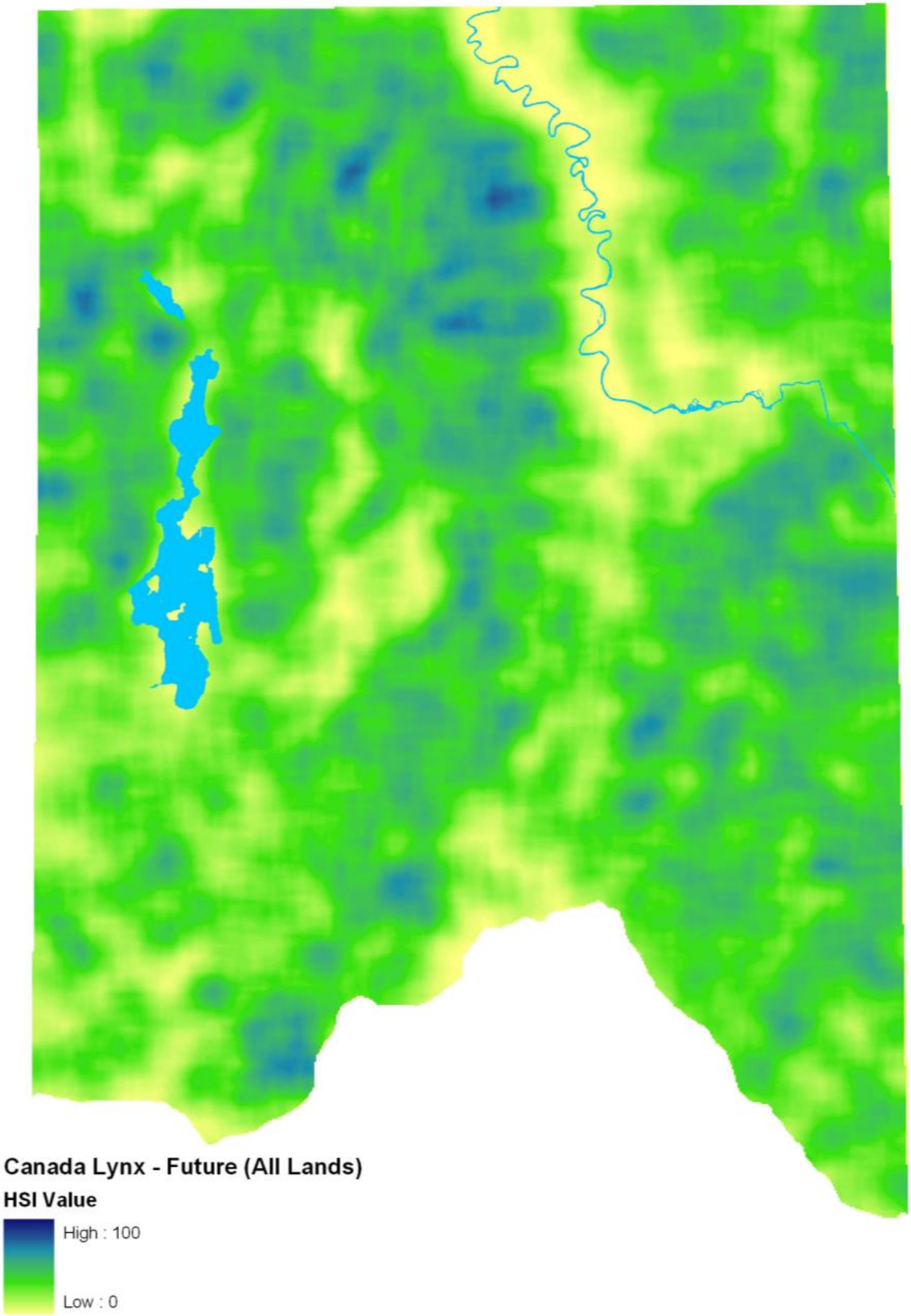


Figure 22. Future habitat suitability index for Canada lynx with 20% representation on all ownerships.

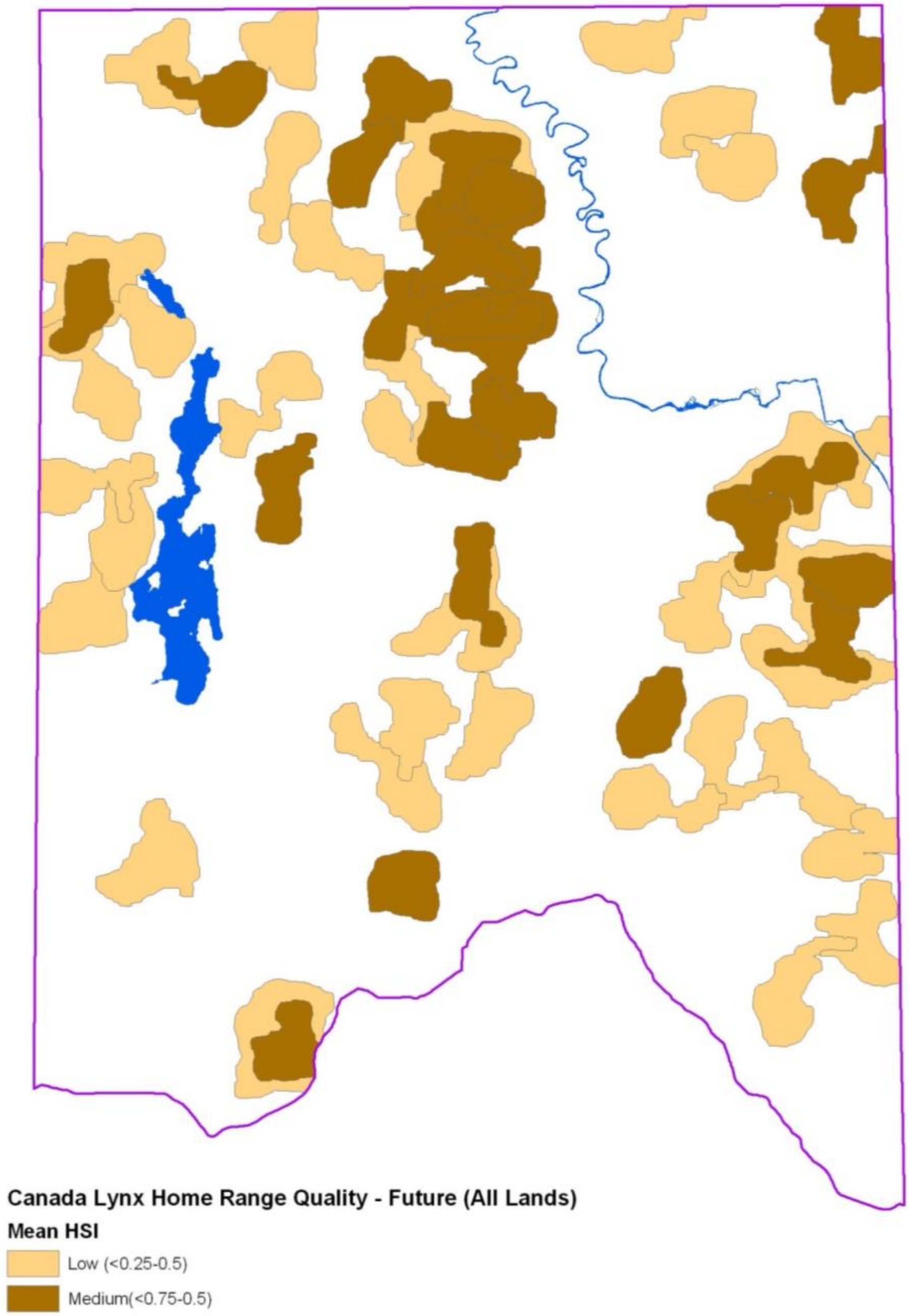


Figure 23. Future home range quality for Canada lynx with 20% representation on all ownerships.

Selkirk Mountains woodland caribou (*Rangifer tarandus caribou*)

The woodland caribou found in northern Idaho are the mountain ecotype of the species (Scott 1985, Stevenson and Hatler 1985) that is found more generally across the boreal forest zone of Canada. They are specially adapted to the wet, mountainous terrain and deep snow that characterizes this landscape. Similar to other caribou species, the mountain ecotype of woodland caribou exhibits seasonal movement patterns, but they are typically along an elevation gradient (Scott and Servheen 1985).

The current range of the woodland caribou in North America is presented in gray, and the historical southern boundary is identified by the dotted line (Gray 1999).

Early winter habitat (October 17- January 18) is considered the most critical time for woodland caribou due to the deep, soft snowpack at that time (Simpson et al. 1985, Rominger and Oldemeyer 1989, Servheen and Lyon 1989, Kinley and Apps 2001). In early winter caribou occurred at their lowest elevations in areas characterized by large, dense overstories of western hemlock (Warren et al. 1996). During this time woodland caribou move to lower elevation forests dominated by old-growth Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) or old-growth western red cedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*). These stands are characterized by high densities of windthrown aboreal lichen and occur between 1,200 and 1,900 m (3,937-6234 ft) (Servheen and Lyon 1989).

During late winter woodland caribou move to higher elevation stands of Engelmann spruce and subalpine fir with high levels of aboreal lichen (Miller 1982, USFWS 1993, Kinley et al. 2003). These stands have canopy cover from 26%-50%, basal area of 2.3-17.2 m^2/ha (10.0-74.9 ft^2/ac), 741-1,235 trees/ha (300-500 trees/ac) and are >1,828 m (5997 ft) in elevation (Servheen and Lyon 1989). At this time of the year the snow pack has hardened enough to support caribou and allows them to forage in the lower tree canopies (Scott and Servheen 1985).

During both early and late winter aboreal lichen is the preferred food source. The density of aboreal lichen varies considerably based on stand age, aspect, elevation, topographic position, and individual tree morphology (Stevenson 1979, VanDaele and Johnson 1983, Armleder and Stevenson 1996). During in vivo trials by Rominger et al. 1996, caribou strongly preferred *Bryoria* spp. over *Alectoria sarmentosa*. During winter field trials caribou refused to forage in *A. sarmentosa* dominated stands and would move to a *Bryoria* spp. stand before initiating foraging. *A. sarmentosa* typically occurs at high densities in glacial basins and valley bottoms, while Bryoria spp. occur mid-slope or on ridgelines.

Several studies have identified early winter as the most critical time for woodland caribou (USFWS 1993). During this period woodland caribou find optimal habitat in stands dominated by subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) >18 inches (45.72 cm) diameter at breast height or hemlock (*Tsuga* spp.) and western red cedar (*Thuja plicata*) stands >26 inches (66.04 cm) diameter at breast height. These stands also have tree canopy cover >80%, high cover of boreal lichens, and generally occur between 1200 and 1900 meters (3,937-6234 ft) (Servheen and Lyon 1989, Rominger et al. 1996). The HSI model for woodland caribou was built based on these optimal conditions. The model variables used were elevation (Figure 24), tree canopy cover (Figure 25), boreal lichen cover (Figure 26), DBH of subalpine fir/Engelmann spruce (Figure 27), DBH of hemlock/cedar (Figure 28), and EDM cell (Table 23). The EDM cell variable is a measure of a site's similarity to boreal ecosystems. A combined HSI grid was created by taking the geometric mean between the EDM cell HSI and the mean of the tree canopy cover, boreal lichen cover, DBH of subalpine fir/Engelmann spruce, and DBH of hemlock/cedar HSIs. For EDM cells lacking stand data the values in Table 24 were used. The final HSI grid was created by multiplying the combined grid by the elevation grid (Figure 29). The values used for the historical conditions model are presented in Table 25. The final historical conditions grid is depicted in Figure 30. The final future conditions grid with 20% representation only on IDL ownership is depicted in Figure 31 and the final future conditions grid with 20% representation on all ownerships is depicted in Figure 32.

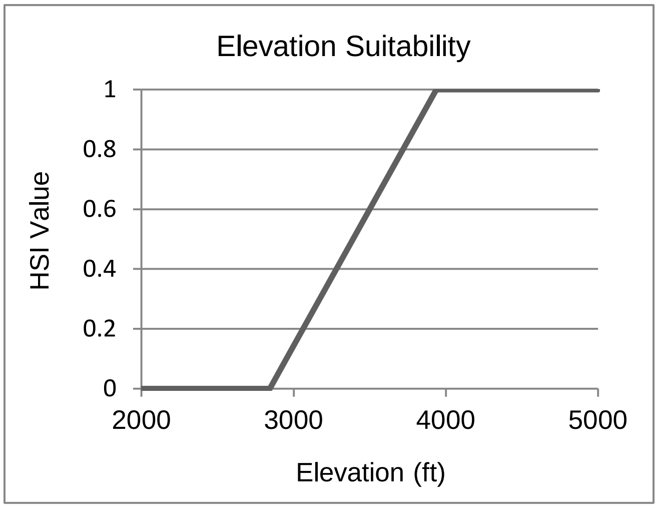


Figure 24. Relationship between elevation and HSI values for woodland caribou. The equation between 2843 and 3937 is *y=0.3x-260*.

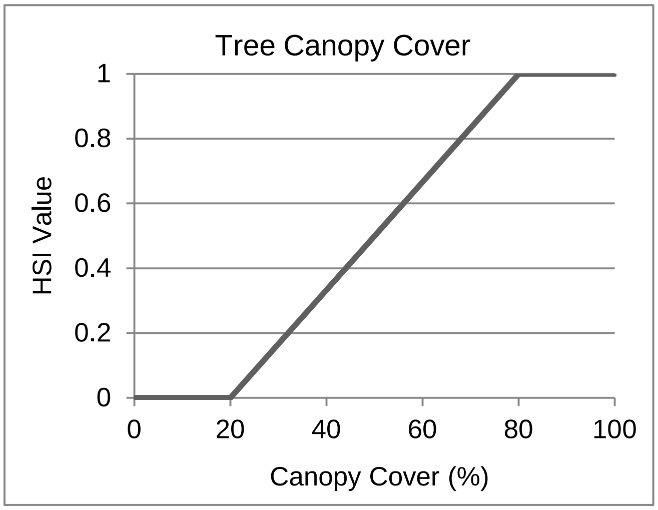


Figure 25. Relationship between tree canopy cover and HSI values for woodland caribou. The equation between 20 and 80 is *y=0.016x-0.333*.

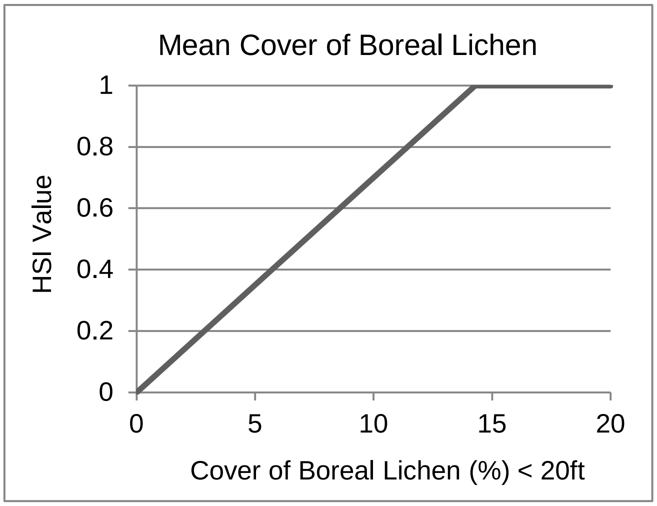


Figure 26. Relationship between absolute cover of boreal lichen and HSI values for woodland caribou. The equation between 0 and 14.286 is *y=0.07x*.

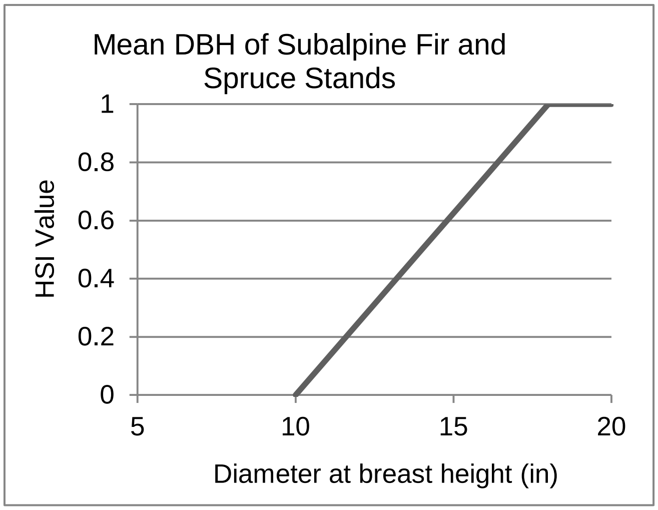


Figure 27. Relationship between mean diameter at breast height of subalpine fir and spruce and HSI values for woodland caribou. The equation between 10 and 18 is *y=0.125x-1.25*.

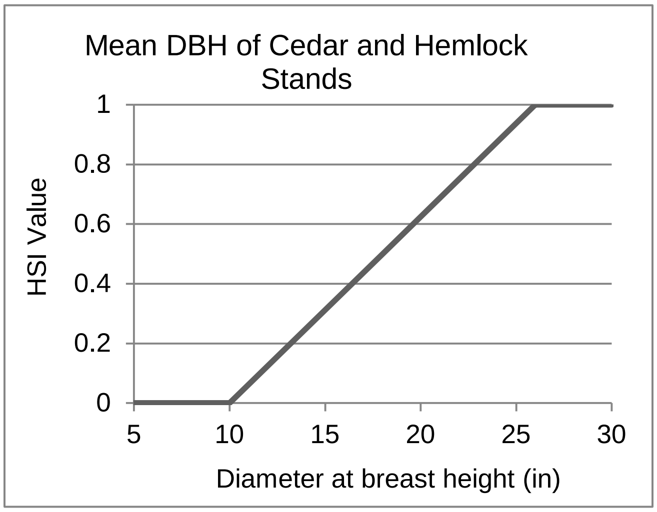


Figure 28. .Relationship between mean diameter at breast height of cedar and hemlock and HSI values for woodland caribou. The equation between 10 and 26 is *y=0.062x-0.625*.

Home ranges were not modeled for woodland caribou due to the nature of their movement patterns and their methods of habitat use. Woodland caribou typically occur in low densities as a predator avoidance behavior and thus favor small, dispersed patches of high quality habitat. The total acres of woodland caribou habitat classified as high, medium, and low quality resulting from the modeling effort, are presented as follows for historical, current and future conditions.

	Historical Conditions	Current Conditions	Future Conditions (IDL)	Future Conditions (All Lands)
High (1.0-0.75)	112,824	19,575	21,331	43,226
Medium (<0.75-0.5)	54,193	39,041	37,975	30,631
Low (<0.5-0.25)	107,498	193,902	193,180	180,028

The acreage numbers show a large shift of high quality habitat under historical conditions to low quality habitat under current conditions. A sizable increase in high quality habitat would be produced under potential future conditions. The reduction in high quality habitat is likely caused by a lack of true old growth stands that characterized historical conditions. Current stands meet the basic size class criteria for inclusion, but lack other habitat characteristics necessary for high quality habitat. These missing characteristics are a result of stands being too young to support ideal conditions. These younger stands have reduced canopy closure and lower densities of boreal lichens. Future conditions of these stands should target a return of these desired habitat characteristics.

Table 23. HSI values assigned for the EDM cell variable in the woodland caribou model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	0	0	0	0	0
POLE	0	0	0	0	0	0	0	0	0
MEDIUM-NL	0	0	0	0	0	0	0	0	0
LARGE-NL	0	0	0	0	0	0	0	0	0
VERY LARGE-NL	0	0	0	0	0	0	0	0	0
MEDIUM-L	0	0	0	50	75	50	100	50	50
LARGE-L	0	0	0	50	100	75	100	75	75
VERY LARGE-L	0	0	0	50	100	100	100	75	75

Table 24. HSI values for woodland caribou used in the current conditions model (* Where available, the mean and ± one standard deviation for each relevant habitat variable from FIA stand data was used to calculate three HSI scores).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	0	0	0	0	0
POLE	0	0	0	0	0	0	0	0	0
MEDIUM-NL	0	0	0	0	0	0	0	0	0
LARGE-NL	0	0	0	0	0	0	0	0	0
VERY LARGE-NL	0	0	0	0	0	0	0	N/A	N/A
MEDIUM-L	0-0-0*	0-0-0*	0-0-0*	15	23-34-43*	18-26-32*	65	40	40
LARGE-L	0	0-0-0*	0-0-0*	40	28-42-59*	25-34-46*	80-85-90	45-60-75	45-60-75
VERY LARGE-L	0-0-0*	0-0-0*	0-0-0*	21-40-52*	31-45-65*	35-47-70*	9-41-61*	39-58-75*	24-46-56*

Table 25. HSI values for woodland caribou used in the historical conditions model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	0	0	0	0	0
POLE	0	0	0	0	0	0	0	0	0
MEDIUM-NL	0	0	0	0	0	0	0	0	0
LARGE-NL	0	0	0	0	0	0	0	0	0
VERY LARGE-NL	0	0	0	0	0	0	0	N/A	N/A
MEDIUM-L	0	0	0	15	40	40	65	40	40
LARGE-L	0	0	0	40	65	65	80-85-90	45-60-75	45-60-75
VERY LARGE-L	0	0	0	40	80-85-90	80-85-90	80-85-90	45-60-75	45-60-75

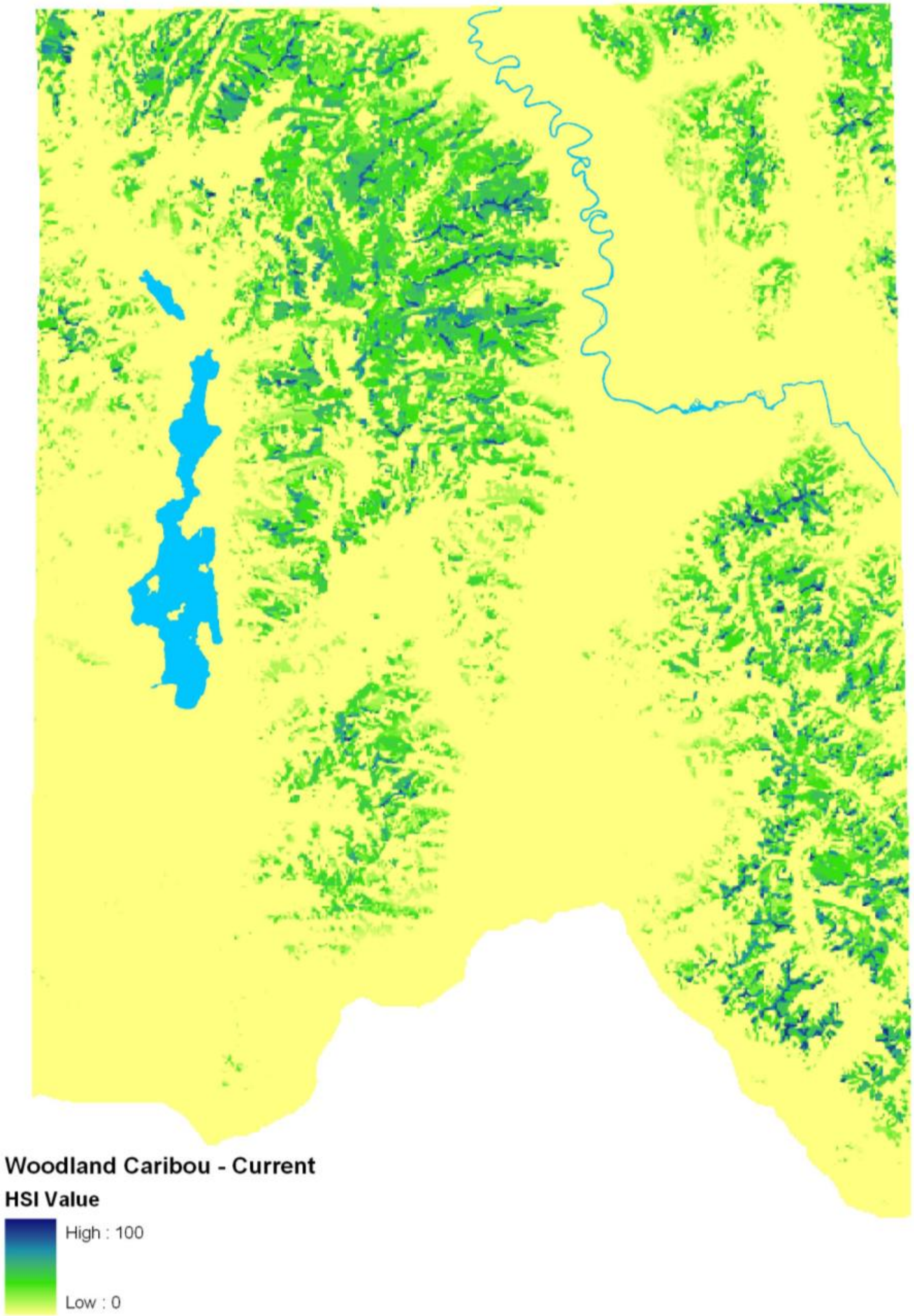


Figure 29. Current habitat suitability index for woodland caribou within the IDL planning landscape.

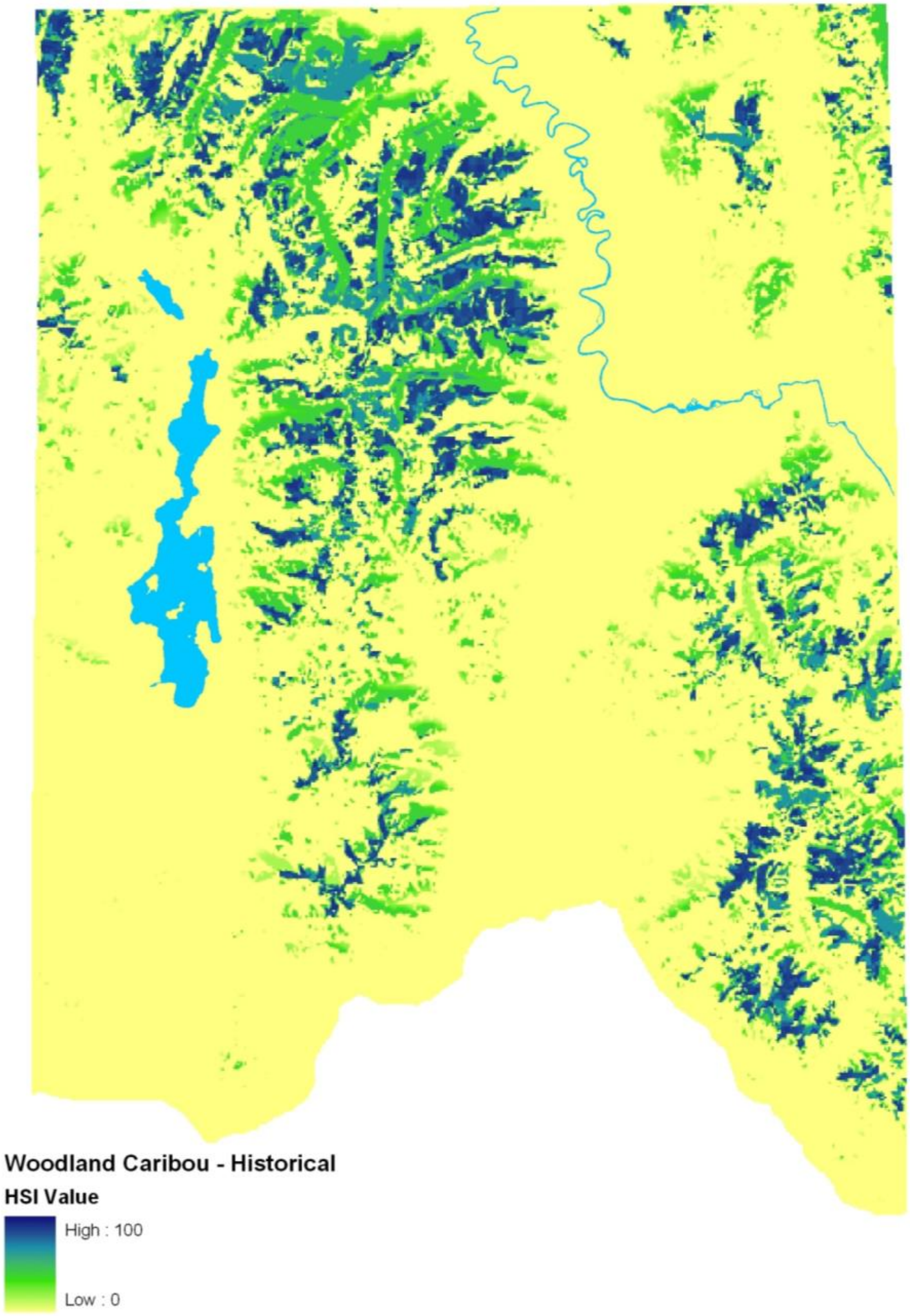


Figure 30. Historical habitat suitability index for woodland caribou within the IDL planning landscape.

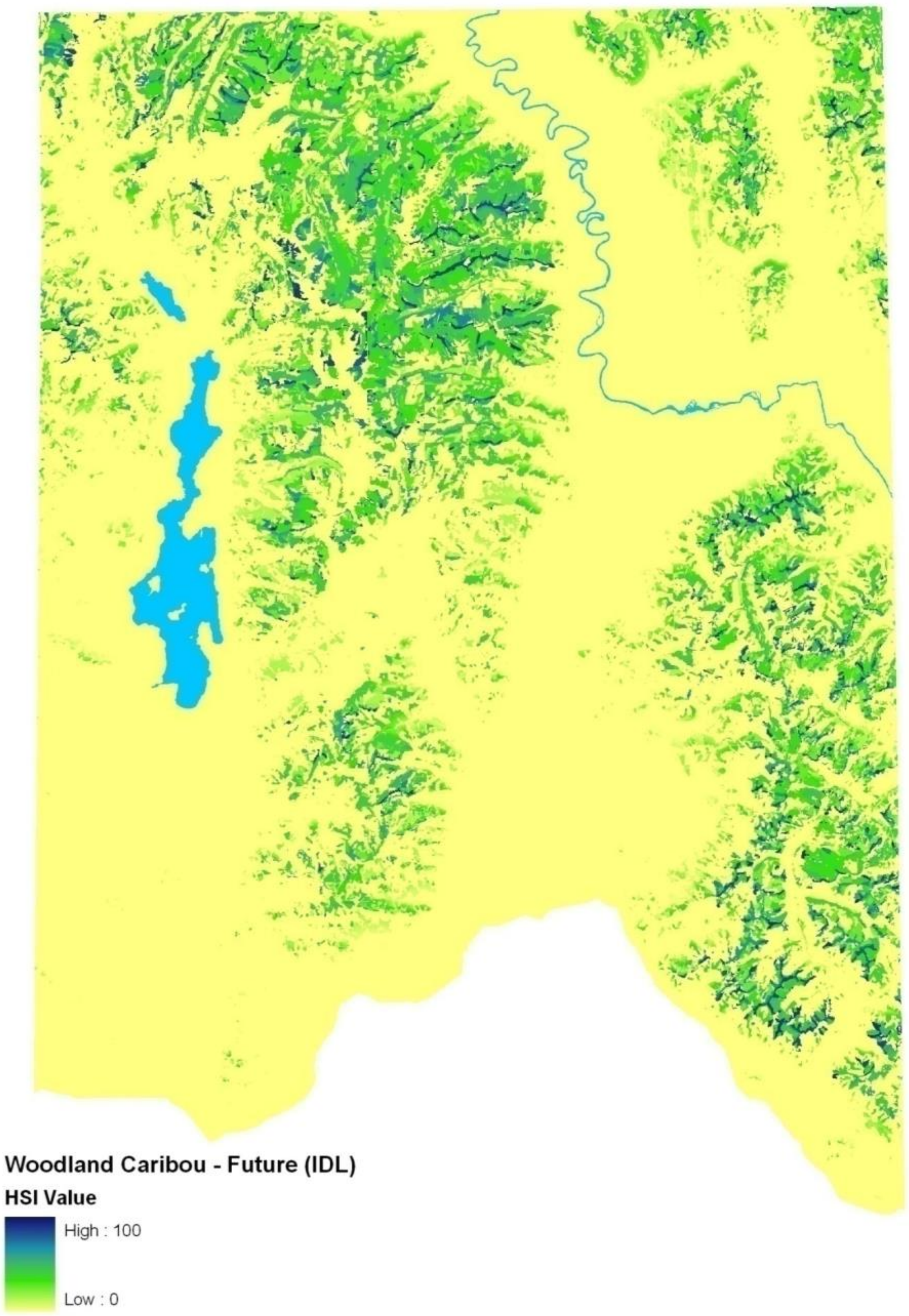


Figure 31. Future habitat suitability index for woodland caribou with 20% representation on IDL ownership only.

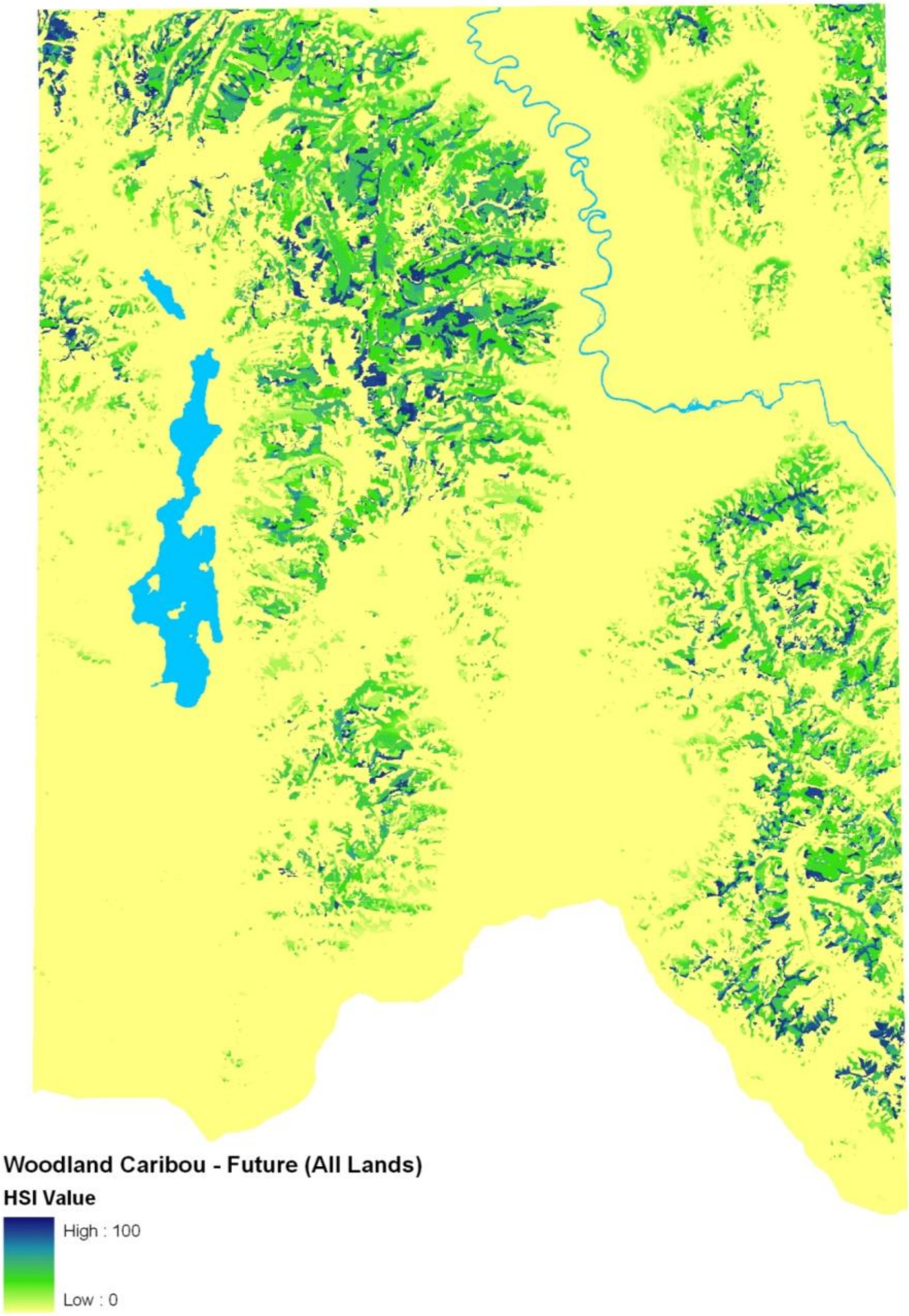
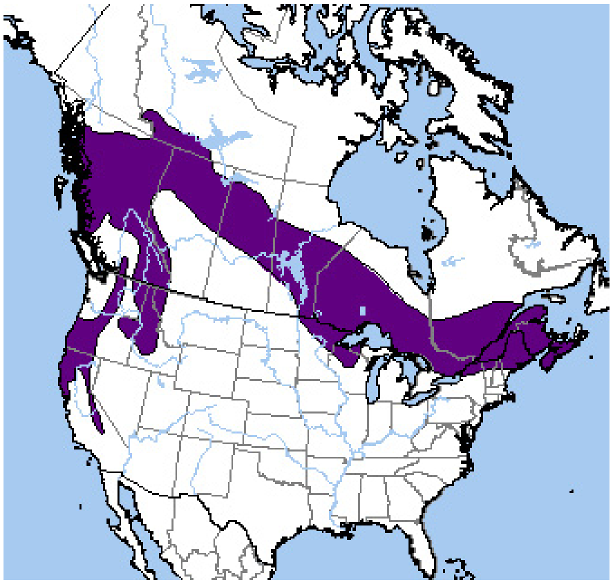


Figure 32. Future habitat suitability index for woodland caribou with 20% representation on all ownerships.

Fisher (Martes pennanti)



Current range of the fisher in North America (Patterson et al. 2005).

The fisher is a medium sized forest carnivore that was nearly extirpated from Idaho, but was reintroduced in the mid 1960's (Powell 1993). In general, fisher habitat is ideal in late-successional conifer stands (USFWS 2004). Specifically, fishers select for stands with canopy cover >50% (preferably 80-100%), large diameter trees (>47 cm; 18.5 in), multi-story stands, and high levels of coarse woody debris (Kelly 1977, Jones 1991, Powell 1993, Powell and Zielinski 1994). There is also preferential selection for riparian area interspersed within a forest stand due to the associated gentle slopes, moderate temperatures, and increased prey densities (Jones 1991, Powell and Zielinski 1994, Lewis and Stinson 1998). In north-central Idaho, stands dominated by grand fir (*Abies grandis*) and Engelmann spruce (*Picea engelmannii*) were preferentially selected (Jones 1991). Fishers avoid nonforested areas (USFWS 2004).

The fisher model was primarily based on the framework set forth in Allen (1983). It was modified by adding a shrub canopy cover variable and spruce/fir canopy variable found in Olsen et al. (1999). Winter habitat is generally considered the limiting factor for fishers. Optimum winter habitat is found in mature stands with high tree canopy cover, a diverse understory, and a mix of deciduous and evergreen overstory trees. The HSI model for fisher was built based on these optimal conditions. The model variables used were tree canopy cover (Figure 33), mean DBH of overstory trees (Figure 34), canopy cover of shrubs ≥1m (3.3 ft) (Figure 35), composition of deciduous trees in the overstory (Figure 36), and canopy cover of spruce and fir (Figure 37). The final HSI grid was calculated with the following formula:

$$\text{Fisher HSI} = \text{Deciduous HSI} \times ((\text{Tree Canopy HSI} \times \text{DBH HSI} \times (\text{Min}\ (1,\ [2 + 0.55 \times \text{Shrub HSI} + 0.85 \times \text{Spruce/Fir HSI}]))^{0.333}$$

HSI values for EDM cells missing stand data (Table 26) were added and the grid was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER (Figure 38). The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 2.25 kg (4.96 lb) female fisher is 246 ha (608 ac) or 52x52 grid cells (Lindstedt et al. 1986).

Three iterations were done in HOMEGROWER. The target home range area was 2 times the allometric home range or 493 ha (1218 ac). The number of seeds was 800,000 and the growth window was 10 cells. Figure 39 shows home ranges and their quality for current conditions. The number of very low quality home ranges was not delineated.

The values used to create the fisher HSI grid for historical conditions are presented in Table 27. Figure 40 is the grid used in HOMEGROWER for historical conditions. The same run parameters used for the current conditions model were also used for the historical conditions model. Figure 41 depicts home range quality for historical conditions. The number of very low quality home ranges was not delineated.

The values used to create the fisher HSI grids for future conditions were a combination of the values used for the current conditions and historical conditions. Areas modified to achieve reference conditions received historical conditions values and all other areas received current conditions values. Figure 42 is the grid used in HOMEGROWER for future conditions applied only to IDL ownership and Figure 44 is the grid used in HOMEGROWER for future conditions applied to all ownerships. The same run parameters used for the current conditions model were also used for the future conditions models. Figure 43 depicts home range quality for future conditions applied only to IDL ownership and Figure 45 depicts home range quality for future conditions applied to all ownerships. The mean numbers of fisher home ranges of high, medium, and low quality, resulting from the modeling effort, are presented as follows for historical, current and future conditions.

	Historical Conditions	Current Conditions	Future Conditions (IDL)	Future Conditions (All Lands)
High (1.0-0.75)	65	41	39	31
Medium (<0.75-0.5)	178	249	243	265
Low (<0.5-0.25)	4	0	0	1

Run results between historical, current, and future conditions were similar. The historical model resulted in more high quality home ranges, but fewer medium quality home ranges. The similarity between the models is likely due to the fisher's proclivity towards dense, complex, multi-storied stands. The slight reduction in high quality home ranges for future conditions applied to all ownerships is due to the need to gain more representation in stand types characterized by frequent, low severity fires. In the current landscape these types are rare. The run results indicate fishers do not appear to have been significantly reduced by changing habitat conditions within the IDL planning landscape.

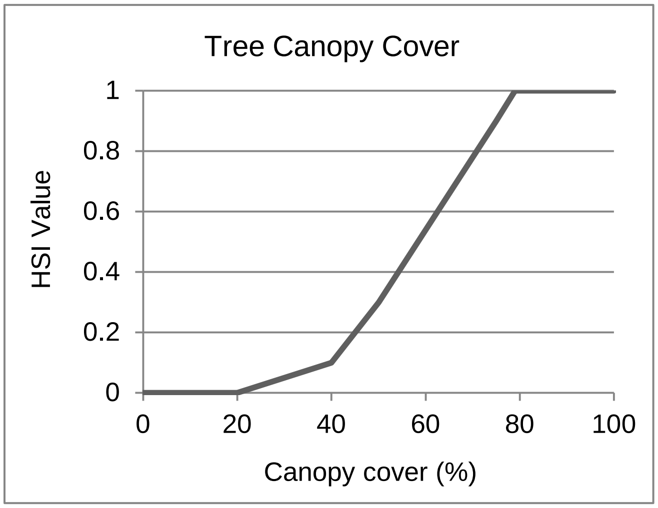


Figure 33. Relationship between tree canopy cover and HSI values for fisher. The equation between 20 and 40 is $y=0.005x-0.1$ and the equation between 40 and 80 is $y=0.022x-0.827$.

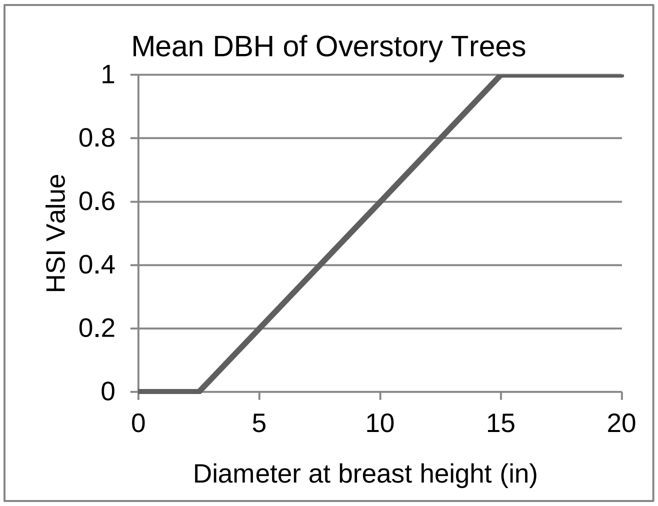


Figure 34. Relationship between mean diameter at breast height of overstory trees and HSI values for fisher. The equation between 2.5 and 15 is $y=0.08x-0.2$.

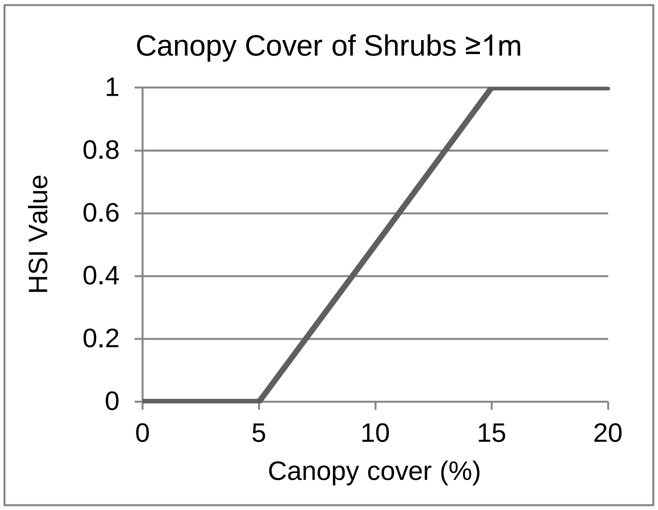


Figure 35. Relationship between canopy cover of shrubs and HSI values for fisher. The equation between 5 and 15 is $y=0.1x-0.5$.

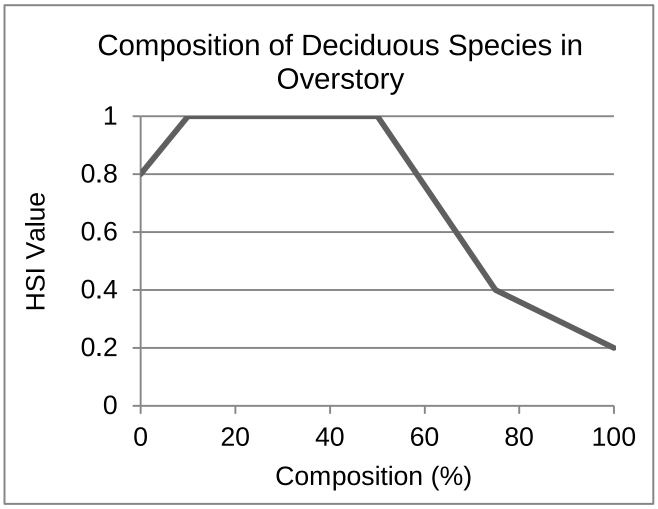


Figure 36. Relationship between composition of deciduous species in the overstory and HSI values for fisher. The equation between 0 and 10 is $y=0.02x+0.8$, the equation between 50 and 75 is $y=-0.024x+2.2$, and the equation between 75 and 100 is $y=-0.008x+1$.

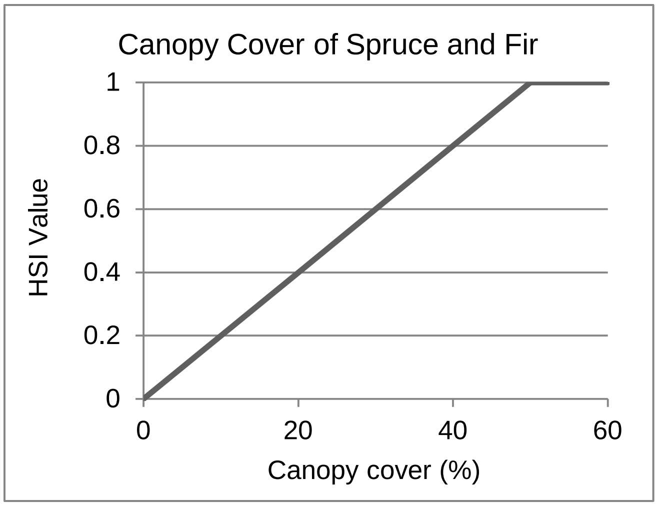


Figure 37. Relationship between canopy cover of spruce and fir and HSI values for fisher. The equation between 0 and 50 is *y=0.02x*.

Table 26. HSI values for fisher used in the current conditions model (* Where available, the mean and ± one standard deviation for each relevant habitat variable from FIA stand data was used to calculate three HSI scores).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	0	0	0	0	0
POLE	0	0	10	10	10	10	10	10	10
MEDIUM-NL	0	5	10	10	10	10	10	25	25
LARGE-NL	0	10	20	30	20	20	10	40	40
VERY LARGE-NL	0	15	25	40	40	40	20	0	0
MEDIUM-L	25-55-76*	56-70-78*	53-76-90*	50-62.5-75	44-71-86*	52-73-87*	20-32.5-45	40-50-60	40-50-60
LARGE-L	20	41-64-86*	75-90-98*	70-80-90	46-71-84*	55-77-91*	40-50-60	50-62.5-75	50-62.5-75
VERY LARGE-L	37-62-80*	52-78-89*	70-94-100*	52-87-93*	56-86-100*	64-87-98*	35-63-83*	48-81-90*	0-61-82*

Table 27. HSI values for fisher used in the historical conditions model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	0	0	0	0	0
POLE	0	0	10	10	10	10	10	10	10
MEDIUM-NL	0	5	10	10	10	10	10	25	25
LARGE-NL	0	10	20	30	20	20	10	40	40
VERY LARGE-NL	0	15	25	40	40	40	20	N/A	N/A
MEDIUM-L	10	50-62.5-75	50-62.5-75	50-62.5-75	50-62.5-75	50-62.5-75	20-32.5-45	40-50-60	40-50-60
LARGE-L	20	60-72.5-85	70-80-90	70-80-90	70-80-90	70-80-90	40-50-60	50-62.5-75	50-62.5-75
VERY LARGE-L	30	60-75-90	70-85-100	70-85-100	70-85-100	70-85-100	50-65-80	60-75-90	60-75-90

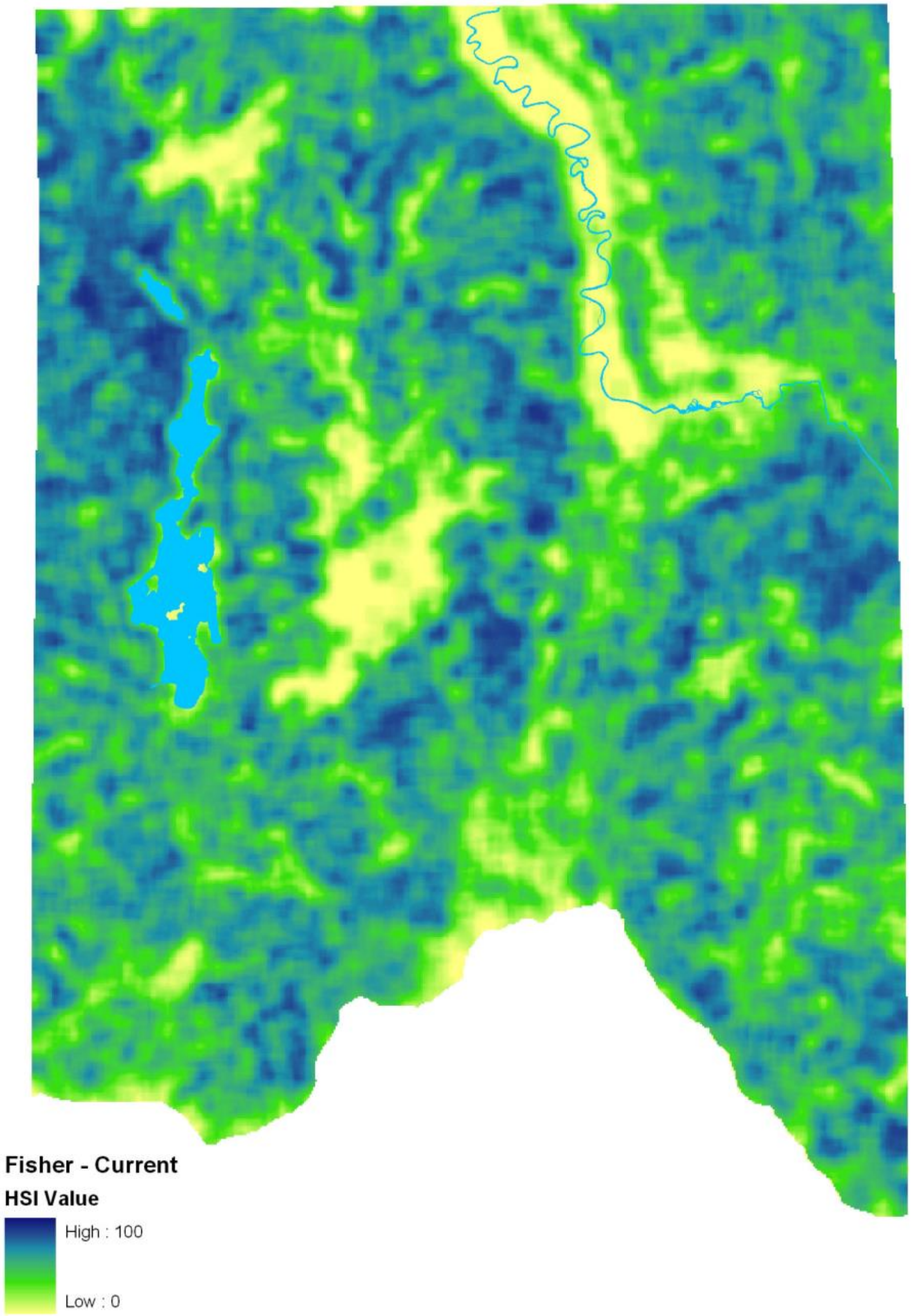


Figure 38. Current habitat suitability index for fisher within the IDL planning landscape.

