Appendix I

Northern Spotted Owls

In the following appendix, DNR provides additional information regarding the analysis of the No Action and Landscape alternatives. DNR also provides limited analysis results for the Pathways Alternative.

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Table of Contents

List of Charts

List of Maps

List of Tables

List of Figures

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What are the Major Threats to Northern Spotted Owl Populations?

The United State Fish and Wildlife Service (USFWS) 2004 review identified the continuing major threats as loss of habitat from past management activities, natural disturbances such as fire, and ongoing habitat loss as a result of timber harvest activities on non-federal lands. Additionally, competition with barred owls (*Strix varia*) was identified as another major threat (Courtney and others 2004; Gutiérrez and others 2006; Olson and others 2004). Following is a description of these major threats as applied to the Olympic Peninsula.

Barred Owls

Barred owls are native to eastern North America and have expanded their range to the west (USFWS 2012). Barred owls were first detected in the Olympic Peninsula in 1985 (Sharpe 1989) and the number of sightings has steadily increased (Forsman and others 2011). The range of the barred owl now completely overlaps with the range of the northern spotted owl (USFWS 2012). Anthony and others (2006) found evidence suggesting that barred owls negatively affect northern spotted owl survival on the Olympic Peninsula.

Loss of Habitat From Past Harvest Activities

A considerable amount of northern spotted owl habitat was lost on the Olympic Peninsula in the 1970s and 1980s as a result of timber harvest activities on private, state, and federal lands. The majority of native forests in the northern part of the OESF were harvested in the 1920s and 1930s and very little structurally complex forest remains there. State trust lands in the central and southern part of the OESF were harvested from the late 1960s to the late 1980s. Forests in those landscapes are currently a mix of young managed stands (15 to 40 year old), forest stands that regenerated from the 1921 windstorm, and existing old-growth.

DNR policies (DNR 1997) and state and federal regulations have reduced northern spotted owl habitat loss since 1990. From 1996 to 2004 Pierce and others (2005) estimated 3.4 percent harvest of northern spotted owl habitat on private and state lands in the western Olympic Peninsula. This is the lowest percentage of habitat loss of any area in Washington State.

Natural Disturbance

Fire has not been identified as a major threat to northern spotted owl habitat on the Olympic Peninsula.

Windthrow (the breaking or blowing down of trees by the wind) is a part of the natural disturbance of forests on the Olympic Peninsula. Courtney and others (2004) concluded that windthrow did not pose a significant risk to northern spotted owl habitat range wide; however, portions of the OESF have experienced significant windthrow events with damage ranging from slight to almost complete removal of trees in some areas (Oliver and Larson 1996). Windthrow can, in some circumstances, help develop structural elements needed for northern spotted owl habitat, such as snags and broken top trees (Franklin and others 2002).

Relationship Between the Analysis, Stand Level, and Territory Models

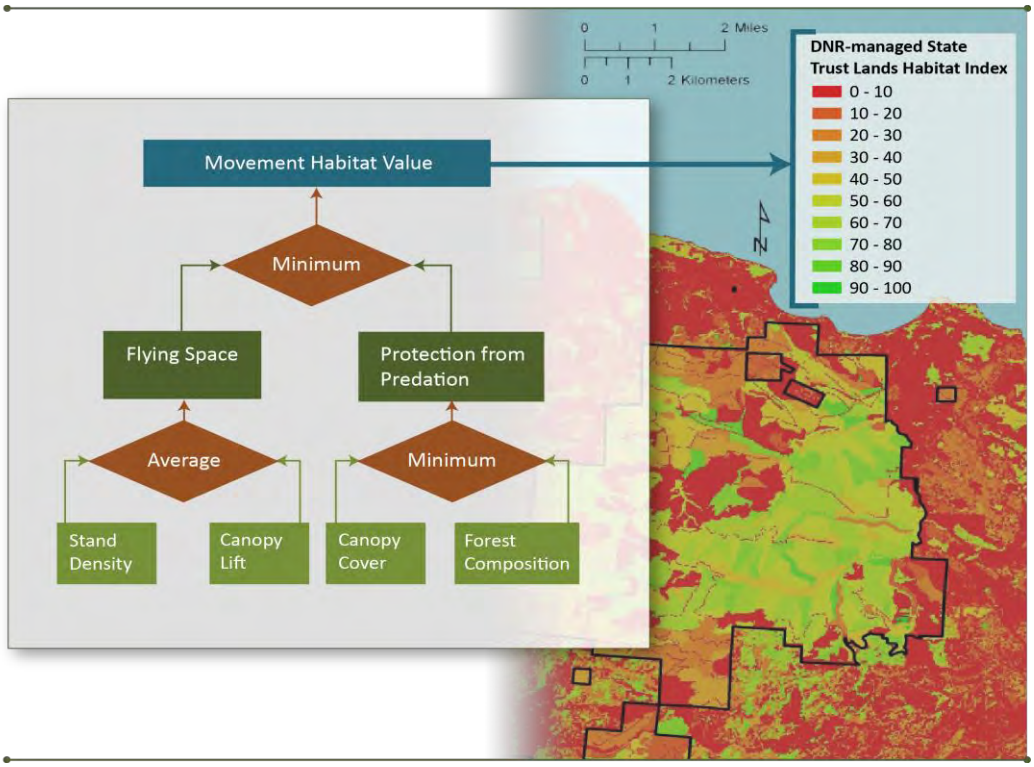
The basis for DNR's environmental analysis is the **analysis model,** which is described in Appendix D. The analysis model makes projections of forest development over ten decades. These projections include the amount and distribution of northern spotted owl habitat (Young Forest or Old Forest Habitat) and attributes of stand conditions such as canopy lift.

As part of this analysis process, DNR developed northern spotted owl stand and territory models. These models have a hierarchical relationship with one another (refer to Figure I-2). These models were used to analyze the No Action and Landscape alternatives.

The four northern spotted owl habitat **stand-level models** DNR developed evaluate output data, including stand attributes such as canopy cover, from the analysis model. These stand-level models assess how well state trust lands in the OESF support northern spotted owls' four major life history requirements (movement, roosting, foraging, and nesting).

The **stand-level models** provide a way to evaluate a number of different habitat indicators (such as canopy cover and snags) with different values types (such as percent and diameter). Each habitat indicator receives a score based on an expert-chosen range of support. For example, a canopy cover below 40 percent offers no support to northern spotted owls and canopy cover of 70 percent or above gives full support. These habitat indicator scores are then combined into overall assessment scores for each life history requirement (0 to 100, 100 being best). The minimum score for supporting a life history requirement is 50.

Figure I-1. Relationship of Stand Level Model and Spatial Example of Index Scores

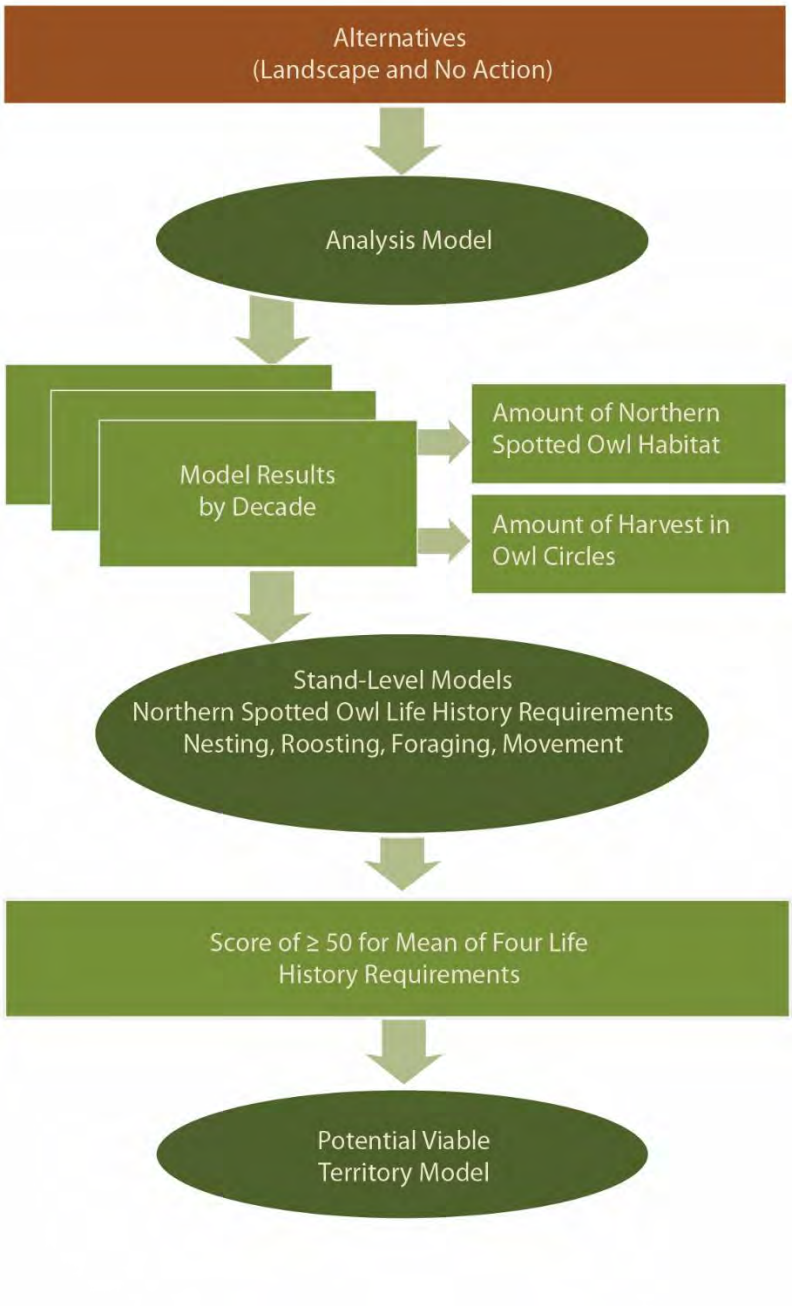


A composite score for life history requirements is used as input data for the **territory model**. The territory model projects the location, amount, and overlap of potential, viable northern spotted owl territories over time. The territory model provides an objective, repeatable analysis of the landscape's capability to support northern spotted owls. The territory model has a set of assumptions on how many acres a territory can encompass, habitat value (factoring in the distance from the point initiating the territory), and how much overlap territories can have. Because the habitat input data for non-state trust lands was held constant through the decades, any increases in landscape capability are due to the increased capability of DNR-managed lands to support northern spotted owl territories. It is expected however, that there will be a substantial amount of habitat development on federal lands (United States Department of Agriculture [USDA] and United States Department of the Interior [USDI] 1994).

For this analysis, 500 iterations of the territory model were run to capture the full range of possible outcomes. Each one of these iterations is a unique outcome of the territory model's evaluation of the analysis landscape. These iterations produce a range in the number of potential territories that the landscape is capable of supporting and the percent of the times each territory amount is chosen. Territory quality is evaluated by the density of northern spotted owl habitat within a territory. The higher the density of habitat, the better the territory quality is assumed to be.

The stand-level models are adapted from models used for analysis in the *South Puget Sound HCP Planning Unit Forest Land Plan Final EIS* (DNR 2010). The territory model is based on a model developed in British Columbia, Canada (Sutherland and others 2007). The territory model rules are based on literature on northern spotted owl ecology. The methodology used to develop the territory and stand-level models is described later in this appendix.

Figure I-2. Relationship of Models Used in Analysis and Indicators



Habitat Definitions

Table I-1. Definitions of Northern Spotted Owl Habitat Types

Old Forest Habitat	
Description	**Inventory Attributes**
High Quality Nesting Habitat	
• At least 31 trees per acre are greater than or equal to 21 inches diameter at breast height (dbh) with at least 15 trees, of those 31 trees, per acre greater than or equal to 31 inches dbh • At least three trees, from the above group of 31 trees, have broken tops • At least 12 snags per acre larger than 21 inches dbh • Canopy closure at least 70% • A minimum of 5 percent ground cover of large woody debris	• At least 3 live trees per acre >21inches dbh with broken tops • At least 16 trees per acre > 21 inches dbh • At least an additional 15 trees per acre >31 inches dbh • Minimum top height of 40 largest trees >85 feet tall • Curtis's Relative Density >= 48 • At least 2,400 cubic feet per acre down wood • At least 12 snags per acre larger than 21 inches dbh
Type A Habitat	
• A multi-layered, multispecies canopy dominated by large (30 inches diameter or greater) overstory trees (typically 15 to 75 trees per acre) • At least 70 percent canopy closure • A high incidence of large trees with various deformities such as large cavities, broken tops, and dwarf mistletoe infection • At least two snags per acre that are at least 30 inches in diameter or larger • Large accumulation of fallen trees and other woody debris on the ground	• At least 2 canopy layers with at least 2 species • At least 20% of trees per acre in minor species • Canopy typically dominated by 75 to 100 trees per acre >20 inch dbh • At least 2 live trees per acre >21inches dbh with broken tops • Two or more snags per acre >30 inches dbh and 16 feet tall • At least 2,400 cubic feet per acre down wood • Curtis's Relative Density >= 48
Type B Habitat	
• Few canopy layers, multi-species canopy dominated by large (greater than 20 inches dbh) overstory trees (typically 75 to 100 trees per acre, but can be fewer if large trees are present) • At least 70 percent canopy closure • Some trees with various deformities • Large (greater than 20 inches dbh) snags present • Large accumulation of fallen trees and other woody debris on the ground	• At least 2 canopy layers with at least 2 species • At least 20% of trees per acre in minor species • Canopy typically dominated by 15 to 75 trees per acre >30 inches dbh • Large trees with various deformities • At least 1 live trees per acre > 21 inches dbh with broken top • At least 1 snag per acre >20 inches dbh and 16 feet tall • One or more snags per acre >20 inches dbh and 16 feet tall • At least 2,400 cubic feet per acre down wood • Curtis's Relative Density >= 48

Young Forest Habitat	
Description	**Inventory Attributes**
Sub-mature habitat	
• Forest community dominated by conifers, or in mixed conifer/hardwood forest, the community is composed of at least 30 percent conifers • At least 70 percent canopy closure • Tree density of between 115 and 280 trees greater than 4 inches per acre • Trees over 85 feet tall • At least three snags per acre that are at least 20 inches in diameter • At least 5 percent groundcover of large woody debris	• 30 and or more percent conifer trees per acre • 115 to 280 trees per acre >4 inches dbh class • Minimum top height of 40 largest trees >85 feet tall • Curtis's Relative Density >= 48 • At least 3 snags per acre >20 inches dbh and 16 feet tall • At least 2,400 cubic feet per acre down wood
Young forest marginal habitat	
• Forest community dominated by conifers, or in mixed conifer/hardwood forest, the community is composed of at least 30 percent conifers • At least 70 percent canopy closure • Tree density of between 115 and 280 trees greater than 4 inches dbh per acre • Trees over 85 feet tall • At least two snags per acre that are at least 20 inches in diameter or equal to 10 percent of the ground covered with 4 inch diameter or larger wood with 25 to 60 percent shrub cover	• 30 percent or more conifer trees per acre • 115 to 280 tree per acre >4” dbh class • Minimum top height of 40 largest trees >85 feet tall • Curtis's Relative Density >= 48 • At least 2 snags per acre >20 inches dbh and 16 feet tall *or* at least 4,800 cubic feet per acre down wood

Old Forest Charts, No Action and Landscape Alternatives

Chart I-1. Acres of Old Forest Habitat on State Trust Lands in the OESF, by Alternative

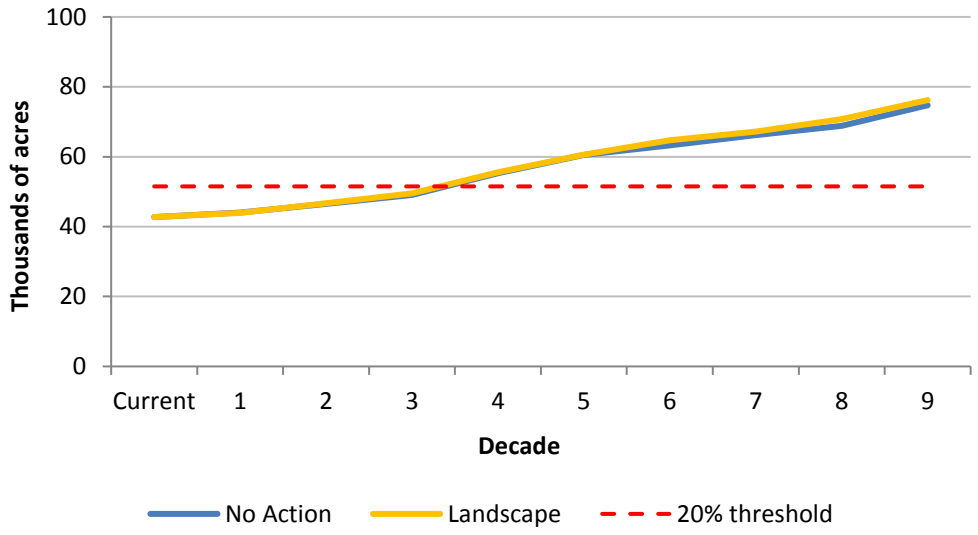


Chart I-2. Acres of Old Forest Habitat on State Trust Lands in the Clallam Landscape, by Alternative

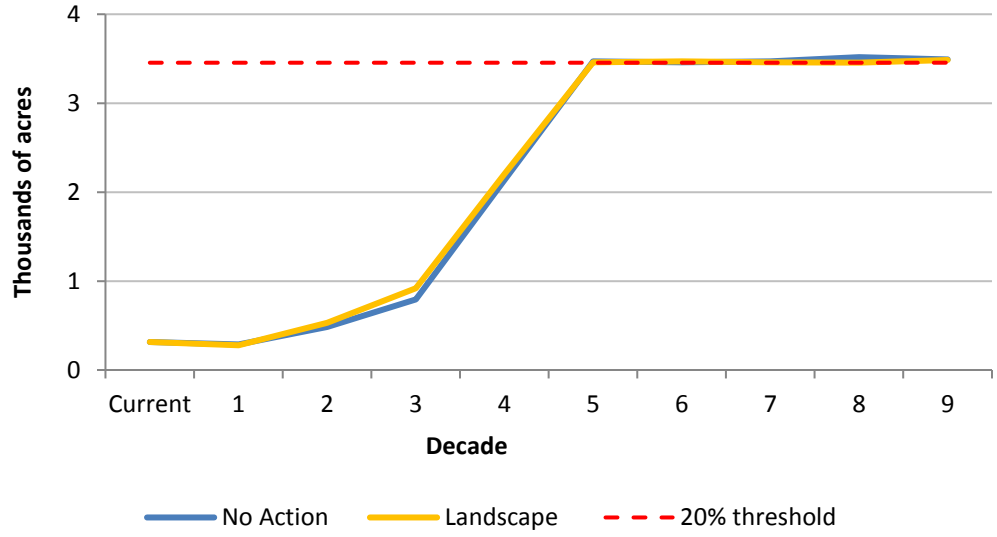


Chart I-3. Acres of Old Forest Habitat on State Trust Lands in the Clearwater Landscape, by Alternative

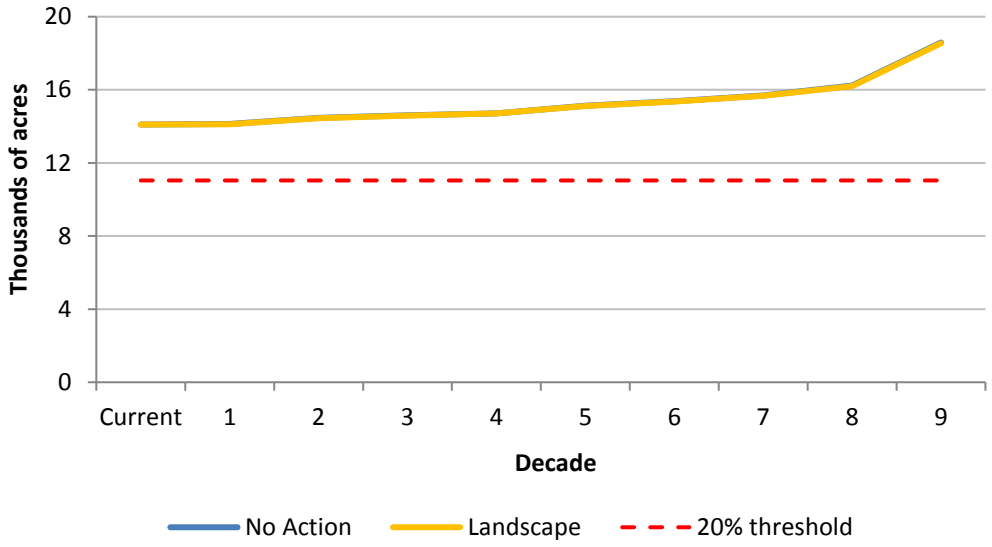


Chart I-4. Acres of Old Forest Habitat on State Trust Lands in the Coppermine Landscape, by Alternative

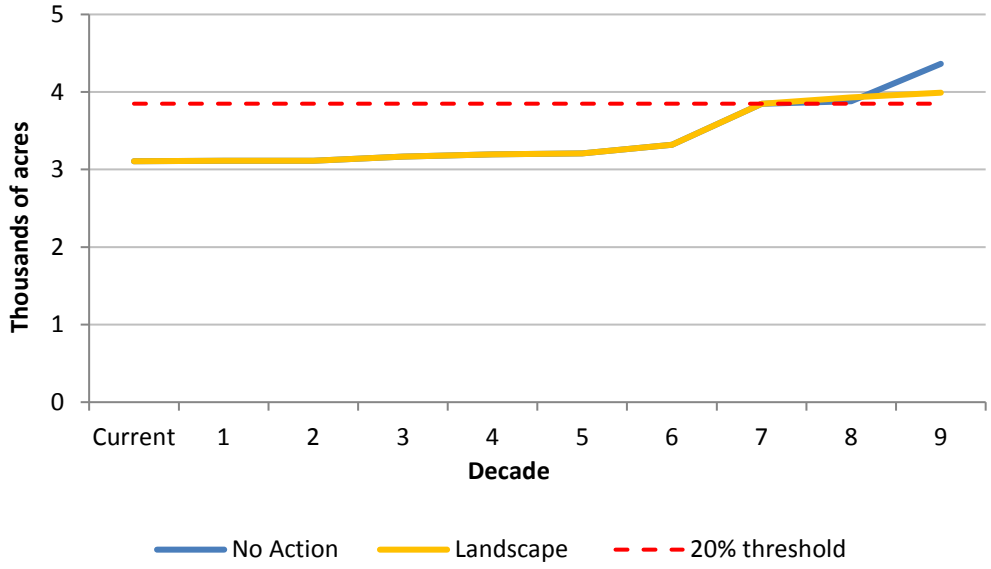


Chart I-5. Acres of Old Forest Habitat on State Trust Lands in the Dickodochtedar Landscape, by Alternative

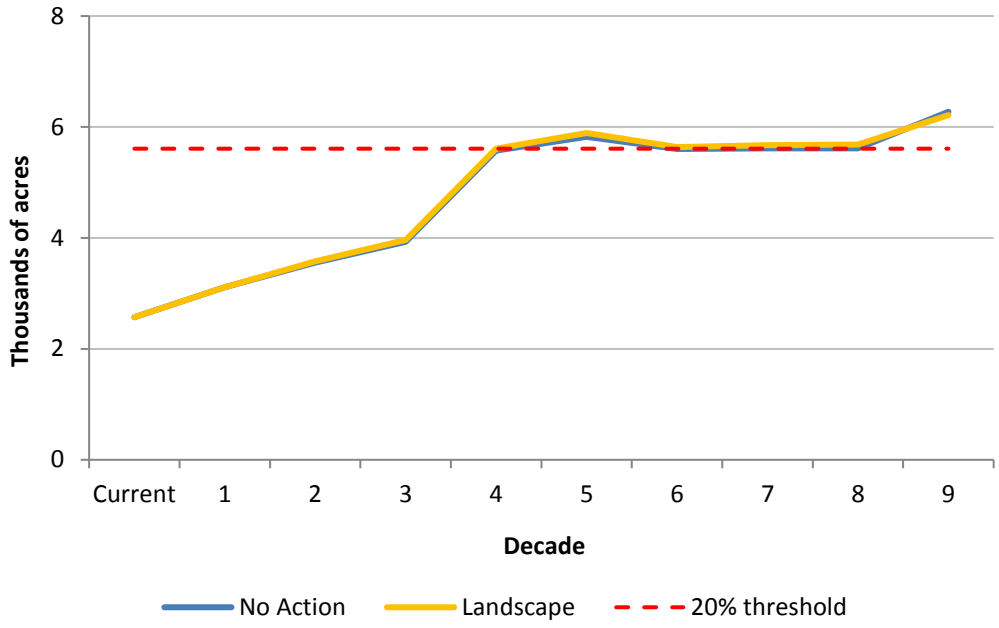


Chart I-6. Acres of Old Forest Habitat on State Trust Lands in the Goodman Landscape, by Alternative

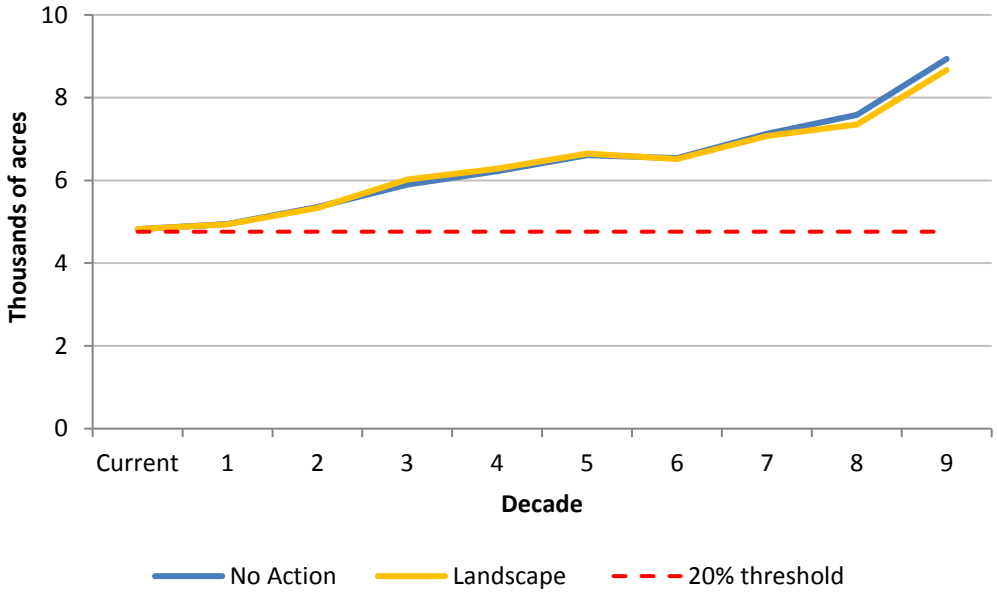


Chart I-7. Acres of Old Forest Habitat on State Trust Lands in the Kalaloch Landscape, by Alternative

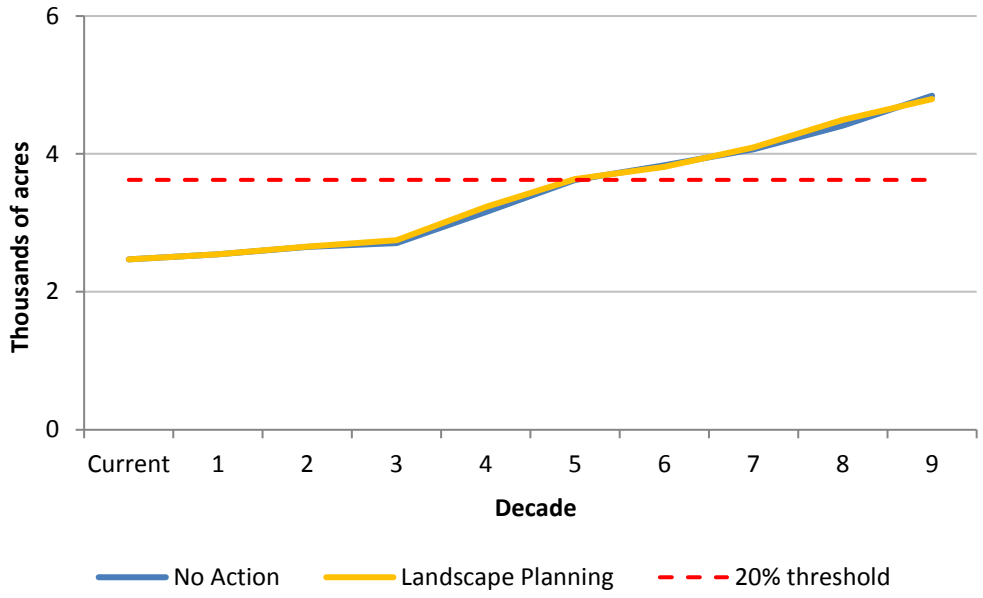


Chart I-8. Acres of Old Forest Habitat on State Trust Lands in the Queets Landscape, by Alternative

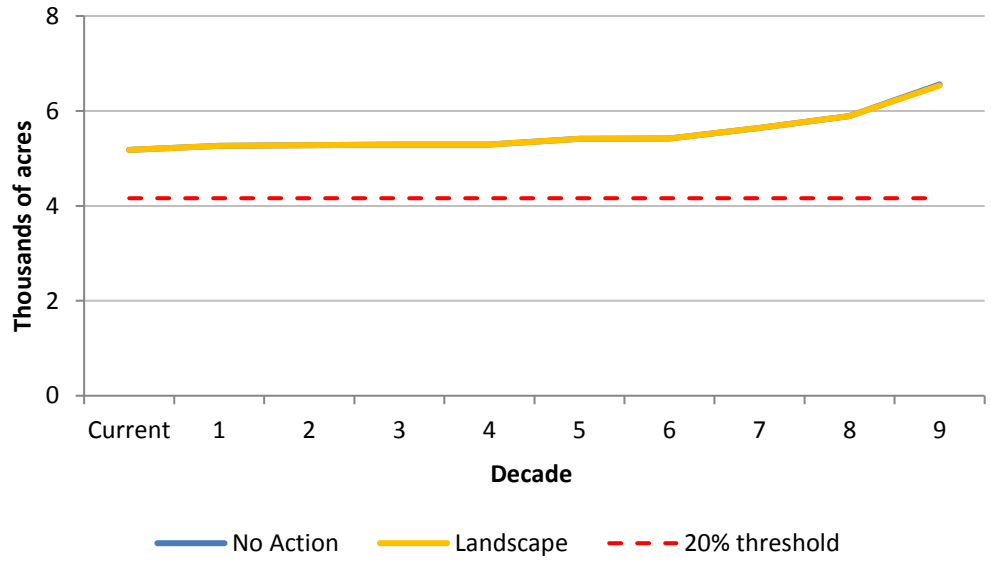


Chart I-9. Acres of Old Forest Habitat on State Trust Lands in the Reade Hill Landscape, by Alternative

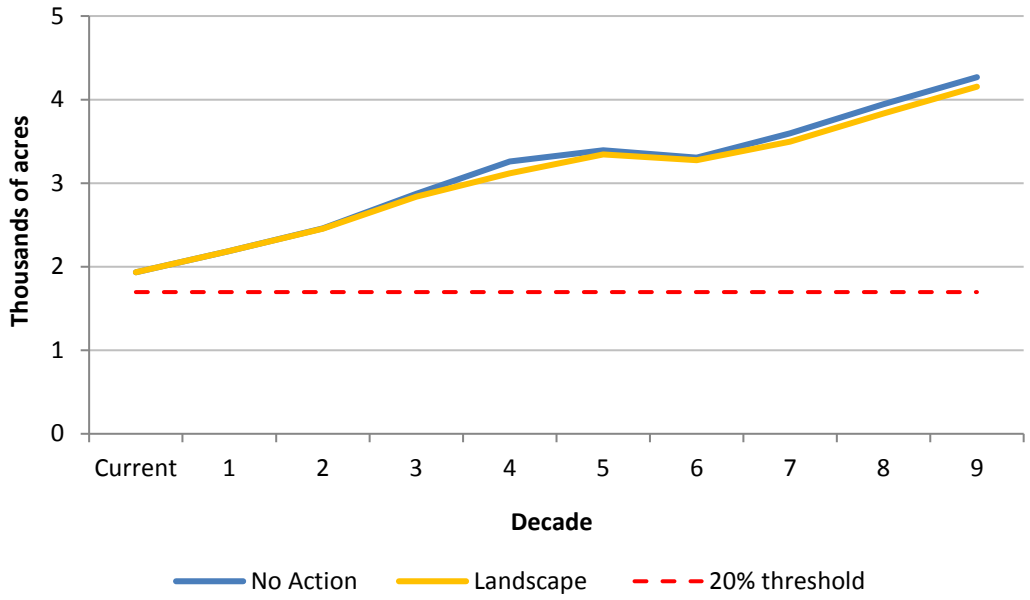


Chart I-10. Acres of Old Forest Habitat on State Trust Lands in the Sekiu Landscape, by Alternative

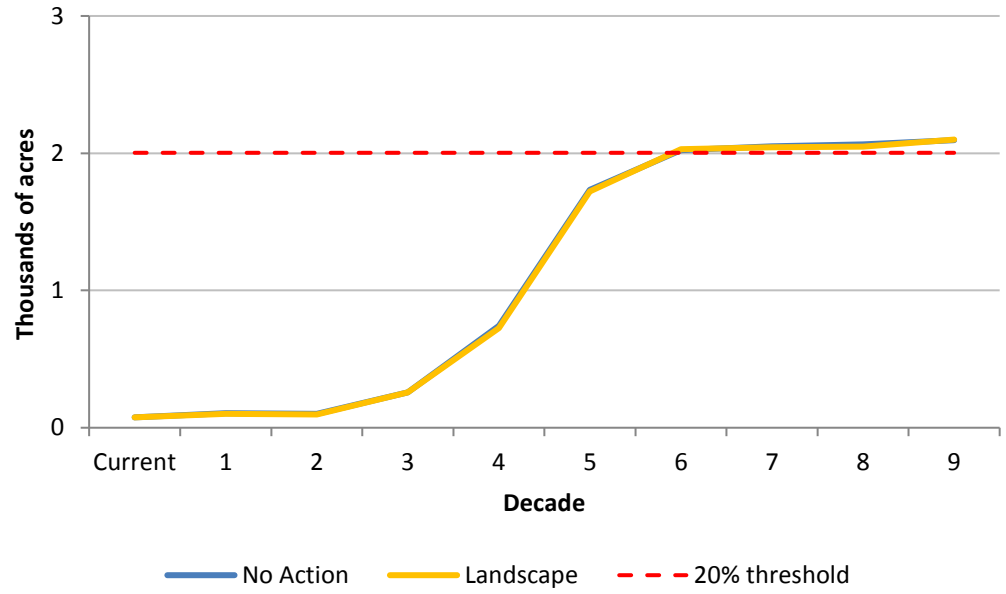


Chart I-11. Acres of Old Forest Habitat on State Trust Lands in the Sol Duc Landscape, by Alternative

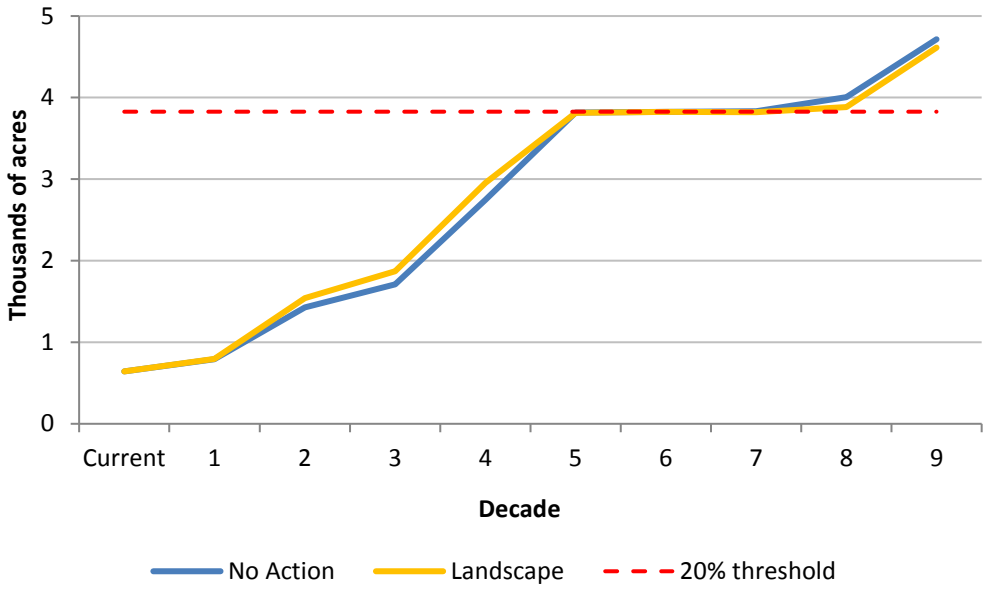
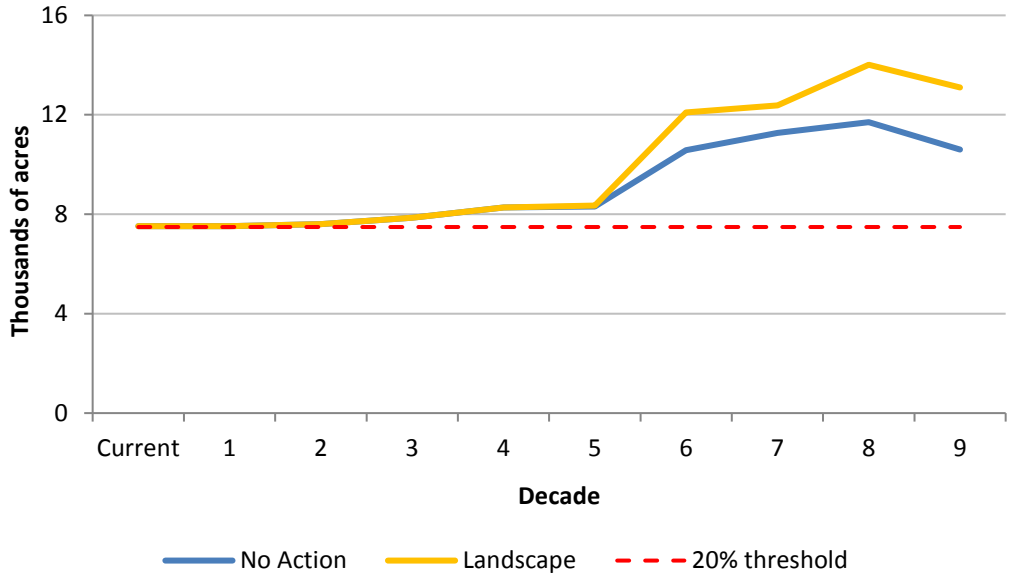


Chart I-12. Acres of Owl Old Forest Habitat on State Trust Lands in the Willy Huel Landscape, by Alternative



Young Forest Habitat and Better Charts, No Action and Landscape Alternatives

Chart I-13. Acres of Young Forest Habitat and Better on State Trust Lands in the OESF, by Alternative

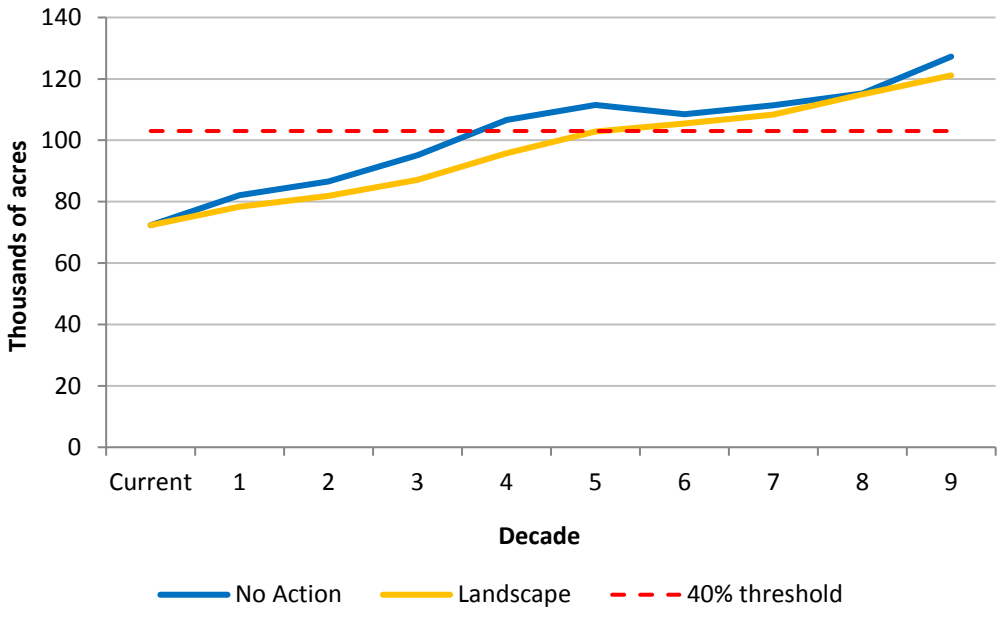


Chart I-14. Acres of Young Forest Habitat and Better on State Trust Lands in the Clallam Landscape, by Alternative

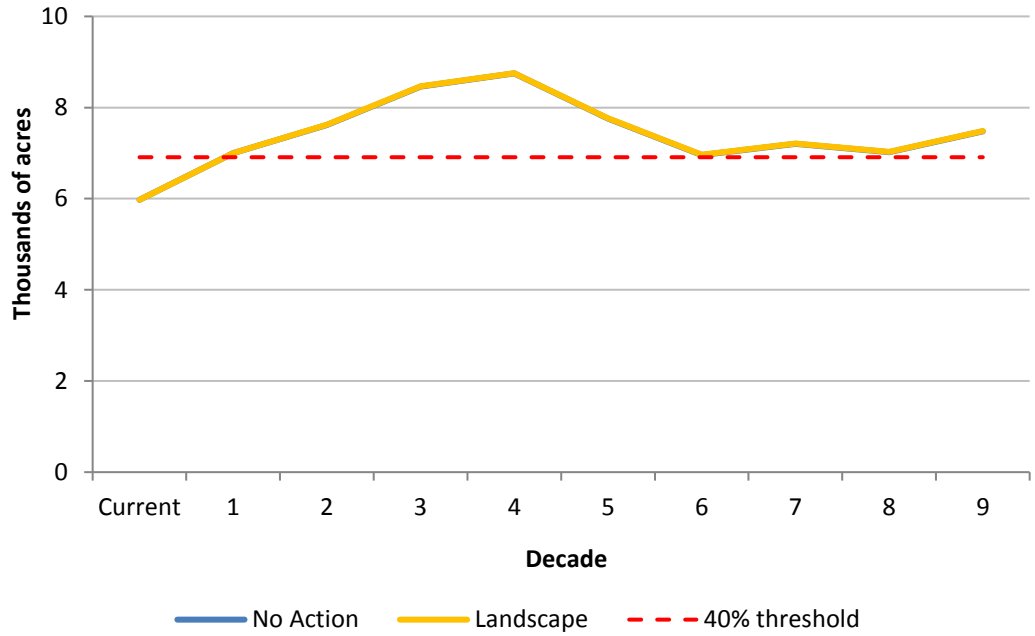


Chart I-15. Acres of Young Forest Habitat and Better on State Trust Lands in the Clearwater Landscape, by Alternative

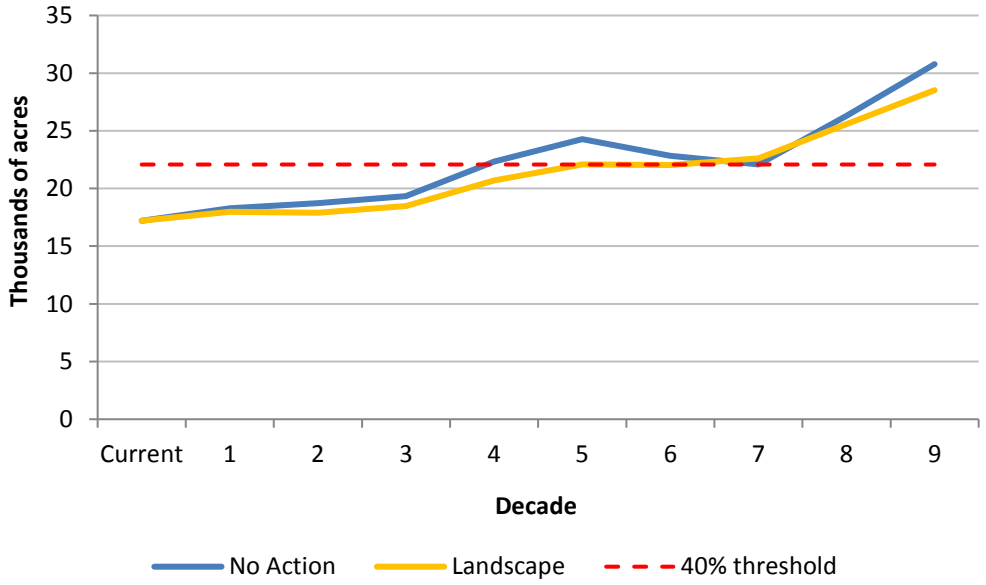


Chart I-16. Acres of Young Forest Habitat and Better on State Trust Lands in the Coppermine Landscape, by Alternative

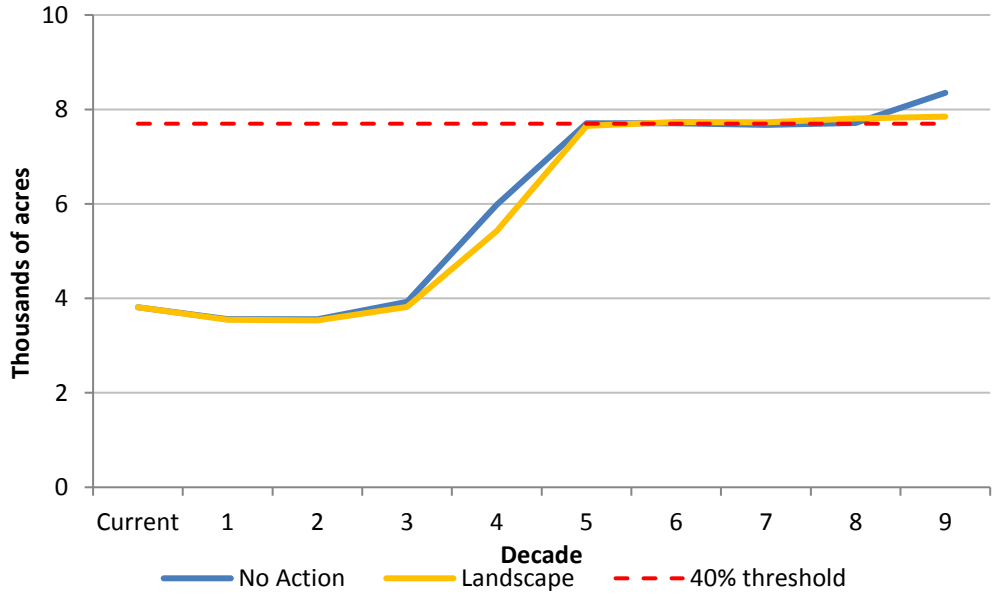


Chart I-17. Acres of Young Forest Habitat and Better on State Trust Lands in the Dickodochtedar Landscape, by Alternative

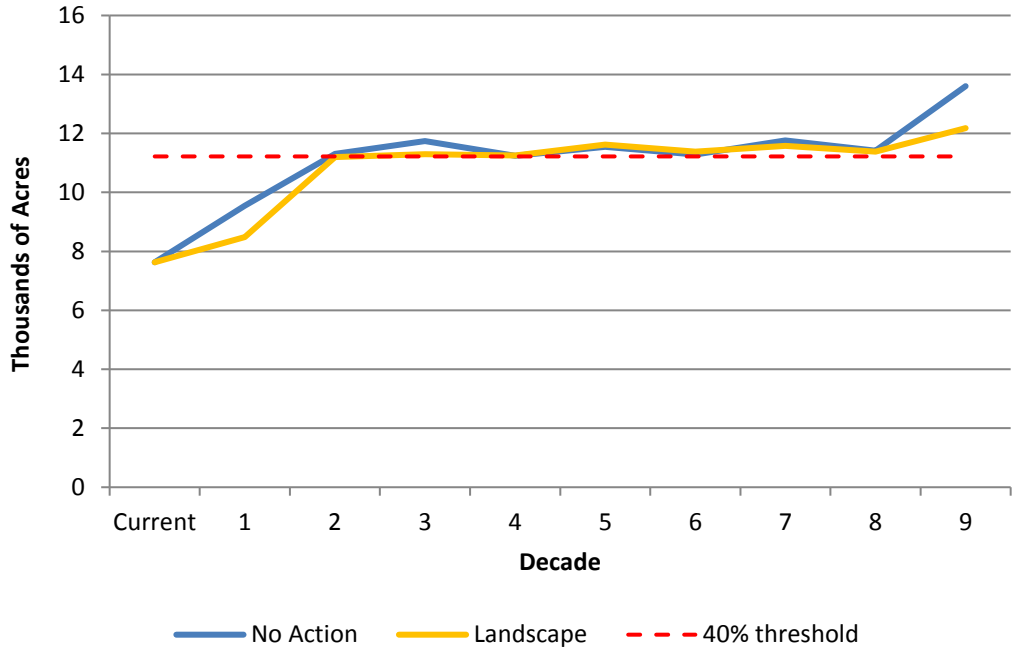


Chart I-18. Acres of Young Forest Habitat and Better on State Trust Lands in the Goodman Landscape, by Alternative

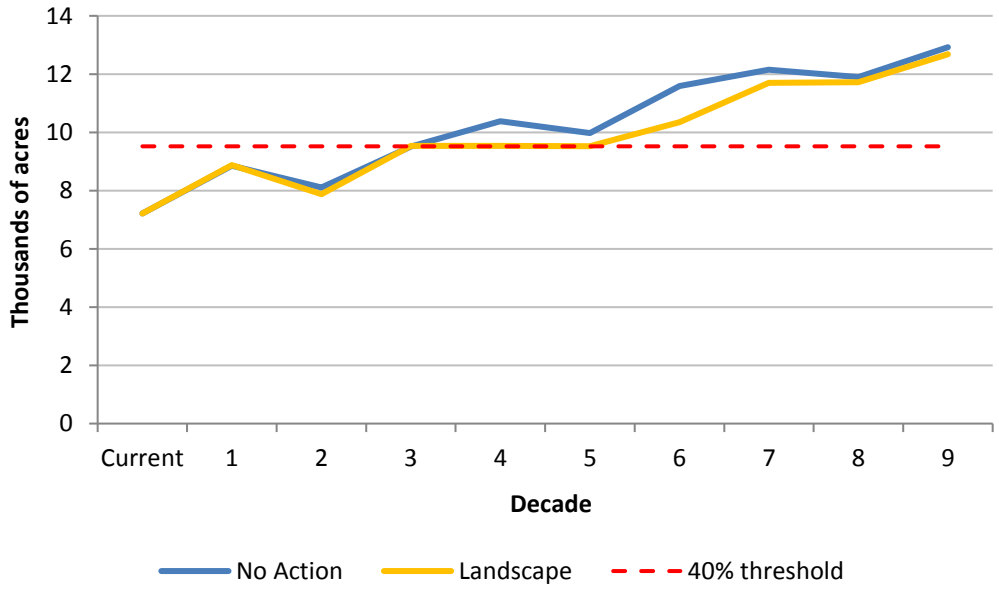


Chart I-19. Acres of Young Forest Habitat and Better on State Trust Lands in the Kalaloch Landscape, by Alternative

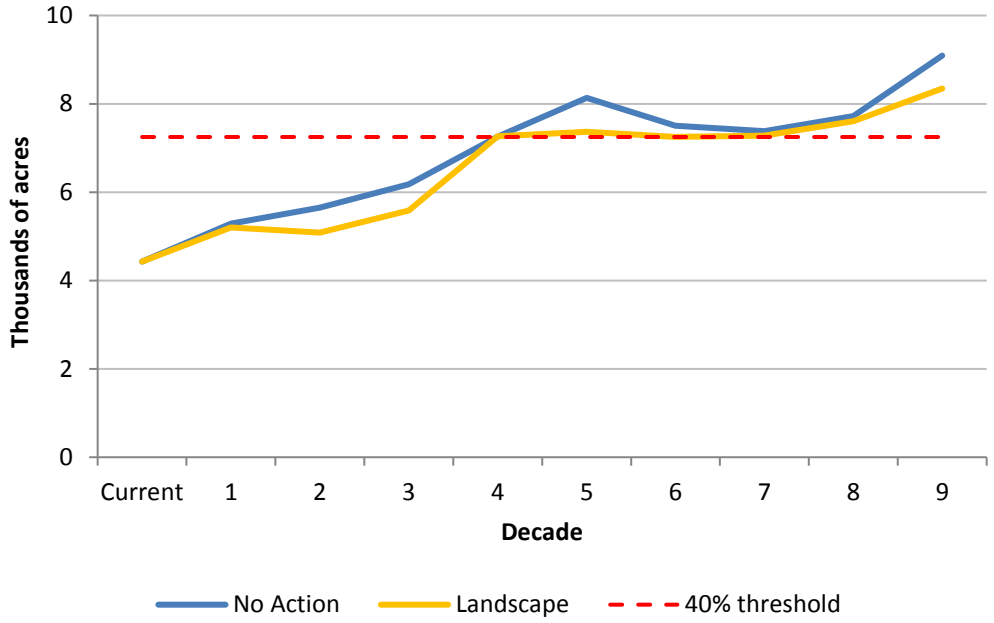


Chart I-20. Acres of Young Forest Habitat and Better on State Trust Lands in the Queets Landscape, by Alternative

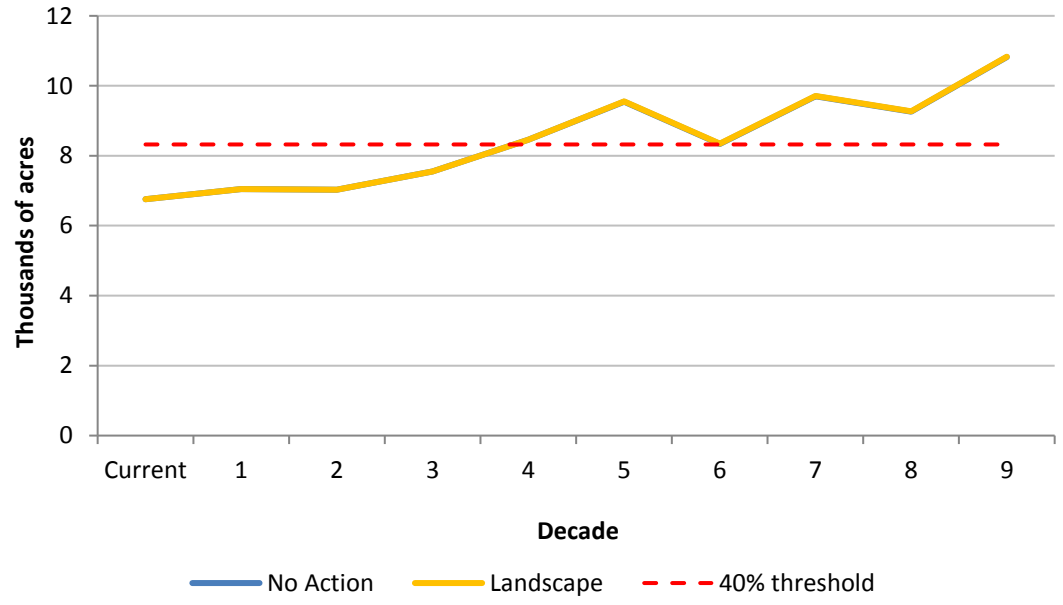


Chart I-21. Acres of Young Forest Habitat and Better on State Trust Lands in the Reade Hill Landscape, by Alternative