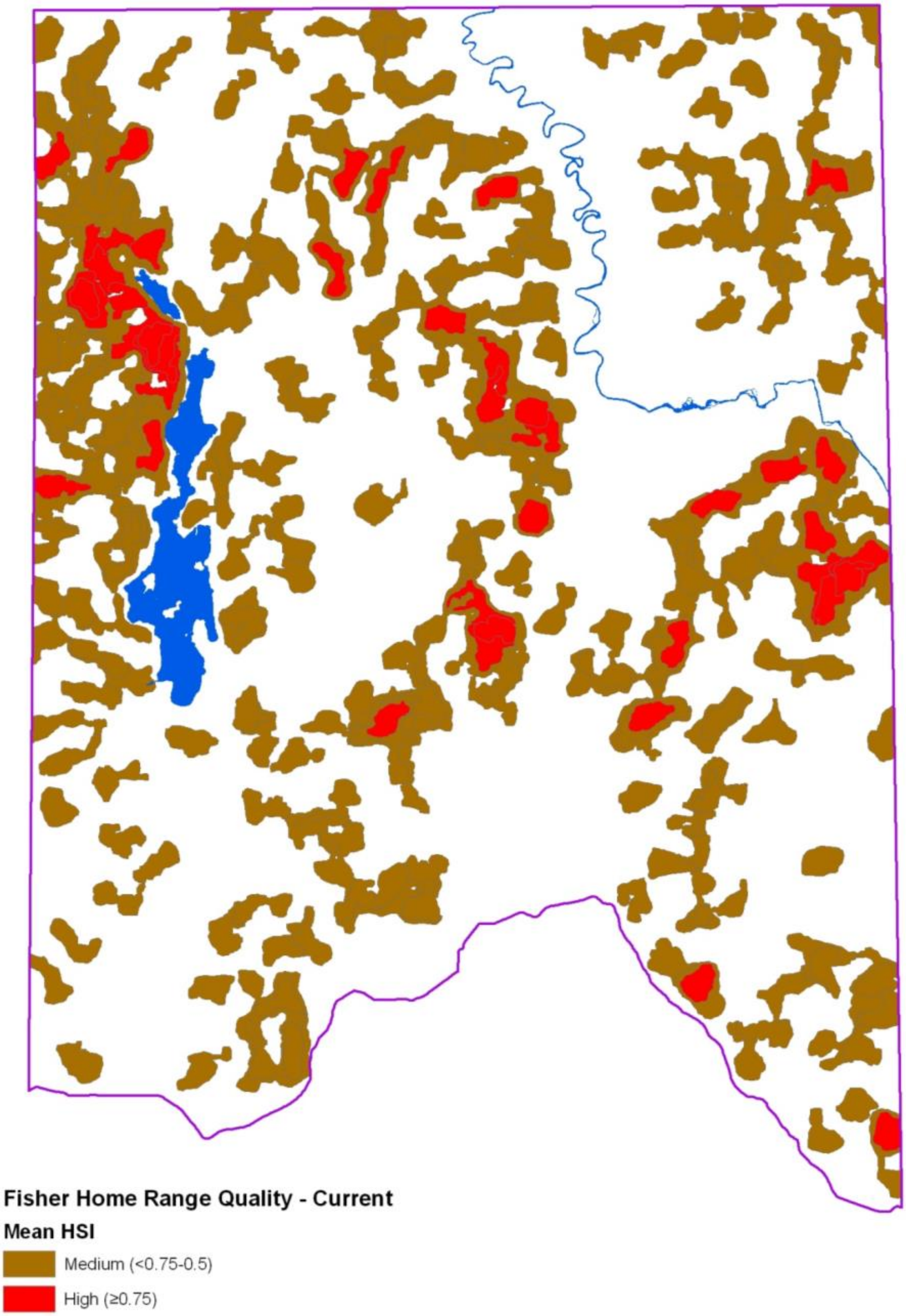


Figure 39. Current home range quality (mean HSI) for fisher within the IDL planning landscape.

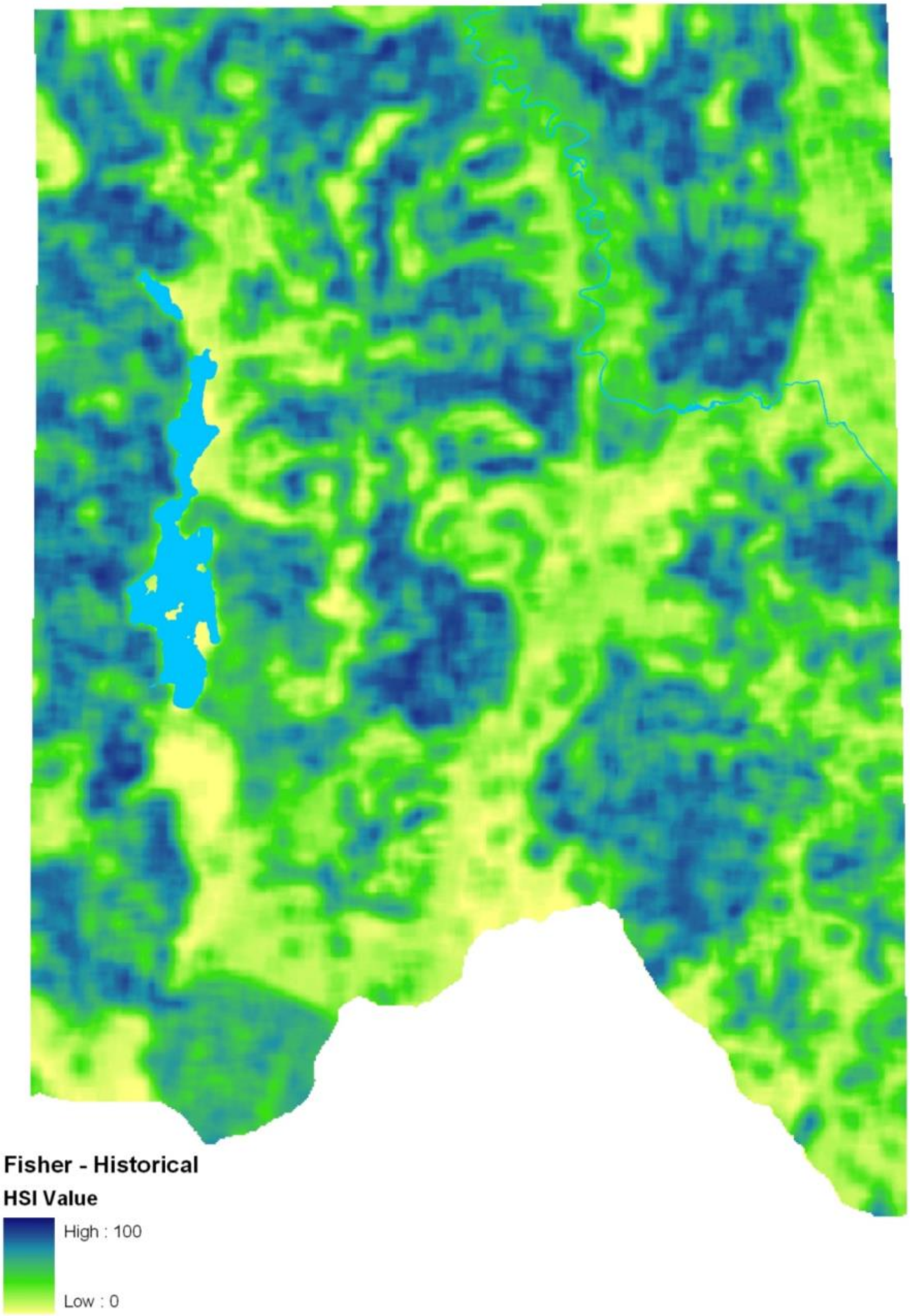


Figure 40. Historical habitat suitability index for fisher within the IDL planning landscape.

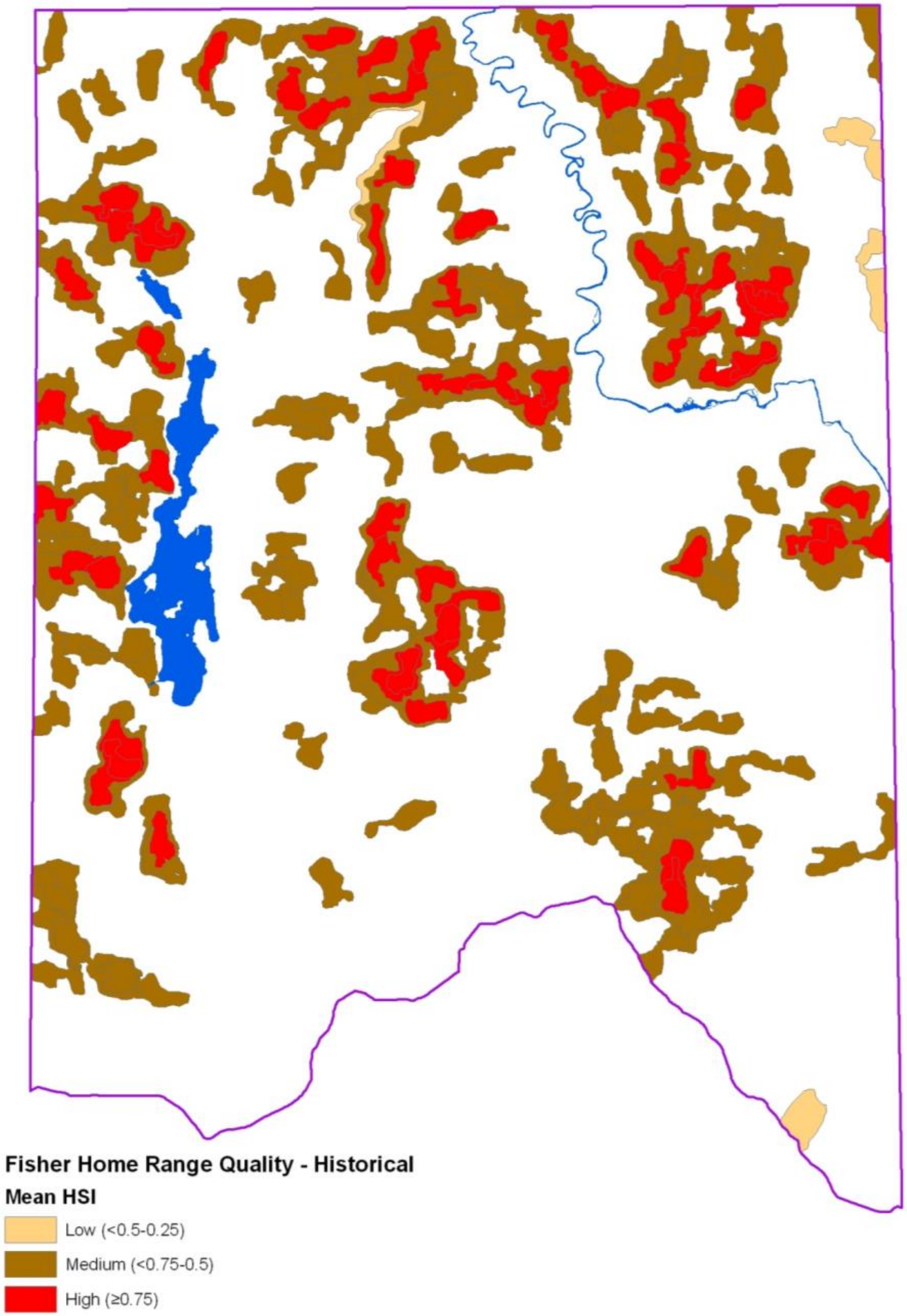


Figure 41. Historical home range quality (mean HSI) for fisher within the IDL planning landscape.

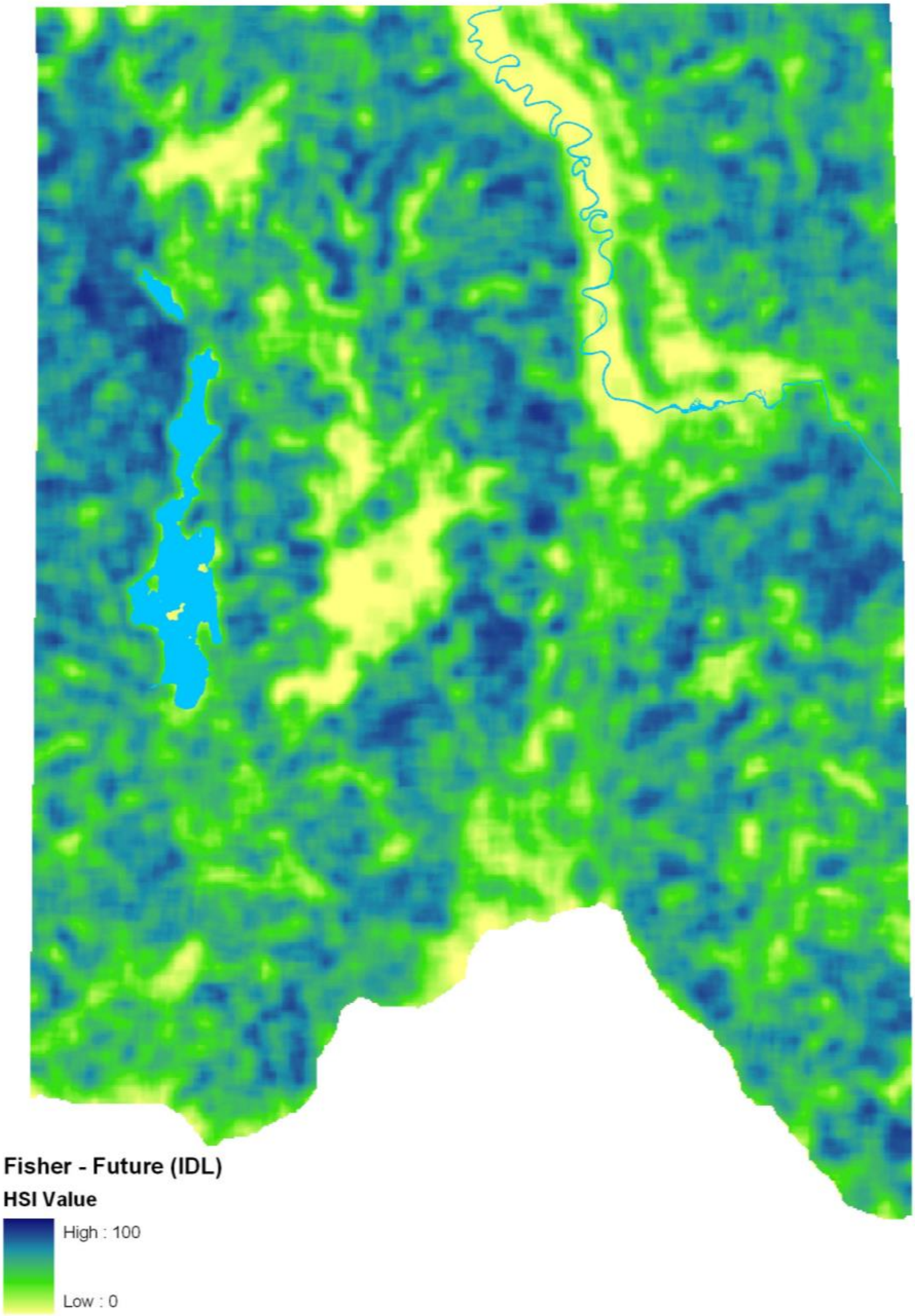


Figure 42. Future habitat suitability index for fisher with 20% representation on IDL ownership only.

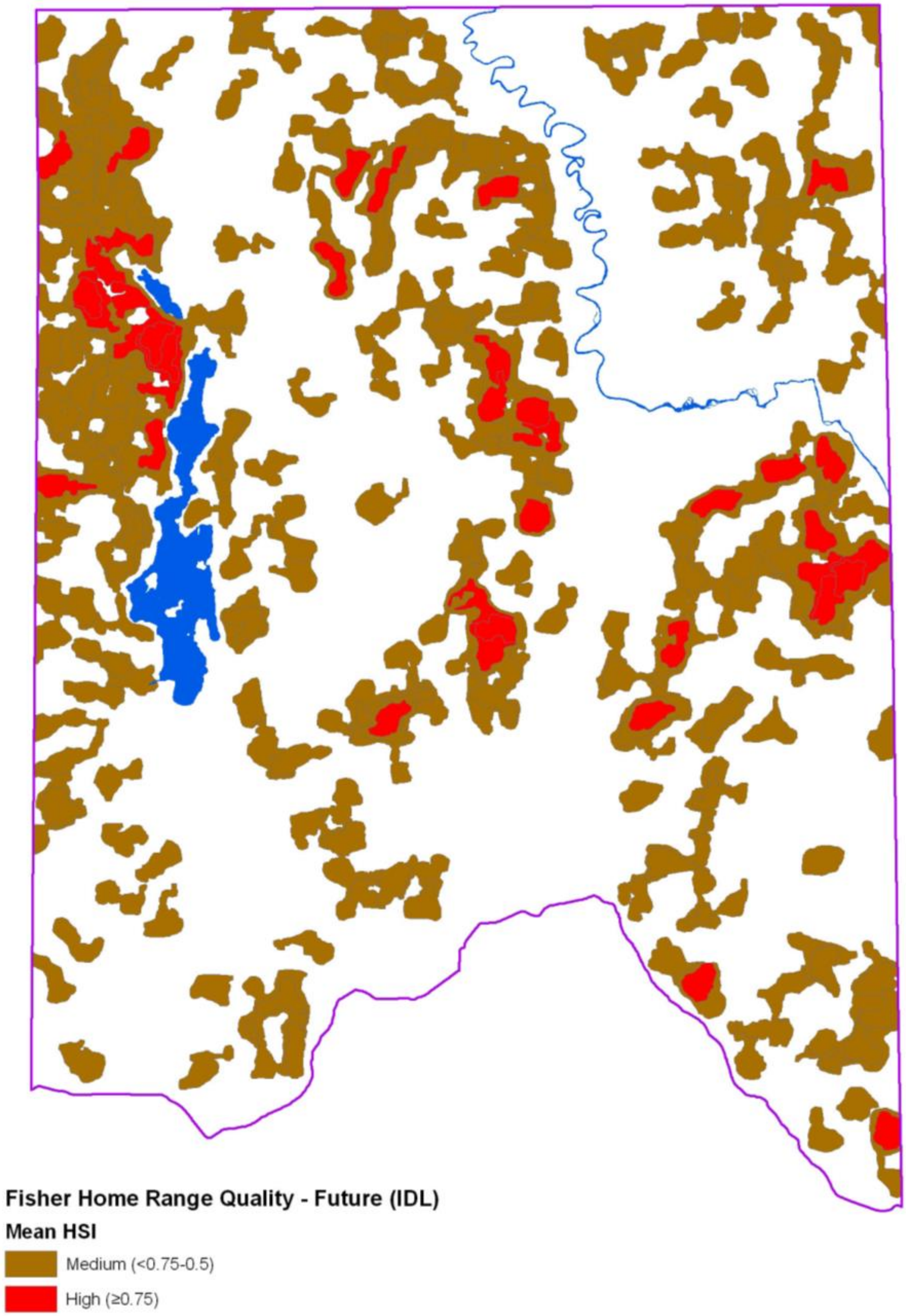


Figure 43. Future home range quality for fisher with 20% representation on IDL ownership only.

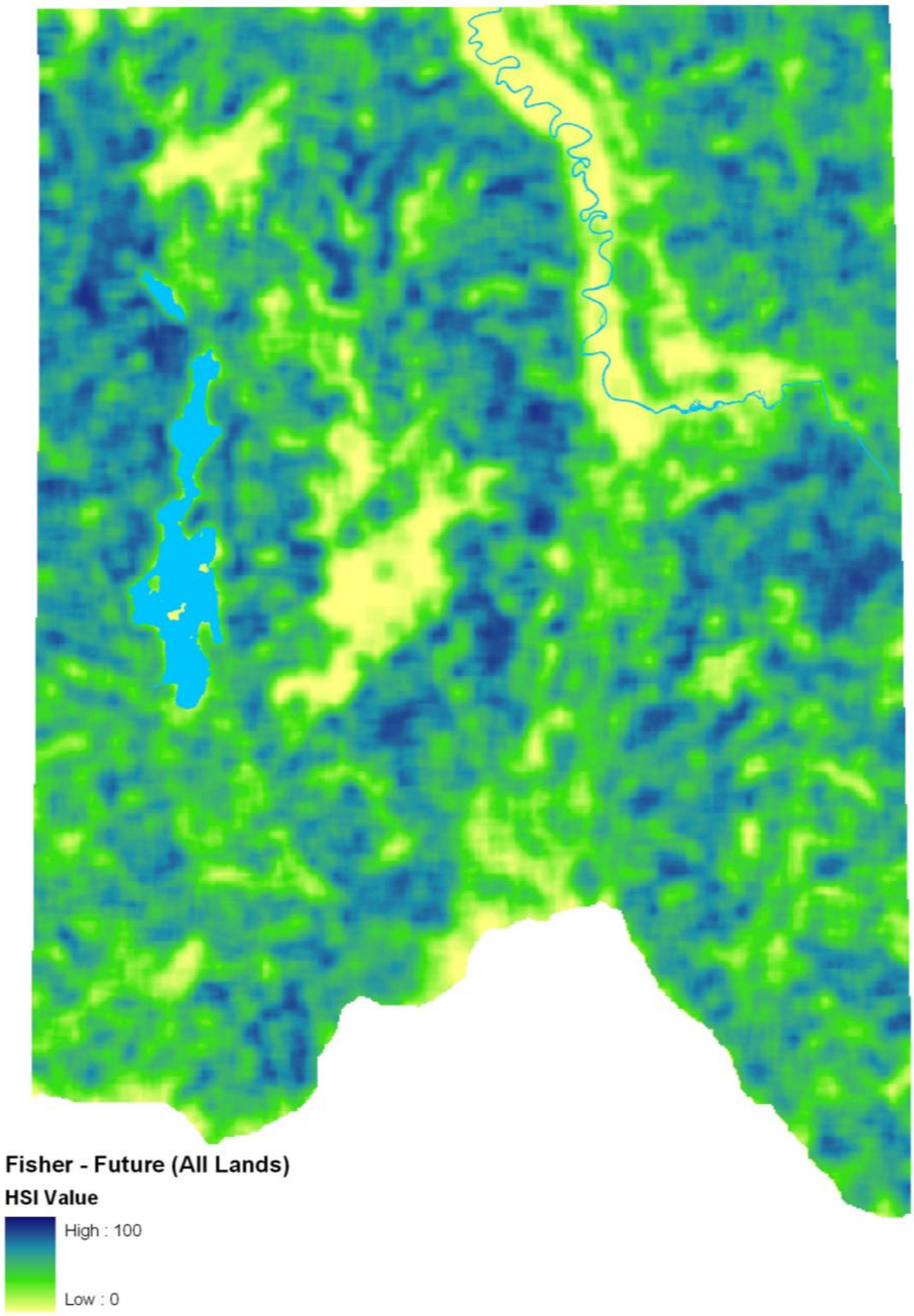


Figure 44. Future habitat suitability index for fisher with 20% representation on all ownerships.

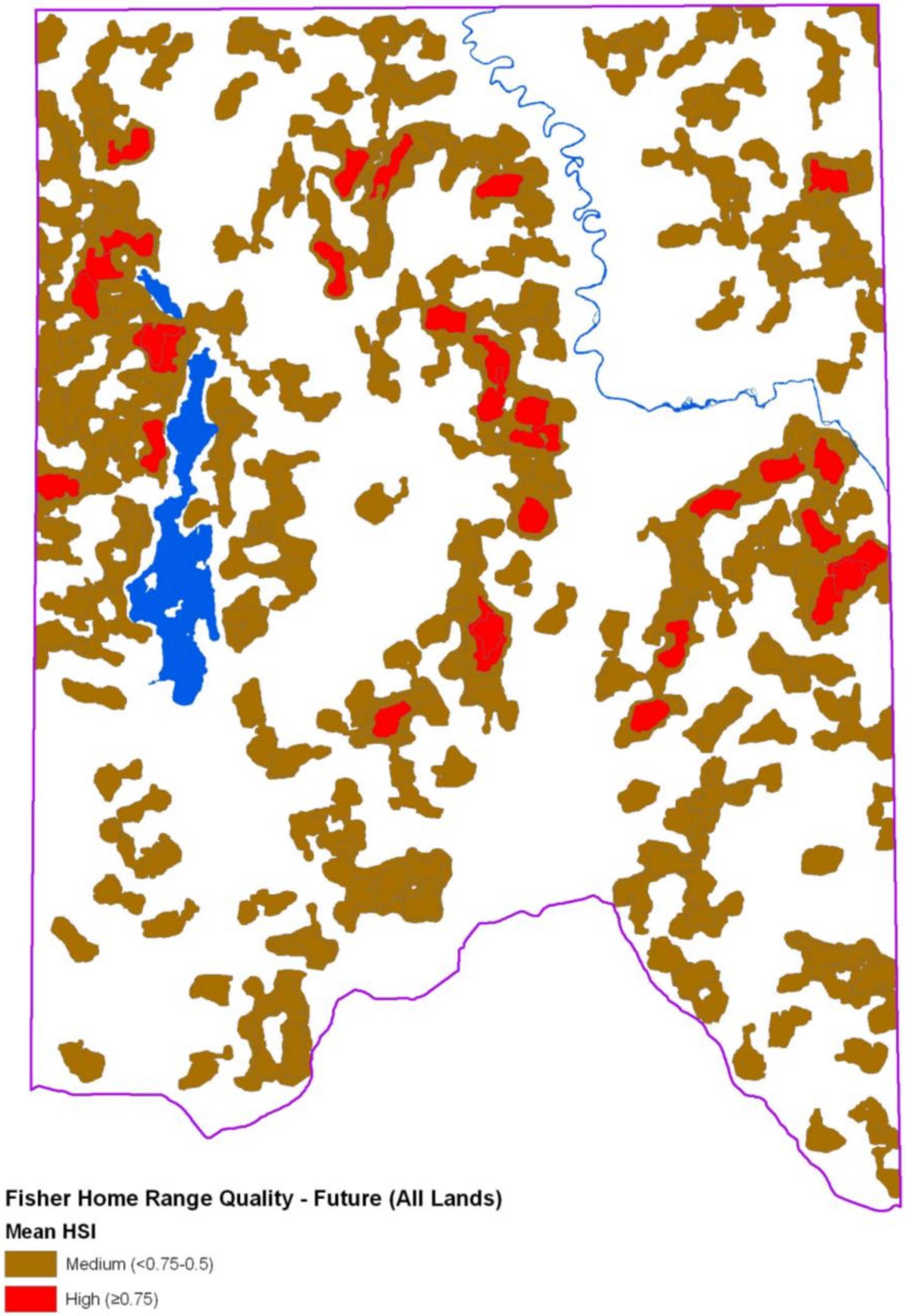
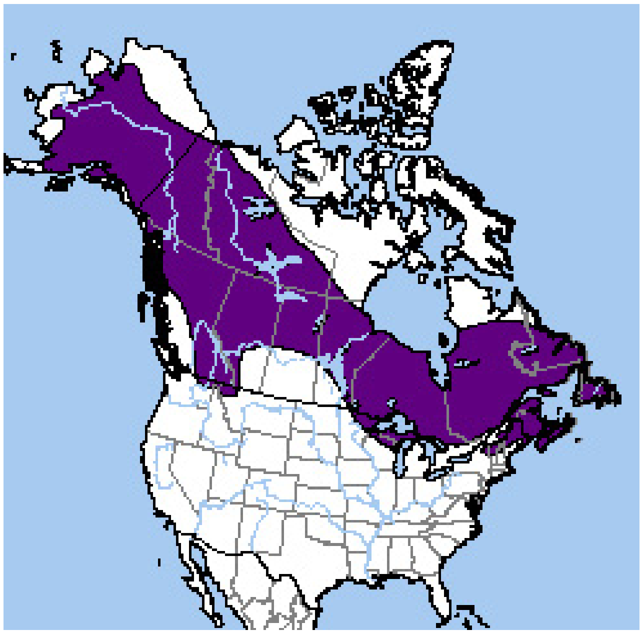


Figure 45. Future home range quality for fisher with 20% representation on all ownerships.

Boreal Chickadee (*Poecile hudsonica*)

The Boreal Chickadee has a limited Idaho distribution, occurring only in the Selkirk Mountains of Boundary and Bonner counties (Stephens and Sturts 1998). The southern and northern limits of its range in North America are limited by the distribution of spruce dominated boreal forests (Ficken et al. 1996). Overall, very little research has been done on Boreal Chickadees and specific habitat information is lacking.

Boreal Chickadees have been observed excavating nest cavities and nesting in stumps or snags <10m (32.8 ft) in height (McClaren 1975). A high proportion of these nests have been located in mature or old-growth stands (Ficken et al. 1996). Black-capped and Boreal Chickadees are not inter-specifically territorial and will utilize nest cavities abandoned by the other species (McClaren 1975).



Current range of the Boreal Chickadee in North America (Ridgely et al. 2005).

The Boreal Chickadee model was primarily based on the Black-capped Chickadee (*Poecile atricapillus*) model described by Schroeder (1983). With a few exceptions, Boreal and Black-capped Chickadees generally forage and nest in similar habitat conditions and often form mixed-species flocks (Hadley 2006), with the Boreal Chickadee selecting boreal forest conditions while Black-capped Chickadees preferring other forest types. Optimum habitat for the Boreal Chickadee is typically found in moist stands dominated by spruce (*Picea* spp.) with tree canopy cover from 50-75%, mean overstory tree height >15 meters (49.2 ft) and >5 10.2-25.4 cm snags per hectare (>2 4-10 inch snags/ac). The HSI model for Boreal Chickadee was built based on these optimal conditions. The model variables used were tree canopy cover (Figure 46), mean height of overstory trees (Figure 47), snags per acre (Figure 48), and EDM cell (Table 28). The EDM cell variable is a measure of a site's similarity to boreal ecosystems. The final HSI grid was calculated by taking the minimum between the snag HSI and the geometric mean of canopy cover HSI and mean height HSI. This value was then multiplied by the EDM cell HSI.

HSI values for EDM cells missing stand data (Table 29) were added and the grid was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER (Figure 49). The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 10 g (0.35 oz) Boreal Chickadee is 0.5 ha (1.24 ac) or 2x2 grid cells (Van Horne and Wiens 1991).

Three iterations were done in HOMEGROWER. The target home range area was 5 times the allometric home range or 2.5 ha (6.2 ac). The number of seeds was 999,999 and the growth window was 1 cell. Figure 50 depicts home range quality for current conditions. Home ranges below medium quality were not delineated due to the number of high and medium quality home ranges.

The values used to create the Boreal Chickadee HSI grid for historical conditions are presented in Table 30. Figure 51 is the grid used in HOMEGROWER for historical conditions. The same run parameters used for the current conditions model were also used for the historical conditions model. Figure 52 depicts home range quality for historical conditions. Home ranges below medium quality were not delineated due to the number of high and medium quality home ranges.

The values used to create the Boreal Chickadee HSI grids for future conditions were a combination of the values used for the current conditions and historical conditions. Areas modified to achieve reference conditions received historical conditions values and all other areas received current conditions values. Figure 53 is the grid used in HOMEGROWER for future conditions applied only to IDL ownership and Figure 55 is the grid used in HOMEGROWER for future conditions applied to all ownerships. The same run parameters used for the current conditions model were also used for the future conditions models. Figure 54 depicts home range quality for future conditions applied only to IDL ownership and Figure 56 depicts home range quality for future conditions applied to all ownerships. The number of very low quality home ranges was not delineated. The mean numbers of Boreal Chickadee home ranges of high, medium, and low quality resulting from the modeling effort are presented as follows for historical, current and future conditions.

	Historical Conditions	Current Conditions	Future Conditions (IDL)	Future Conditions (All Lands)
High (1.0-0.75)	6,098	5,926	5,866	5,741
Medium (<0.75-0.5)	18,169	12,543	12,489	12,465
Low (<0.5-0.25)	5,405	6,956	6,927	6,435

The most significant difference between the historical model and the current and future conditions models is the decrease in the number of medium quality home ranges. The number of high quality home ranges is similar between the four models. The small size of Boreal Chickadee home ranges allows for them to interact with their environment on a much smaller spatial scale that many other species. As a result, departures from historical conditions tend to have a less notable impact on number of home ranges.

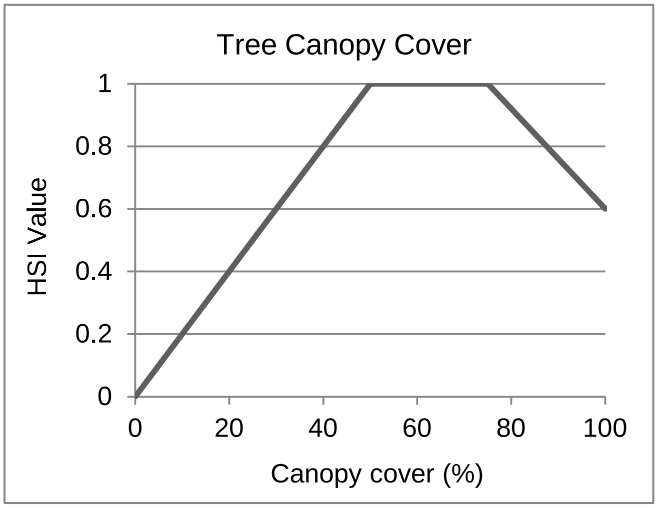


Figure 46. Relationship between tree canopy cover and HSI values for Boreal Chickadee. The equation between 0 and 50 is *y=0.02x* and the equation between 75 and 100 is *y=-0.016x+2.2*

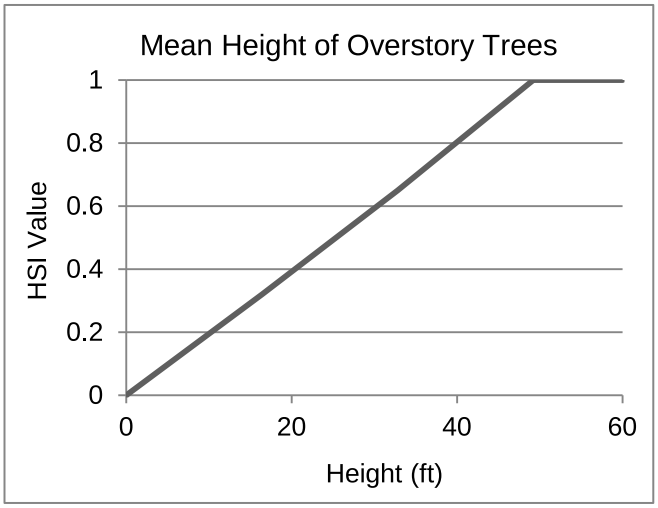


Figure 47. Relationship between mean height of overstory trees and HSI values for Boreal Chickadee. The equation between 0 and 49.2 is *y=0.020-0.007*.

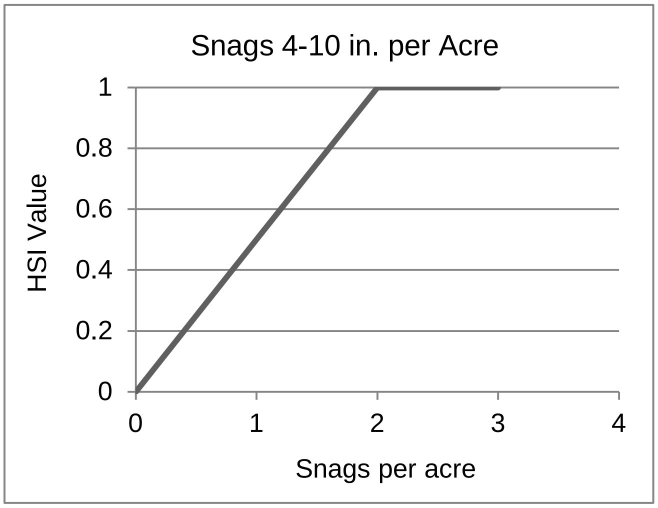


Figure 481. Relationship between snags per acre and HSI values for Boreal Chickadee. The equation between 0 and 2 is *y=0.5x*.

Table 28. HSI values assigned for the EDM cell variable in the Boreal Chickadee model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	50	50	0	50	50
POLE	0	0	0	0	75	75	0	75	75
MEDIUM-NL	0	0	0	50	0	0	0	75	75
LARGE-NL	0	0	0	50	0	0	0	100	100
VERY LARGE-NL	0	0	0	0	0	0	0	100	100
MEDIUM-L	0	0	0	0	75	0	0	50	50
LARGE-L	0	0	0	75	100	75	50	75	75
VERY LARGE-L	0	0	0	0	75	50	50	75	75

Table 29. HSI values for Boreal Chickadee used in the current conditions model (* Where available, the mean and ± one standard deviation for each relevant habitat variable from FIA stand data was used to calculate three HSI scores).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	20	50	50	20	50	50
POLE	0	0	10	50	75	75	50	75	75
MEDIUM-NL	0	0	15	0	0	0	0	0	0
LARGE-NL	0	0	20	0	0	0	0	0	0
VERY LARGE-NL	0	0	20	0	0	0	0	0	0
MEDIUM-L	0-0-0*	0-0-0*	0-0-0*	20	42-50-50*	16-25-25*	20	50	50
LARGE-L	0	0-0-0*	0-0-0*	50	63-75-75*	67-75-75	20-35-50	50-65-80	50-65-80
VERY LARGE-L	0-0-0*	0-0-0*	0-0-0*	18-20-17*	65-75-72*	46-50-50*	11-18-20*	69-75-66*	46-68-75*

Table 30. HSI values for Boreal Chickadee used in the historical conditions model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	20	50	50	20	50	50
POLE	0	0	10	50	75	75	50	75	75
MEDIUM-NL	0	0	15	0	0	0	0	0	0
LARGE-NL	0	0	20	0	0	0	0	0	0
VERY LARGE-NL	0	0	20	0	0	0	0	N/A	N/A
MEDIUM-L	0	0	15	20	50	25	20	50	50
LARGE-L	0	0	20	50	50-65-80	50-65-80	20-35-50	50-65-80	50-65-80
VERY LARGE-L	0	0	20	20	50-65-80	50-65-80	20-35-50	50-65-80	50-65-80

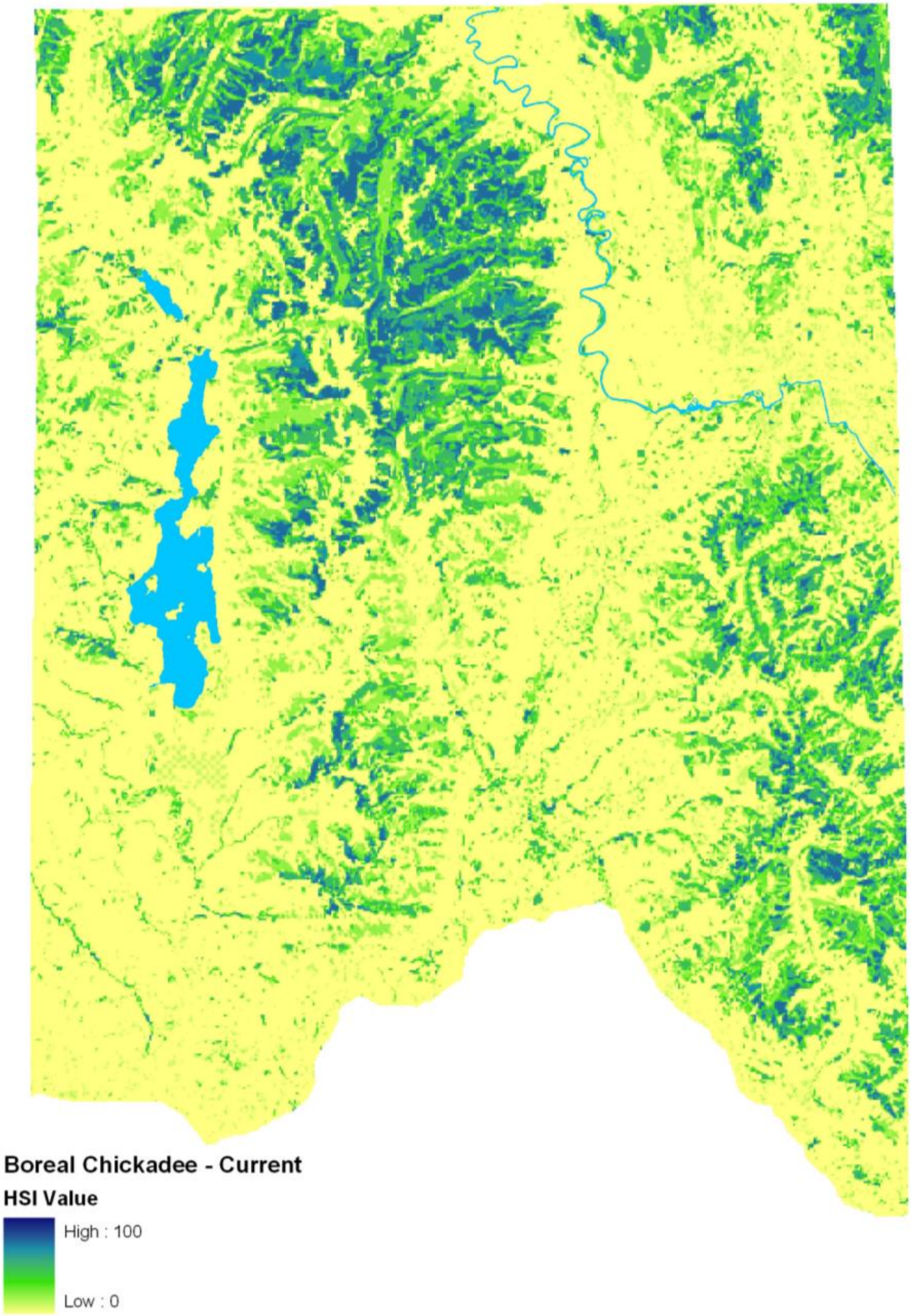


Figure 49. Current habitat suitability index for Boreal Chickadee within the IDL planning landscape.

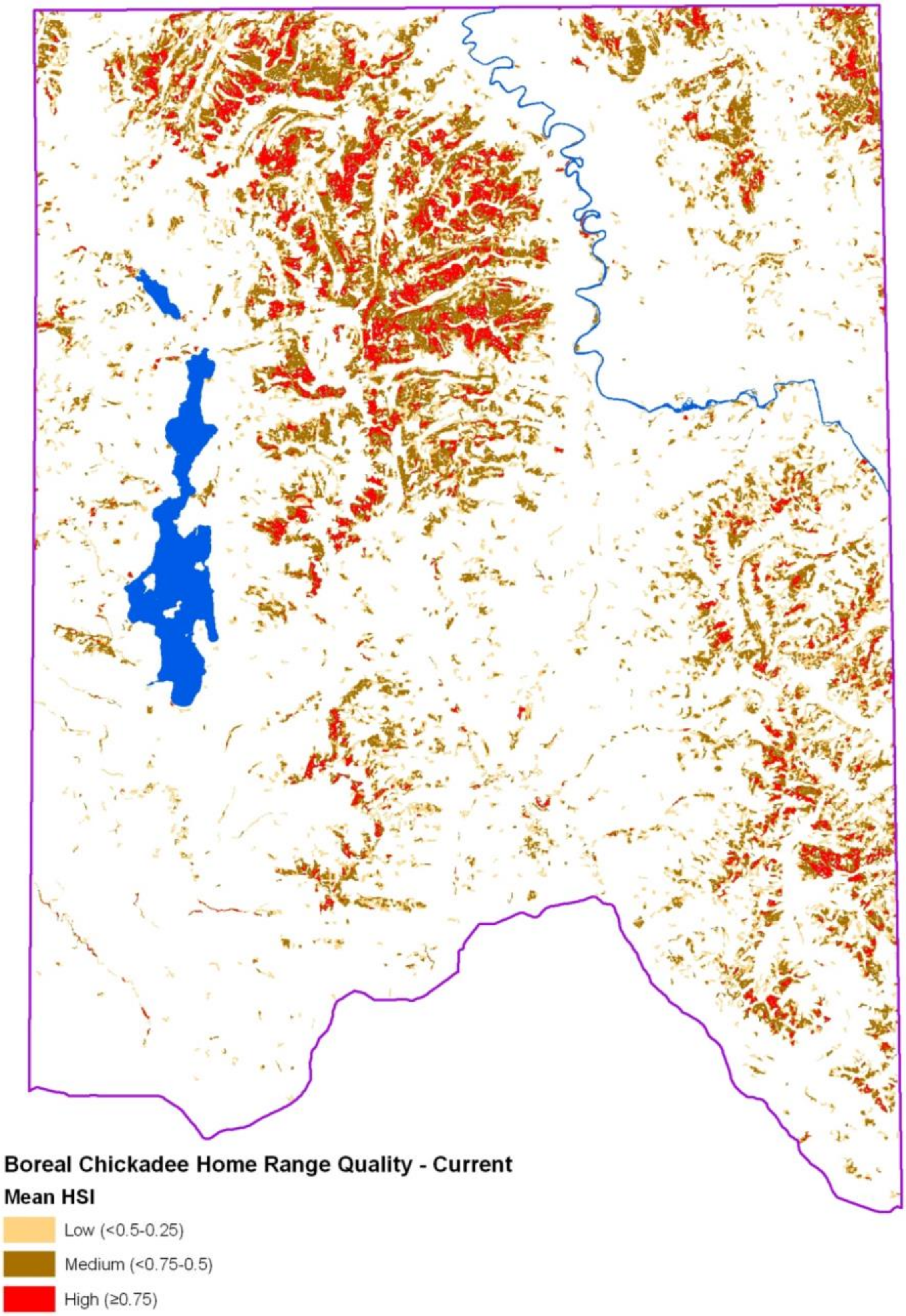


Figure 50. Current home range quality (mean HSI) for Boreal Chickadee within the IDL planning landscape.

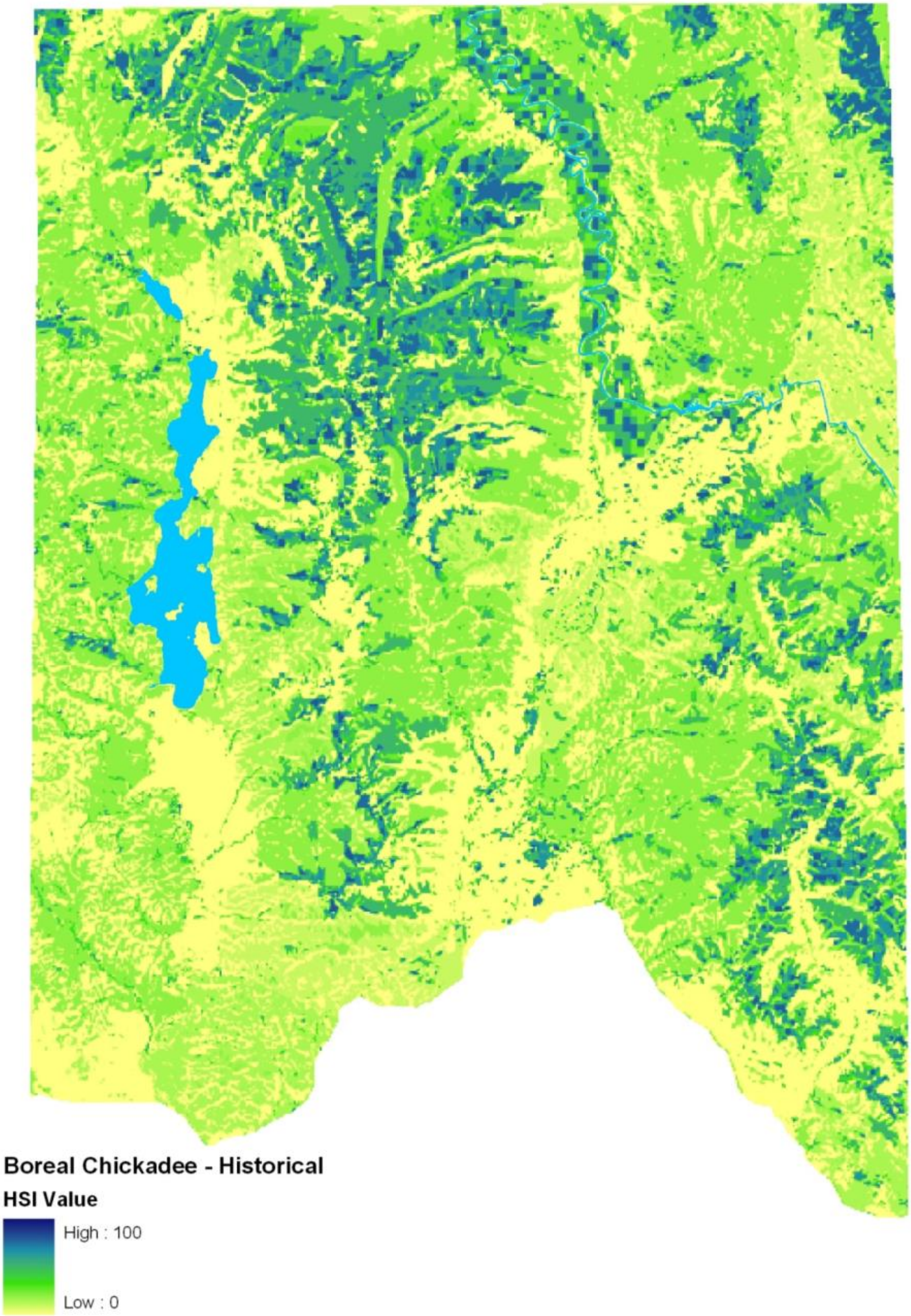


Figure 51. Historical habitat suitability index for Boreal Chickadee within the IDL planning landscape.

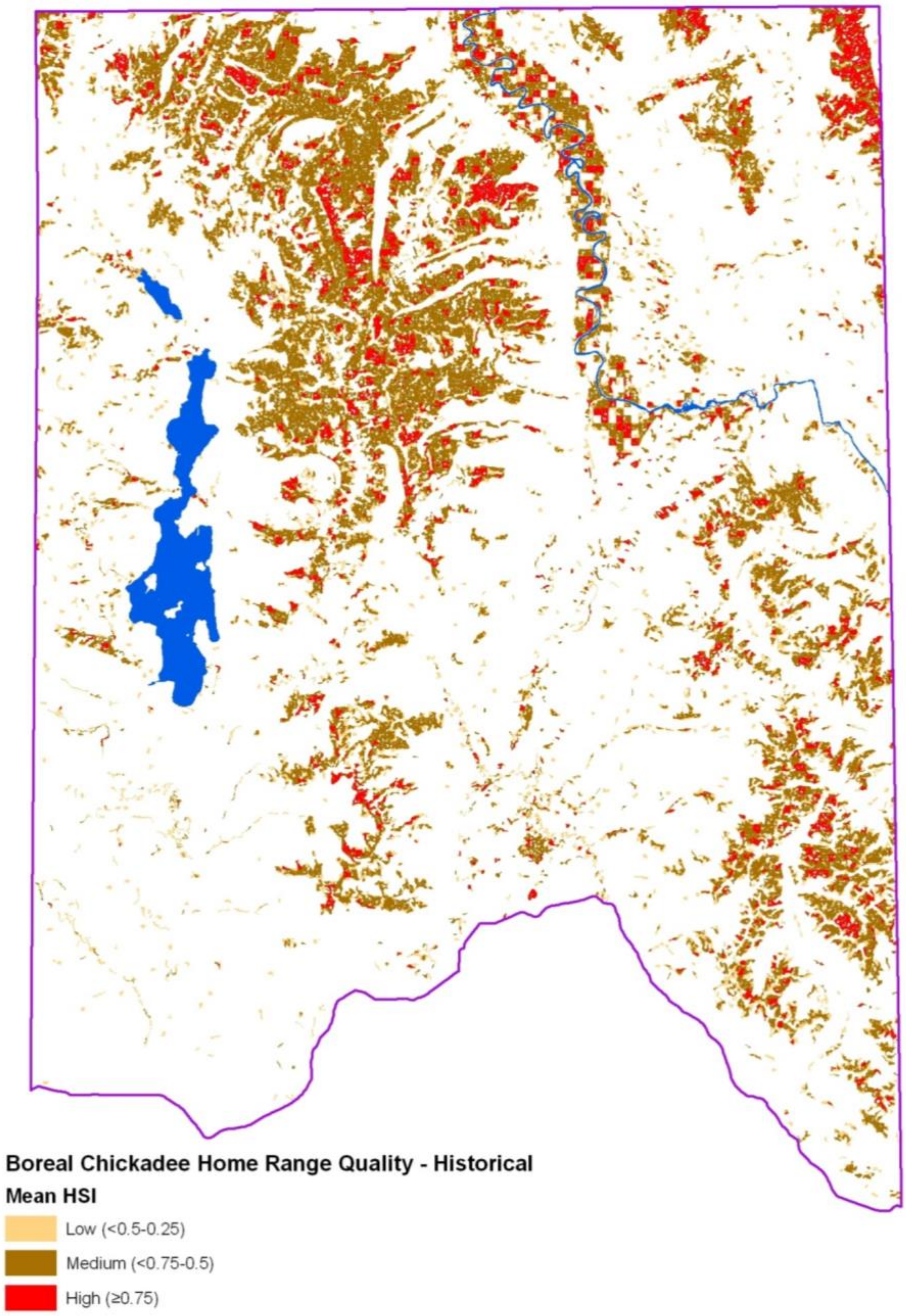


Figure 52. Historical home range quality (mean HSI) for Boreal Chickadee within the IDL planning landscape.

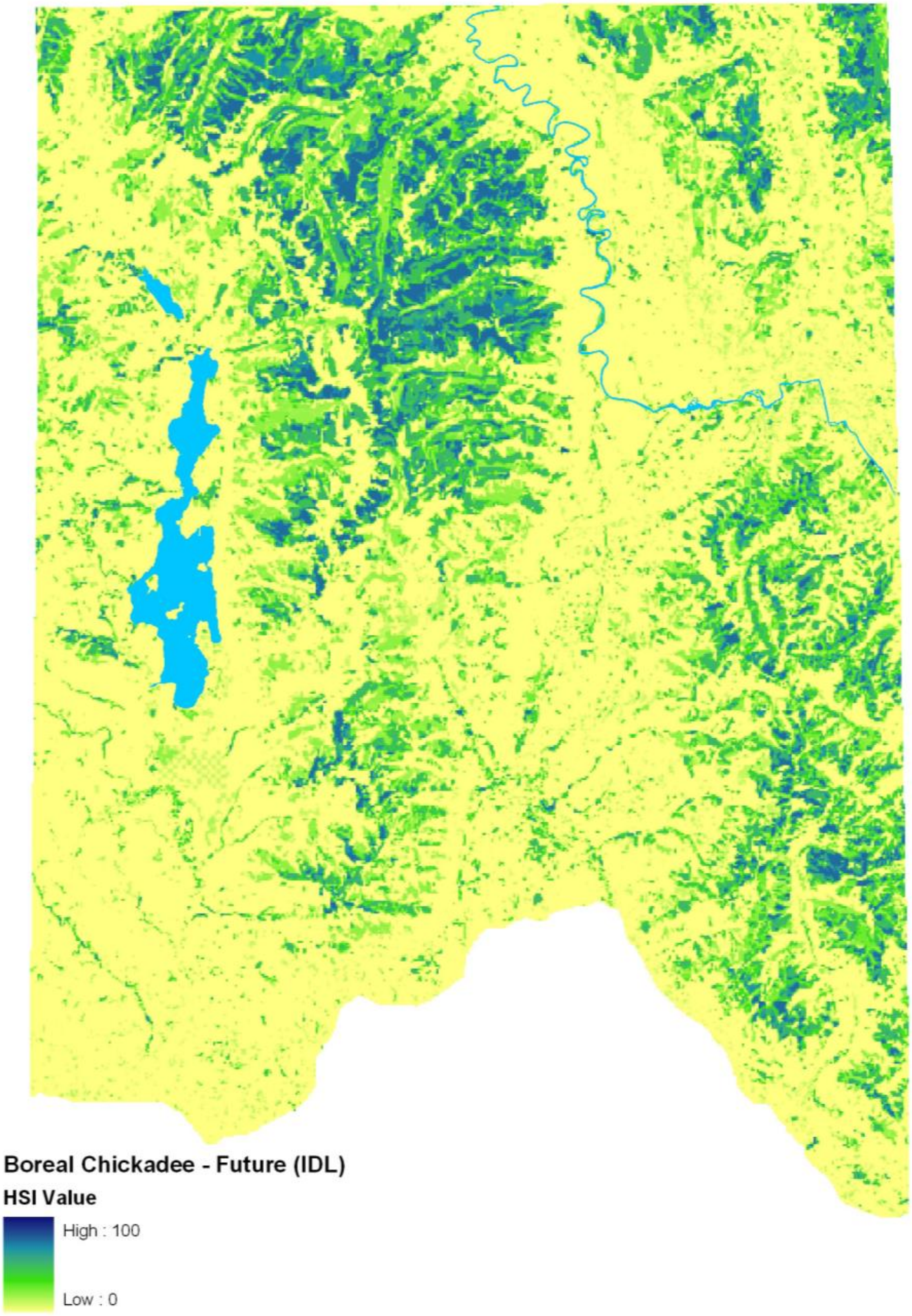


Figure 53. Future habitat suitability index for Boreal Chickadee with 20% representation on IDL ownership only.

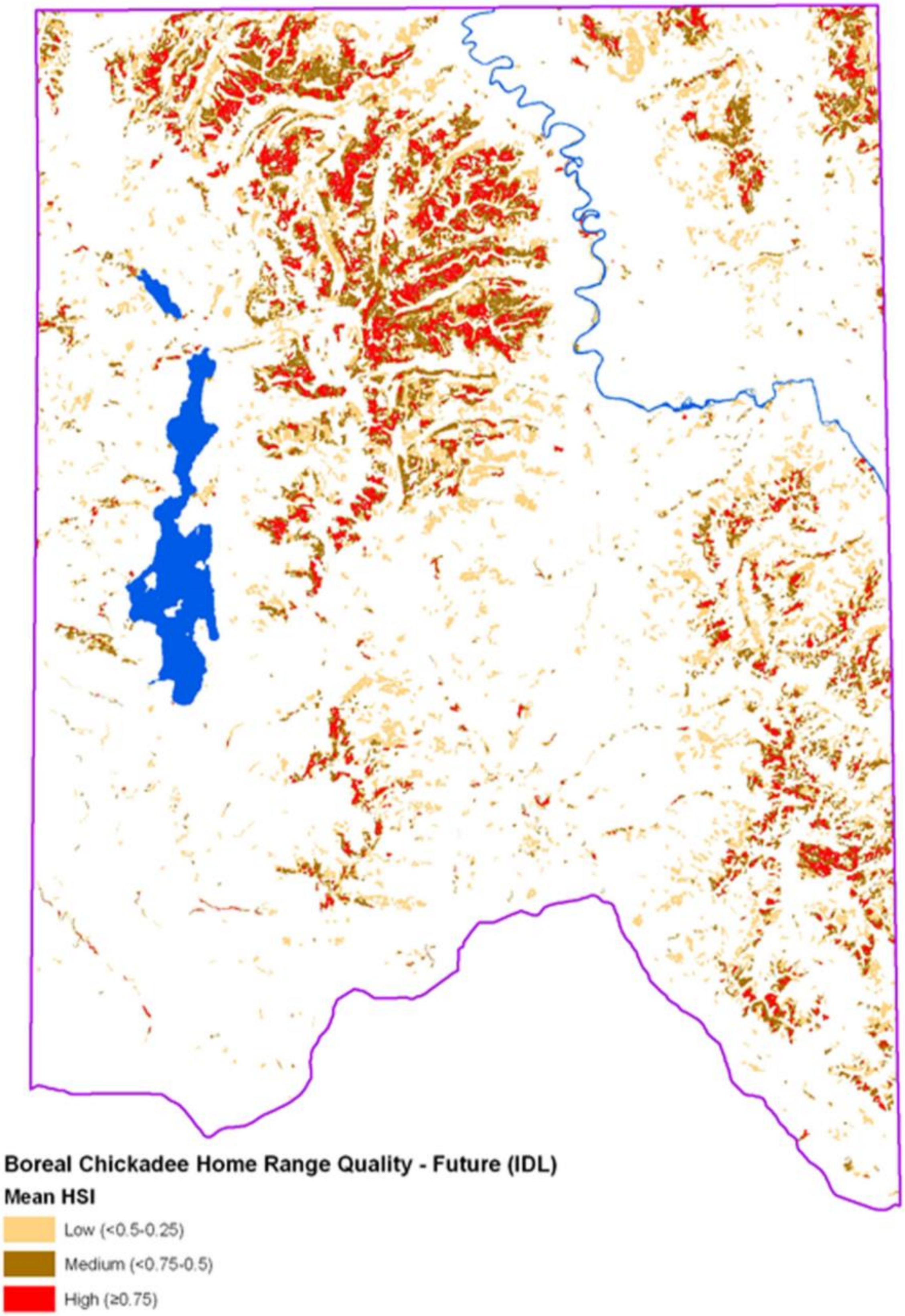


Figure 54. Future home range quality for Boreal Chickadee with 20% representation on IDL ownership only.

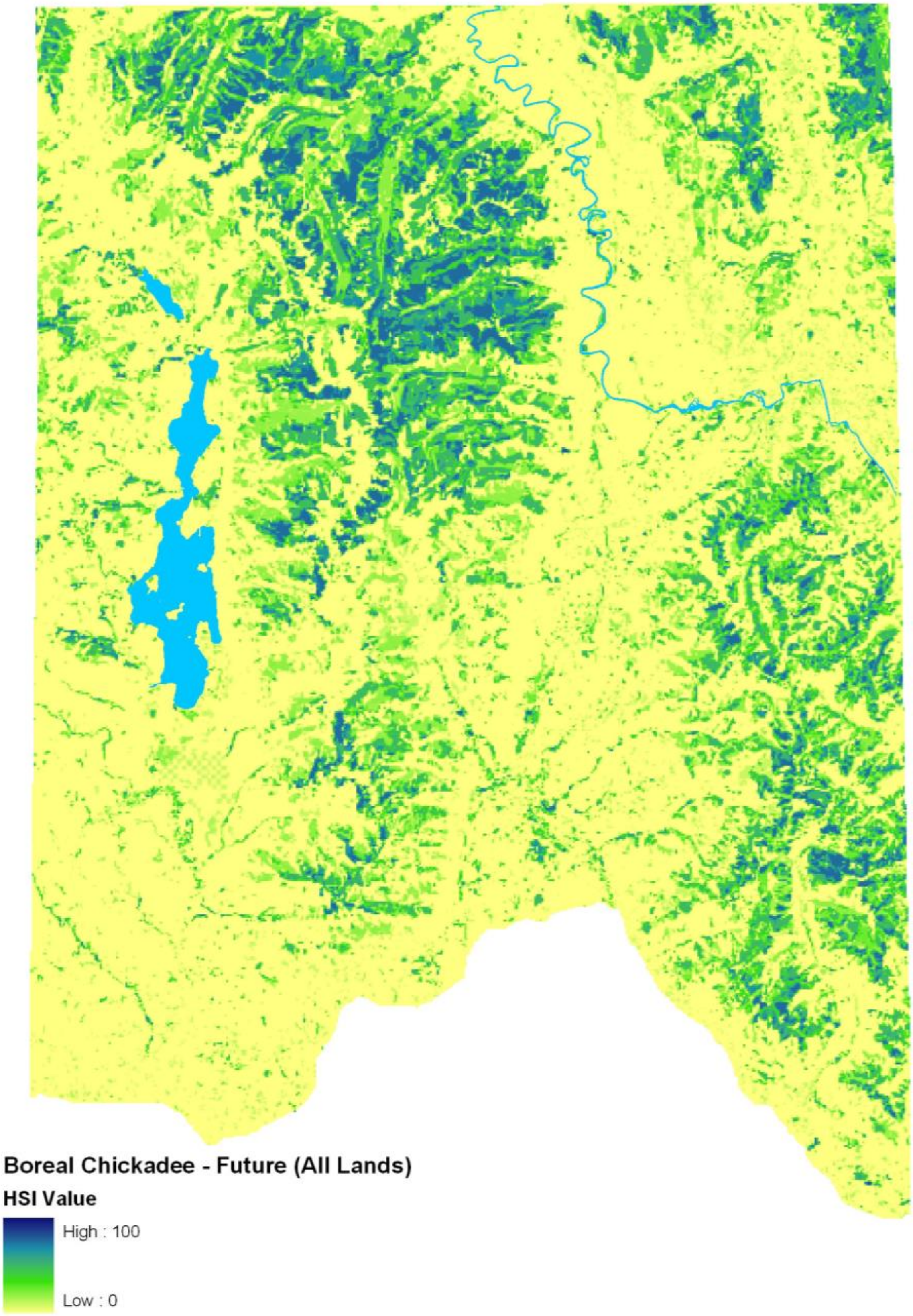


Figure 55. Future habitat suitability index for Boreal Chickadee with 20% representation on all ownerships.

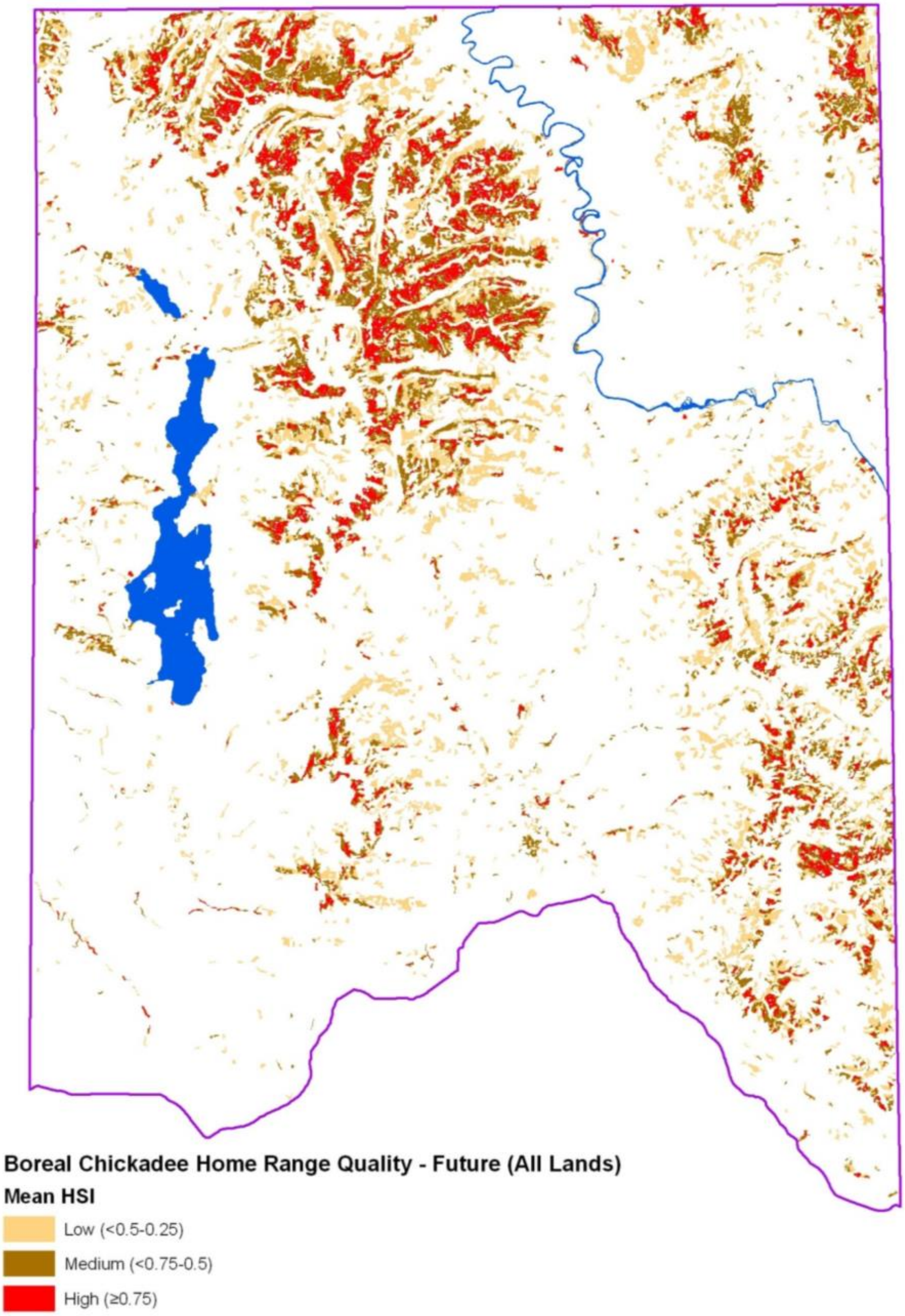
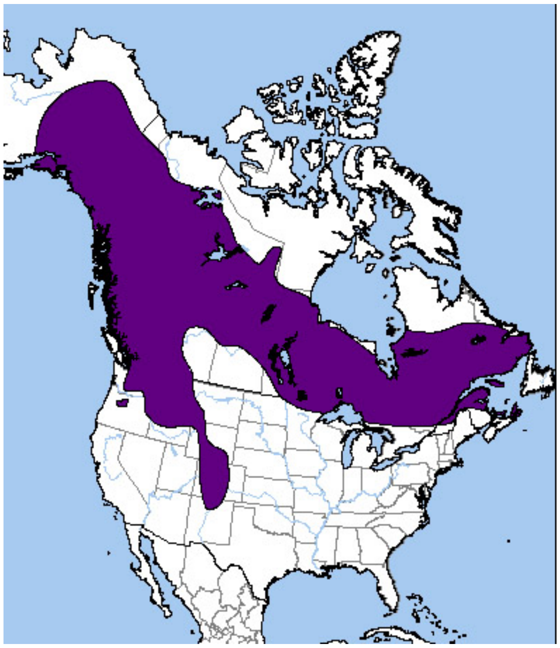


Figure 56. Future home range quality for Boreal Chickadee with 20% representation on all ownerships.

Boreal Owl (Aegolius funereus)

Boreal Owls breed throughout Idaho, mainly in higher elevation mature forests dominated by subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), and western hemlock (*Tsuga heterophylla*) (Hayward et al. 1987, Hayward and Hayward 1993). Other tree species that commonly occur in nesting stands include Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*) and aspen (*Populus tremuloides*) (Hayward et al. 1987, Hayward et al. 1993). Most nesting takes place in stands >1500 m (4921 ft) in elevation (Hayward et al. 1987, Holt and Hillis 1987, O'Connell 1987).



Current general range of the Boreal Owl in North America (Ridgely et al. 2005).

Nests are often placed in cavities created by Pileated Woodpeckers (*Dryocopus pileatus*) and Northern Flickers (*Colaptes auratis*) (Hayward et al. 1993). In Idaho, nest trees were in stands with an average of 398 trees/ha (161 trees/ac) of 2.5-23.0 cm (0.98-9.1 in) and 212 trees/ha >23.0 cm (86 trees/ac > 9.1 in) diameter at breast height (Hayward et al. 1993).

The Boreal Owl model was primarily based on the framework described by Heinrich et al. (1999). The limiting factor for Boreal Owl is nesting and roosting habitat, so the model focuses on habitat variables that characterize those conditions. Optimum habitat is found in mature conifer forests consisting of Engelmann spruce, subalpine fir and western hemlock. The optimum stand has >183 trees per hectare (74 trees/ac) suitable for nesting, tree canopy cover >50%, and mean overstory tree height >15 meters (49.2 ft). In Idaho, Boreal Owls have rarely been found below 1292m (4239 ft) (Hayward et al. 1993). The HSI model for Boreal Owl was built based on these optimum conditions. The model variables used were deciduous trees and snags per acre (Figure 57), tree canopy cover (Figure 58), mean height of overstory conifers (Figure 59), and species composition of tree overstory (Figure 60). The final HSI grid was calculated by multiplying these four variables. The output was then masked with an elevation grid to assign a HSI of 0.0 to all stands lower than 1292m (4239 ft).

HSI values for EDM cells missing stand data (Table 31) were added and the grid was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER (Figure 61). The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 0.125 kg (0.276 lb) male Boreal Owl is 9 ha (22 ac) or 10x10 cells (Van Horne and Wiens 1991).

Three iterations were done in HOMEGROWER. The target home range area was 5 times the allometric home range or 45 ha (111 ac). The number of seeds was 400,000 and the growth window was 5 cells. Figure 62 depicts home range quality for current conditions. The number of very low quality home ranges has not been delineated.

The values used to create the Boreal Owl HSI grid for historical conditions are presented in Table 32. Figure 63 is the grid used in HOMEGROWER for historical conditions. The same run parameters used for the current conditions model were also used for the historical conditions model. Figure 64 depicts home range quality for historical conditions. The number of very low quality home ranges has not been delineated.

The values used to create the Boreal Owl HSI grids for future conditions were a combination of the values used for the current conditions and historical conditions. Areas modified to achieve reference conditions received historical conditions values and all other areas received current conditions values. Figure 65 is the grid used in HOMEGROWER for future conditions applied only to IDL ownership and Figure 67 is the grid used in HOMEGROWER for future conditions applied to all ownerships. The same run parameters used for the current conditions model were also used for the future conditions models. Figure 66 depicts home range quality for future conditions applied only to IDL ownership and Figure 68 depicts home range quality for future conditions applied to all ownerships. The number of very low quality home ranges was not delineated. The mean numbers of Boreal Owl home ranges of high, medium, and low quality, resulting from the modeling effort, are presented as follows for historical, current and future conditions.

	Historical Conditions	Current Conditions	Future Conditions (IDL)	Future Conditions (All Lands)
High (1.0-0.75)	448	373	364	366
Medium (<0.75-0.5)	555	606	613	584
Low (<0.5-0.25)	336	458	453	473

As with other boreal dependent species the run results for the historical, current, and future conditions models indicate minimal changes in habitat quality over time. Boreal Owls are predominately found in forest stands at higher elevations. These stands, while modified by timber harvest, have not seen the same levels of conversion as the drier, low elevations stands. Furthermore, these stands occur in larger blocks than privately held lands at lower elevations which allows for management at larger spatial scales. The reduction in the number of high quality home ranges in the future conditions for all ownerships is caused by the proposed management of currently dense stands at mid-elevations towards more historically occurring thinner densities, resulting in a reduction in value of these stands to Boreal Owls. The shift in densities of these stands to the conditions maintained historically lowers the quality of some of these moderate quality home ranges to conditions more resembling historical conditions.

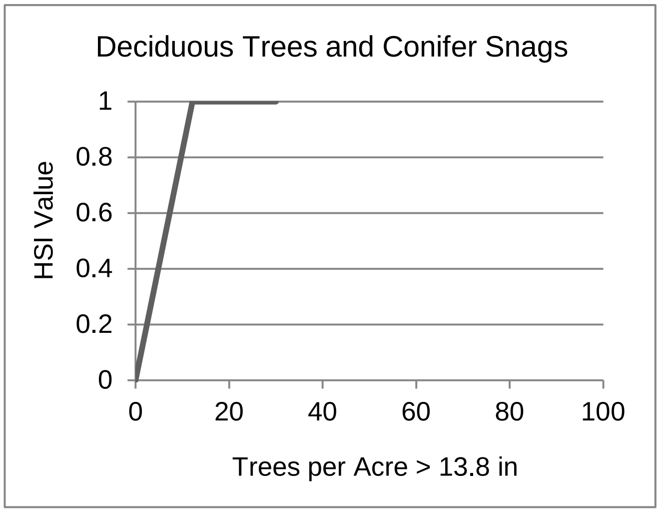


Figure 57. Relationship between number of deciduous trees and conifer snags and HSI values for Boreal Owl. The equation between 0 and 74.132 is *y=0.13x*.

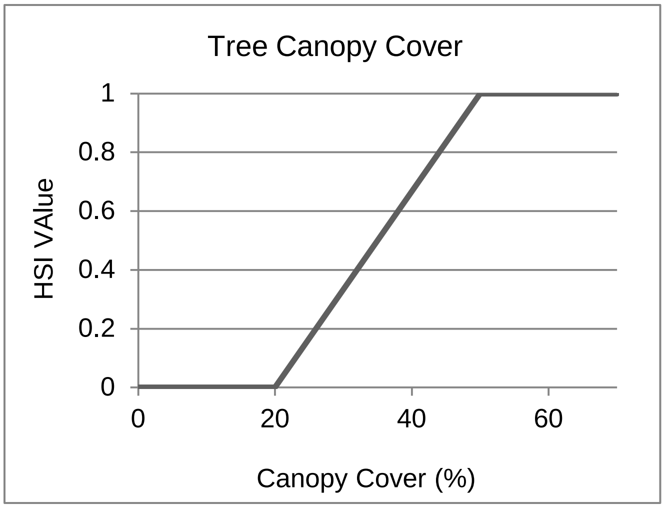


Figure 58. The relationship between tree canopy cover and HSI values for Boreal Owl. The equation between 20 and 50 is *y=0.033x-0.666*.

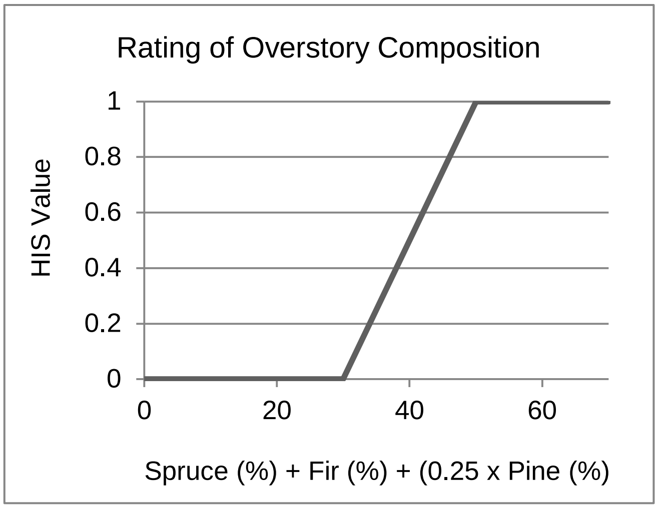


Figure 59. The relationship between mean height of overstory conifers and HSI values for Boreal Owl. The equation between 16.404 and 45.932 is *y=0.033x-0.555*.

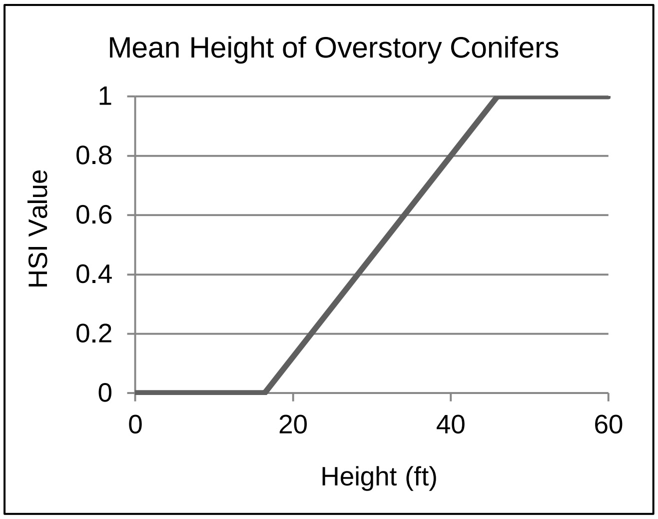


Figure 60. The relationship between overstory composition and HSI values for Boreal Owl. The equation between 30 and 50 is *$y=0.05x-1.5$*.

Table 31. HSI values for Boreal Owl used in the current conditions model (* Where available, the mean and ± one standard deviation for each relevant habitat variable from FIA stand data was used to calculate three HSI scores).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	5	10	10	10	10	10	10	10
SAPLING	0	0	0	0	5	10	10	10	10
POLE	0	0	0	0	10	10	10	10	10
MEDIUM-NL	0	5	5	5	10	10	10	25	25
LARGE-NL	0	10	15	25	30	30	40	50	50
VERY LARGE-NL	0	10	25	40	50	50	50	0	0
MEDIUM-L	0-0-0*	0-0-0*	0-0-0*	5	0-37-83*	0-0-0*	25	25	40
LARGE-L	0	0-47-81*	35-67-74*	30-40-50	0-71-100*	0-86-96*	60-70-80	60-70-80	60-70-80
VERY LARGE-L	0-0-88*	0-79-88*	0-89-100*	0-0-90*	0-84-90*	0-96-100*	0-90-100*	0-0-60*	0-78-100*

Table 32. HSI values for Boreal Owl used in the historical conditions model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	5	10	10	10	10	10	10	10
SAPLING	0	0	0	0	5	10	10	10	10
POLE	0	0	0	0	10	10	10	10	10
MEDIUM-NL	0	5	5	5	10	10	10	25	25
LARGE-NL	0	10	15	25	30	30	40	50	50
VERY LARGE-NL	0	10	25	40	50	50	50	N/A	N/A
MEDIUM-L	0	10	5	5	25	25	25	25	40
LARGE-L	0	10	15-25-35	30-40-50	60-70-80	60-70-80	60-70-80	60-70-80	60-70-80
VERY LARGE-L	0	10	30-40-50	40-50-60	80-90-100	80-90-100	80-90-100	80-90-100	80-90-100

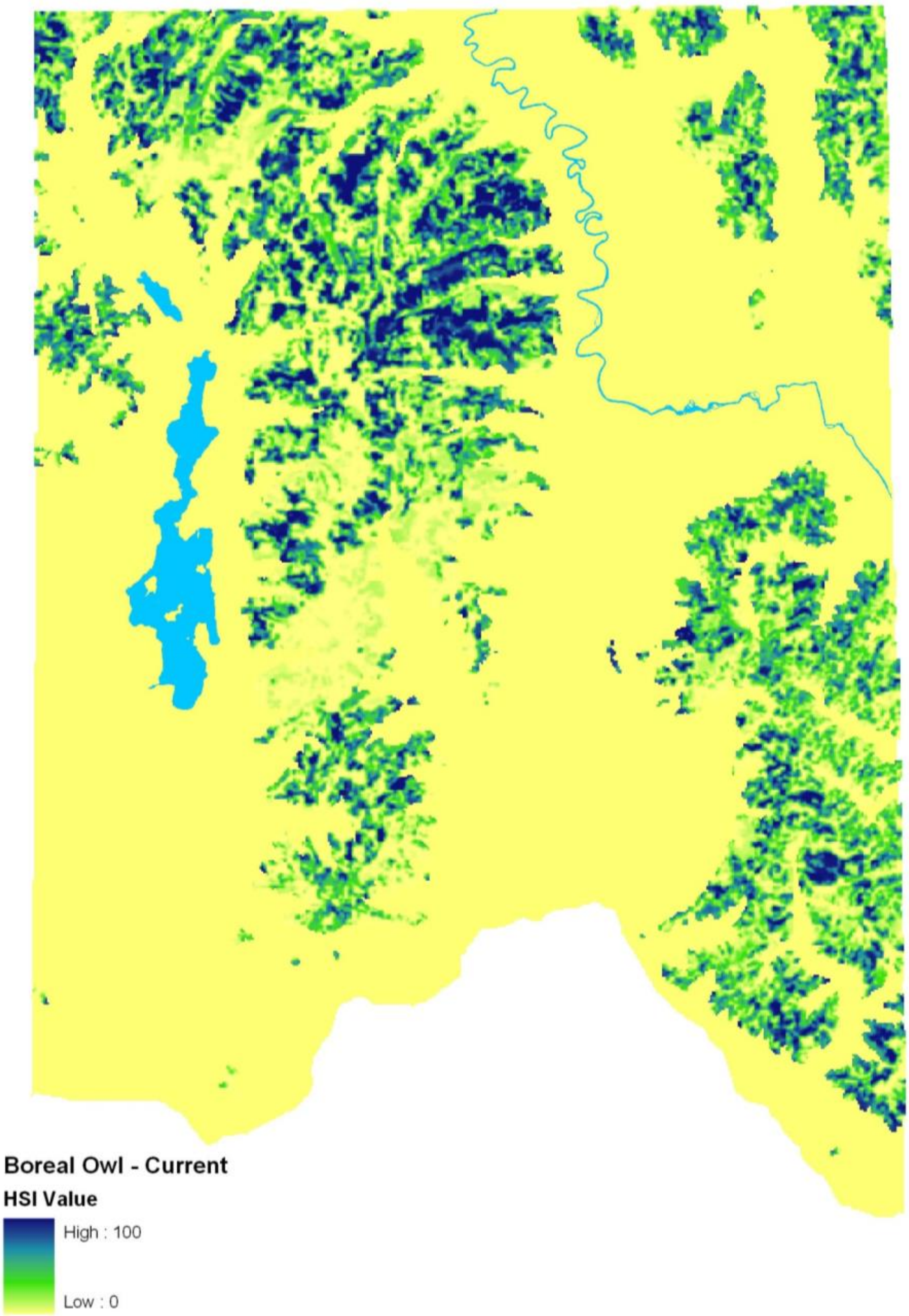


Figure 61. Current habitat suitability index for Boreal Owl within the IDL planning landscape.

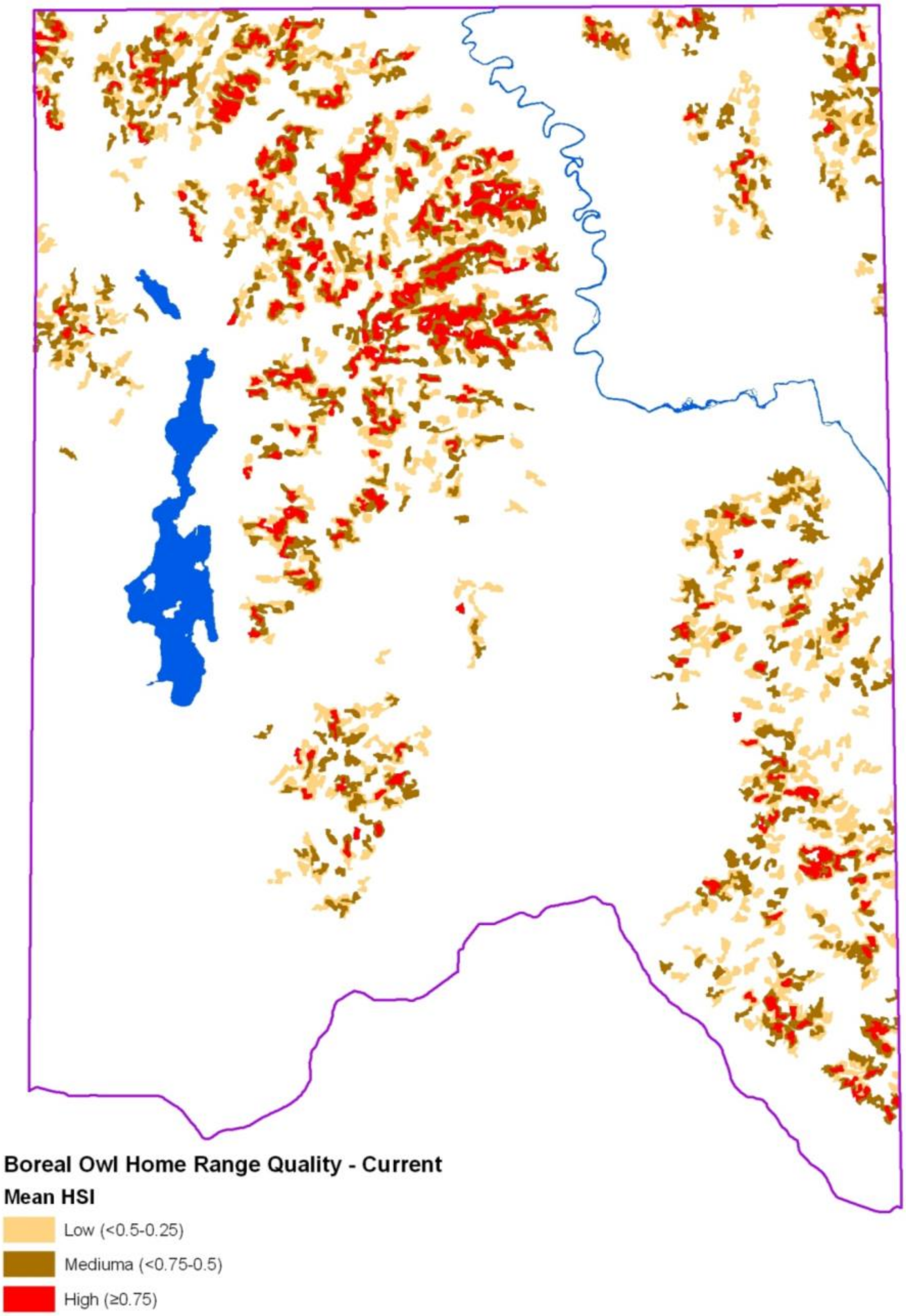


Figure 62. Current home range quality (mean HSI) for Boreal Owl within the IDL planning landscape.

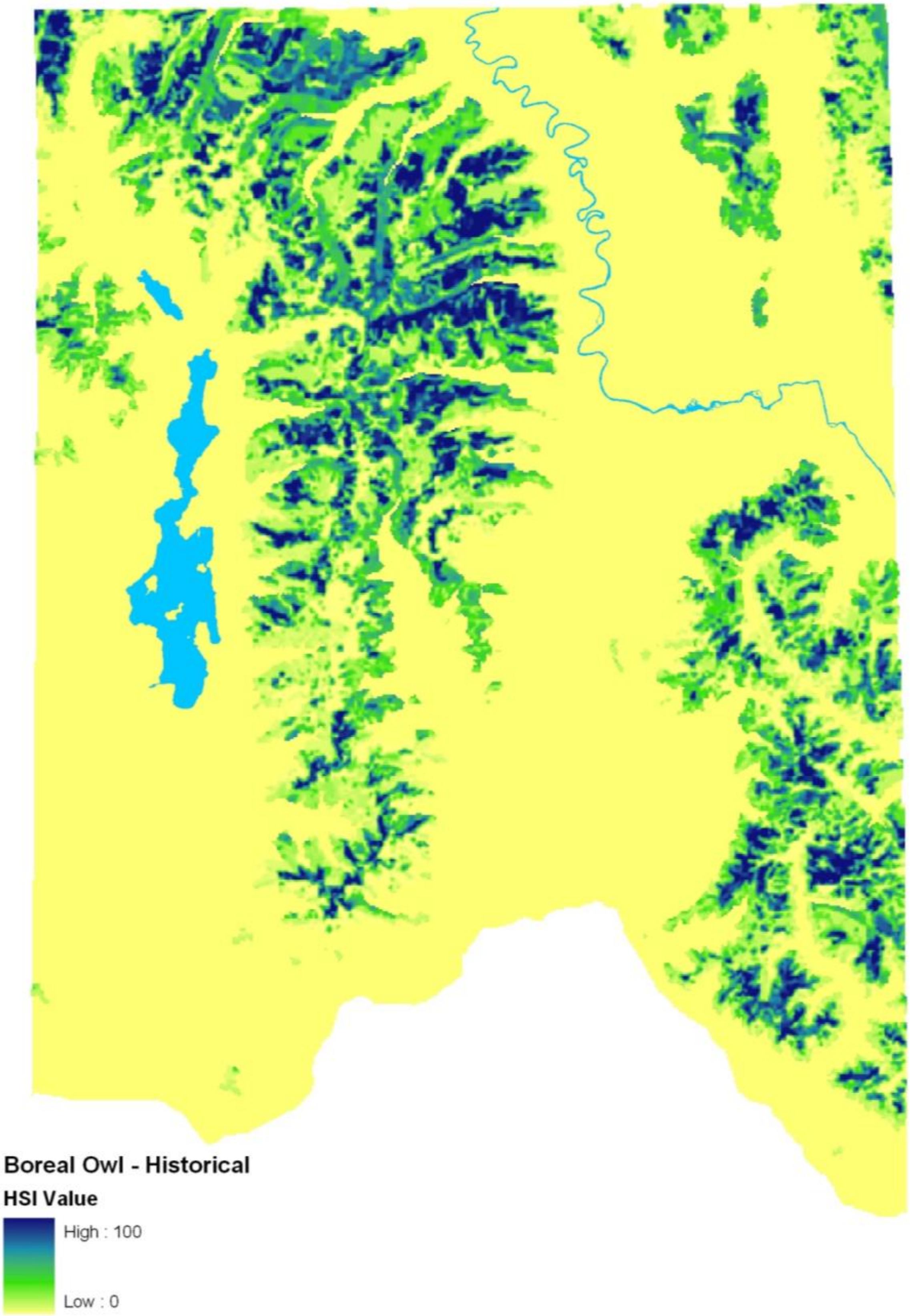


Figure 63. Historical habitat suitability index for Boreal Owl within the IDL planning landscape.

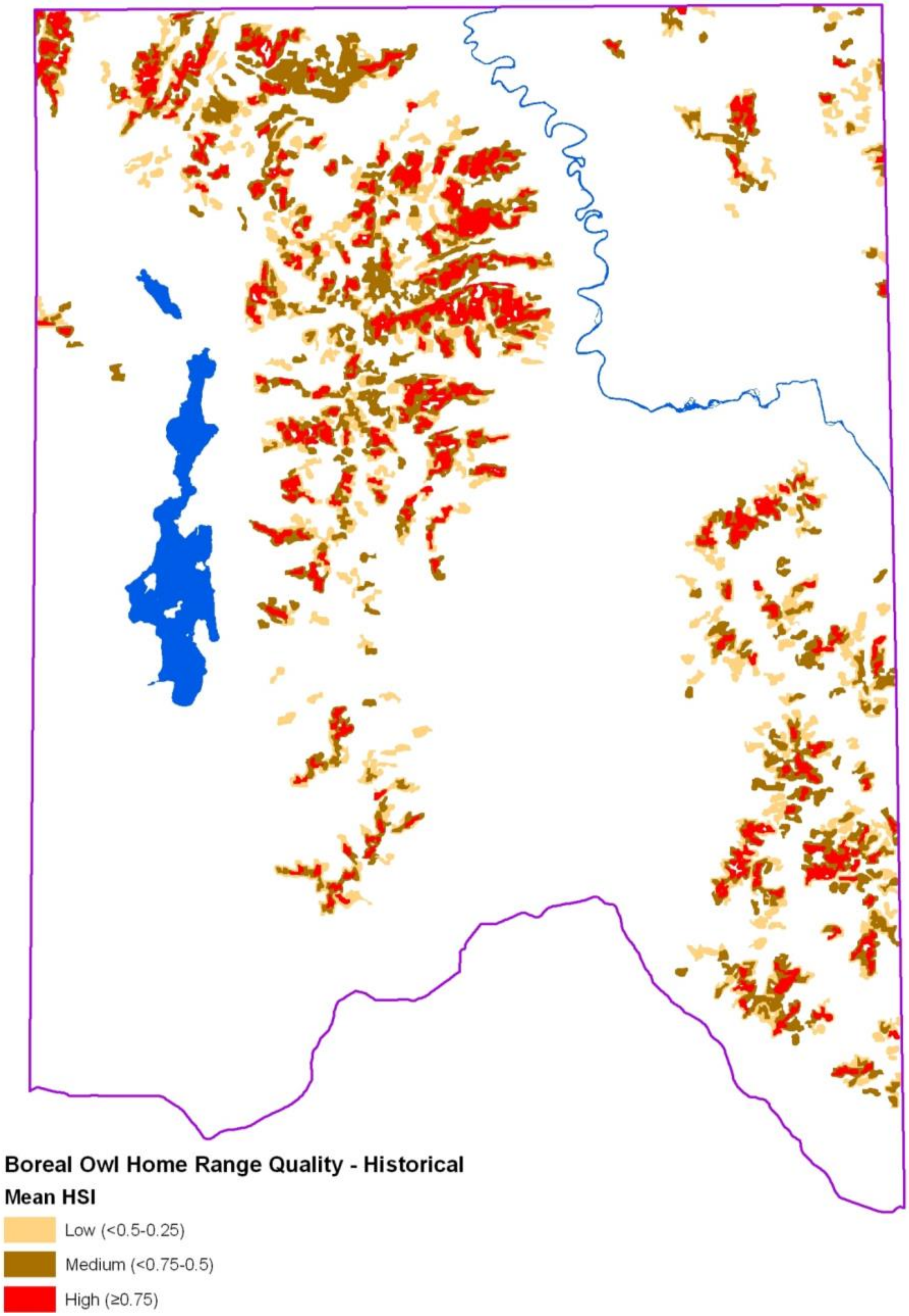


Figure 64. Historical home range quality (mean HSI) for Boreal Owl within the IDL planning landscape.

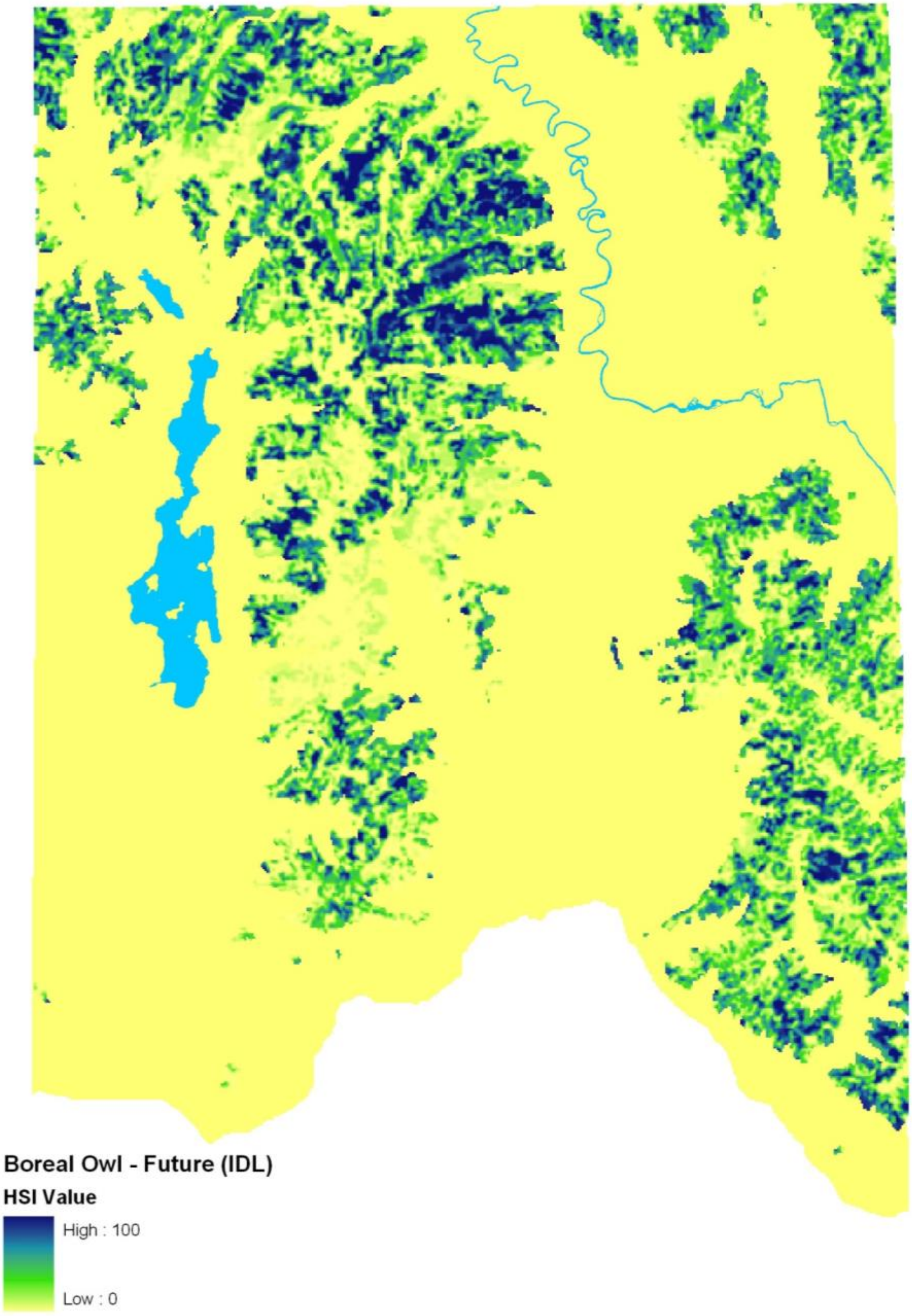


Figure 65. Future habitat suitability index for Boreal Owl with 20% representation on IDL ownership only.