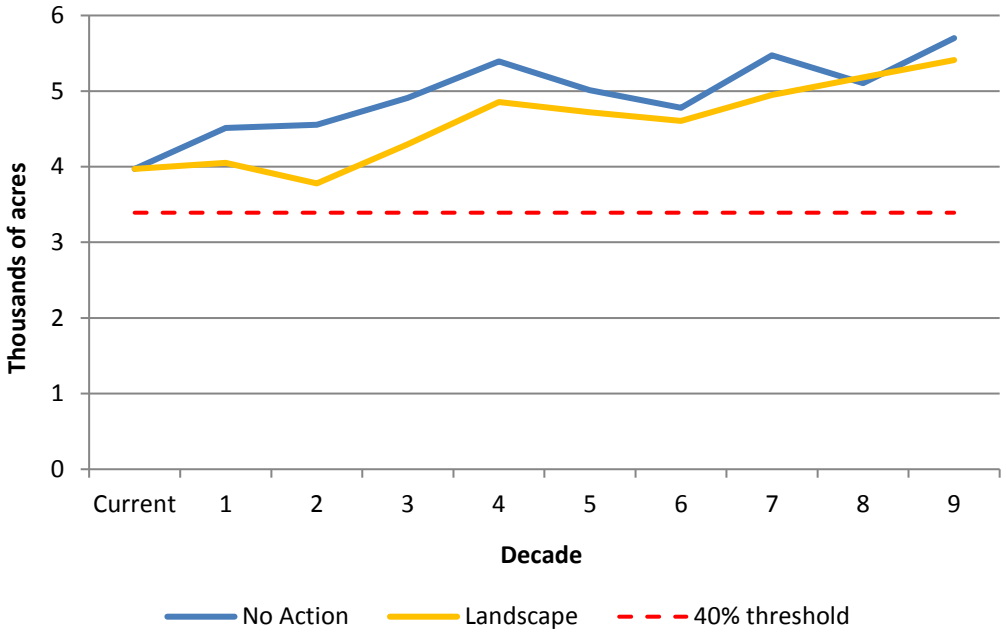


Chart I-22. Acres of Young Forest Habitat and Better on State Trust Lands in the Sekiu Landscape, by Alternative

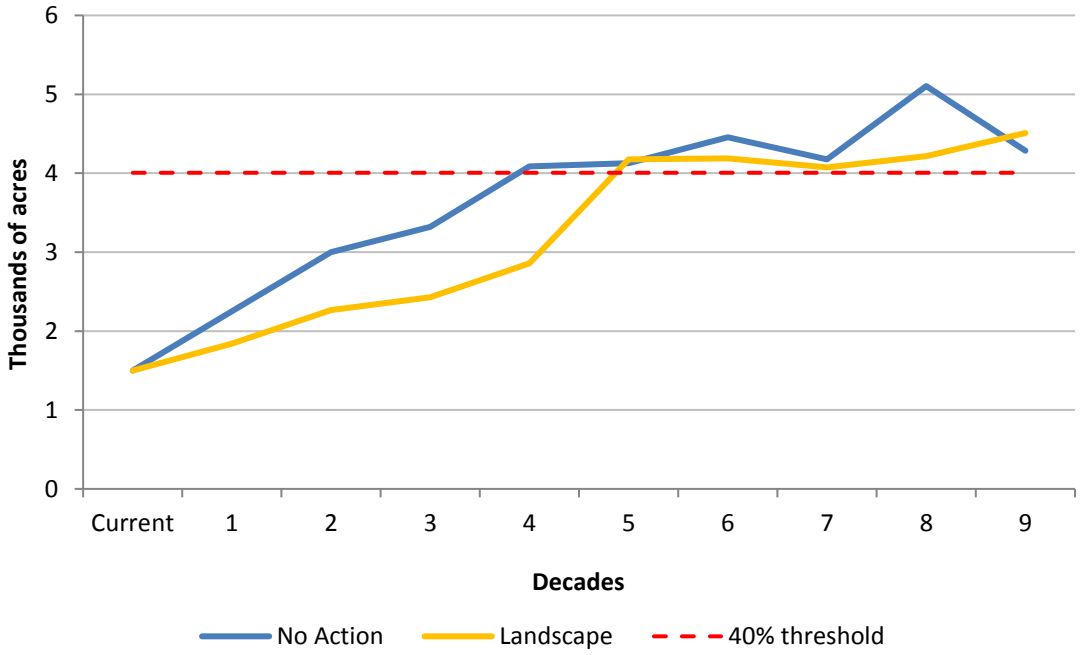


Chart I-23. Acres of Young Forest Habitat and Better on State Trust Lands in the Sol Duc Landscape, by Alternative

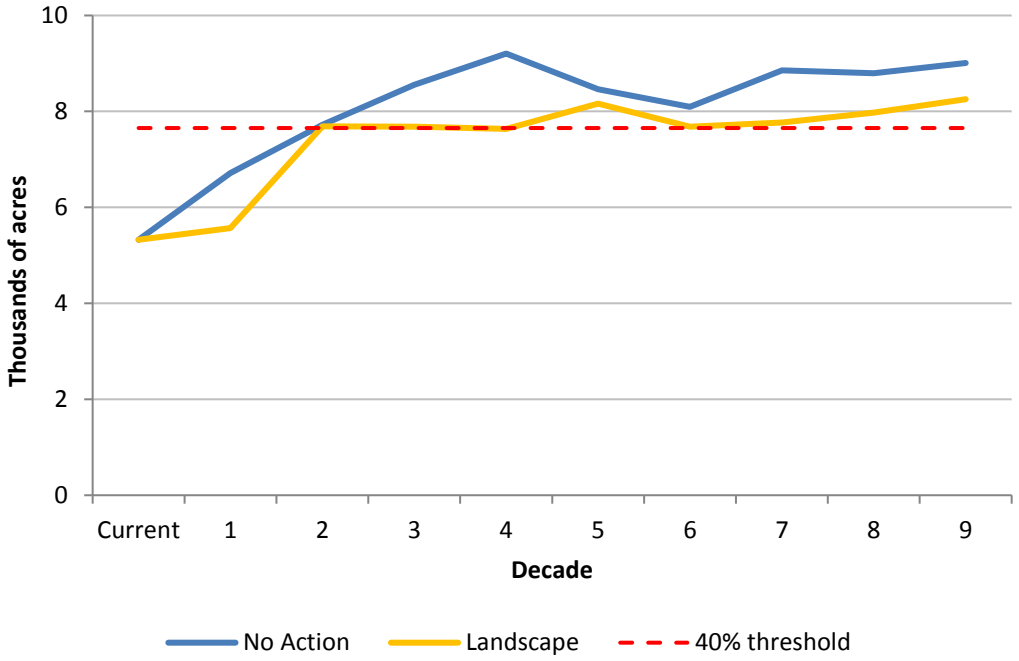
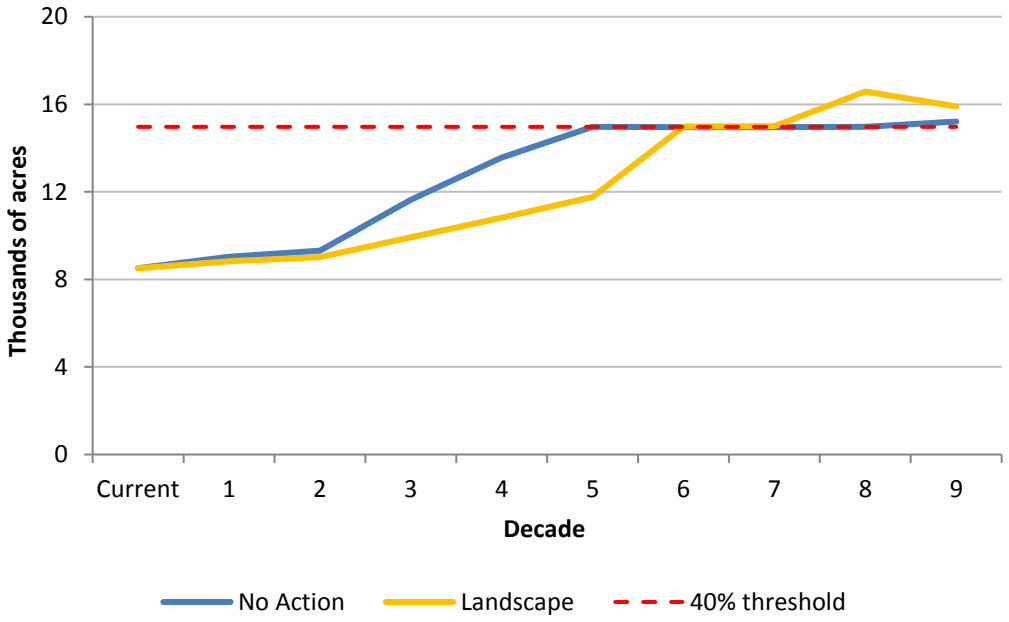


Chart I-24. Acres of Young Forest Habitat and Better on State Trust Lands in the Willy Huel Landscape, by Alternative



Pathways Alternative Charts With Upper and Lower Bounds for Young Forest Habitat and Old Forest Habitat

Chart I-25. Clallam Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

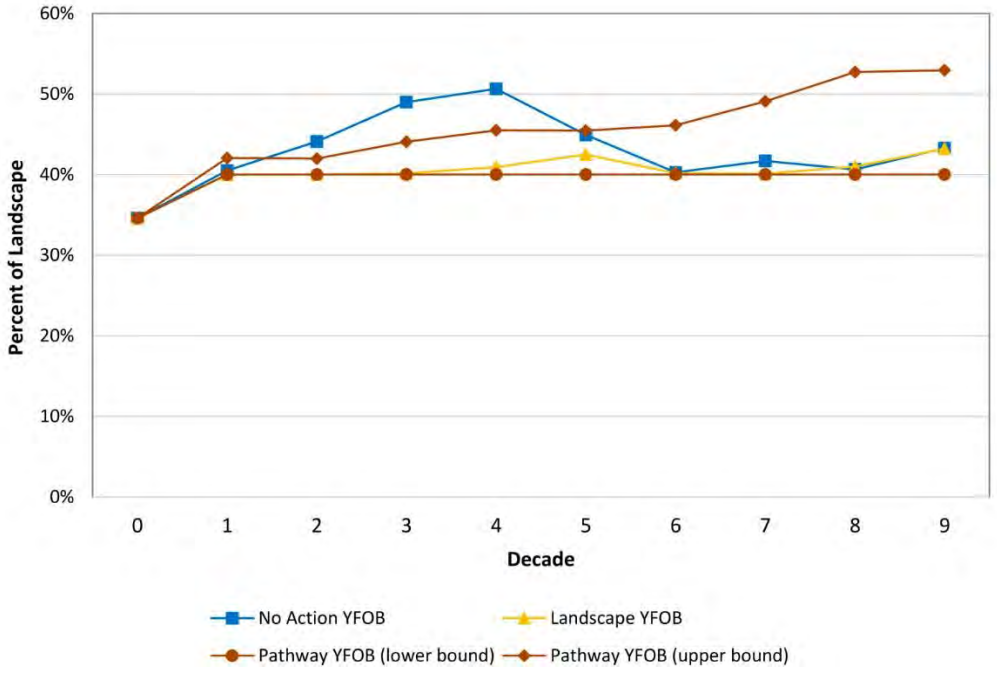


Chart I-26. Clallam Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

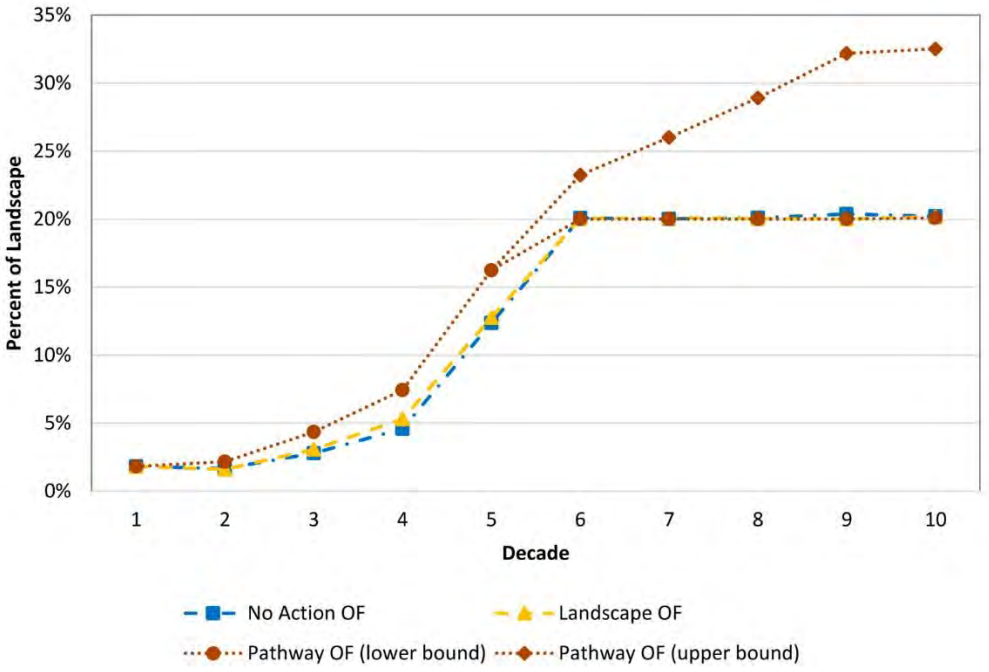


Chart I-27. Clearwater Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

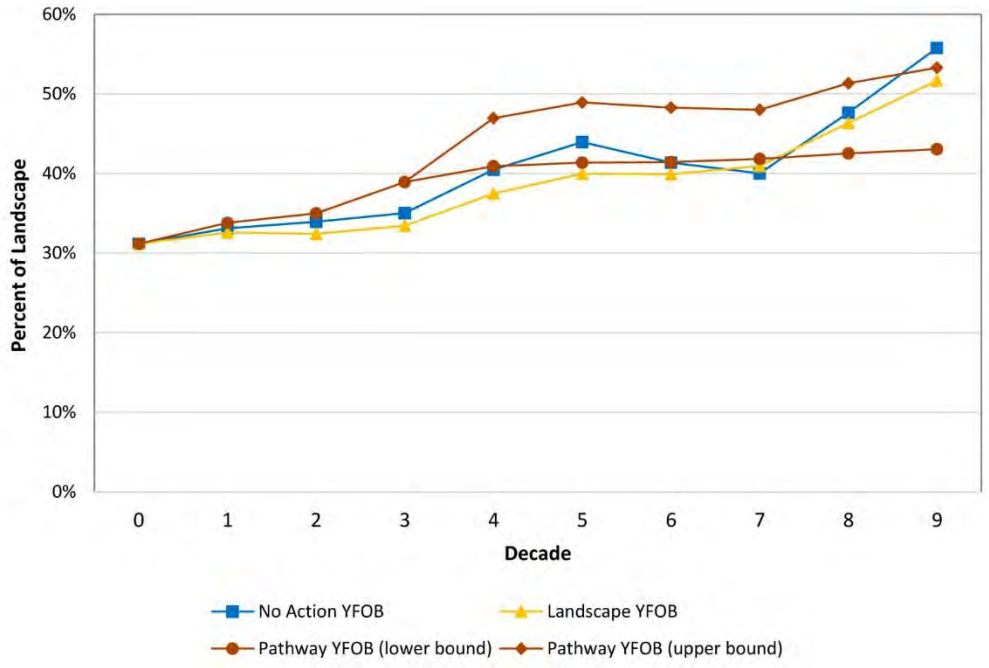


Chart I-28. Clearwater Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

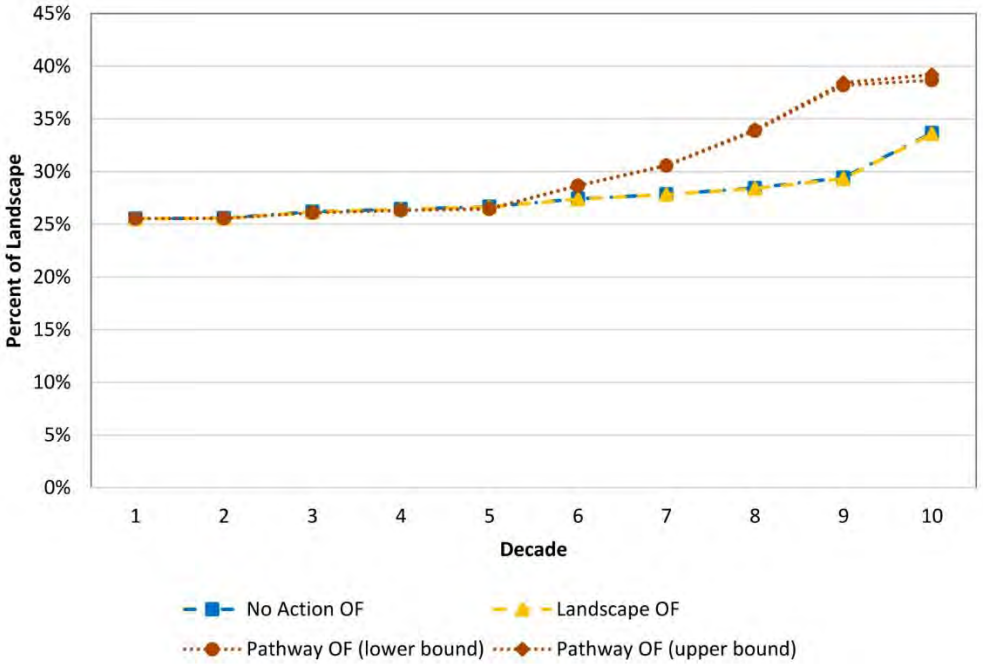


Chart I-29. Coppermine Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

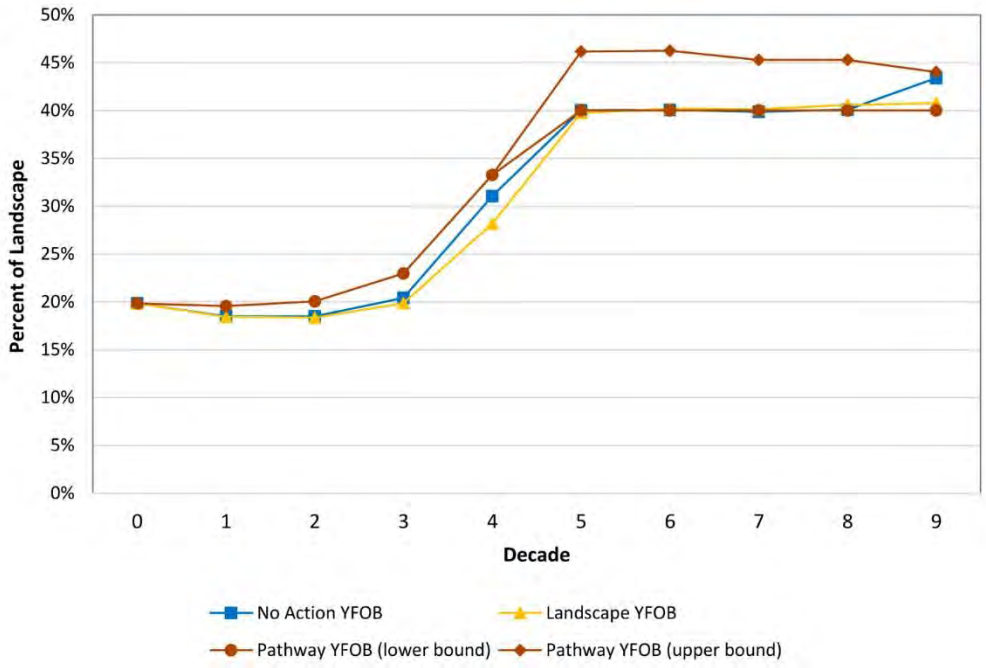


Chart I-30. Coppermine Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

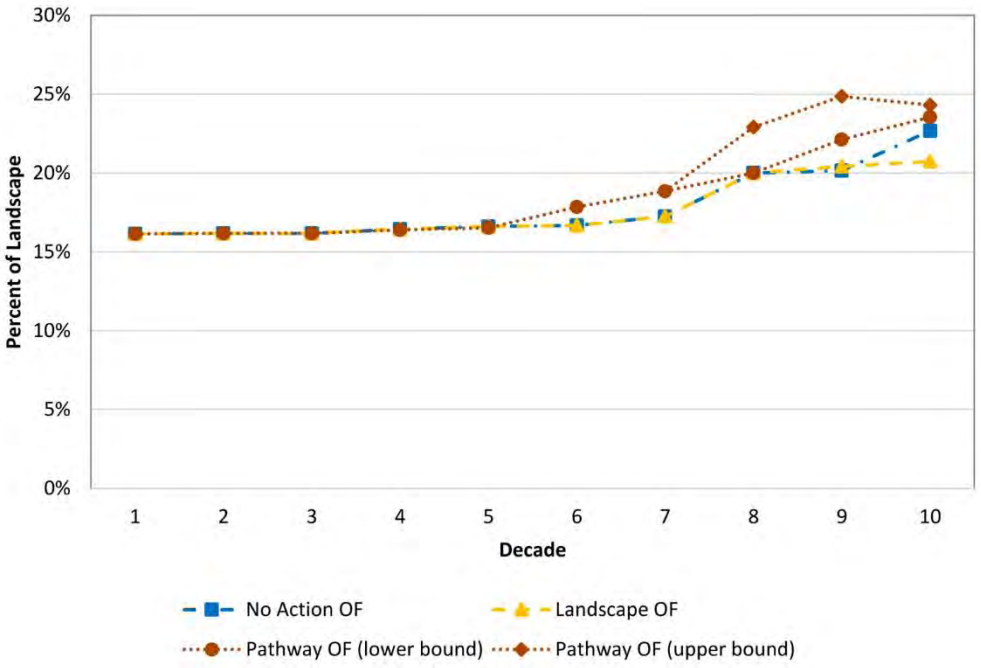


Chart I-31. Dickodochtedar Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

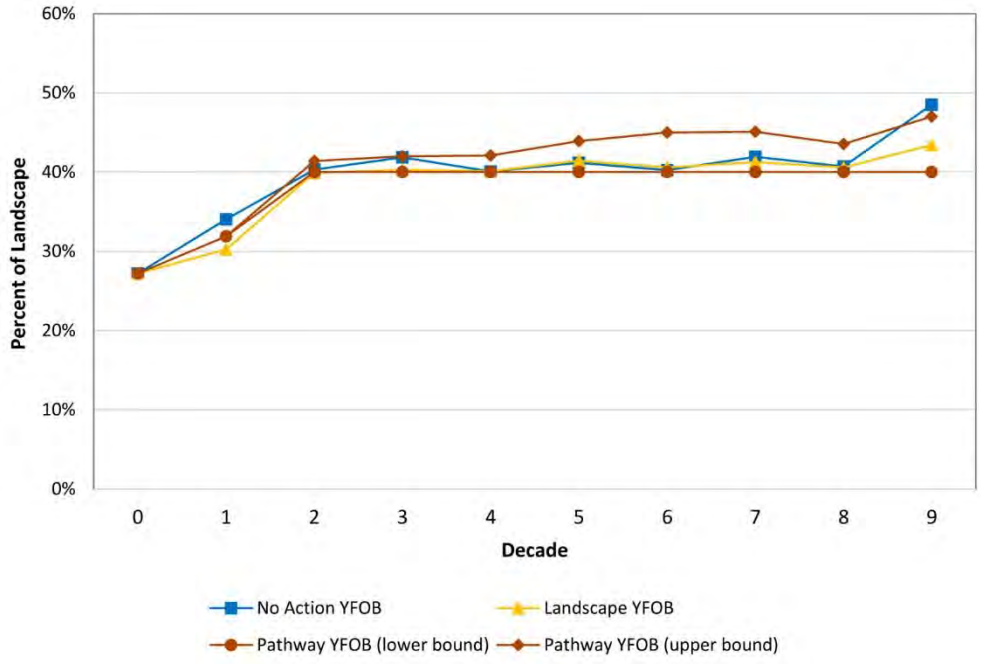


Chart I-32. Dickodochtedar r Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

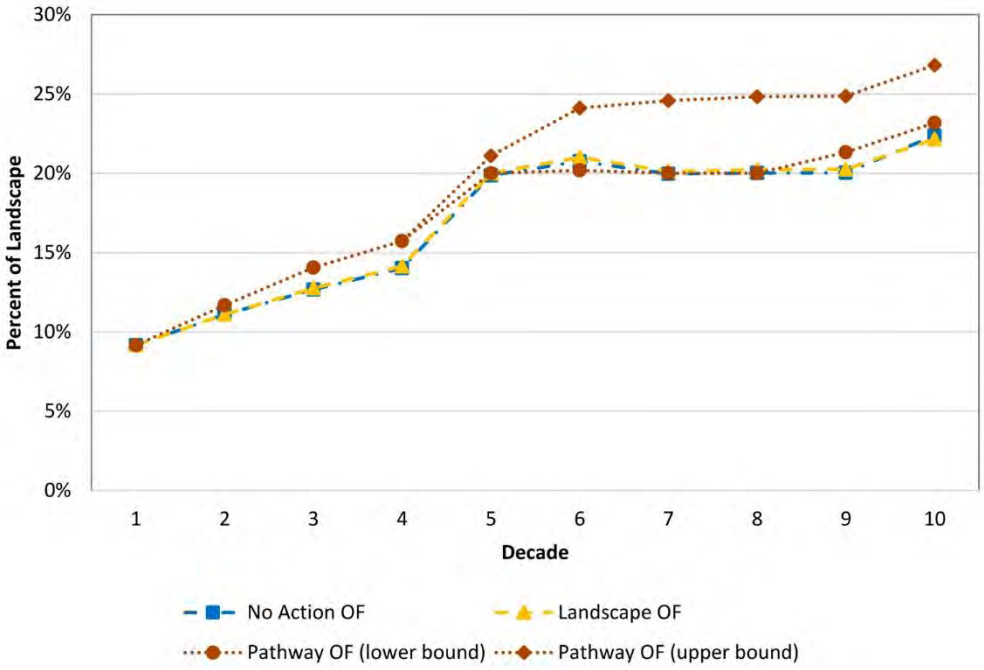


Chart I-33. Goodman Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

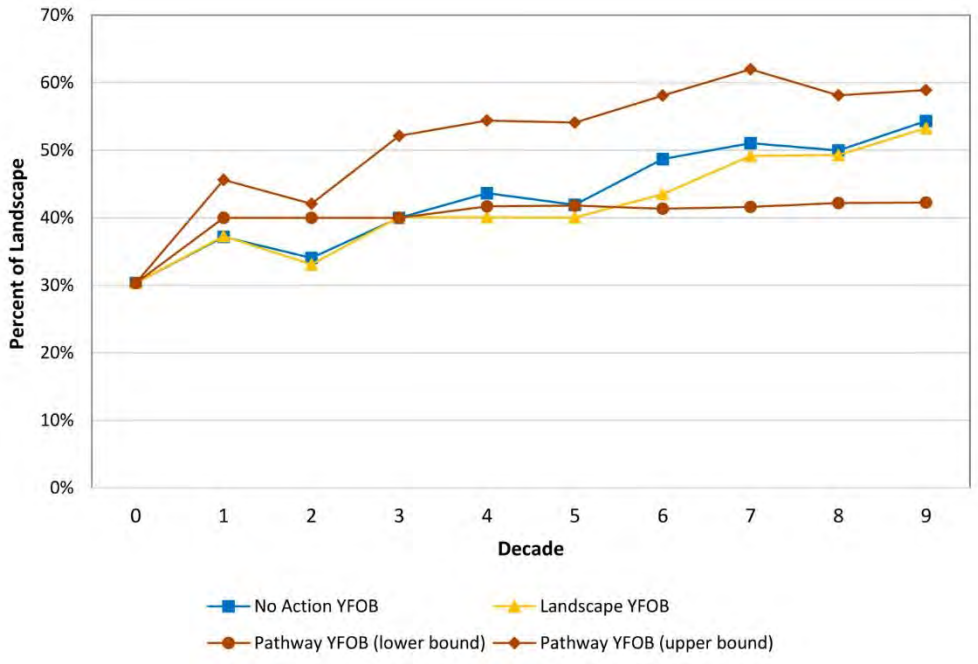


Chart I-34. Goodman Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

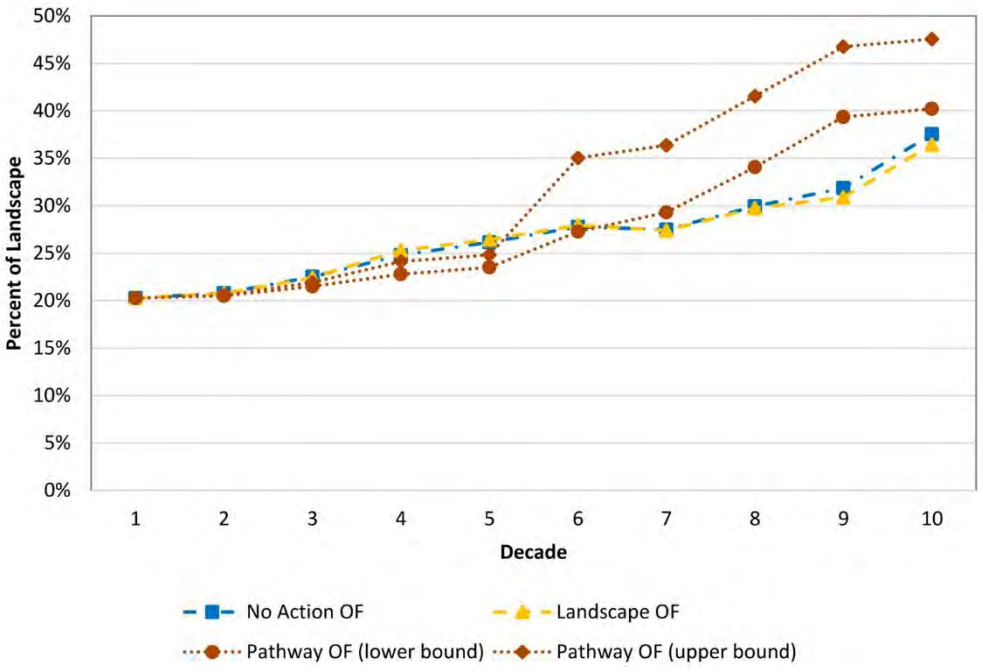


Chart I-35. Kalaloch Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

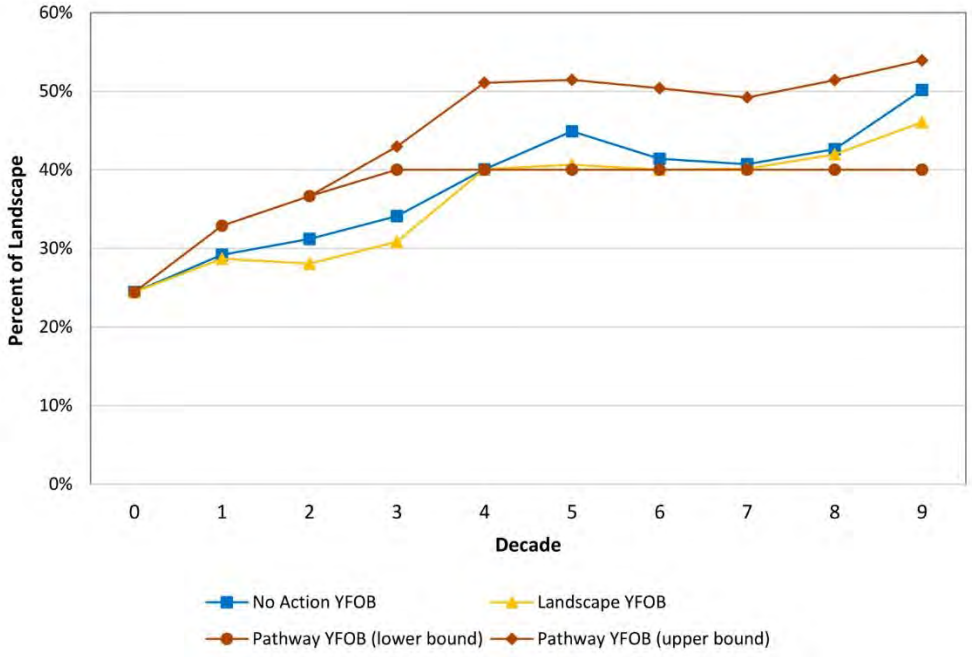


Chart I-36. Kalaloch Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

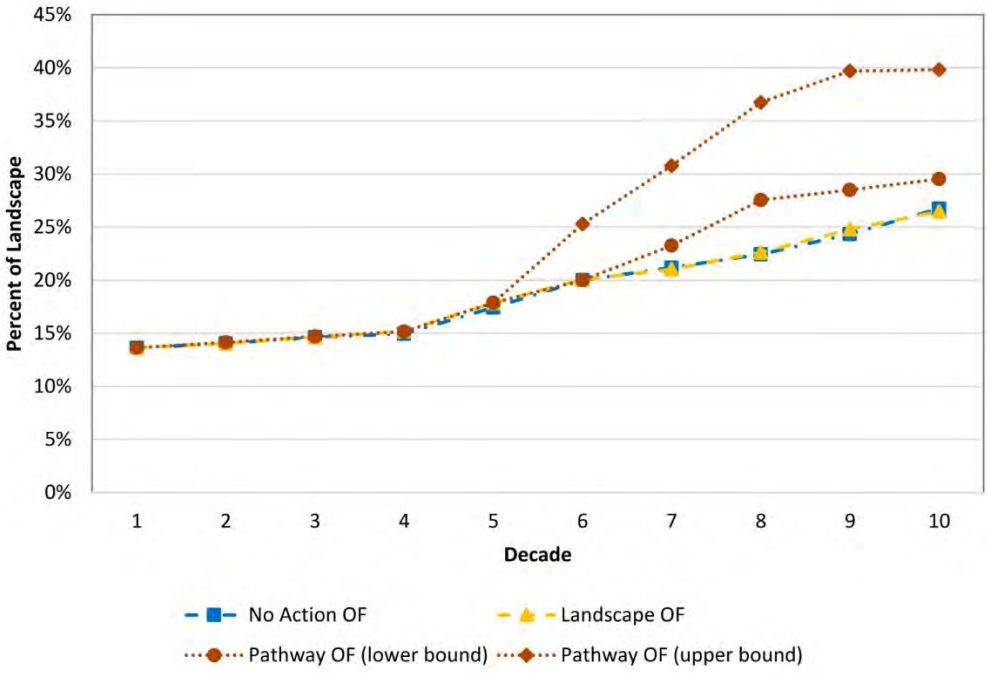


Chart I-37. Queets Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

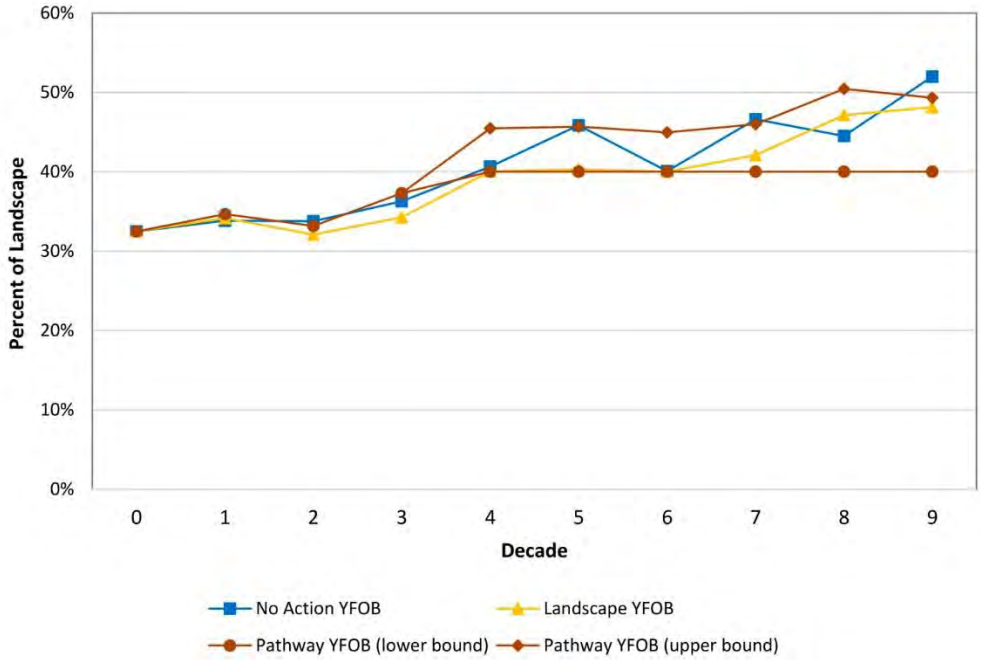


Chart I-38. Queets Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

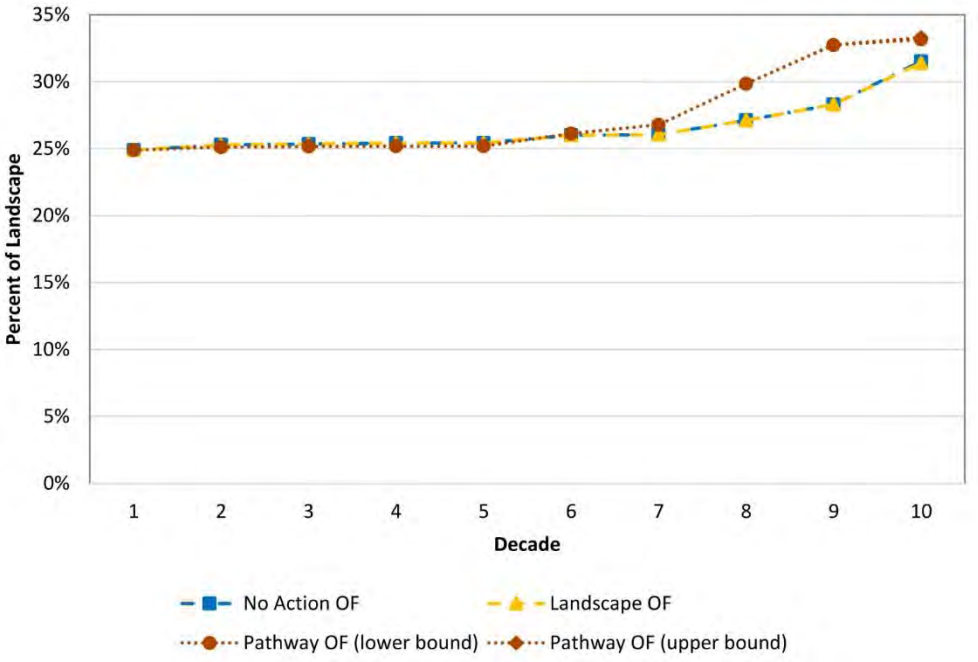


Chart I-39. Reade Hill Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

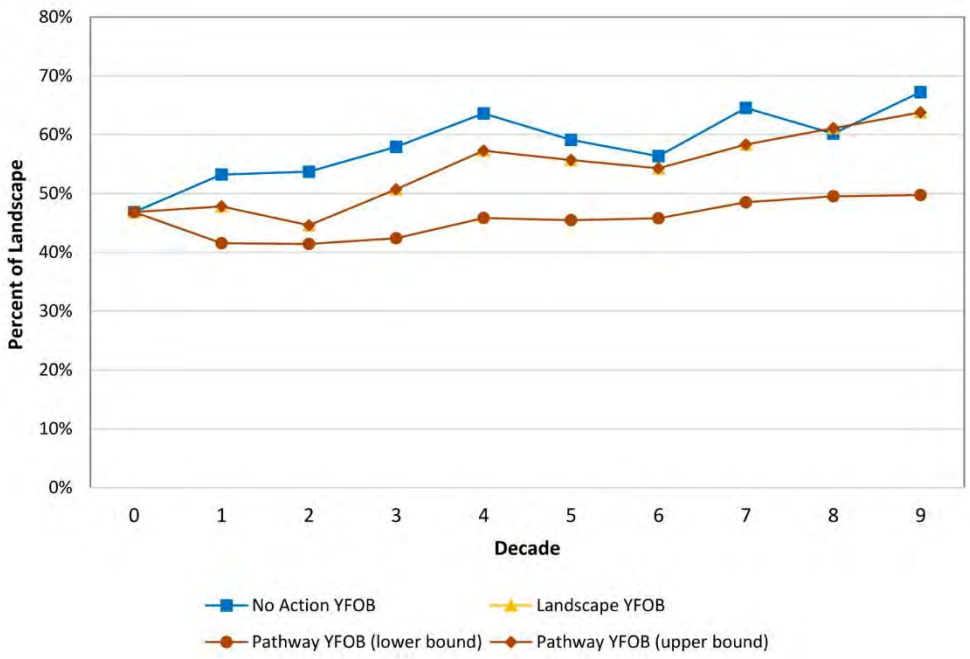


Chart I-40. Reade hill Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

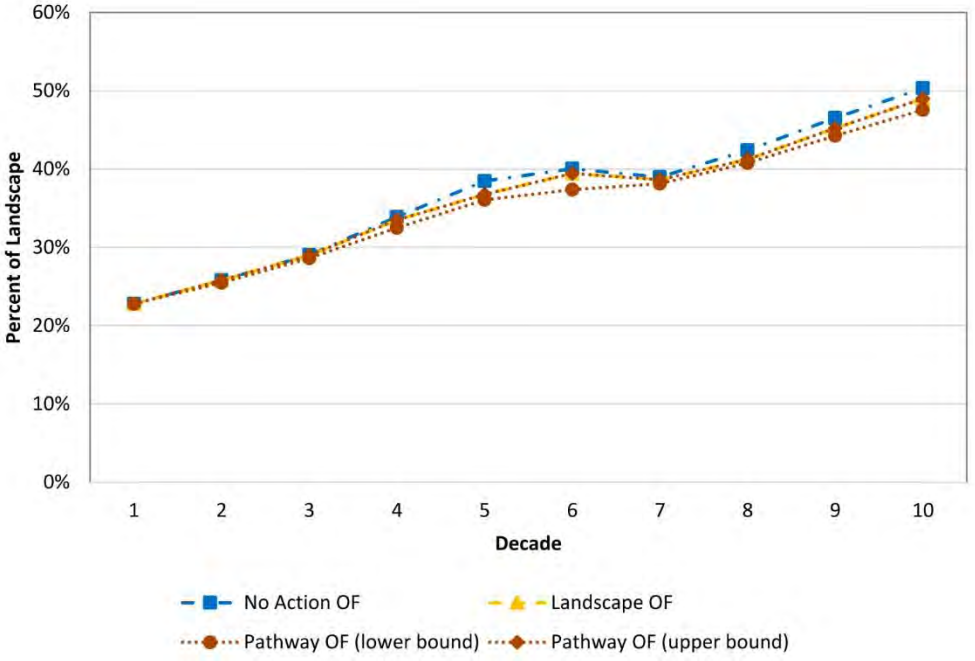


Chart I-41. Sekiu Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

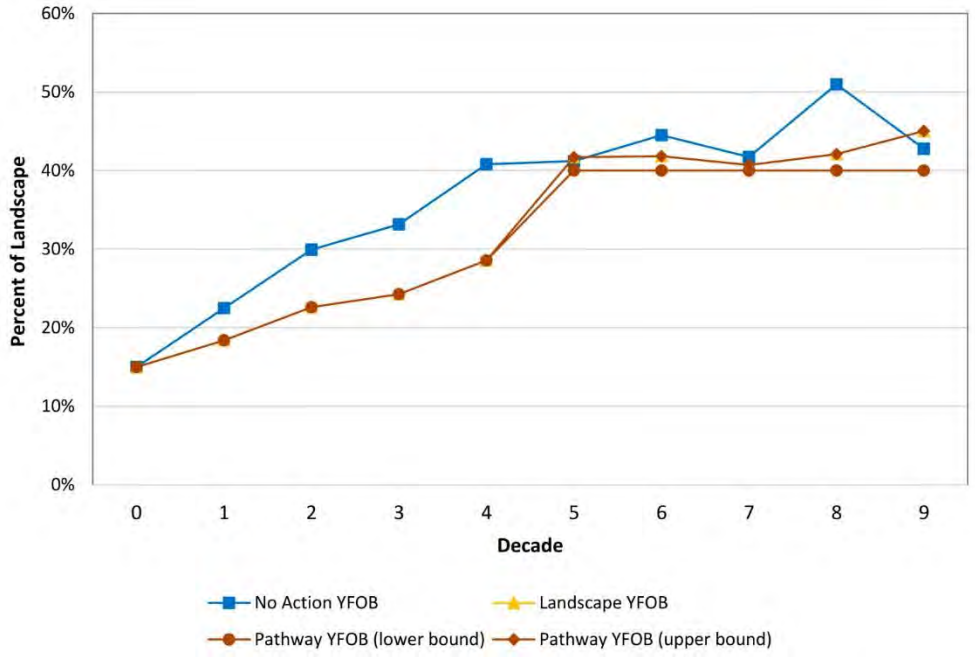


Chart I-42. Sekiu Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

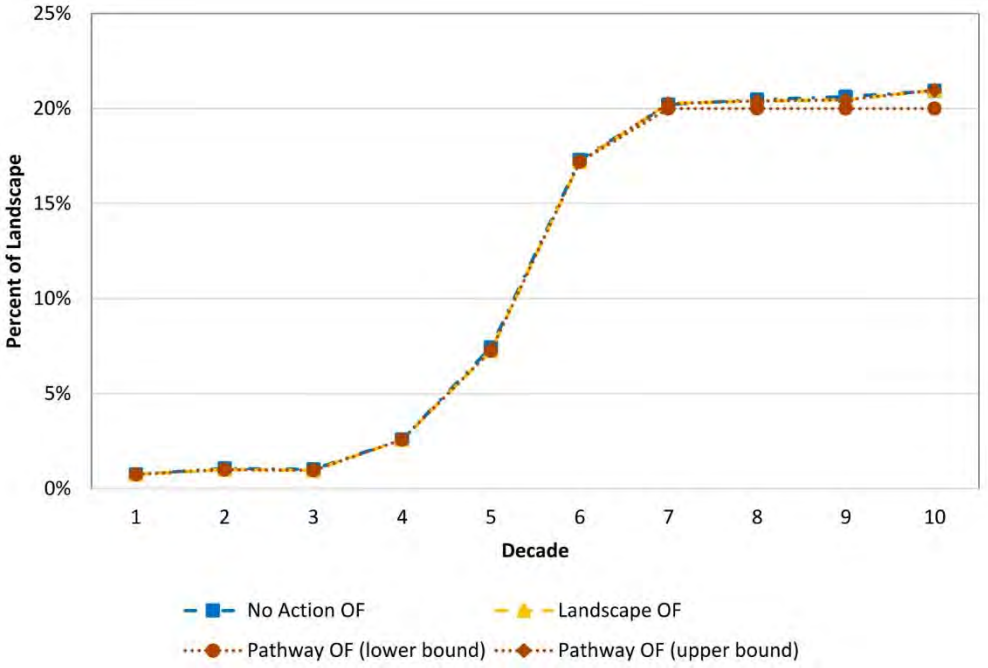


Chart I-41. Sol Duc Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

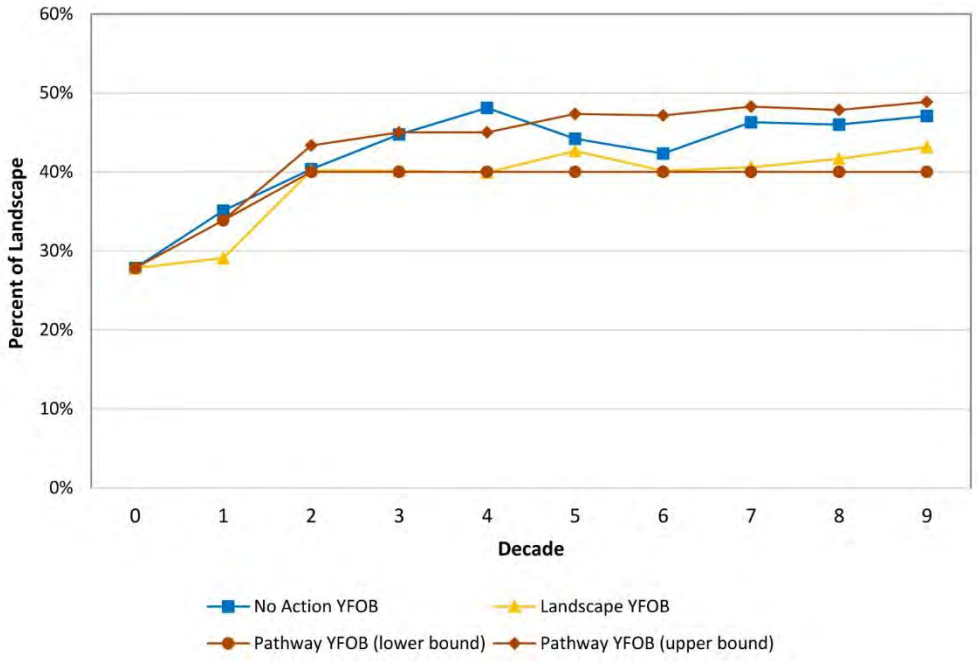


Chart I-42. Sol Duc Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

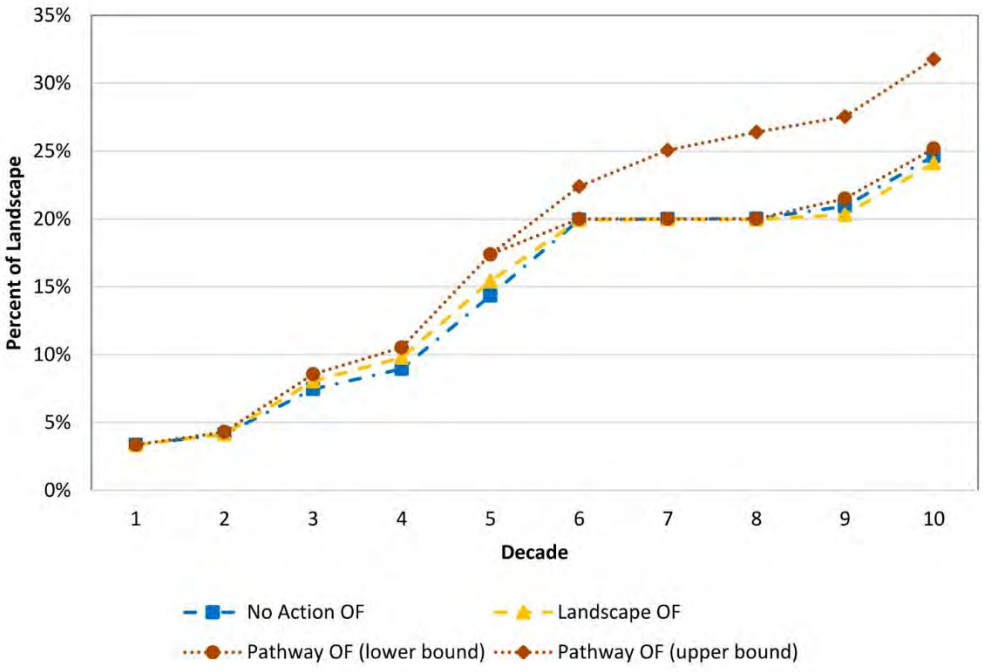


Chart I-41. Willy Huel Landscape: Percentage of Landscape as Young Forest and Better Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference

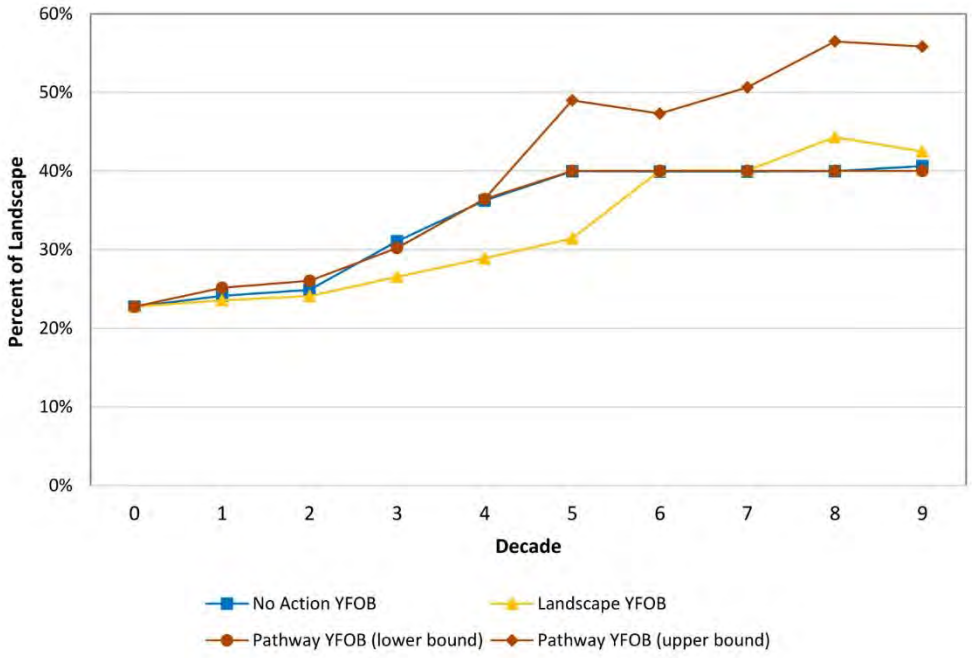
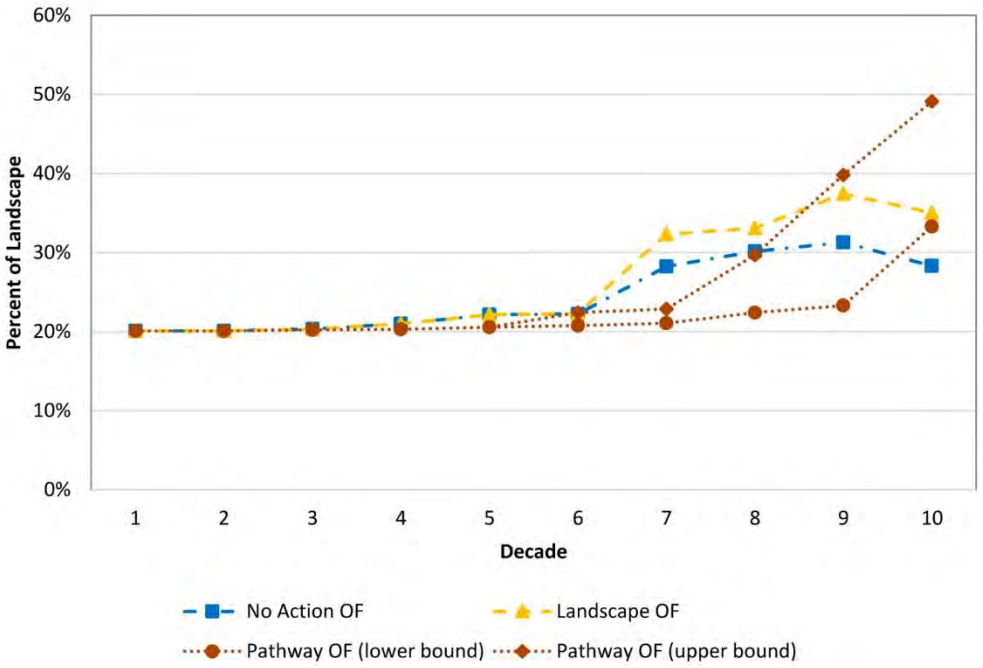


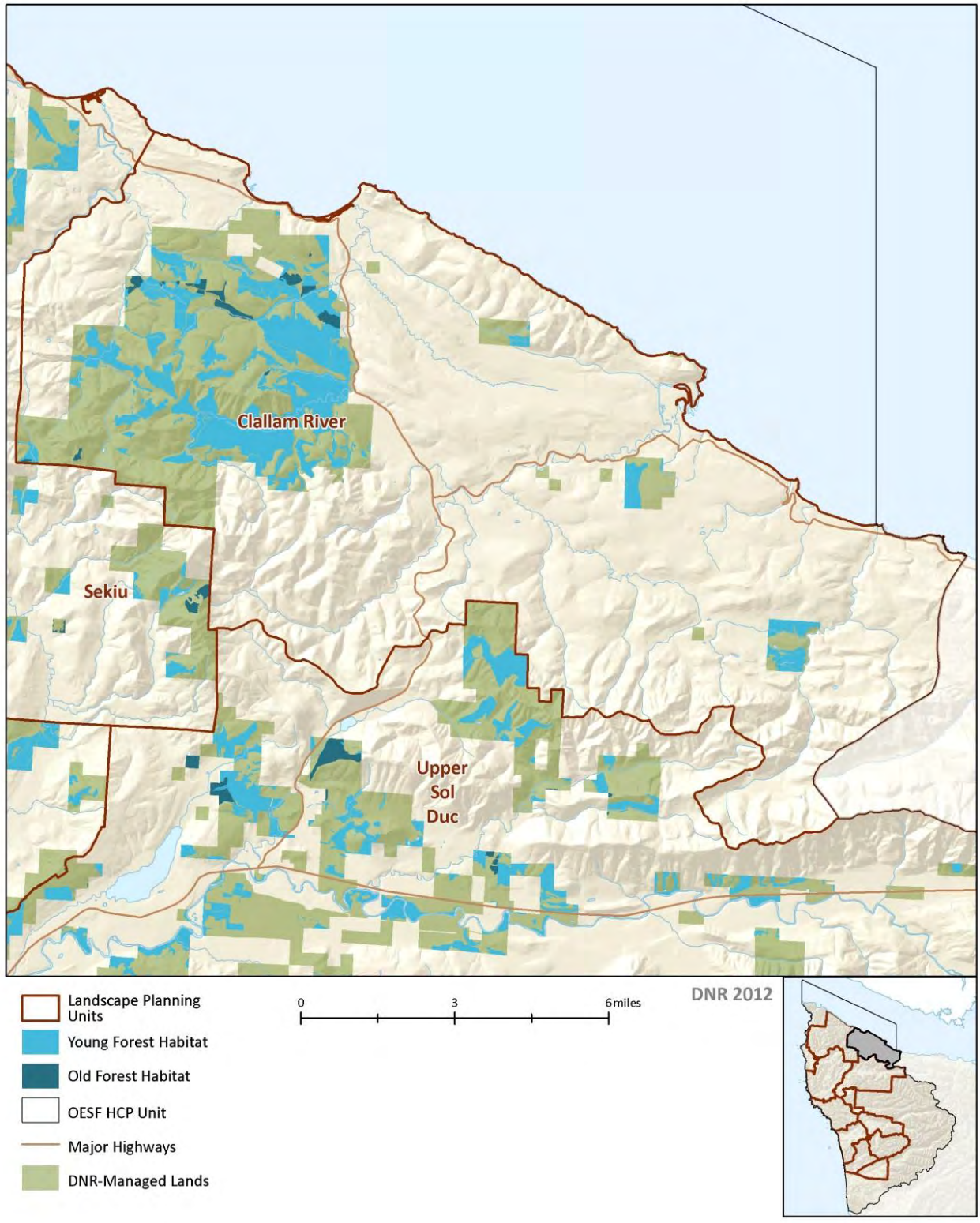
Chart I-42. Willy Huel Landscape: Percentage of Landscape as Old Forest Habitat under the Pathways Alternative; Upper and Lower Bounds Shown, No Action and Landscape Alternatives Provided as Reference



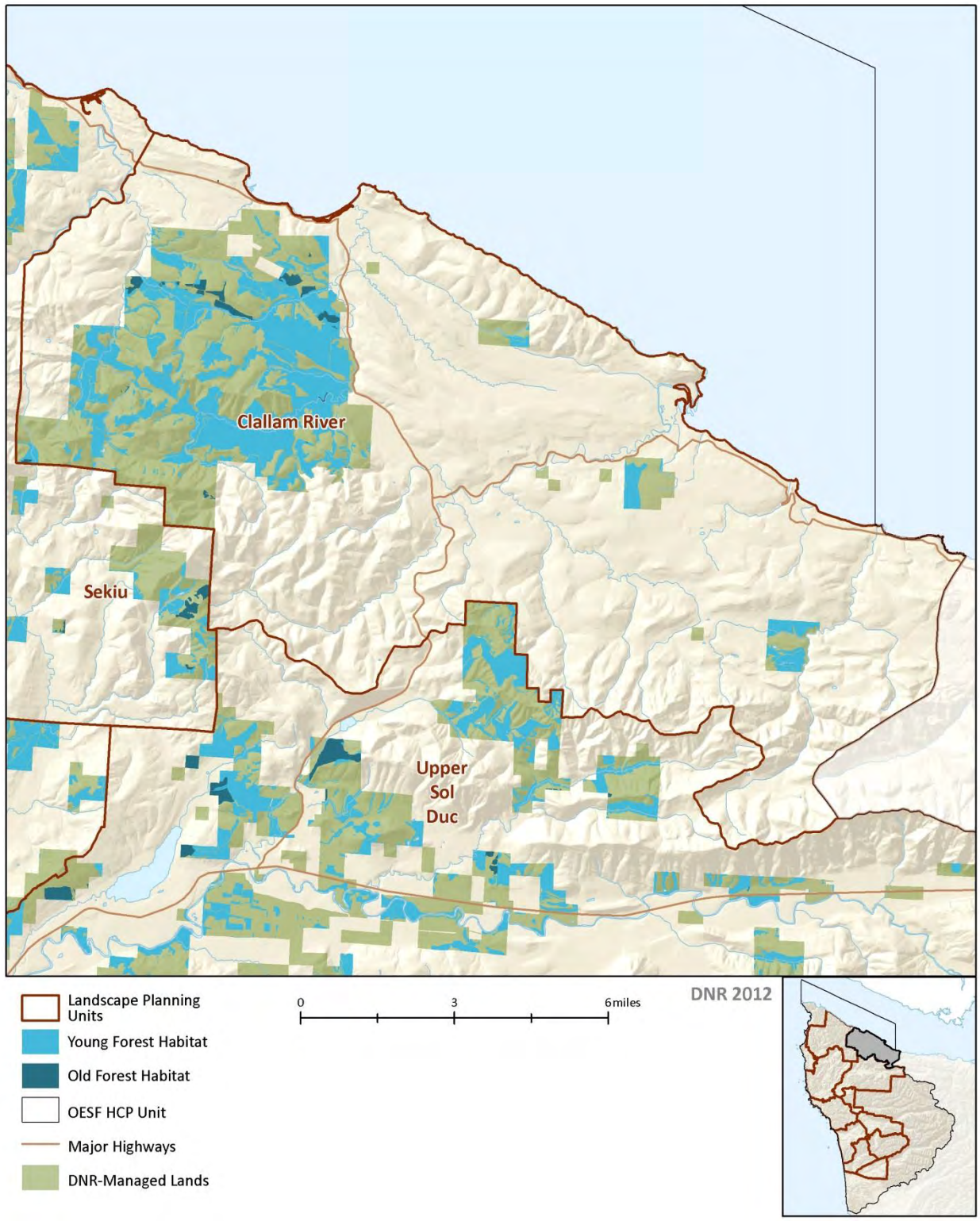
Maps of Old Forest and Young Forest Habitat Development over Time by Landscape, No Action and Landscape Alternatives

■ Clallam Landscape Old Forest and Young Forest Habitat Maps

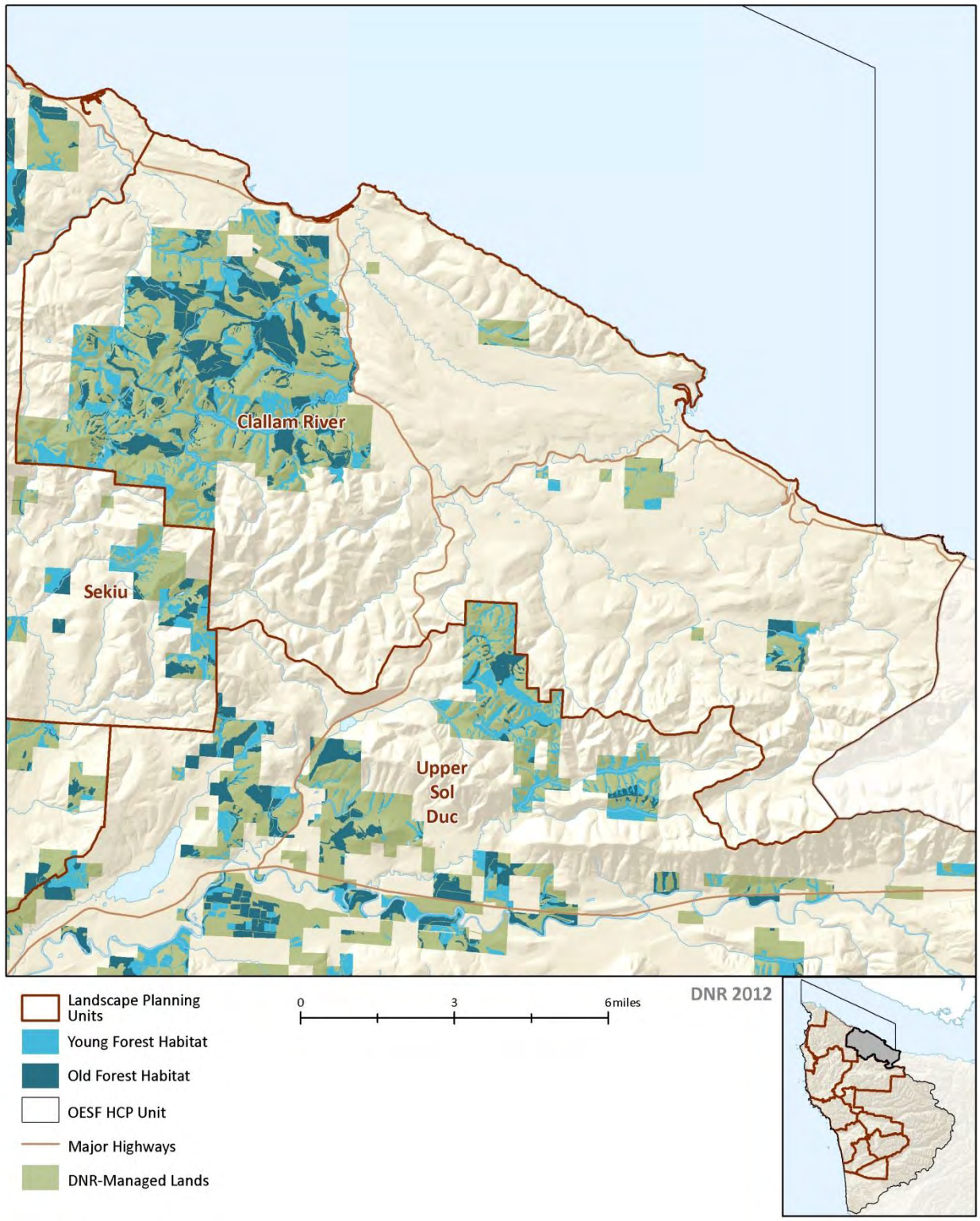
Map I-1. Old Forest and Young Forest Habitat on State Trust Lands in the Clallam Landscape, Current Conditions



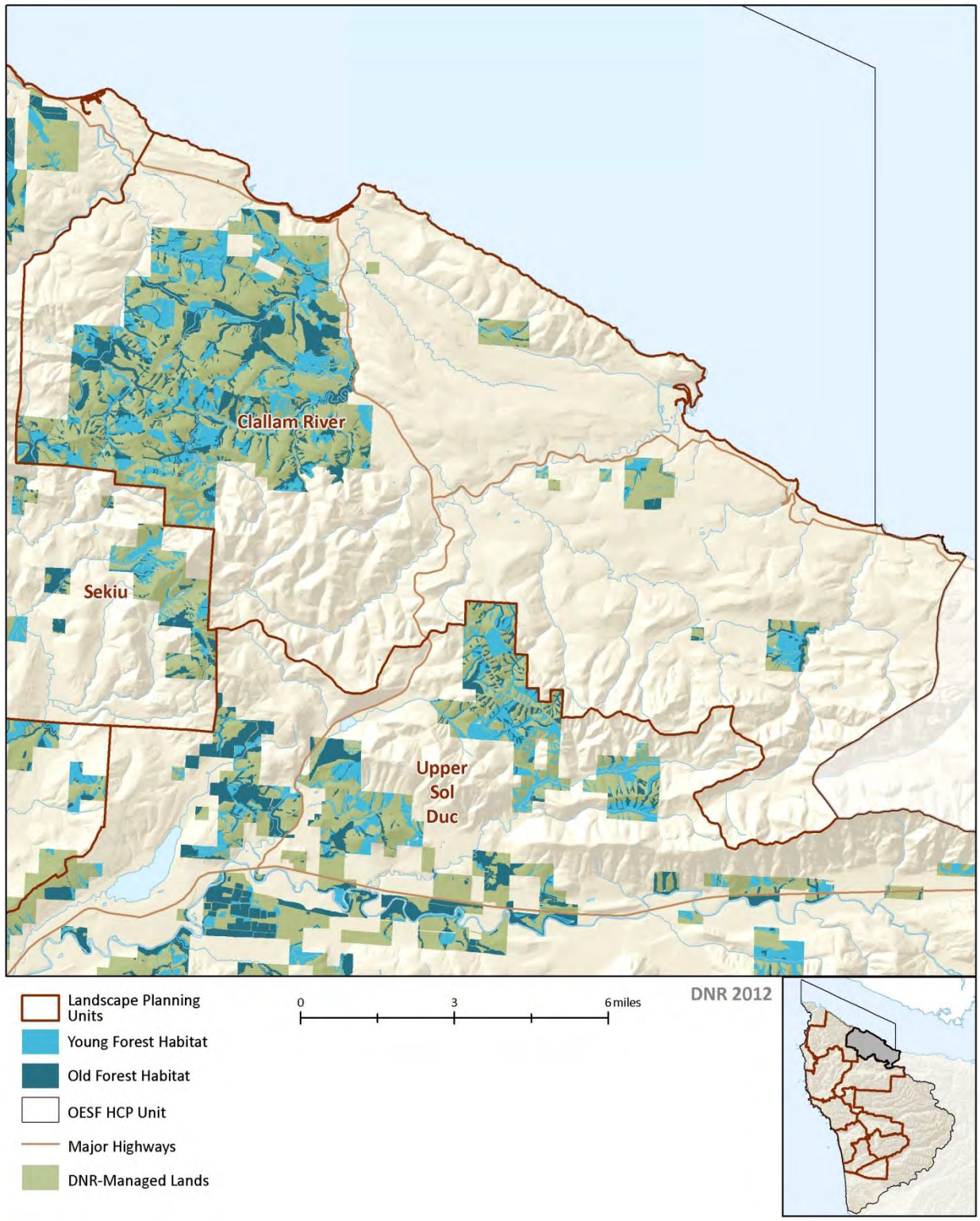
Map I-2. Old Forest and Young Forest Habitat on State Trust Lands in the Clallam Landscape, No Action Alternative, Decade 1



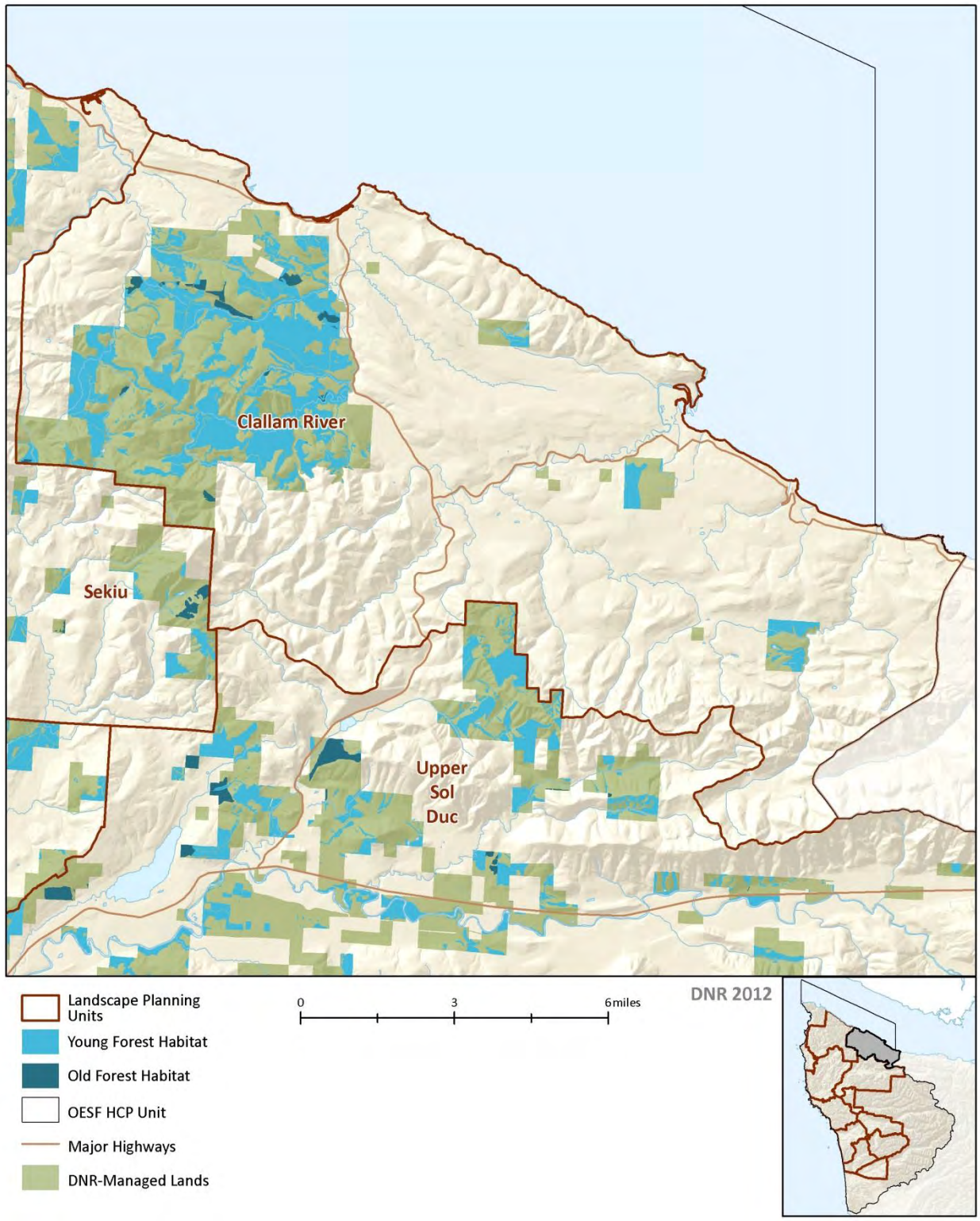
Map I-3. Old Forest and Young Forest Habitat on State Trust Lands in the Clallam Landscape, No Action Alternative, Decade 6



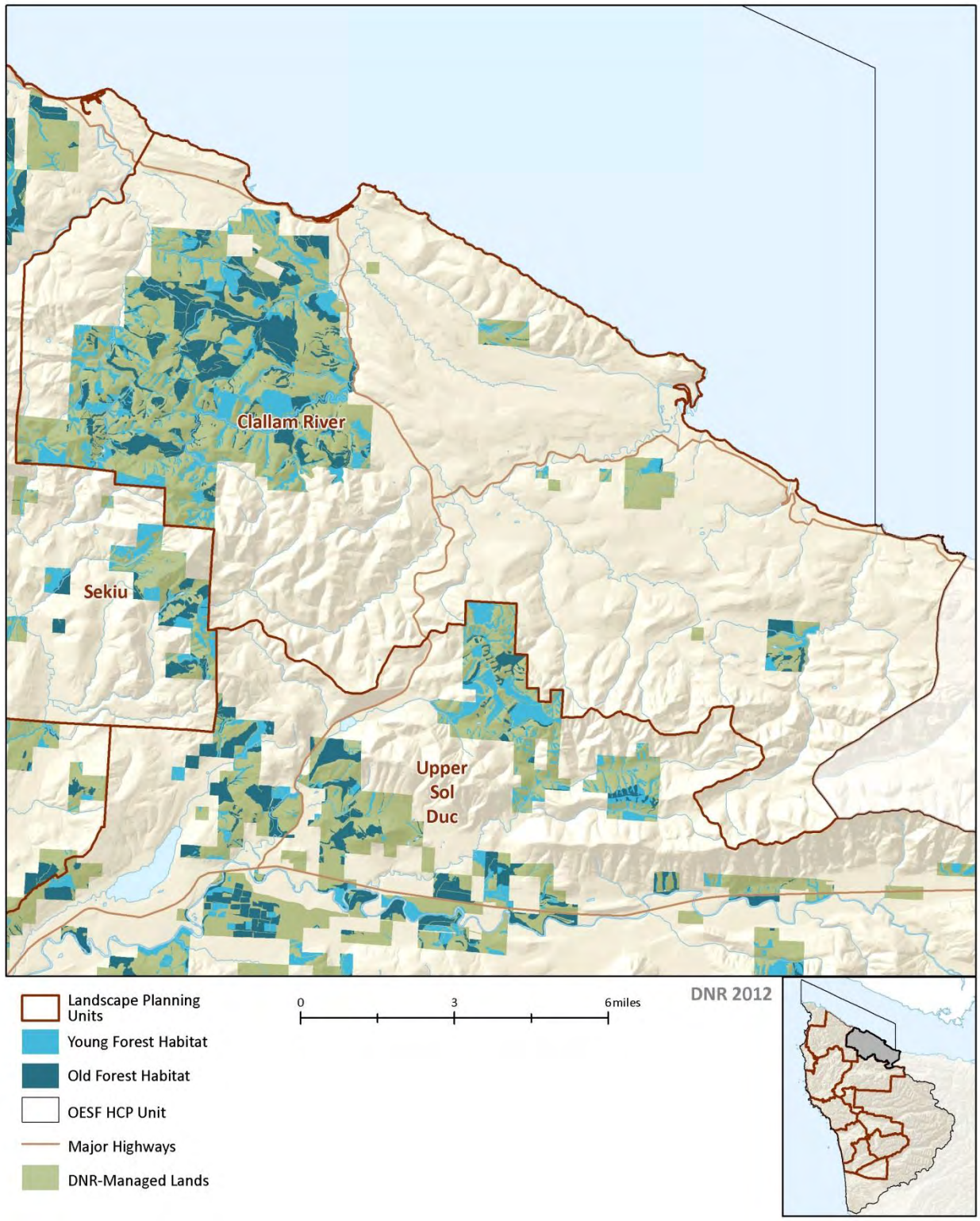
Map I-4. Old Forest and Young Forest Habitat on State Trust Lands in the Clallam Landscape, No Action Alternative, Decade 9



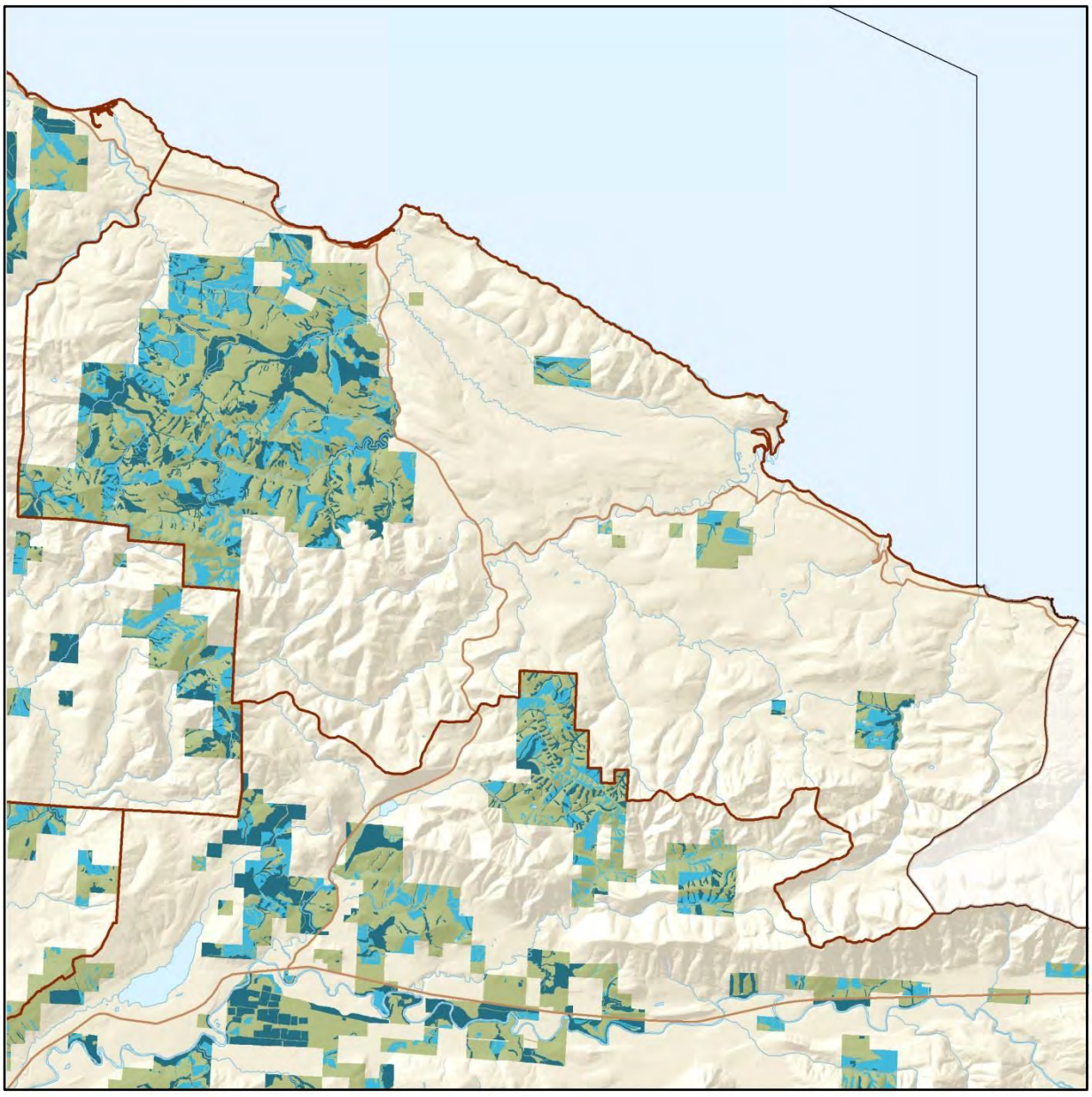
Map I-5. Old Forest and Young Forest Habitat on State Trust Lands in the Clallam Landscape, Landscape Alternative, Decade 1



Map I-6. Old Forest and Young Forest Habitat on State Trust Lands in the Clallam Landscape, Landscape Alternative, Decade 6

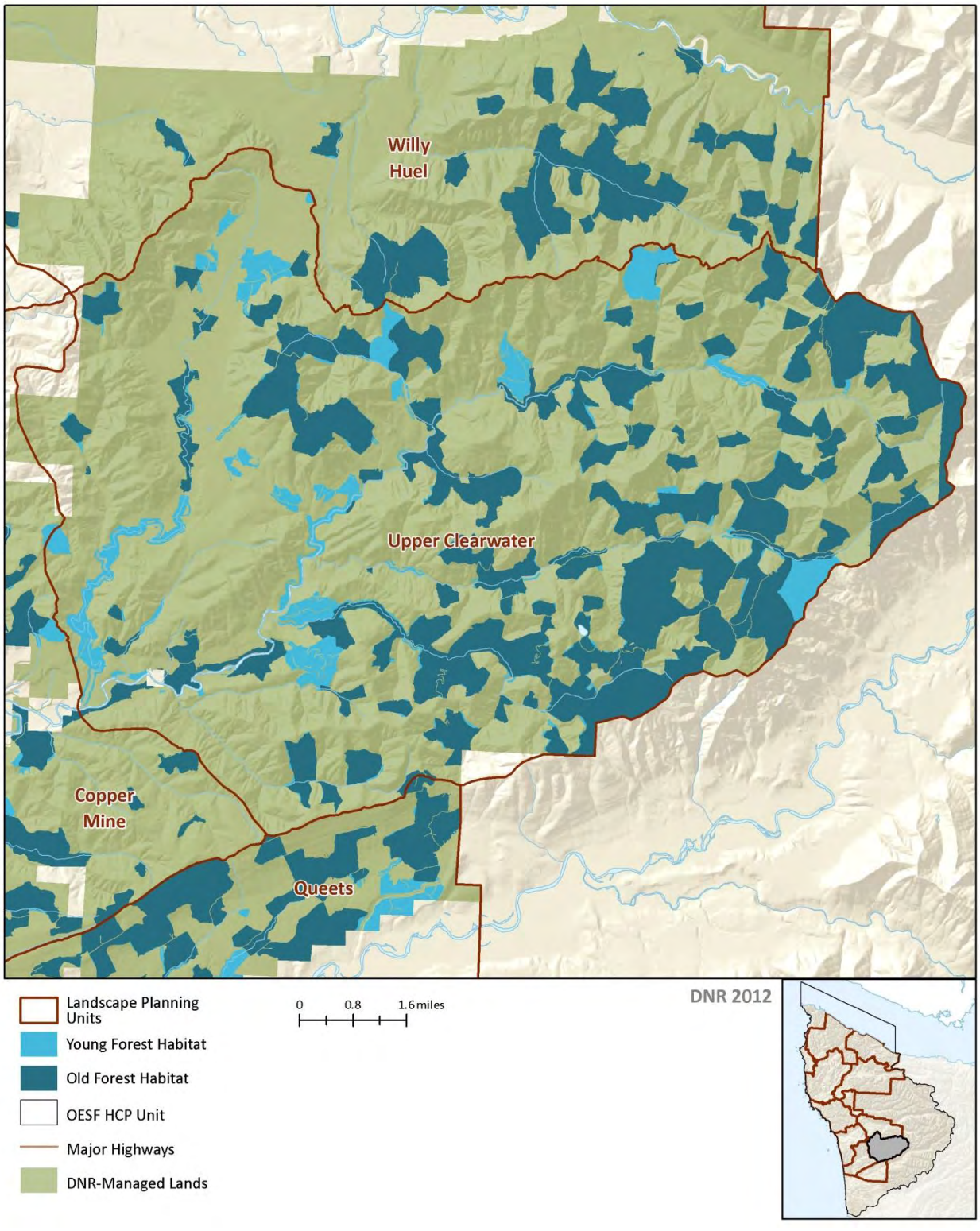


Map I-7. Old Forest and Young Forest Habitat on State Trust Lands in the Clallam Landscape, Landscape Alternative, Decade 9

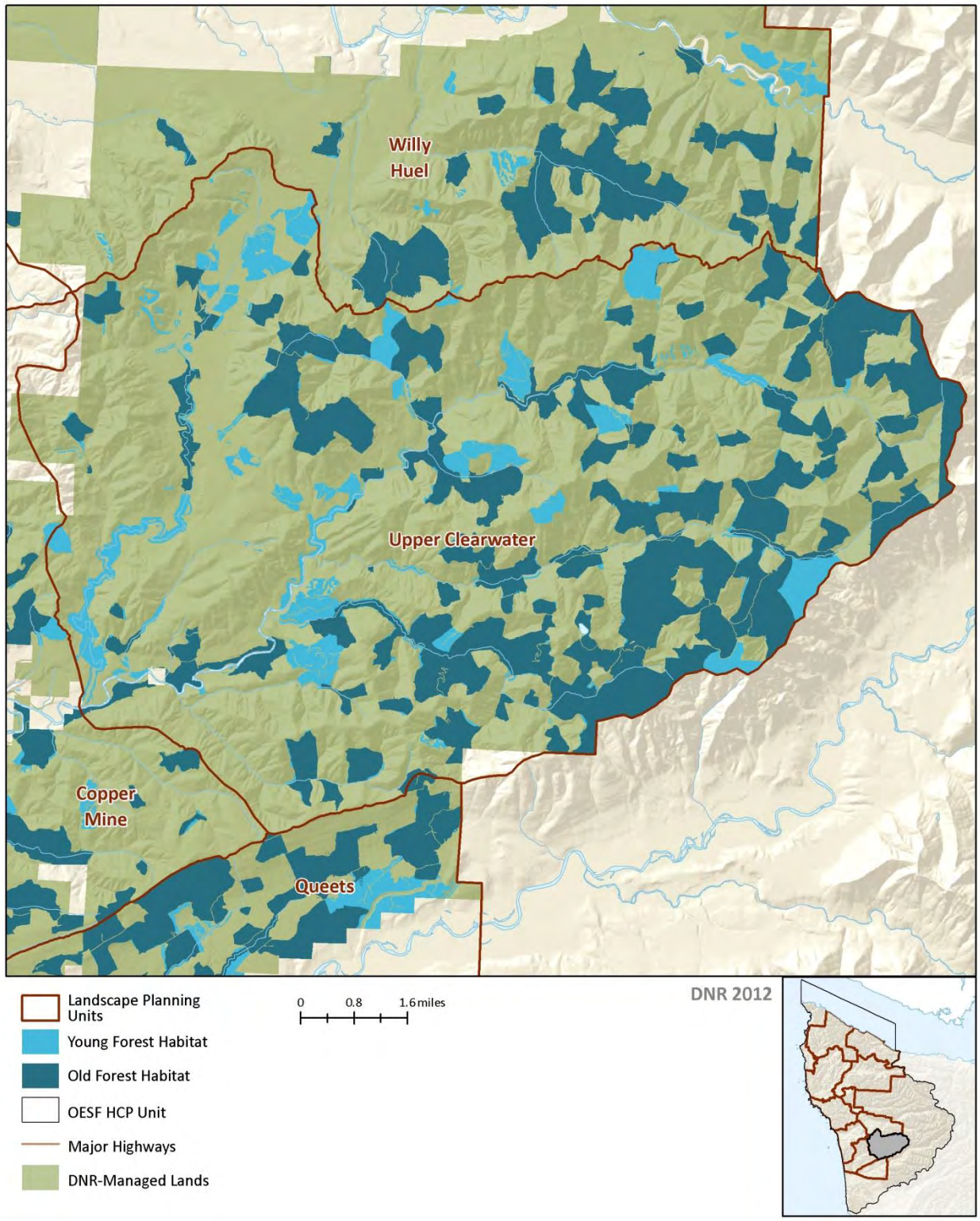


■ Clearwater Landscape Old Forest and Young Forest Habitat Maps

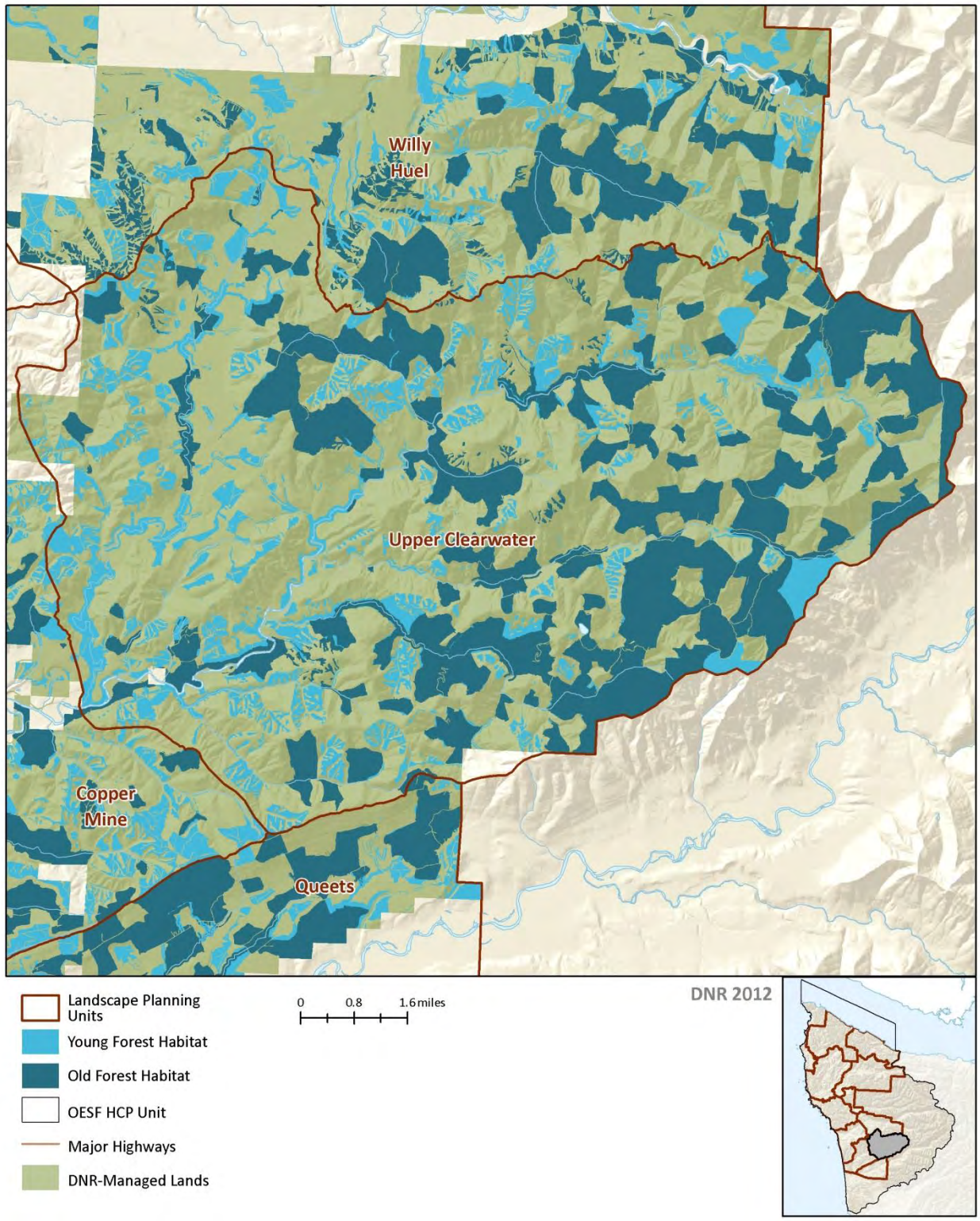
Map I-8. Old Forest and Young Forest Habitat on State Trust Lands in the Clearwater Landscape, Current Conditions



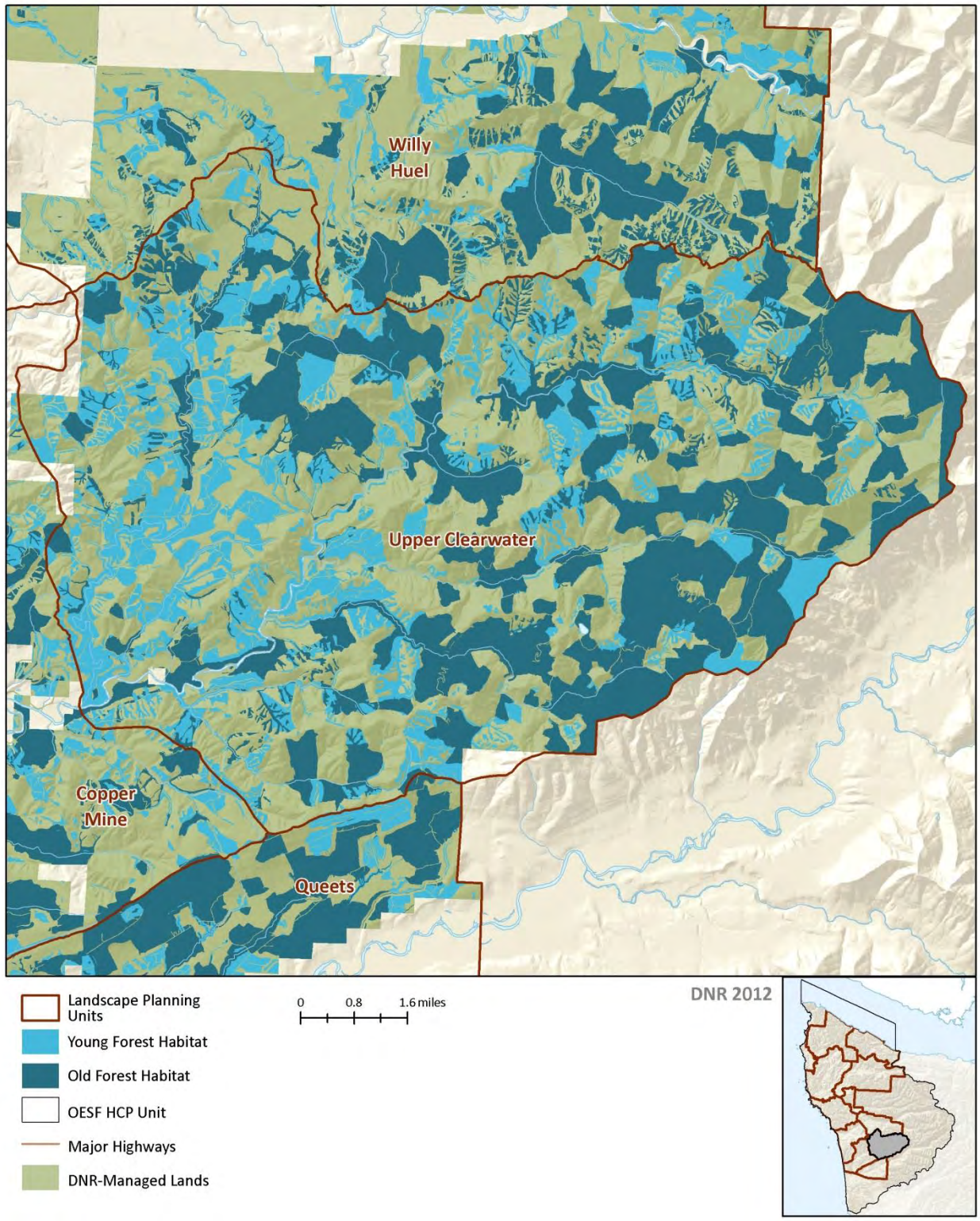
Map I-9. Old Forest and Young Forest Habitat on State Trust Lands in the Clearwater Landscape, No Action Alternative, Decade 1



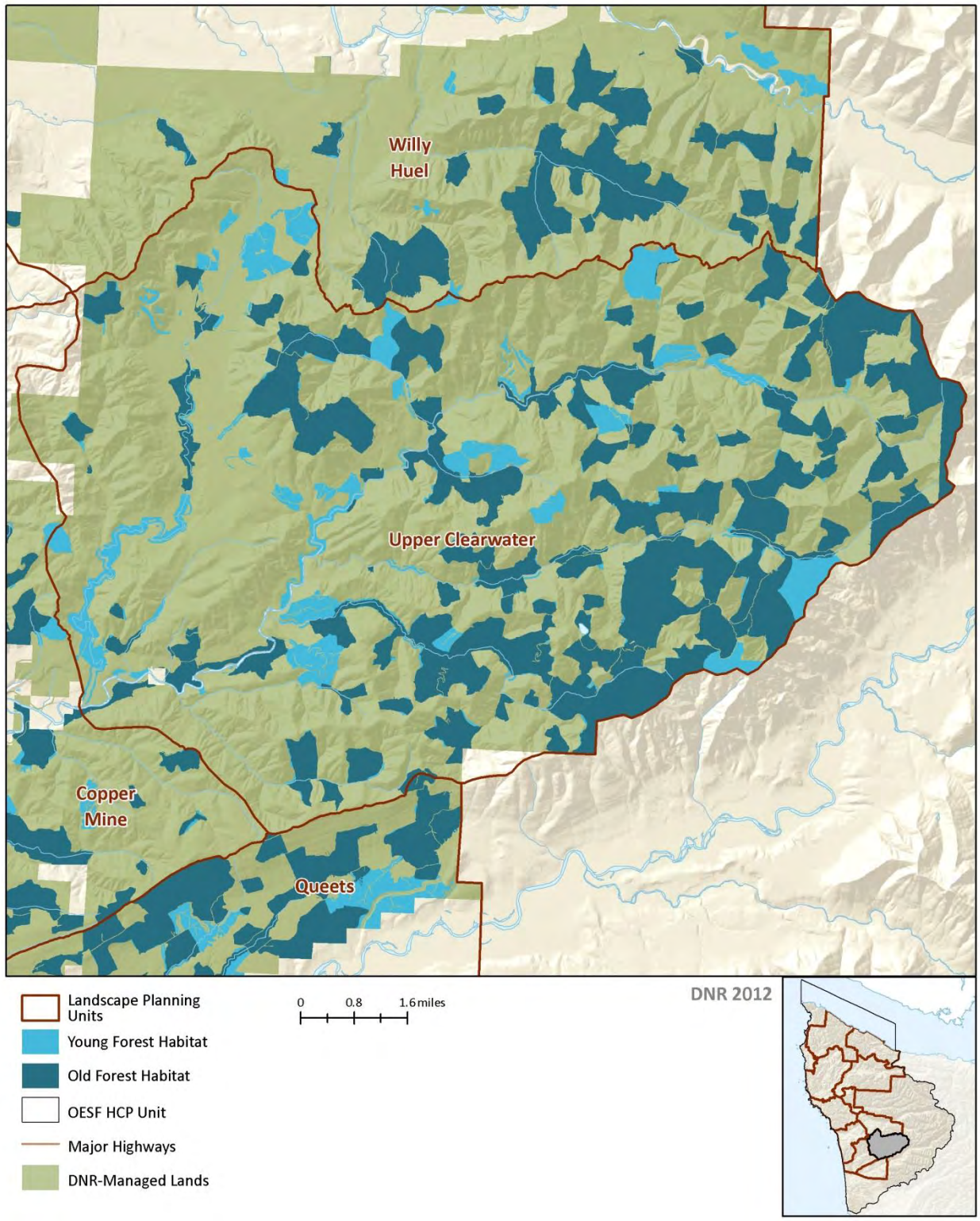
Map I-10. Old Forest and Young Forest Habitat on State Trust Lands in the Clearwater Landscape, No Action Alternative, Decade 6



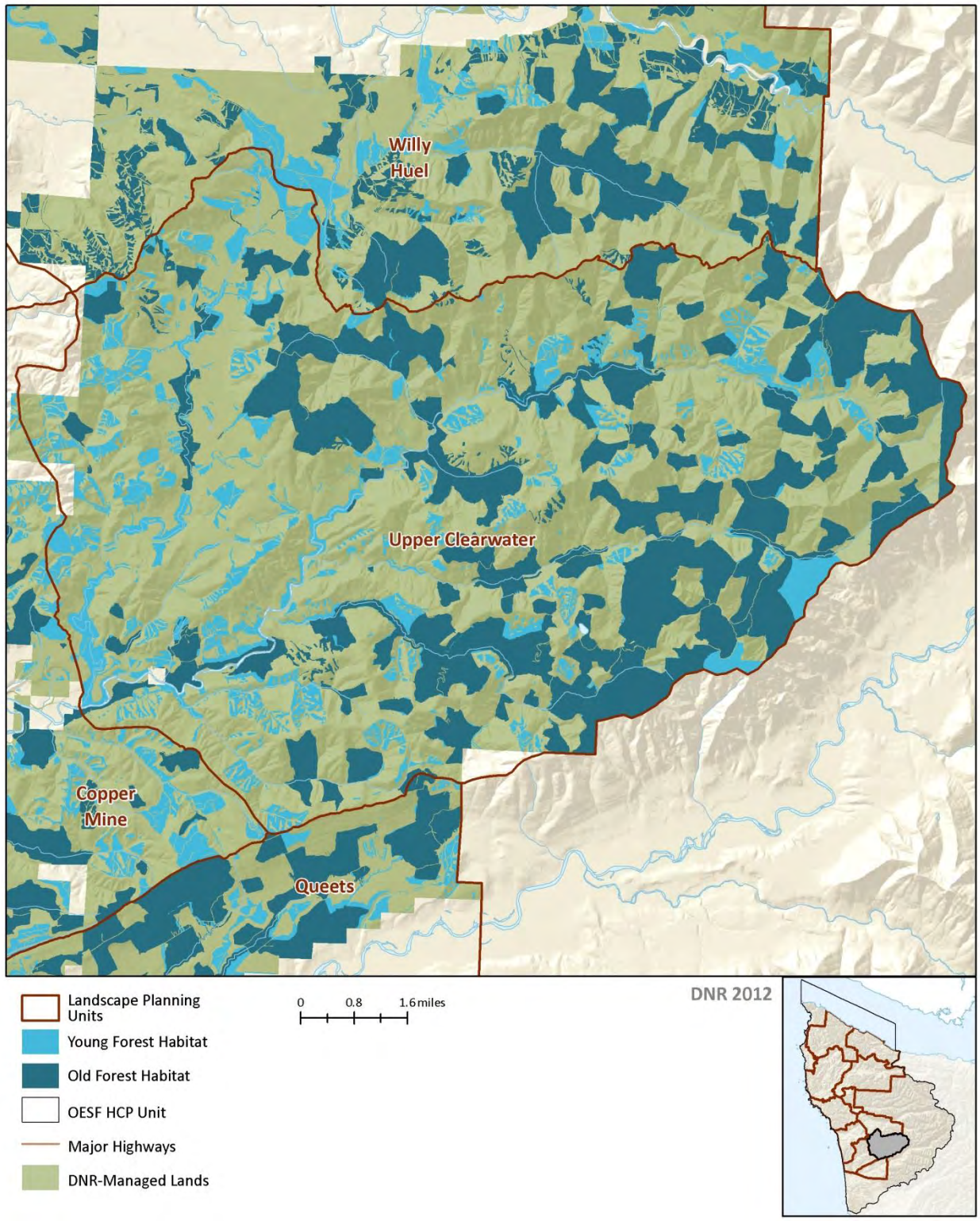
Map I-11. Old Forest and Young Forest Habitat on State Trust Lands in the Clearwater Landscape, No Action Alternative, Decade 9



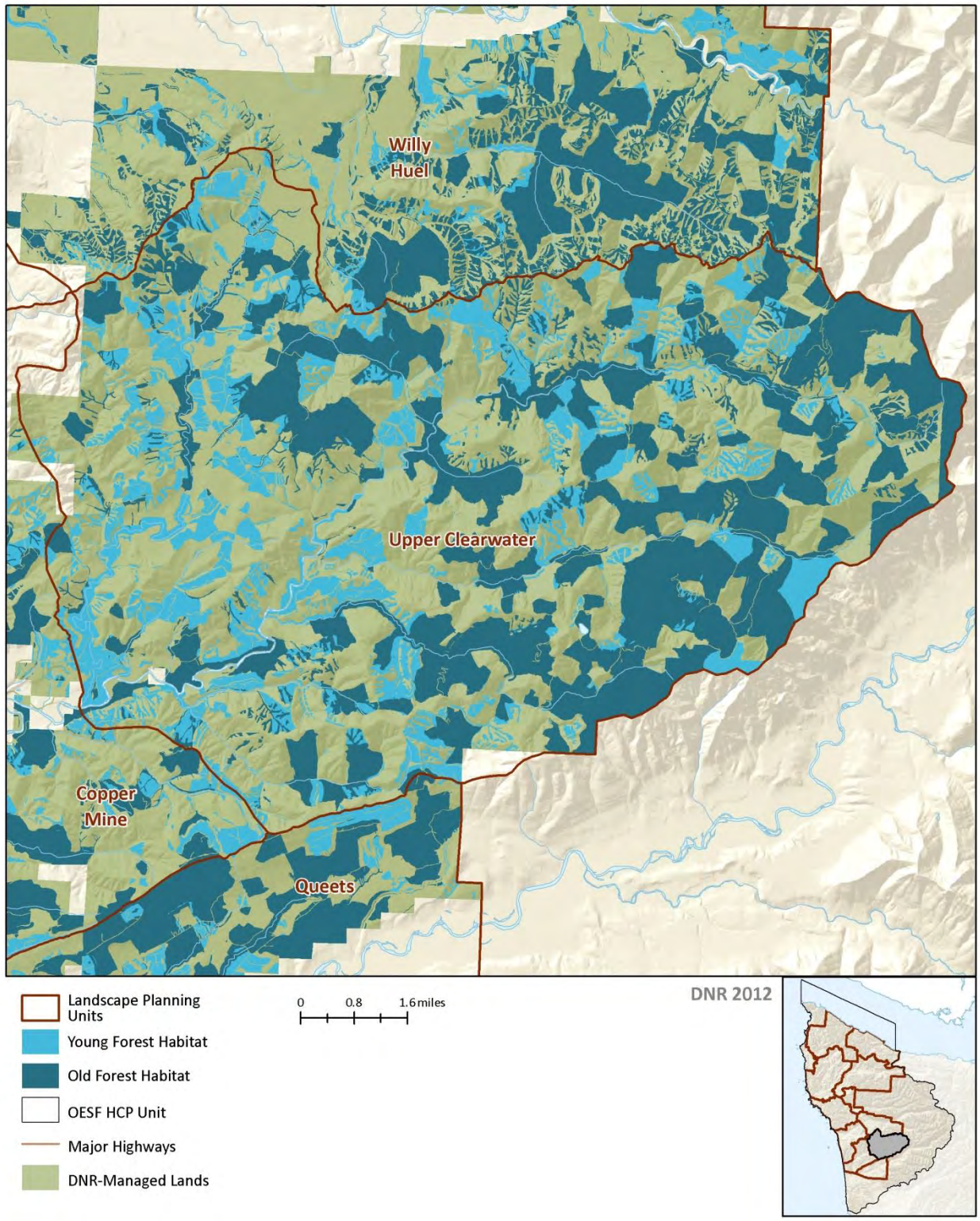
Map I-12. Old Forest and Young Forest Habitat on State Trust Lands in the Clearwater Landscape, Landscape Alternative, Decade 1



Map I-13. Old Forest and Young Forest Habitat on State Trust Lands in the Clearwater Landscape, Landscape Alternative, Decade 6

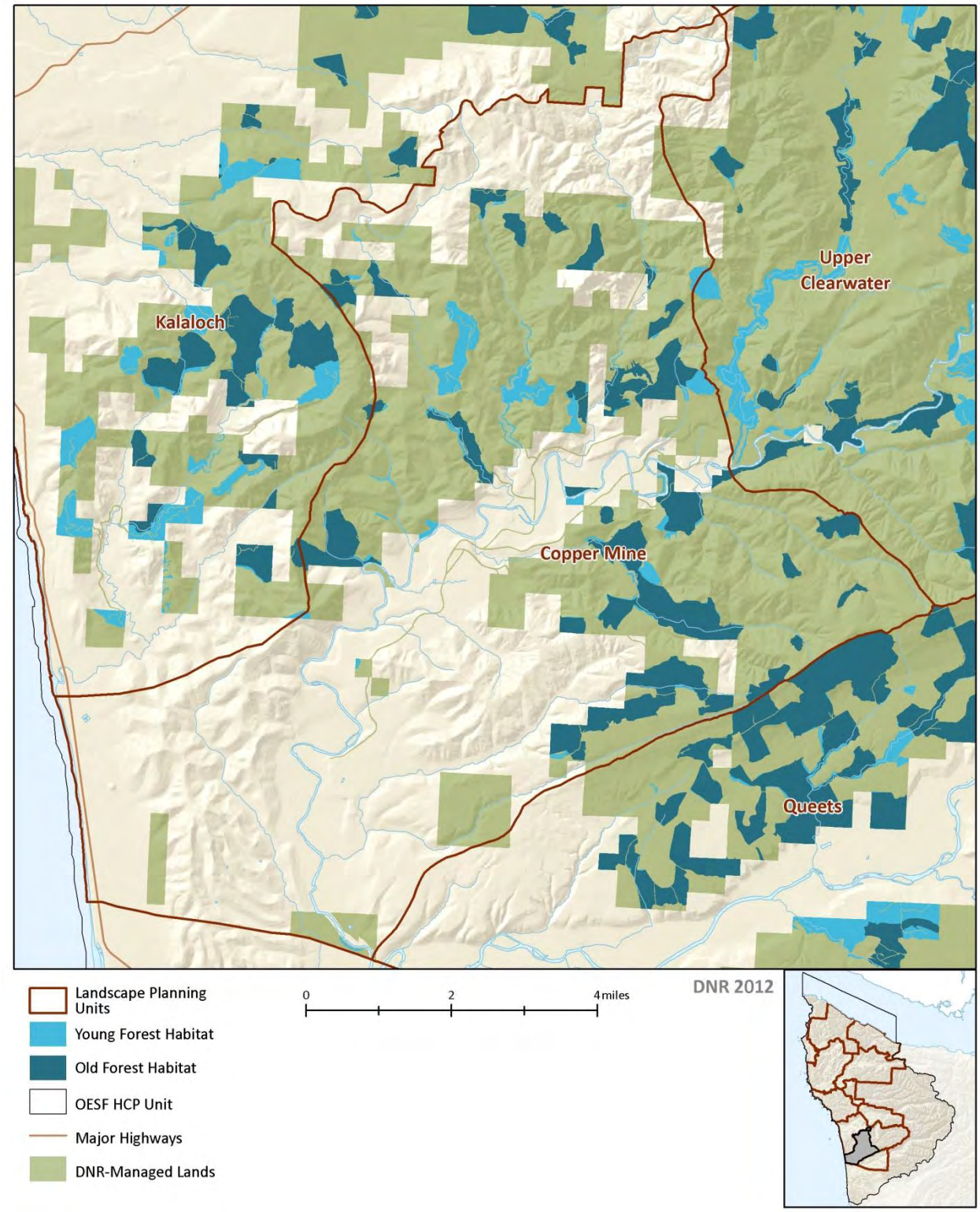


Map I-14. Old Forest and Young Forest Habitat on State Trust Lands in the Clearwater Landscape, Landscape Alternative, Decade 9