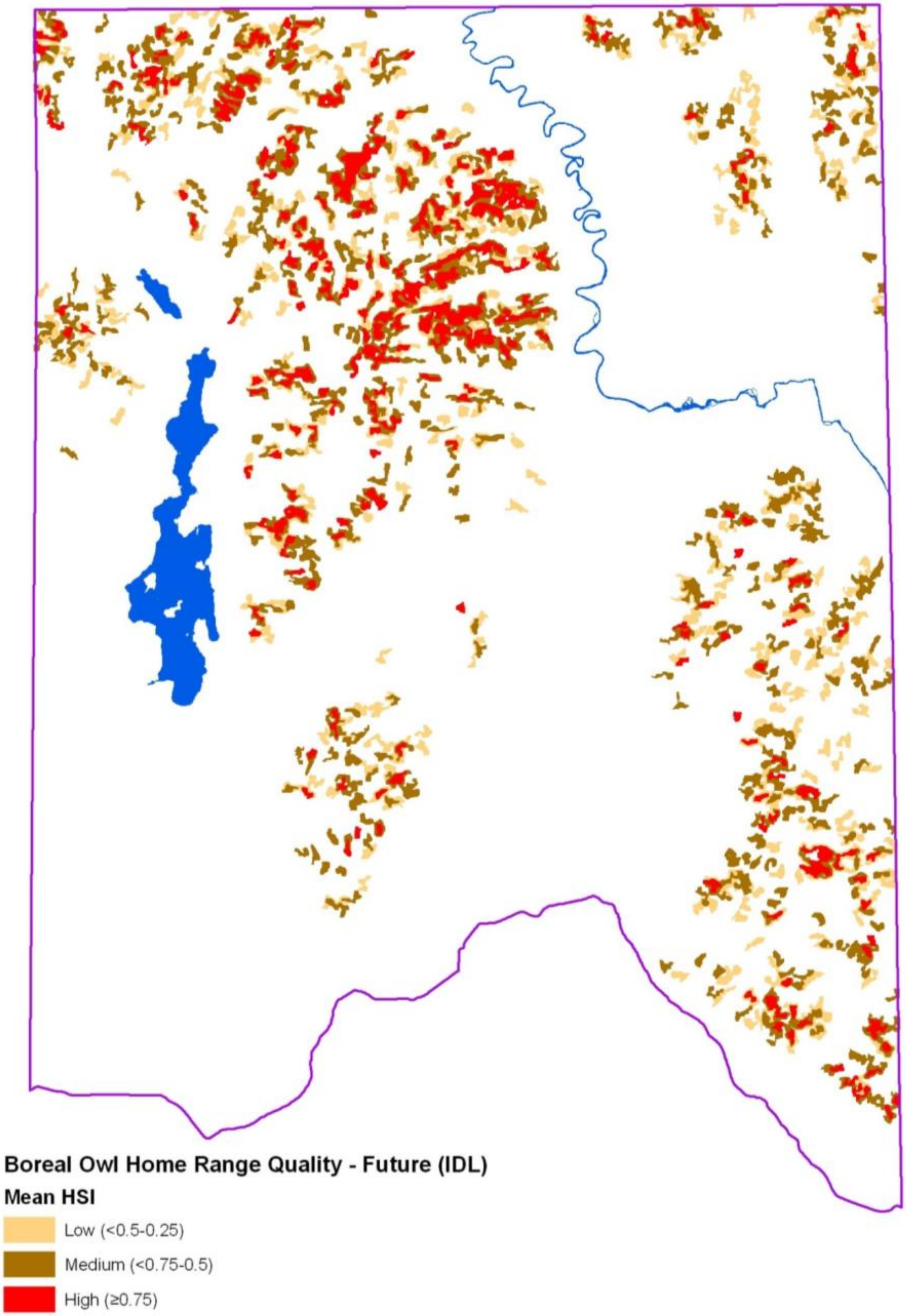


Figure 66. Future home range quality for Boreal Owl with 20% representation on IDL ownership only.

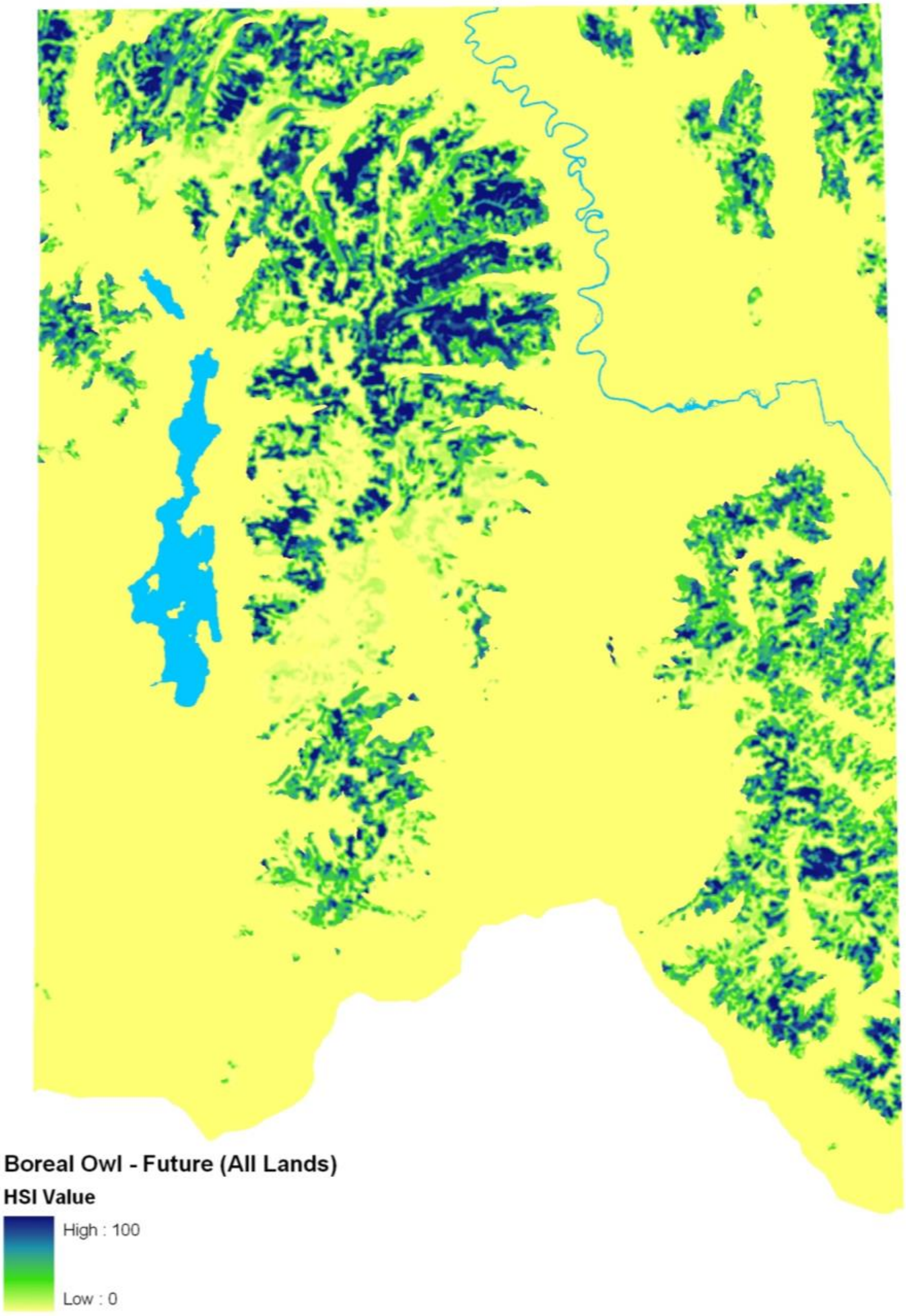


Figure 67. Future habitat suitability index for Boreal Owl with 20% representation on all ownerships.

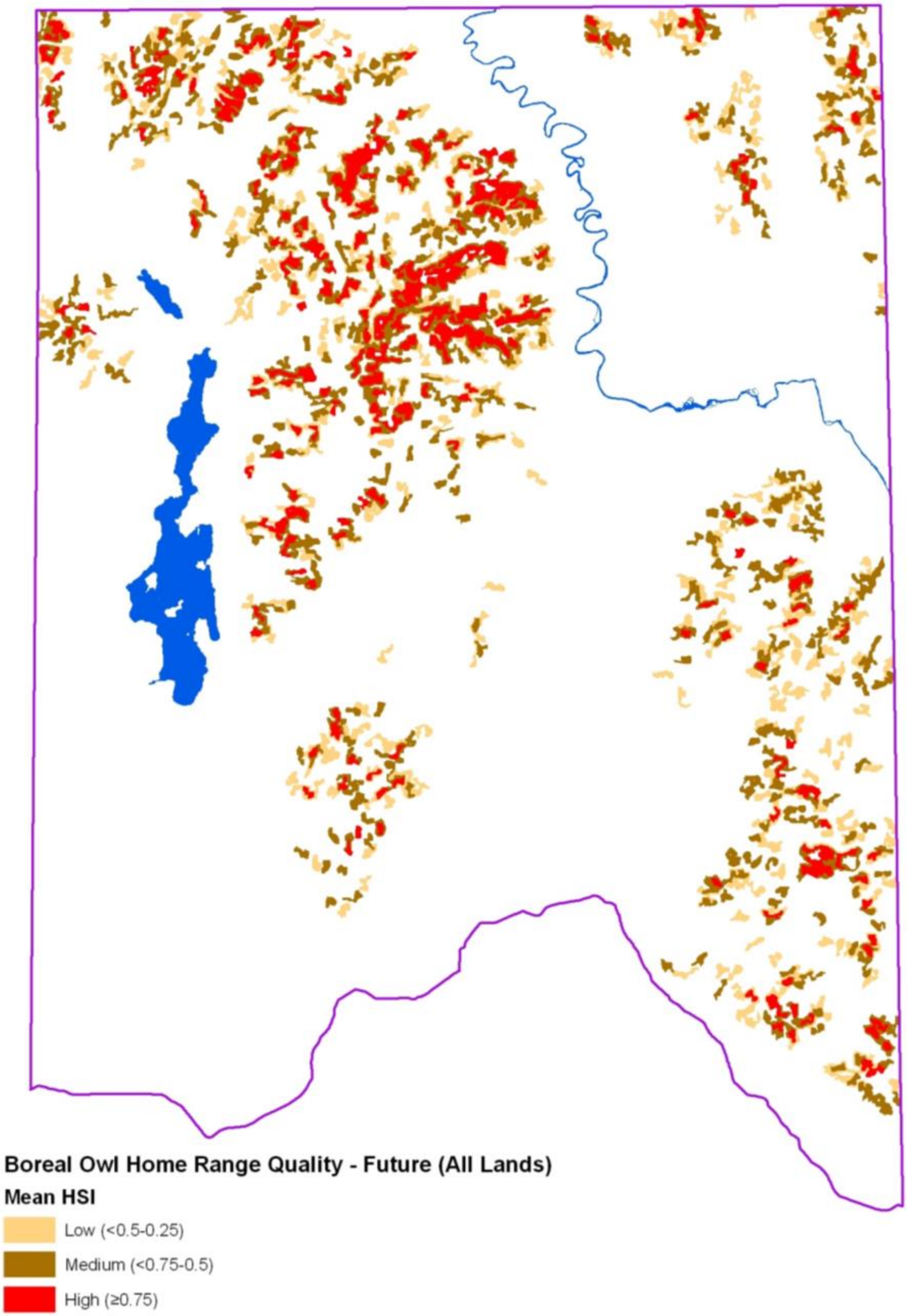


Figure 68. Future home range quality for Boreal Owl with 20% representation on all ownerships.

Flammulated Owl (*Otus flammeolus*)

Flammulated Owls are a small owl found throughout Idaho, but typically limited to dry, conifer dominated stands (Groves et al. 1997). In northern Idaho, these are low elevation stands dominated by mature to old-growth ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) with multiple canopies, low stocking rates, open canopies, and moderate shrub cover (McCallum 1994, Groves et al. 1997). Flammulated Owls have also been documented nesting successfully in stands dominated by Douglas-fir and lacking ponderosa pine (Howie and Ritcey 1987, Powers et al. 1996). The mature trees are important for nesting while the younger trees and shrubs in the understory provide roosting areas and the openings facilitate foraging (Goggans 1986, Reynolds and Linkhart 1987). Tree densities average 500 trees/ha (202 trees/ac) with a mean diameter at breast height from 28.3-38.1 cm (11.1-15 in) (Groves et al. 1997). Due to their preference for dry conditions and intolerance of high humidity, riparian areas are considered non-habitat (McCallum 1994).

Current range of the Flammulated Owl; red represents breeding resident (Ridgely et al. 2005).

The Flammulated Owl model is based on optimum conditions for nesting, roosting, and foraging. Flammulated Owls prefer xeric, open, old growth ponderosa pine and Douglas-fir with scattered clumps of dense younger trees and a component of large snags (Christie and van Woudenberg 1997). Sites can be further characterized by the lack of moist site indicator species such as *Salix* and *Vaccinium* (Wright et al. 1997). The optimum stand has tree canopy cover between 23.3% and 40%, percent of maximum stand density index (SDI) between 33.3 and 40, and is in a xeric habitat type. The percent of maximum SDI is a variable that provides more detail about stand conditions than trees per acre or basal area (Woodall and Miles 2006). The HSI model for Flammulated Owl was built based on these optimum conditions. The model variables used were tree canopy cover (Figure 69), percent max SDI (Figure 70), and habitat type (Figure 71). The final HSI grid was calculated by multiplying the geometric mean of the canopy cover HSI and SDI HSI by the habitat type HSI. The habitat type HSI was based on the relative moisture of a site as indicated by the presence of understory species such as *Salix* and *Vaccinium*.

HSI values for EDM cells missing stand data (Table 33) were added and the grid was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER (Figure 72). The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 54 g (1.9 oz) male Flammulated Owl is 3.4 ha (8.4 ac) or 6x6 cells (Van Horne and Wiens 1991).

Three iterations were done in HOMEGROWER. The target home range area was 5 times the allometric home range or 17 ha (42 ac). The number of seeds was 500,000 and the growth window was 5 cells. Figure 73 depicts home range quality for current conditions. The number of very low quality home ranges has not been delineated.

The values used to create the Flammulated Owl HSI grid for historical conditions are presented in Table 34. Figure 74 is the grid used in HOMEGROWER for historical conditions. The same run parameters used for the current conditions model were also used for the historical conditions model. Figure 75 depicts home range quality for historical conditions. The number of very low quality home ranges has not been delineated.

The values used to create the Flammulated Owl HSI grids for future conditions were a combination of the values used for the current conditions and historical conditions. Areas modified to achieve reference conditions received historical conditions values and all other areas received current conditions values. Figure 76 is the grid used in HOMEGROWER for future conditions applied only to IDL ownership and Figure 78 is the grid used in HOMEGROWER for future conditions applied to all ownerships. The same run parameters used for the current conditions model were also used for the future conditions models. Figure 77 depicts home range quality for future conditions applied only to IDL ownership and Figure 79 depicts home range quality for future conditions applied to all ownerships. The number of very low quality home ranges was not delineated. The mean numbers of Flammulated Owl home ranges of high, medium, and low quality, resulting from the modeling effort, are presented as follows for historical, current and future conditions.

	Historical Conditions	Current Conditions	Future Conditions (IDL)	Future Conditions (All Lands)
High (1.0-0.75)	2,120	141	174	581
Medium (<0.75-0.5)	1,647	763	846	1,114
Low (<0.5-0.25)	1,702	2,032	2,090	2,166

The run results for Flammulated Owls show a significant reduction in the number and quality of home ranges from historical to current conditions. The driving factor behind these results is a major reduction in the acreage of low elevation ponderosa pine habitat of good quality, due to habitat conversion. The remaining stands are extremely fragmented, making it difficult to aggregate enough high quality cells to create a high quality home range. The future models, particularly the all ownership model, show a significant increase in the number and quality of home ranges. This is a result of increased representation of low elevation ponderosa pine stands in the future conditions models. Under current conditions this in one of the rarest stand types in comparison to historical amounts.

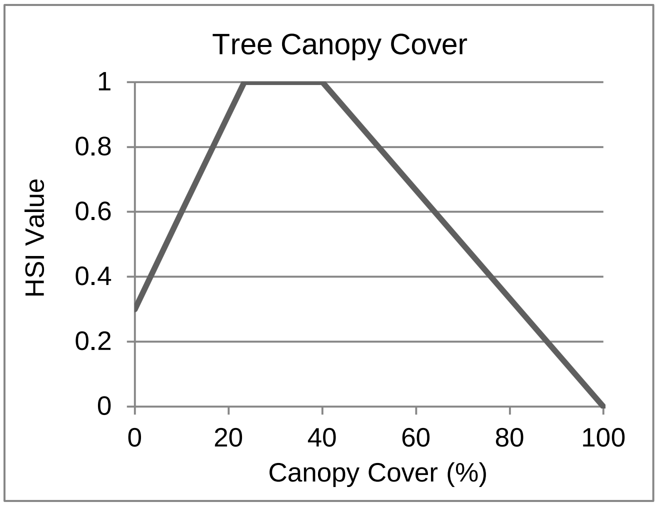


Figure 69. Relationship between tree canopy cover and HSI values for Flammulated Owl. The equation between 0 and 23.33 is *y=0.03x+0.3* and the equation between 40 and 100 is *y=-0.016x+1.666*.

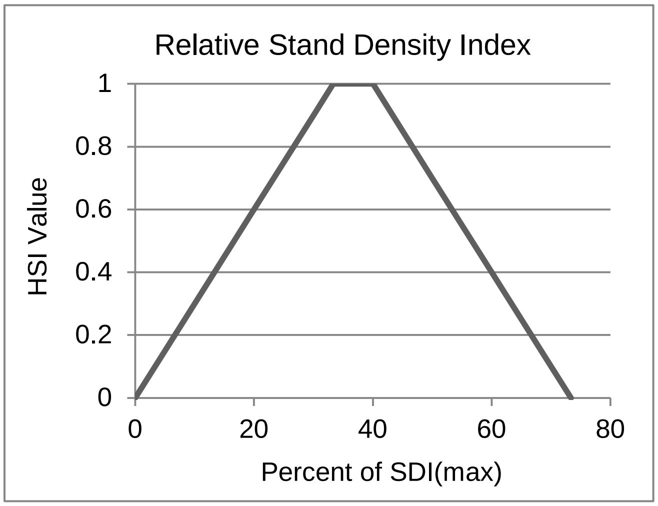


Figure 70. Relationship between relative stand density index and HSI values for Flammulated Owl. The equation between 0 and 33.33 is *y=0.03x* and the equation between 40 and 73.33 is *y=-0.03x+2.2*.

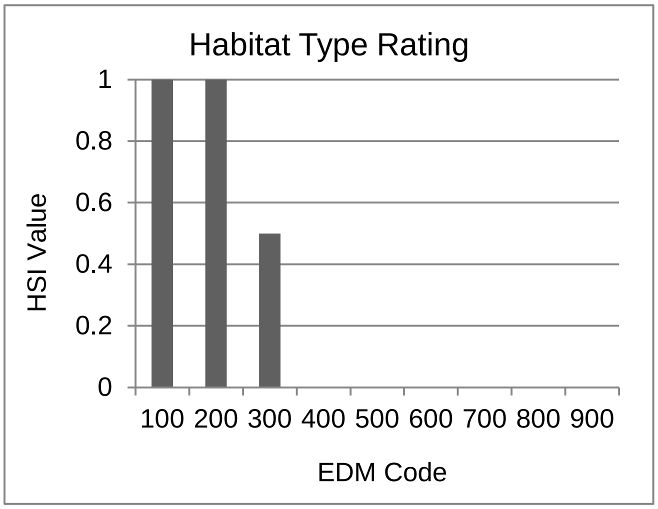


Figure 71. Relationship between habitat type and HSI values for Flammulated Owl.

Table 33. HSI values for Flammulated Owl used in the current conditions model (* Where available, the mean and ± one standard deviation for each relevant habitat variable from FIA stand data was used to calculate three HSI scores).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	5	5	5	0	0	0	0	0	0
POLE	10	20	10	0	0	0	0	0	0
MEDIUM-NL	25	25	20	0	0	0	0	0	0
LARGE-NL	75	75	30	0	0	0	0	0	0
VERY LARGE-NL	100	100	90	0	0	0	0	0	0
MEDIUM-L	85-99-81*	97-77-54*	45-29-4*	0	0-0-0*	0-0-0*	0	0	0
LARGE-L	40-60-80	71-45-0*	19-7-0*	0	0-0-0*	0-0-0*	0	0	0
VERY LARGE-L	89-76-50*	0-0-0*	0-0-0*	0-0-0*	0-0-0*	0-0-0*	0-0-0*	0-0-0*	0-0-0*

Table 34. HSI values for Flammulated Owl used in the historical conditions model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	5	5	5	0	0	0	0	0	0
POLE	10	20	10	0	0	0	0	0	0
MEDIUM-NL	50	50	20	0	0	0	0	0	0
LARGE-NL	75	75	30	0	0	0	0	0	0
VERY LARGE-NL	100	100	90	0	0	0	0	N/A	N/A
MEDIUM-L	40	40	5	0	0	0	0	0	0
LARGE-L	40-60-80	40-60-80	10	0	0	0	0	0	0
VERY LARGE-L	50-75-100	50-70-90	15	0	0	0	0	0	0

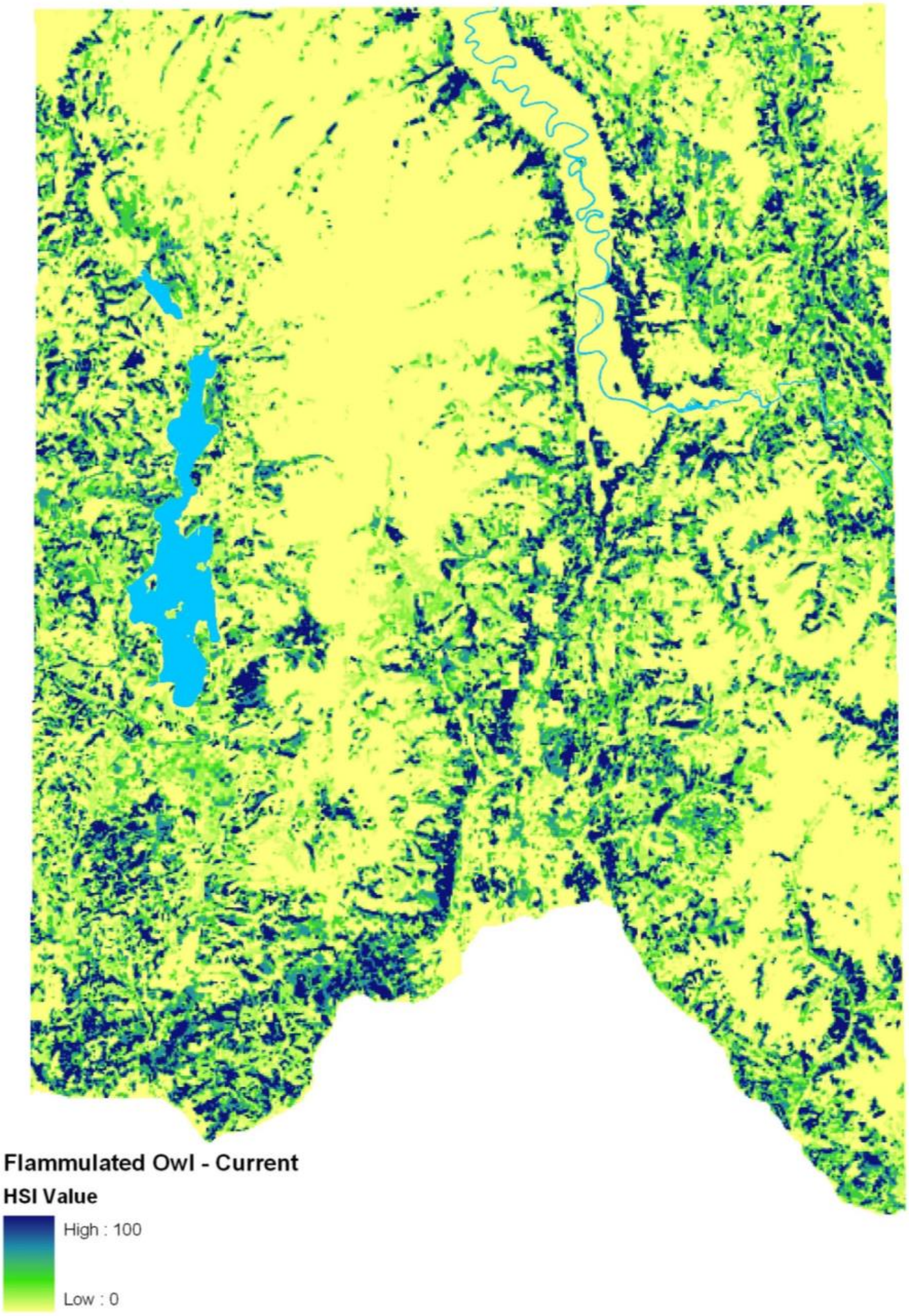


Figure 72. Current habitat suitability index for Flammulated Owl within the IDL planning landscape.

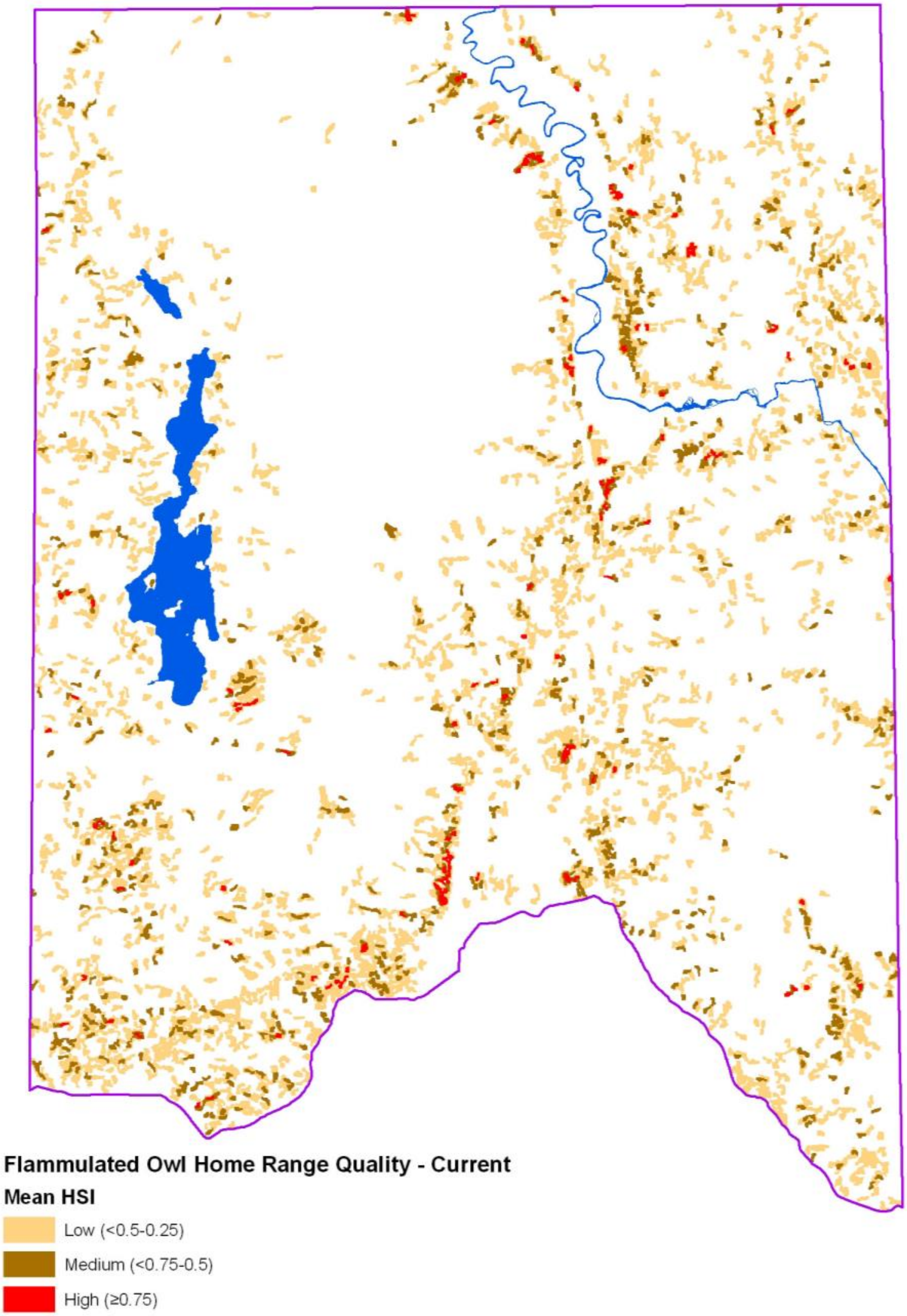


Figure 73. Current home range quality (mean HSI) for Flammulated Owl within the IDL planning landscape.

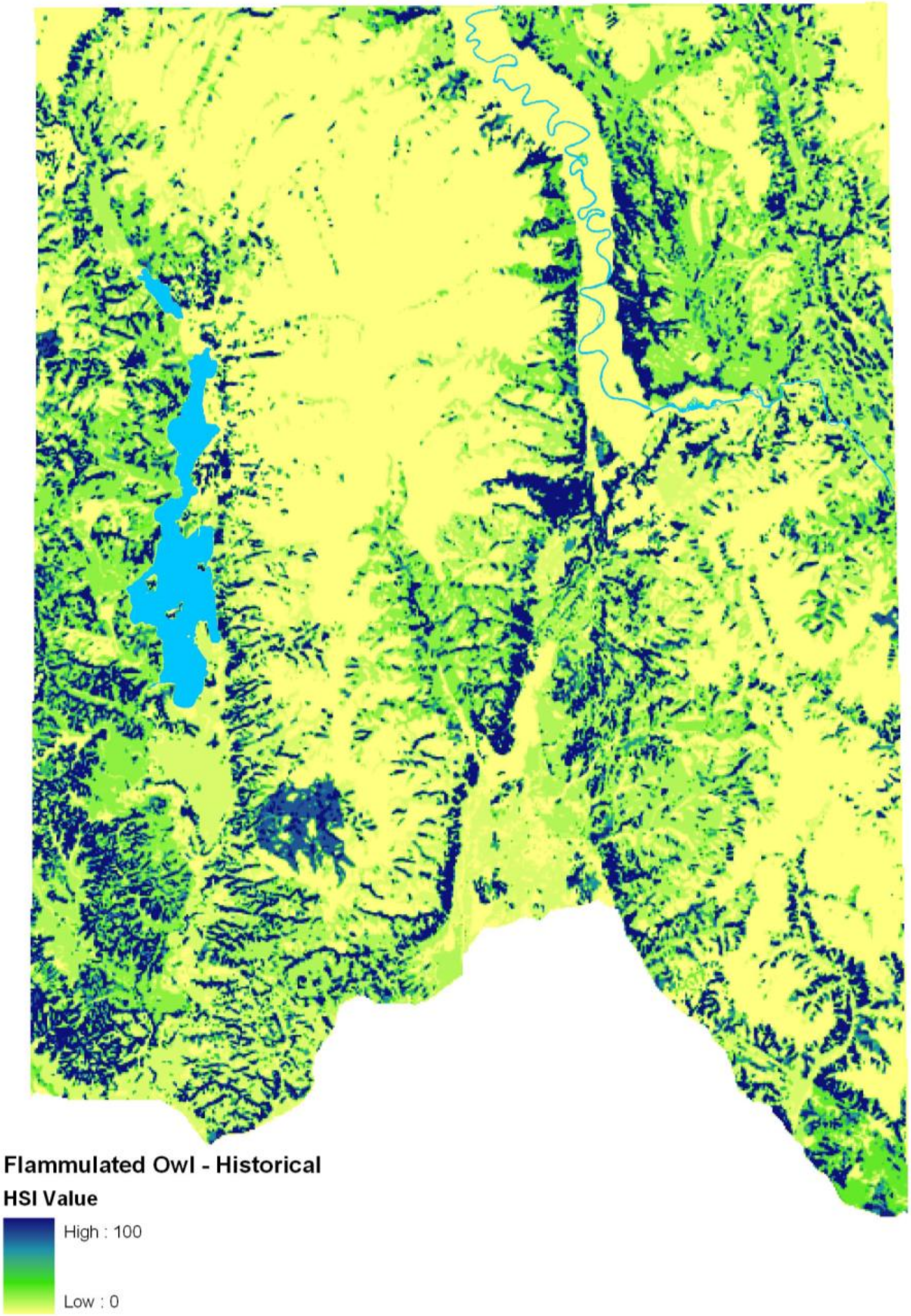


Figure 74. Historical habitat suitability index for Flammulated Owl within the IDL planning landscape.

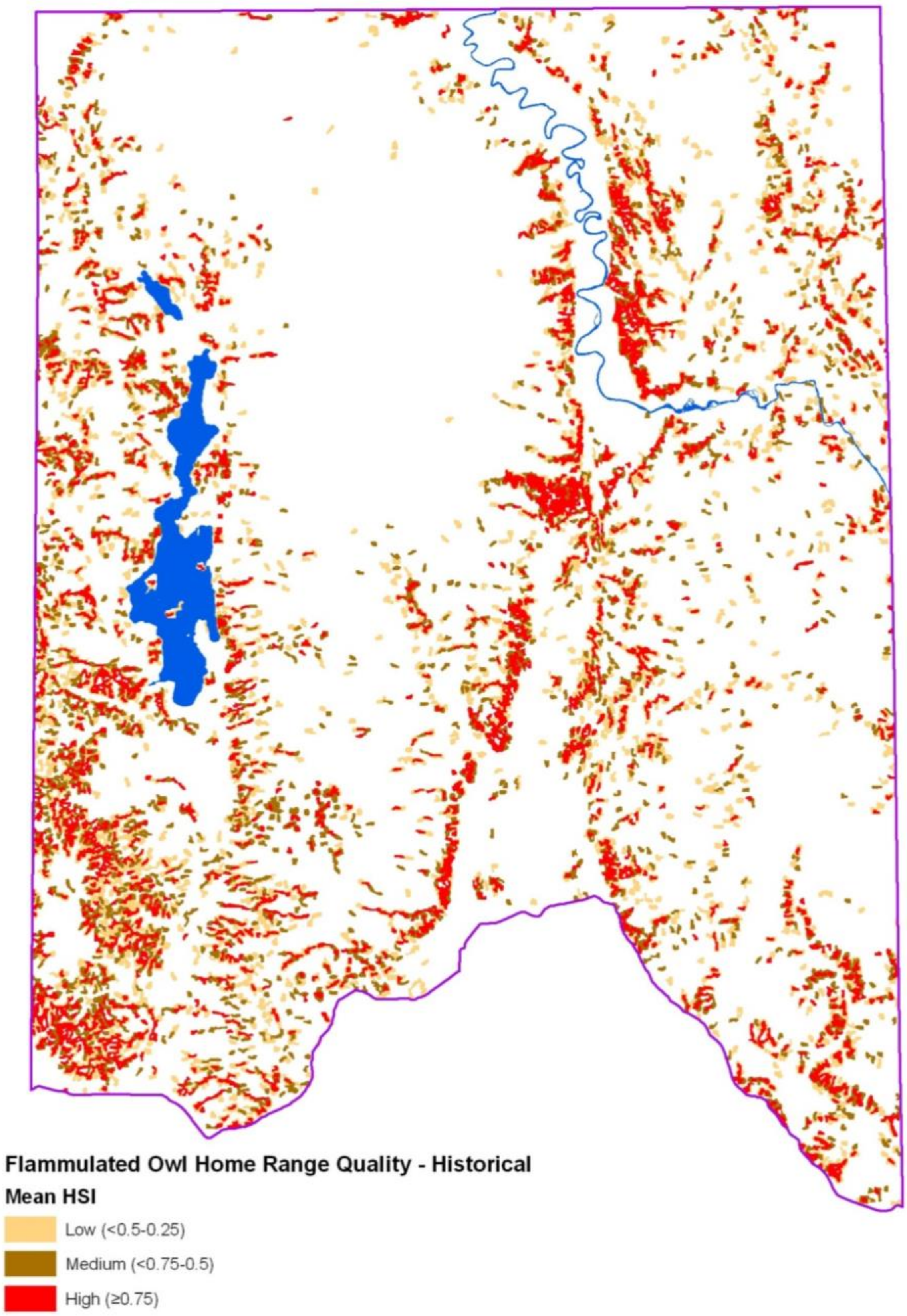


Figure 75. Historical home range quality (mean HSI) for Flammulated Owl within the IDL planning landscape.

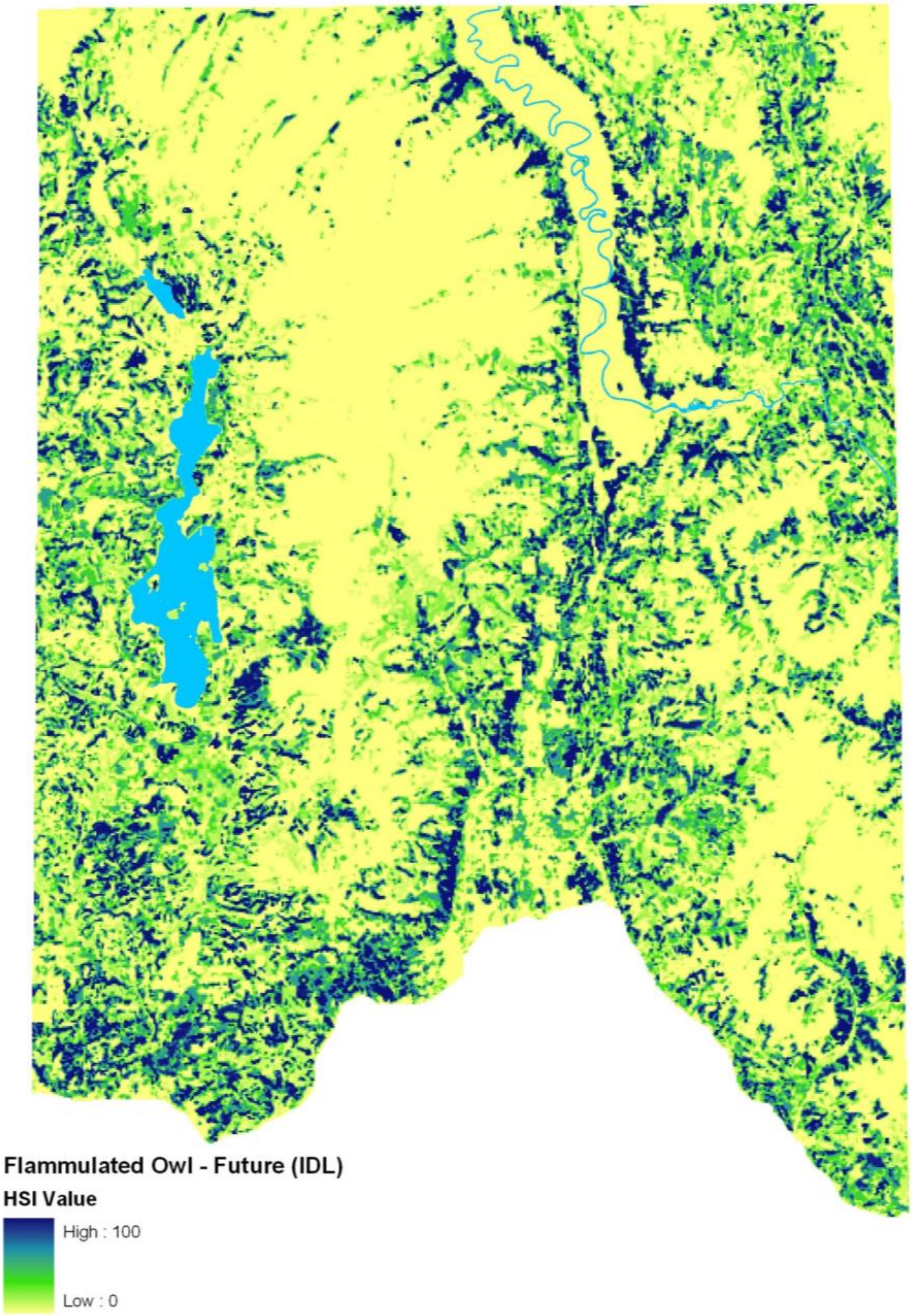


Figure 76. Future habitat suitability index for Flammulated Owl with 20% representation on IDL ownership only.

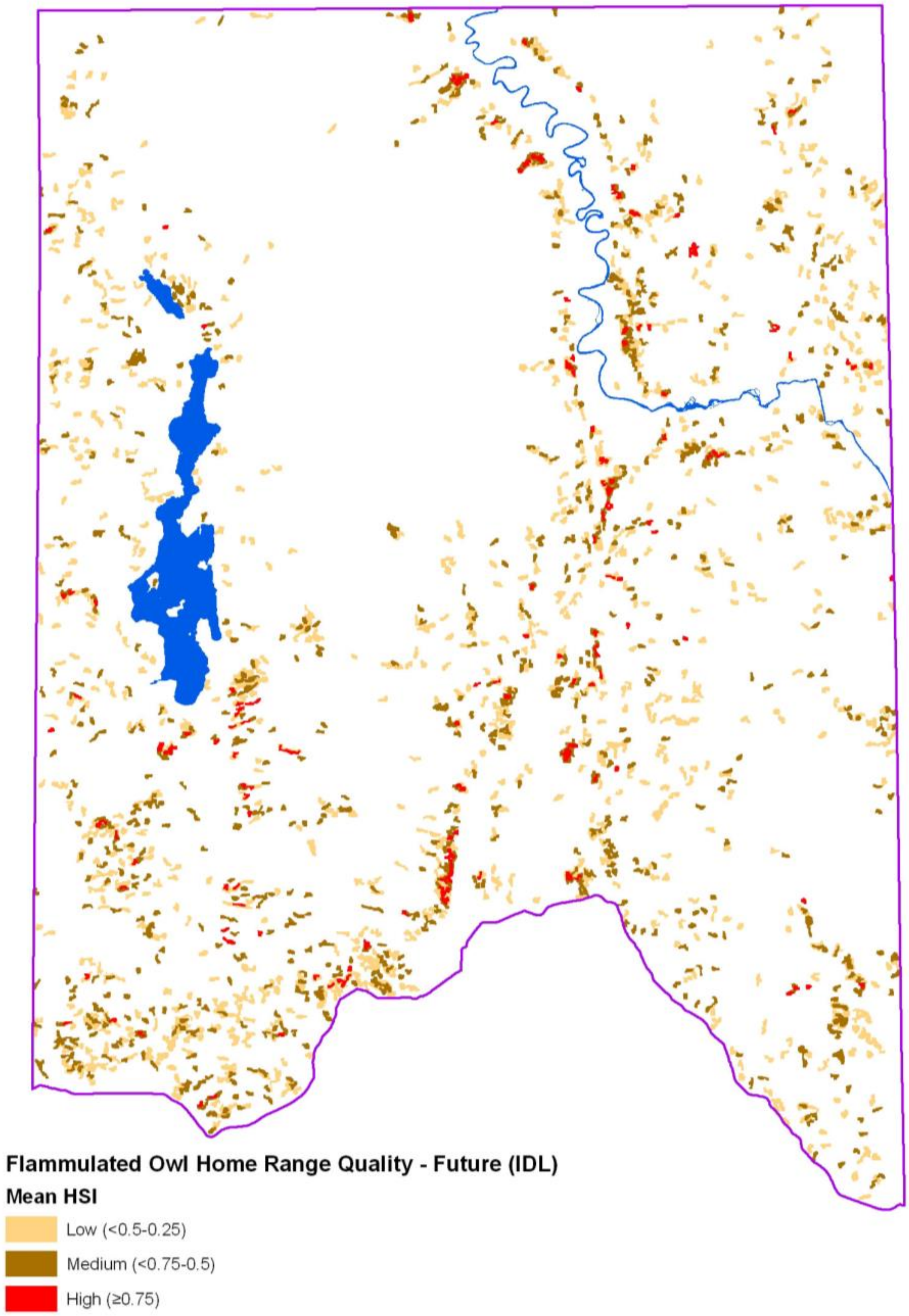


Figure 77. Future home range quality for Flammulated Owl with 20% representation on IDL ownership only.

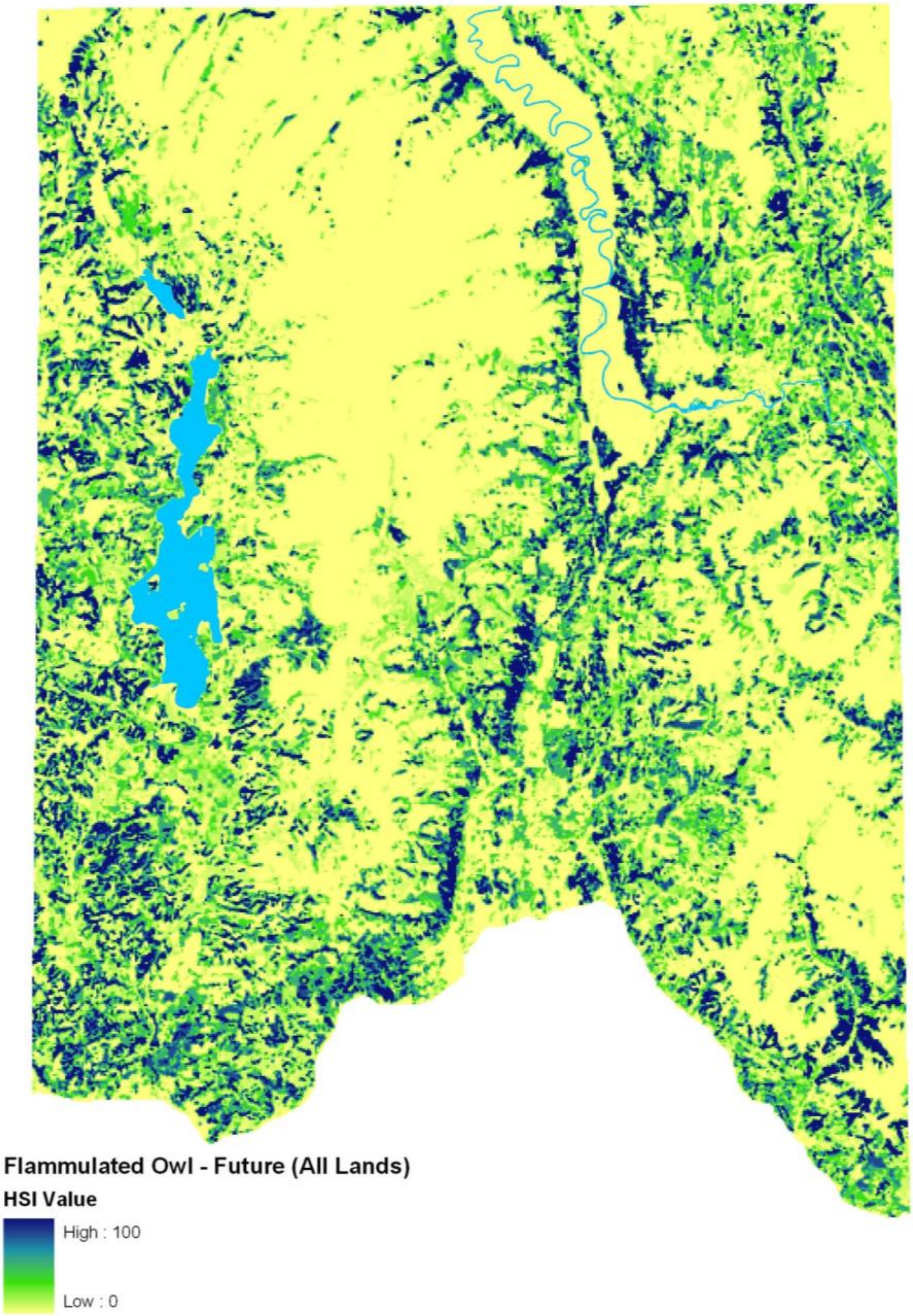


Figure 78. Future habitat suitability index for Flammulated Owl with 20% representation on all ownerships.

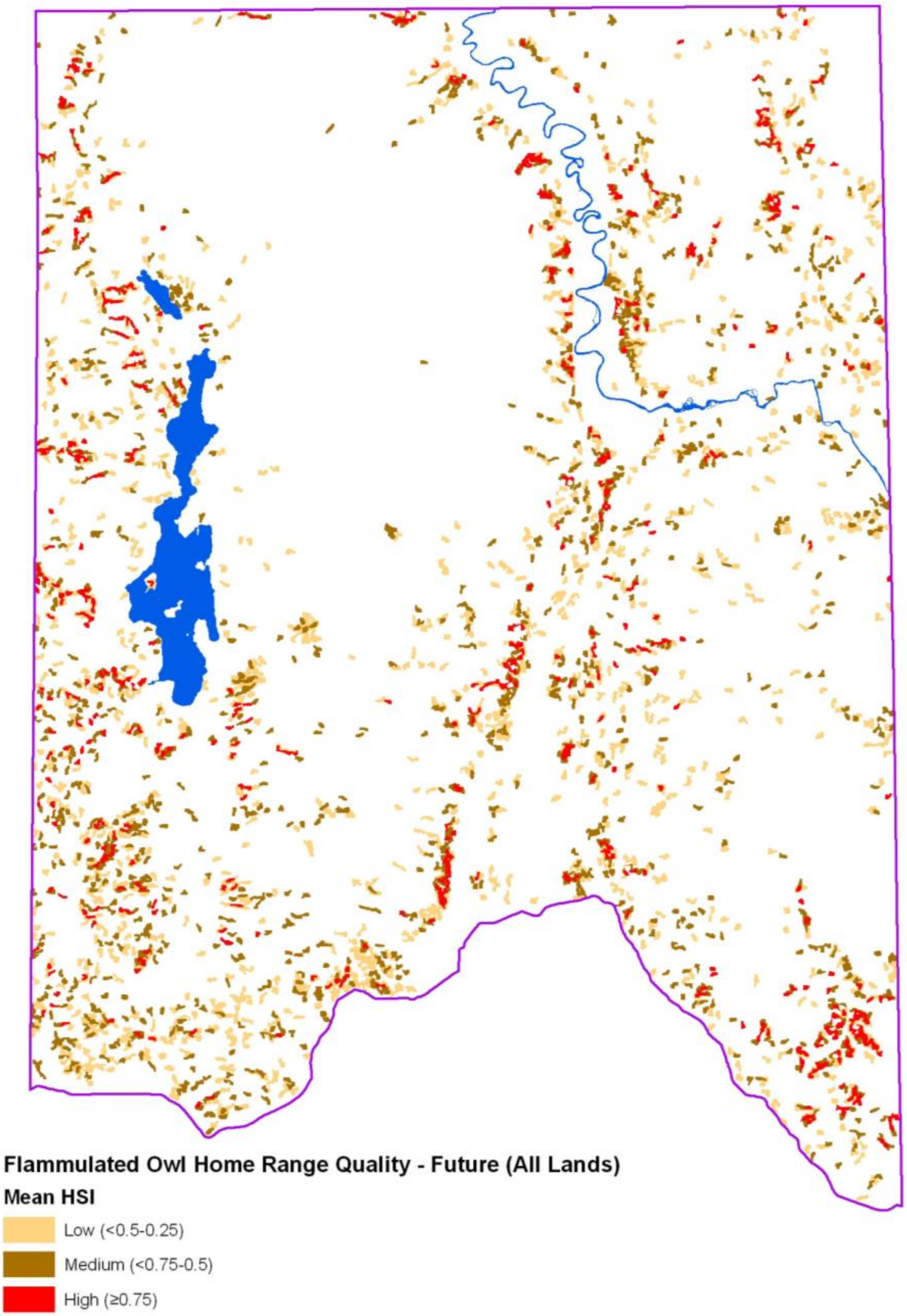
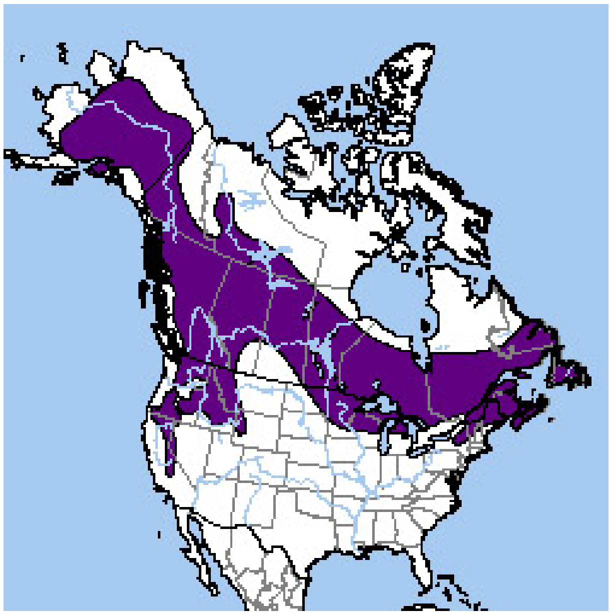


Figure 79. Future home range quality for Flammulated Owl with 20% representation on all ownerships.

Black-backed Woodpecker (*Picoides arcticus*)



Current general range of the Black-backed woodpecker in North America (Ridgely et al. 2005).

The Black-backed Woodpecker is a relatively uncommon bird that breeds in the coniferous forests of northern Idaho (Bock and Bock 1974, Stephens and Sturts 1998, Dixon and Saab 2000). Multiple studies have documented irruptions in response to forest disturbance in the form of fire (Hutto 1995, Villard and Schiek 1996, Murphy and Lenhausen 1998, Saab and Dudley 1998), insects and disease (Lester et al. 1980, Goggans et al. 1988), and wind (Wickman 1965). Irruptions typically only last for several years post disturbance and then local populations decline to minimal levels (Harris 1982, Murphy and Lenhausen 1998).