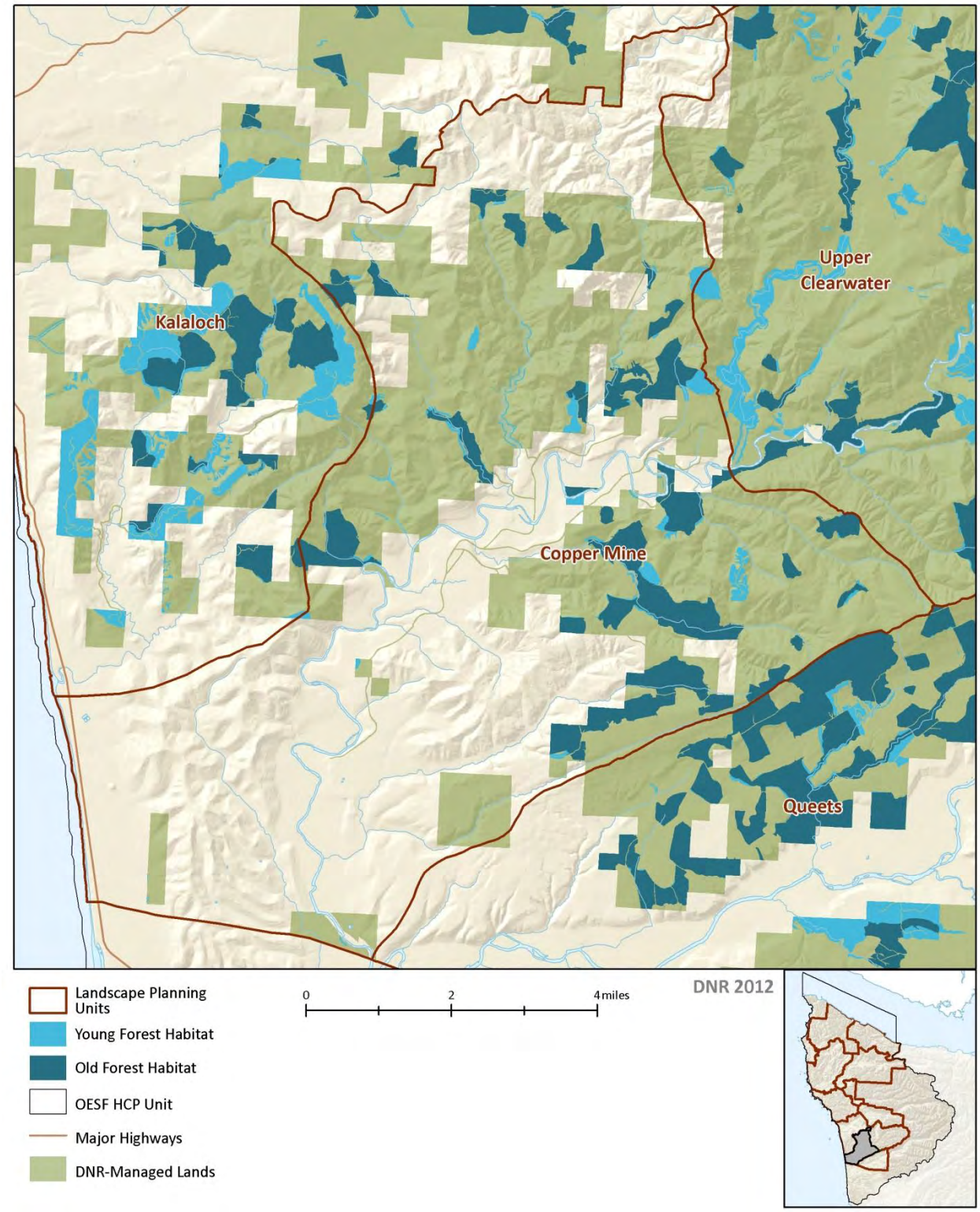


■ Coppermine Landscape Old Forest and Young Forest Habitat Maps

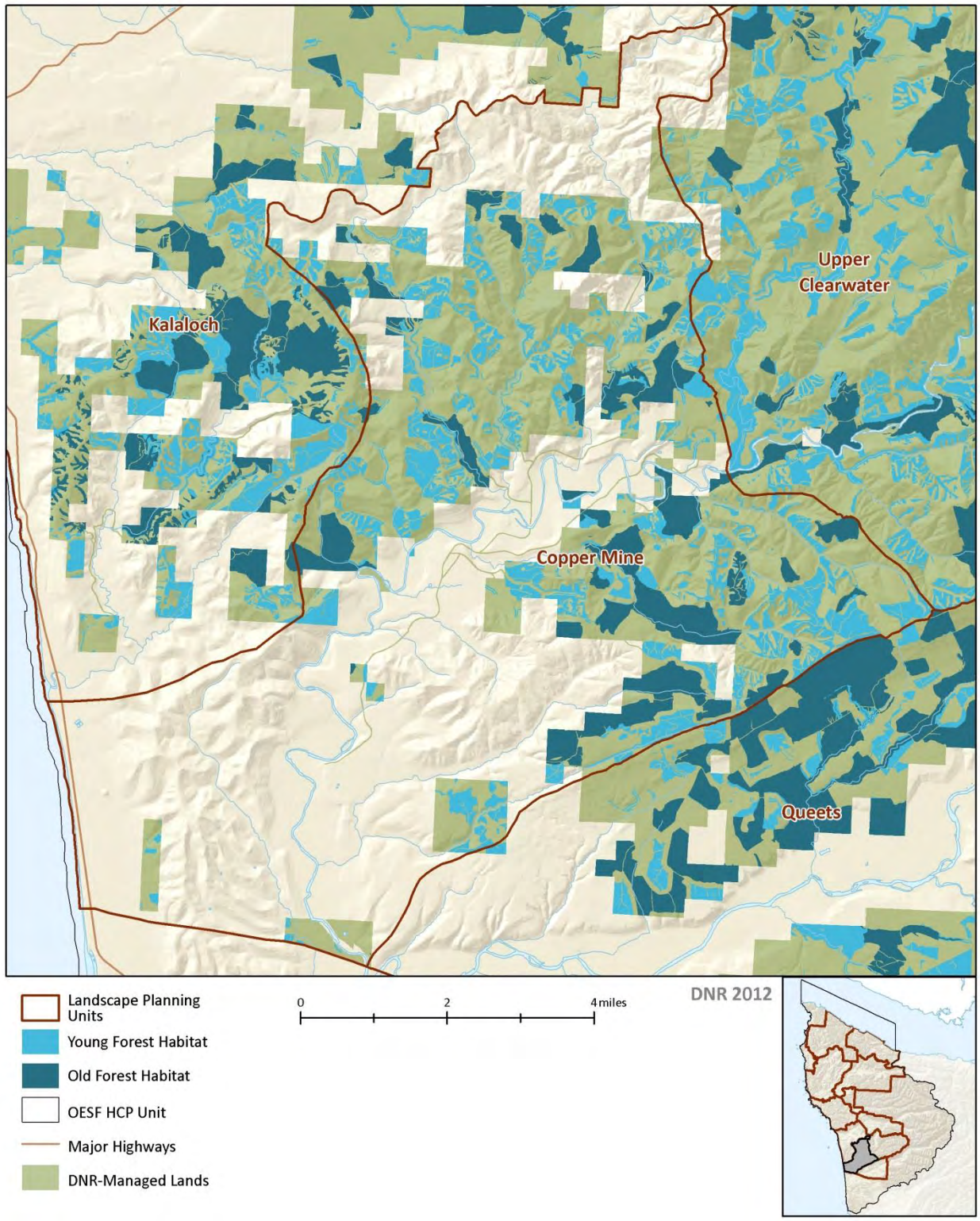
Map I-15. Old Forest and Young Forest Habitat on State Trust Lands in the Coppermine Landscape, Current Conditions



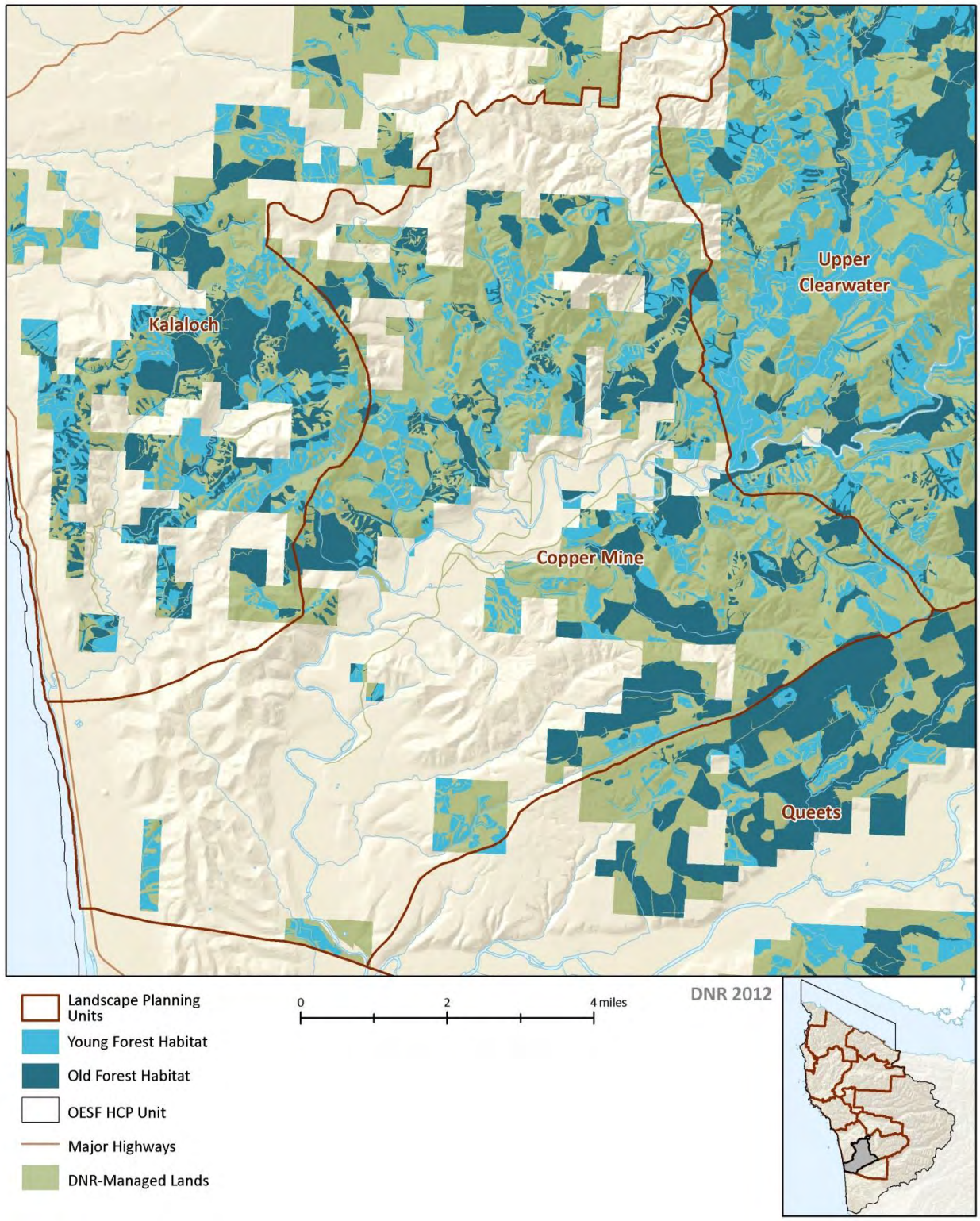
Map I-16. Old Forest and Young Forest Habitat on State Trust Lands in the Coppermine Landscape, No Action Alternative, Decade 1



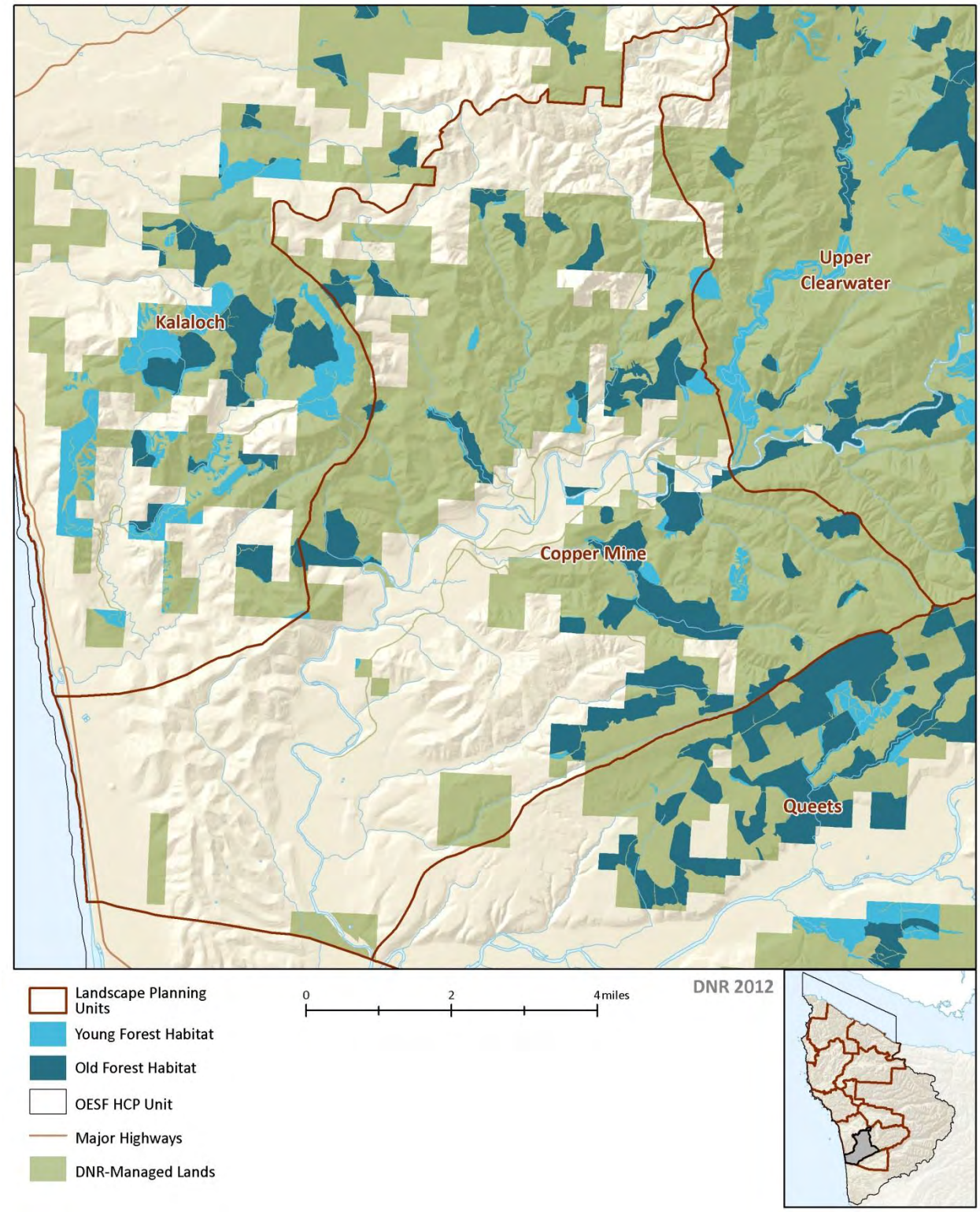
Map I-17. Old Forest and Young Forest Habitat on State Trust Lands in the Coppermine Landscape, No Action Alternative, Decade 6



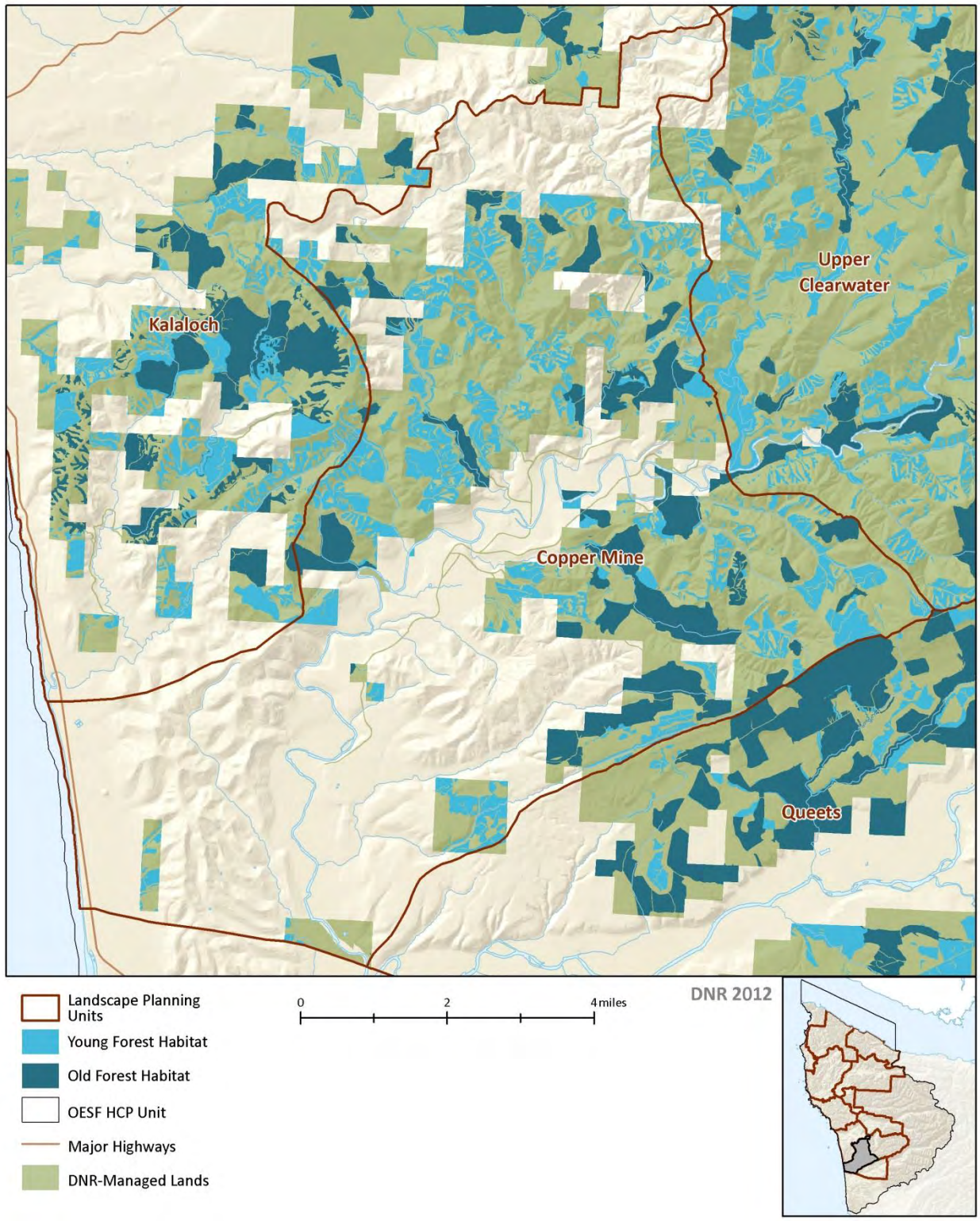
Map I-18. Old Forest and Young Forest Habitat on State Trust Lands in the Coppermine Landscape, No Action Alternative, Decade 9



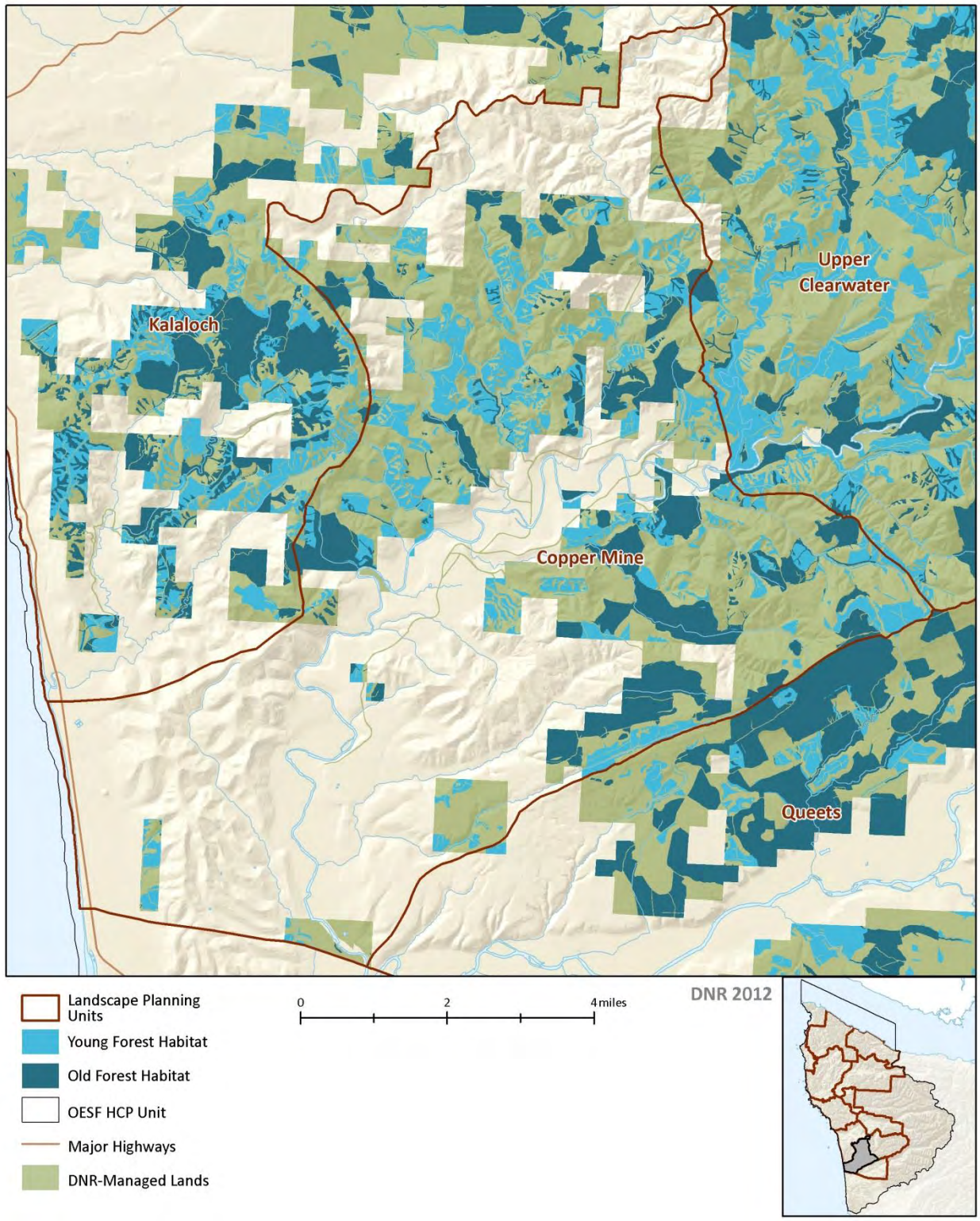
Map I-19. Old Forest and Young Forest Habitat on State Trust Lands in the Coppermine Landscape, Landscape Alternative, Decade 1



Map I-20. Old Forest and Young Forest Habitat on State Trust Lands in the Coppermine Landscape, Landscape Alternative, Decade 6

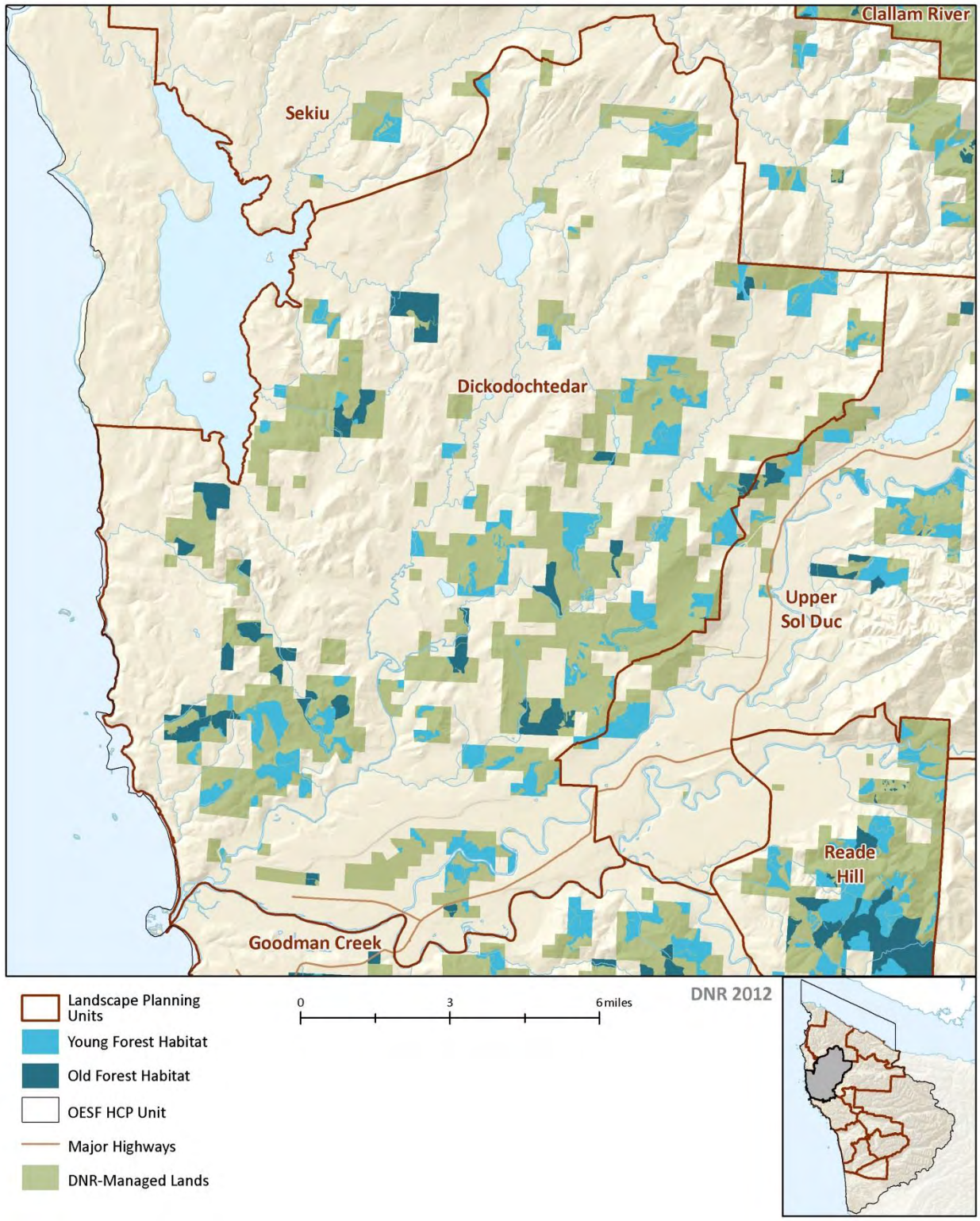


Map I-21. Old Forest and Young Forest Habitat on State Trust Lands in the Coppermine Landscape, Landscape Alternative, Decade 9

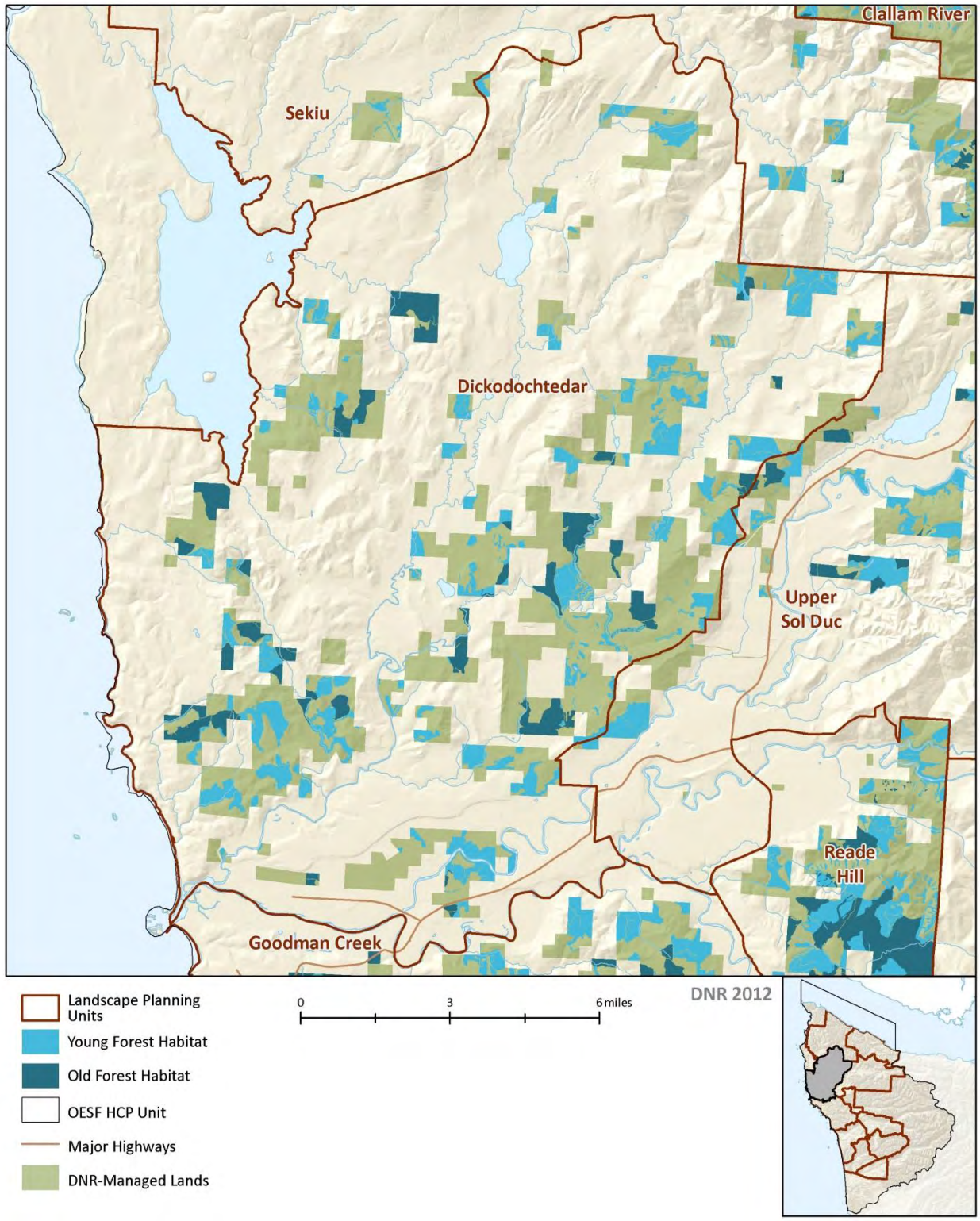


■ Dickodochtedar Landscape Old Forest and Young Forest Habitat Maps

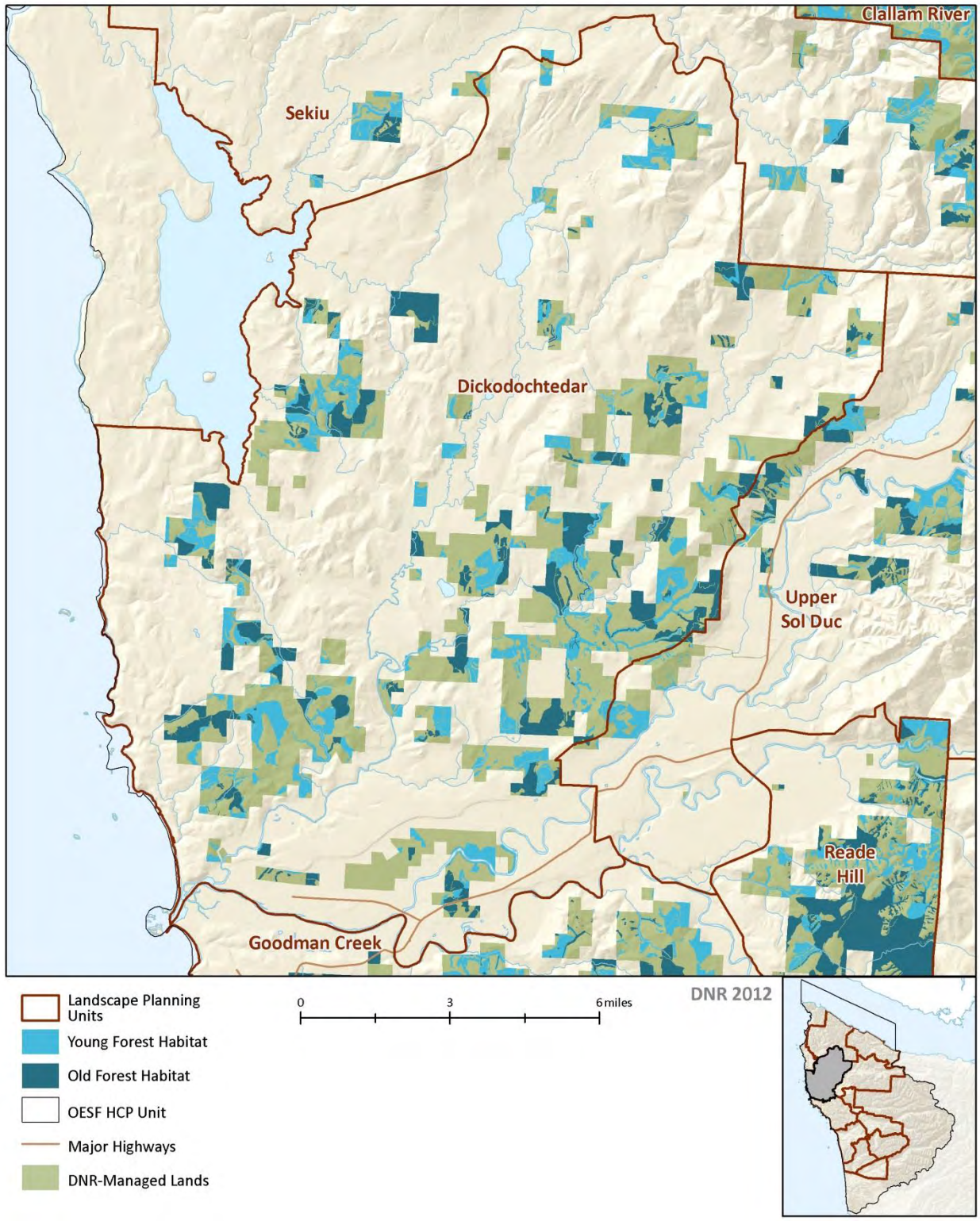
Map I-22. Old Forest and Young Forest Habitat on State Trust Lands in the Dickodochtedar Landscape, Current Conditions



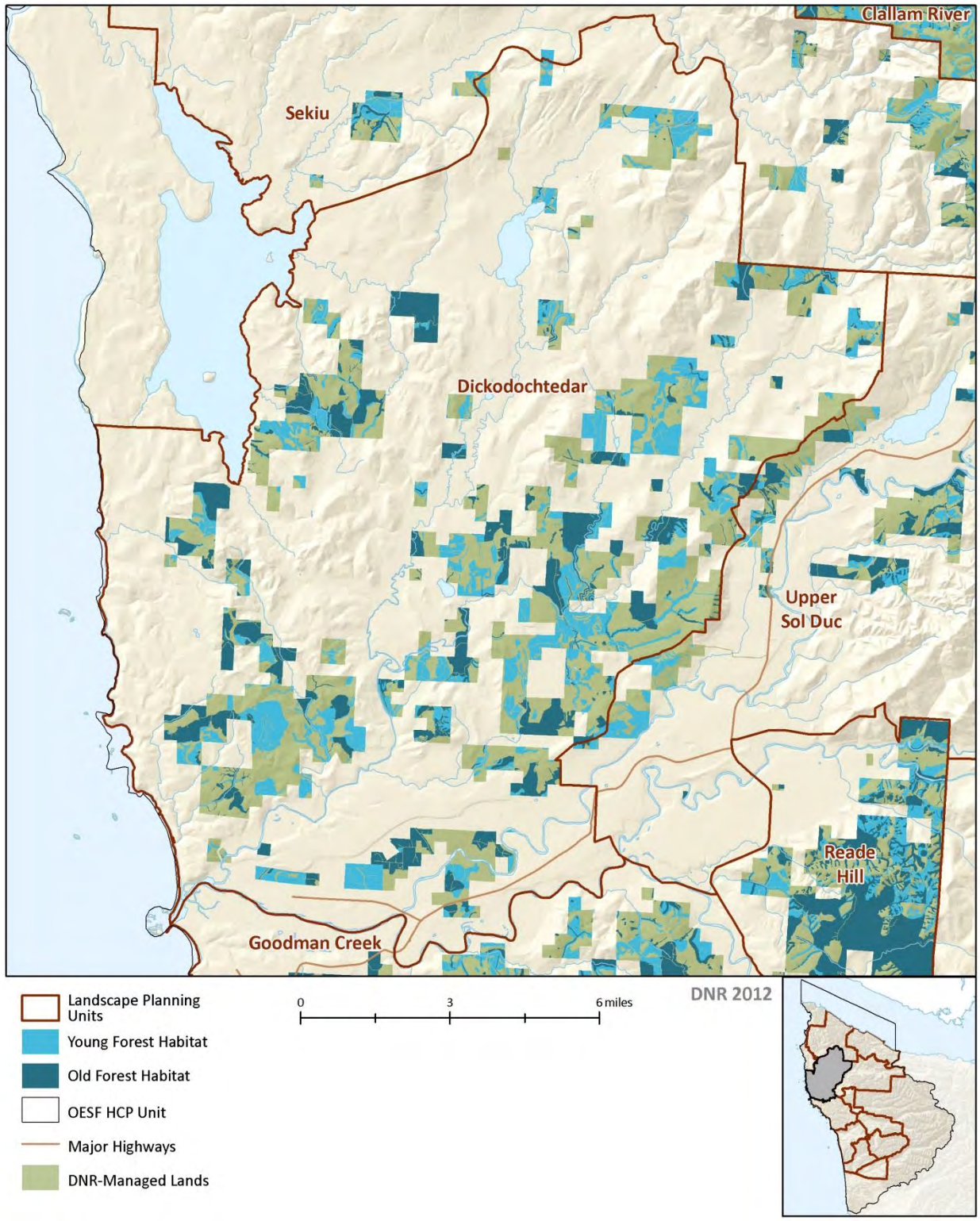
Map I-23. Old Forest and Young Forest Habitat on State Trust Lands in the Dickodochtedar Landscape, No Action Alternative, Decade 1



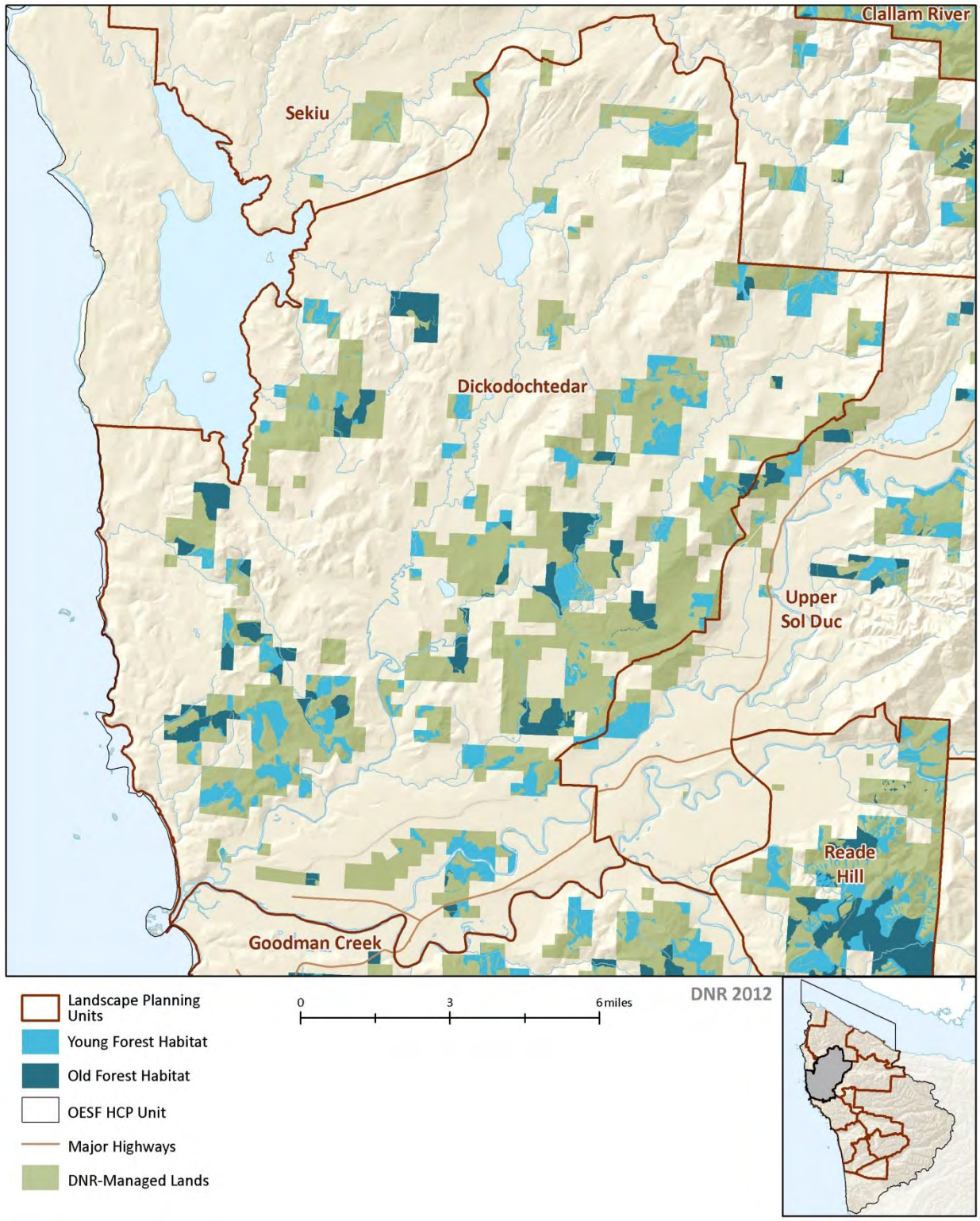
Map I-24. Old Forest and Young Forest Habitat on State Trust Lands in the Dickodochtedar Landscape, No Action Alternative, Decade 6



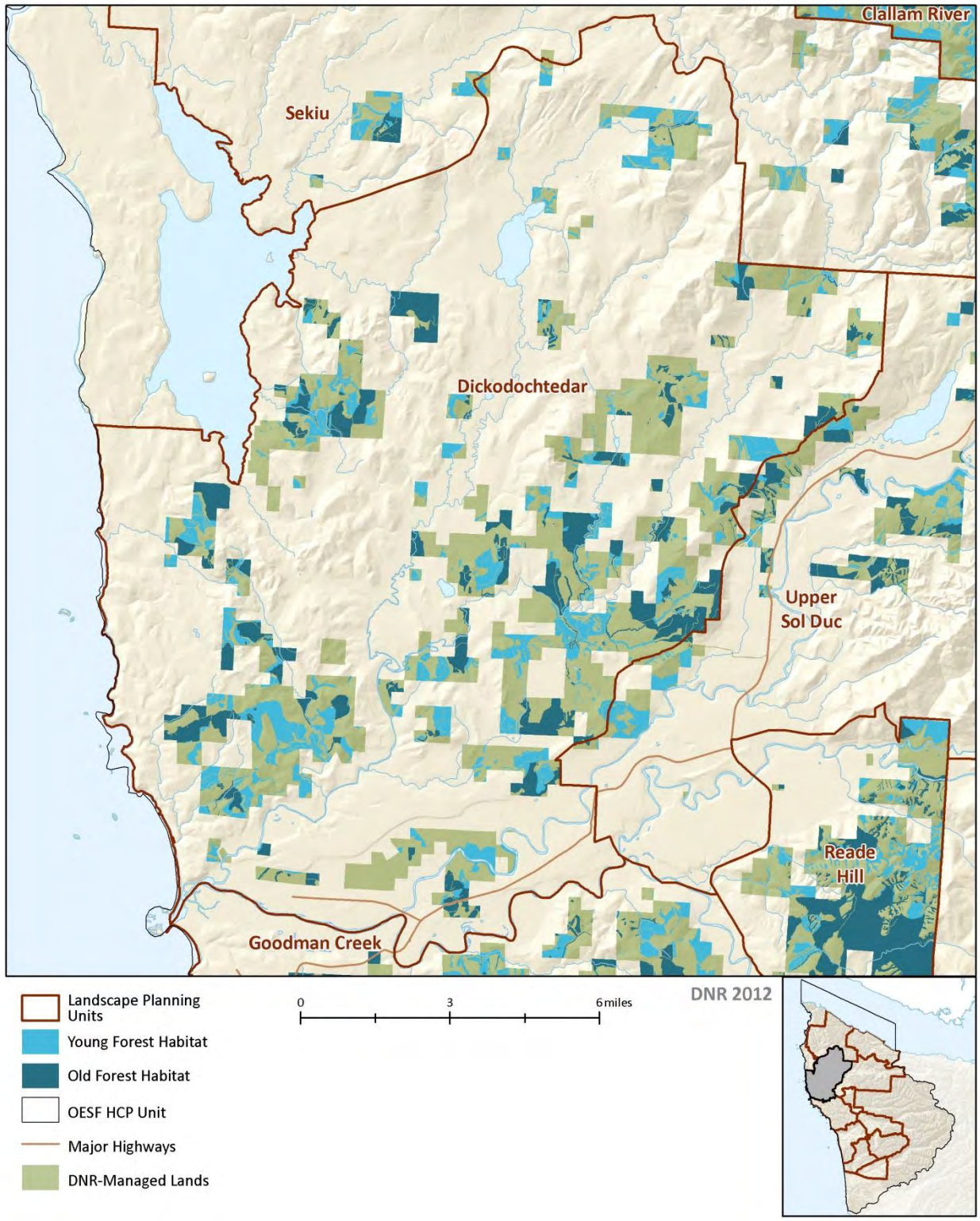
Map I-25. Old Forest and Young Forest Habitat on State Trust Lands in the Dickodochtedar Landscape, No Action Alternative, Decade 9



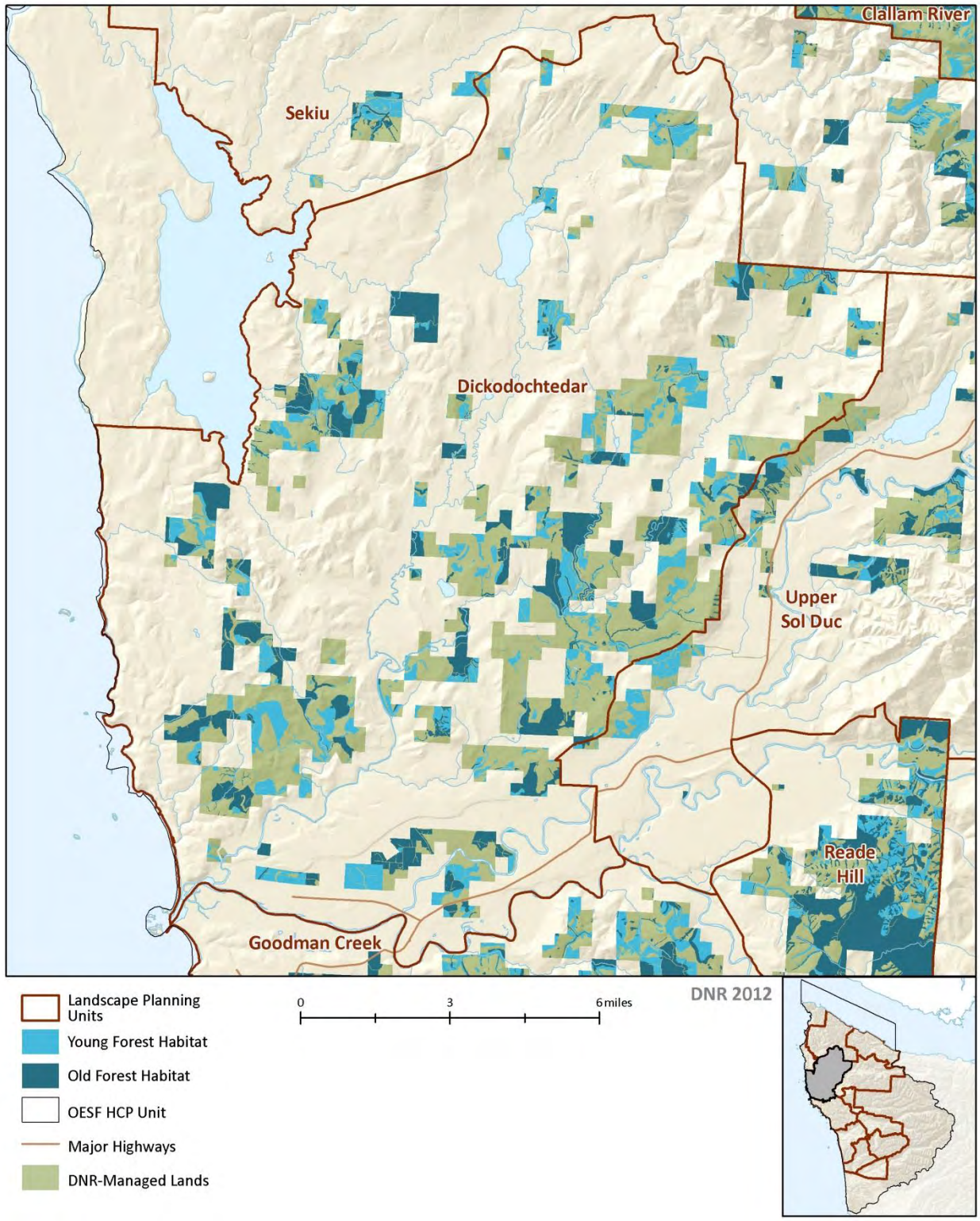
Map I-26. Old Forest and Young Forest Habitat on State Trust Lands in the Dickodochtedar Landscape, Landscape Alternative, Decade 1



Map I-27. Old Forest and Young Forest Habitat on State Trust Lands in the Dickodochtedar Landscape, Landscape Alternative, Decade 6

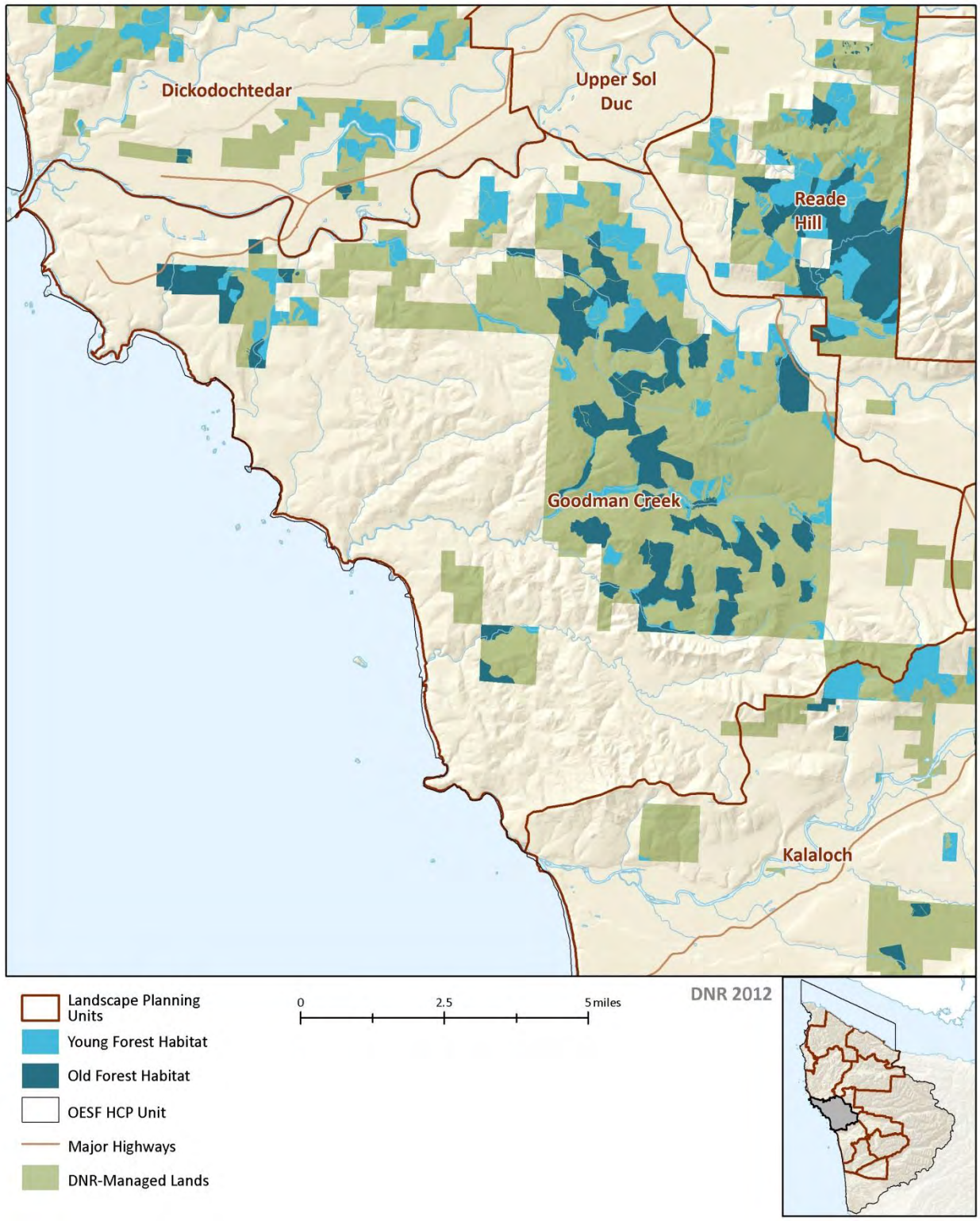


Map I-28. Old Forest and Young Forest Habitat on State Trust Lands in the Dickodochtedar Landscape, Landscape Alternative, Decade 9