Black-backed Woodpeckers are most commonly associated with recently burned stands (Hutto 1995, Kotliar et al. 2002). Black-backed Woodpeckers were 20 times more abundant in burned stands then unburned stands in northeast Washington (Kreisel and Stein 1999). Burned stands were typically used for breeding <7 years post fire, with the highest use in the first 3-4 years (Caton 1996). High density burned stands composed of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) with a mean DBH of 39 cm (15.4 in) were used for nesting in southwest Idaho (Saab and Dudley 1998). By comparison, burned subalpine fir was not utilized for foraging by male Black-backed Woodpeckers (Dudley 2005) and in Montana abundance was higher in lower elevation pine and Douglas-fir stands than in higher elevation subalpine fir stands (Bock and Bock 1974). The density of trees suitable for nesting has been identified as the most important factor in determining abundance (Hutto 1995).

Black-backed Woodpeckers also nest in unburned stands, but these stands usually have some degree of insect infestation or are adjacent to a burned stand (Goggans et al. 1998, Dudley 2005). Nests have been documented in a wide range of tree species including ponderosa pine, Douglas-fir, western larch (*Larix occidentalis*), spruce (*Picea* spp.), lodgepole pine (*Pinus contorta*), mountain hemlock (*Tsuga mertensiana*), and quaking aspen(*Populus tremuloides*) (Dixon and Saab 2000). Goggans et al. (1988) documented Black-backed Woodpeckers nesting in mature and old growth lodgepole pine stands following a mountain pine beetle epidemic. Both Johnsgard (1986) and Goggans et al. (1988) observed Black-backed Woodpeckers nesting in the same habitats as American Three-toed Woodpeckers (*Picoides dorsalis*) and exhibiting little inter-specific competition.

Given the importance of recent burns for Black-backed Woodpecker nesting success, the model assumes all historical stands in the seedling stage resulted from burns. These stands were given HSI scores of 100. Stands in current conditions likely reached the seedling stage due to management activity. As a result all the scores for the current conditions are multiplied by a factor of 0.8 to insure that ideal conditions can only be met as a result of a recent burn. Recent burns occurring in the project area were assigned a HSI of 100. The Black-backed Woodpecker model was primarily based on the American Three-toed Woodpecker model described by Zapisocki et al. (2000). These two sympatric species have very similar habitat needs (Hoyt and Hannon 2002). The Black-backed Woodpecker model is based on optimum conditions for year-round occupancy. Optimum habitat occurs on sites that have a mean canopy tree diameter at breast height > 20 centimeters (7.87 in), mean height of overstory trees >8 meters (26.25 ft), snag density >124 trees per hectare (50 trees/ac), a tree canopy composed of >50% fir, spruce, pine, and larch, tree canopy cover >60%, and burned within the past 6 years. The HSI model for Black-backed Woodpecker was built based on these optimum conditions. The model variables used were mean DBH of canopy trees (Figure 80), mean height of overstory trees (Figure 81), snags per acre (Figure 82), species composition of tree canopy (Figure 83), and tree canopy cover (Figure 84). The final HSI grid was calculated by multiplying the DBH HSI, height HSI, snag HSI, and the geometric mean of the species composition HSI and the canopy cover HSI.

HSI values for EDM cells missing stand data (Table 35) were added and the grid was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER (Figure 85). The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 71 g (2.5 oz) Black-backed Woodpecker is 4.7 ha (11.6 ac) or 7x7 cells (Van Horne and Wiens 1991).

Three iterations were done in HOMEGROWER. The target home range area was 5 times the allometric home range or 24 ha (59 ac). The number of seeds was 999,999 and the growth window was 3 cells. Figure 86 depicts home range quality for current conditions. The number of very low quality home ranges has not been delineated.

The values used to create the Black-backed Woodpecker HSI grid for historical conditions are presented in Table 36. Figure 87 is the grid used in HOMEGROWER for historical conditions. The same run parameters used for the current conditions model were also used for the historical conditions model. Figure 88 depicts home range quality for historical conditions. The number of very low quality home ranges has not been delineated.

The values used to create the Black-backed Woodpecker HSI grids for future conditions were a combination of the values used for the current conditions and historical conditions. Areas modified to achieve reference conditions received historical conditions values and all other areas received current conditions values. Figure 89 is the grid used in HOMEGROWER for future conditions applied only to IDL ownership and Figure 91 is the grid used in HOMEGROWER for future conditions applied to all ownerships. The same run parameters used for the current conditions model were also used for the future conditions models. Figure 90 depicts home range quality for future conditions applied only to IDL ownership and Figure 92 depicts home range quality for future conditions applied to all ownerships. The number of very low quality home ranges was not delineated. The mean numbers of Black-backed Woodpecker home ranges of high, medium, and low quality, resulting from the modeling effort, are presented as follows for historical, current and future conditions.

	Historical Conditions	Current Conditions	Future Conditions (IDL)	Future Conditions (All Lands)
High (1.0-0.75)	776	152	150	147
Medium (<0.75-0.5)	858	2,004	1,976	1,882
Low (<0.5-0.25)	5,095	3,166	3,164	3,259

The Black-backed Woodpecker models are driven by disturbance in the form of mixed-severity or lethal fire. As a result, the number of high quality home ranges is directly tied to the availability of recently burned stands. The bulk of the high quality home ranges occurring under the current and future conditions models fall within the perimeter of one large fire. The high number of medium and low quality home ranges indicated current forest conditions are sufficient to support background levels of Black-backed Woodpeckers until the next disturbance event.

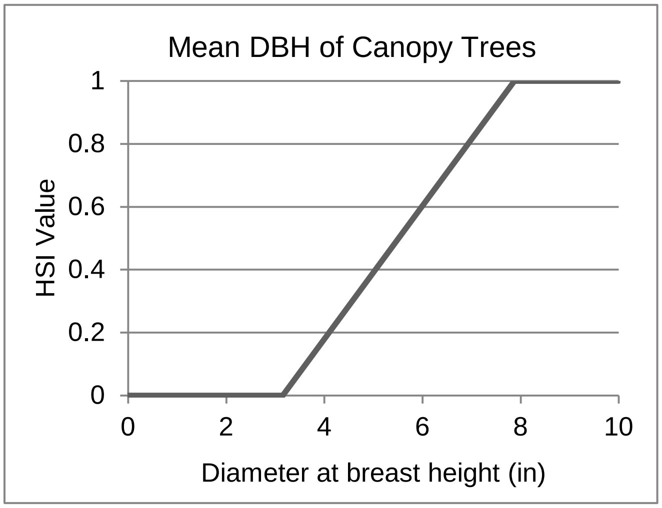


Figure 80. Relationship between mean diameter at breast height of canopy trees and HSI values for Black-backed Woodpecker. The equation between 3.15 and 7.87 is $y=0.211x-0.667$

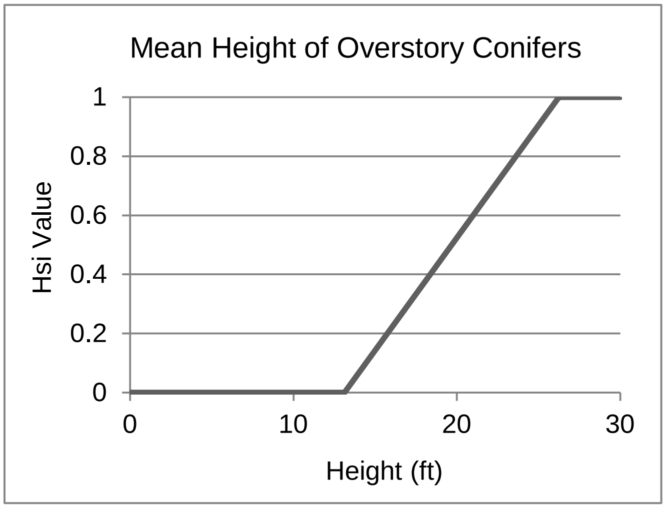


Figure 81. Relationship between mean height of overstory conifers and HSI values for Black-backed Woodpecker. The equation between 13.12336 and 26.24671 is $y=0.76x-1$.

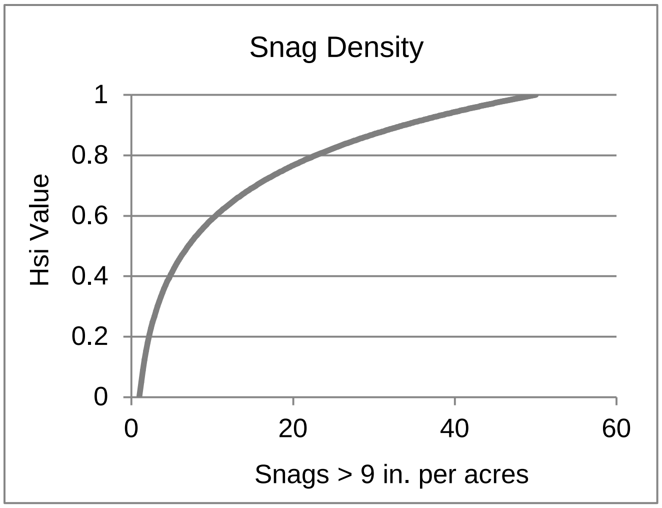


Figure 82. Relationship between snag density and HSI values for Black-backed Woodpecker. The equation between 1 and 50 is *y=0.255ln(x)+0.002*. When x>50, y=1.

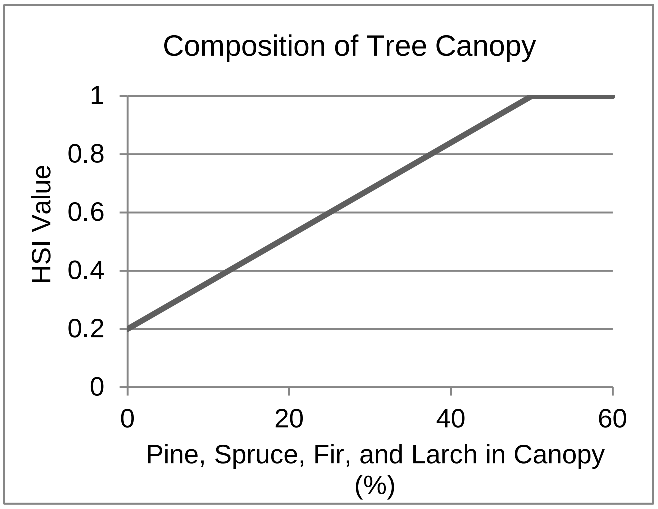


Figure 83. Relationship between composition of tree canopy and HSI values for Black-backed Woodpecker. The equation between 0 and 50 is *y=0.016x+0.2*.

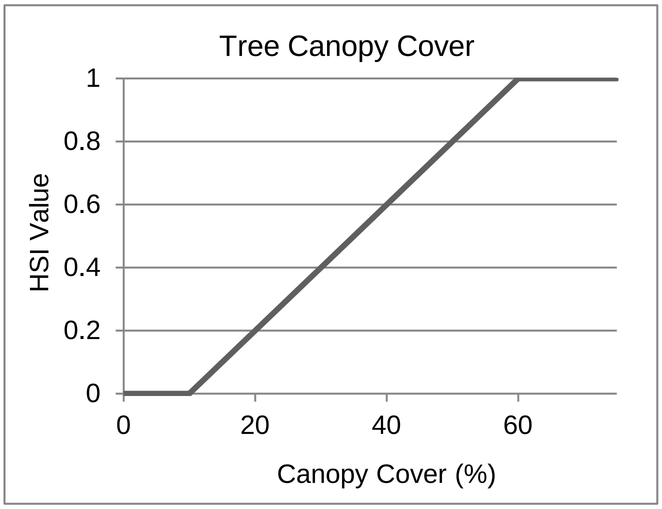


Figure 84. Relationship between tree canopy cover and HSI values for Black-backed Woodpecker. The equation between 10 and 60 is *y=0.02x-0.2*.

Table 35. HSI values for Black-backed Woodpecker used in the current conditions model (* Where available, the mean and ± one standard deviation for each relevant habitat variable from FIA stand data was used to calculate three HSI scores).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	50	80	100	100	100	100	100	80	80
SAPLING	0	0	0	0	0	0	0	0	0
POLE	5	30	30	30	30	30	20	5	5
MEDIUM-NL	10	40	40	40	40	40	20	10	10
LARGE-NL	10	40	40	40	40	40	20	10	10
VERY LARGE-NL	10	40	40	40	40	40	20	0	0
MEDIUM-L	0-18-40*	0-0-16*	8-29-41*	50	26-60-72*	27-61-76*	30	10	10
LARGE-L	10	9-46-75*	45-69-76*	50	50-88-100*	54-85-96*	30	10	10
VERY LARGE-L	14-39-67*	30-59-67*	28-72-80*	25-49-69*	28-70-77	45-77-82*	26-74-98*	26-44-58*	20-56-91*

Table 36. HSI values for Black-backed Woodpecker used in the historical conditions model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	50	80	100	100	100	100	100	80	80
SAPLING	0	0	0	0	0	0	0	0	0
POLE	5	30	30	30	30	30	20	5	5
MEDIUM-NL	10	40	40	40	40	40	20	10	10
LARGE-NL	10	40	40	40	40	40	20	10	10
VERY LARGE-NL	10	40	40	40	40	40	20	N/A	N/A
MEDIUM-L	10	50	50	50	50	50	30	10	10
LARGE-L	10	50	50	50	50	50	30	10	10
VERY LARGE-L	10	50	50	50	50	50	30	10	10

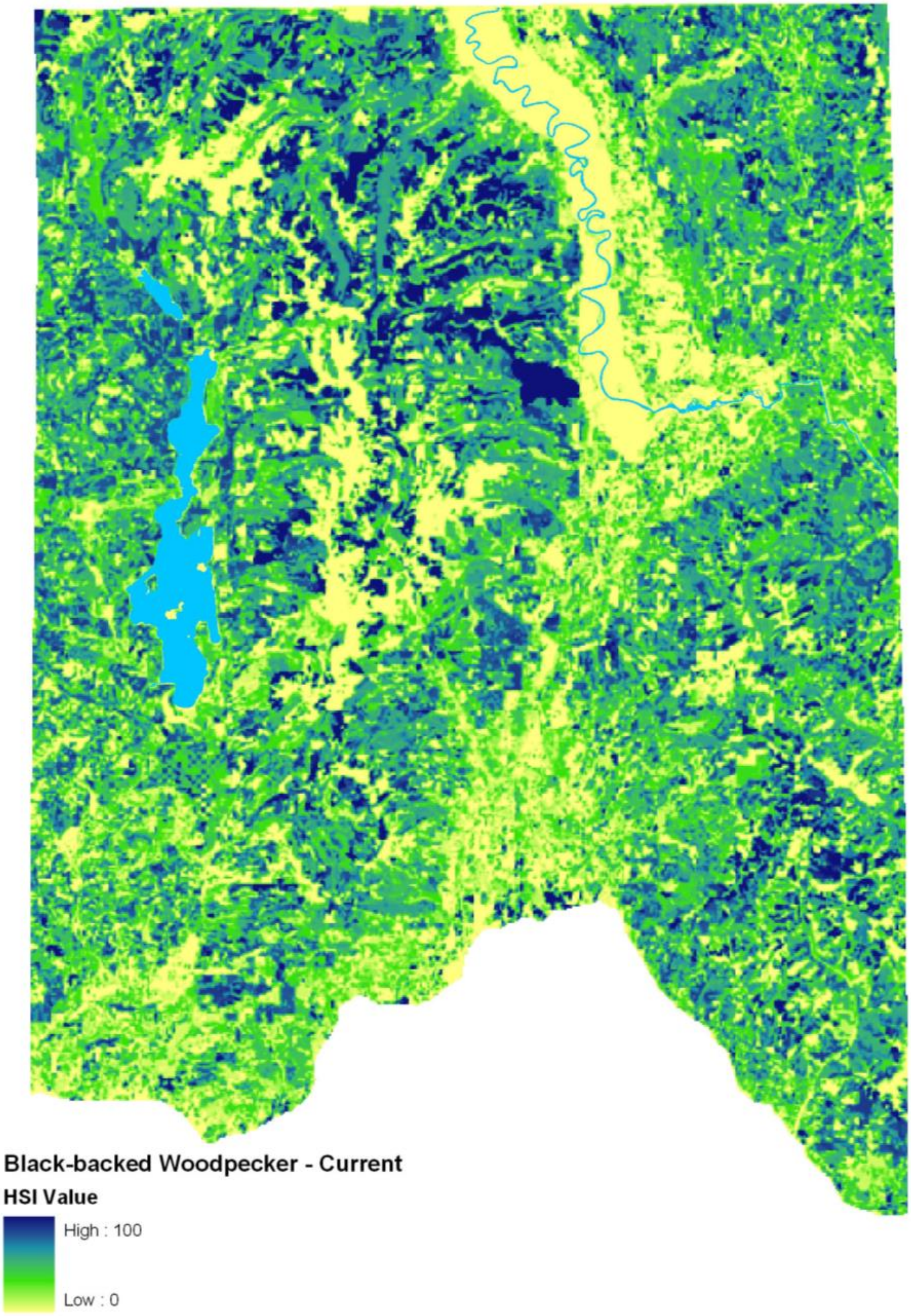


Figure 85. Current habitat suitability index for Black-Backed Woodpecker within the IDL planning landscape.

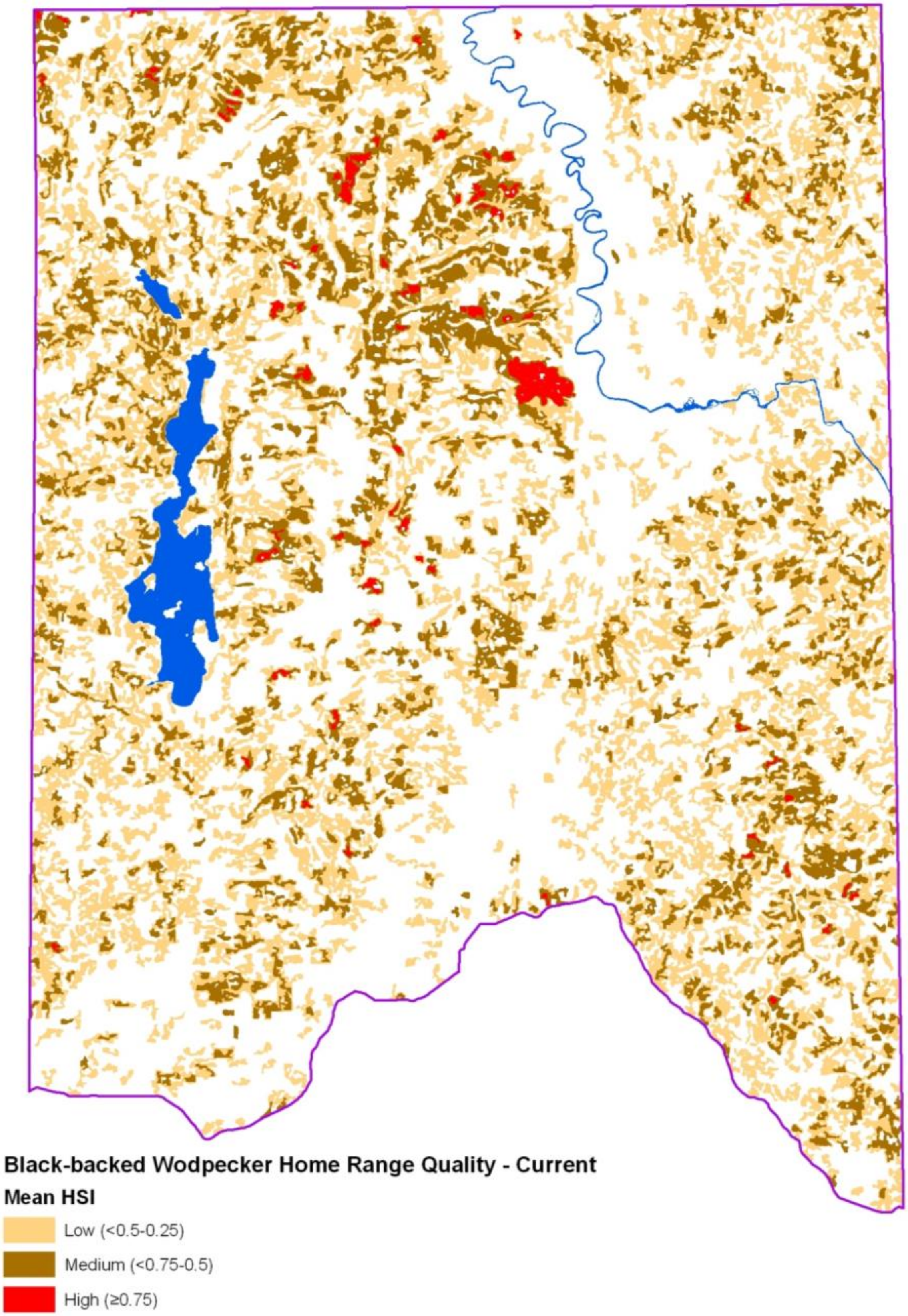


Figure 86. Current home range quality (mean HSI) for Black-backed Woodpecker within the IDL planning landscape.

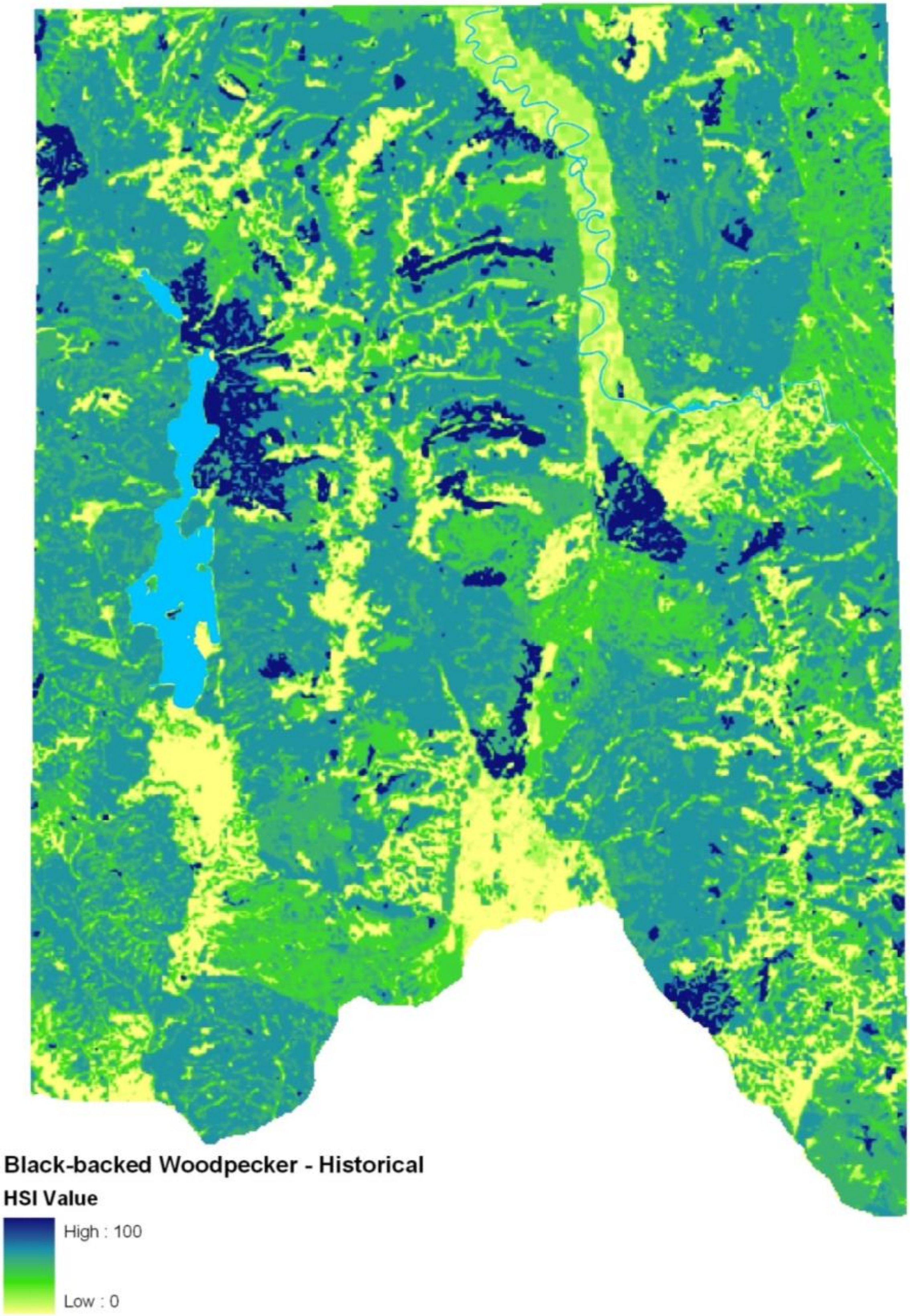


Figure 87. Historical habitat suitability index for Black-backed Woodpecker within the IDL planning landscape.

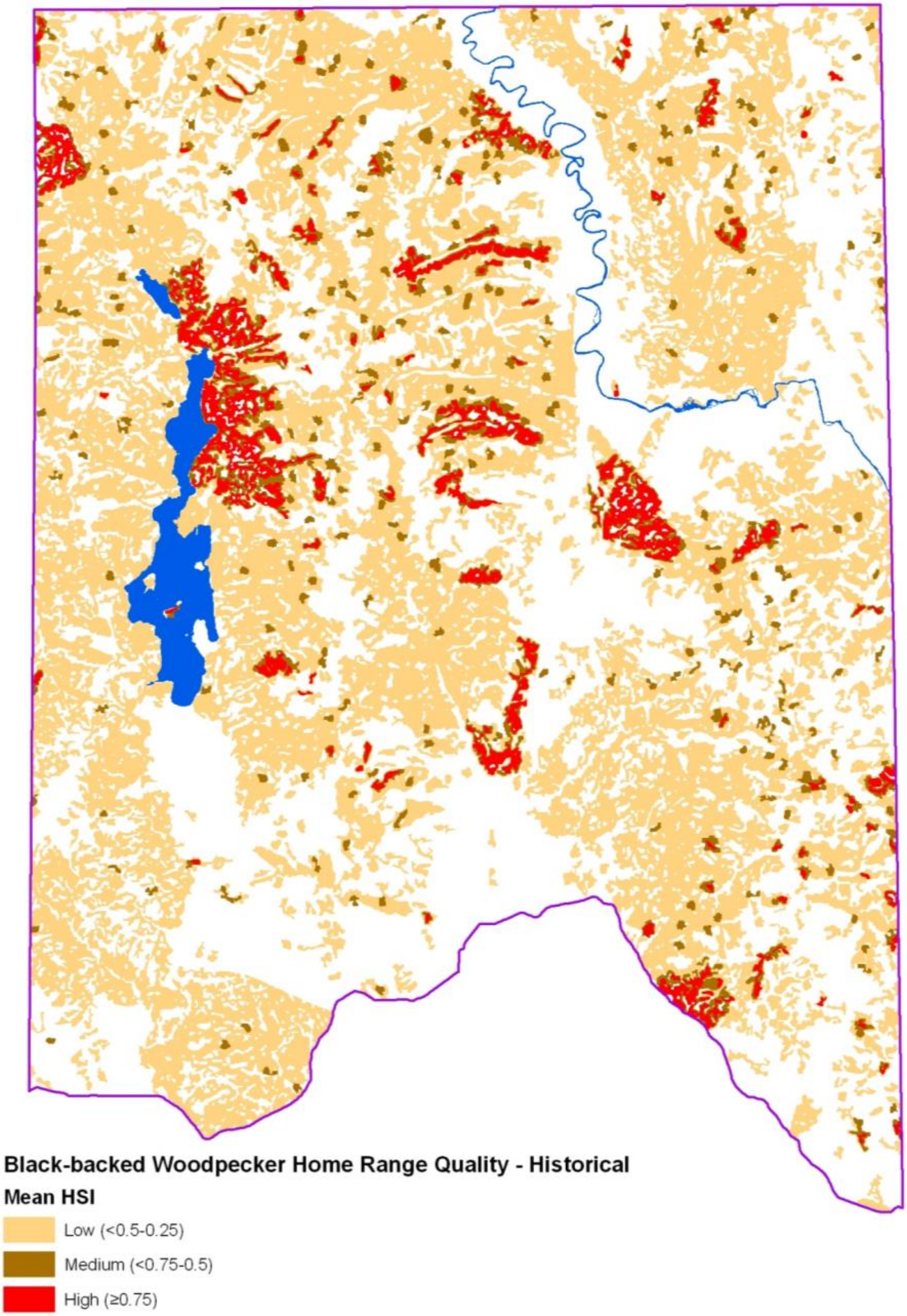


Figure 88. Historical home range quality (mean HSI) for Black-backed Woodpecker within the IDL planning landscape.

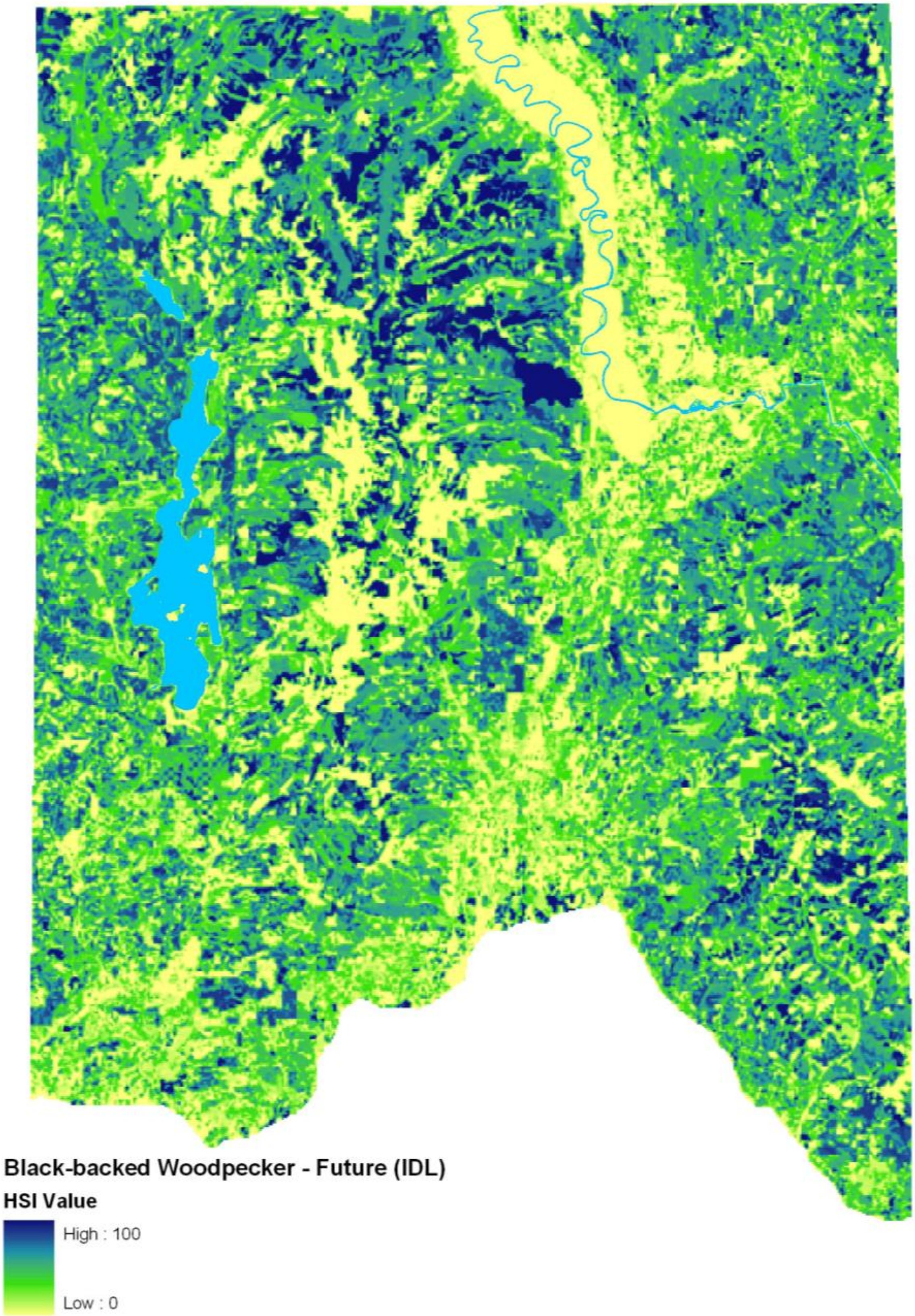


Figure 89. Future habitat suitability index for Black-backed Woodpecker with 20% representation on IDL ownership only.

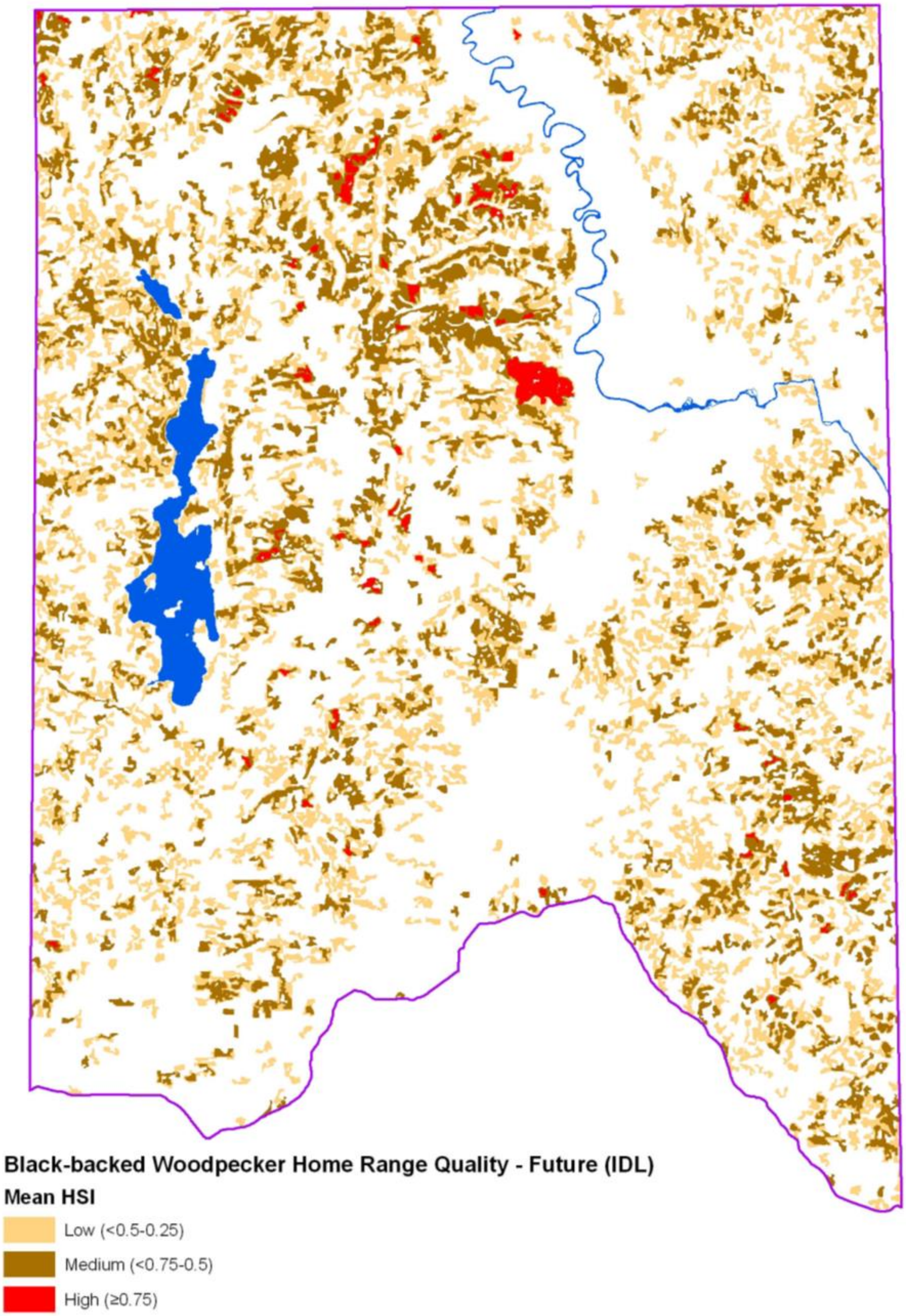


Figure 90. Future home range quality for Black-backed Woodpecker with 20% representation on IDL ownership only.

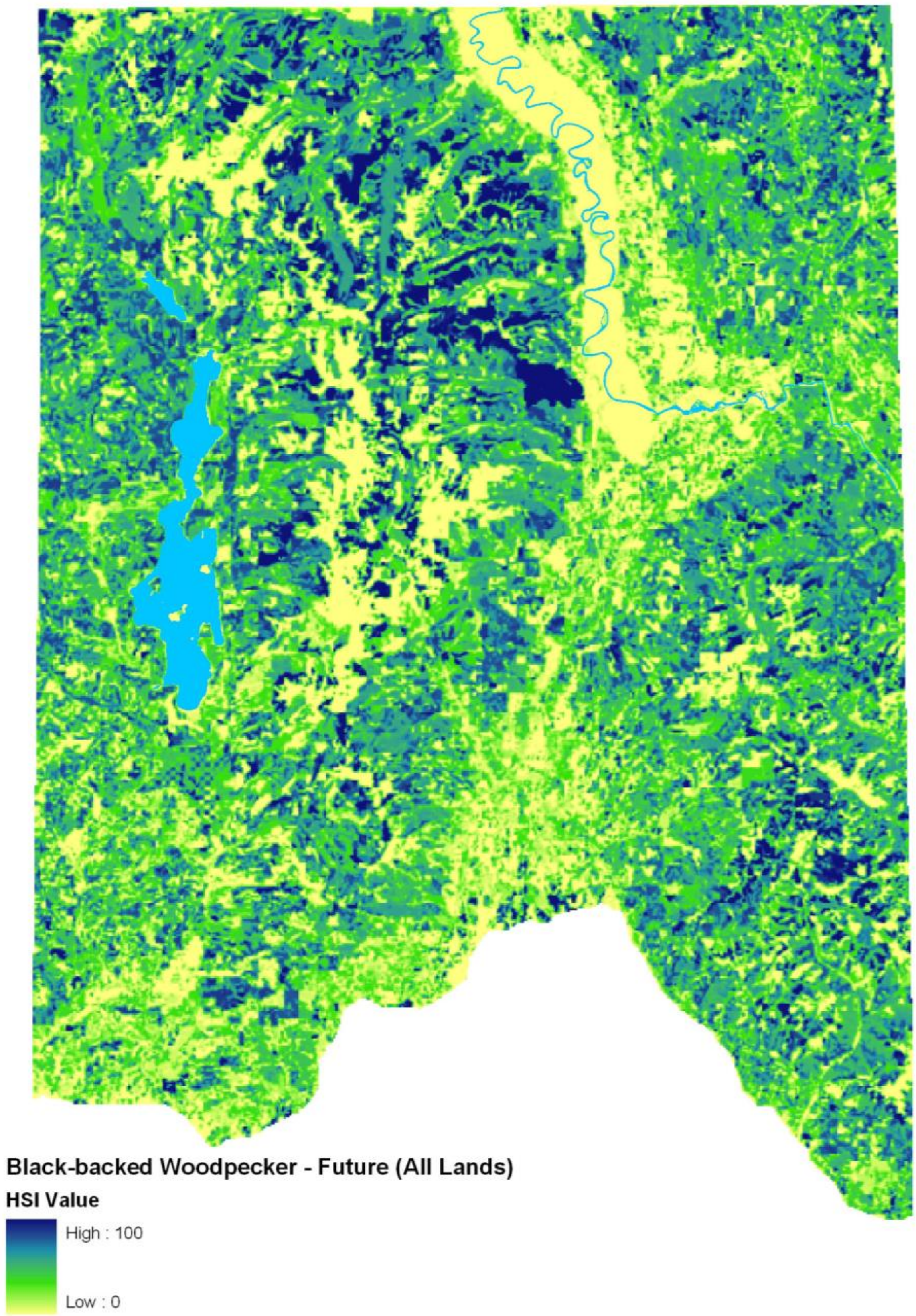


Figure 91. Future habitat suitability index for Black-backed Woodpecker with 20% representation on all ownerships.

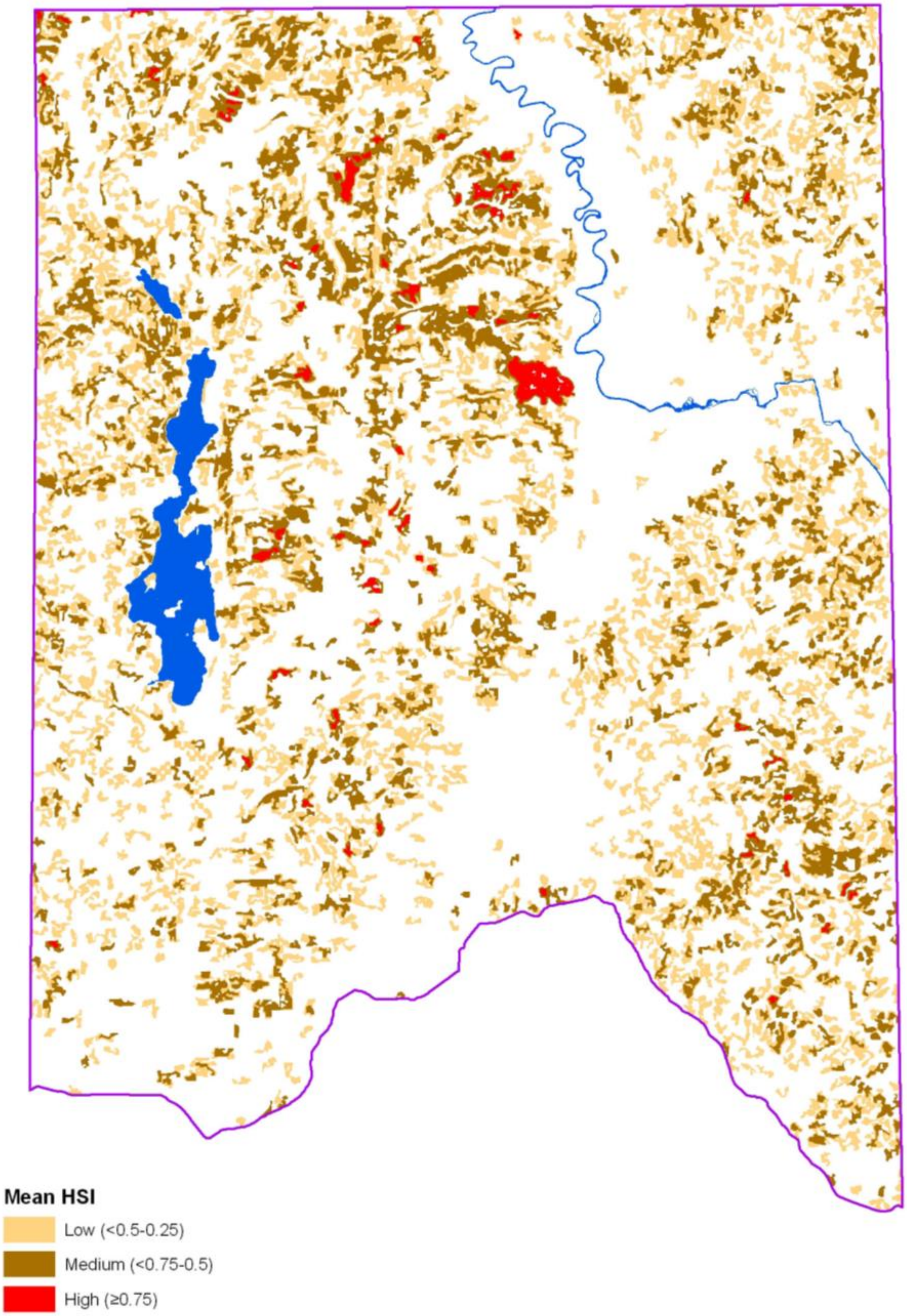
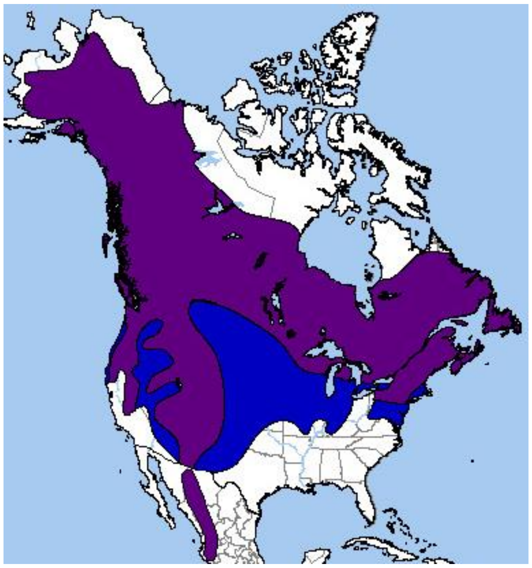


Figure 92. Future home range quality for Black-backed Woodpecker with 20% representation on all ownerships.

Northern Goshawk (*Accipiter gentilis*)



Current range of the Northern Goshawk in North America; purple indicates permanent resident and blue indicates non-breeding range (Ridgely et al. 2005).

Northern Goshawks are a large accipiter found in forested areas throughout Idaho with breeding confirmed in Bonner and Boundary counties (Stephens and Sturts 1998). Northern Goshawks have long been considered sympatric with mature or old-growth conifer stands and the bulk of available literature supports this (Greenwald et al. 2005). Nest sites in particular require mature stands with high canopy cover (>75%), large trees, and multiple canopies (Crocker-Bedford and Chaney 1988, Hayward and Escano 1989, Squires and Reynolds 1997). However, the nest stand can be fairly small (down to 10 ha) (USFWS 1998). In northern Idaho, the mean nest height was 12.5 meters (41 ft), in trees with a mean height of 26 meters (85 ft) and a mean diameter at breast height of 50 centimeters (20 in) (Hayward and Escano 1989). Also, the canopy cover around the nest was higher than the mean cover for the stand.

Ideal conditions for foraging are stands with a closed canopy, but an open understory that provides clear flight corridors (Reynolds et al. 1982, Hayward and Escano 1989). Goshawks have been found to avoid open areas, such as meadows, shrublands, and logged early seral stands (<30 years in age) (Austin 1993, Titus et al. 1996, Lapinski 2000, Boal et al. 2001, Bloxton 2002). Avoidance of mature and old-growth stands with <40% canopy cover has also been documented (Austin 1993, Bright-Smith and Mannan 1994, Beier and Drennan 1997).

Separate nesting and foraging models were developed for Goshawks. They were based on the framework described by Shaffer et al. (1999). Goshawk prefer mature stands with complex canopies, high canopy cover, a mix of deciduous and conifer species, and minimal disturbance for nesting. The optimum stand for nesting has a mean overstory tree height >20 meters (65.6 ft), tree canopy cover >50%, an overstory between 5% and 90% deciduous species, and >50 meters (164 ft) from human disturbance. The HSI model for Goshawk nesting was based on these optimum conditions. The model variables used were mean overstory tree height (Figure 93), tree canopy cover (Figure 94), and species composition of overstory (Figure 95). The final nesting HSI grid (Figure 99) was calculated by taking the geometric mean of these four variables, then adding the HSI values for EDM cells missing stand data (Table 37).

The optimum stand for foraging has an overstory comprised of between 10% and 90% deciduous species, tree canopy cover >20%, and mean overstory tree height >16 meters (52.5 ft). The HSI model for Goshawk foraging was based on these optimum conditions. The model variables used were species composition of overstory (Figure 96), tree canopy cover (Figure 97), and mean overstory tree height (Figure 98). The final foraging HSI grid was calculated by taking the geometric mean of these three variables. HSI values for EDM cells missing stand data (Table 38) were added and the grid was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER (Figure 100). The size of the moving window is equal to the allometric home range (Roloff and Haufler

1997). The allometric home range for a 0.713 kg (0.157 lb) male Goshawk is 67 ha (166 ac) or 27x27 cells (Van Horne and Wiens 1991).

Three iterations were done in HOMEGROWER. HOMEGROWER is able to use both a nesting and foraging grid for model runs and insure each home range meets a species' needs for each category. The target home range area was 5 times the allometric home range or 334 ha (825 ac) for the foraging grid and 10 ha (25 ac) for the nesting grid. The number of seeds was 800,000 and the growth window was 10 cells. Figure 101 shows home ranges and their quality. The number of very low quality home ranges has not been delineated at this time.

The values used to create the Northern Goshawk nesting and foraging HSI grids for historical conditions are presented in Table 39. Figure 102 and Figure 103 are the grids used in HOMEGROWER for historical conditions. The same run parameters used for the current conditions model were also used for the historical conditions model. Figure 104 depicts home range quality for historical conditions. The number of very low quality home ranges has not been delineated at this time.

The values used to create the Northern Goshawk HSI grids for future conditions were a combination of the values used for the current conditions and historical conditions. Areas modified to achieve reference conditions received historical conditions values and all other areas received current conditions values. Figure 105 and Figure 106 are the grids used in HOMEGROWER for future conditions applied only to IDL ownership and Figure 108 and Figure 109 are the grids used in HOMEGROWER for future conditions applied to all ownerships. The same run parameters used for the current conditions model were also used for the future conditions models. Figure 107 depicts home range quality for future conditions applied only to IDL ownership and Figure 110 depicts home range quality for future conditions applied to all ownerships. The number of very low quality home ranges was not delineated. The mean numbers of Northern Goshawk home ranges of high, medium, and low quality, resulting from the modeling effort, are presented as follows for historical, current and future conditions.

	Historical Conditions	Current Conditions	Future Conditions (IDL)	Future Conditions (All Lands)
High (1.0-0.75)	105	39	38	61
Medium (<0.75-0.5)	243	530	535	514
Low (<0.5-0.25)	61	26	31	24

The primary factor behind Northern Goshawk home range quality is stand density. Northern Goshawks prefer to forage in closed canopy, multi-layer stands with an open understory. Historically, Goshawks were favored by the mixed severity fire areas, intermixed with non-lethal fire areas. Under current conditions many stands are overstocked and relatively uniform compared to historical conditions. This is primarily due to fire exclusion in stands that historically burned relatively frequently. Under current conditions, the majority of stands fall under a long return, non-lethal fire regime. These stands are typically characterized as having closed canopies and a well developed second canopy. However, there is a high degree of variation among stands, resulting in a high number of medium quality Northern Goshawk home ranges. The lower number of high quality home ranges under current conditions compared to historical conditions is an indication of the effect of increased stand densities and the more uniform conditions. With proposed restoration treatments, an increase in high quality home ranges under future conditions applied to all ownerships would be expected.

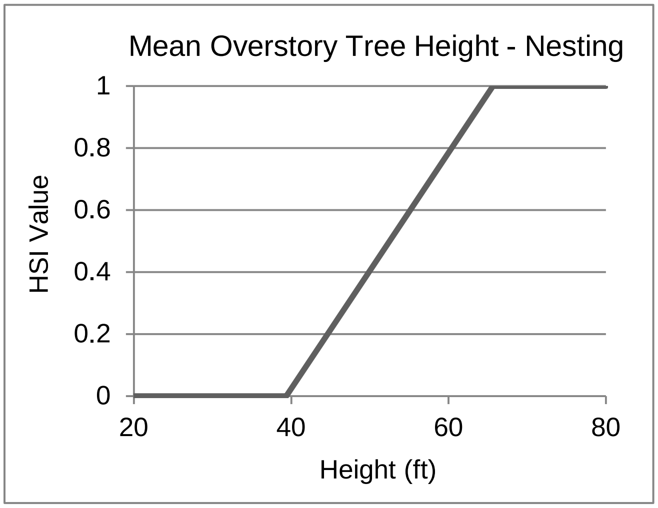


Figure 93. Relationship between mean overstory tree height and HSI values for Northern Goshawk nesting. The equation between 39.37 and 65.617 is $y=0.038x-1.5$.

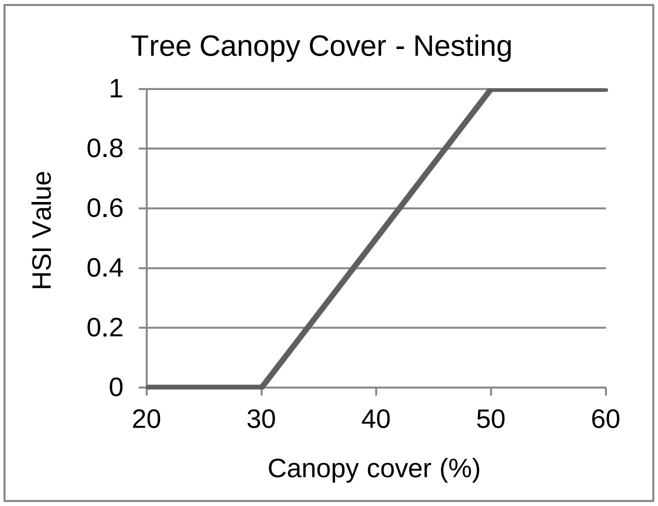


Figure 94. Relationship between tree canopy cover and HSI values for Northern Goshawk nesting. The equation between 30 and 50 is $y=0.05x-1.5$.

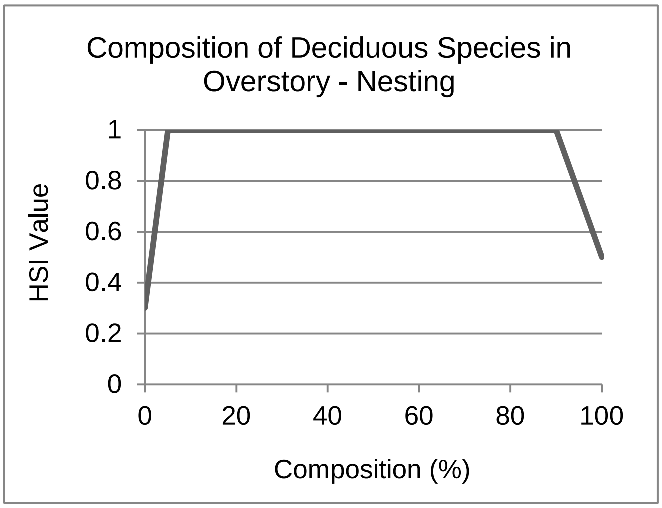


Figure 95. Relationship between composition of deciduous species in the overstory and HSI values for Northern Goshawk nesting. The equation between 0 and 5 is $y=0.14x+0.3$ and the equation between 90 and 100 is $y=-0.05x+5.5$.

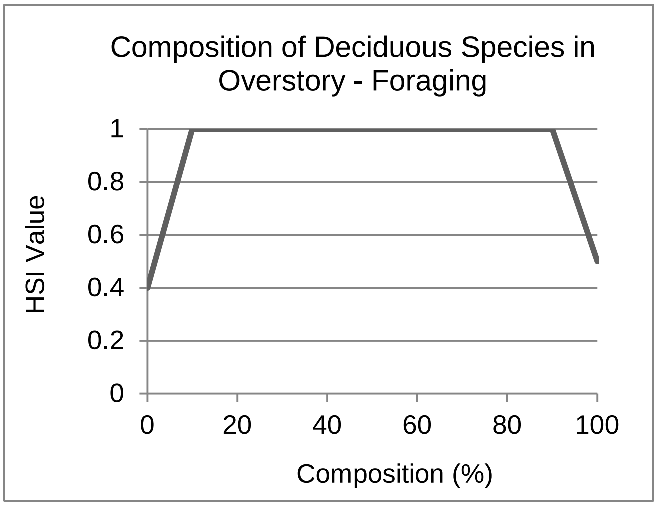


Figure 96. Relationship between composition of deciduous species in the overstory and HSI values for Northern Goshawk foraging. The equation between 0 and 10 is *y=0.06x+0.4* and the equation between 90 and 100 is *y=-0.05x+5.5*.

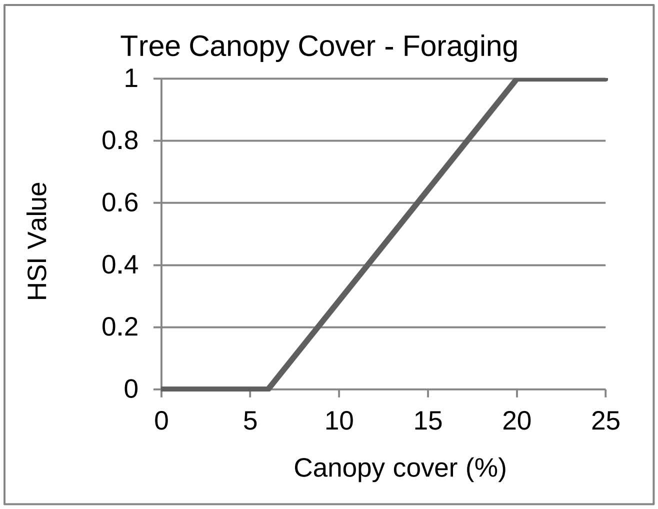


Figure 97. Relationship between tree canopy cover and HSI values for Northern Goshawk foraging. The equation between 6 and 20 is *y=0.071x-0.428*.

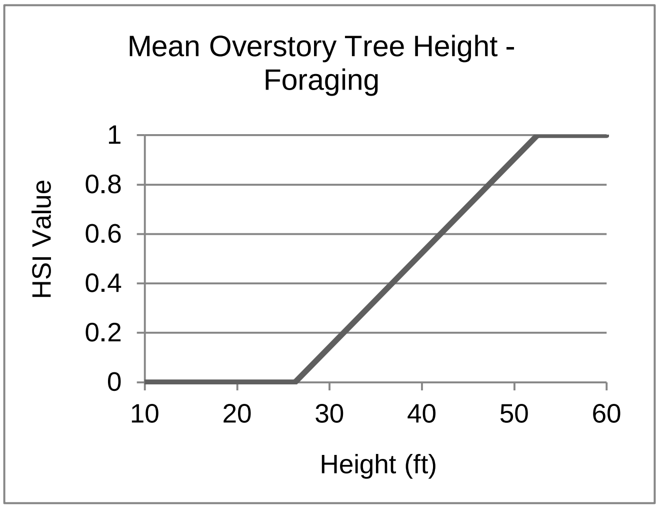


Figure 98. Relationship between mean overstory tree height and HSI values for Northern Goshawk foraging. The equation between 26.247 and 52.493 is *y=0.038x-1*.

Table 37. HSI values for Northern Goshawk nesting and foraging used in the current conditions model (* Where available, the mean and ± one standard deviation for each relevant habitat variable from FIA stand data was used to calculate three HSI scores).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
Goshawk Nesting Component									
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	0	0	0	0	0
POLE	0	0	0	0	0	0	0	0	0
MEDIUM-NL	10	10	10	10	10	10	10	10	10
LARGE-NL	20	20	20	20	20	20	20	20	20
VERY LARGE-NL	40-60-80	40-60-80	40-60-80	75	75	75	60	0	0
MEDIUM-L	0-0-0*	26-50-61*	30-96-100*	10	30-60-67*	21-54-65*	10	10	10
LARGE-L	30	0-59-89*	66-71-74*	40-50-60	31-65-67*	43-64-67*	20-35-50	40-50-60	20-35-50
VERY LARGE-L	0-36-67*	17-65-75*	66-80-84*	56-76-83*	36-65-67*	41-82-93*	0-33-56*	57-67-67*	0-54-67*
Goshawk Foraging Component									
SEEDLING	10	10	10	10	10	10	10	10	10
SAPLING	10	10	10	10	10	10	10	10	10
POLE	10	10	10	10	10	10	10	10	10
MEDIUM-NL	10	10	10	10	10	10	10	25	25
LARGE-NL	50	50	50	50	50	50	10	75	75
VERY LARGE-NL	60	60-80-100	100	100	100	100	25	0	0
MEDIUM-L	43-49-54*	62-72-74*	81-90-98*	10	69-74-74*	63-74-74*	10	10	10
LARGE-L	30	61-79-83*	74-75-76*	30	71-74-74*	74-74-74	20	25	25
VERY LARGE-L	24-70-74*	63-75-77*	77-79-81*	74-77-80*	69-74-74*	71-80-85*	49-65-74*	74-74-74*	72-74-74*

Table 38. HSI values for Northern Goshawk nesting and foraging used in the historical conditions model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
HSI Values for Northern Goshawk Nesting - Historical									
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	0	0	0	0	0
POLE	0	0	0	0	0	0	0	0	0
MEDIUM-NL	10	10	10	10	10	10	10	10	10
LARGE-NL	30-50-70	50-70-90	50-70-90	20	20	20	20	20	20
VERY LARGE-NL	40-60-80	80-90-100	80-90-100	75	75	75	60	N/A	N/A
MEDIUM-L	10	10	10	10	10	10	10	10	10
LARGE-L	40	40-50-60	40-50-60	40-50-60	40-50-60	40-50-60	20-35-50	40-50-60	20-35-50
VERY LARGE-L	40-60-80	75-87.5-100	75-87.5-100	75-87.5-100	75-87.5-100	75-87.5-100	40-50-60	75-87.5-100	50-62.5-75
HSI Values for Northern Goshawk Foraging - Historical									
SEEDLING	10	10	10	10	10	10	10	10	10
SAPLING	10	10	10	10	10	10	10	10	10
POLE	10	10	10	10	10	10	10	10	10
MEDIUM-NL	10	10	10	10	10	10	10	25	25
LARGE-NL	50	50	50	50	50	50	10	75	75
VERY LARGE-NL	50-70-90	80-90-100	90	90	90	90	25	N/A	N/A
MEDIUM-L	10	10	10	10	10	10	10	10	10
LARGE-L	30	30	30	30	30	30	20	25-50-75	20-35-50
VERY LARGE-L	40-60-80	50-70-90	20-50-80	20-50-80	20-50-80	20-50-80	20-50-80	40-60-80	40-60-80

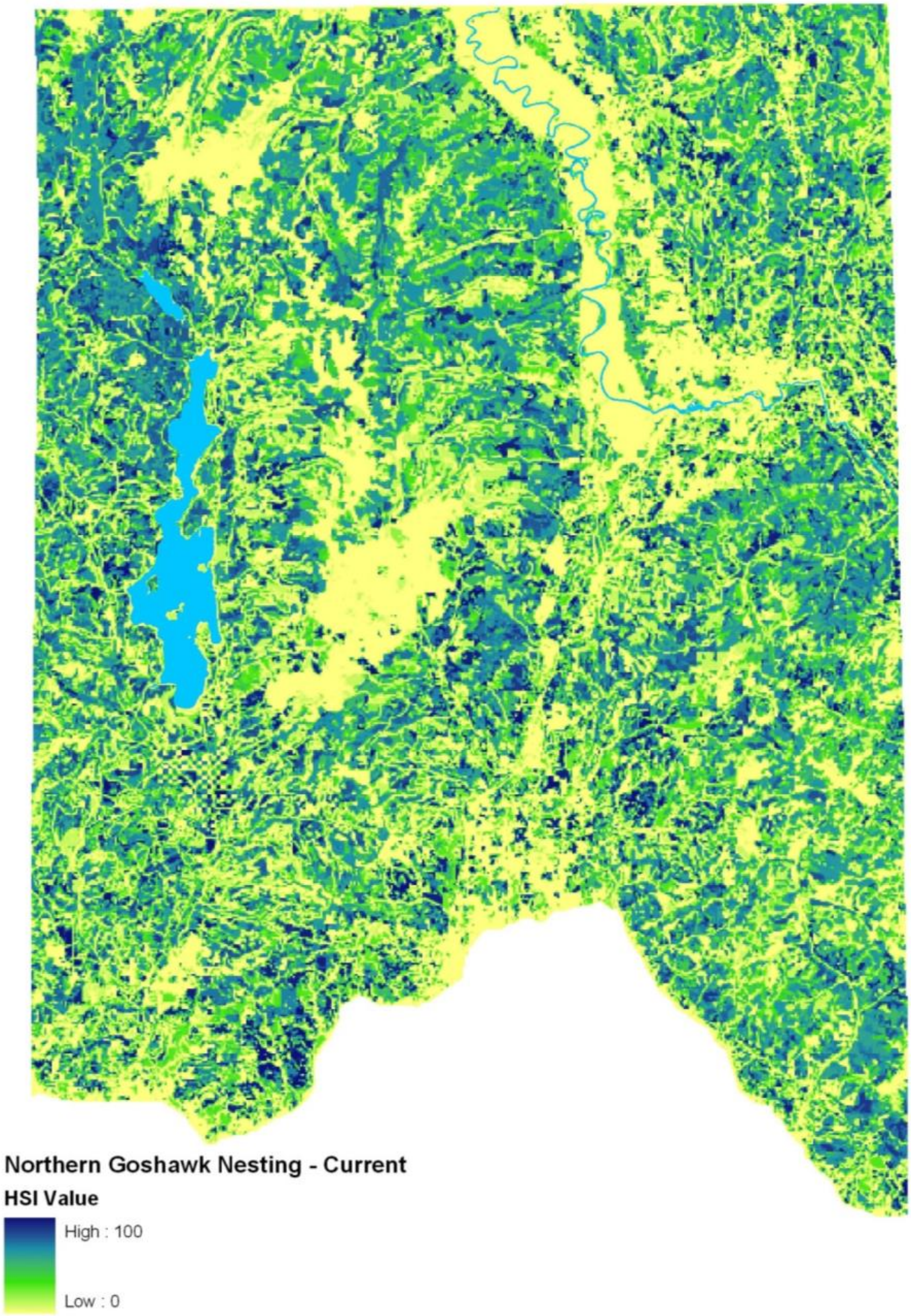


Figure 99. Current habitat suitability index for Northern Goshawk nesting within the IDL planning landscape.

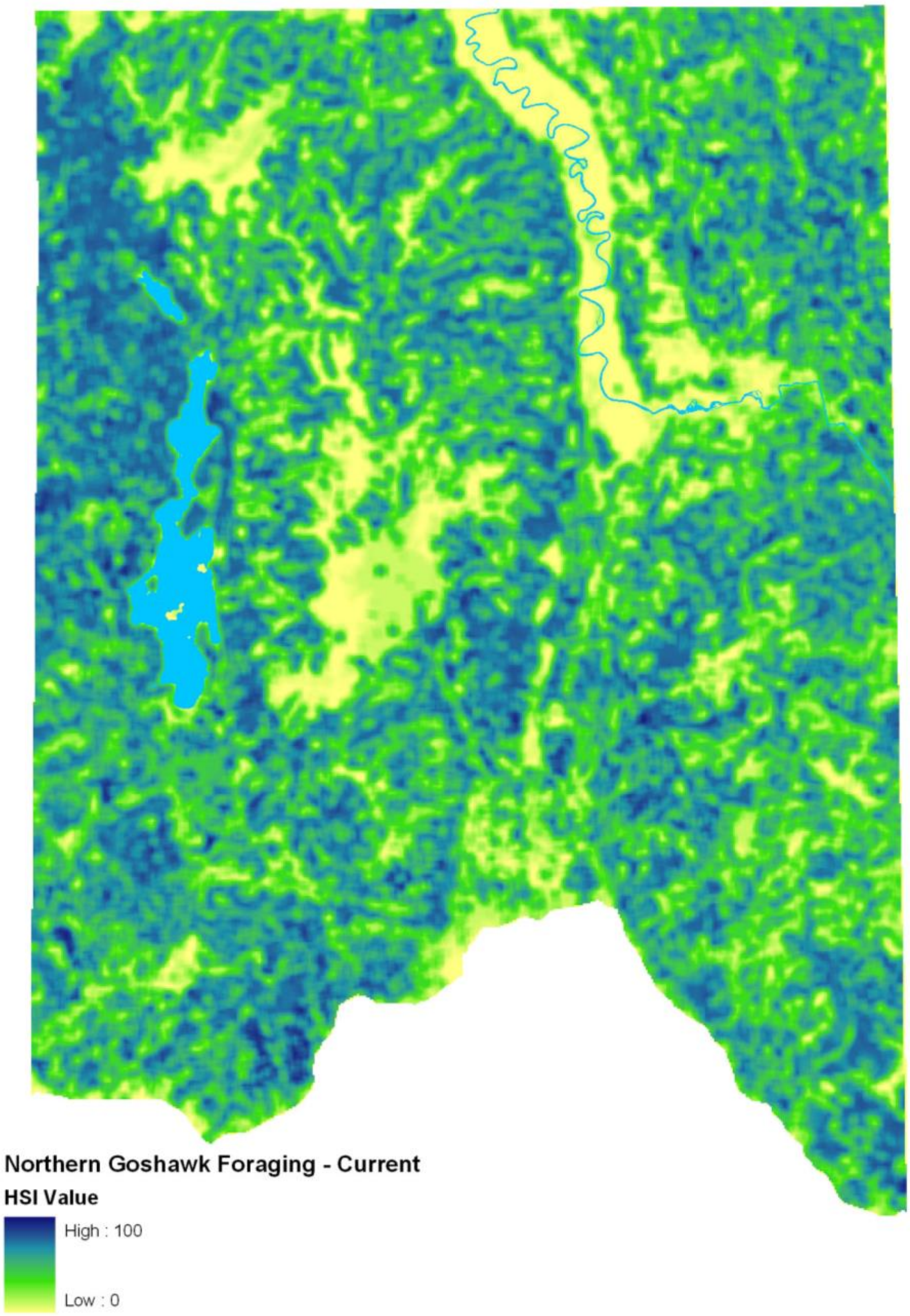


Figure 100. Current habitat suitability index for Northern Goshawk foraging within the IDL planning landscape.

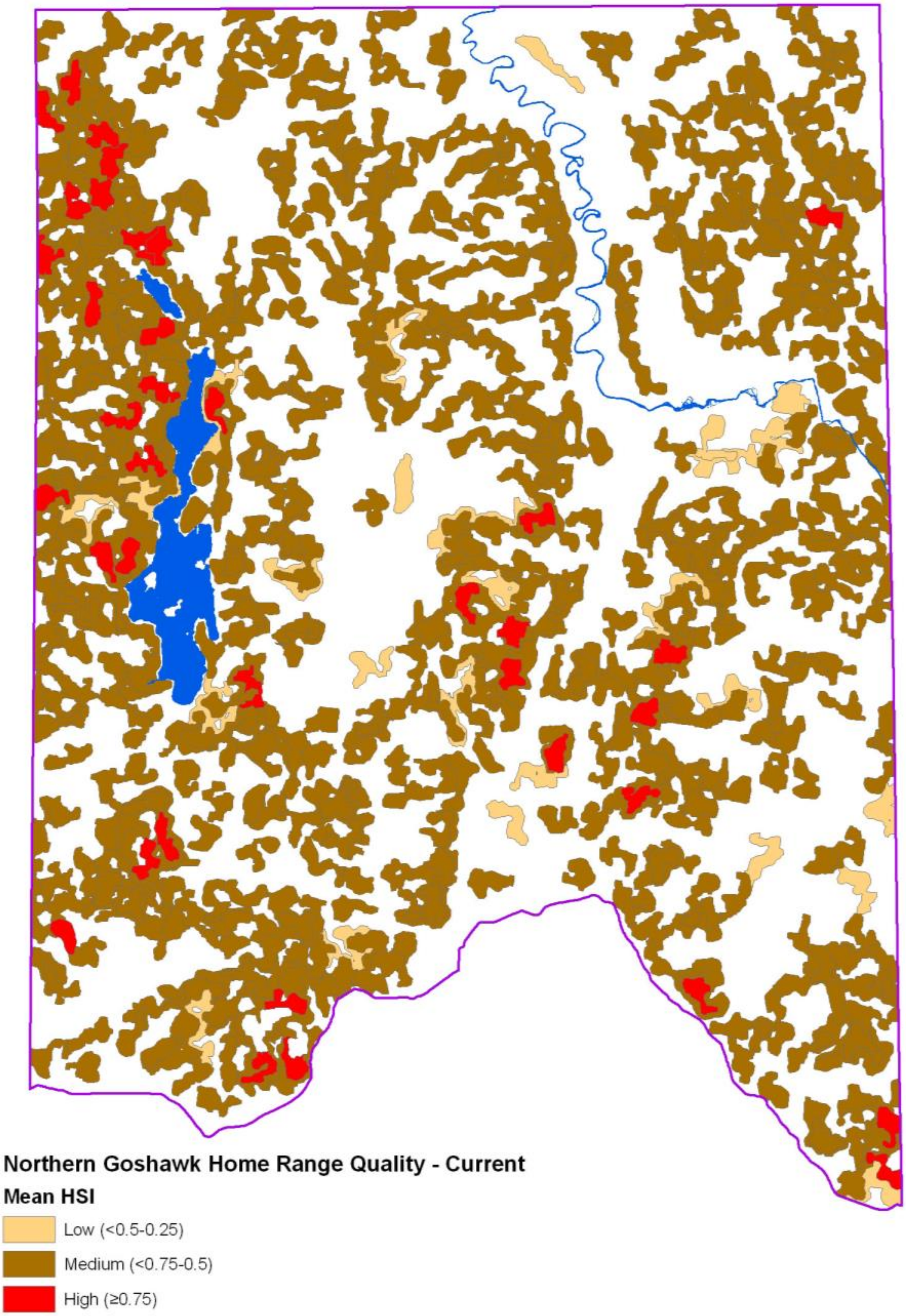


Figure 101. Current home range quality (mean HSI) for Northern Goshawk within the IDL planning landscape.

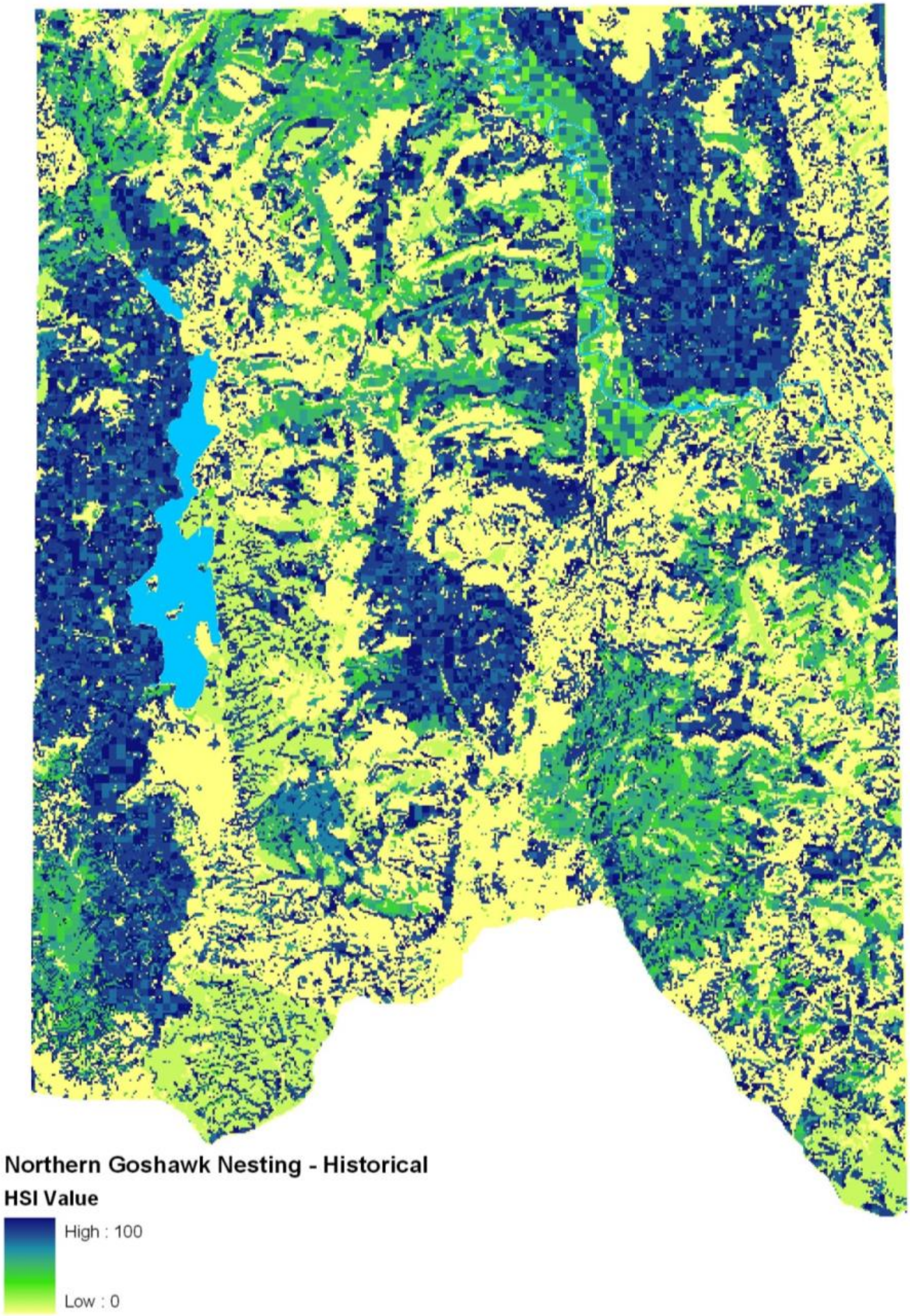


Figure 102. Historical habitat suitability index for Northern Goshawk nesting within the IDL planning landscape.

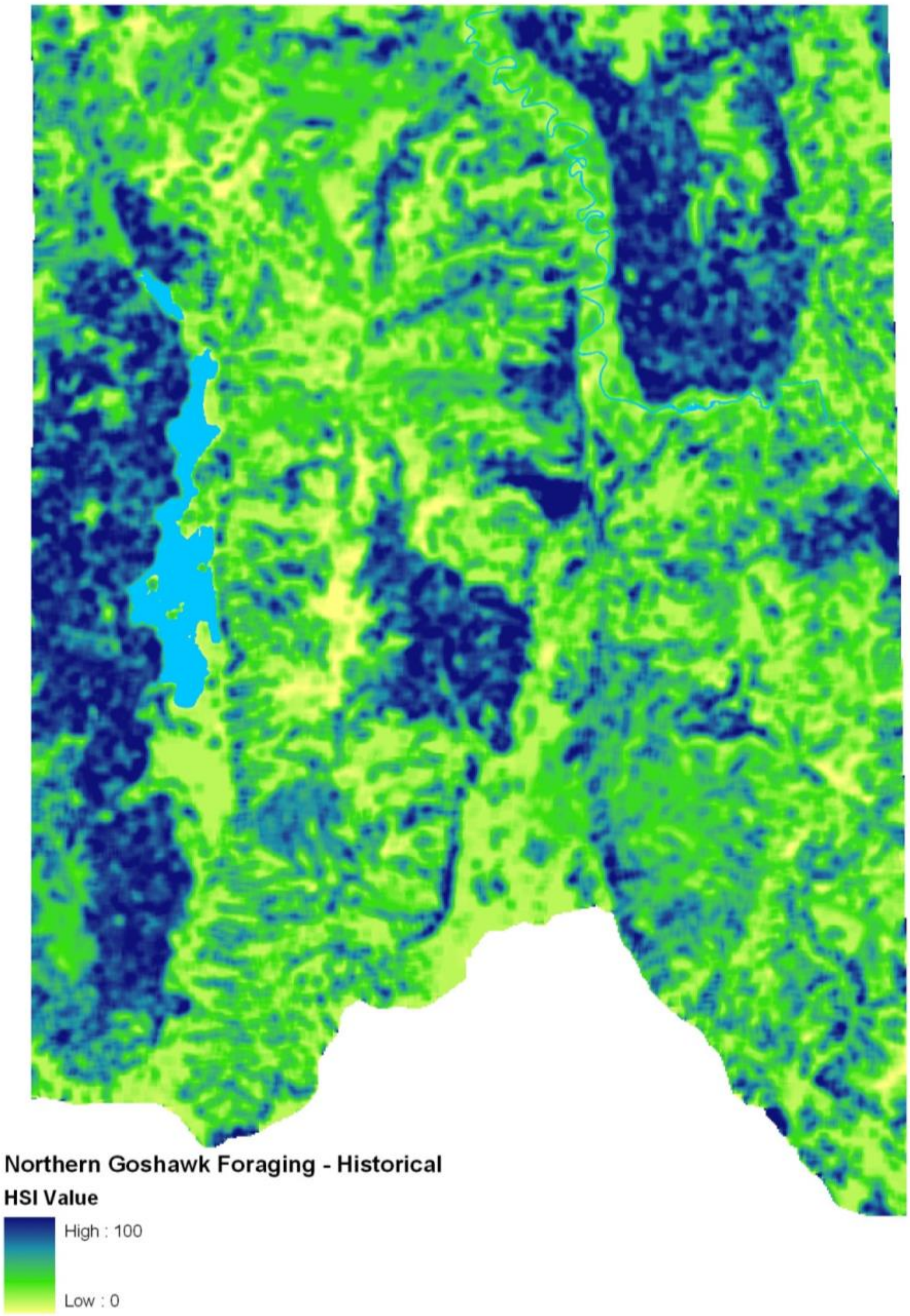


Figure 103. Historical habitat suitability index for Northern Goshawk foraging within the IDL planning landscape.

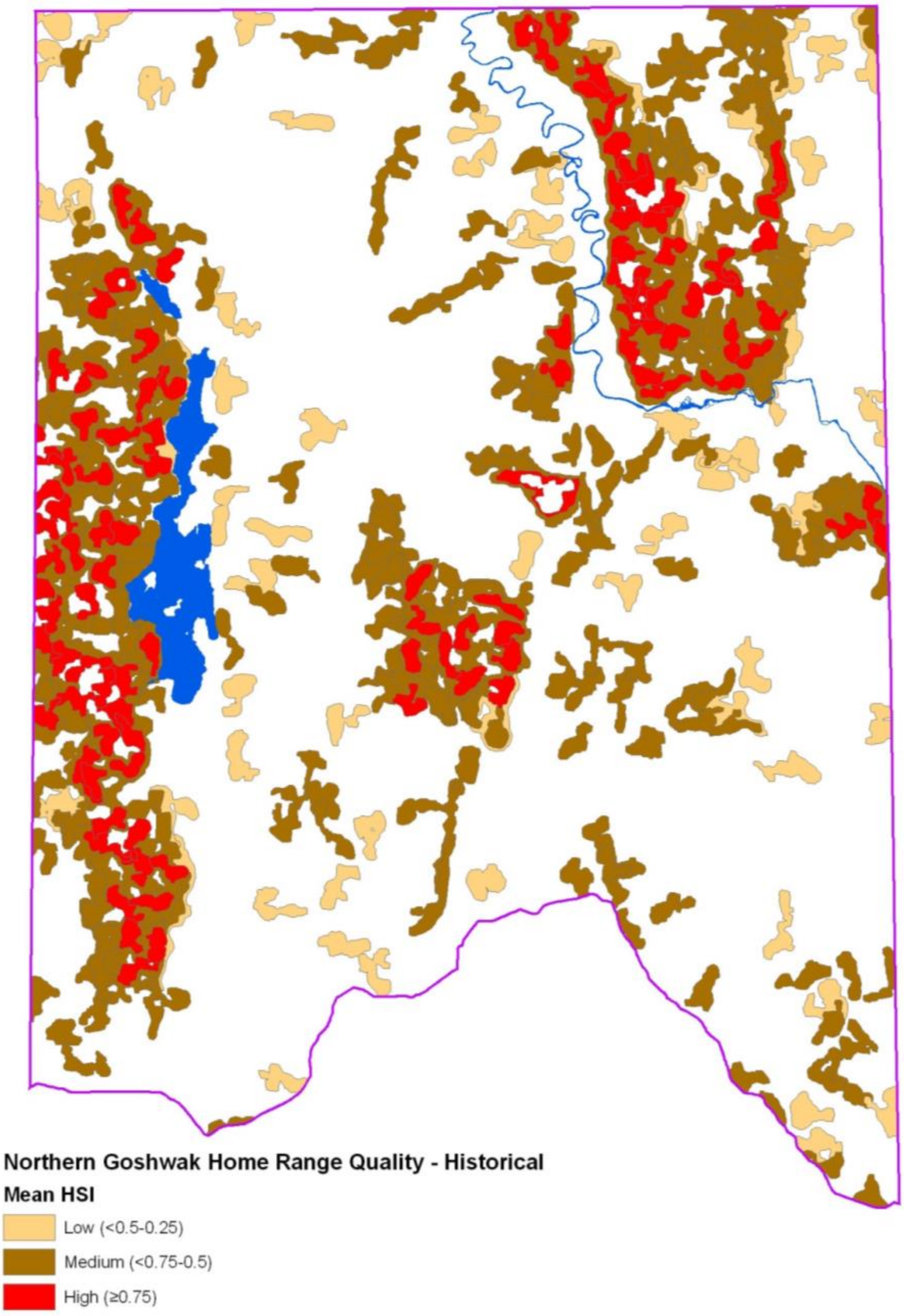


Figure 104. Historical home range quality (mean HSI) for Northern Goshawk within the IDL planning landscape.

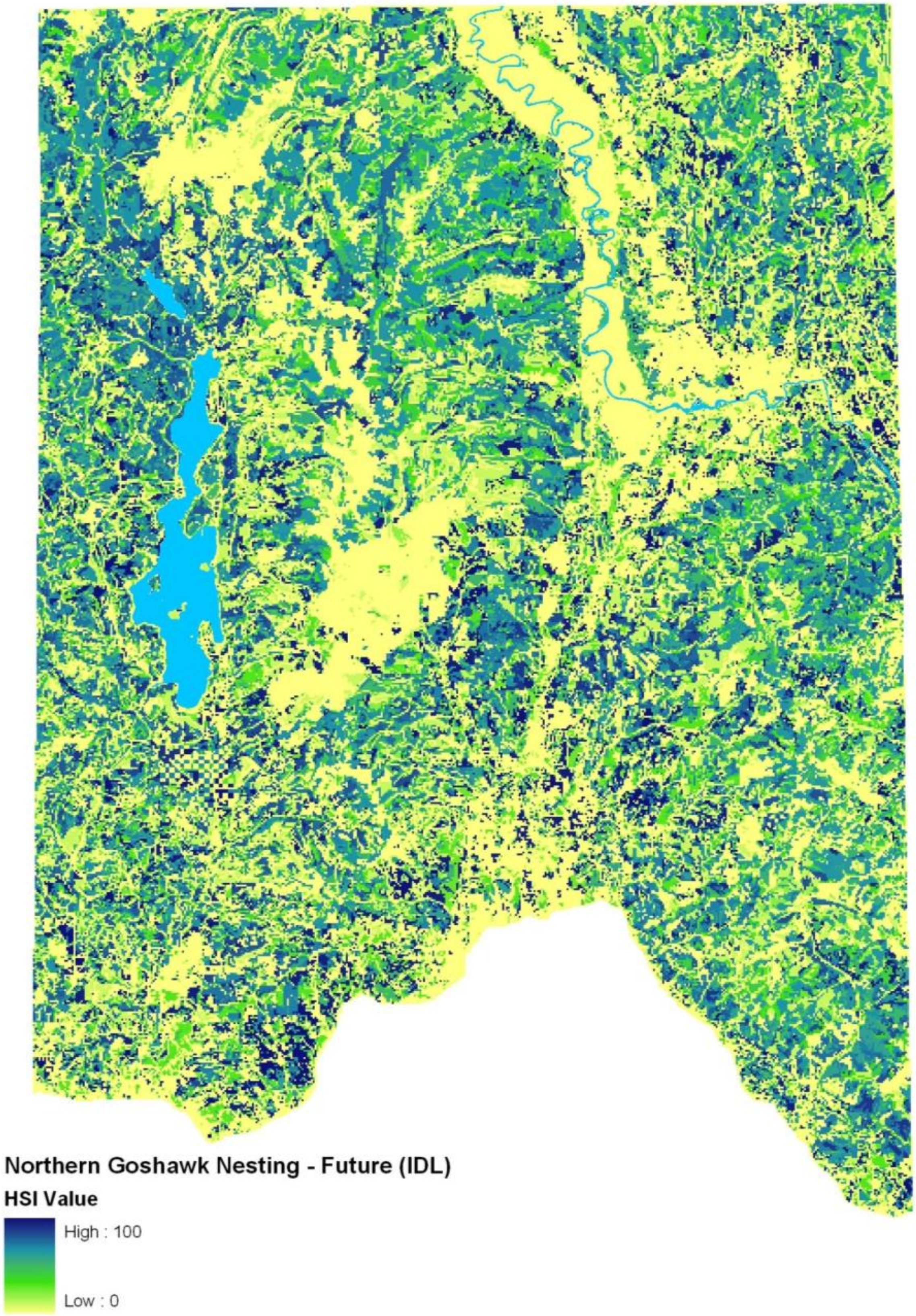


Figure 105. Future habitat suitability index for Northern Goshawk nesting with 20% representation on IDL ownership only.

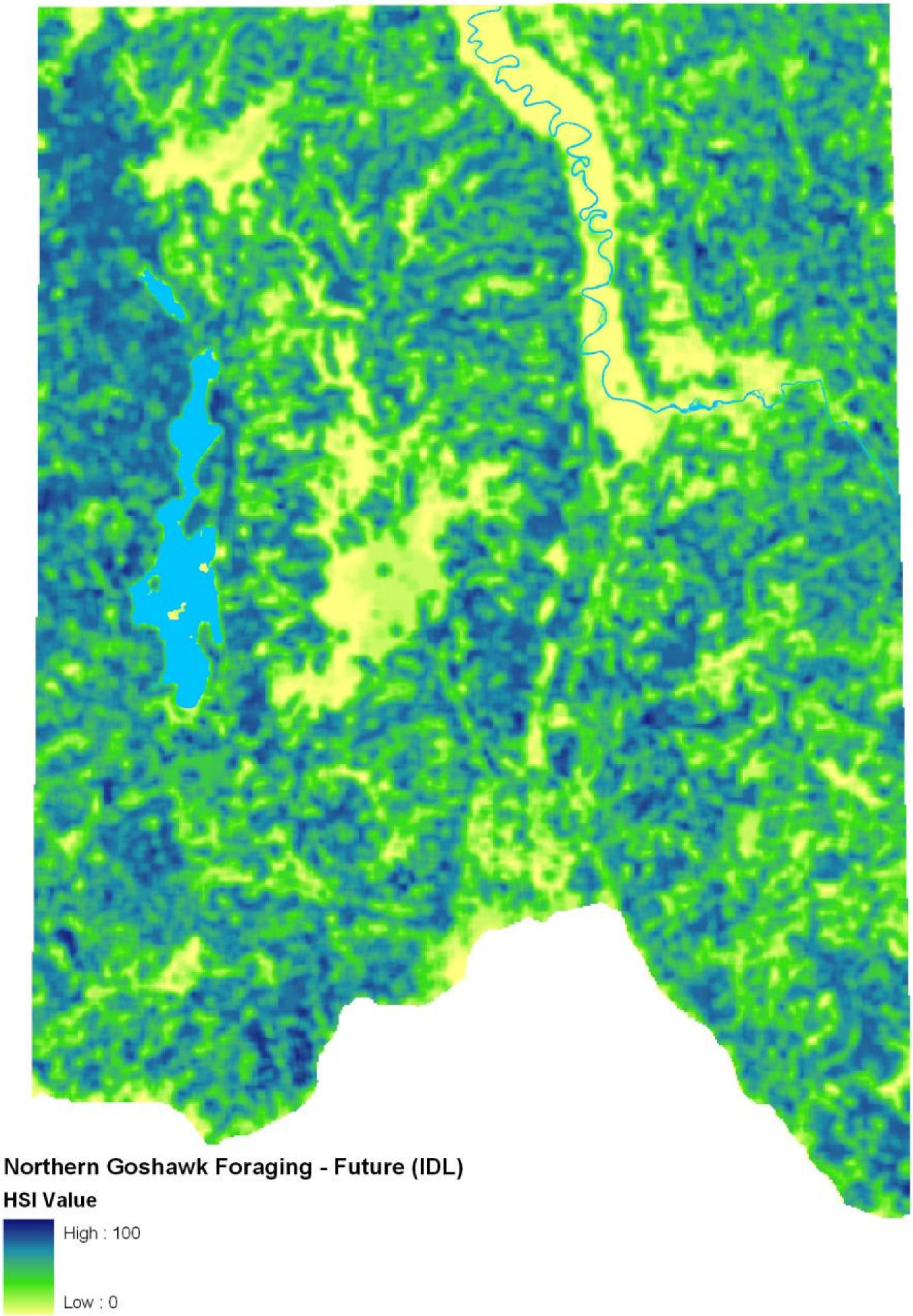


Figure 106. Future habitat suitability index for Northern Goshawk foraging with 20% representation on IDL ownership only.

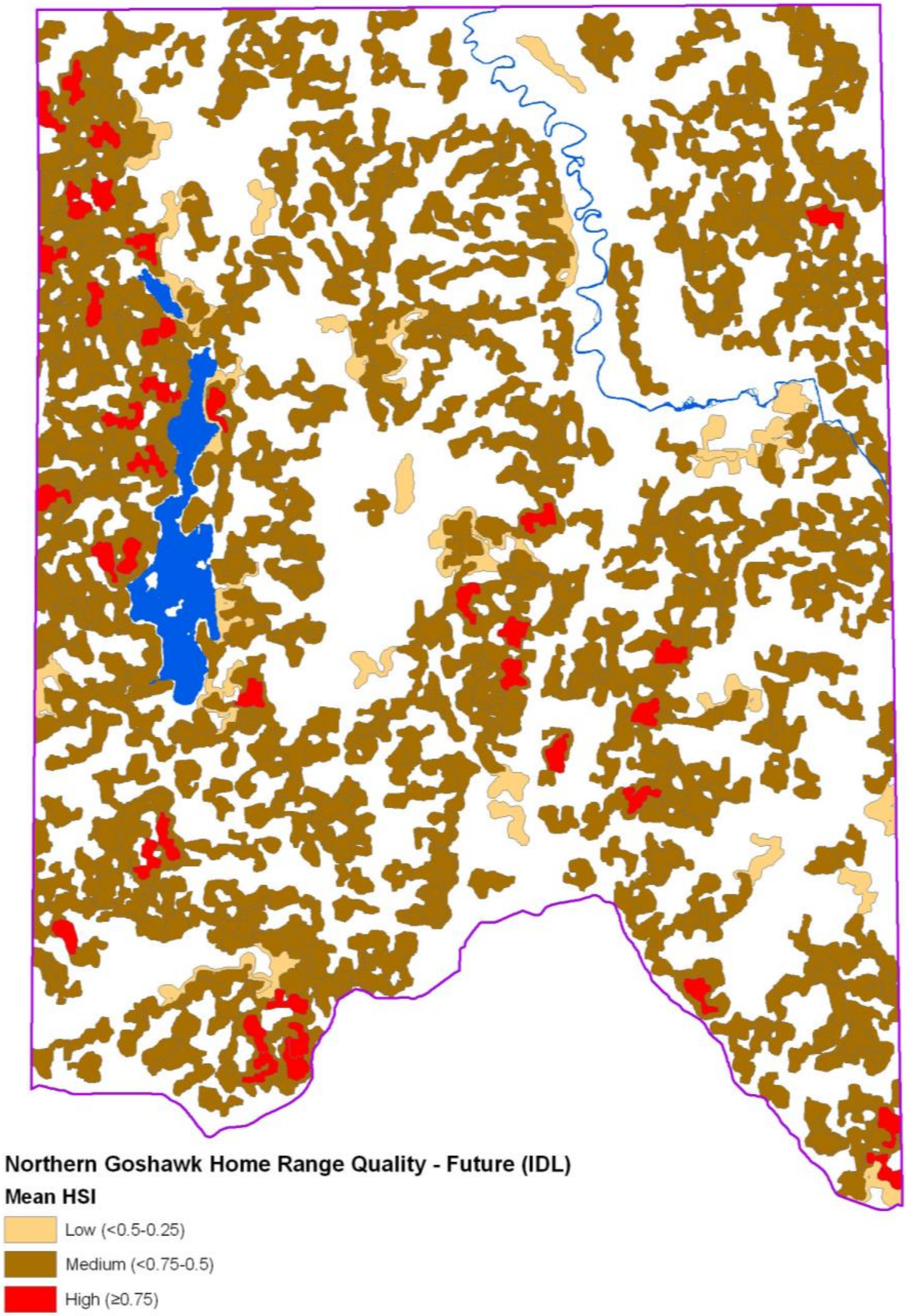


Figure 107. Future home range quality for Northern Goshawk with 20% representation on IDL ownership only.

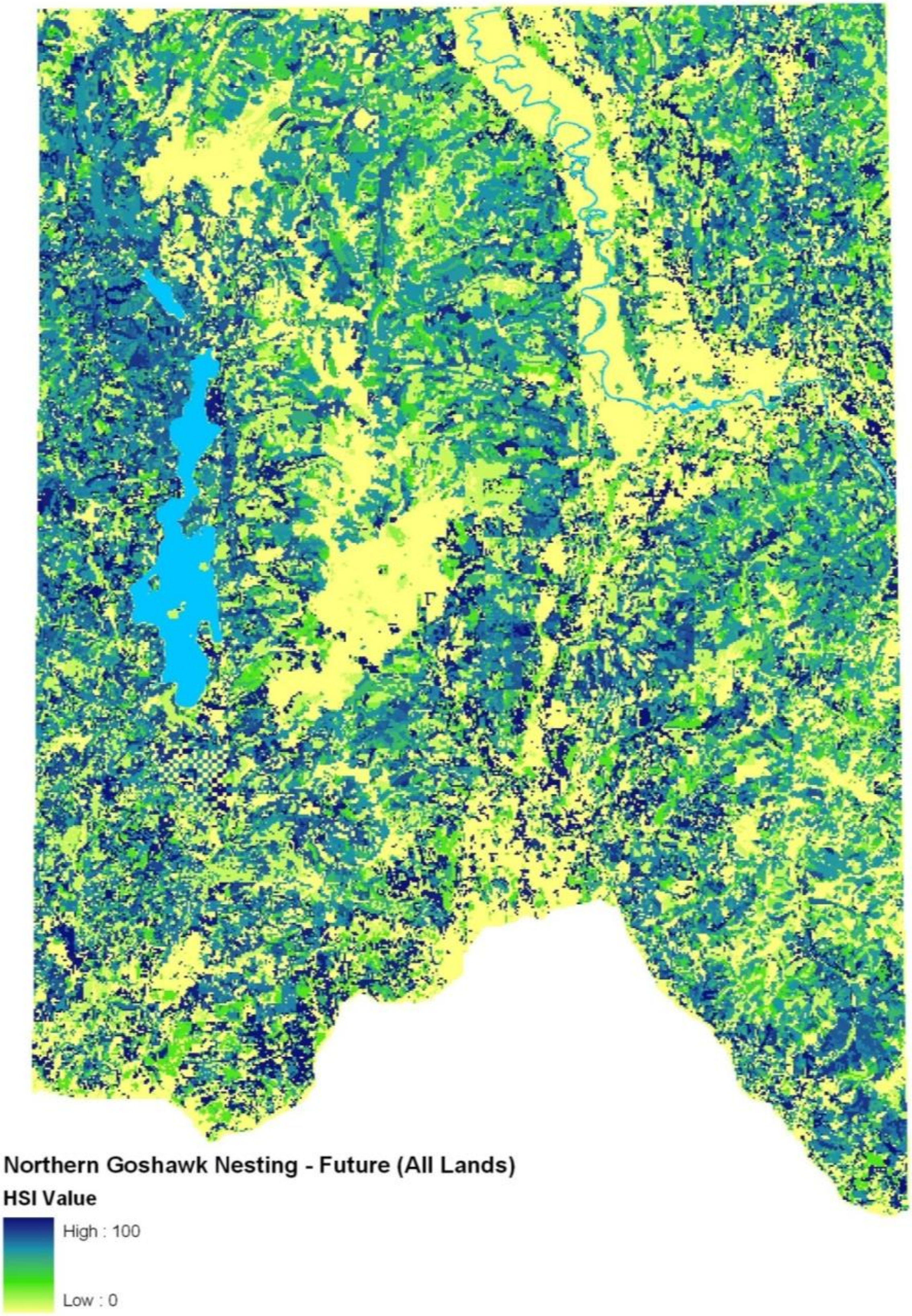


Figure 108. Future habitat suitability index for Northern Goshawk nesting with 20% representation on all ownerships.

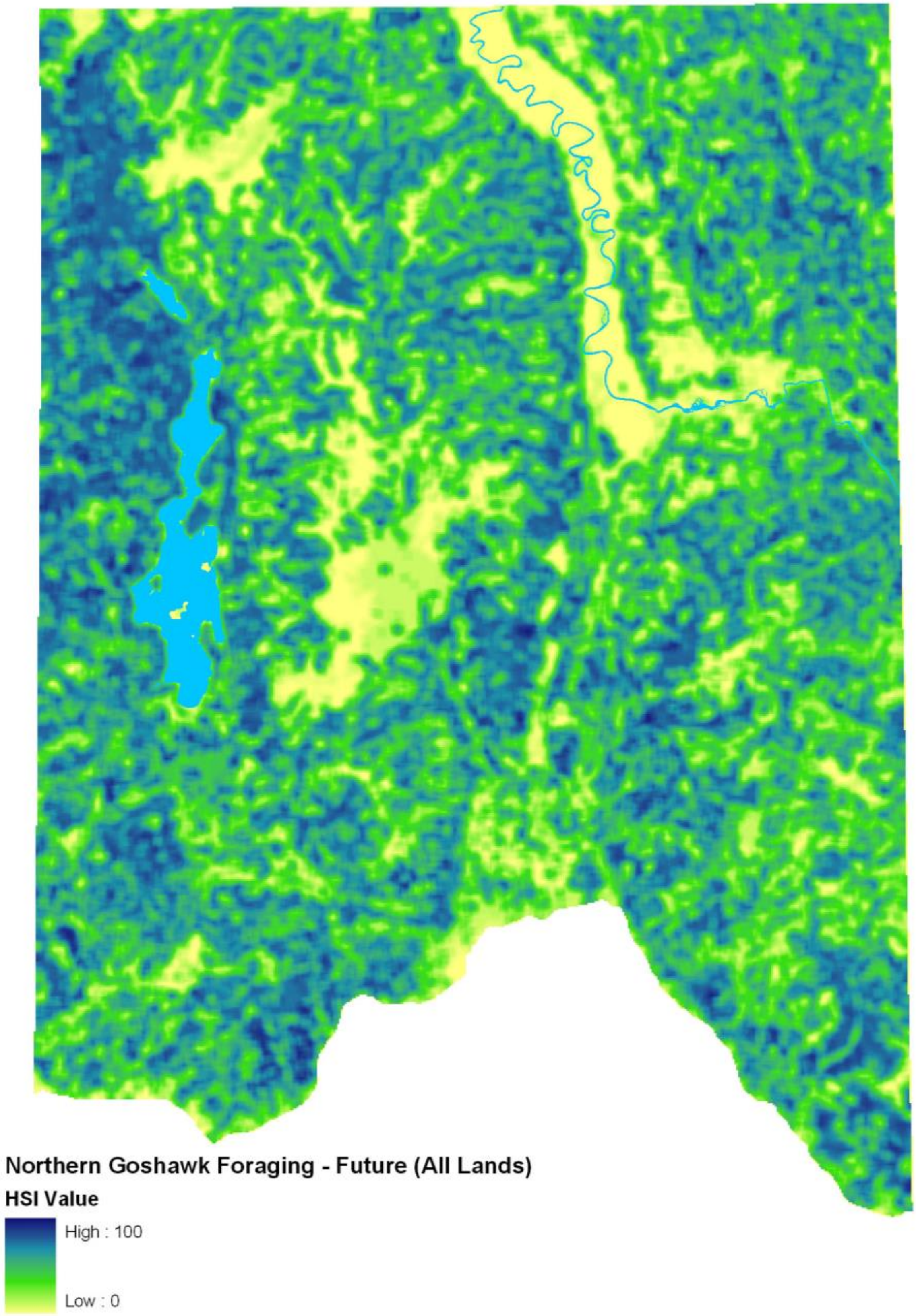


Figure 109. Future habitat suitability index for Northern Goshawk foraging with 20% representation on all ownerships.