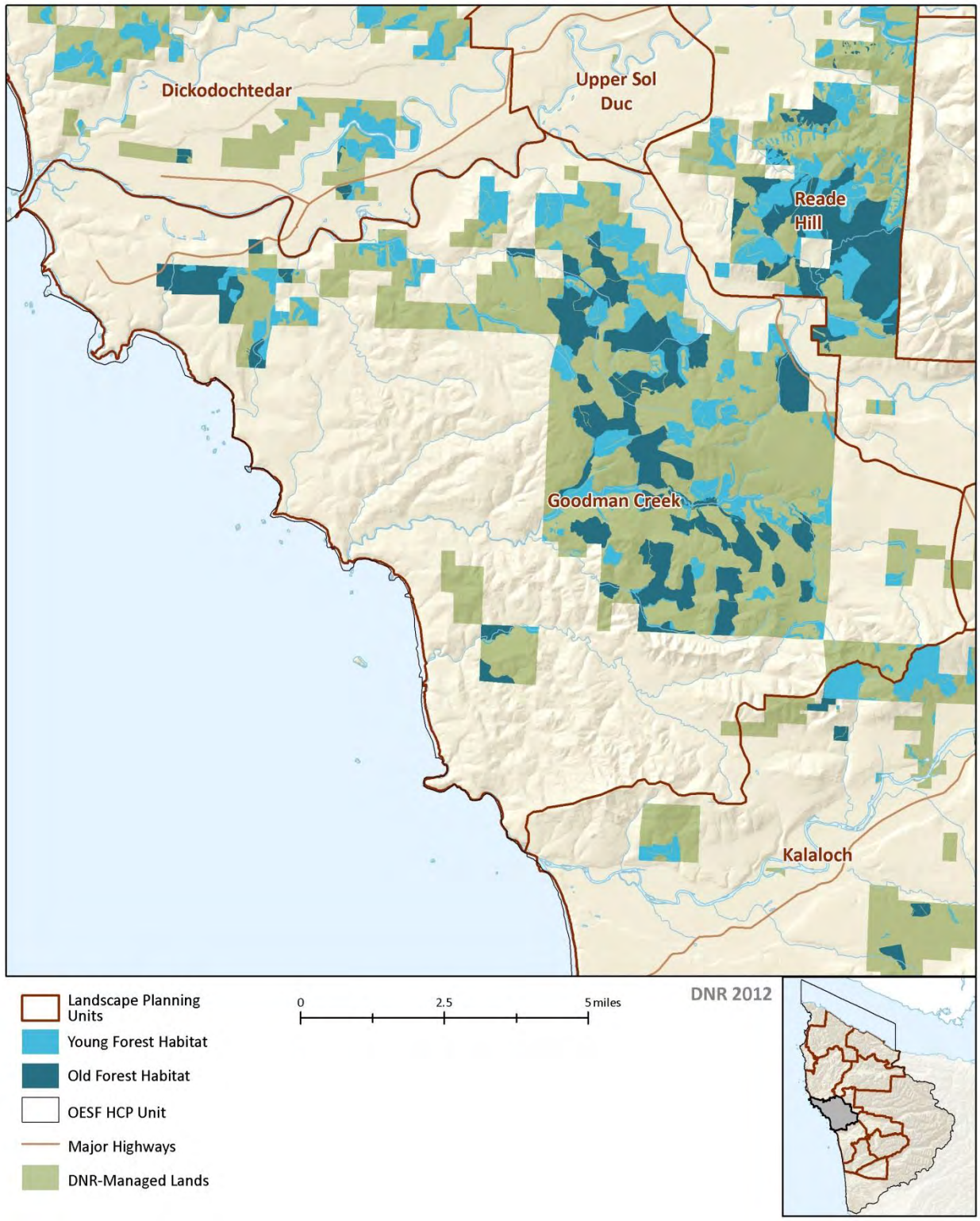


■ Goodman Landscape Old Forest and Young Forest Habitat Maps

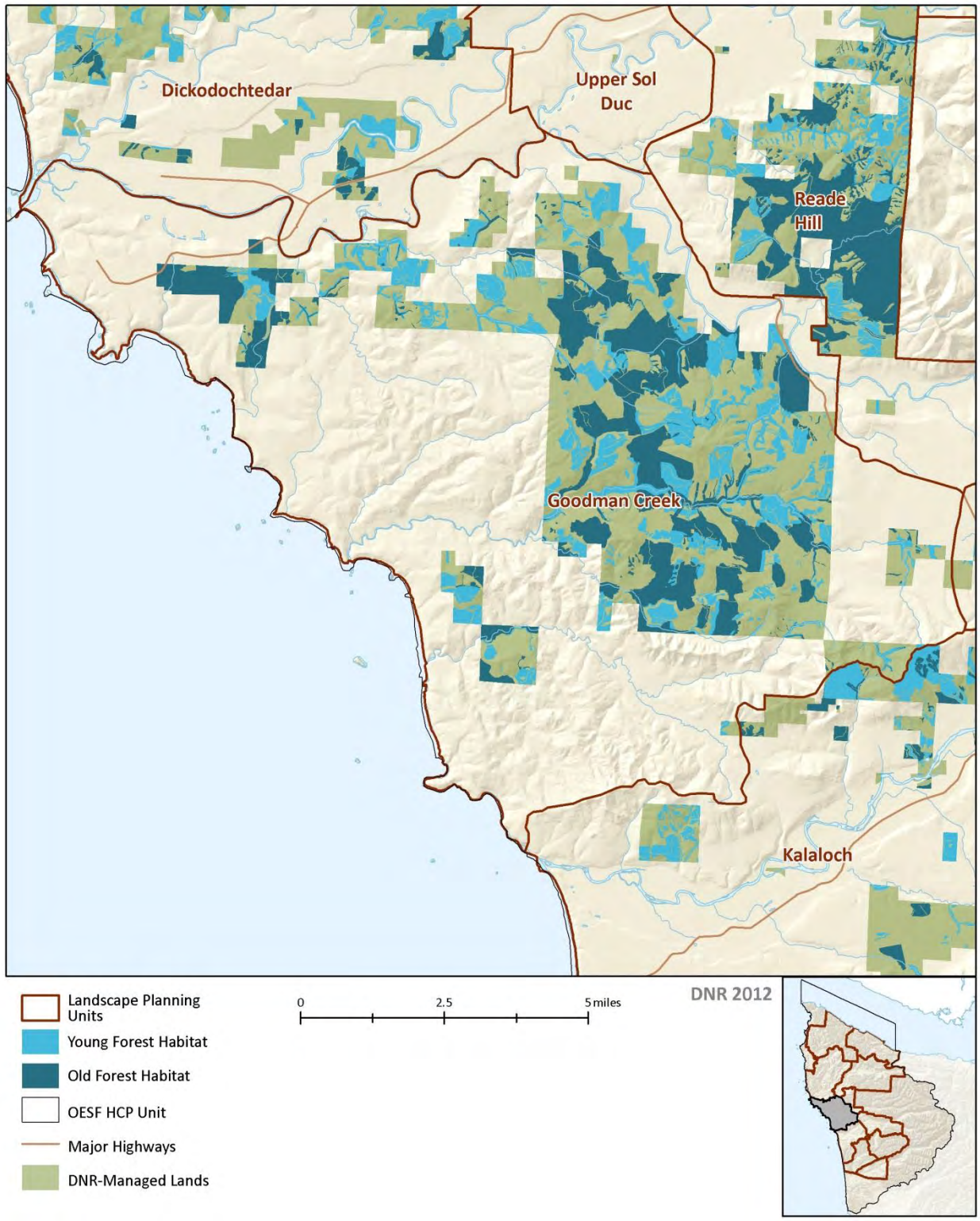
Map I-29. Old Forest and Young Forest Habitat on State Trust Lands in the Goodman Landscape, Current Conditions



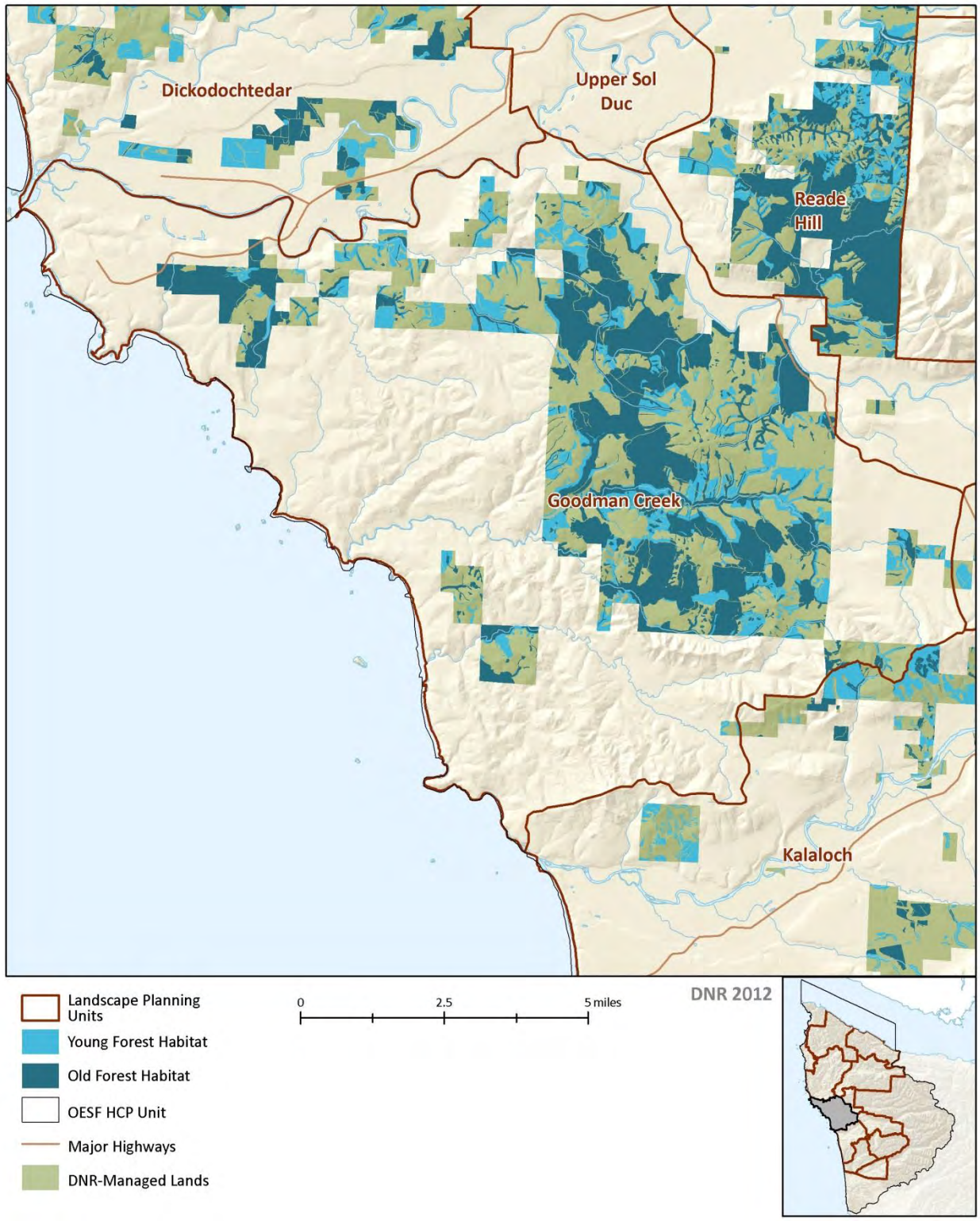
Map I-30. Old Forest and Young Forest Habitat on State Trust Lands in the Goodman Landscape, No Action Alternative, Decade 1



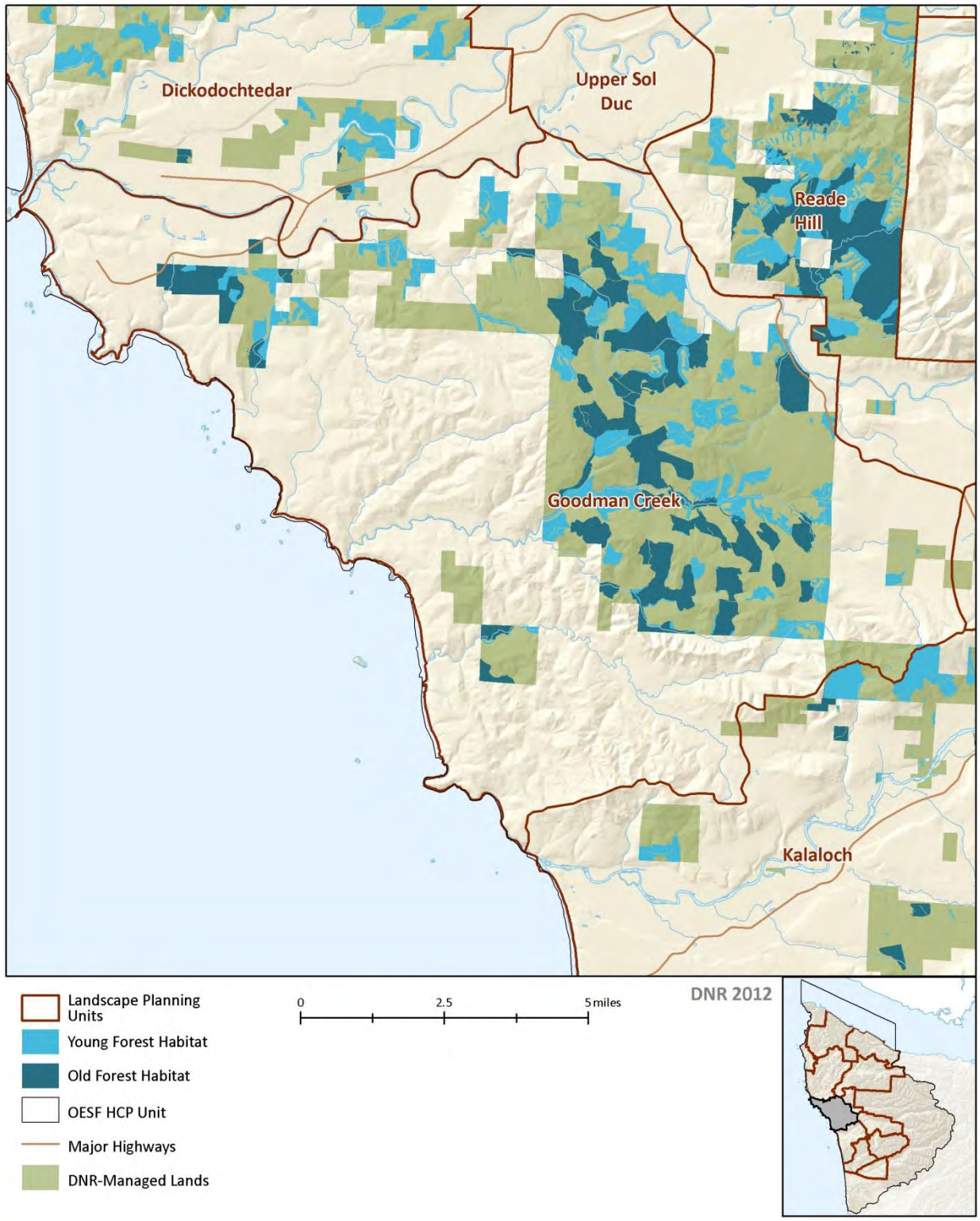
Map I-31. Old Forest and Young Forest Habitat on State Trust Lands in the Goodman Landscape, No Action Alternative, Decade 6



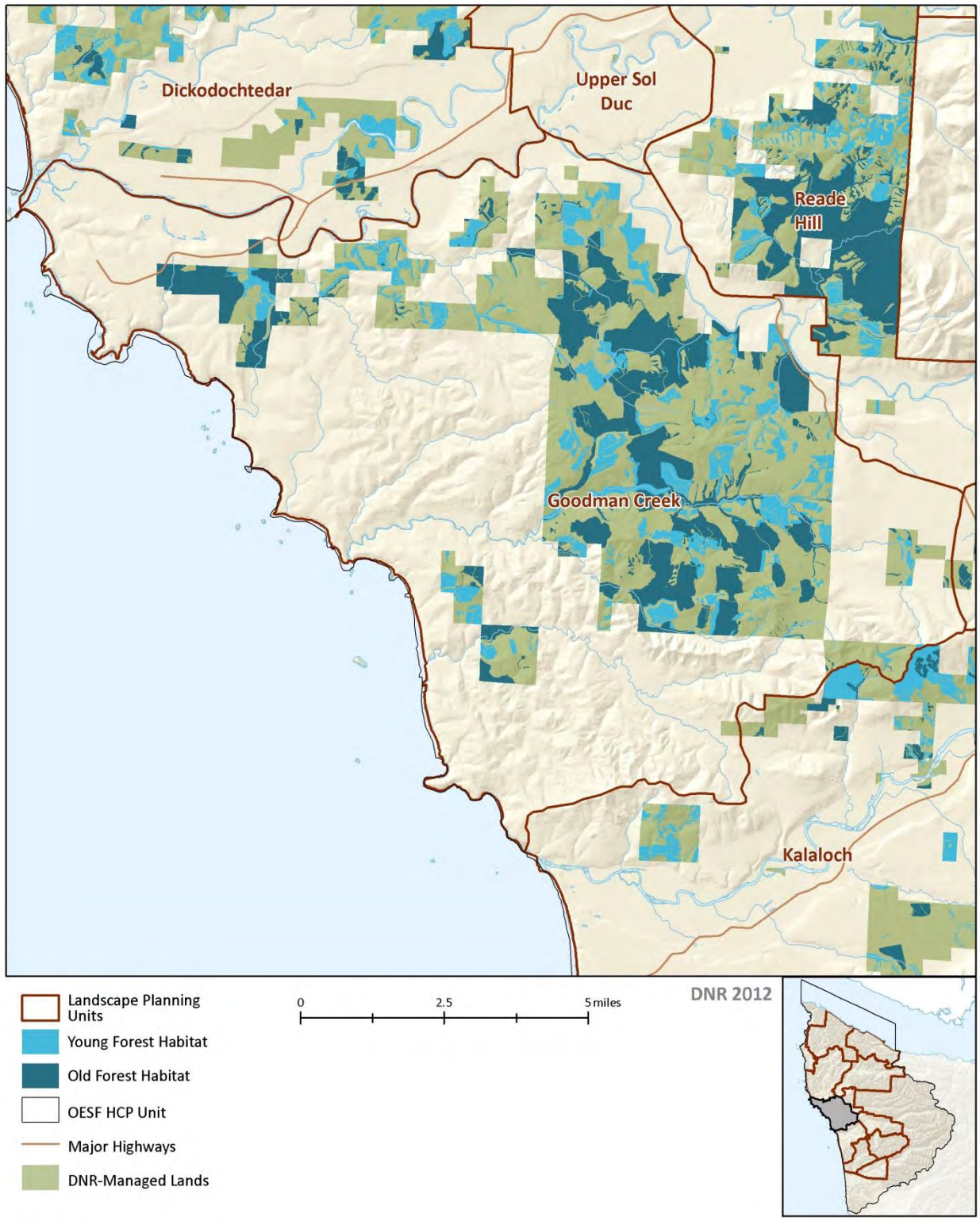
Map I-32. Old Forest and Young Forest Habitat on State Trust Lands in the Goodman Landscape, No Action Alternative, Decade 9



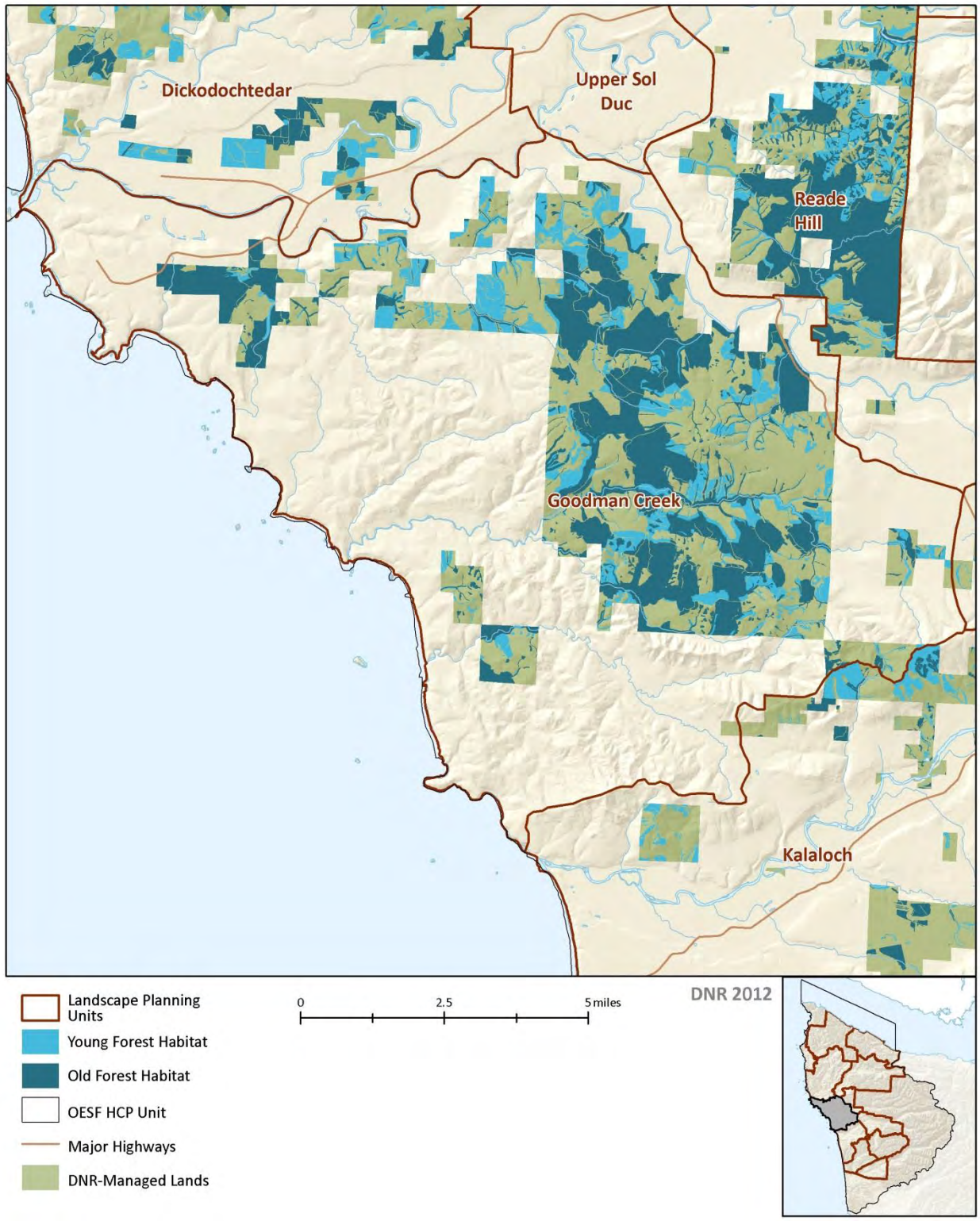
Map I-33. Old Forest and Young Forest Habitat on State Trust Lands in the Goodman Landscape, Landscape Alternative, Decade 1



Map I-34. Old Forest and Young Forest Habitat on State Trust Lands in the Goodman Landscape, Landscape Alternative, Decade 6

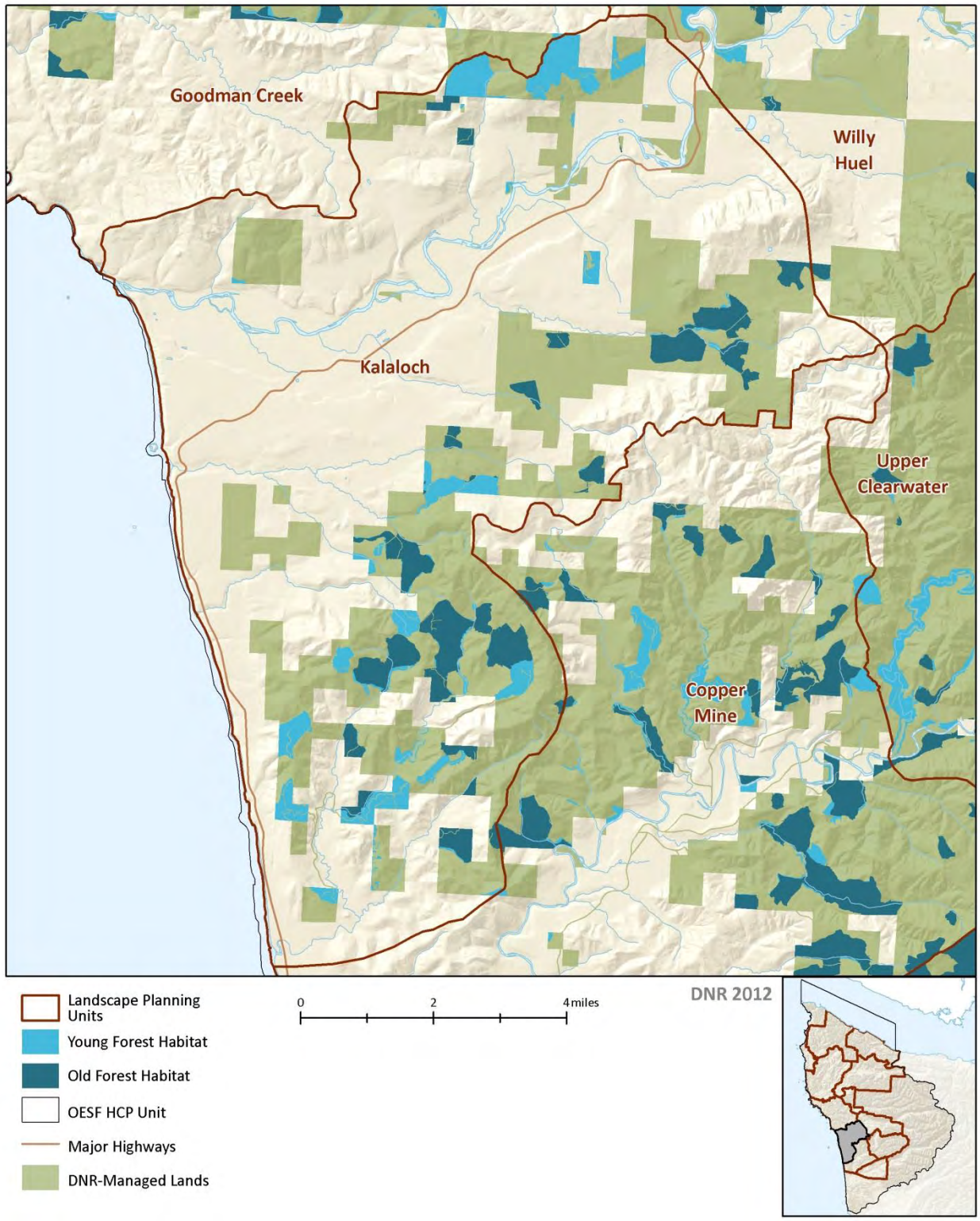


Map I-35. Old Forest and Young Forest Habitat on State Trust Lands in the Goodman Landscape, Landscape Alternative, Decade 9

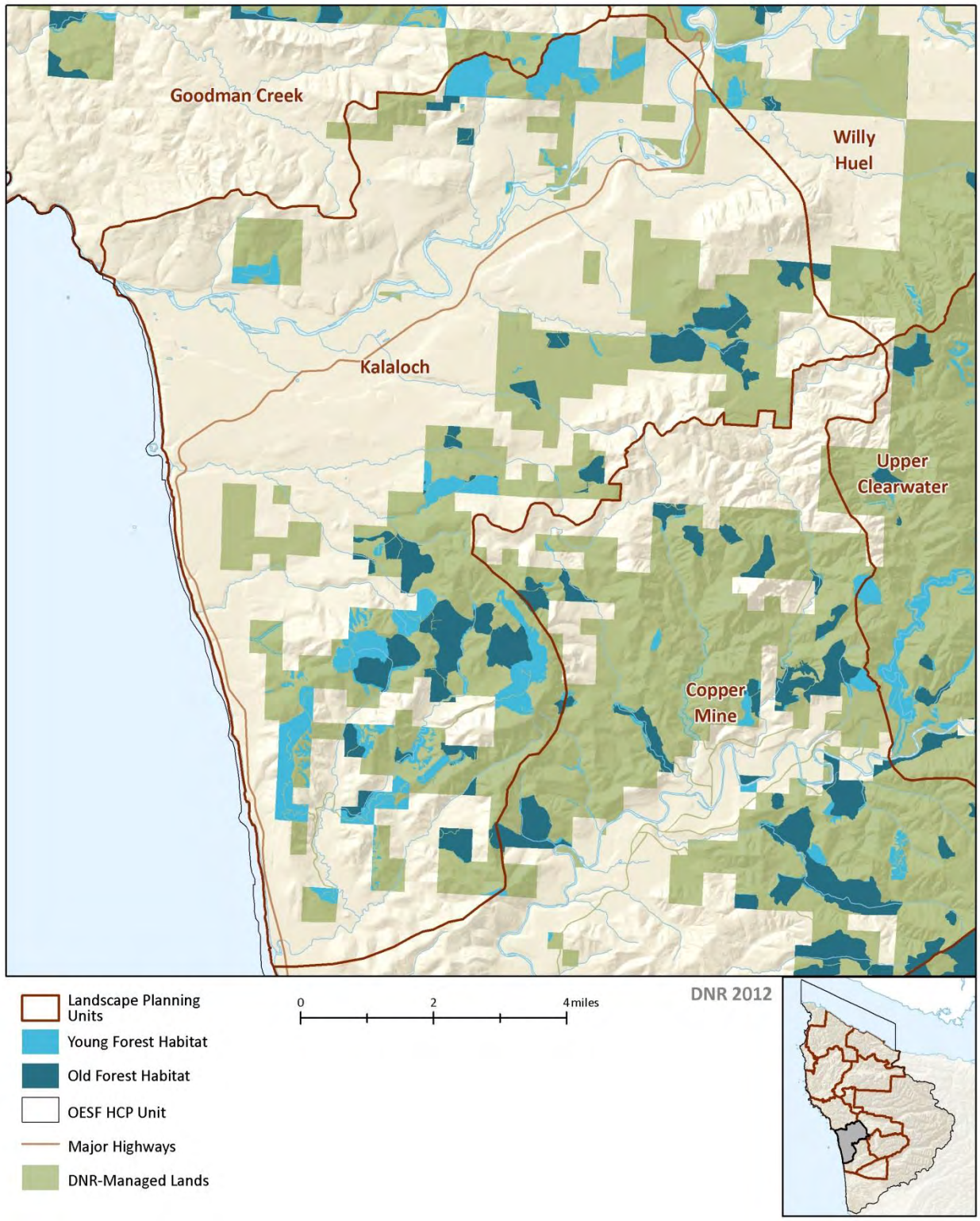


■ Kalaloch Landscape Old Forest and Young Forest Habitat Maps

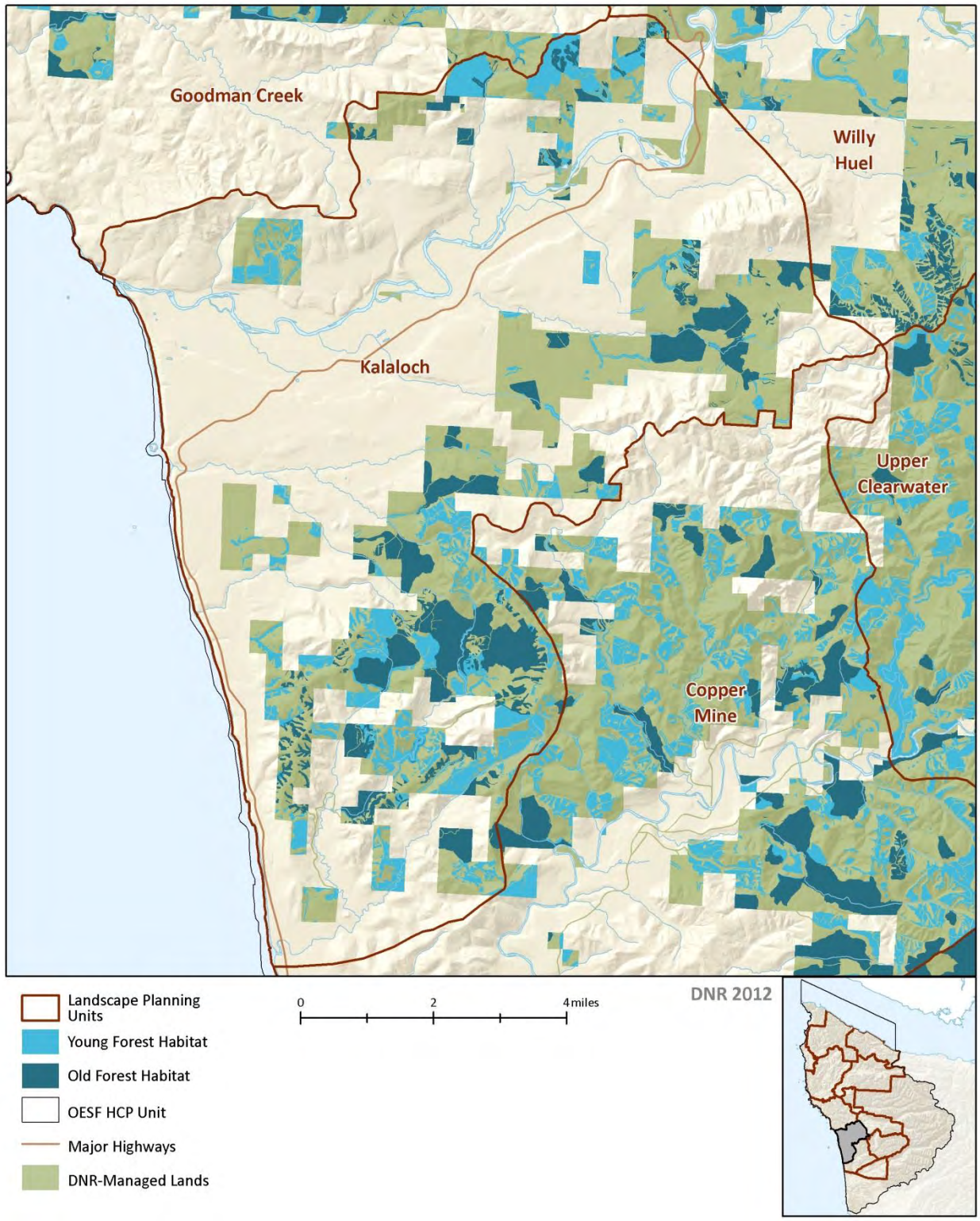
Map I-36. Old Forest and Young Forest Habitat on State Trust Lands in the Kalaloch Landscape, Current Conditions



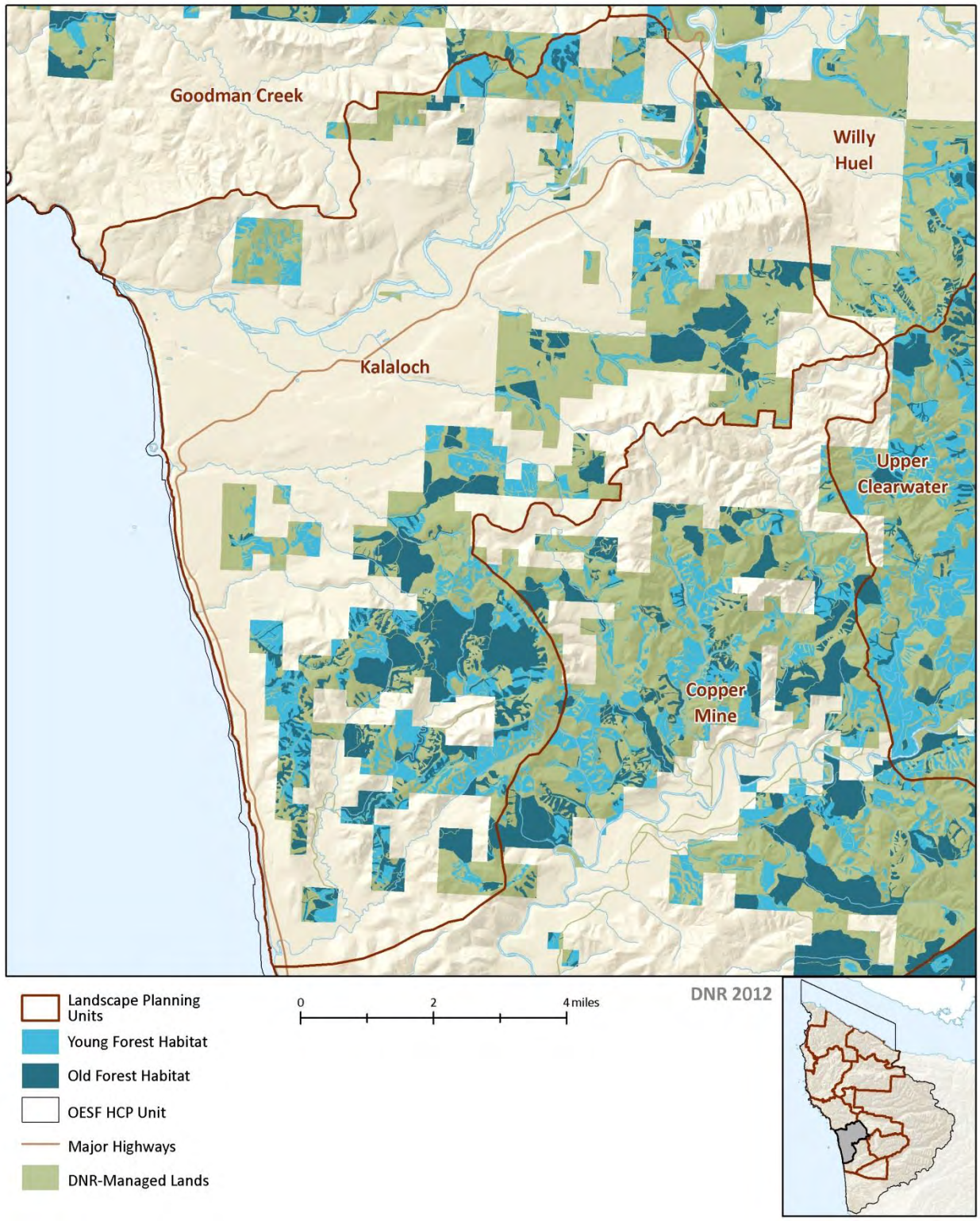
Map I-37. Old Forest and Young Forest Habitat on State Trust Lands in the Kalaloch Landscape, No Action Alternative, Decade 1



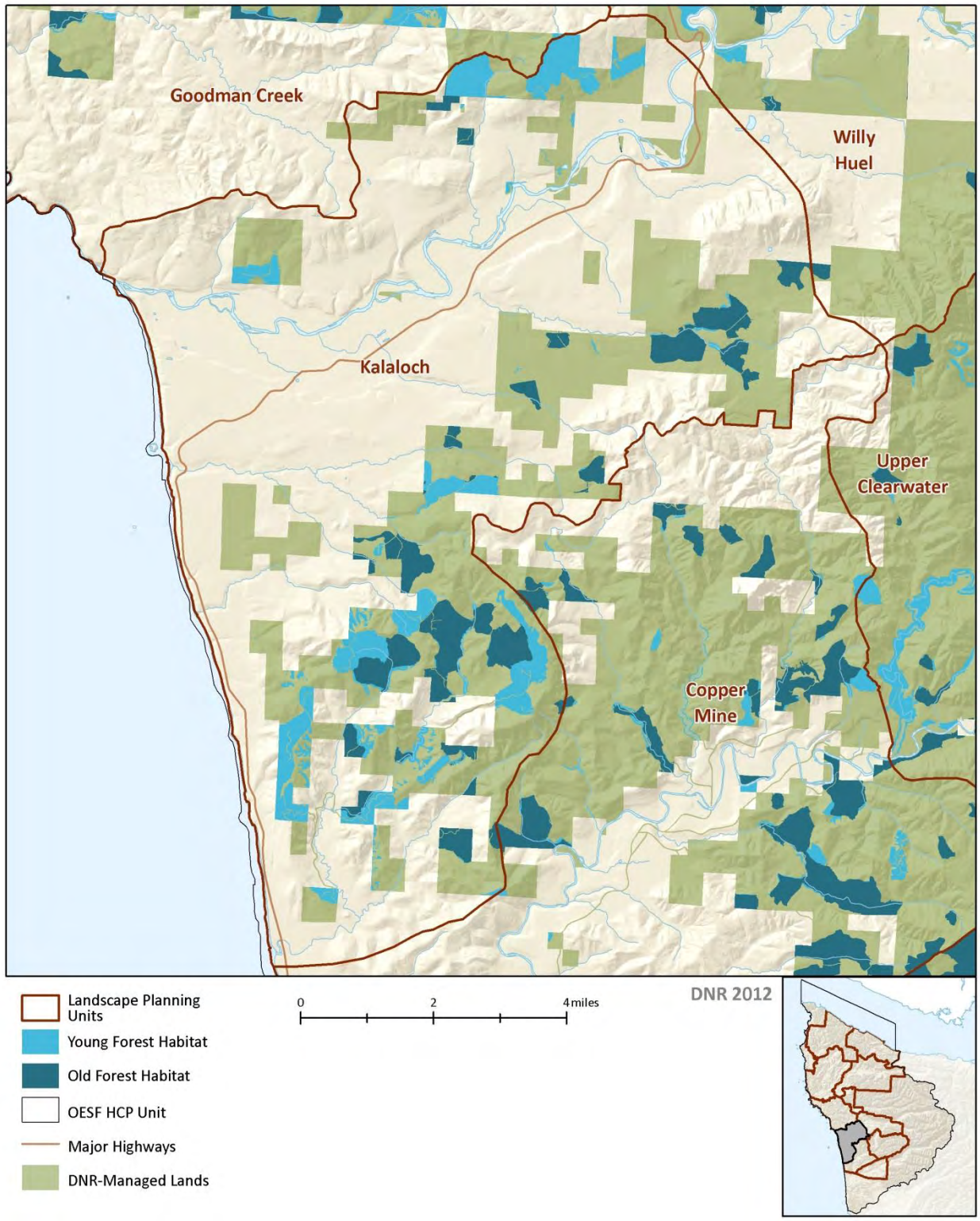
Map I-38. Old Forest and Young Forest Habitat on State Trust Lands in the Kalaloch Landscape, No Action Alternative, Decade 6



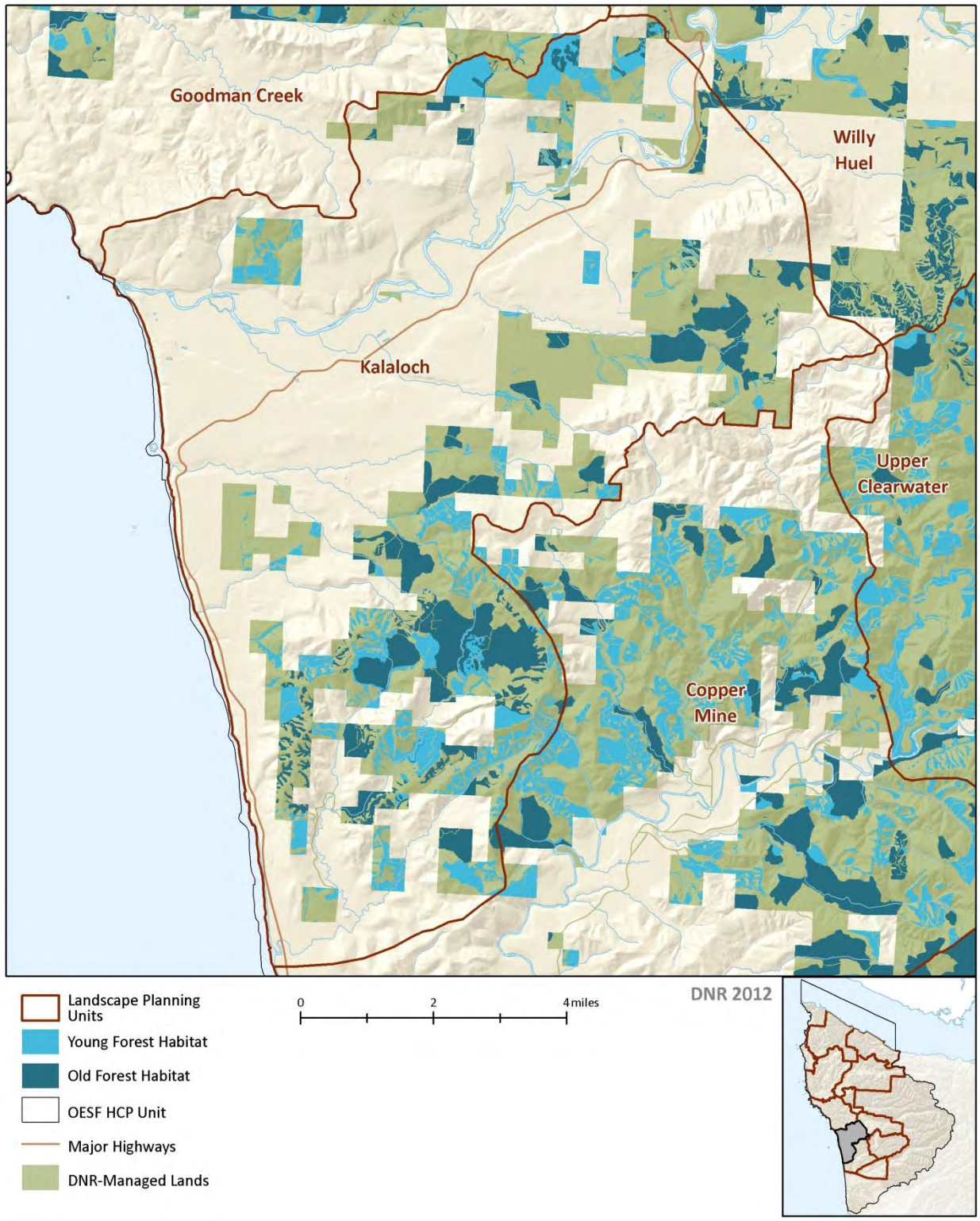
Map I-39. Old Forest and Young Forest Habitat on State Trust Lands in the Kalaloch Landscape, No Action Alternative, Decade 9



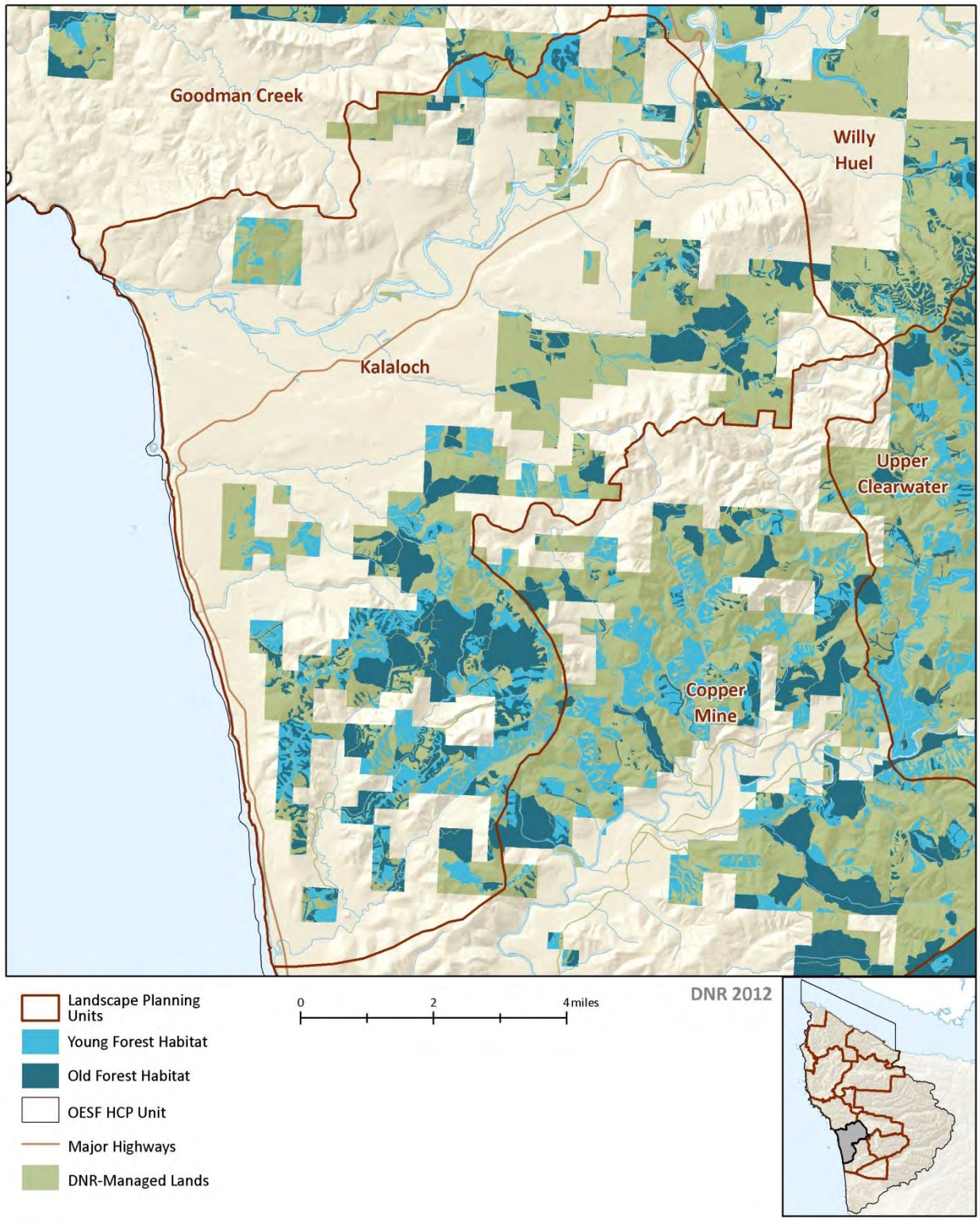
Map I-40. Old Forest and Young Forest Habitat on State Trust Lands in the Kalaloch Landscape, Landscape Alternative, Decade 1



Map I-41. Old Forest and Young Forest Habitat on State Trust Lands in the Kalaloch Landscape, Landscape Alternative, Decade 6

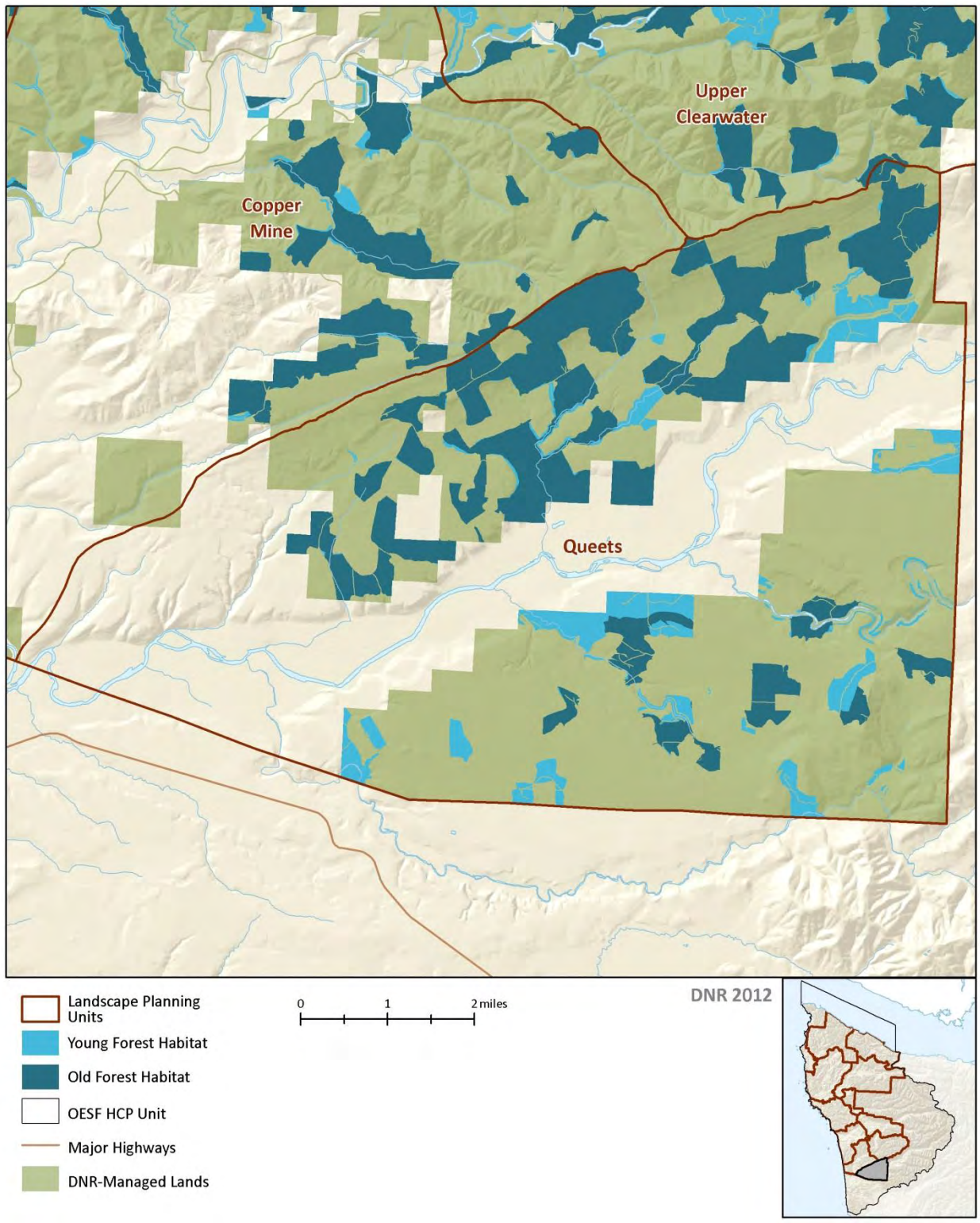


Map I-42. Old Forest and Young Forest Habitat on State Trust Lands in the Kalaloch Landscape, Landscape Alternative, Decade 9