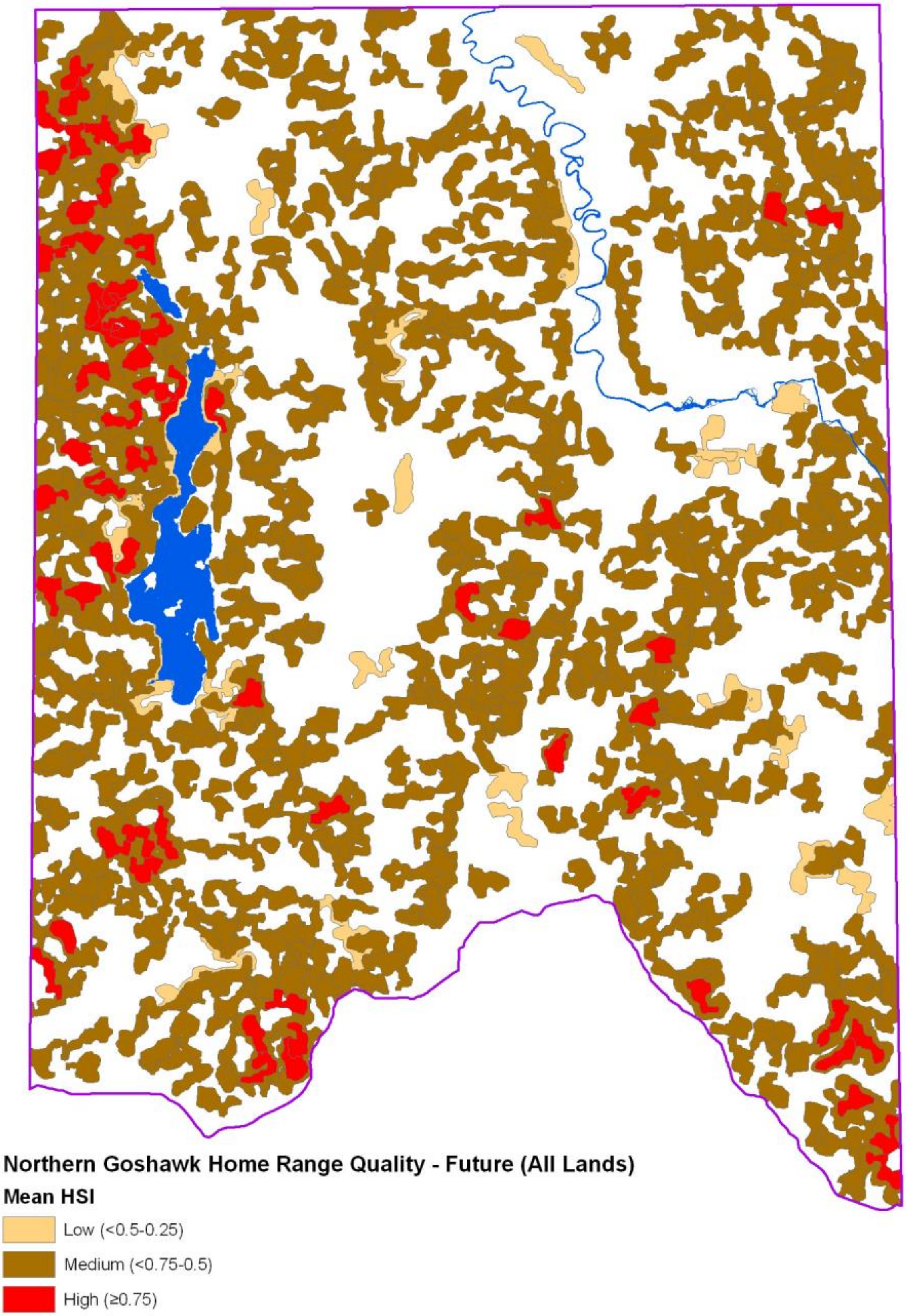


Figure 110. Future home range quality for Northern Goshawk with 20% representation on all ownerships.

Great Gray Owl (*Strix nebulosa*)

The Great Gray Owl is a large owl, with a patchy distribution in Idaho. They are typically found in conifer dominated stands with a mosaic of open areas suitable for foraging (Franklin 1988). Most recorded nests have been in the broken tops of snags or stick nests built by another species and they were located in mature to old-growth stands with high canopy cover and an open understory (Bryan and Forsman 1987, Franklin 1988, Bull and Henjum 1990). Tree type and stand dominance play only a minor role with most conifer stands being suitable (Franklin 1998, Bull and Henjum 1990). Great Gray Owls are known to forage from perches in natural meadows, wetlands, clear cuts, and open forest with low shrub cover (Brunton and Pittaway 1971, Bryan and Forsman 1987, Franklin 1988, Bull and Henjum 1990). In northwestern Oregon foraging was documented in stands with 11-59% canopy cover and multiple canopy layers (Bull and Henjum 1990). In the western Cascades the majority of foraging took place in small (<0.4 ha; 1 ac) openings or on the edges of clearcuts or other man-made openings (Quintana-Coyer et al. 2004). Prey dominance in the diet varied based on the primary foraging area. Owls foraging in natural meadows had diets dominated by voles (*Microtus* spp.), while owls foraging in clearcuts had diets dominated by pocket gophers (*Thomomys* spp.) (Franklin 1988).

Current general range of the Great Gray Owl in North America (Ridgely et al. 2005).

There were separate nesting and foraging models developed for Great Gray Owls. They were based on the framework described by Piorecky et al. (1999). Great Gray Owls prefer mature to old growth stands with dense canopies, a mix of deciduous and conifer species, and good numbers of snags for nesting. The optimum stand has >12.3 deciduous trees per hectare (5 trees/ac) >35 centimeters (13.8 in), mean diameter at breast height of deciduous and conifer canopy trees >25 centimeters (9.8 in), distance to nearest open area >140 meters (459 ft), and tree canopy cover >35%. The HSI model for Great Gray Owl nesting was based on these optimum conditions. The model variables used were deciduous trees per acre (Figure 111), mean DBH of deciduous trees (Figure 112), mean DBH of conifer trees (Figure 113), distance to nearest open area (Figure 114), and tree canopy cover (Figure 115). The final nesting HSI was calculated by taking the MAX of deciduous TPA HSI, DBH of deciduous HSI, and 0.5×DBH of conifer HSI then multiplying by the canopy cover HSI. The HSI values for EDM cells missing stand data were then added (Table 40). This output was multiplied by a separate grid consisting of distance to open areas to create the final nesting layer (Figure 118).

The optimum conditions for foraging are open areas with <40% tree and shrub cover and <20 meters (65.6 ft) from forested areas. The HSI model for Great Gray Owl foraging was based on these optimum conditions. The model variables used were canopy cover of trees and shrubs ≥1m (3.3 ft) (Figure 116) and distance to nearest forested area (Figure 117). The final foraging HSI grid was calculated by multiplying these two variables. HSI values for EDM cells missing stand data (Table 41) were added and the grid was contoured using a moving window analysis to produce the final input layer needed for HOMEGROWER (Figure 119). The size of the moving window is equal to the allometric home range (Roloff and Haufler 1997). The allometric home range for a 1.3 kg (2.87 lb) male Great Gray Owl is 133 ha (329 ac) or 38x38 cells (Van Horne and Wiens 1991).

Three iterations were done in HOMEGROWER. HOMEGROWER is able to use both a nesting and foraging grid for model runs and insure each home range meets a species' needs for each category. The target home range area was 5 times the allometric home range or 667 ha (1648 ac) for the foraging grid and 10 ha (25 ac) for the nesting grid. The number of seeds was 600,000 and the growth window was 5 cells. Figure 120 shows home ranges and their quality. The number of very low quality home ranges has not been delineated at this time.

The values used to create the Great Gray Owl nesting and foraging HSI grids for historical conditions are presented in Table 42. Figure 121 and Figure 122 are the grids used in HOMEGROWER for historical conditions. The same run parameters used for the current conditions model were also used for the historical conditions model. Figure 123 depicts home range quality for historical conditions. The number of very low quality home ranges has not been delineated at this time.

The values used to create the Great Gray Owl HSI grids for future conditions were a combination of the values used for the current conditions and historical conditions. Areas modified to achieve reference conditions received historical conditions values and all other areas received current conditions values. Figure 124 and Figure 125 are the grids used in HOMEGROWER for future conditions applied only to IDL ownership and Figure 127 and Figure 128 are the grids used in HOMEGROWER for future conditions applied to all ownerships. The same run parameters used for the current conditions model were also used for the future conditions models. Figure 126 depicts home range quality for future conditions applied only to IDL ownership and Figure 129 depicts home range quality for future conditions applied to all ownerships. The number of very low quality home ranges was not delineated. The mean numbers of Great Gray Owl home ranges of high, medium, and low quality, resulting from the modeling effort, are presented as follows for historical, current and future conditions.

	Historical Conditions	Current Conditions	Future Conditions (IDL)	Future Conditions (All Lands)
High (1.0-0.75)	8	0	0	0
Medium (<0.75-0.5)	84	39	41	60
Low (<0.5-0.25)	61	156	160	143

The key factor driving the Great Gray Owl model is the juxtaposition of foraging habitat. Great Gray Owls prefer to forage in small openings or under an open forest canopy. When foraging in openings they rarely take prey more than 15 m (49.2 ft) from a perch on the edge, so large openings are considered unsuitable for foraging. Under current conditions many stands are overstocked compared to historical conditions. This is primarily due to fire exclusion in stands that historically burned relatively frequently. Under current conditions, the majority of stands fall under a long return, stand replacing fire regime. These stands are typically characterized as having closed canopies and a well developed second canopy. Current stand conditions result in lower quality home ranges due to the limited quality of foraging habitat compared to historical conditions. Also, mixed severity fires that occurred historically would produce small openings surrounded by forest that would have resulted in higher quality habitat. Home range quality improves under future conditions. This is due to the restoration of more mixed-severity fire conditions. However, the large spatial scale of Great Gray Owl habitat use requires large areas of habitat change for substantial improvements in high quality home ranges.

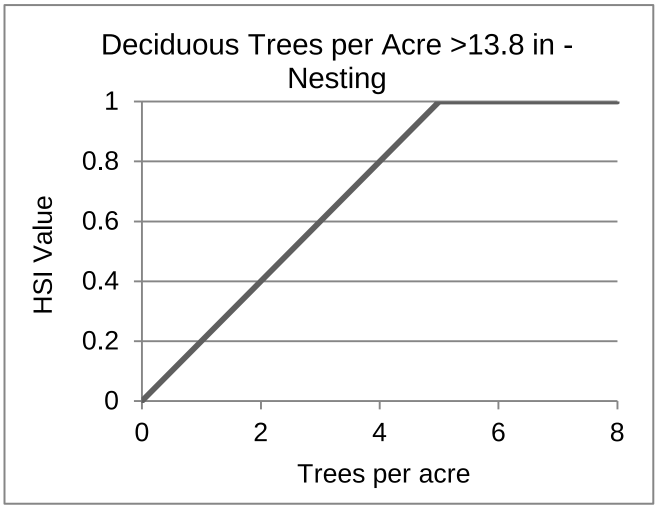


Figure 111. Relationship between deciduous trees per acre and HSI values for Great Gray Owl nesting. Equation between 0 and 5 is *y=0.2x*.

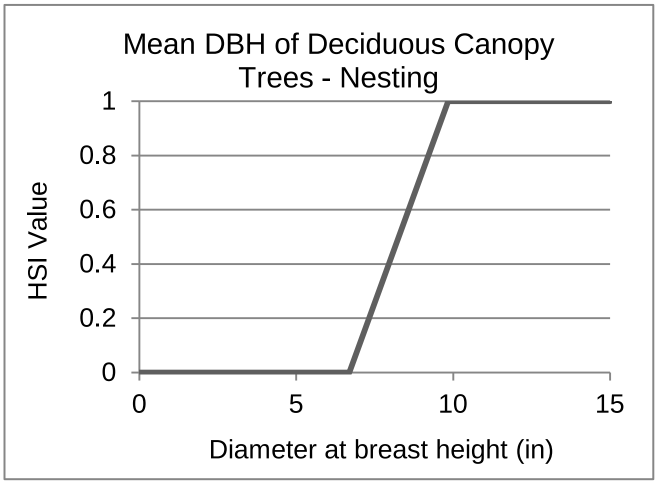


Figure 112. Relationship between mean diameter at breast height of deciduous canopy trees and HSI values for Great Gray Owl nesting. The equation between 6.693 and 9.843 is *y=0.317x-2.125*.

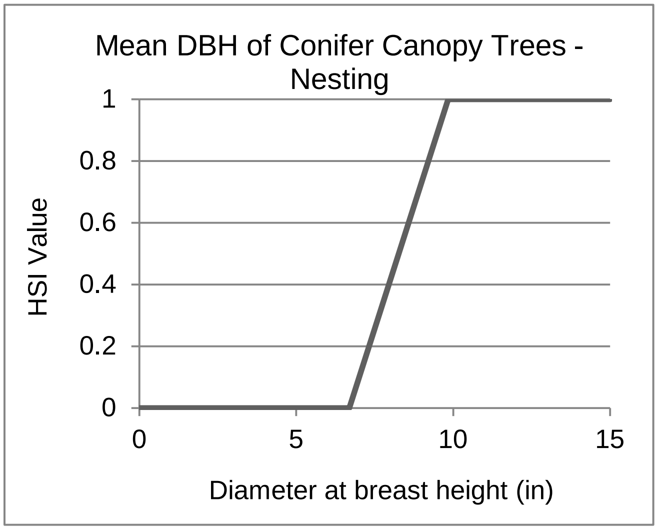


Figure 113. Relationship between mean diameter at breast height of conifer canopy trees and HSI values for Great Gray Owl nesting. The equation between 6.693 and 9.843 is *y=0.317x-2.125*.

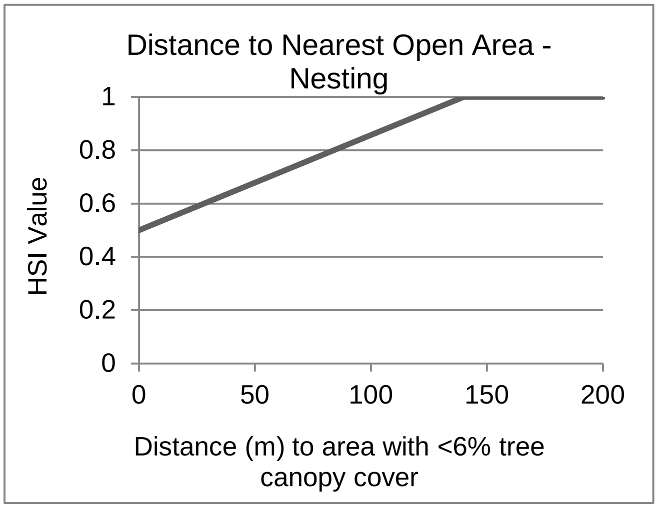


Figure 114. Relationship between distance to nearest open area and HSI values for Great Gray Owl nesting. The equation between 0 and 140 is *y=0.003x+0.5*.

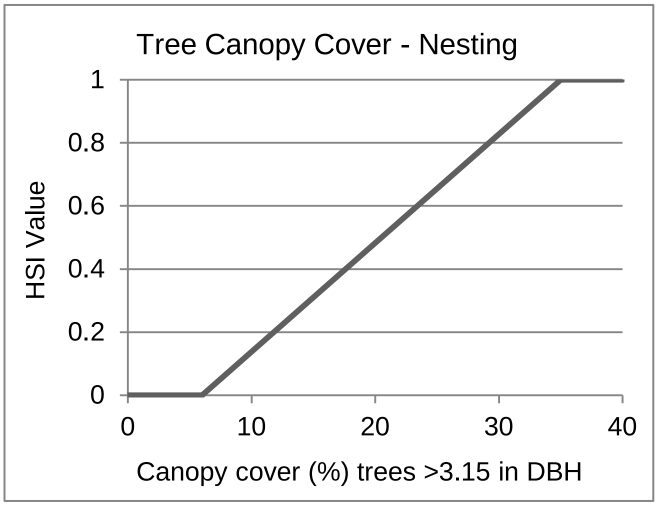


Figure 115. Relationship between tree canopy cover and HSI values for Great Gray Owl nesting. The equation between 6 and 35 is *y=0.034x-0.206*.

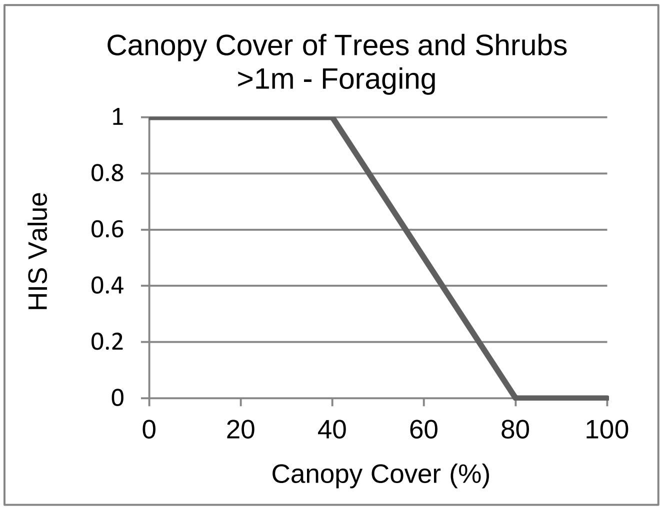


Figure 116. Relationship between canopy cover of trees and shrubs and HSI values for Great Gray Owl foraging. The equation between 40 and 80 is *y=-0.025x+2*.

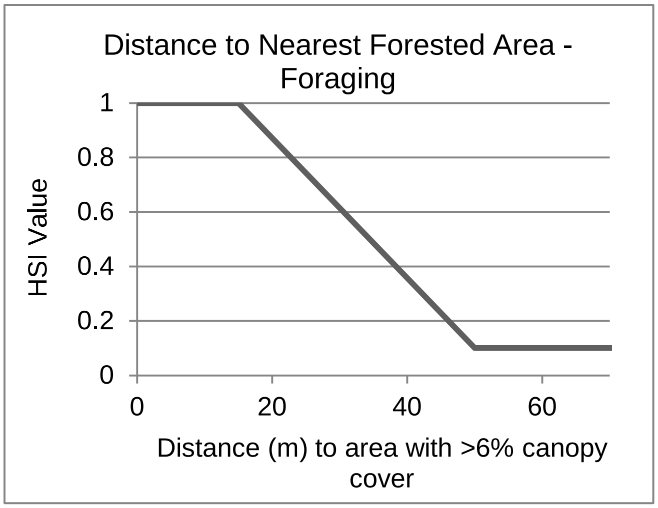


Figure 117. Relationship between distance to nearest forested area and HSI values for Great Gray Owl foraging. The equation between 15 and 50 is $y=-0.28x+1.428$.

Table 40. HSI values for Great Gray Owl nesting and foraging used in the current conditions model (* Where available, the mean and ± one standard deviation for each relevant habitat variable from FIA stand data was used to calculate three HSI scores).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
Great Gray Owl Nesting Component									
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	0	0	0	0	0
POLE	0	0	0	0	0	0	0	0	0
MEDIUM-NL	0	10	10	10	10	10	10	40	40
LARGE-NL	10	10	10	30	30	30	20	75	75
VERY LARGE-NL	20-40-60	30-50-70	40-60-80	75	75	75	60	N/A	N/A
MEDIUM-L	0-0-0*	26-30-35*	37-45-49*	20	27-31-34*	26-31-36*	10	75-87.5-100	75-87.5-100
LARGE-L	20	34-50-50*	50-50-50*	50-75-100	50-50-50*	42-49-50*	30	75-87.5-100	75-87.5-100
VERY LARGE-L	29-50-50*	47-50-50*	0-50-50*	0-50-50*	50-50-50*	50-50-50*	27-50-50*	0-50-50*	22-50-50*
Great Gray Owl Foraging Component									
SEEDLING	100	100	100	100	100	100	100	100	100
SAPLING	30	30	30	30	30	30	30	30	30
POLE	30	30	30	30	30	30	30	30	30
MEDIUM-NL	75	75	75	75	75	75	75	75	75
LARGE-NL	75	75	75	75	75	75	75	75	75
VERY LARGE-NL	75	100	100	75	75	75	75	N/A	N/A
MEDIUM-L	100-78-21*	60-14-0*	59-0-0*	10-25-50	91-34-0*	3-0-0*	10-25-50	10-25-50	10-25-50
LARGE-L	65	100-51-0*	0-0-0*	10-25-50	100-45-0*	0-0-0*	10-25-50	10-25-50	10-25-50
VERY LARGE-L	100-72-41*	85-24-0*	29-0-0*	32-0-0*	73-12-0*	2-0-0*	100-37-0*	42-0-0*	100-57-0*

Table 41. HSI values for Great Gray Owl nesting and foraging used in the historical conditions model.

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
HSI Values for Great Gray Owl Nesting - HRV									
SEEDLING	0	0	0	0	0	0	0	0	0
SAPLING	0	0	0	0	0	0	0	0	0
POLE	0	0	0	0	0	0	0	0	0
MEDIUM-NL	0	10	10	10	10	10	10	40	40
LARGE-NL	20-40-60	20-40-60	50-70-90	30	30	30	10	75	75
VERY LARGE-NL	30-50-70	30-50-70	80-90-100	50	50	50	10	N/A	N/A
MEDIUM-L	10	10	10	20	10	10	10	60	60
LARGE-L	30	30	20	50-75-100	40-60-80	40-60-80	30	75-87.5-100	75-87.5-100
VERY LARGE-L	30-50-70	40-60-80	50-65-80	50-75-100	40-60-80	40-60-80	40	75-87.5-100	75-87.5-100
HSI Values for Great Gray Owl Foraging - HRV									
SEEDLING	100	100	100	100	100	100	100	100	100
SAPLING	30	30	30	30	30	30	30	30	30
POLE	30	30	30	30	30	30	30	30	30
MEDIUM-NL	75	75	75	75	75	75	75	75	75
LARGE-NL	75	75	75	75	75	75	75	75	75
VERY LARGE-NL	75	100	100	75	75	75	75	N/A	N/A
MEDIUM-L	30	0-25-50	0-25-50	0-25-50	0-25-50	0-25-50	10-25-50	10-25-50	10-25-50
LARGE-L	30	0-25-50	0-25-50	0-25-50	0-25-50	0-25-50	10-25-50	10-25-50	10-25-50
VERY LARGE-L	30	0-40-75	0-30-60	0-30-60	0-25-50	0-25-50	10-25-50	10-25-50	10-25-50

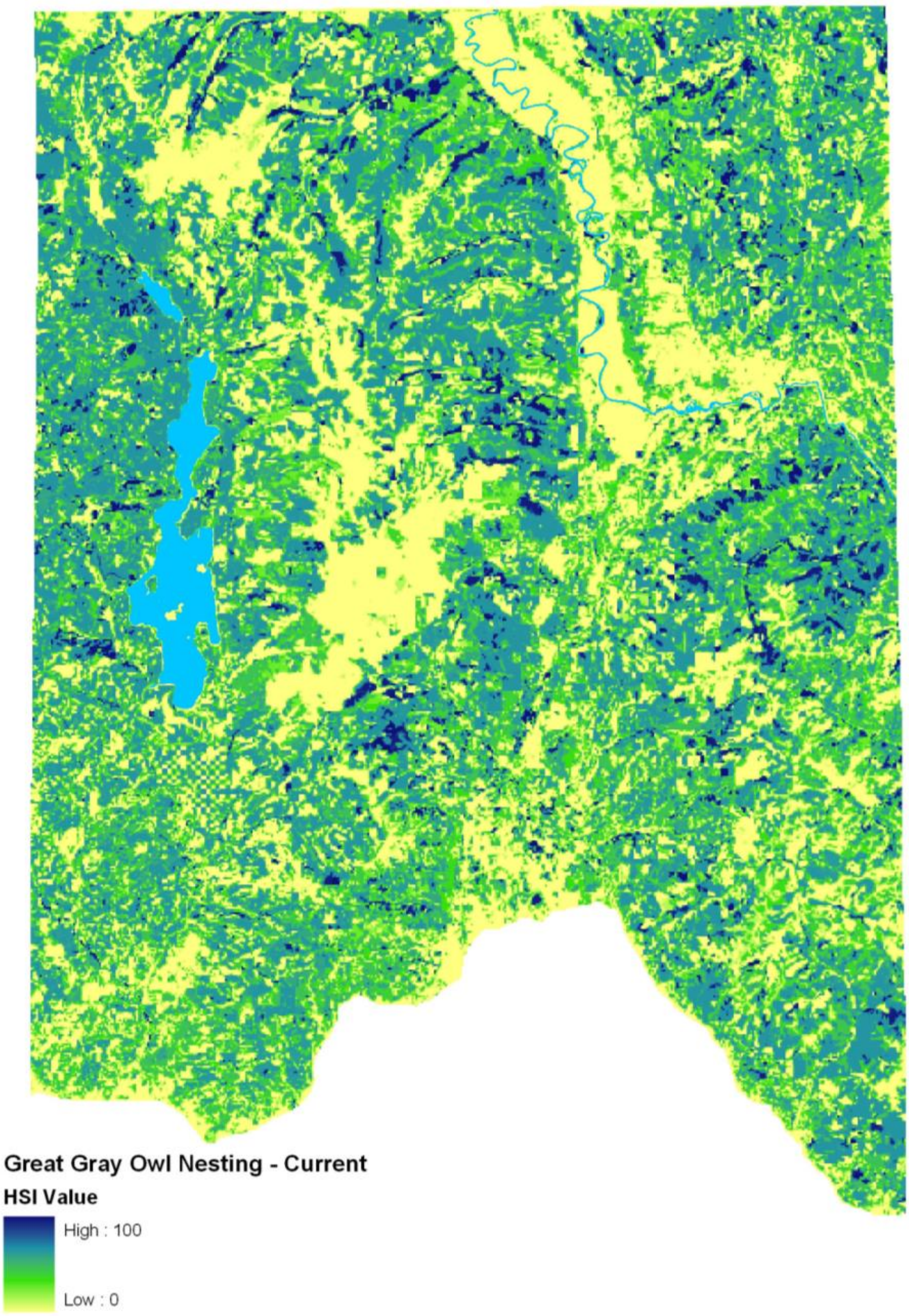


Figure 118. Current habitat suitability index for Great Gray Owl nesting within the IDL planning landscape.

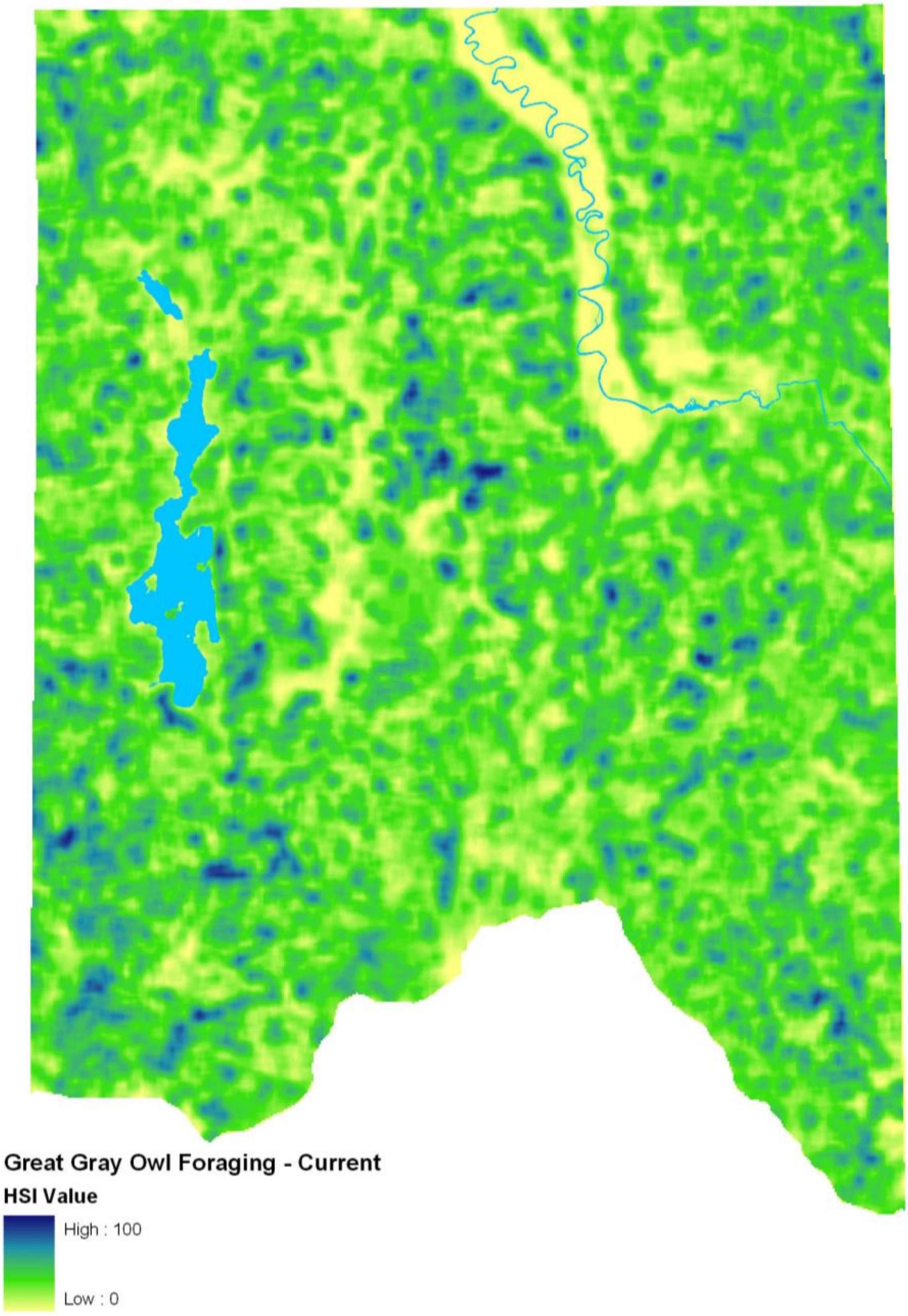


Figure 119. Current habitat suitability index for Great Gray Owl foraging within the IDL planning landscape.

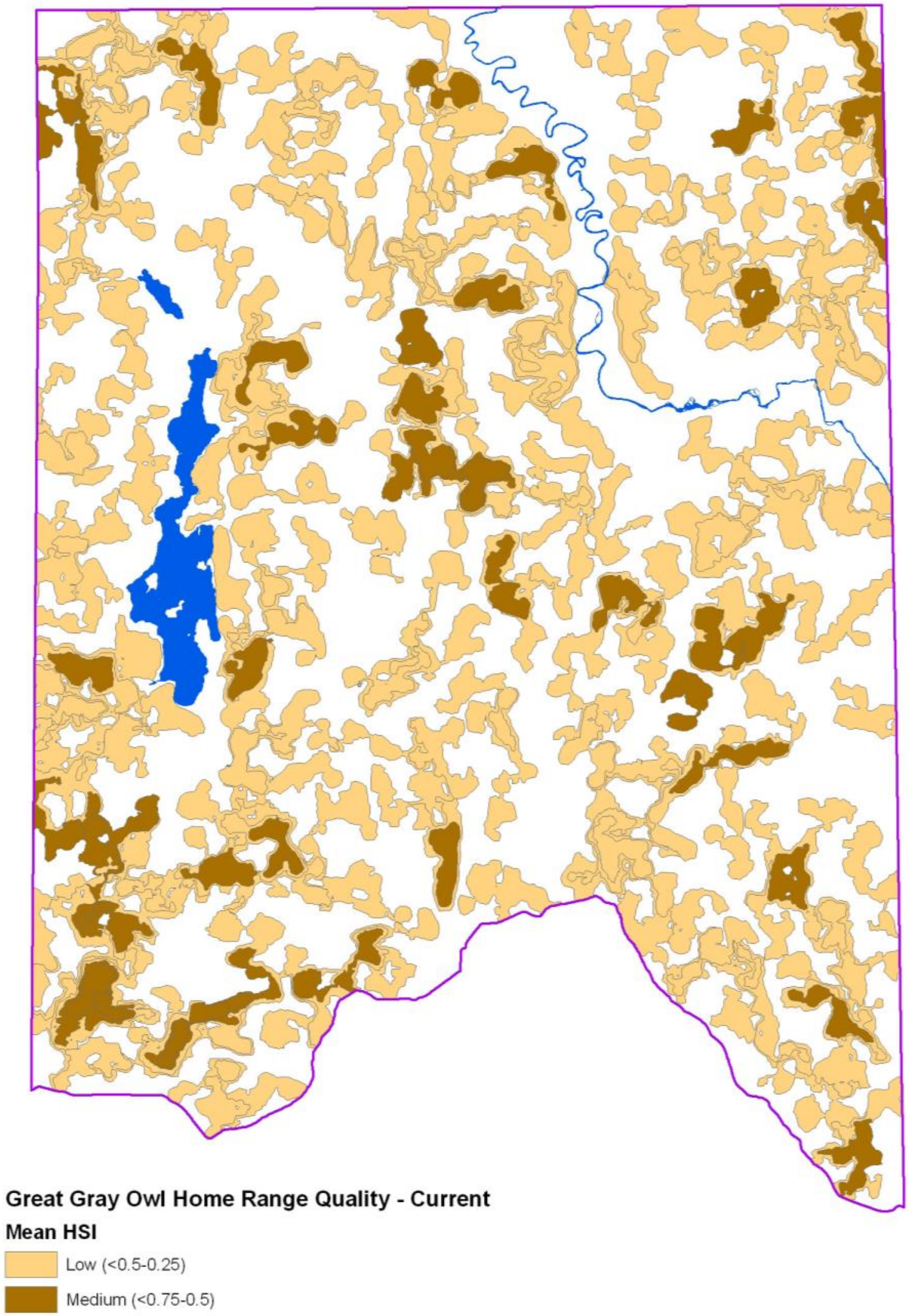


Figure 120. Current home range quality (mean HSI) for Great Gray Owl within the IDL planning landscape.

Figure 121. Historical habitat suitability index for Great Gray Owl nesting within the IDL planning landscape.

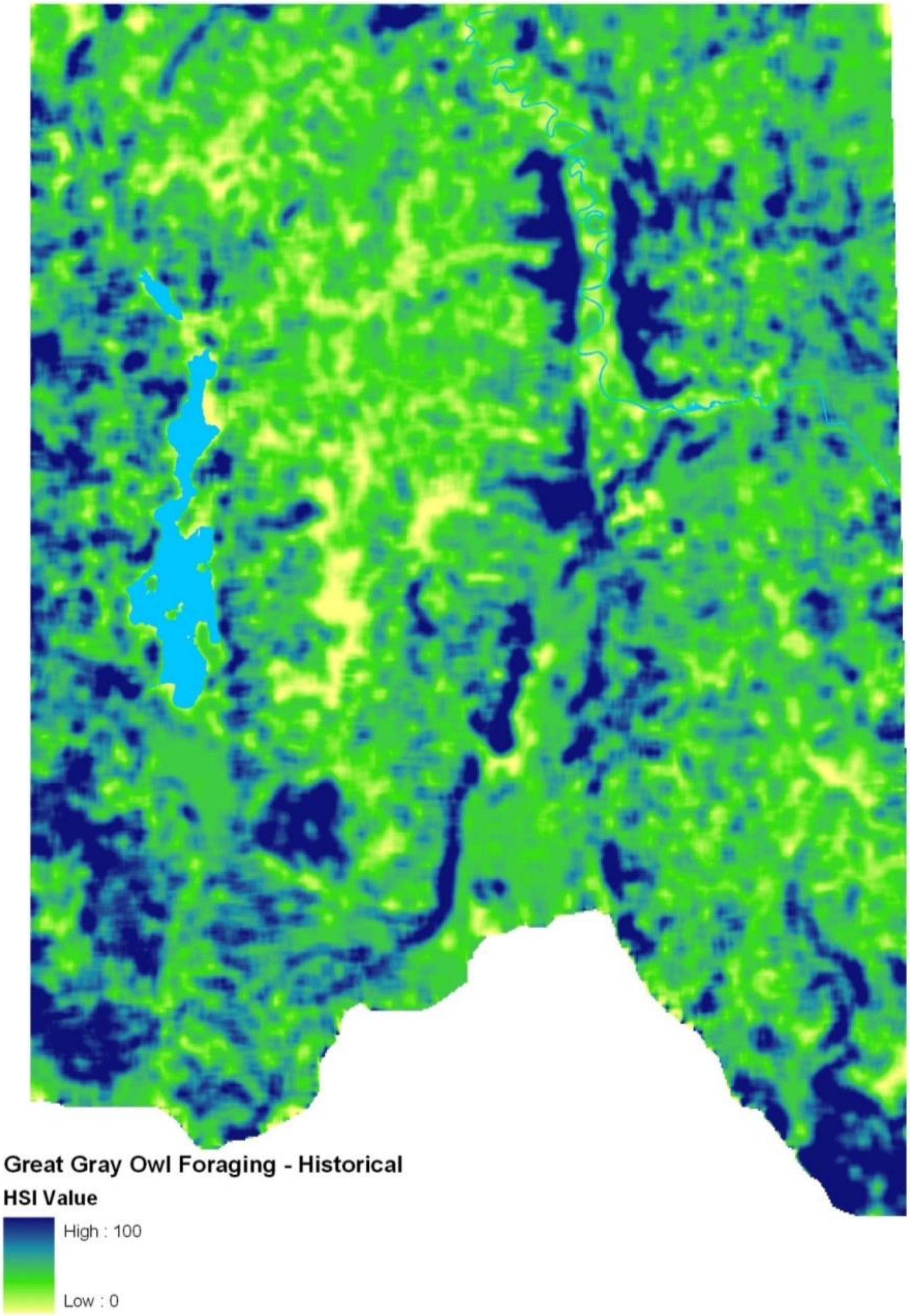


Figure 122. Historical habitat suitability index for Great Gray Owl foraging within the IDL planning landscape.

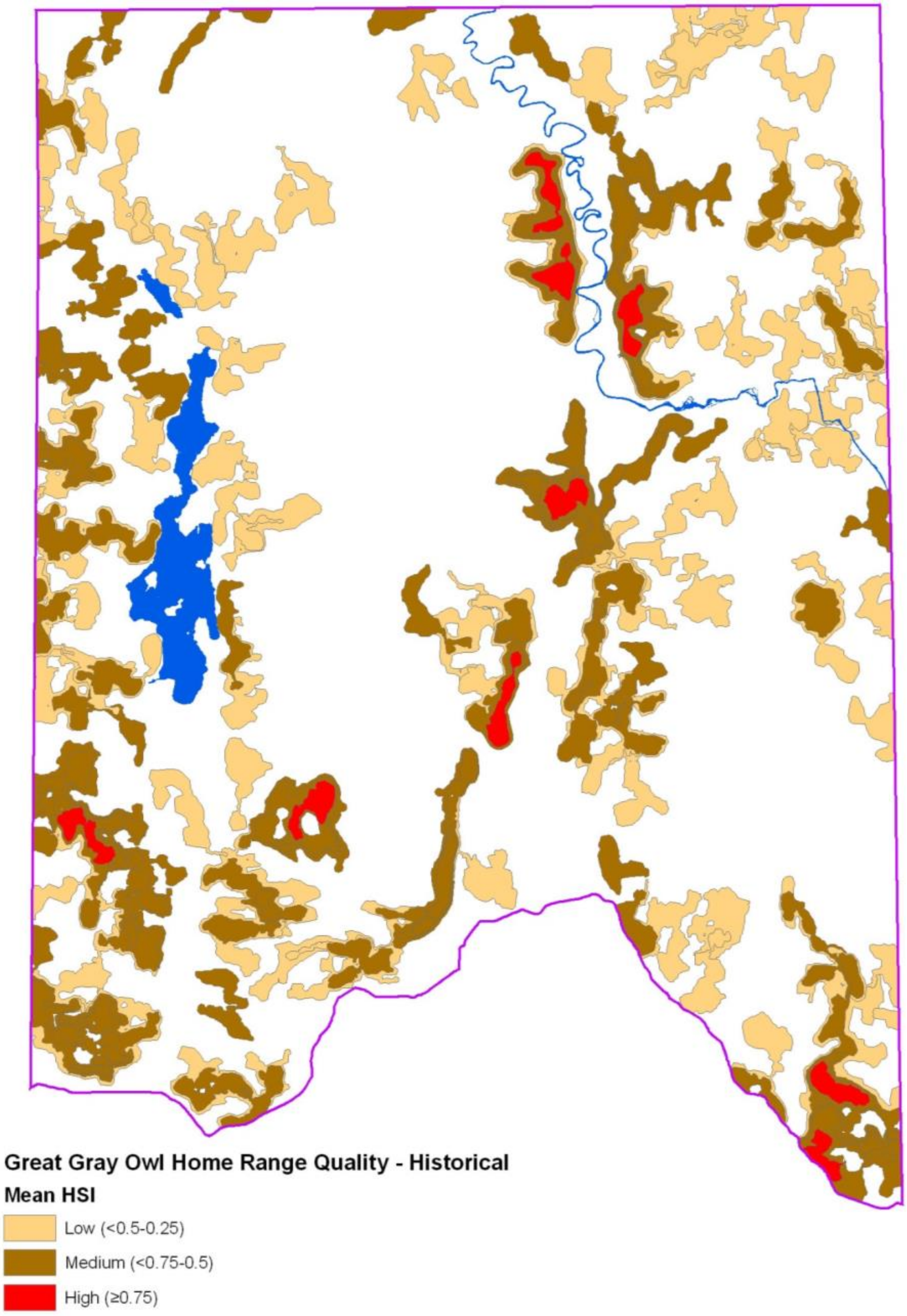


Figure 123. Historical home range quality (mean HSI) for Great Gray Owl within the IDL planning landscape.

Figure 124. Future habitat suitability index for Great Gray Owl nesting with 20% representation on IDL ownership only.

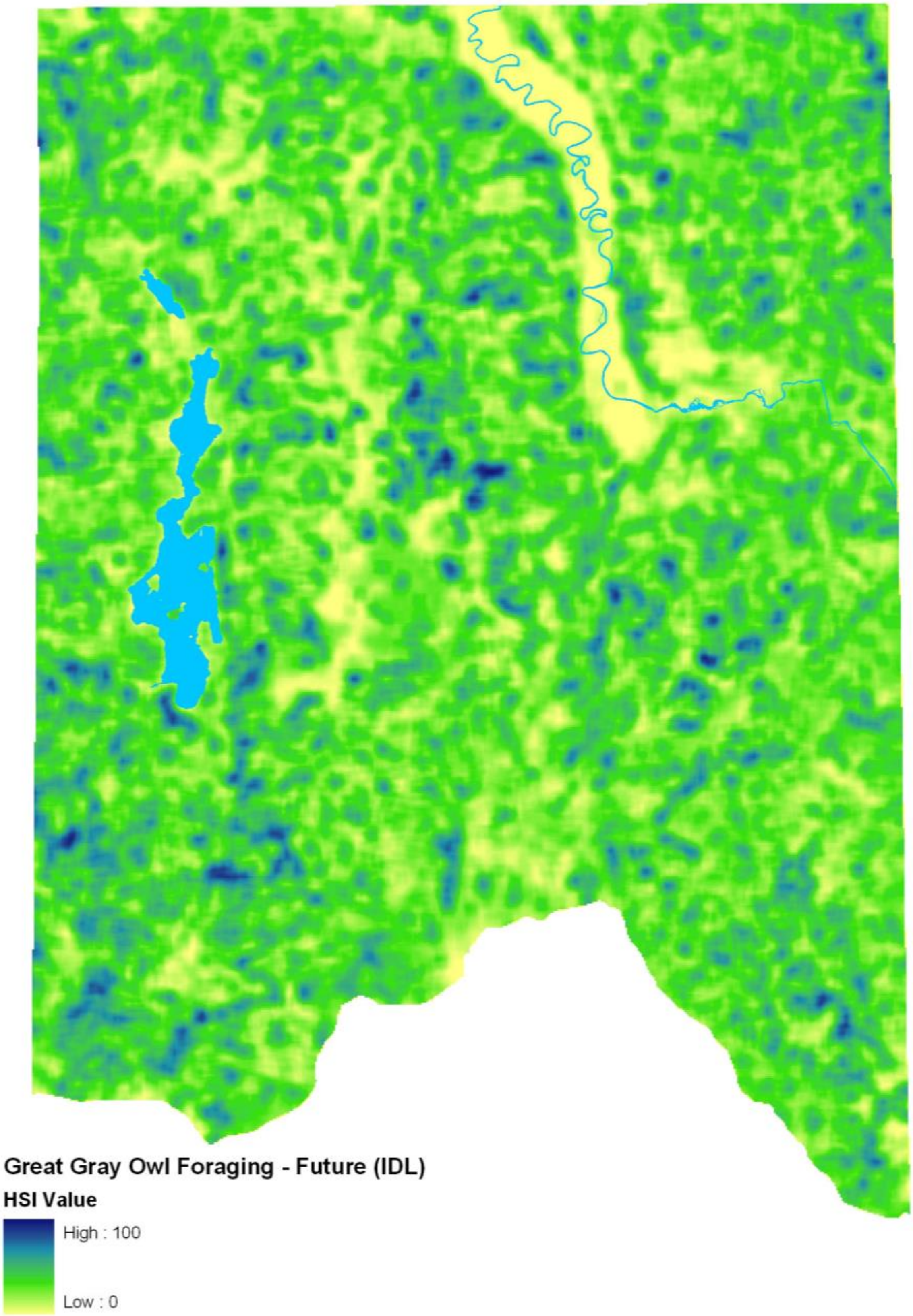


Figure 125. Future habitat suitability index for Great Gray Owl foraging with 20% representation on IDL ownership only.

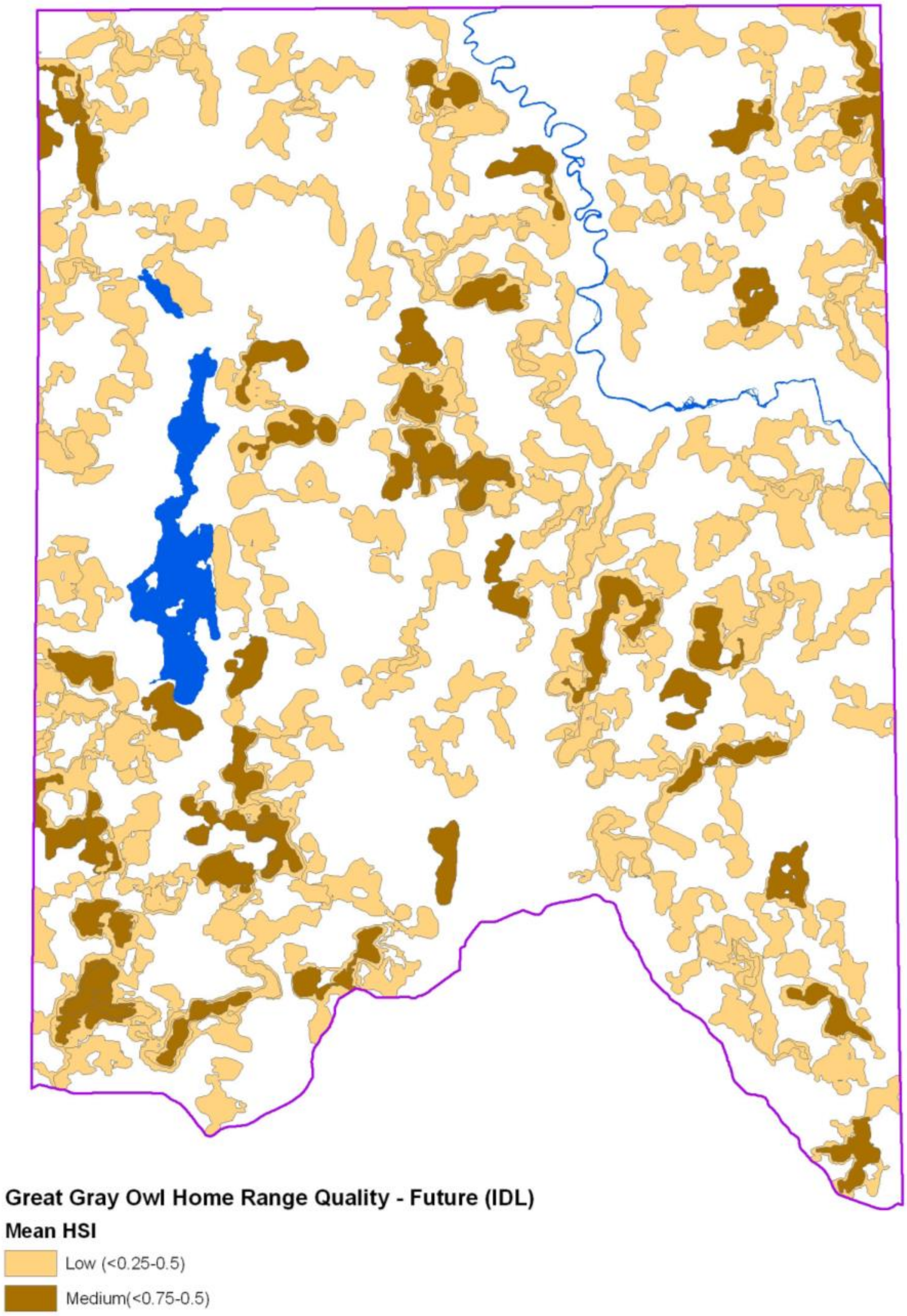


Figure 126. Future home range quality for Great Gray Owl with 20% representation on IDL ownership only.

Figure 127. Future habitat suitability index for Great Gray Owl nesting with 20% representation on all ownerships.

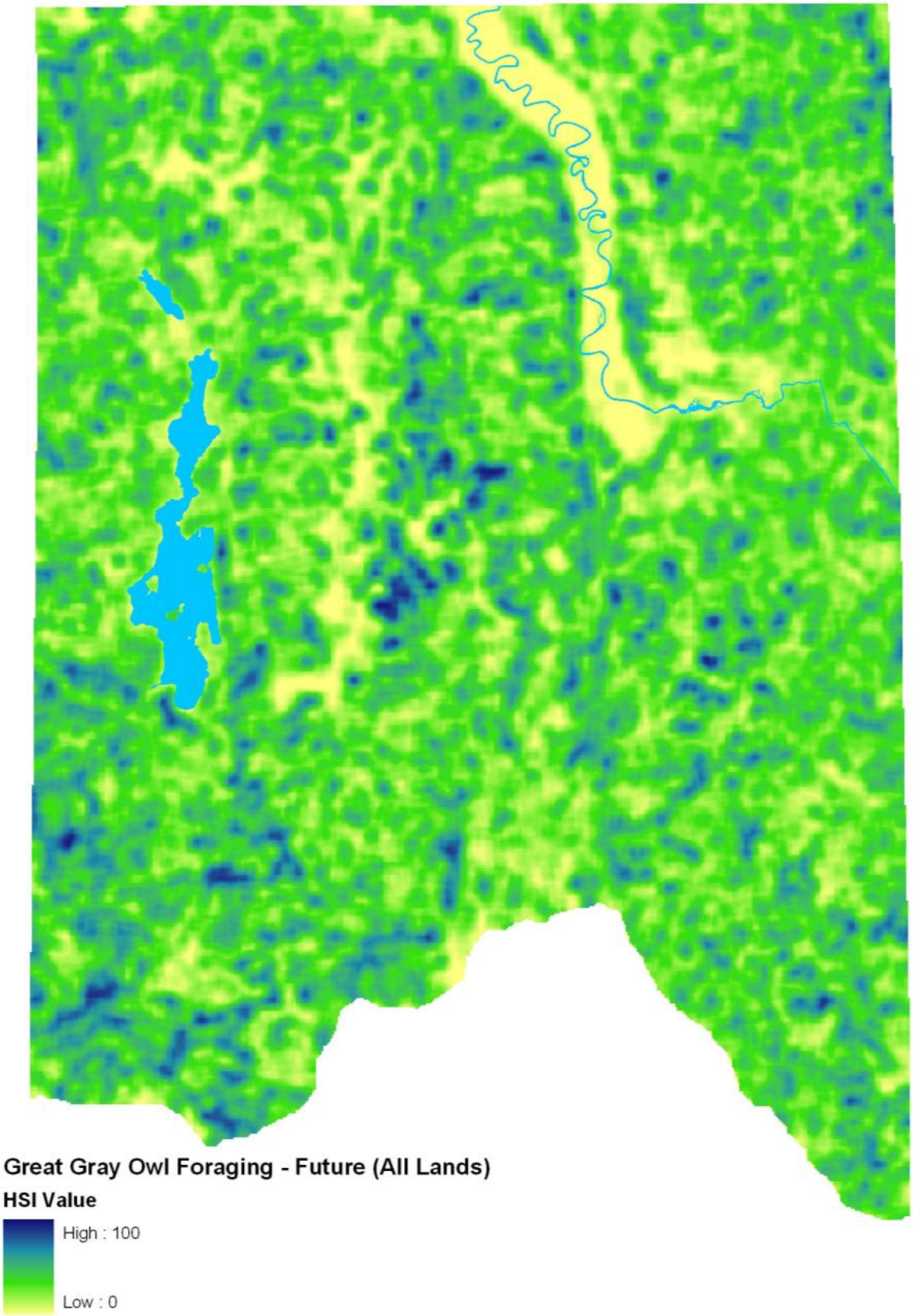


Figure 128. Future habitat suitability index for Great Gray Owl foraging with 20% representation on all ownerships.