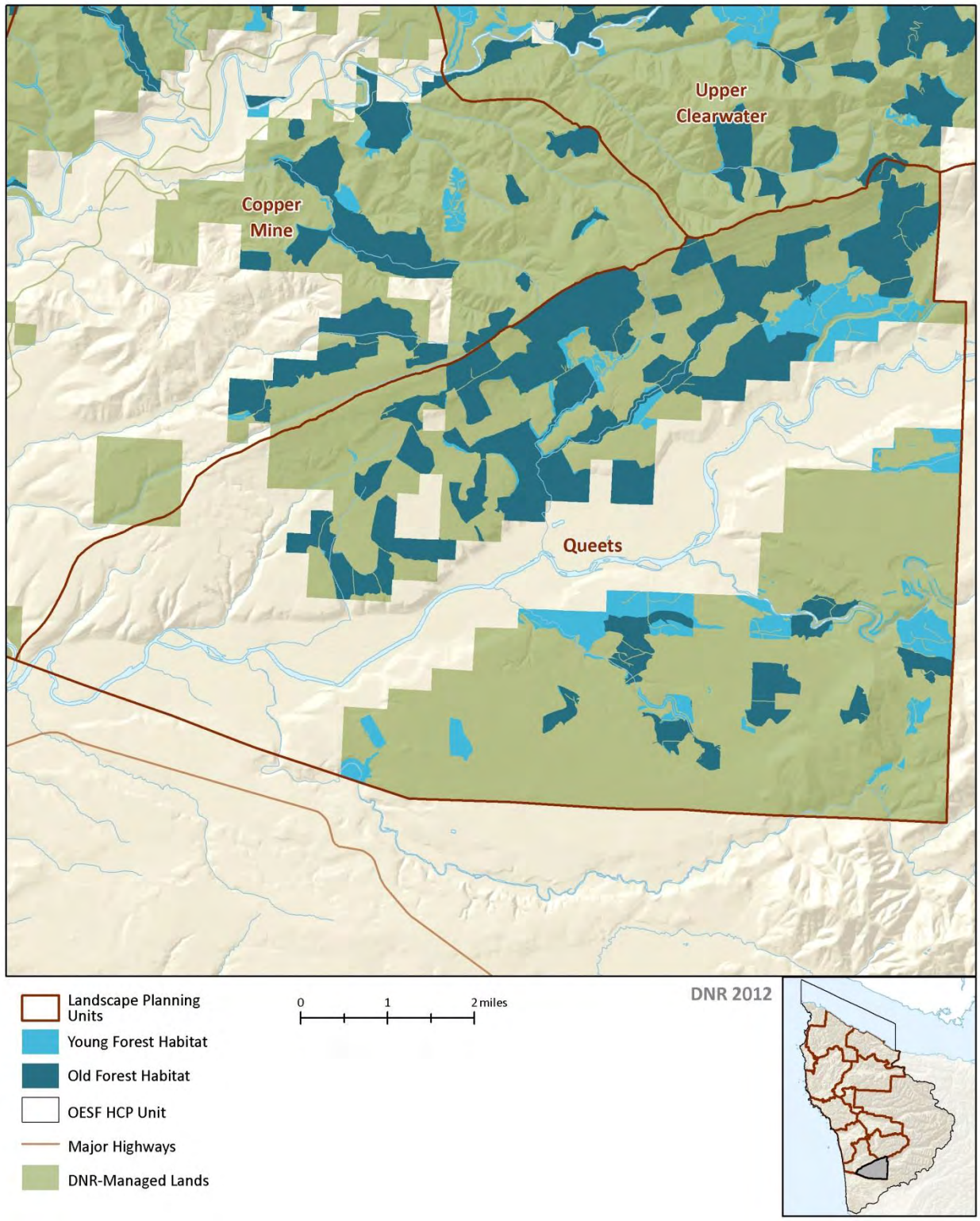


■ Queets Landscape Old Forest and Young Forest Habitat Maps

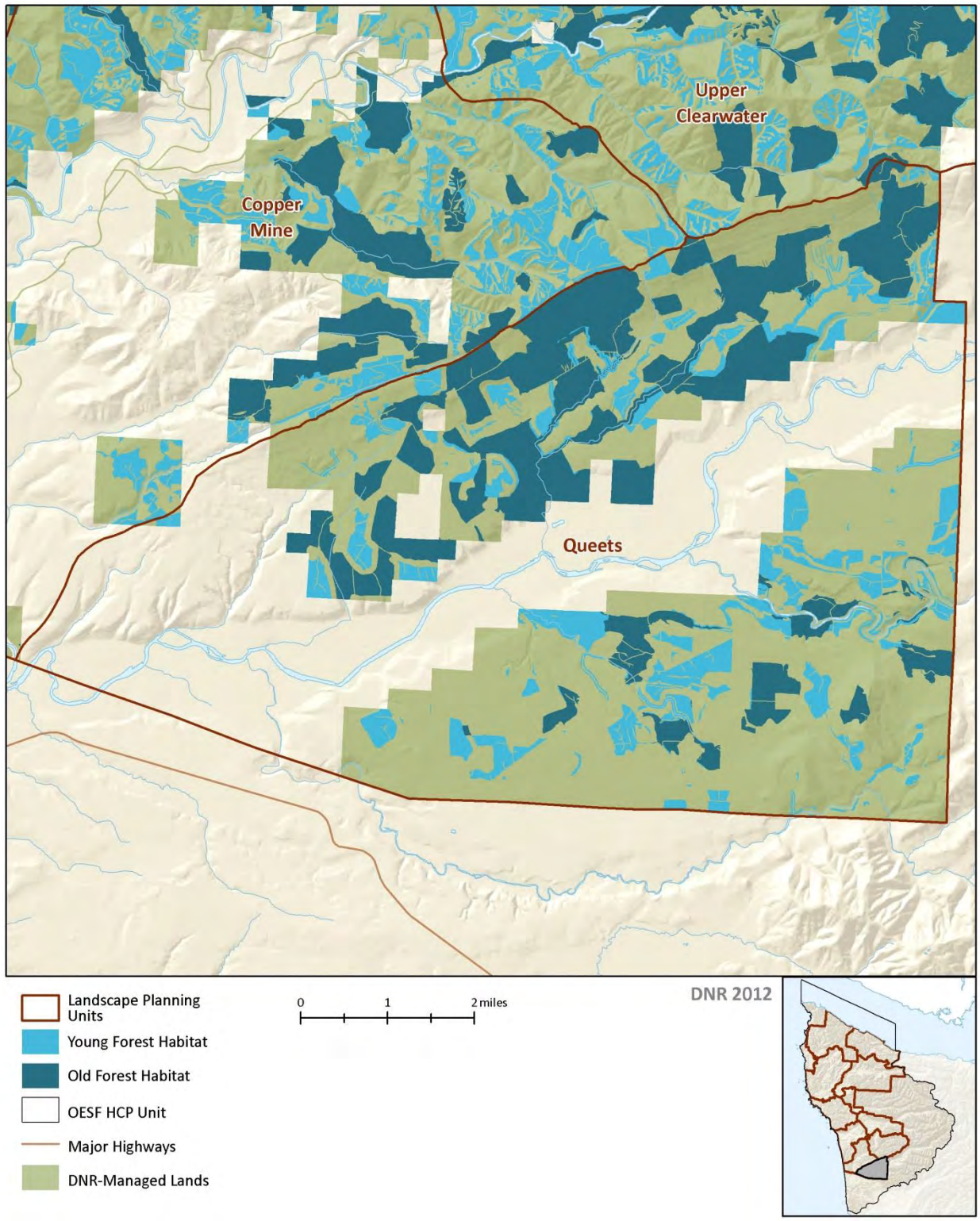
Map I-43. Old Forest and Young Forest Habitat on State Trust Lands in the Queets Landscape, Current Conditions



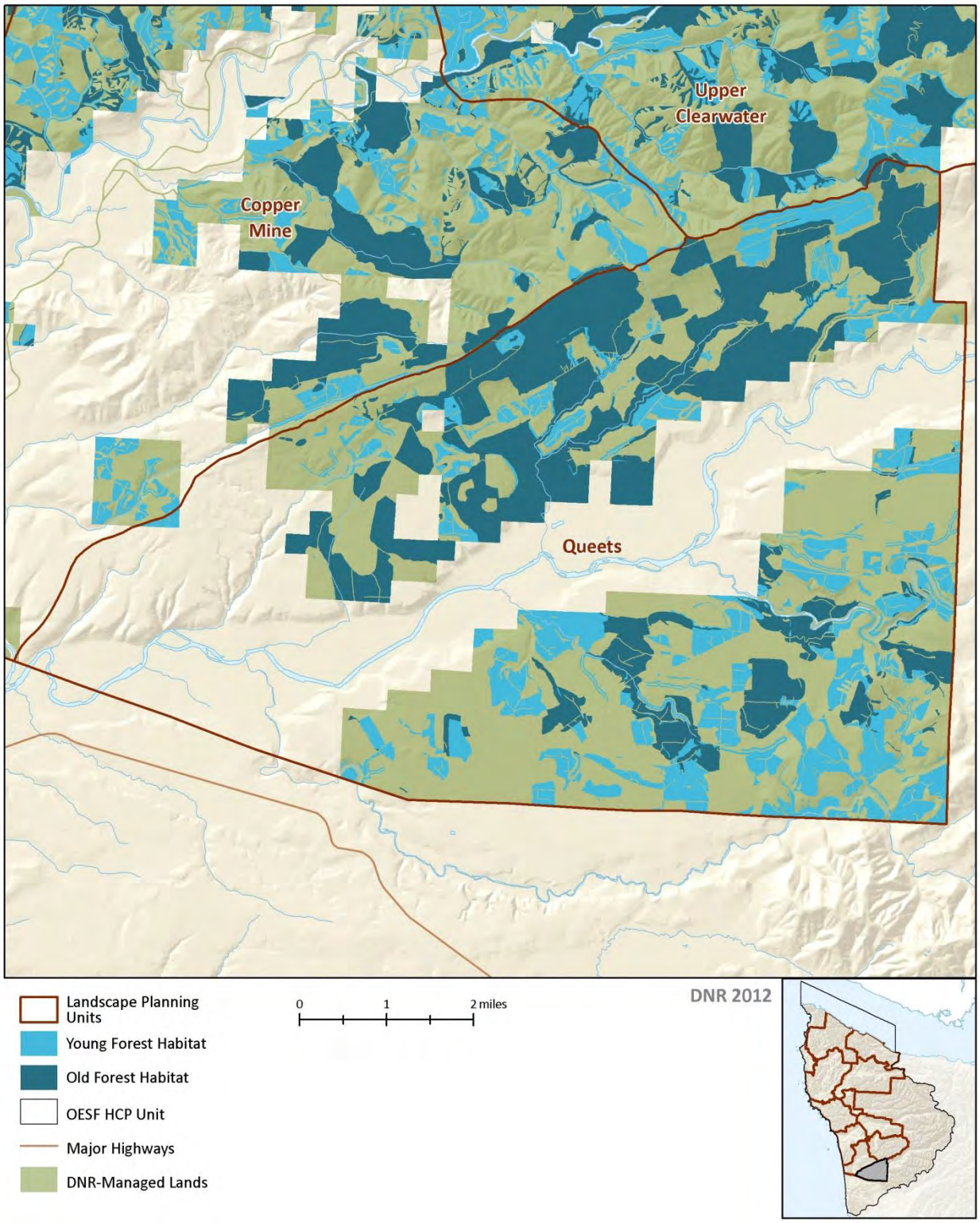
Map I-44. Old Forest and Young Forest Habitat on State Trust Lands in the Queets Landscape, No Action Alternative, Decade 1



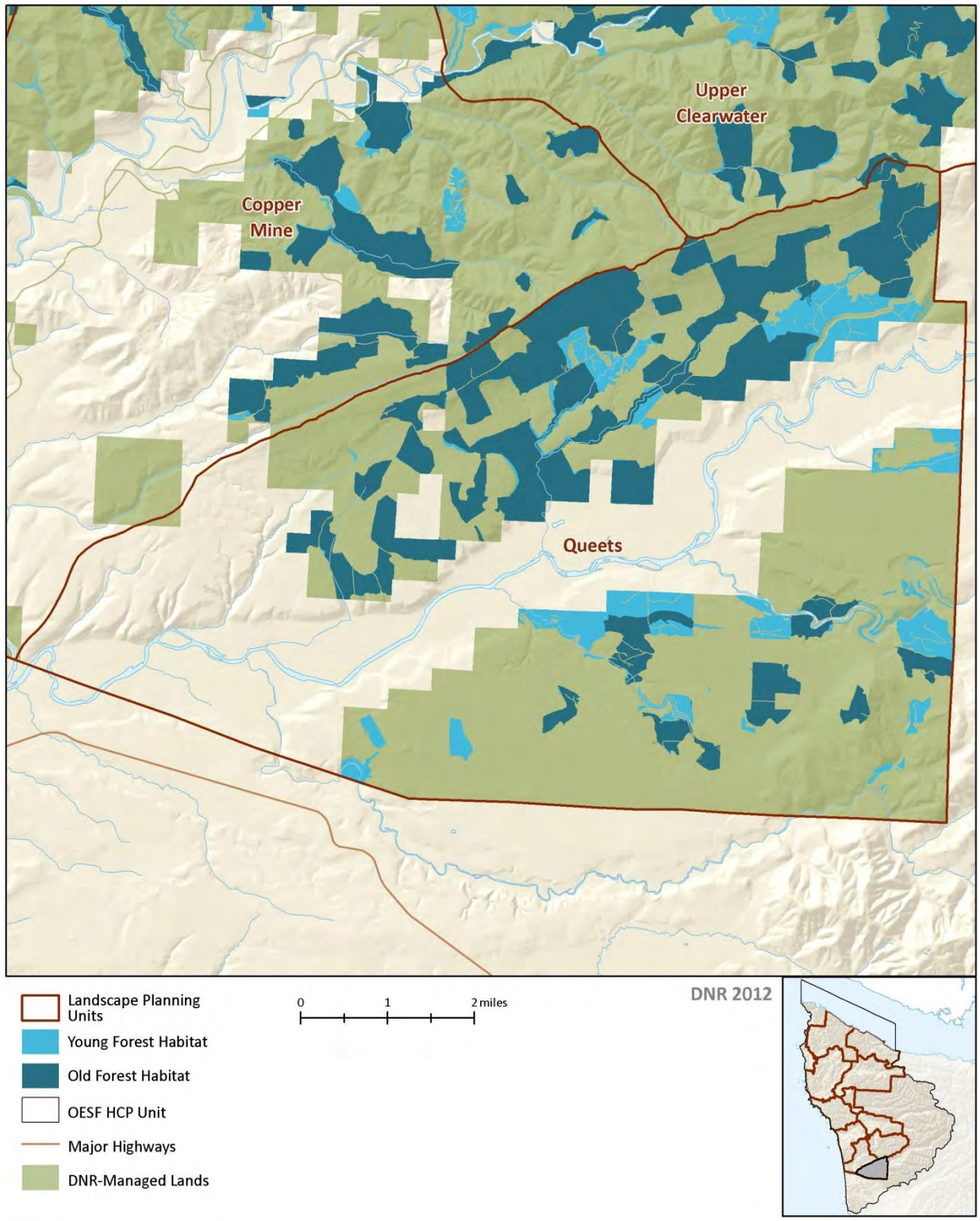
Map I-45. Old Forest and Young Forest Habitat on State Trust Lands in the Queets Landscape, No Action Alternative, Decade 6



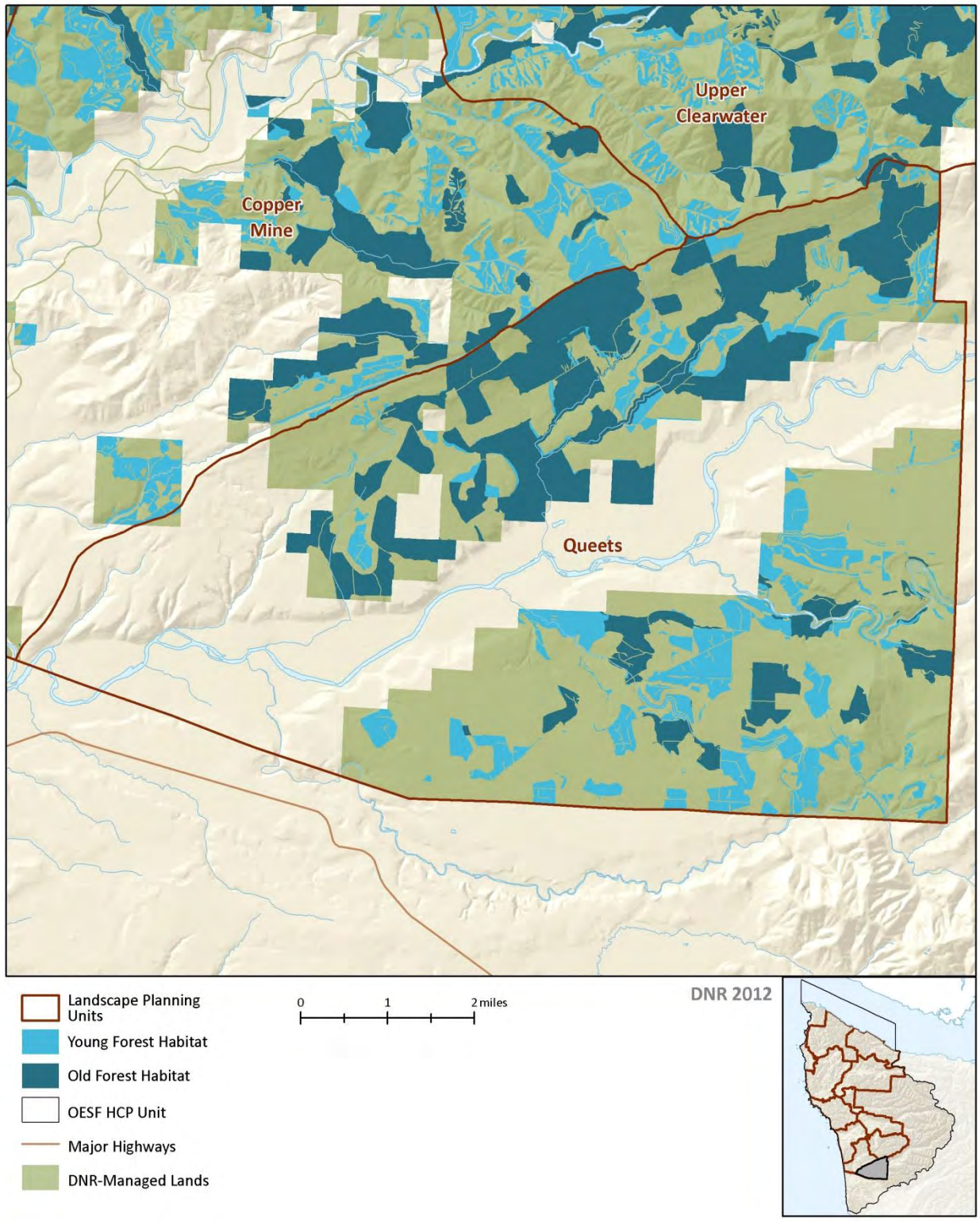
Map I-46. Old Forest and Young Forest Habitat on State Trust Lands in the Queets Landscape, No Action Alternative, Decade 9



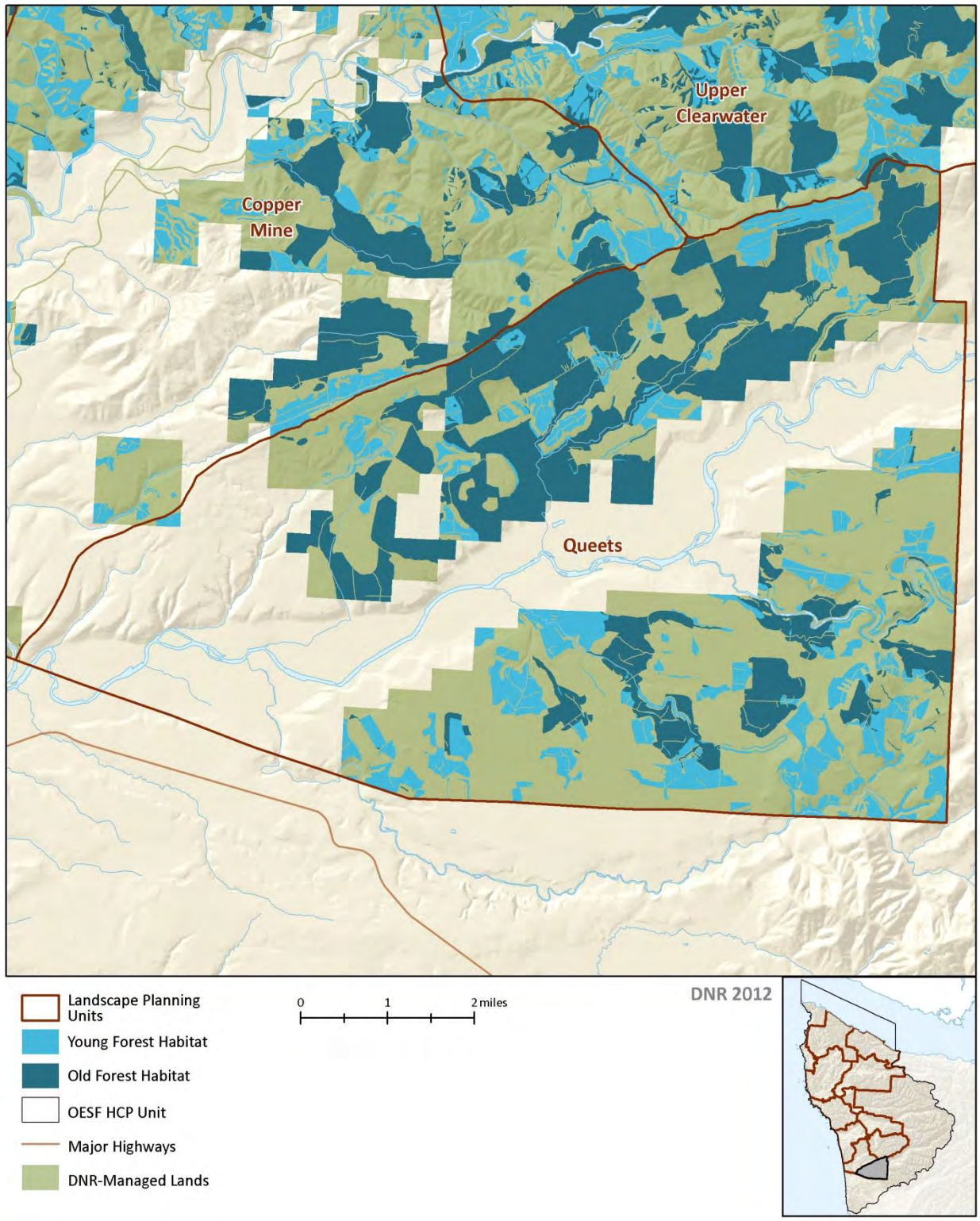
Map I-47. Old Forest and Young Forest Habitat on State Trust Lands in the Queets Landscape, Landscape Alternative, Decade 1



Map I-48. Old Forest and Young Forest Habitat on State Trust Lands in the Queets Landscape, Landscape Alternative, Decade 6

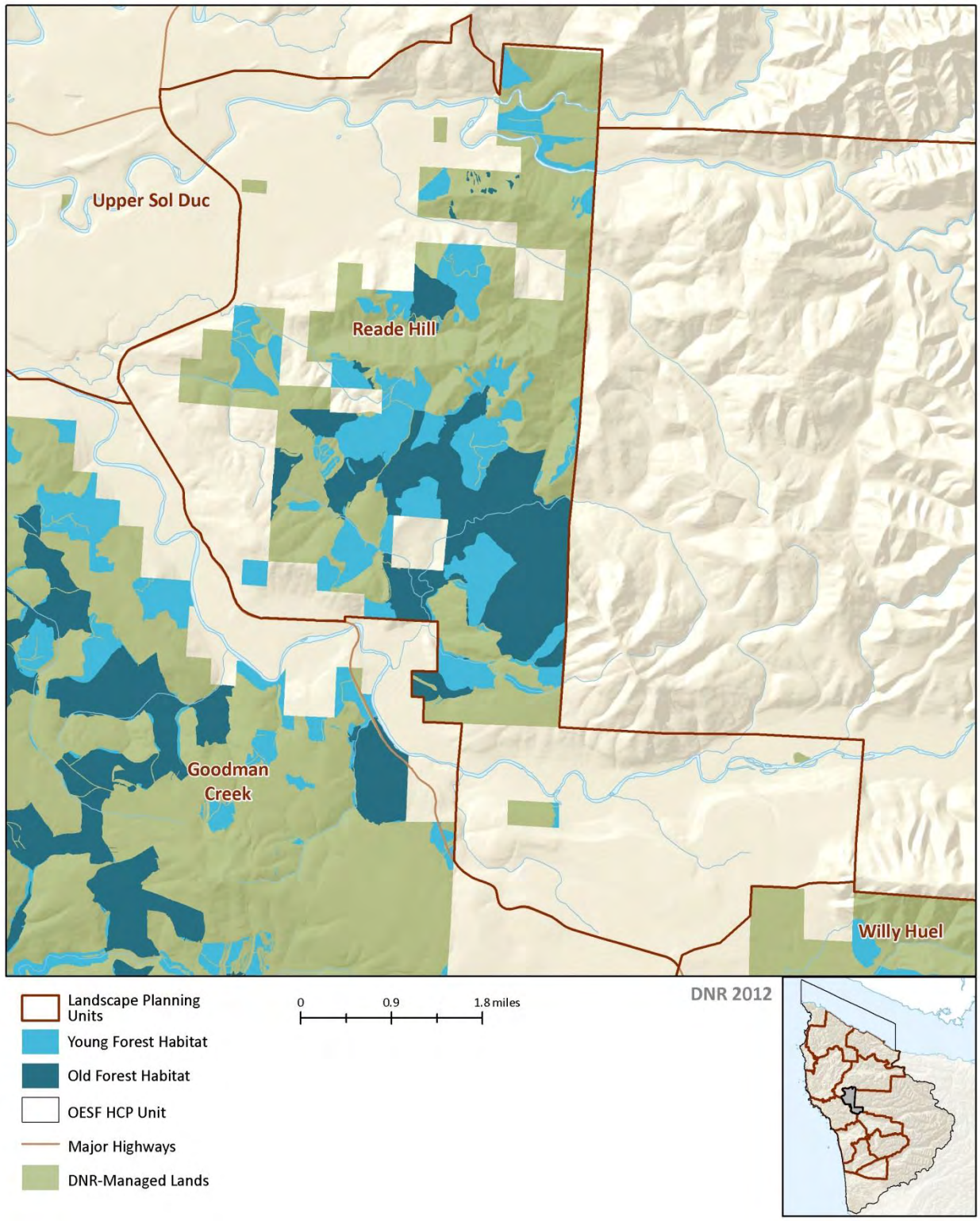


Map I-49. Old Forest and Young Forest Habitat on State Trust Lands in the Queets Landscape, Landscape Alternative, Decade 9

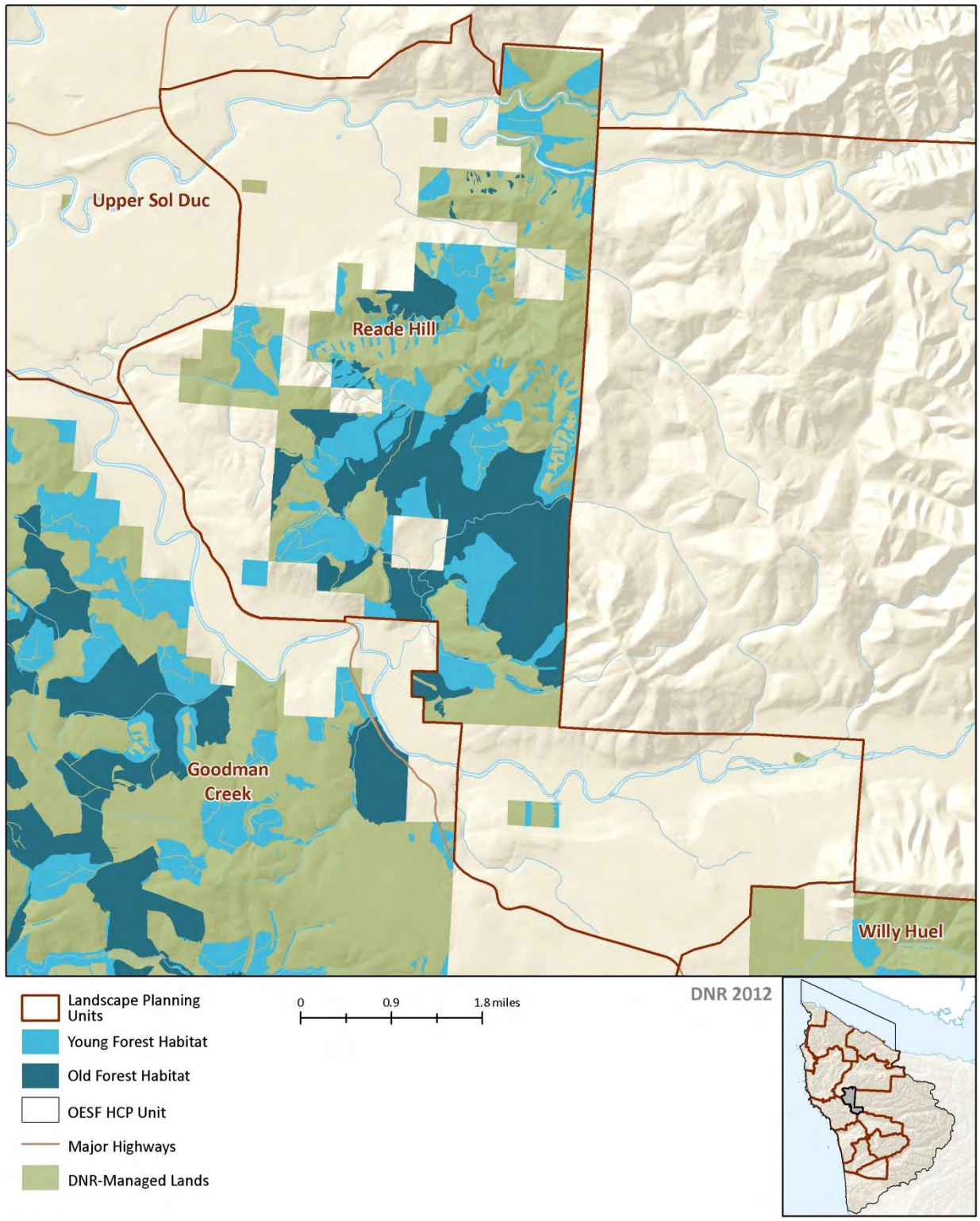


■ Reade Hill Landscape Old Forest and Young Forest Habitat Maps

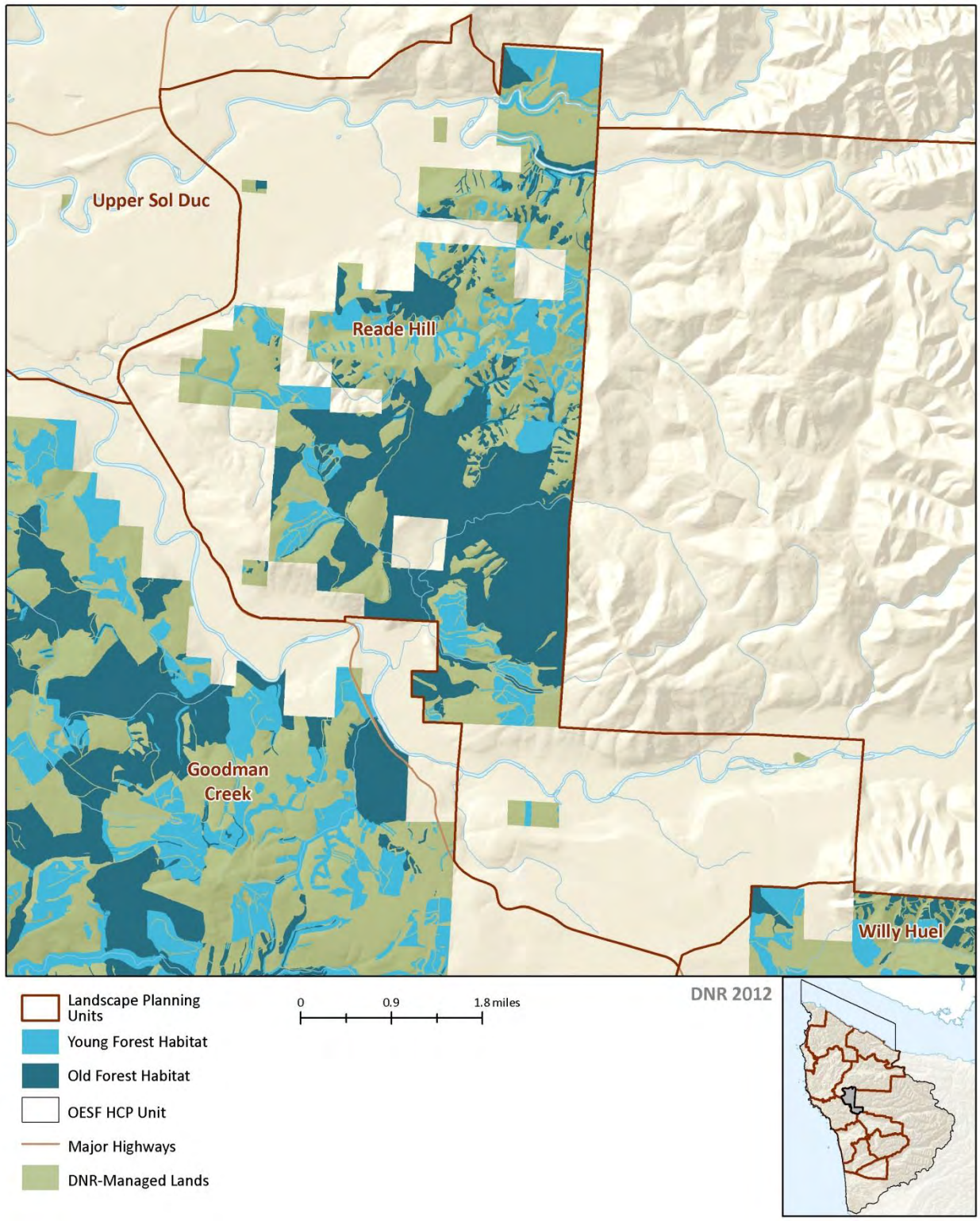
Map I-50. Old Forest and Young Forest Habitat on State Trust Lands in the Reade Hill Landscape, Current Conditions



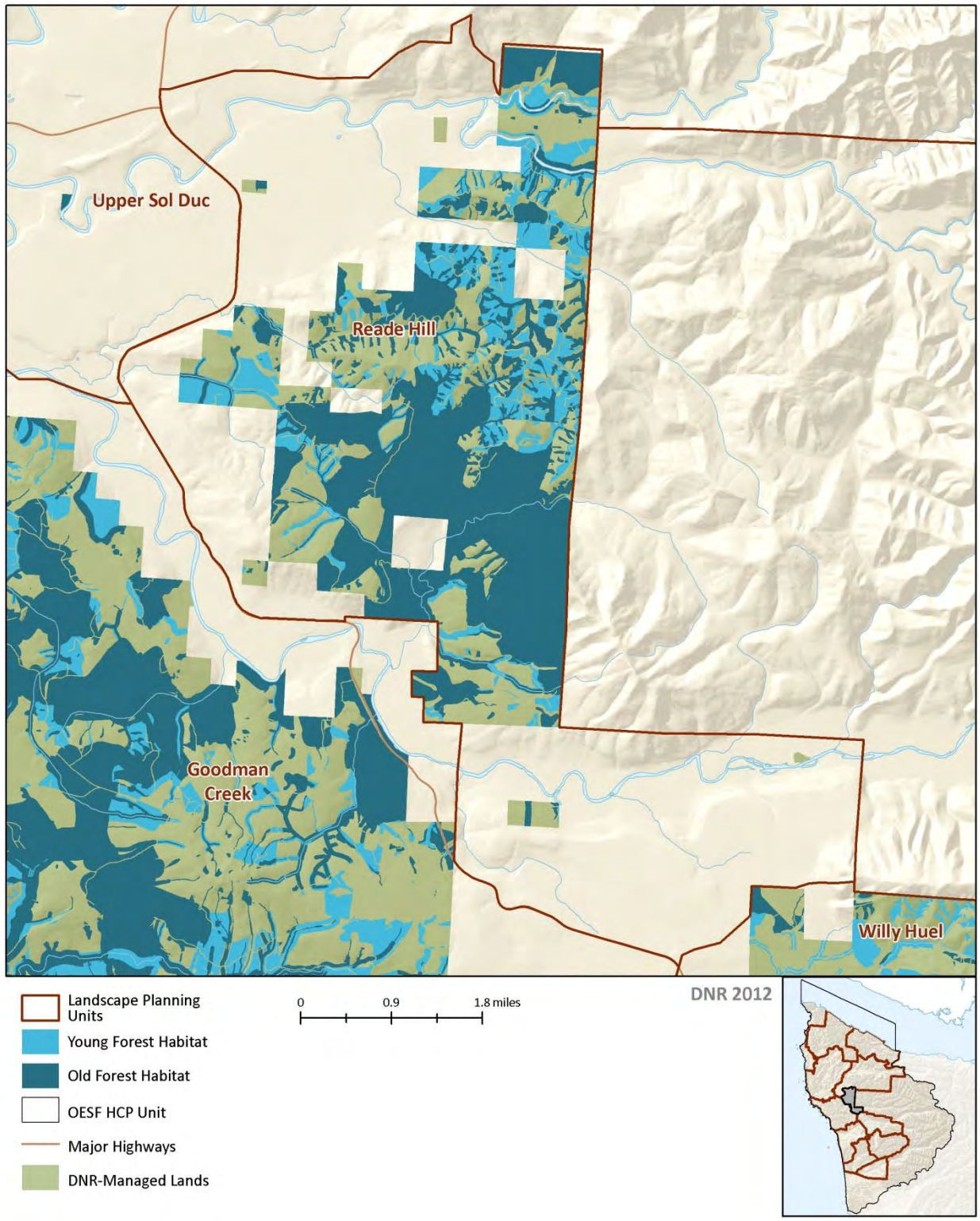
Map I-51. Old Forest and Young Forest Habitat on State Trust Lands in the Reade Hill Landscape, No Action Alternative, Decade 1



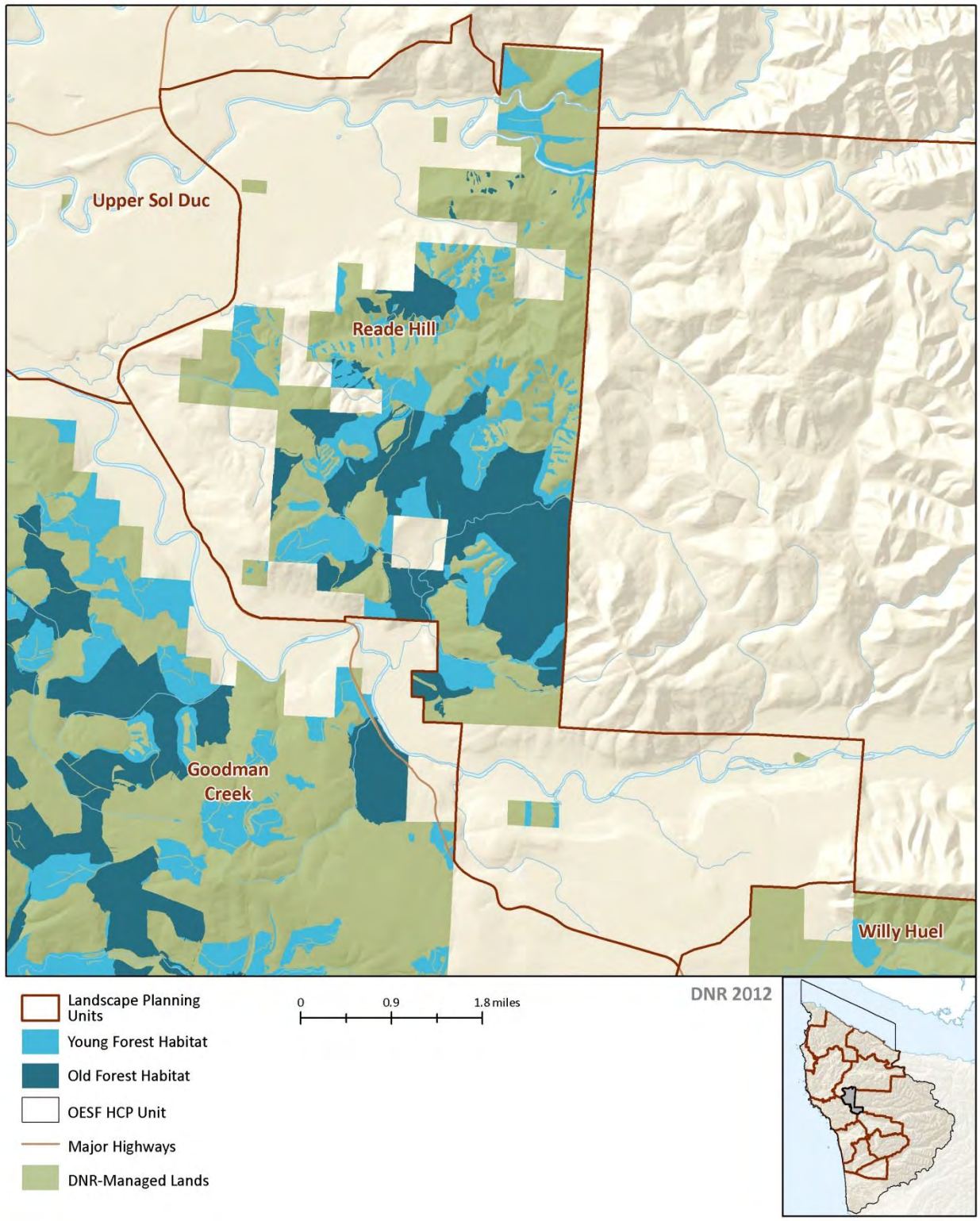
Map I-52. Old Forest and Young Forest Habitat on State Trust Lands in the Reade Hill Landscape, No Action Alternative, Decade 6



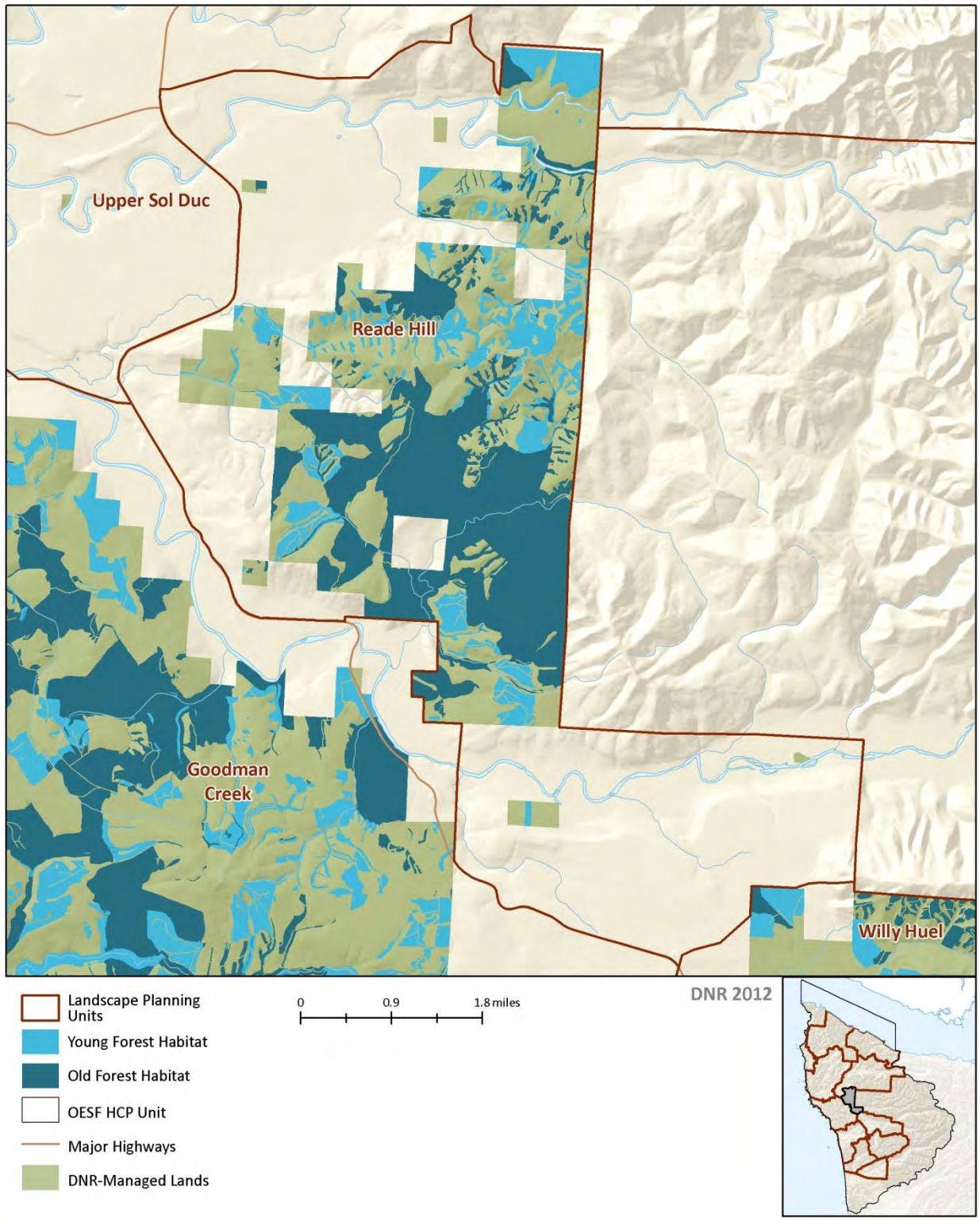
Map I-53. Old Forest and Young Forest Habitat on State Trust Lands in the Reade Hill Landscape, No Action Alternative, Decade 9



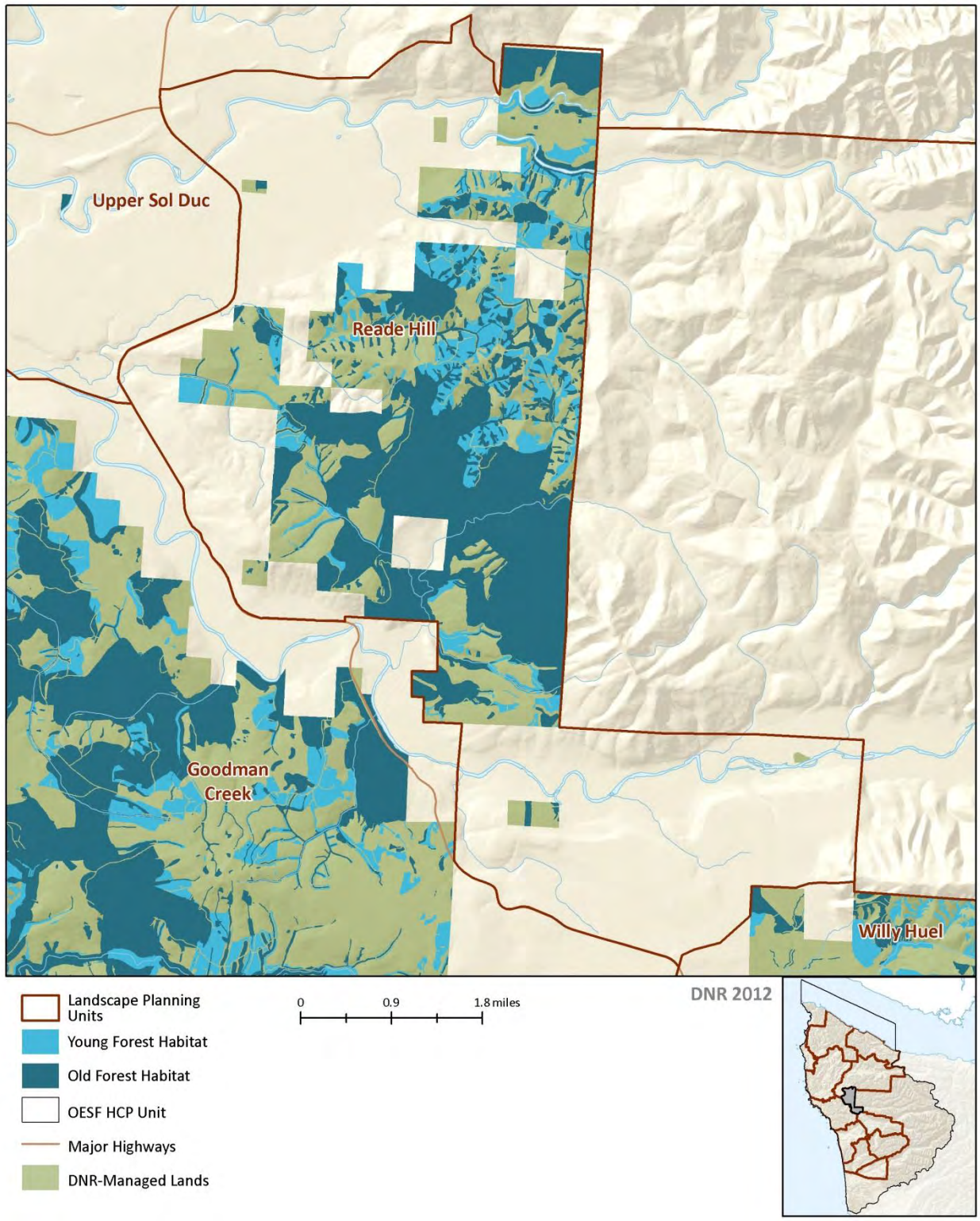
Map I-54. Old Forest and Young Forest Habitat on State Trust Lands in the Reade Hill Landscape, Landscape Alternative, Decade 1



Map I-55. Old Forest and Young Forest Habitat on State Trust Lands in the Reade Hill Landscape, Landscape Alternative, Decade 6

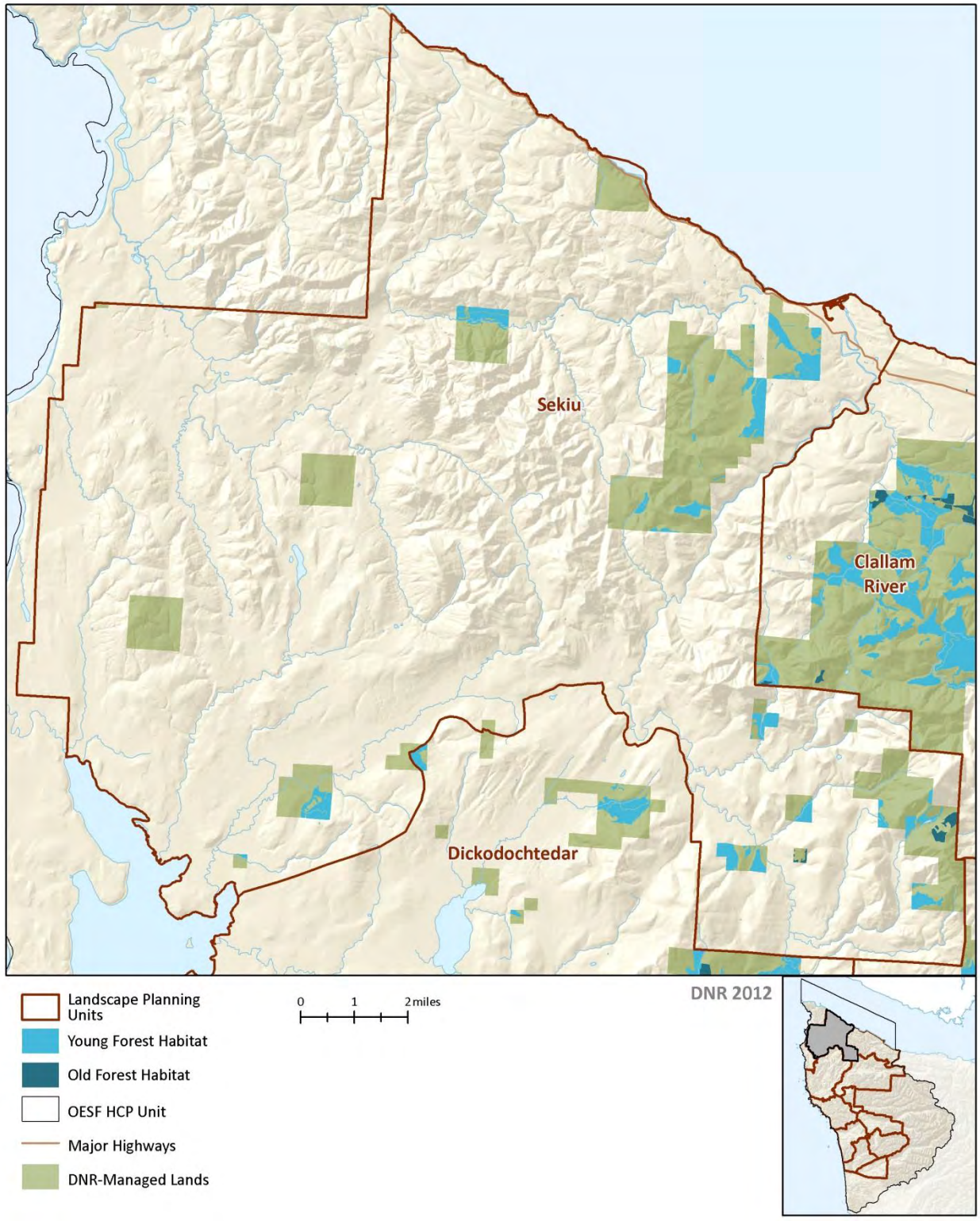


Map I-56. Old Forest and Young Forest Habitat on State Trust Lands in the Reade Hill Landscape, Landscape Alternative, Decade 9

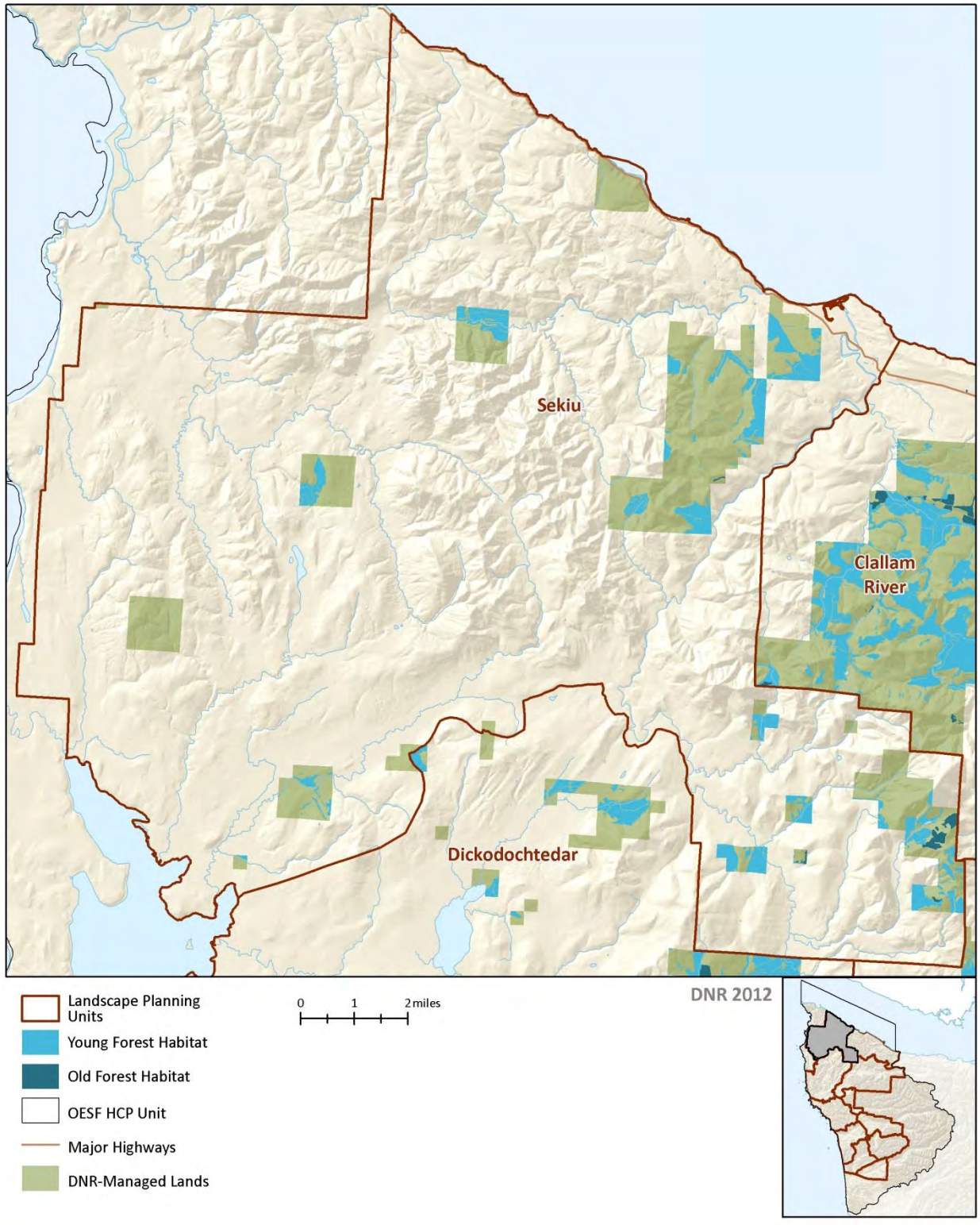


■ Sekiu Landscape Old Forest and Young Forest Habitat Maps

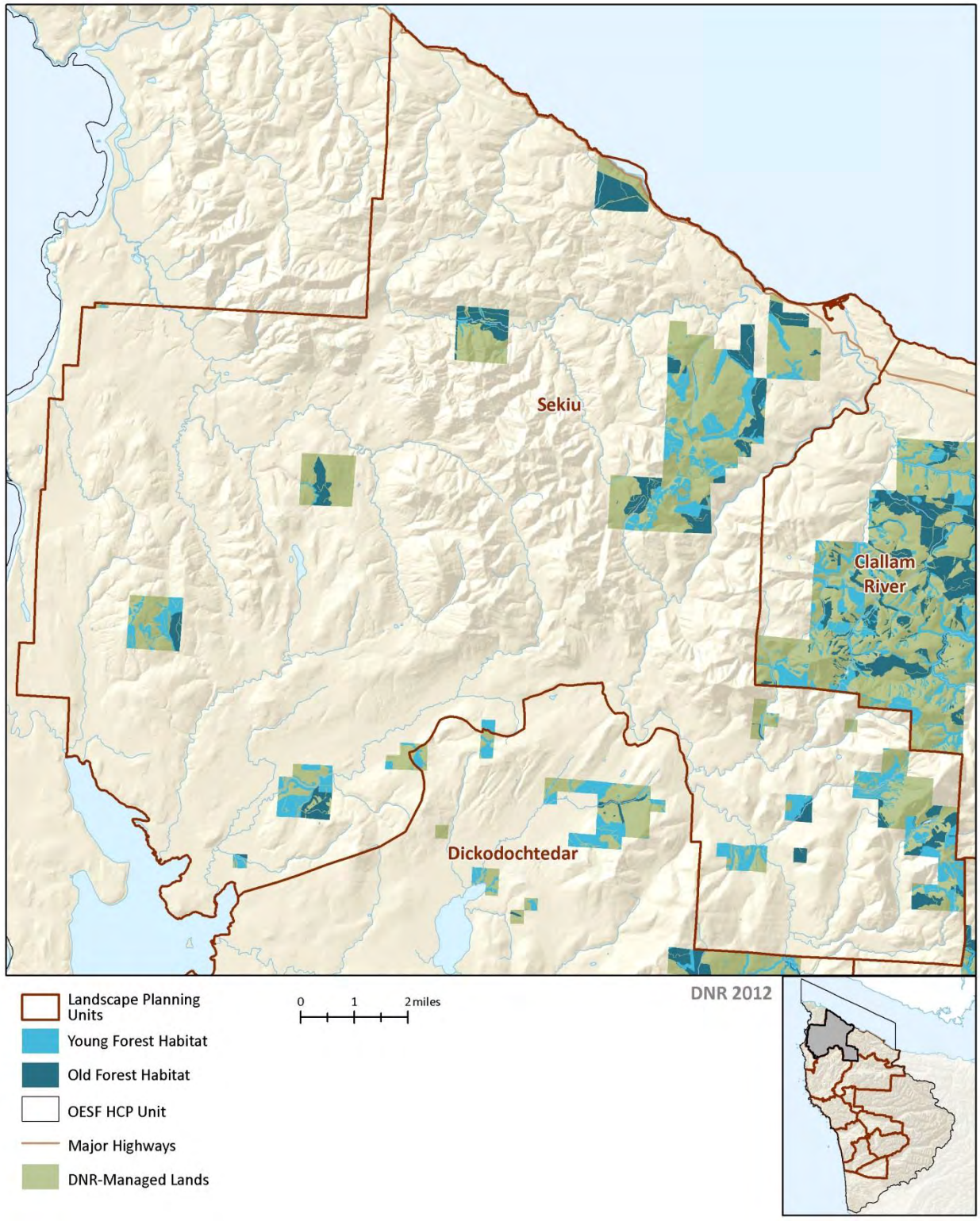
Map I-57. Old Forest and Young Forest Habitat on State Trust Lands in the Sekiu Landscape, Current Conditions



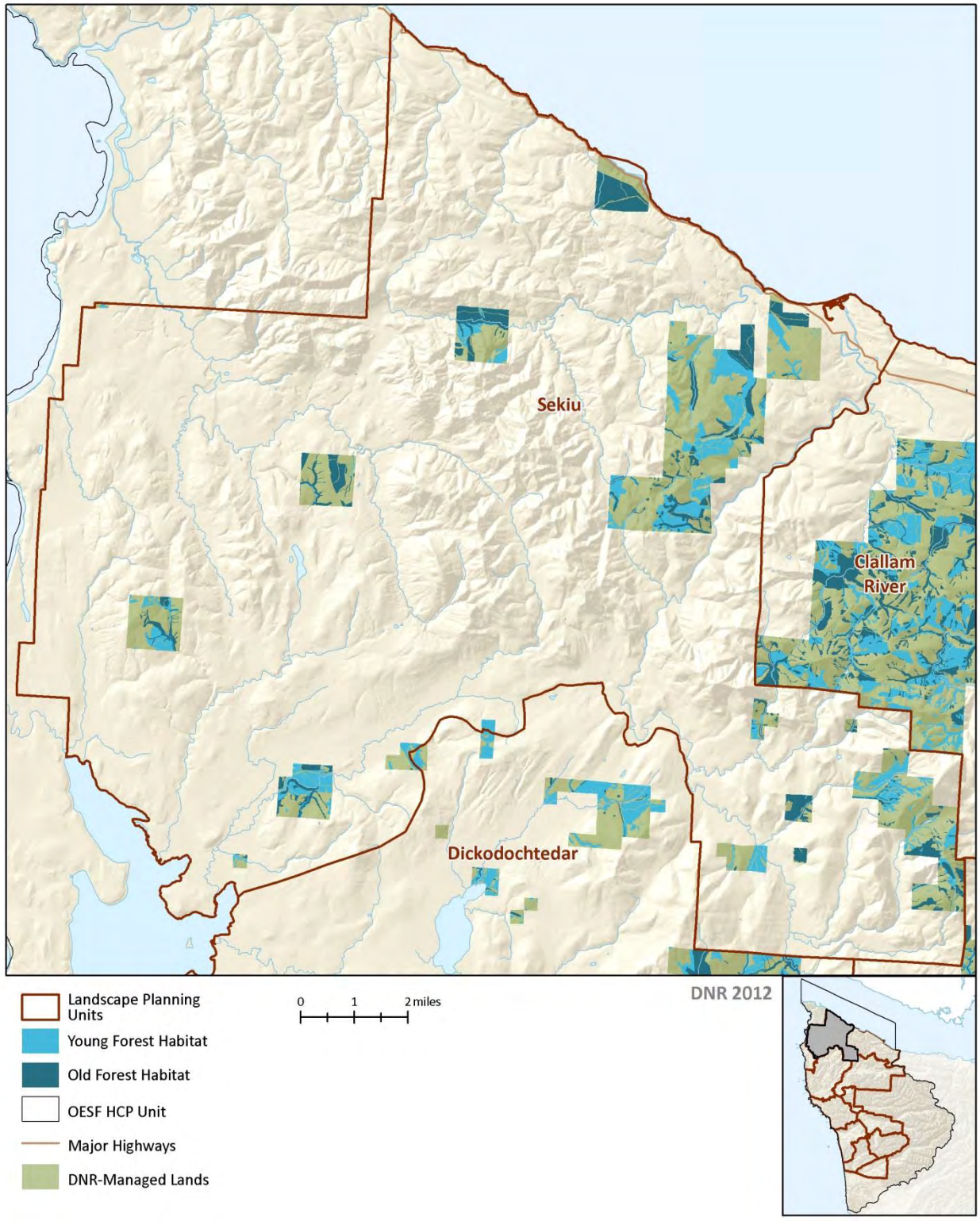
Map I-58. Old Forest and Young Forest Habitat in the Sekiu Landscape – No Action Alternative Decade 1



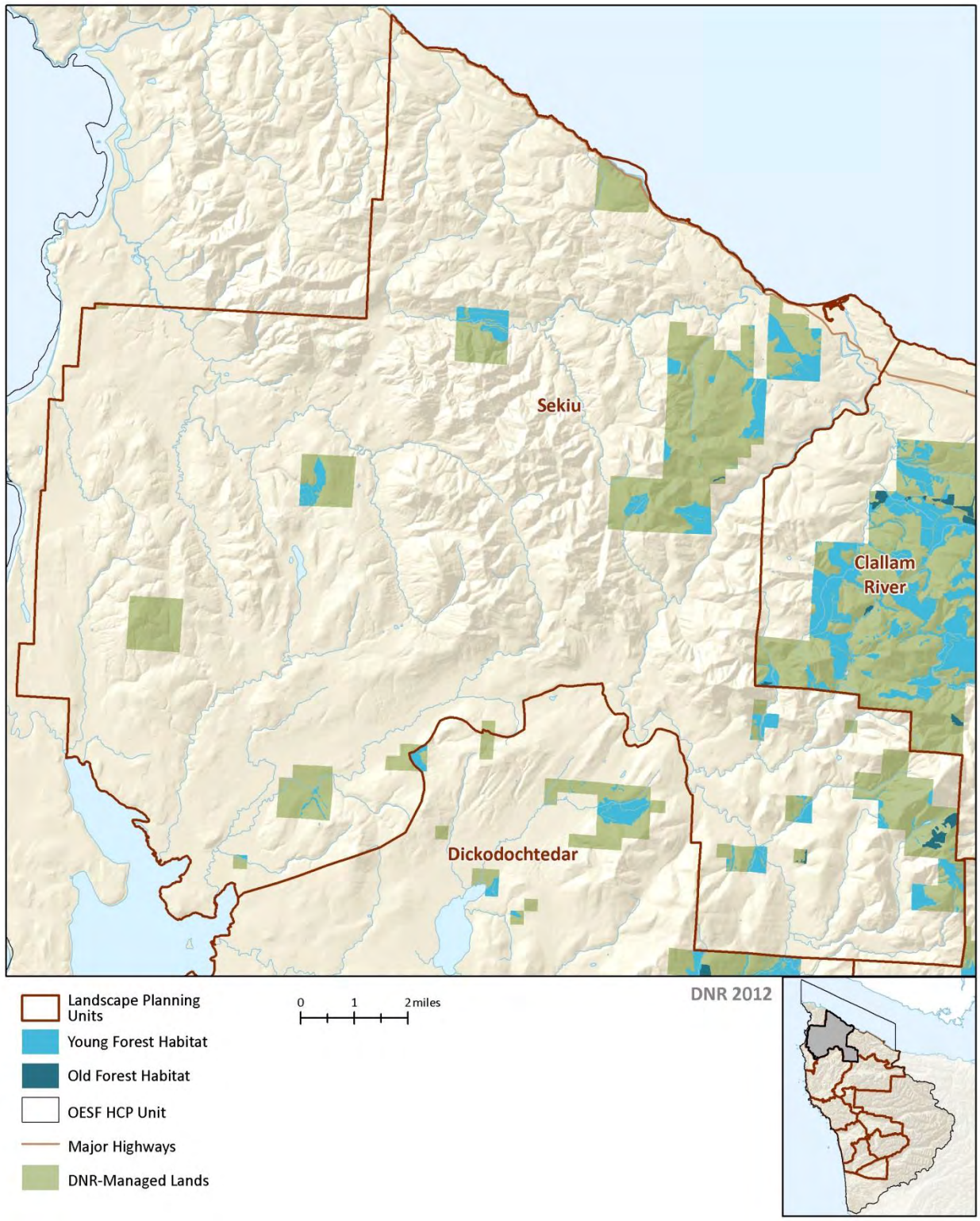
Map I-59. Old Forest and Young Forest Habitat in the Sekiu Landscape – No Action Alternative Decade 6



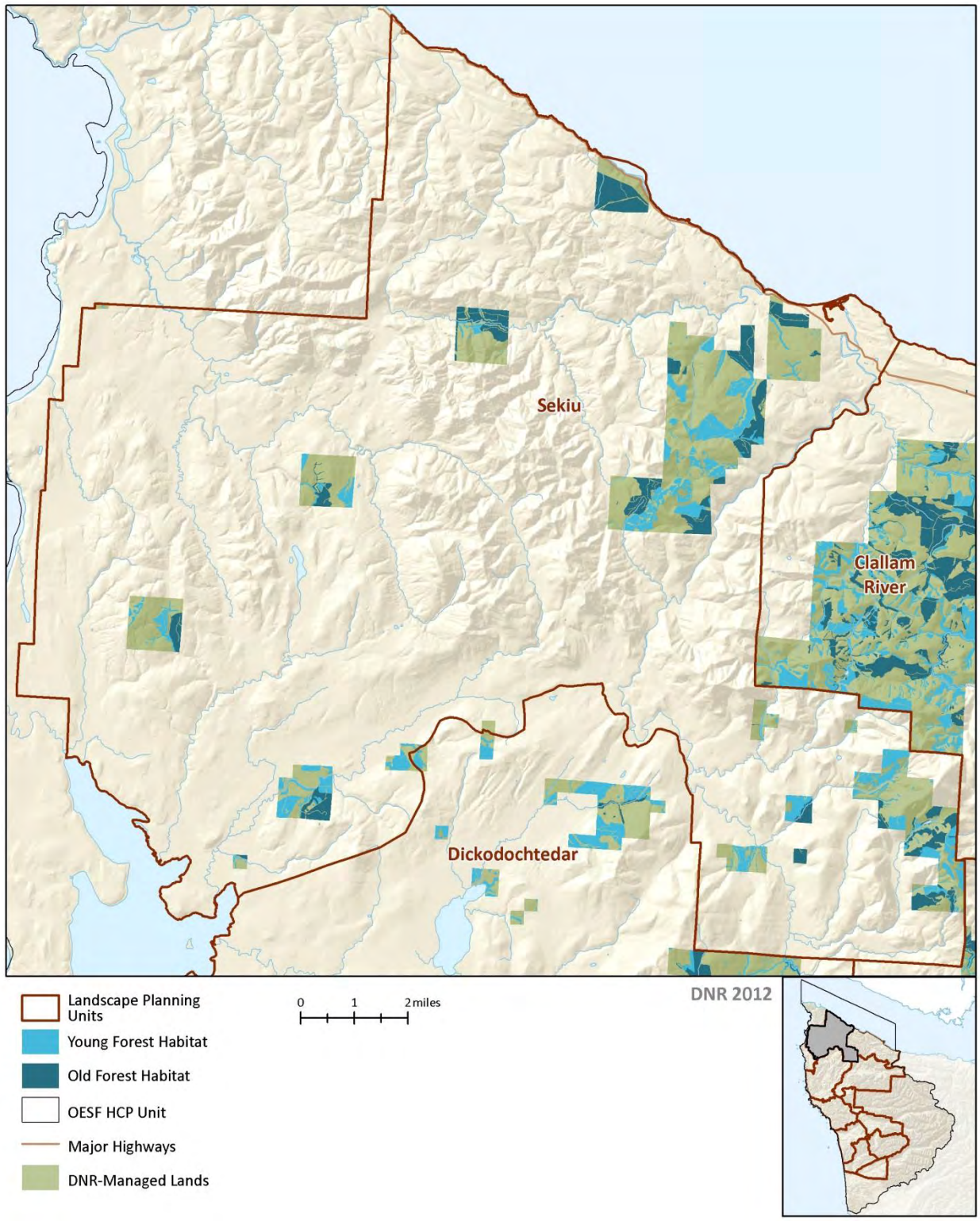
Map I-60. Old Forest and Young Forest Habitat in the Sekiu Landscape – No Action Alternative Decade 9



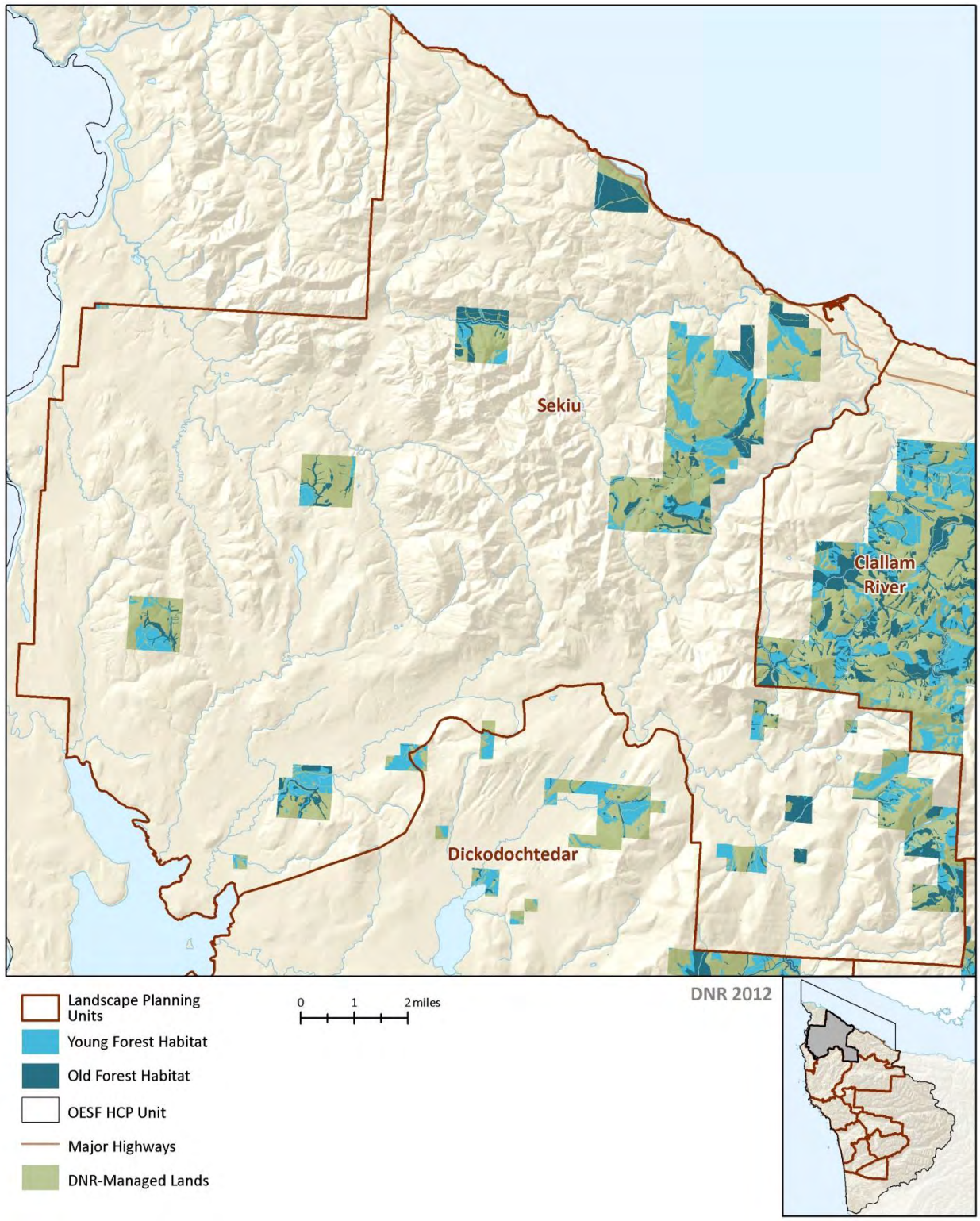
Map I-61. Old Forest and Young Forest Habitat on State Trust Lands in the Sekiu Landscape, Landscape Alternative, Decade 1



Map I-62. Old Forest and Young Forest Habitat on State Trust Lands in the Sekiu Landscape, Landscape Alternative, Decade 6

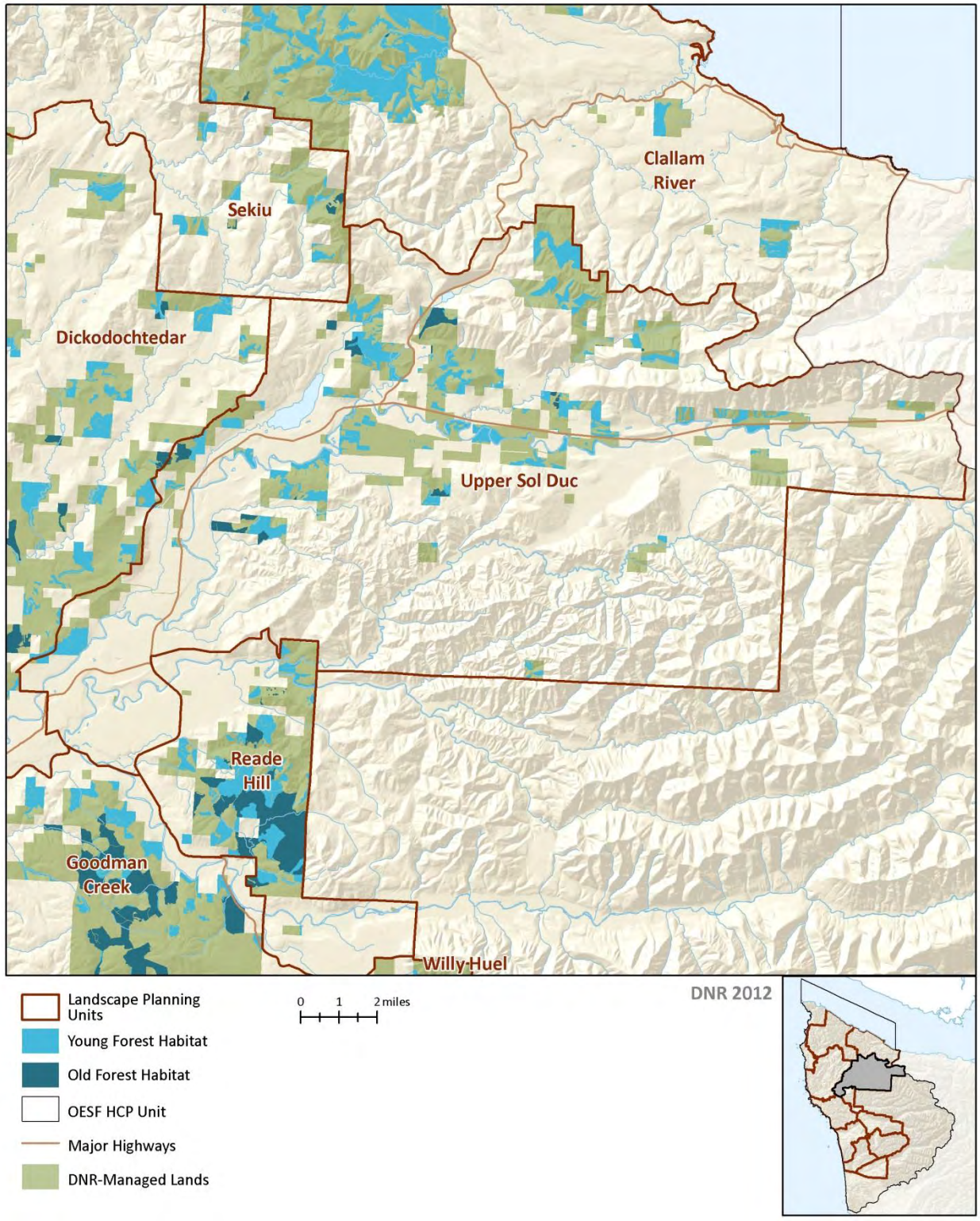


Map I-63. Old Forest and Young Forest Habitat on State Trust Lands in the Sekiu Landscape, Landscape Alternative, Decade 9

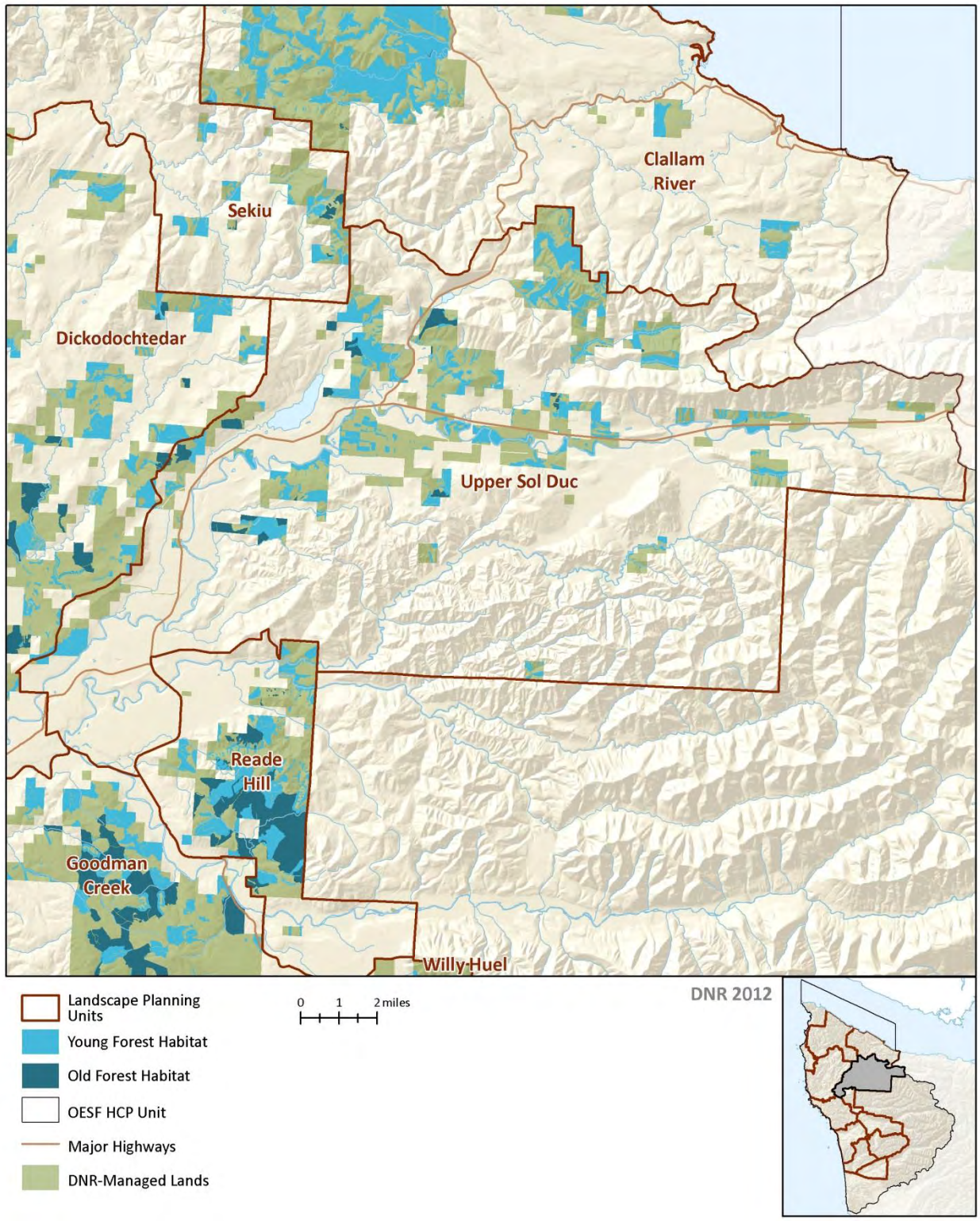


Sol Duc Landscape Old Forest and Young Forest Habitat Maps

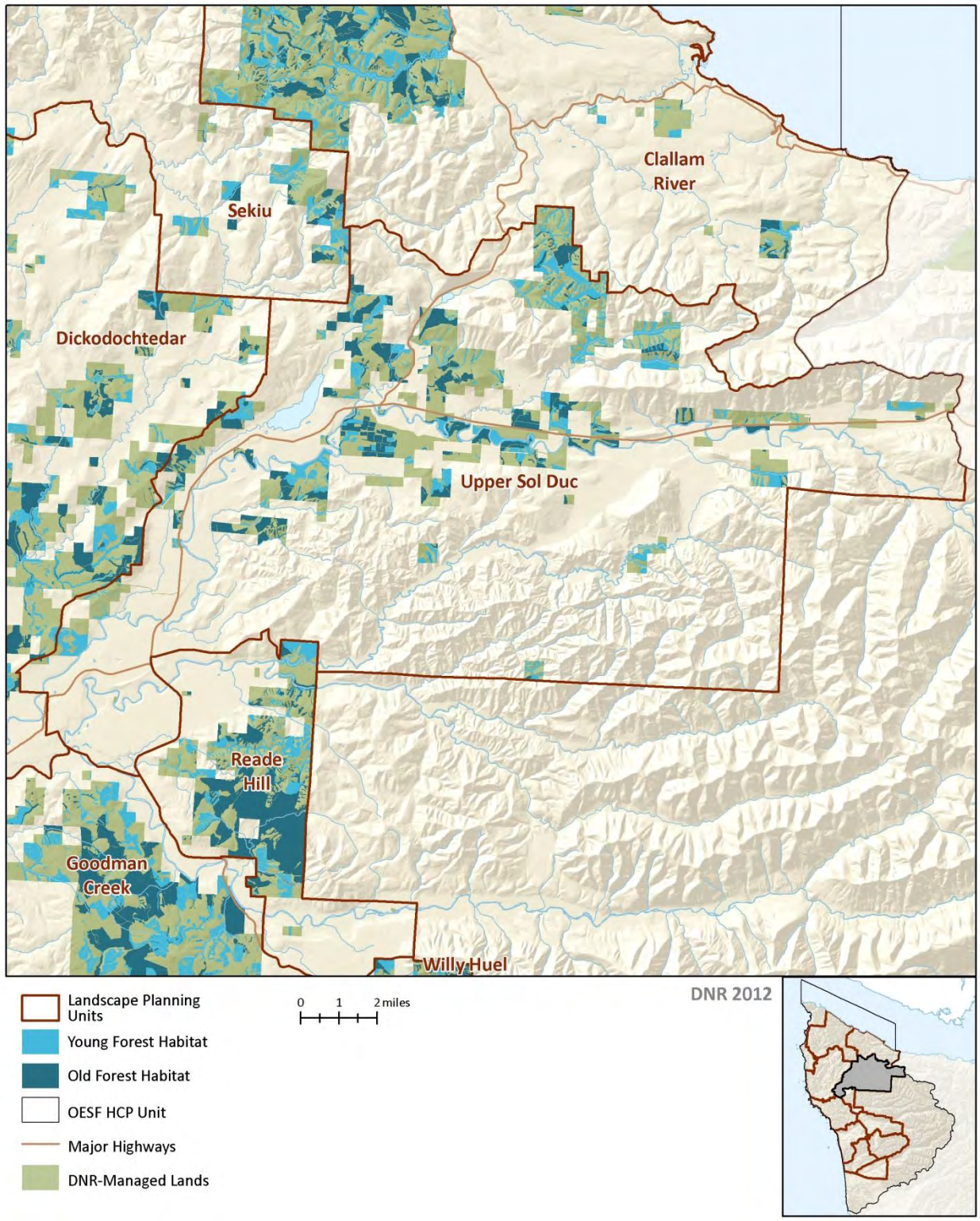
Map I-64. Old Forest and Young Forest Habitat on State Trust Lands in the Sol Duc Landscape, Current Conditions



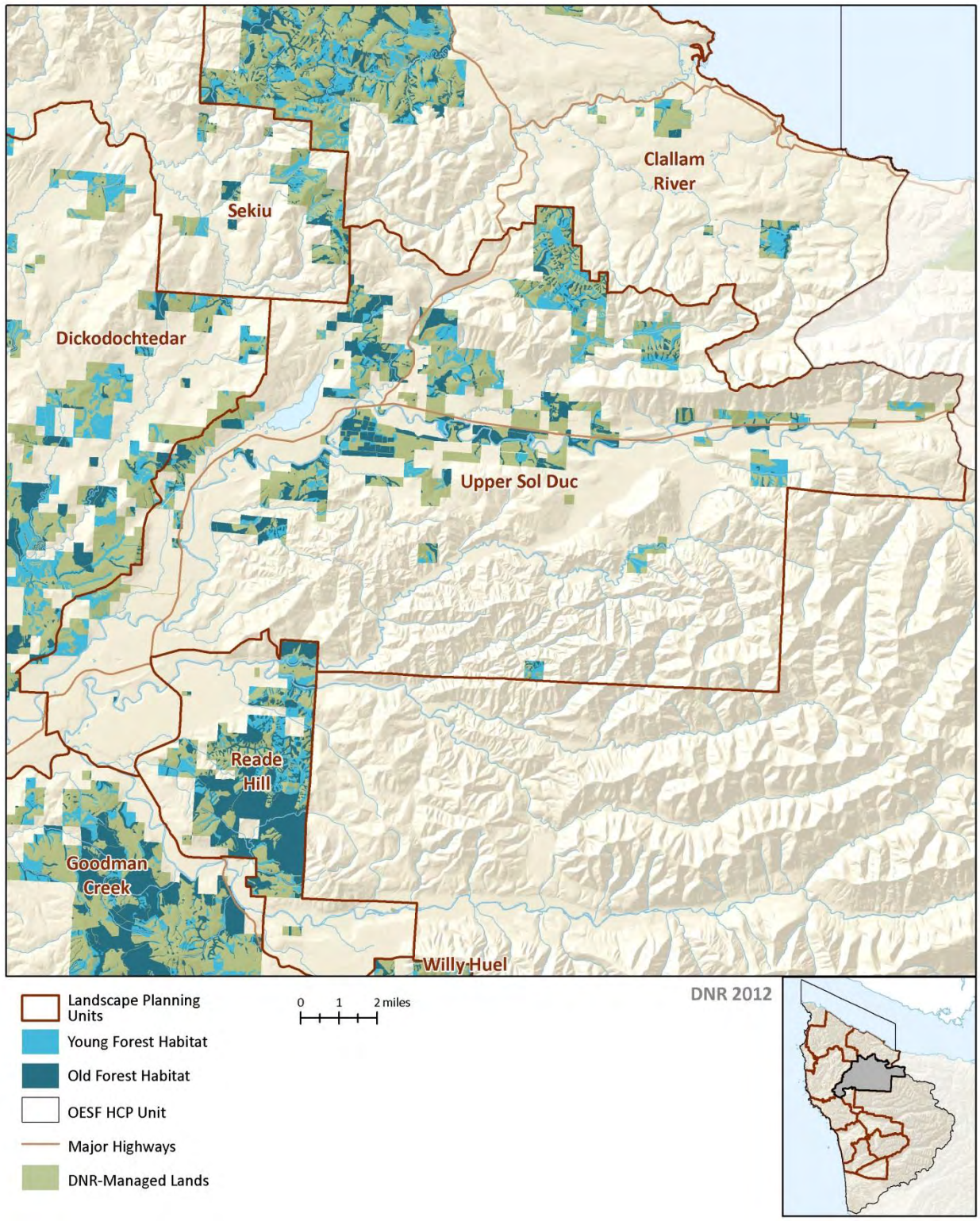
Map I-65. Old Forest and Young Forest Habitat on State Trust Lands in the Sol Duc Landscape, No Action Alternative, Decade 1



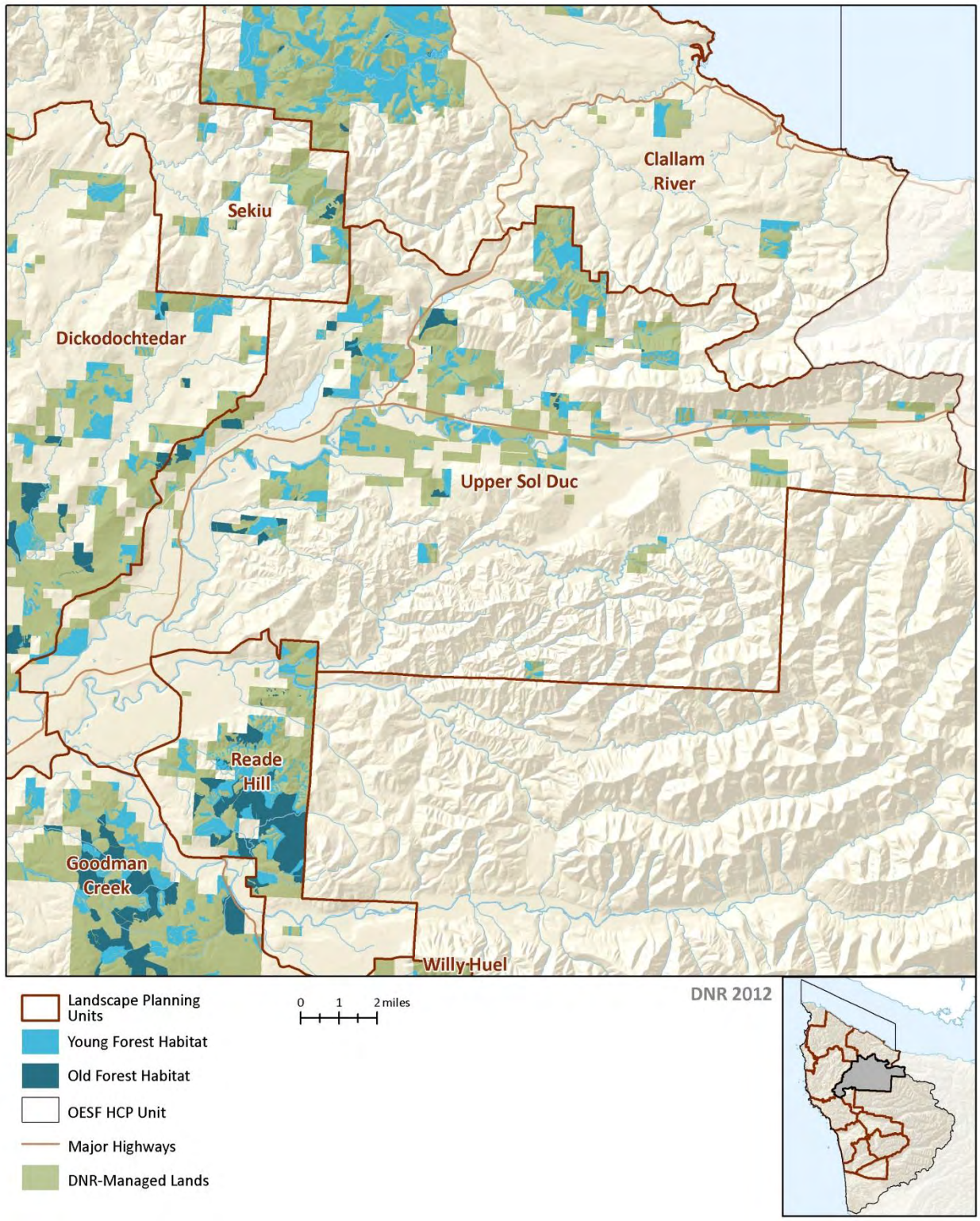
Map I-66. Old Forest and Young Forest Habitat on State Trust Lands in the Sol Duc Landscape, No Action Alternative, Decade 6



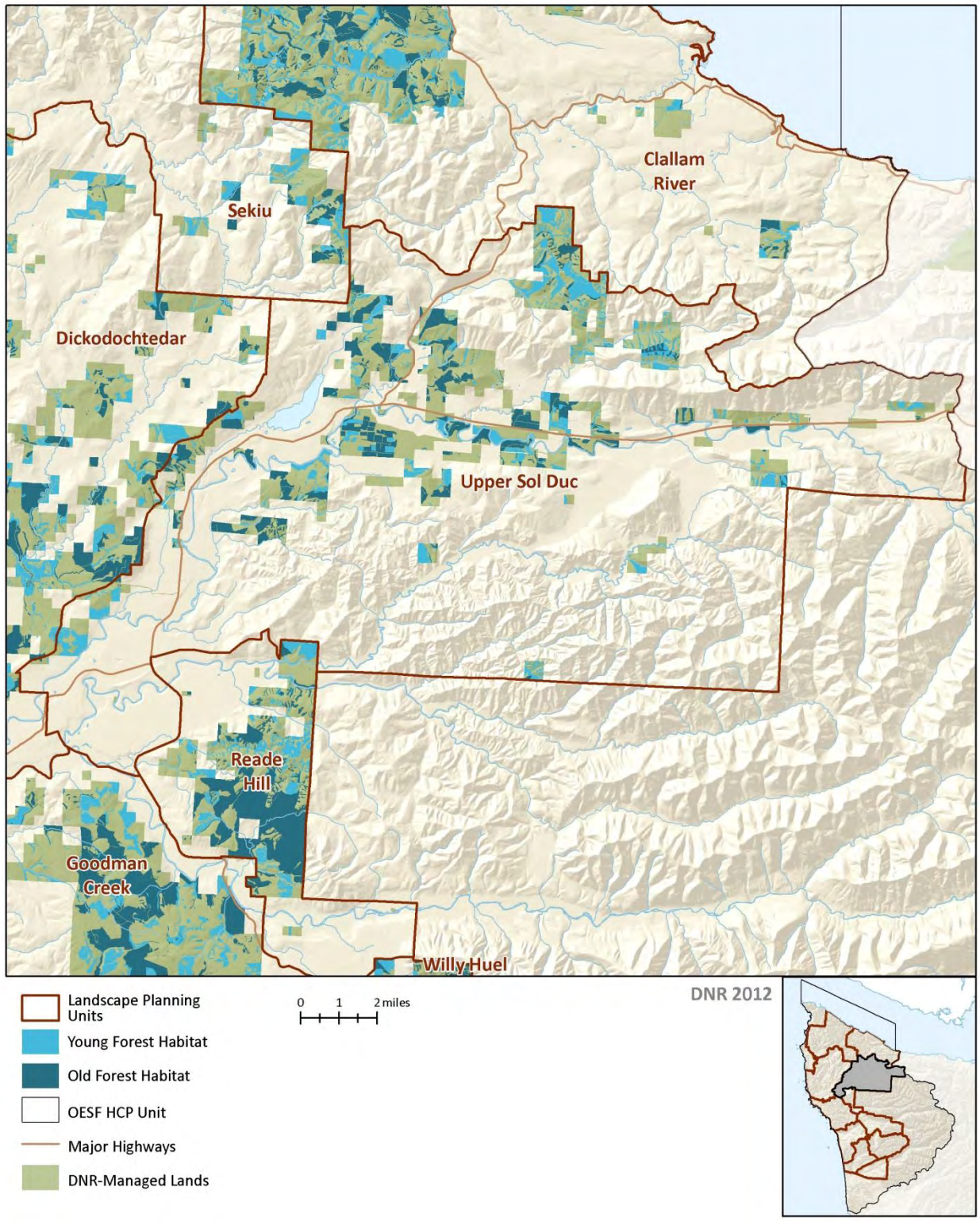
Map I-67. Old Forest and Young Forest Habitat on State Trust Lands in the Sol Duc Landscape, No Action Alternative, Decade 9



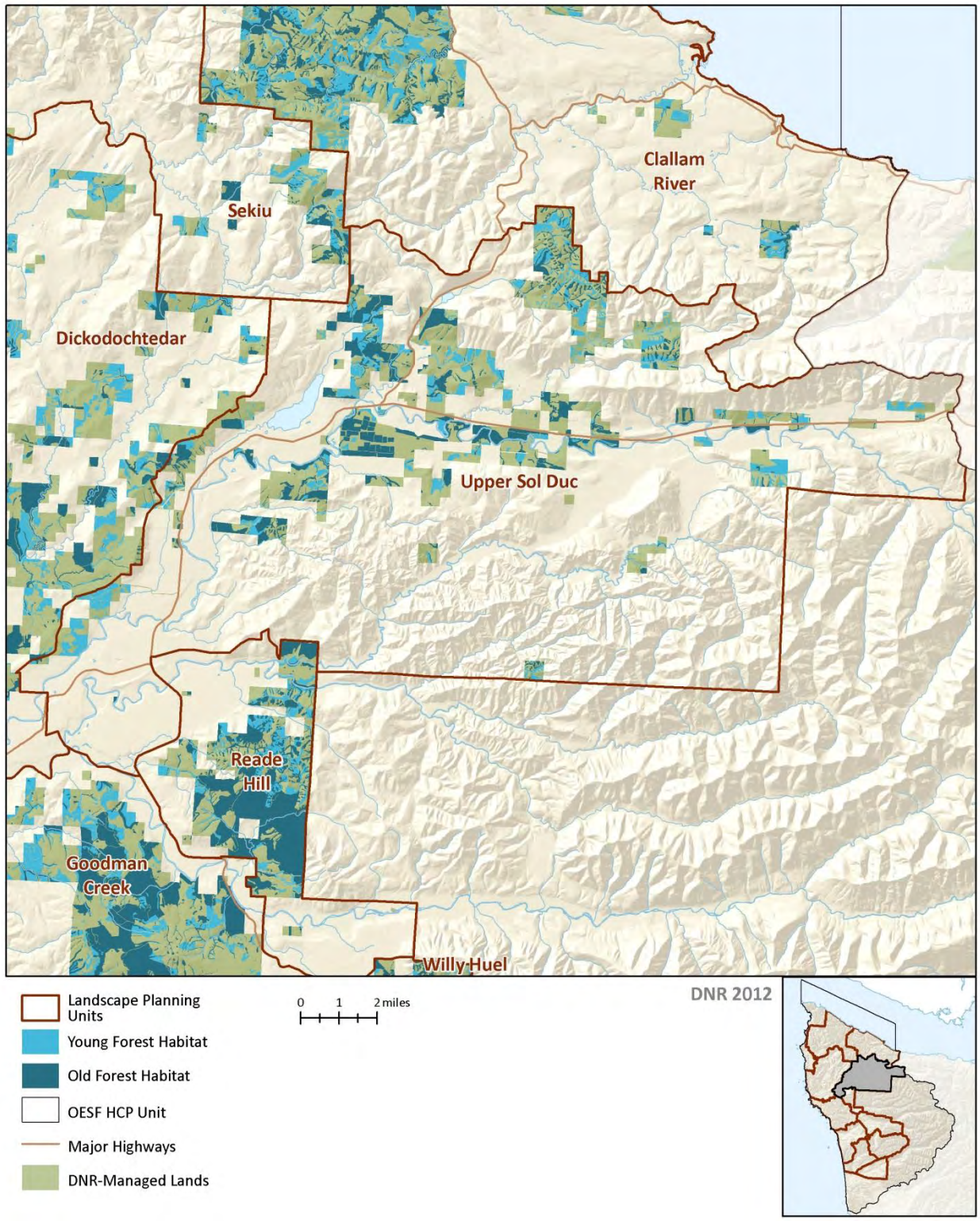
Map I-68. Old Forest and Young Forest Habitat on State Trust Lands in the Sol Duc Landscape, Landscape Alternative, Decade 1



Map I-69. Old Forest and Young Forest Habitat on State Trust Lands in the Sol Duc Landscape, Landscape Alternative, Decade 6

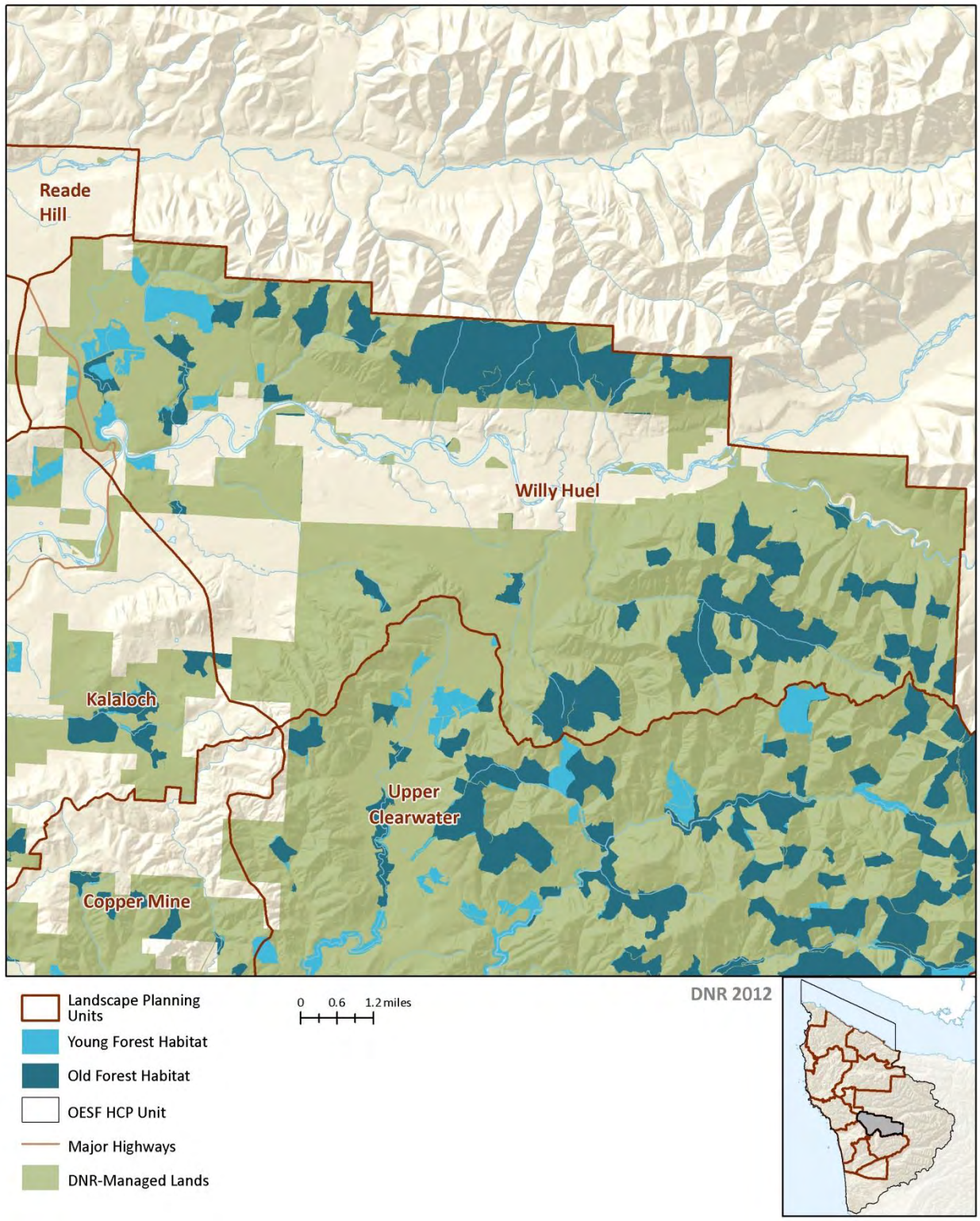


Map I-70. Old Forest and Young Forest Habitat on State Trust Lands in the Sol Duc Landscape, Landscape Alternative, Decade 9

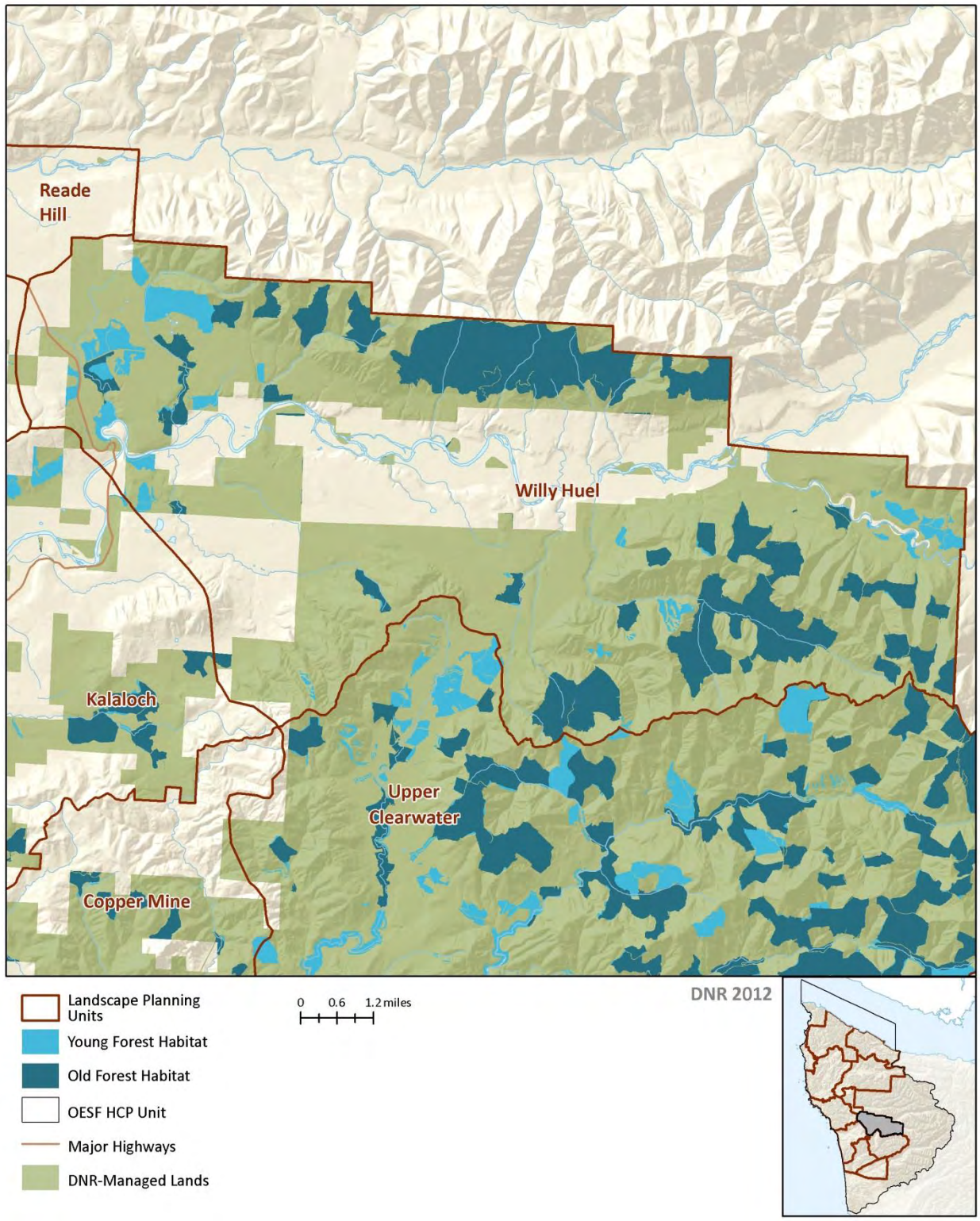


■ Willy Huel Landscape Old Forest and Young Forest Habitat Maps

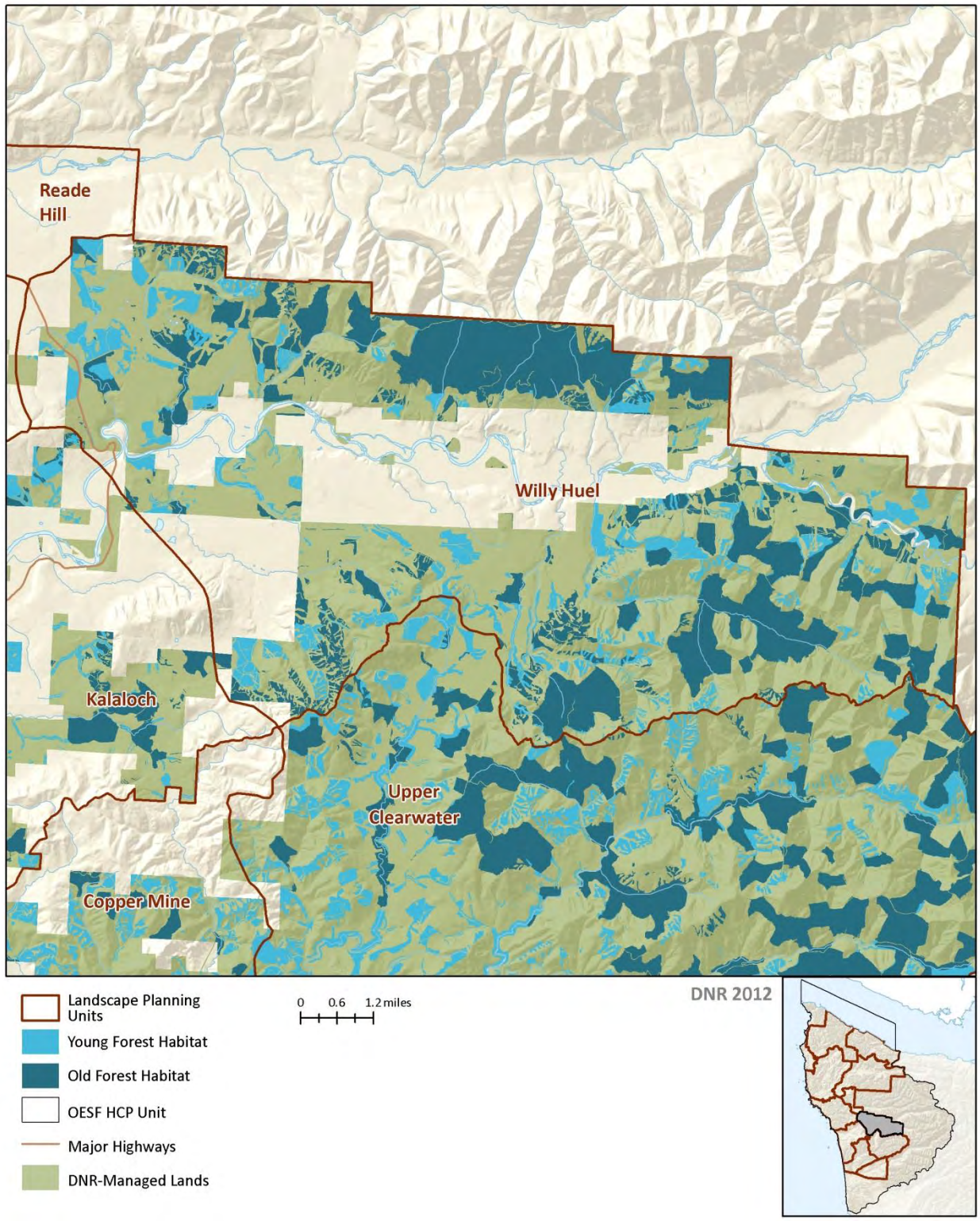
Map I-71. Old Forest and Young Forest Habitat on State Trust Lands in the Willy Huel Landscape, Current Conditions