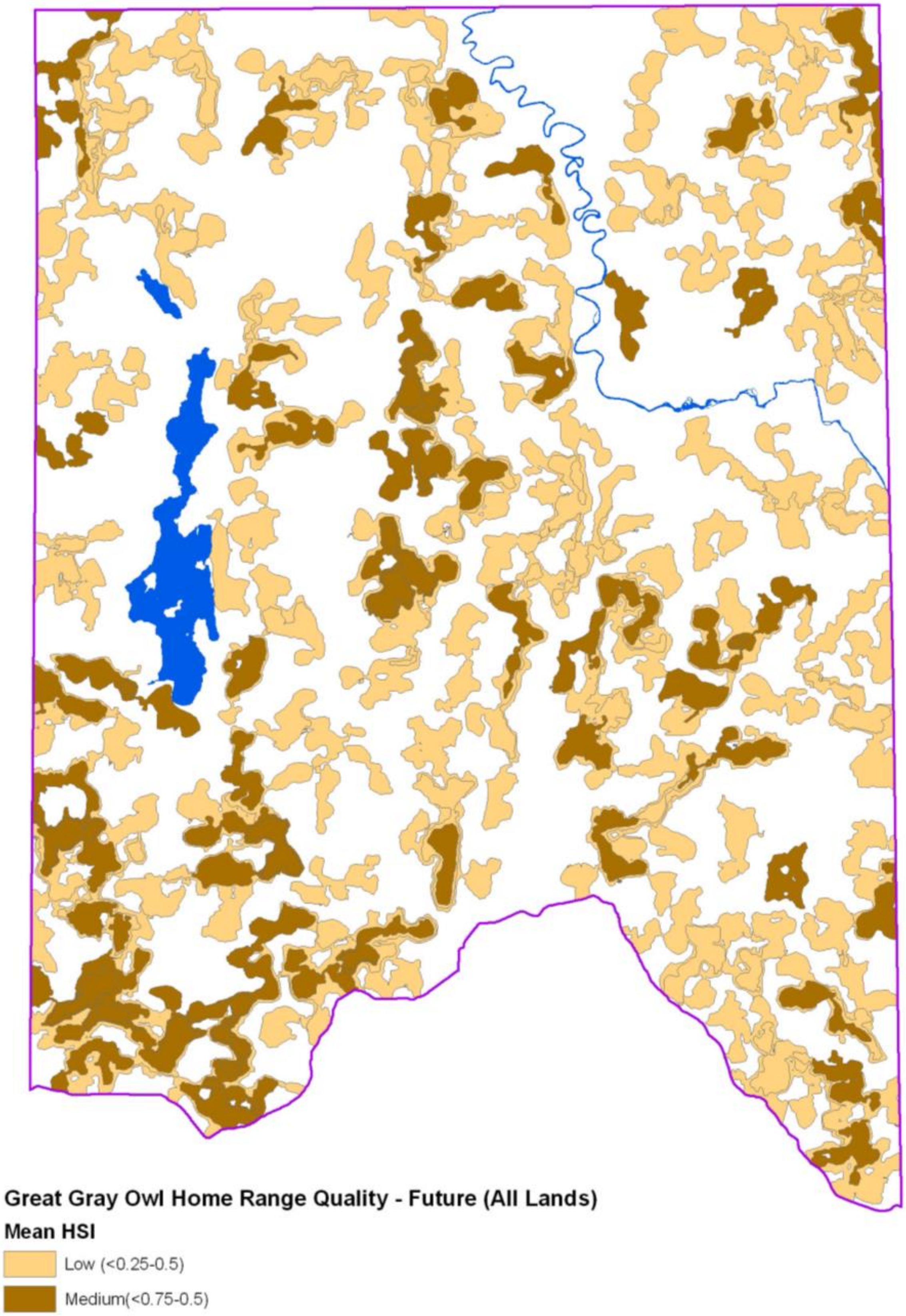


Figure 129. Future home range quality for Great Gray Owl with 20% representation on all ownerships.

CONNECTIVITY ANALYSIS

A final consideration in providing for the 9 species assessed in this project is whether or not they can move throughout the landscape, or if their distribution may be limited by barriers to their movements. The 6 avian species included in the analysis were not deemed to be limited in their abilities to move around the landscape because of their flight capabilities. Therefore, connectivity analysis was not conducted for the avian species. Connectivity analysis was conducted for the three mammal species.

Connectivity was based on a species' HSI score and movement costs associated with traveling through the landscape. The creation of HSI grids has been covered in a previous section, but the movement grids will be discussed in more detail in this section. All of the connectivity analysis was done in ESRI® ArcInfo 8.3.

The initial step was to reclassify the Idaho land cover layer developed for the Idaho Gap Analysis Project. The land cover layer was reclassified by assigning cost values to the respective GAP code as shown in Table 42. The reclassification resulted in a grid with values from 1-10.

Table 42. Cost values assigned to the Idaho GAP vegetation grid for types occurring within the project area.

Cost Codes Used in Land Cover Layer

GAP Code	Description	Cost
1000	Urban	10
2000	Agricultural land	10
3101	Foothills Grassland	8
3104	Montane Parklands and Subalpine Meadow	3
3202	Warm Mesic Shrubs	1
3312	Rabbitbrush	1
4102	Cottonwood	1
4201	Englemann Spruce	1
4203	Lodgepole Pine	1
4206	Ponderosa Pine	1
4207	Grand Fir	1
4208	Subalpine Fir	1
4210	Western Red Cedar	1
4211	Western Hemlock	1
4212	Douglas-fir	1
4215	Western Larch	1
4219	Mixed Whitebark Pine Forest	1
4220	Mixed Subalpine Forest	1
4221	Mixed Mesic Forest	1
4222	Mixed Xeric Forest	1
4223	Douglas-fir/Lodgepole Pine	1
4225	Douglas-fir/Grand Fir	1

4226	Western Red Cedar/Grand Fir Forest	1
4227	Western Red Cedar/Western Hemlock	1
4228	Western Larch/Lodgepole Pine	1
4229	Western Larch/Douglas-fir	1
4301	Mixed Needleleaf/Broadleaf Forest	1
5000	Water	5
6101	Needleleaf Dominated Riparian	1
6102	Broadleaf Dominated Riparian	1
6103	Needleleaf/Broadleaf Dominated Riparian	1
6104	Mixed Riparian (Forest and Non-forest)	1
6201	Graminoid or Forb Dominated Riparian	3
6202	Shrub Dominated Riparian	1
6203	Mixed Non-forest Riparian	1
7300	Exposed Rock	5
7800	Mixed Barren Land	5

Next, a road density grid was created by generating points at 30 m intervals along all active roads within the project area. A simple density was calculated using a radius of 3000 m around each location in the landscape. The resulting grid was reclassified using equal intervals of road densities and assigned movement barrier values from 1-10. Thus, a location with high road density in the surrounding 3000m would receive a higher movement barrier score than a location with a lower surrounding road density. The reclassified land cover grid described above and the road density grid were then added together. All values over 10 were reclassified to equal 10, but all other value remained the same. Finally, major highways were buffered by 30 m, and used to assign a cost value of 10 to any intersecting grid cell. This resulted in the creation of the final cost grid.

The HSI grid for each species was also modified. This was done by selecting all cells greater than or equal to 0.25 and reclassifying them to 1. All other cells were classified as non-habitat. Connectivity was calculated by using the Cost Weighted Distance function in Spatial Analyst. The reclassified HSI grid was used as the source raster and the cost grid was used as the cost raster. In other words, all areas with a habitat value greater than 0.25 for a species were considered habitat (source grid), and movements were assumed to be possible through these areas. All areas with a habitat value less than 0.25 were considered non-habitat (cost grid), and evaluated for their ability to support movement of each species.

Figure 130 shows Canada lynx connectivity for current conditions and Figure 131 shows Canada lynx connectivity for future conditions. Figure 132 shows woodland caribou connectivity for current conditions and Figure 133 shows woodland caribou connectivity for future conditions. Figure 134 shows fisher connectivity for current conditions and Figure 135 shows fisher connectivity for future conditions.

The figures show there is little variation in connectivity between current and future conditions as influenced by the changes expected to occur from IDL operations. In both current and future conditions the major barrier for all species is the north to south running Kootenai River Valley. While movement across this Valley could be a future concern, especially for caribou, IDL activities should not influence potential connectivity across this Valley.

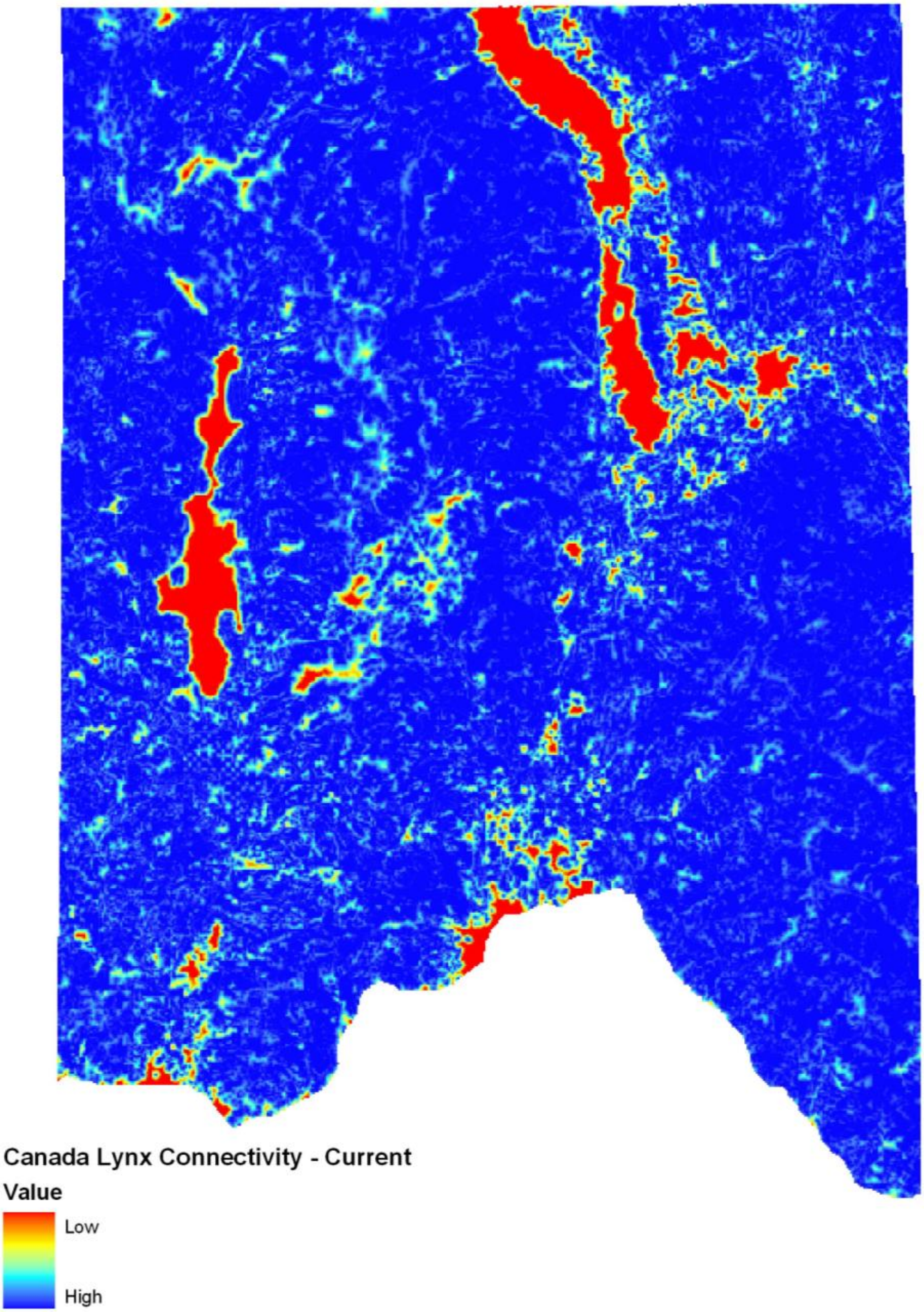


Figure 130. Current connectivity expressed as movement capabilities of Canada lynx in northern Idaho.

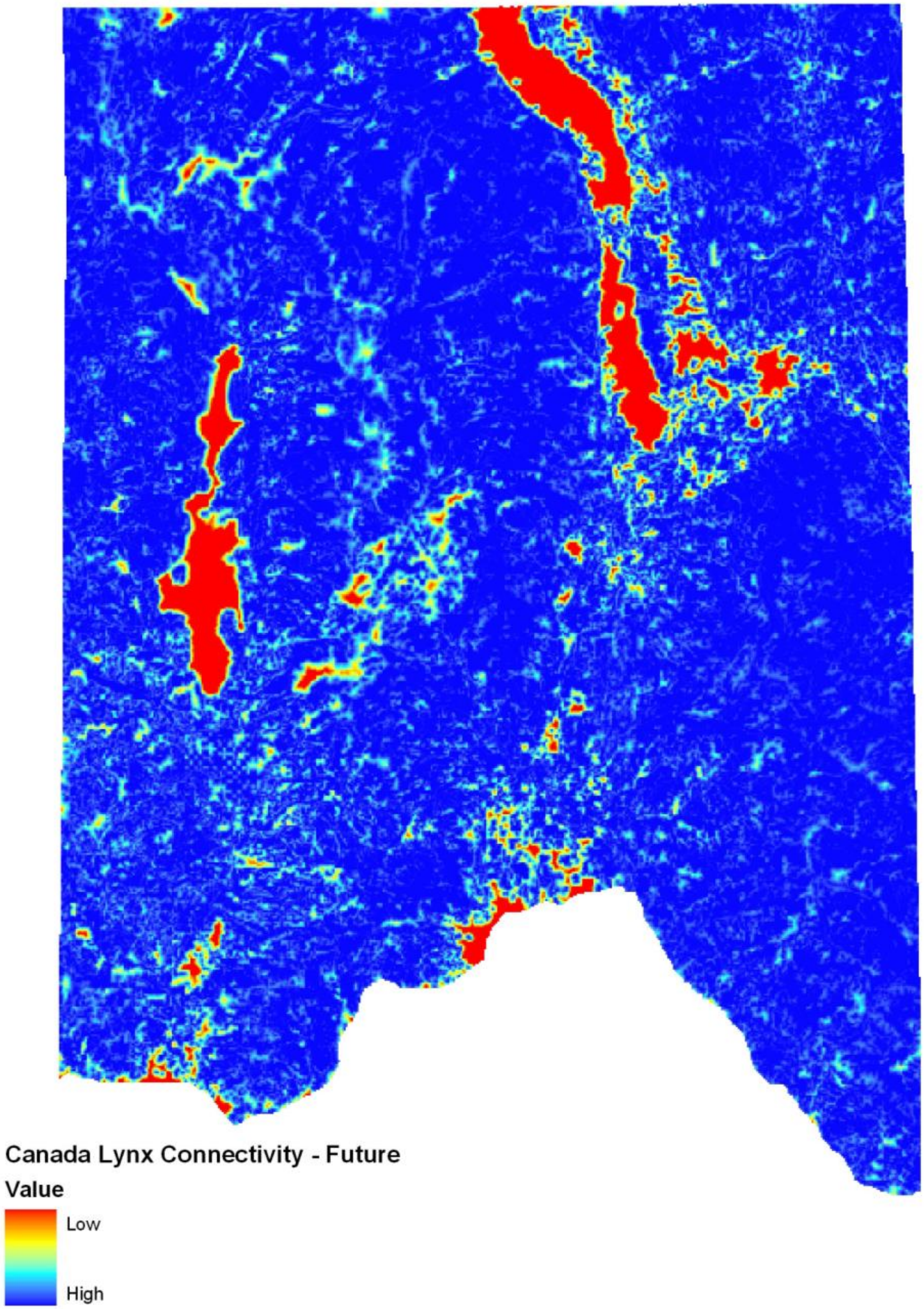


Figure 131. Estimated future connectivity expressed as movement capability of Canada lynx based on projected future forest ecosystem diversity using 20% representation of historical conditions.

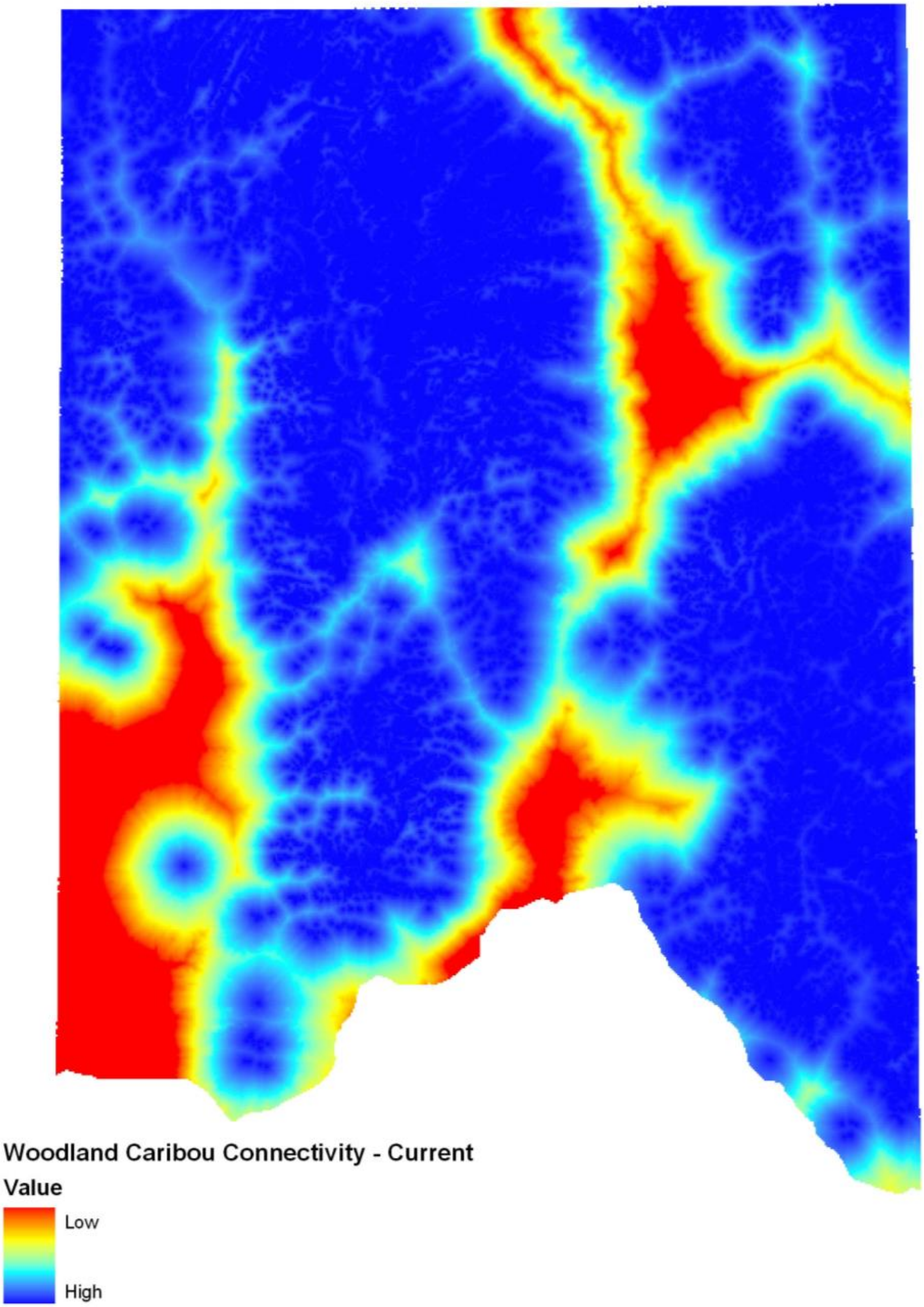


Figure 132. Current connectivity expressed as movement capability for woodland caribou in northern Idaho.

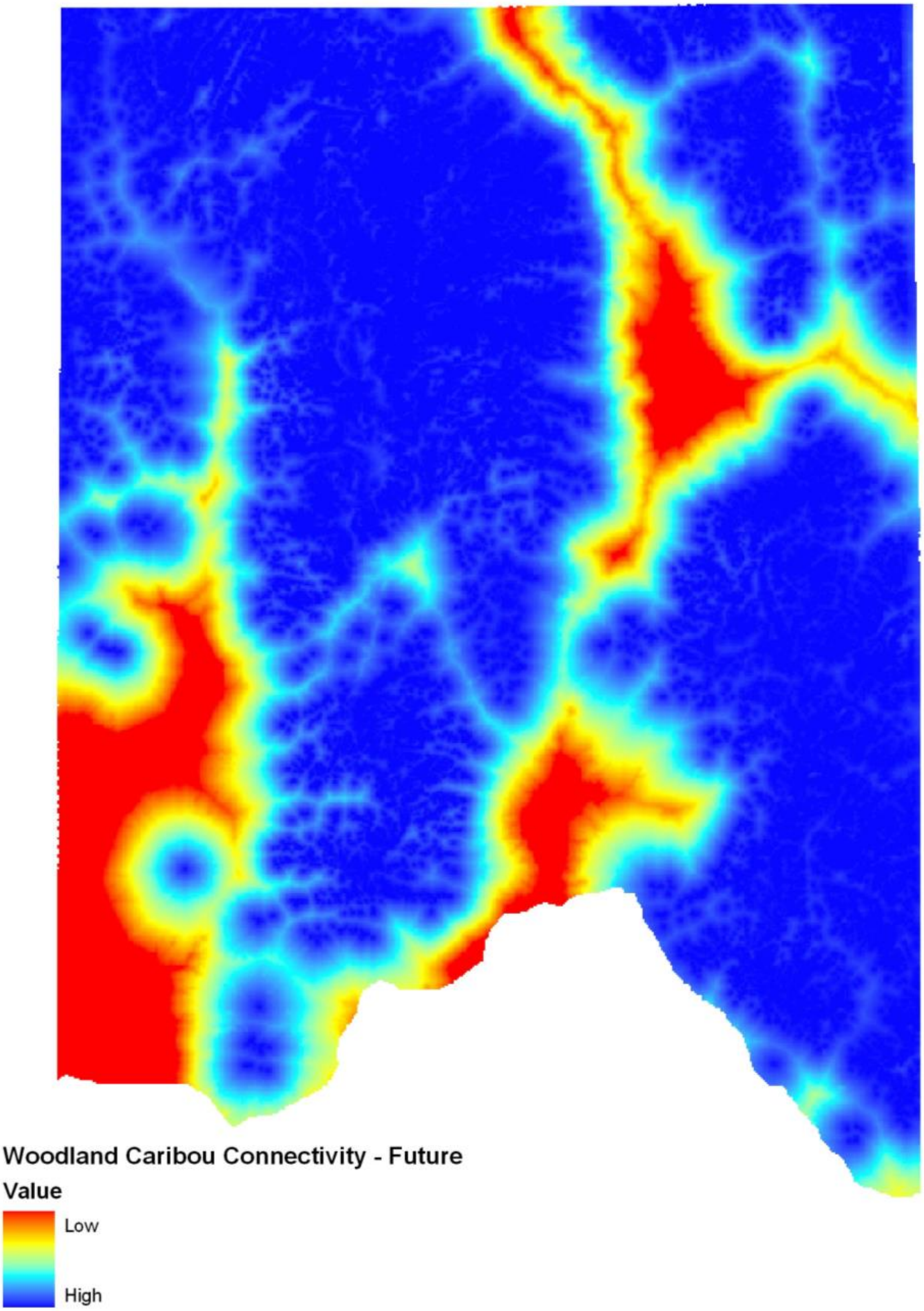


Figure 133. Estimated future connectivity expressed as movement capability of woodland caribou based on projected future forest ecosystem diversity using 20% representation of historical conditions.

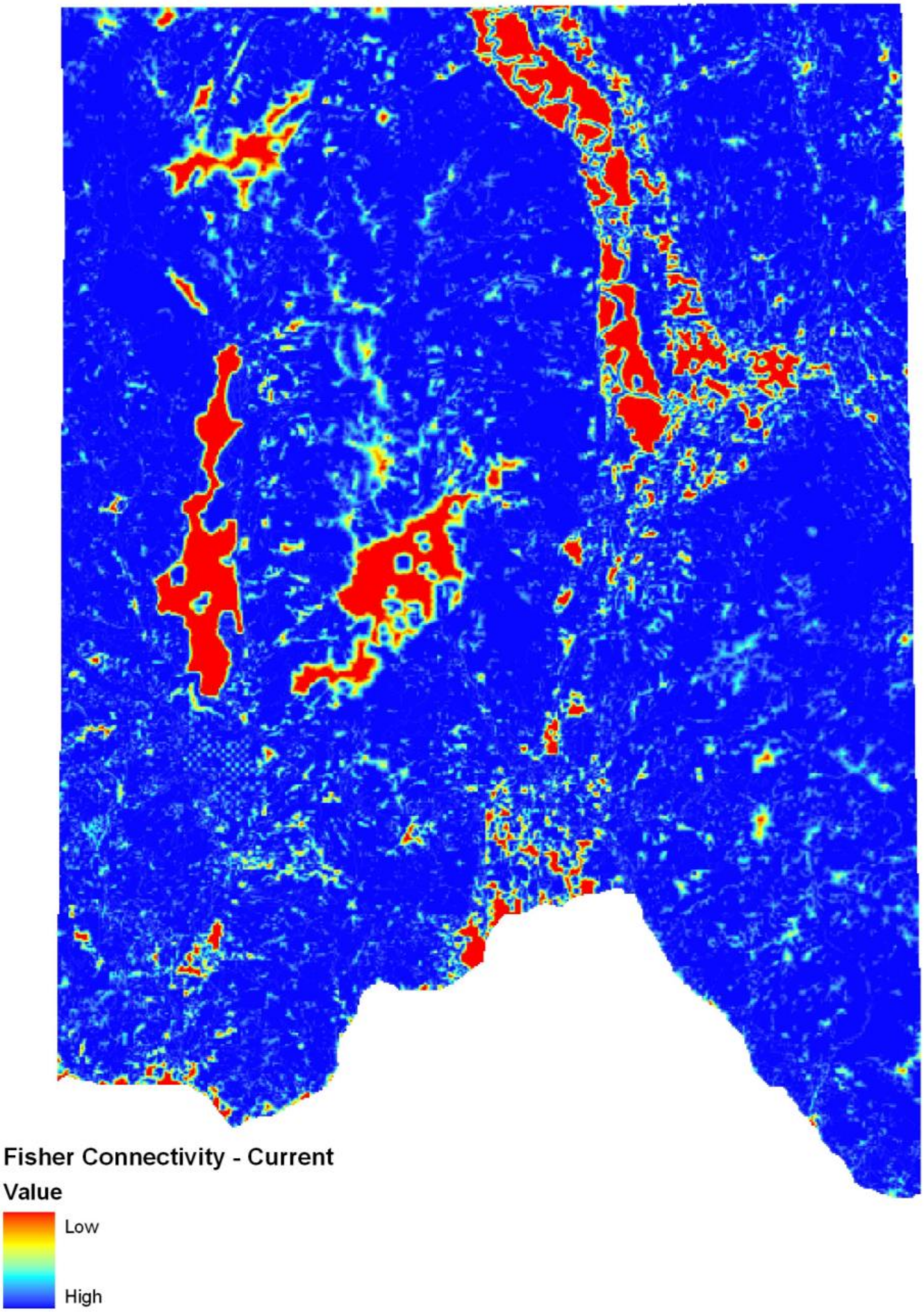


Figure 134. Current connectivity expressed as movement capability of fisher in northern Idaho.

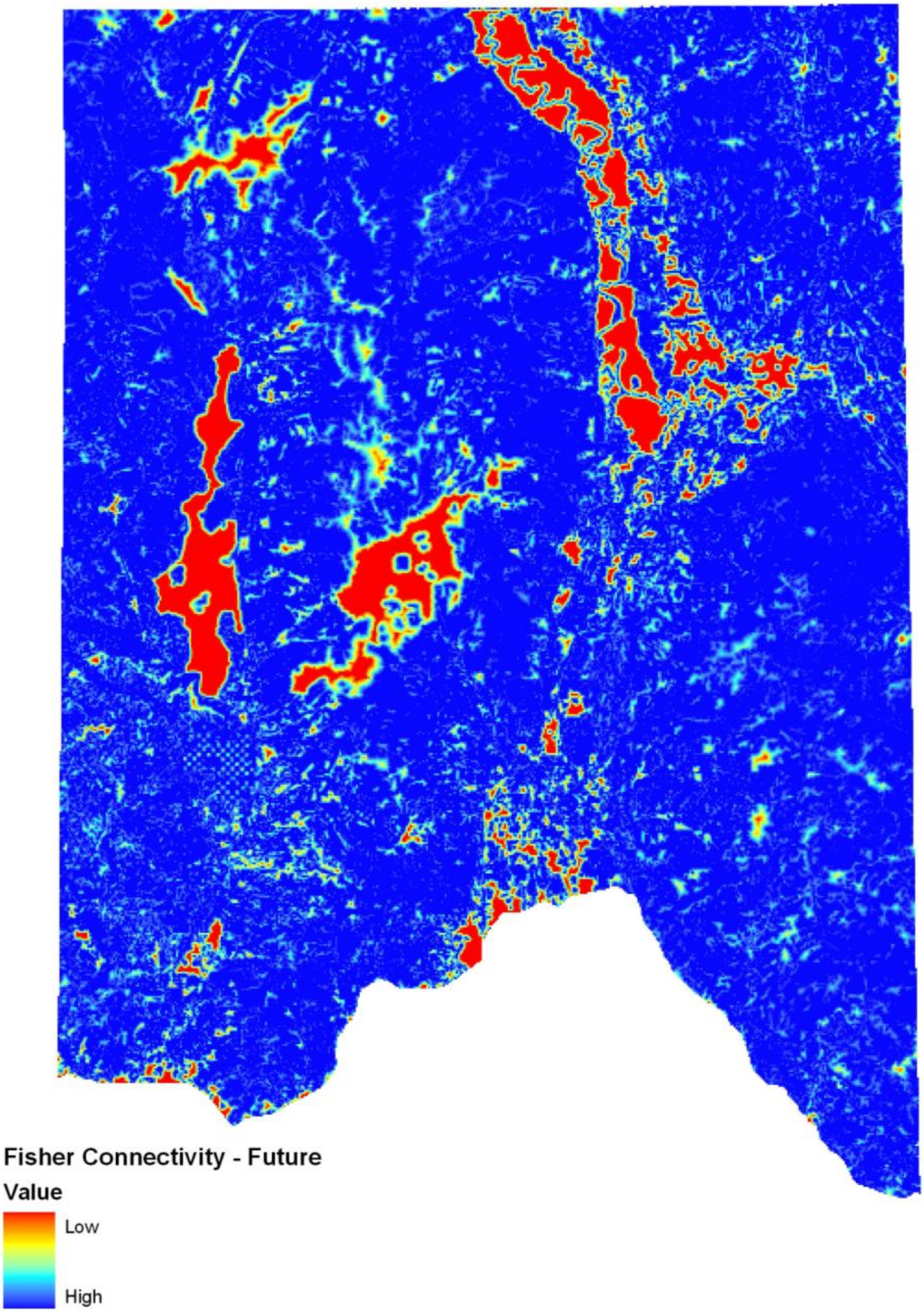


Figure 135. Estimated future connectivity expressed as movement capability of fisher based on projected future forest ecosystem diversity using 20% representation of historical conditions.

APPLICATION OF FINDINGS FOR CONSERVATION PLAN

Idaho Department of Lands (IDL) proposes to maintain or restore 20% representation of historical forest ecosystem diversity on its lands in northern Idaho. This is a level of representation that equals or exceeds most other conservation initiatives that have set coarse filter conservation goals. This level of representation, especially given the condition of the "matrix" lands that representation areas occur within, should maintain the biological diversity associated with forest ecosystems in northern Idaho if all landowners adopted similar conservation actions. Additional non-habitat factors such as maintaining appropriate road densities for grizzly bears may also be addressed outside the coarse filter, but the 20% representation should provide for the habitat needs of forest associated species.

To meet the goal of 20% representation, IDL intends to maintain the desired conditions for 60,148 acres of its forest land. At present, 46,669 acres already support conditions representative of the desired ecosystem conditions. The remaining 13,479 acres will need to be restored to the desired conditions. For some of these, restoration can be accomplished by changes to the compositions and structures of existing stands. For example, IDL currently has an estimated 9,462 acres that are in the very large tree-lethal fire regime for the Warm, Dry Ponderosa pine/Douglas-fir/Grand fir habitat type, but only an estimated 85 acres in the very large tree non-lethal fire regime structural stage. The 20% goal is 2,424 acres for the very large tree lethal fire regime, and 5,348 acres for the very large tree non-lethal fire regime. These goals can be met by maintaining 2,424 acres of the 9,462 acres currently in the very large tree lethal fire regime structural stage, and treating 5,263 acres to achieve the desired conditions for the very large tree non-lethal fire regime structural stage.

The effectiveness of 20% representation for meeting the objective of maintaining biodiversity was evaluated based on the projected population status of the 9 species. Many of these species are at the southern fringe of their range, being primarily boreal forest associated species. This includes the Boreal Chickadee, Canada lynx, woodland caribou, and Boreal Owl. The Great Gray Owl is also a northern species, though it is not as linked to the boreal forest as many of the other species. Species occurring on the fringe of their ranges are typically in marginal habitat conditions, while high quality habitat is generally located in the more central areas of a species range. The analysis of population status of these species under modeled historical conditions demonstrates that this was true for these more northern species.

Table 42 identifies the expected distribution of the 9 species relative to the cumulative impacts of vegetation change identified in Table 9 for IDL ownership. Each species' distribution was determined using high value (≥75 HSI) habitat as calculated or expected under historical conditions. Management goals that target restoration of 20% or more of the ecosystems associated with the red and orange colored cells will particularly benefit those species identified. Maintaining 20% or more of the ecosystems associated with the green colored cells will maintain conditions for those species identified. The mixed-severity structural conditions and species compositions will require additional evaluation on a stand by stand basis to maintain or restore the desired compositions and structures of these stands, as discussed previously. As also discussed previously, those stands targeted to represent the very large tree lethal fire regime should be managed to encourage old growth characteristics, to ensure enough of these conditions are being provided on the landscape to support the habitat needs of those species associated with these conditions.

The Canada lynx was not determined to have any high quality home ranges in northern Idaho, even under historical conditions. In fact, it was estimated that it only had 47 medium quality home ranges under historical conditions. With the restoration of 20% representation for all lands, 24 medium quality home ranges and 33 low quality home ranges would be provided. While this is not a large number, it is a very reasonable number given that under historical conditions only 47 medium and 3 low quality home ranges were estimated to occur.

The Boreal Chickadee has very small home ranges, and was estimated to have over 6,098 high quality home ranges under historical conditions, 5,926 under current conditions, and 5,741 high quality home ranges with 20% representation. Habitat for this species, while one of the least studied of the 9 species, appears to be stable under all current and projected future conditions.

The Boreal Owl was estimated to have 448 high quality home ranges, 555 medium quality home ranges, and 336 low quality home ranges under historical conditions. Current conditions were estimated to provide 373 high, 606 medium, and 458 low quality home ranges, while projected 20% representation would provide 279 high, 755 medium, and 711 low quality home ranges. These comparisons indicate that habitat for this species should be adequately provided in current and future conditions as compared to the historical amounts.

Fisher is a species with extensive range in Canada, but that also occurs in more northern coniferous forests of the United States. It was estimated to have 65 high and 178 medium quality home ranges under historical conditions. Current conditions were estimated to support 41 high quality and 249 medium quality home ranges, while 20% representation would support 31 high quality and 265 medium quality home ranges. This reduction in quality appears to be a result of the projected thinning in some stands to restore non-lethal and mixed severity fire regime stand conditions. While a slight reduction in high quality home ranges is projected, an increase in medium quality home ranges is also projected. This species should have sufficient habitat present to maintain a persistent population in northern Idaho. Of greater risk to this species may be other mortality factors such as trapping losses.

The black-backed woodpecker is a species closely associated with recently burned forests. Projecting future conditions for this species is difficult, as lethal fires have not been planned as a future treatment. However, it is highly likely that future fires will occur, especially with the increased risk of lethal fires projected to occur as a result of climate change. Other habitat conditions for this species are shown to be maintained in the future.

The Great Gray Owl habitat models estimated 8 high quality, 84 medium quality, and 61 low quality home ranges under historical conditions. Current conditions modeled no high quality, 39 medium quality, and 156 low quality home ranges for this species, while 20% representation estimated no high quality, 60 medium quality, and 13 low quality home ranges. It is suspected that northern Idaho has never been optimal habitat for this species, but fair to good quality habitat should be provided in the future especially if 20% representation of historical conditions is provided. Improvements in mixed severity fire regime conditions will provide the greatest gains for this species.

The Northern Goshawk was estimated to have 105 high, 243 medium, and 61 low quality home ranges under historical conditions. Current conditions were estimated to be good for this species, with 39 high, 530 medium, and 26 low quality home ranges. With restoration of 20% representation for all lands, the number of high quality home ranges would increase to 61, with 513 medium and 24 low quality home ranges occurring. Habitat conditions for this species would be improved under the proposed level of representation, especially in the restoration of mixed severity fire conditions.

Flammulated Owls are near the northern edge of their range in northern Idaho. This species displayed the most dramatic departures from estimated historical amounts when compared with current conditions (2,120 high quality and 1,647 medium quality home ranges under historical conditions compared to 141 high quality and 763 medium quality home ranges under current conditions). The low elevation non-lethal fire regime has the greatest changes from historical conditions due to direct conversions, past logging practices, and disruption of historical fire regimes. Restoration of 20% representation of historical conditions would dramatically increase numbers of high and medium quality home ranges for Flammulated Owls (581 high and 1,114 medium). This species would clearly benefit from the proposed management plan.

The Selkirk Mountains woodland caribou were not evaluated for home ranges. Rather, only the amounts of habitat categorized into high, medium and low quality were tracked for this species. As discussed above, there was a substantial reduction in high quality habitat from the amounts estimated to have occurred historically to what is present today. Most of this reduction can be attributed to the lack of old growth stands for important habitat type classes that provide the optimum habitat for this species in northern Idaho. When the reduction in old growth is coupled with the marginal conditions in northern Idaho for this species even under historical conditions as it represents the very southern fringe of the range of caribou, the resulting habitat conditions are very low. Improvement of old growth attributes of stands as a separate structural stage has not been specifically identified in the 20% representation figures because of the inability to accurately track this stand condition, as discussed previously. However, those acres targeted to represent the very large tree lethal fire regimes should be allowed to succeed to old growth conditions. When old growth conditions are attributed to these stands the amount and quality of woodland caribou habitat increases. Under current conditions, only 19,575 acres of high quality habitat are present, while with 20% representation, this would more than double to 43,226 acres. The amounts of medium quality habitat decreased slightly, as a number of these acres switch to high quality under the restoration plan. The more than doubling of habitat for this species with restoration of 20% representation on all lands demonstrates a clear improvement to the habitat quality of this species.

The connectivity analysis of the 3 mammal species reveals that the movements of these species should not be constrained under the proposed management plan. The biggest potential movement barrier, the Kootenai River Valley, would have the greatest potential to affect woodland caribou. However, the conditions that would influence movement capability of these species in this Valley are not associated with the forest management plan of IDL. The IDL proposed activities should not limit the connectivity of any of these species.

The representation goal of 20% of historical amounts should maintain or increase the amounts of habitat for the 9 species evaluated in this assessment. In addition to maintaining or improving the habitat conditions for the 9 species included in this assessment, by providing 20% representation of historical forest ecosystem diversity, all native species of the landscape should benefit and be maintained. If all landowners provided similar commitments, such actions should preclude the need for any future listing of species in this landscape, at least from a habitat standpoint.

Table 42. Expected distribution of high value (≥75 HSI) habitat for nine species of concern relative to the cumulative impacts of vegetation change identified in Table 9 for Idaho Department of Lands ownership. Cells highlighted green indicate present conditions that represent = >30% of conditions that occurred historically, orange represents 10 to 30%, and red represents =<10% of. (*NL= non-lethal fire regime, L = mixed-severity/lethal fire regime).

	HOT PIPO/ XERIC PSME	WARM PSME/ ABGR	WARM THPL/ TSHE/ABGR	COOL THPL/ TSHE/ABGR	COOL, DRY ABLA/TSME	COOL, MOIST ABLA/TSME	COLD ABLA/ PIAL	MOD, WET THPL	COOL, WET ABLA
SEEDLING	🟩 Great Gray Owl	🟩 Black-backed Woodpecker Great Gray Owl	🟩 Black-backed Woodpecker Great Gray Owl	🟩 Black-backed Woodpecker Great Gray Owl	🟩 Black-backed Woodpecker Great Gray Owl	🟩 Black-backed Woodpecker Great Gray Owl	🟩 Black-backed Woodpecker Great Gray Owl	🟩 Black-backed Woodpecker Great Gray Owl	🟩 Black-backed Woodpecker Great Gray Owl
SAPLING	🟩	🟩	🟥	🟥 Lynx	🟥 Lynx	🟥 Lynx	🟥 Lynx	🟧 Lynx	🟩
POLE	🟩	🟩	🟩	🟩	🟧 Lynx Boreal Chickadee	🟧 Lynx Boreal Chickadee	🟥 Lynx	🟧 Boreal Chickadee	🟩
MEDIUM-NL	🟩 Great Gray Owl	🟩 Great Gray Owl	🟧 Great Gray Owl	🟧 Great Gray Owl	🟥 Great Gray Owl	🟥 Great Gray Owl	🟥 Great Gray Owl	🟩 Great Gray Owl	🟩 Great Gray Owl
LARGE-NL	🟩 Flammulated Owl Northern Goshawk Great Gray Owl	🟥 Flammulated Owl Northern Goshawk Great Gray Owl	🟥 Northern Goshawk Great Gray Owl	🟥 Great Gray Owl	🟥 Great Gray Owl	🟥 Great Gray Owl	🟥 Great Gray Owl	🟩 Great Gray Owl	🟩 Northern Goshawk Great Gray Owl
VERY LARGE-NL	🟥 Flammulated Owl Northern Goshawk Great Gray Owl	🟥 Flammulated Owl Northern Goshawk Great Gray Owl	🟥 Flammulated Owl Northern Goshawk Great Gray Owl	🟥 Northern Goshawk Great Gray Owl	🟥 Northern Goshawk Great Gray Owl	🟥 Northern Goshawk Great Gray Owl	🟥 Northern Goshawk Great Gray Owl	🟩	🟩
MEDIUM-L	🟩	🟩 Fisher	🟩 Fisher	🟩 Fisher	🟩 Fisher	🟩 Fisher	🟧 Fisher	🟩	🟩
LARGE-L	🟩	🟩 Fisher Flammulated Owl	🟩 Fisher Flammulated Owl	🟩 Fisher Great Gray Owl	🟩 Fisher Boreal Chickadee Boreal Owl Great Gray Owl	🟩 Fisher Boreal Chickadee Boreal Owl Great Gray Owl	🟩 Lynx Caribou Boreal Owl	🟧 Lynx Caribou Fisher Boreal Chickadee Boreal Owl Great Gray Owl	🟥 Lynx Caribou Fisher Boreal Chickadee Boreal Owl Northern Goshawk Great Gray Owl
VERY LARGE-L	🟩 Northern Goshawk Great Gray Owl	🟩 Fisher Flammulated Owl Northern Goshawk Great Gray Owl	🟩 Lynx Fisher Flammulated Owl Northern Goshawk Great Gray Owl	🟩 Lynx Fisher Northern Goshawk Great Gray Owl	🟧 Lynx Caribou Fisher Boreal Chickadee Boreal Owl Northern Goshawk Great Gray Owl	🟩 Lynx Caribou Fisher Boreal Chickadee Boreal Owl Northern Goshawk Great Gray Owl	🟧 Lynx Caribou Fisher Boreal Chickadee Boreal Owl Northern Goshawk	🟩 Lynx Caribou Fisher Boreal Chickadee Boreal Owl Northern Goshawk Great Gray Owl	🟩 Lynx Caribou Fisher Boreal Chickadee Boreal Owl Northern Goshawk Great Gray Owl

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APPENDICES

DISTURBANCE STATE/STRUCTURAL STAGE – METHODS

Idaho Department of Lands

IDL forest stand data was provided by the Idaho Department of Lands. 2005 through 2007 stand cruise data were used to develop a classification system based on the vegetation structural stage inclusion rules (Figure 10) and the fire regime inclusion rules (Table 3). The results of re-classifying the stand cruise data to the EDM vegetation structural stage were then related to the corresponding existing IDL stand classification. The percentage of each EDM structural stage relating to each IDL stand classification was calculated. This percentage was then multiplied by the total number of acres in each IDL stand classification and a target number of acres for each EDM structure were calculated. These acres were then used to randomly assign IDL stands with each of the EDM structures. Those stands within the targeted 20% restoration areas were manually checked for accuracy relative to structural stage classification and adjusted, where necessary.

The EDM structures were then related to the IDL stand layers using stand identification numbers to spatially assign these structural classes. The EDM vegetation structural stage GIS layer was then overlaid with the habitat type predictive model results to quantify the number of acres within each structural stage by habitat type class. In addition, the non-lethal and mixed severity/lethal fire regimes were assigned by evaluating the percentage of acres in the original stand cruise data by each EDM structure that met the inclusion rules for fire regime. This percentage was then used to divide the number of acres by each structure (i.e., MEDIUM, LARGE, VERY LARGE) into the appropriate non-lethal and mixed severity/lethal fire regimes.

Idaho Department of Lands stand data was used to classify approximately 14% of the overall planning area.

Forest Service Stand Data

GIS polygon layer and stand data for the Idaho Panhandle National Forest were obtained from the IPNF GIS portal website.

In addition to the GIS polygon data, two attribute tables (comp.dbf and fs_stands.dbf) were used to reclassify FS data to the EDM dbh structures and disturbance categories using the EDM inclusion rules (Figure 10 and Table 3). The best detail on dbh classes and species compositions were obtained from the 'comp.dbf' provided with the GIS data. These data were used to reclassify according to the structural and fire disturbance rule sets identified in the EDM. The steps used to reclassify this data include:

- Reclassify comp_code according to EMRI structures (Figure 10) using avg_dbh variable. For avg_dbh >19, the EMRI structure VERY LARGE was applied.
- The number of trees >6 inch dbh were tracked by dominant species and a stand was coded SERAL or MATURE depending on the combined number of seral or mature species >6 inch dbh.
- The number of trees >6 inch dbh were also tracked.
- The results of number 2 and 3 were used to determine the disturbance pathway using the criteria described in Table 3.

Comp.dbf data limitations-

By using avg_dbh >19, the VERY LARGE structure is likely underestimated in the landscape due to the averaging affect of all trees.

The 'comp.dbf' data was not available for all IP National Forest stands so the reclassification results were extrapolated to the data available in the 'fs_stand.dbf'. The steps used to reclassify this data include:

Reclassify fs_stands.dbf using the avg_dbh variable. EMRI structures were applied to the range of avg_dbh variables corresponding to the dbh breaks in EDM structure inclusion rules. Results of the reclassification of 'comp.dbf' data were then related to the stand_id's for 'fs_stand.dbf' and quantified relative to their percent occurrence within the new EMRI structure calls for fs_stands.dbf as based on the avg_dbh variable. The percent occurrence of structure and disturbance pathways developed from 'comp.dbf' was then extrapolated to the remaining acres for fs_stands.dbf.

The combined results of reclassifying Forest Service stands using both comp.dbf and extrapolating comp.dbf percentages to the FS structures in fs_stand.dbf, allowed us to develop a GIS layer of EDM structures. This GIS layer was then unioned with the habitat type class predictive model results to quantify the EDM ecosystem diversity class.

Forest Service stand data was used to classify approximately 52% of the overall planning area.

Forest Capital Partners Stand Data

Forest Capital Partners (FConservation Plan) forest stand data relevant to the planning region was provided to EMRI by Forest Capital Partners. Stand data were used to develop a classification system based on the vegetation structural stage inclusion rules (Figure 10) and the fire regime inclusion rules (Table 3). The results of re-classifying the stand cruise data to the EDM vegetation structural stage were then related to the corresponding existing FConservation Plan stand classification. The percentage of each EDM structural stage relating to each FConservation Plan stand classification was calculated. This percentage was then multiplied by the total number of acres in each FConservation Plan stand classification and a target number of acres for each EDM structure were calculated. These acres were then used to randomly assign FConservation Plan stands with each of the EDM structures.

The EDM structures were then related to the FConservation Plan stand layers using stand identification numbers to spatially assign these structural classes. The EDM vegetation structural stage GIS layer was then overlaid with the habitat type predictive model results to quantify the number of acres within each structural stage by habitat type class. In addition, the non-lethal and mixed severity/lethal fire regimes were assigned by evaluating the percentage of acres in the original stand cruise data by each EDM structure that met the inclusion rules for fire regime. This percentage was then used to divide the number of acres by each structure (i.e., MEDIUM, LARGE, VERY LARGE) into the appropriate non-lethal and mixed severity/lethal fire regimes.

Forest Capital Partners stand data was used to classify approximately 5% of the overall planning area.

VMAP Satellite Imagery

VMAP satellite imagery was acquired to allow classification of structures and disturbance pathways on land outside the USFS and Idaho Department of Lands ownership. VMAP data was obtained from U.S. Forest Service Region 1. The VMAP data was limited to a dominant cover type class, dominant structure class, and dominant canopy cover class for application to the EDM. No additional information was available to allow reclassification to the EDM structures and disturbance pathways. Most of the existing structural classes were reasonably close to the EDM classification dbh breaks except the VERY LARGE structure class was not represented in the VMAP classification. The VMAP structures were based on the dbh class with the largest number of trees per acre rather than the EDM structure criteria identified in Figure 10. In addition, the disturbance pathway information was based on the dominant species call for the dominant structure further limiting our ability to reclassify the VMAP data relative to the EDM fire regime rule set identified in Table 3. We expect that the classification methodology used to develop VMAP will decrease the number of acres representing the LARGE and VERY LARGE tree structures relative to the methodology used in the EDM classification. It was also evident from the results that the number of acres representing the non-lethal fire regime was overestimated due to the coarseness of the VMAP classification criteria. These acres were adjusted to instead represent the mixed severity/lethal fire regime where it made sense to do so. It should be recognized that the VMAP data presents limitations for determining existing conditions relative to the EDM classification.

The VMAP structures and fire regime classification GIS layer were overlayed with the results of the habitat type class predictive model to quantify the EDM ecosystem diversity class.

VMAP data was used to classify approximately 29% of the overall planning area.