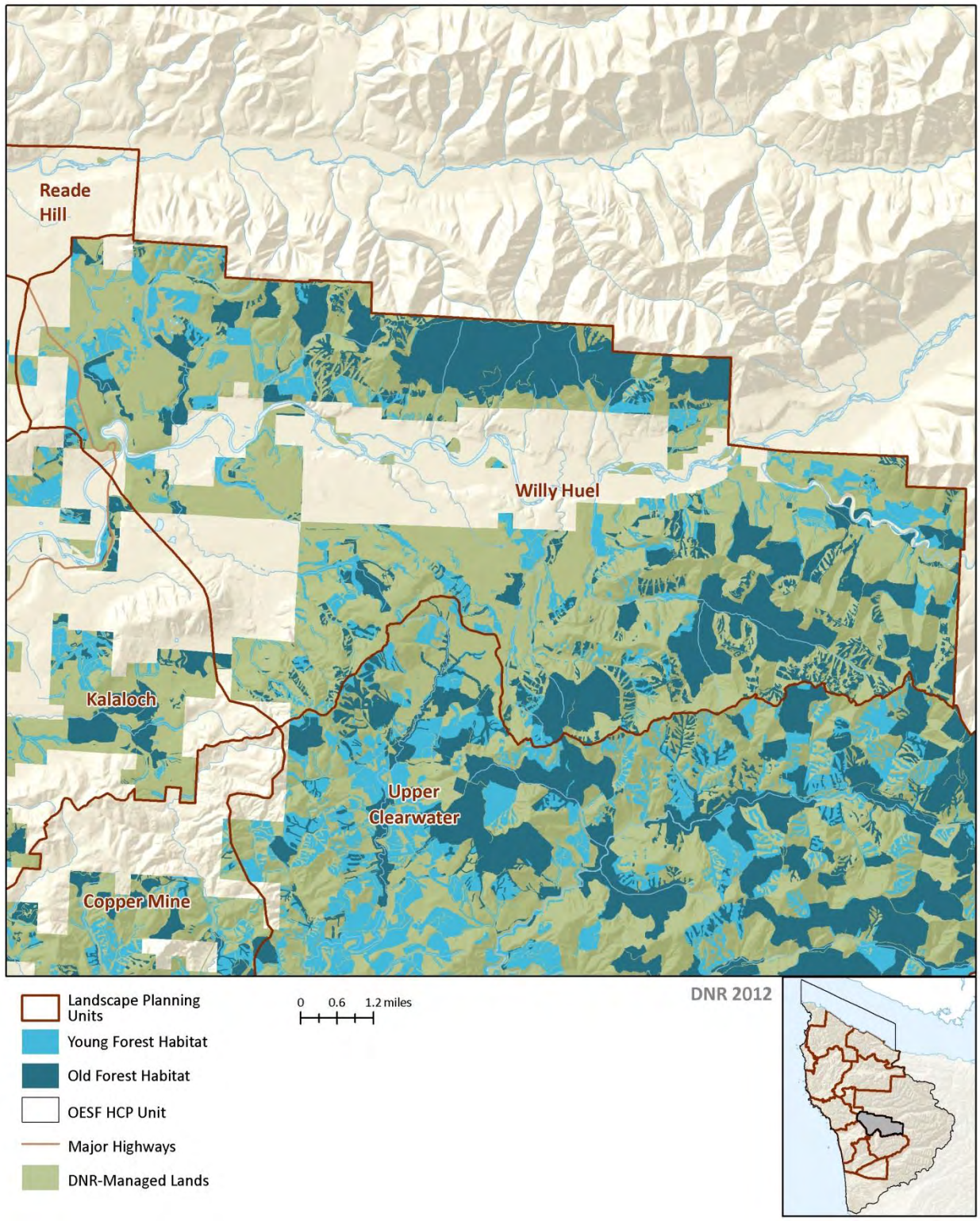
Map I-72. Old Forest and Young Forest Habitat on State Trust Lands in the Willy Huel Landscape, No Action Alternative, Decade 1



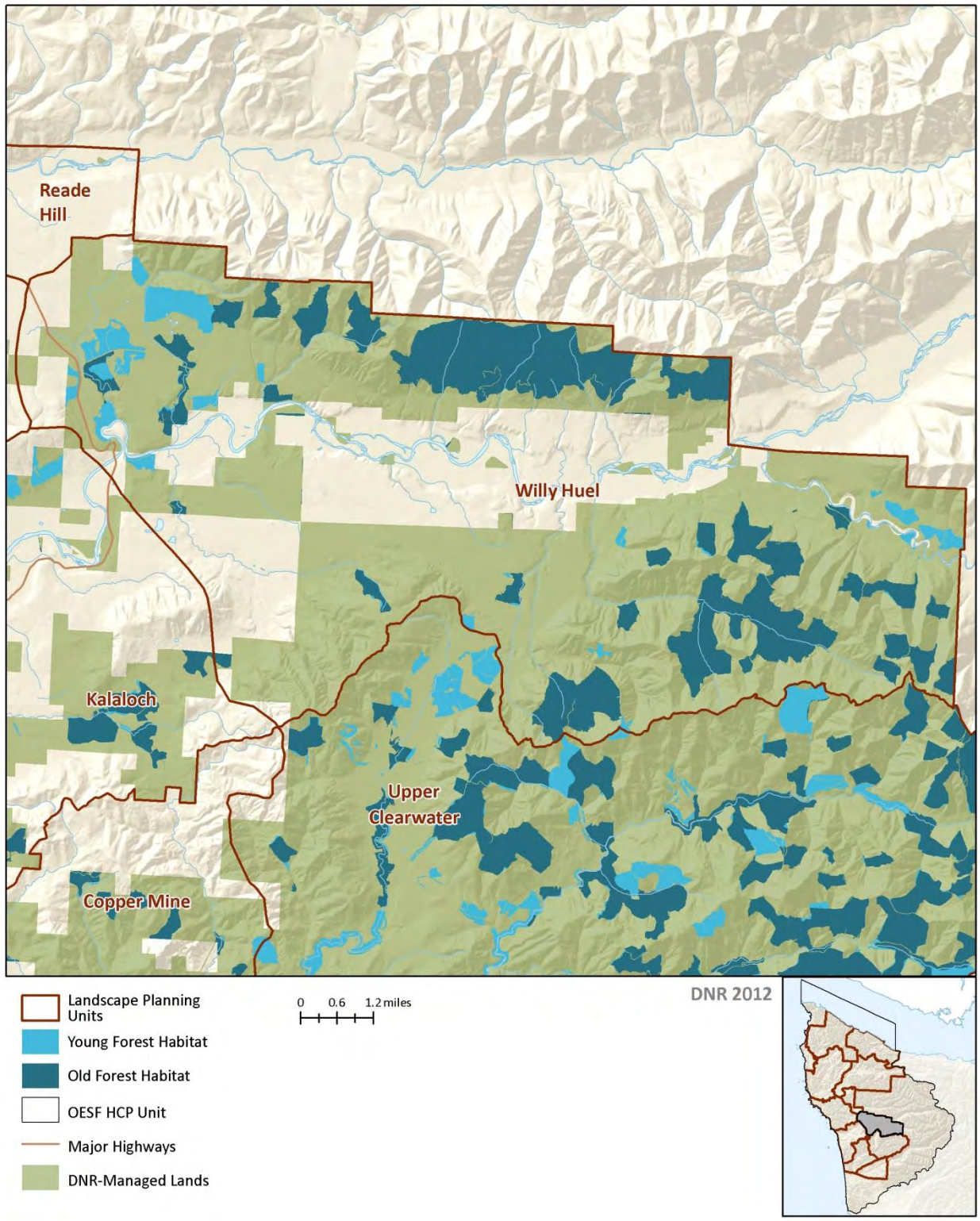
Map I-73. Old Forest and Young Forest Habitat on State Trust Lands in the Willy Huel Landscape, No Action Alternative, Decade 6



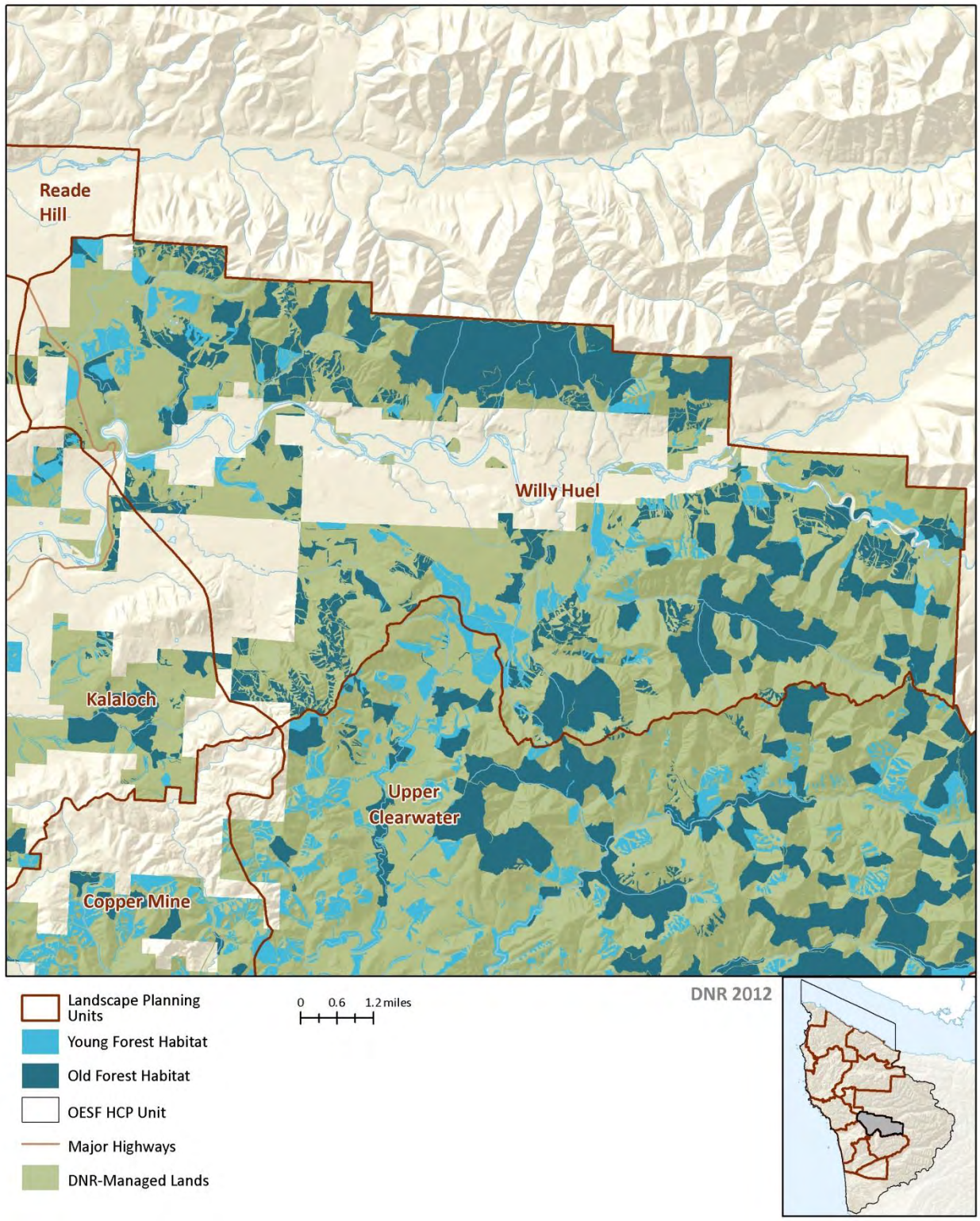
Map I-74. Old Forest and Young Forest Habitat on State Trust Lands in the Willy Huel Landscape, No Action Alternative, Decade 9



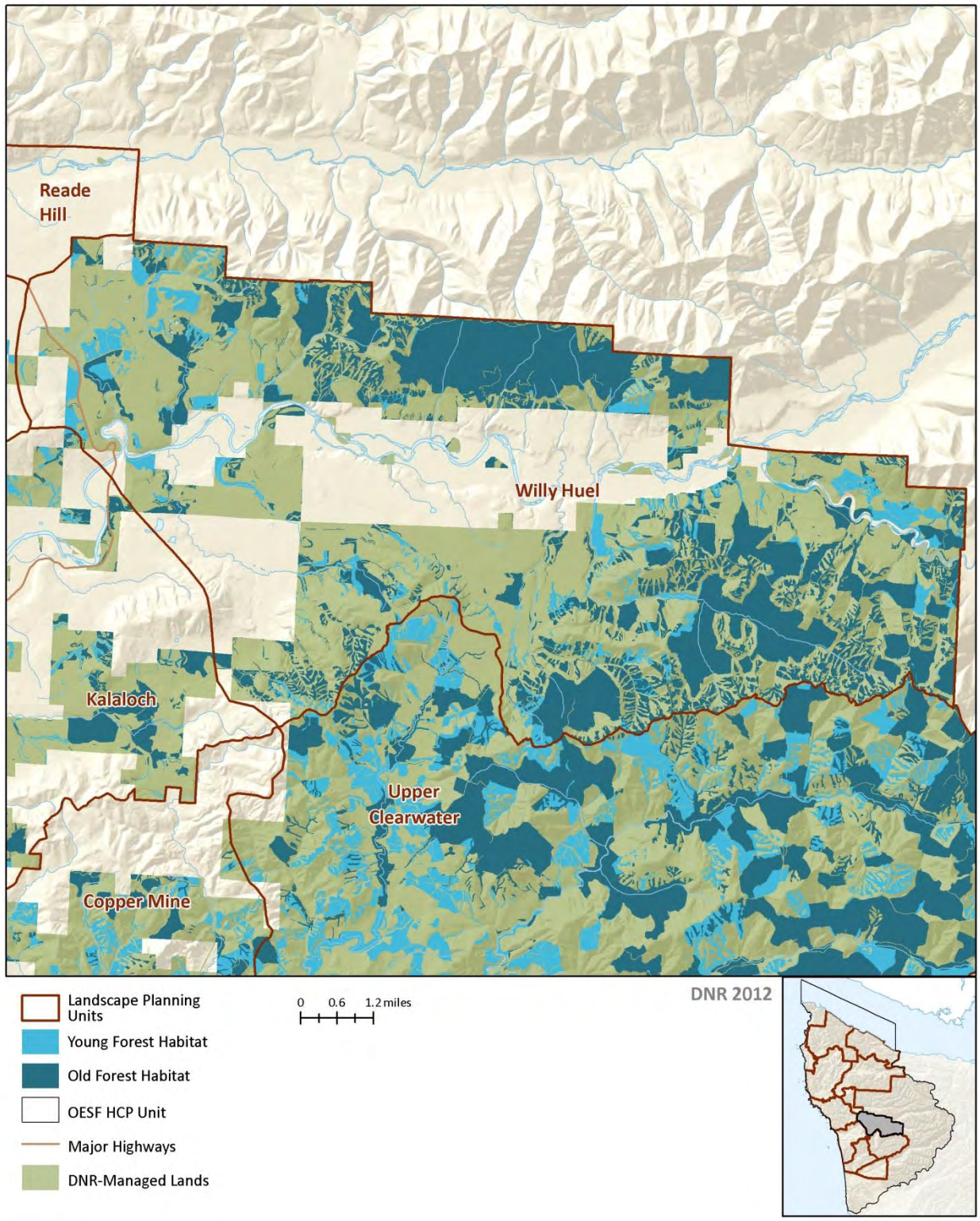
Map I-75. Old Forest and Young Forest Habitat on State Trust Lands in the Willy Huel Landscape, Landscape Alternative, Decade 1



Map I-76. Old Forest and Young Forest Habitat on State Trust Lands in the Willy Huel Landscape, Landscape Alternative, Decade 6



Map I-77. Old Forest and Young Forest Habitat on State Trust Lands in the Willy Huel Landscape, Landscape Alternative, Decade 9



Northern Spotted Owl Stand-Level Model for Life History Requirements

Introduction

The overall goal of the northern spotted owl conservation strategy in the OESF is to not appreciably reduce the chances for the recovery and survival of the subpopulation of northern spotted owls in the Olympic Peninsula. This goal is to be achieved by restoring and maintaining northern spotted owl habitat capability in the OESF at both the forest stand and landscape level. Forest stands can function as nesting, roosting, and foraging habitat in landscapes with composition and pattern capable of supporting reproductively successful northern spotted owls.

The northern spotted owl stand-level model for life history requirements is a functional rather than structural approach to the environmental assessment. In other words, it assesses the functional role of individual forest stands and landscapes for northern spotted owls. These assessments rely on "models," in other words descriptions of how nature works, structured to incorporate scientific knowledge of spotted owl ecology. The northern spotted owl stand-level model indexes the ability of forest stands to provide for each of the following life requirements of the northern spotted owl: movement, roosting, foraging, and nesting.

Description of the Northern Spotted Owl Stand-Level Model

For the stand-level model, DNR used a process adapted from "Ecosystem Management Decision Support" (EMDS) software (Reynolds 1999, http://emds.mountain-viewgroup.com/) as a framework for the analysis because it provides a relatively simple and flexible tool for developing ecological assessment models linked to geographic information systems (GIS). The model structures and parameters are modified from the analysis done for northern spotted owl in *South Puget Habitat Conservation Plan Planning Unit Forest Land Plan Final Environmental Impact Statement* (DNR 2010).

Model Structures

The basic idea behind stand-level models (and most habitat suitability indices) is to take a number of measurable indicators and then add them together into an overall assessment score. The model structure provides an outline of what is added together and how. Habitat suitability indices models are commonly expressed as mathematical equations or more qualitative habitat matrices. Stand-level models use

elements of both of these approaches by providing a number of basic building blocks that can be used to perform quantitative or qualitative evaluations.

These building blocks are generally arranged in a hierarchical network, which decomposes the overall goal of the assessment into finer and finer sub-components until measurable indicators are reached. In describing these models, the word "indicator" is used to refer to a measurable aspect of habitat and "topic" is used to describe a group of indicators combined as a particular theme. Four basic needs of northern spotted owls include foraging, roosting, nesting and movement. A separate model was built to assess habitat in relation to each of these needs (refer to Figures I-4 to I-7).

Weights

Some model elements may be deemed by experts as more important for northern spotted owls than others. This difference can be captured in the model by assigning weights to an indicator. All indicators start with a default weight of one. If one indicator is twice as important as another, it is assigned a weight of two (or alternatively, the less important one assigned a weight of 0.5). The scope of a particular weight is limited to the place where two or more indicators are combined into a higher level topic in the hierarchy (for example, the combination of large and small snags in Figure I-4). Grouping indicators into topics, as just discussed, usually makes weighting easier. In Figures I-4 through I-7, weights are indicated in parentheses following the topic/indicator name.

Combination Operators

Stand models provide a number of "operators" for use in combining individual topic/indicator values to the next higher node in the hierarchy. Operators are simple mathematical concepts. The following three operators are currently used in the stand models:

- **AVE (average)**: The average of the sub-nodes is passed up the model (good sub-node scores can partially compensate for poor sub-scores and vice-versa).
- **MIN (minimum)**: The minimum of the sub-nodes is passed up the model (akin to a limiting factor type analysis).
- **wtMIN (weighted minimum)**: If any one of the scores is –1, then –1 is passed up to the condition score, otherwise it passes up a result weighted toward the lowest sub-node score. This operator provides an option in between the average and minimum operators. The precise function is: wtMIN(subnodes) = min(subnodes) + [average(subnodes) - min(subnodes)]*[min(subnodes)+1] / 2

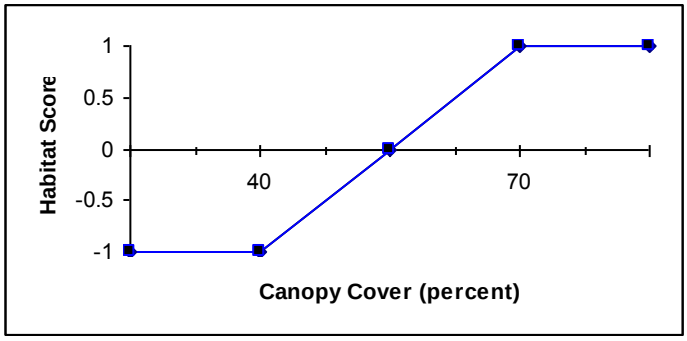
Evaluation Functions

In order to combine indicators, they first must be converted (normalized) to a common scale. In the stand-level models, this is done by setting up evaluation criteria, which are standards to which a particular indicator value is compared to decide whether it reflects positively or negatively on the assessment

objective. The result of this comparison is a normalized evaluation score between "-1" and "+1". The criteria can be hard and fast (as they often are in habitat matrix approaches). For example, canopy cover > 70 percent is acceptable (evaluated score = +1) and < 70 percent is not acceptable (-1). However, one of the advantages of an EMDS-like approach is that it allows more flexible criteria that produce a finer gradation of results.

An example using canopy cover is presented in Figure I-3. The horizontal axis represents the indicator measure and the vertical axis represents the resulting evaluated (and normalized) score. The line connecting the squares represents the evaluation function. What it says is that at a canopy cover of ≤ 40 percent, the habitat value is -1 (not at all indicative of suitable dispersal habitat); at 70 percent and above, the habitat is rated +1 (fully functional). Canopy covers between 40 and 70 percent receive an intermediate score based on a linear interpolation between the two (55 percent would produce a score of 0). This scale was then converted to 0 to 100 and re-programmed into the GIS system (using the Python programming language). Values for the inflection points on the evaluation criteria curves are derived from the most reliable available source, from peer-reviewed scientific publications, analysis of existing data sets, and best professional judgment. Since literature and data on owl dispersal are limited and often not focused precisely on the indicators chosen for the models, the Science and Modeling Team for this analysis used professional judgment to interpret, synthesize and estimate the criteria. Evaluation criteria for each indicator are detailed in the following section.

Figure I-3. Evaluation Curve for Canopy Cover



Context Switches

Context switches use input data to change when and how to evaluate other indicators. For example, many old growth stands have canopy cover of < 70 percent, so the Science and Modeling Team decided to allow the +1 threshold for canopy cover to go down to 60 percent if the stand structure resembled old growth. The context indicator used is stand development stage, and the rule is when stand development stage > 4 (either Niche Diversification or Fully Functional stages) then the +1 threshold is set to 60 percent.

Figure I-4. Northern Spotted Owl Nesting Model

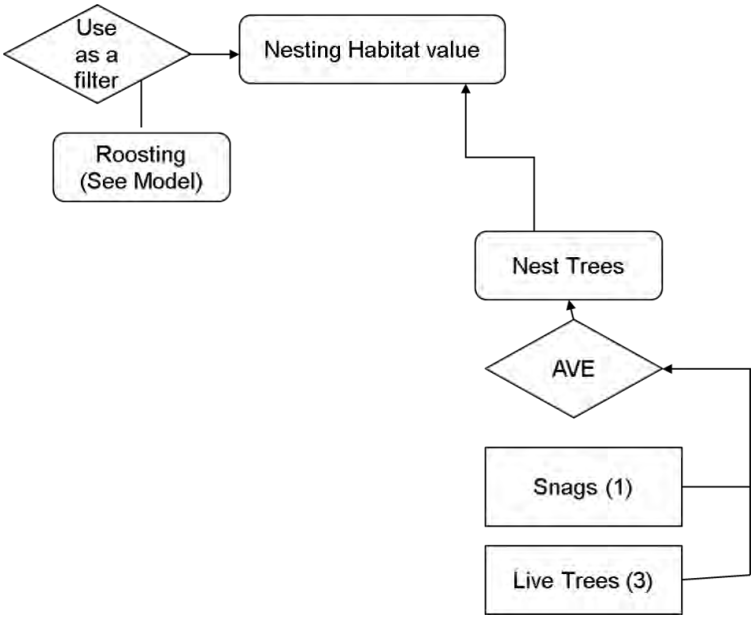


Figure I-5. Northern Spotted Owl Roosting Model

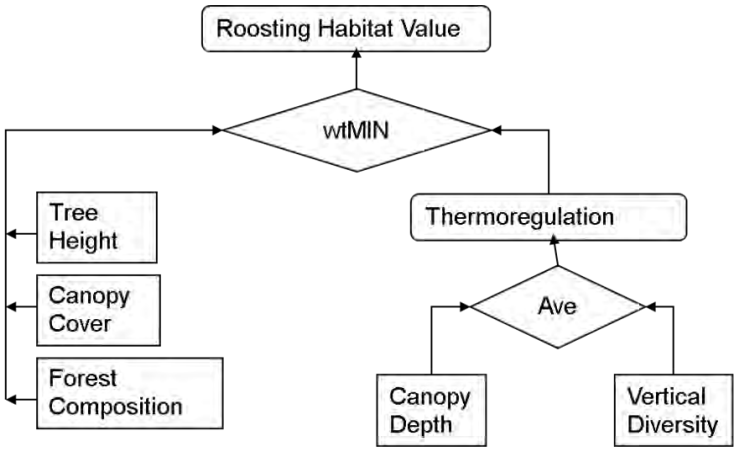


Figure I-6. Northern Spotted Owl Foraging Model

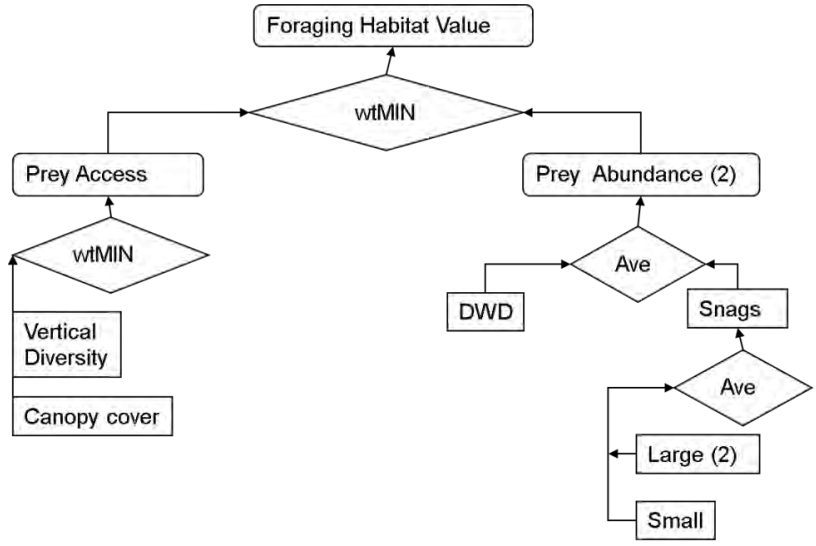
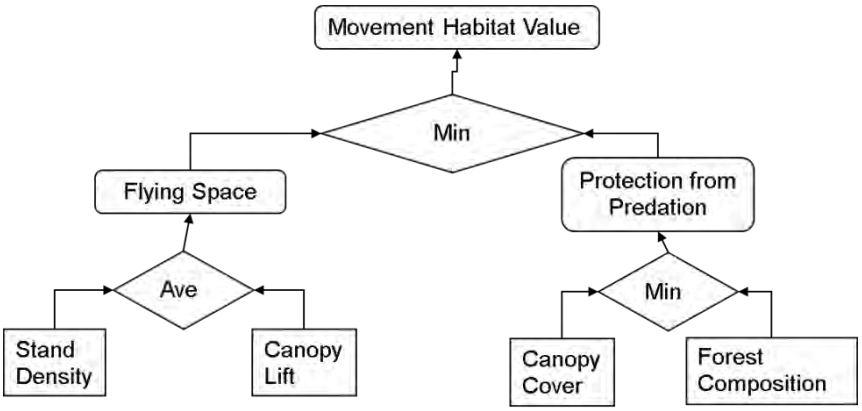


Figure I-7. Northern Spotted Owl Movement Model



■ Roosting, Foraging, Movement, and Nesting Models

The rest of this section follows the model structures from the top down, and describes the essential features of each branch or node. As an example, the roosting habitat topic node contains a description of the rationale for choosing its sub-nodes and the aggregator used to combine them. Indicator node descriptions use the following format:

Rationale: Brief rationale for choosing the indicator

Literature: A very brief summary of the literature on this indicator, especially as related to evaluation criteria

Measure: How the indicator is measured (for example, average height of the forty tallest trees)

Data source: Where the data for the indicator comes from

Criteria: Evaluation criteria (in other words, threshold values used to score the indicator from -1 to +1) and rationale

Roosting Model

Model Structure Rationale

Tree height, canopy cover and forest composition are seen as the most fundamental indicators for identifying roosting habitat and are therefore evaluated at the top level. Canopy depth and vertical diversity are combined to form the thermoregulation input to roosting habitat.

Model Aggregator Rationale

Tree height, canopy cover, forest composition and the thermoregulation branch each need to be met, so they are combined with a weighted minimum (wtMIN) operator.

Tree Height

Rationale: Northern spotted owls require a certain tree height for adequate roosting opportunities.

Literature: The Scientific Advisory Group (SAG) (Hanson 1993, p. 57) cites studies where the average height of roost trees was between 85 to 110 feet.

Measure: Average height of the forty largest diameter trees.

Data source: Height as recorded in the Forest Resources Inventory System (FRIS) and projected by the forest vegetation simulator (FVS).

Criteria: Roost trees are not necessarily the largest trees in the stand, so the model places the average roost tree height (85') near the center of the evaluation curve.

Table I-2. Tree Height Indicator

Indicator	**Tree height**		
Shape	Evaluation score	Thresholds	Units
			
	+1	120	Feet
	-1	50	Feet

Forest Composition

Rationale: A certain percentage of conifers in the forest stand is important for thermoregulation and cover from predators.

Literature: Thomas and others (1990) noted that northern spotted owls are virtually always located in conifer-dominated forest types. SAG (Hanson 1993) found a definition of mixed conifer stands as 30-70 percent conifers. In contrast, Herter and others (2002) found 5-8 percent of roost sites on lands not classified as habitat by DNR, and these were primarily areas of high hardwood canopy cover (< 70 percent conifer).

Measure: Percent of stand basal area in conifers (trees > 3.5" dbh).

Data source: Calculated from FVS tree lists.

Criteria: SAG (Hanson 1993) and the 1997 HCP (WADNR 1997) used a minimum definition of 30 percent.

Table I-3. Forest Composition Indicator

Indicator	**Forest composition**		
Shape	Evaluation score	Thresholds	Units
			
	+1	90	% conifer
	-1	30	% conifer

Canopy Cover

Rationale: Provides protection from predation and thermal cover. Great horned owls, which are the greatest predator threat to the northern spotted owl, hunt in more open areas.

Literature: SAG (Hanson 1993) cited average values of heavily used stands from 60-90 percent.

Measure: FVS-generated percent canopy cover calculated without overlap. A reliable crosswalk between closure (measured from below, typically used in wildlife studies) and cover (measured from above, generated by remote sensing and forest models) would help refine the criteria but has not been found.

Data source: The current model uses an FVS-generated estimate of canopy cover for all trees > 3.5" dbh (assuming smaller trees would not provide cover at typical roosting heights).

Criteria: Canopy closure on old-growth stands can often fall below 70 percent and the initial idea was to lower +1 value to 60 percent if a stand was classified as beyond the stand development stage 4. However, because the FVS calculates canopy cover by adding all canopy strata, the multistrata older stands have high percent canopy cover although they may have gaps. The fact that canopy cover is calculated as average per stand and not per acre also contributes to that (multistrata and closed-canopy patches compensate for the gaps). As a result, stands in the OESF have fairly similar canopy cover independent of stand development stage and closure is usually above 70 percent.

Table I-4. Forest Canopy Cover Indicator

Indicator	**Canopy cover**		
Shape	Evaluation score	Thresholds	Units
	+1	70	%
	-1	40	%

Thermoregulation

Model Structure Rationale

Canopy depth and vertical diversity are used to measure the amount and diversity of vertical roosting choices, primarily important for thermoregulation.

Model Aggregator Rationale

Canopy depth and vertical diversity are partially compensatory, so they are combined with the AVERAGE operator.

►Canopy Depth

Rationale: Deeper canopies provide a larger thermal buffer (more insulation) and greater predation avoidance possibilities.

Literature: No published studies have measured canopy depth relative to northern spotted owl use; however, North and others (1999) found a greater foliage volume in high use stands.

Measure: Average height of the dominant stratum minus the average height to live crown (lift) of the lowest stratum. If the lift measure is < 20', it is set to 20' (assuming that canopy below 20' is generally not useful for roosting).

Data source: Not measured as part of the field inventory. FVS models the average tree height and height-to-base-of-live-crown (canopy lift) for each identified vertical stratum or layer. Canopy depth is defined as the difference between these two measurements, for the tallest identified stratum.

Criteria: Based on expert judgment at February 8, 2007 DNR workshop.

Table I-5. Forest Canopy Depth Indicator

Indicator	**Canopy depth**		
Shape	Evaluation score	Thresholds	Units
			
	+1	85	Feet
	-1	40	Feet

►Vertical Diversity

Rationale: A greater diversity of tree heights provides more thermal microhabitats for roosting.

Literature: Two methods for estimating this attribute has recently been used at DNR: 1) tree diameter diversity index (DDI) used as a surrogate for the tree height diversity (used in calculating the weighted old growth habitat index (WOGHI) and 2) FVS algorithm for determining tree height diversity (Crookston and Stage 1999 extension) used in FRIS and in the MoRF (Movement, Roosting, and Foraging) owl habitat definition for in the *South Puget Habitat Conservation Plan Planning Unit Forest Land Plan Final Environmental*

Impact Statement (DNR 2010). (Identification of canopy layers for the MoRF definition is modified from Croockston and Stage). The Science and Modeling Team made a decision to use the FVS stratification as it is a direct measurement of tree height unlike the DDI, which uses an allometric relationship between tree diameters and heights.

The Berger-Parker Index for estimating of canopy layering, used in the EMDS northern spotted owl models for the in *South Puget Habitat Conservation Plan Planning Unit Forest Land Plan Final Environmental Impact Statement* (DNR 2010), is not considered here because of its subjectivity in assigning height class categories.

Measure: FVS identifies canopy layers using an algorithm described by Crookston and Stage (1999): "The canopy strata are initially defined by naturally occurring gaps in the distribution of tree heights. The gaps are found when the heights of two trees in a list sorted by heights differ more than 30 percent of the height of the taller and at least 10 ft. The two largest gaps define three potential strata. If there is only one gap, two potential strata are defined and if there are no gaps, one potential stratum is defined…. Initially defined strata must have over 5 percent canopy cover or they are rejected. Nominal stratum dbh and height are computed by averaging the nine sample trees centered on the 70th percentile tree."

FVS canopy layers from 1 to 3.

Data source: FVS projected data, calculated as described above.

Criteria: Based on expert judgment at February 24, 2010 DNR meeting.

Table I-6. Forest Vertical Diversity Indicator

Indicator	**Vertical diversity**		
Shape	Evaluation score	Thresholds	Units
			
	+1	3	FVS Layers
	0	1.9	FVS layers
	-1	0	FVS layers

Foraging Model

Model Structure Rationale

The quality of habitat for northern spotted owl foraging is determined by the abundance of prey species and the accessibility of prey to owl predation. The importance of snags and down wood (related to prey abundance) is the best documented factor, so it is given twice the weight of the prey accessibility.

Model Aggregator Rationale

These attributes can partially compensate for each other in determining habitat quality, so they are combined using the wtMIN operator.

Prey Abundance

Model Structure Rationale

Abundance of prey species for the northern spotted owl has primarily been associated with the quantities of snags, down wood, and food sources in an area.

Model Aggregator Rationale

These attributes can partially compensate for each other in determining habitat quality, so they are combined using the AVERAGE operator.

► **Snags**

Rationale: Flying squirrels are the principal prey species of northern spotted owl in Western Washington, and they mainly den in cavities in snags and live trees. Large snags (as defined by SAG 1993) are more important, but the group believes smaller snags also have value.

Literature: SAG (Hanson 1993) cites unpublished data (Carey) illustrating that flying squirrels only reach high abundance in areas with more than two 20" dbh snags per acre. Carey (1995) recommends retaining all large snags (>50 cm / 20” dbh) up to 20 snags/ha (8 snags/acre). The 1997 HCP set criteria of 3 snags or cavity trees per acre of 20"+ dbh. North and others (1999), looking at principally old-growth stands in western Washington, found that snag volume greater than 142.1 cubic m/ha was correlated with an increase in foraging use and that 70 percent of the snag volume came from snags >70 cm (28 in) dbh.

Measure: Snags per acre in two size classes: large (> 20” dbh & >16' ht.) and medium (15-20” dbh & >10’ ht.).

Data source: Snags are modeled using the fire and fuels (FFE) extension of FVS. In this model snags decay differently deepening on species (two classes: hard and soft) and fall at a rate of 90 percent within 25 years.

Criteria: Following Carey (1995), 8 snags/acre was set as the upper threshold. No snags were set as the lower threshold. Based on the 1997 HCP threshold for Young Forest, two snags/acre was set to provide neutral support.

Table I-7. Large Snags Indicator

Indicator:	**Large snags (>20" dbh & >16' height)**		
Shape	Evaluation score	Thresholds	Units
			
	+1	8	# / acre
	0	2	
	-1	0	

Table I-8. Small Snags Indicator

Indicator:	**Small snags (15-20" dbh & >10' height)**		
Shape	Evaluation score	Thresholds	Units
			
	+1	8	# / acre
	0	2	
	-1	0	

► Down Wood

Rationale: Provides living space, movement, and cover for prey.

Literature: The 1997 HCP set an expected value of 5 percent, but cited it as a management hypothesis based on estimate of 15 percent needed to maintain full small mammal populations (Carey and Johnson 1995). Herter and others (2002) actually found less down wood at roost sites than random locations and discussed the hypothesis that owls select habitat according to prey accessibility in addition to prey abundance.

Measure: Volume in cubic feet for pieces >4" diameter is the measure in the inventory. DNR has cross-walked cubic feet to the percent cover measure commonly used in the wildlife literature using a linear equation (5 percent cover = 2400 ft^3, 10 percent = 4800 ft^3, etc.).

Data source: Numbers are modeled using the FFE extension of FVS. FFE calculates weights, not volumes, so weights of all pieces > 3" diameter are converted into cubic volume. No minimum piece length has been applied.

Criteria: The upper threshold was set to the median value for old stands found in Spies and Franklin (1991). A 5 percent cover value (= 2400 ft^3) was seen as a minimum needed to maintain adequate populations (so set to a model value of 0).

Table I-9. Down Wood Indicator

Indicator:	**Down wood (volume)**		
Shape	Evaluation score	Thresholds	Units
	+1	5700	Cu. Ft/ac
	0	2,400	Cu. Ft/ac
	-1	0	Cu. Ft/ac

Prey Access

Model Structure Rationale

Northern spotted owl access to prey is influenced by the availability of a variety of perching heights and a variety of conditions within the stand. Hunting can be impeded by an overly dense overstory and/or understory. Canopy cover provides protection for hunting owls.

Model Aggregator Rationale

These attributes can partially compensate for each other in determining habitat quality, so they are combined using the AVERAGE operator.

► Vertical Diversity

Review: (refer to Roosting)

Rationale: A greater diversity of tree heights provides more options for perch heights.

Literature: (refer to Roosting)

Measure: FVS layers 1 through 3 (refer to Roosting)

Data source: (refer to Roosting)

Criteria: (same as for Roosting)

Table I-10. Forest Vertical Diversity Indicator

Indicator	Vertical diversity		
Shape	Evaluation score	Thresholds	Units
	+1	3	FVS Layers
	0	1.9	FVS layers
	-1	0	FVS layers

► Canopy Cover

Rationale: Provides protection from predation. Great horned owls hunt in more open areas and are the greatest predator threat to the northern spotted owl (Forsman and others 2002).

Literature: (refer to Roosting)

Measure: (refer to Roosting)

Data source: (refer to Roosting)

Criteria: (same as for Roosting)

Table I-11. Forest Canopy Cover Indicator

Indicator	Canopy cover		
Shape	Evaluation score	Thresholds	Units
	+1	70	%
	-1	40	%

Movement Model

Model Structure Rationale

The ability of owls to move through a stand is primarily determined by adequate flying space under the canopy and sufficient cover for protection from predators.

Model Aggregator Rationale

Flying space and protection from predation are combined with the MINIMUM operator because both elements are needed and cannot substitute for one another.

Flying Space

Structure Rationale

The ability of owls to fly through a stand is determined primarily by the density of the stand and the amount of flying space available under the canopy.

Model Aggregator Rationale

Stand density and canopy lift are partially compensatory, i.e. a dense stand may be better if it has sufficient lift and vice-versa, therefore the AVERAGE of the two determines the suitability of the stand.

► Stand Density

Rationale: If a stand is too dense, it is difficult for owls to move through.

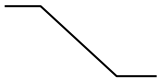
Literature: Owls need a canopy that is open enough to allow owls to fly within and beneath it (Thomas and others 1990). The literature has not looked at stand density from a movement-only perspective. Instead, it has been combined with the canopy closure concept to produce a density range that includes enough trees to provide cover but not so many as to be over-dense. SAG (Hanson 1993) settled on 115-280 trees per acre (tpa) by summarizing a variety of studies on intensively used stands: Allen and others (1989) found 190-210 tpa 4 inches dbh and larger, North found 152 tpa 2 inches dbh and larger, and Hicks (unpubl.) found 196 tpa 4 inches dbh and larger. Beak Consultants (1993) set the Murray Pacific HCP guidelines at between 130-300 tpa of dbh 10 inches dbh and larger.

Measure: Trees per acre > 2" dbh (which have an average height ~15' for DNR stands). Higher diameter limit were considered (i.e. starting at 4, 7 or 10" dbh, ~30-70' height) but would potentially miss overly dense stands composed of smaller trees.

Data source: An FVS variable is used to count all trees ≥ 2" dbh.

Criteria: Given that the lower density thresholds in the literature appear to have been set for the purpose of "cover" rather than "flying space," the model does not use a lower threshold here (a lack of trees does not impede foraging or movement). Further, canopy layers or vertical diversity may affect flying space: a multi-layered or vertically diverse stand may accommodate more stems and still provide reasonable flying space. To reflect this idea, the model increases the maximum tpa thresholds by 100 for each identified canopy layer beyond 1 (as calculated by FVS, ranging from 1 to 3).

Table I-12. Forest Stem Density Indicator

Indicator:	**Stem density (> 2" dbh)**		
Shape	Evaluation score	Thresholds	Units
	+1	1 Layer: 300 2 Layers: 400 3 Layers: 500	tpa
	-1	1 Layer: 0, 500 2 Layers: 0, 600 3 Layers: 0, 700	tpa

► Canopy Lift

Rationale: Owls need flying space under the canopy.

Literature: The Murray Pacific HCP (Beak Consultants Inc. 1993) set a minimum threshold of 20 ft. below canopy (beyond an assumed 10' shrub layer).

Measure: Space below the canopy (including an assumed 10 ft. tall shrub layer) of dominant and co-dominant trees.

Data source: DNR's FRIS does not contain crown information. The FVS 'Strclass' keyword calculates the average height to the base of live crown for each identified stratum. The model uses the height to crown base of the top stratum identified for a stand.

Criteria: The 30' Murray Pacific HCP value (20' + 10' shrubs) was seen as an absolute minimum necessary (-1 threshold) with the value increasing to an upper threshold of 55'.

Table I-13. Forest Canopy Lift Indicator

Indicator:	**Canopy lift**		
Shape	Evaluation score	Thresholds	Units
			
	+1	55	feet
	-1	20	feet

Protection from Predators

Model Structure Rationale

Canopy cover is the best predictor of protection from northern spotted owl predation by great horned owls. In the wintertime, the amount of conifers in the stand is the primary determinant of cover and so is also included.

Model Aggregator Rationale

In this context, canopy cover and forest composition do not compensate for one another, since they are used to represent different seasons of the year. Therefore, they are combined with a MINIMUM operator.

► Canopy Cover

Rationale: Provides protection from predation. Great horned owls, which are the greatest predator threat to the northern spotted owl, hunt in more open areas.

Literature: SAG (Hanson 1993) cited average values of heavily used stands from 60-90 percent.

Measure: (refer to Roosting)

Data source: (refer to Roosting)

Criteria: The lower evaluation criterion is less stringent than for foraging (30 percent vs. 40 percent) because the northern spotted owl needs less canopy cover for moving through a stand.

Table I-14. Forest Canopy Closure Indicator

Indicator	**Canopy closure**		
Shape	Evaluation score	Thresholds	Units
	+1	70	%
	-1	40	%

► Forest Composition

Rationale: Loss of hardwood leaf cover during the winter months increases the vulnerability of the northern spotted owl to predation by great horned owls.

Literature: Thomas and others (1990) state that northern spotted owls are frequently located in conifer-dominated forest types. SAG (Hanson 1993) used a definition of mixed conifer stands as 30 to 70 percent conifers.

Measure: (refer to Roosting)

Data source: (refer to Roosting)

Criteria: Lack of conifers is not as great a risk as posed by the more general openness measure of canopy cover, so the lower bound for the model score is set to zero.

Table I-15. Forest Composition Indicator

Indicator	**Forest composition**		
Shape	Evaluation score	Thresholds	Units
			
	+1	50	% BA conifer
	0	30	% BA conifer

Nesting Model

Model Structure Rationale

Northern spotted owls nest on big live or dead trees. The quality of the habitat patch immediately surrounding the nest structure is important (owls cannot nest on a remnant tree in the middle of a clear cut), therefore DNR made a requirement for a stand to first provide roosting support. In order for a stand to be considered for nesting it must have already achieved a Roosting stand score of 0 (or 50 if the scale is 0 to 100). Forsman and Giese (1997) characterized 116 nesting sites in Olympic Peninsula and found that 71 percent of nests were in forests dominated by trees greater than or equal to 100cm (40 inches) dbh with multilayered canopies; 19 percent were in forests dominated by trees 50-99 cm (20 to 39.6 inches) dbh with multilayered canopies; 8 percent were in forests with mosaic of small 13-49 cm (5.2 to 19.6 inches) dbh and large (greater than or equal to 50cm (20 inches) dbh) trees; 2 percent were in relatively even-aged forests of trees with dbh 50-99 cm (20 to 39.6 inches).

Nesting Structures

Structure Rationale

Owls in the Olympic Peninsula nest on big live trees or snags. Forsman and Giese (1997) measured 116 nest trees in the Olympic peninsula. Seventy eight percent of the nests were in live trees and 22 percent in snags. Seventy one percent of the nests on the west side of the peninsula were inside cavities, less were in top cavities, and even less were in external platforms. Hershey and others (1998) found only 7 percent of

the nest in the Olympic Peninsula to be external platforms. The majority of the nests were side cavities (67 percent), followed by top cavities (27 percent).

Model Aggregation Rationale

Snags and nest trees are compensatory, though live trees are weighted 3 to 1 for snags, therefore the AVERAGE of the two determines the suitability of the stand.

► Live Trees

Rationale: Large trees are needed for nest cavities to be present.

Literature: According to Forsman and Giese (1997), the mean dbh of all (n=116) nest trees (snags and live trees) on the Olympic Peninsula was 137 cm (SE 5.9, range 30-379 cm) or 54" (SE 2.3, range 11-150"), while the mean dbh of nest trees in the western Olympic Peninsula was 158 cm or 62".

Measure: Number of live trees per acre of 30"+, 40"+ or 50"+ dbh at least 16' tall.

Data source: FRIS

Criteria: Considering the literature and the FRIS for the OESF, the Science and Modeling Team set three dbh size classes for live trees: minimum 30", minimum 40" dbh and minimum of 50" dbh. There is no minimum height requirement for large diameter live trees.

Table I-16. Live Nest Trees Indicator

Indicator:	Live nest trees		
Shape	Evaluation score	Thresholds	Units
	+1	4 in 40" dbh class 2 in 50" dbh class	tpa
	-1	0 in 40" dbh class 0 in 50" dbh class	tpa

► Snags

Rationale: Large snags are needed for nest cavities to be present.

Literature: The mean dbh of all (n=116) nest trees (snags and live trees) on the Olympic Peninsula was 137 cm (SE 5.9, range 30-379 cm), while the mean dbh of nest trees in the western Olympic Peninsula was 158 cm or 62". Side cavities are the predominant nesting structure on the Olympic Peninsula – Hershey and others (1998) found 67 percent of the studied nests in the Olympic Peninsula to be in side cavities. Nesting live trees or snags with cavities have greater diameter than the ones with external platforms (Hershey 1998). External platforms are very unlikely for snags, therefore the dbh requirement for snags in

the OESF is higher the one for live trees. The Science and Modeling Team set it at minimum 50” dbh compared to minimum 30” and 40” dbh for live trees.

Measure: Large snags per acre > 50” dbh and >16' height

Data source: Snags are modeled using the FFE extension of FVS. In this model snags decay differently depending on species (2 classes: hard and soft) and fall at a rate of 90 percent within 25 years.

Criteria: The literature finds that most nests are in large snags.

Table I-17. Nest Tree Snags Indicator

Indicator	**Nest tree snags**		
Shape	Evaluation score	Thresholds	Units
	+1	1	tpa
	0	0.1	tpa
	-1	0	tpa

■ Stand Level Model Charts of Scores 50 and Above and 75 and Above by Landscape, No Action and Landscape Alternatives

Roosting, Foraging, Movement, and Nesting Stand Model Average Scores

Chart I-43. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 and Above for the Entire OESF, by Alternative

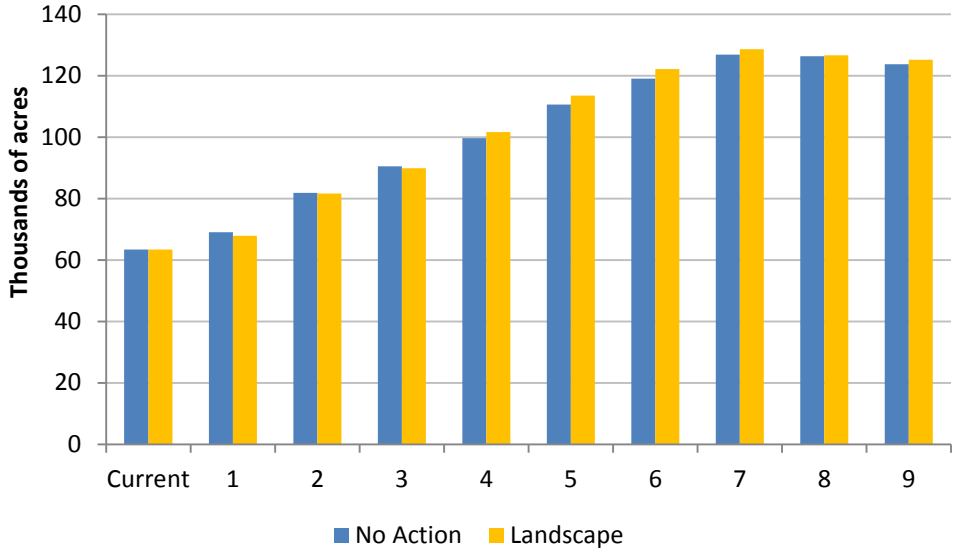


Chart I-44. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Entire OESF, by Alternative

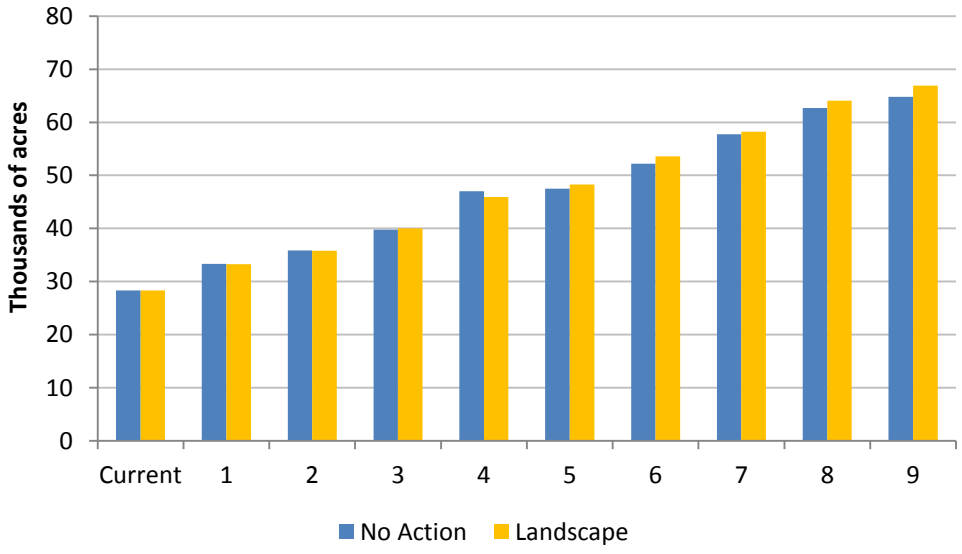


Chart I-45. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Clallam Landscape, by Alternative

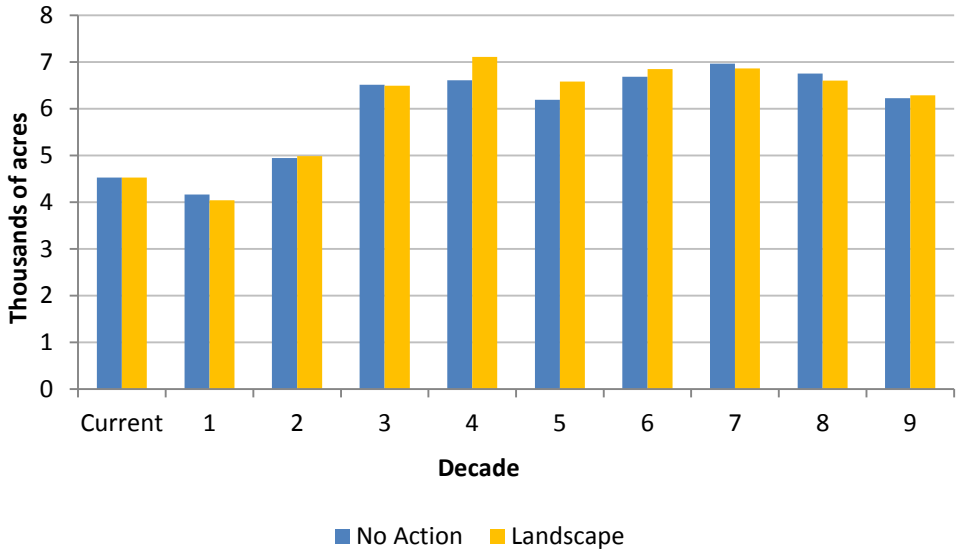


Chart I-46. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Clallam Landscape, by Alternative

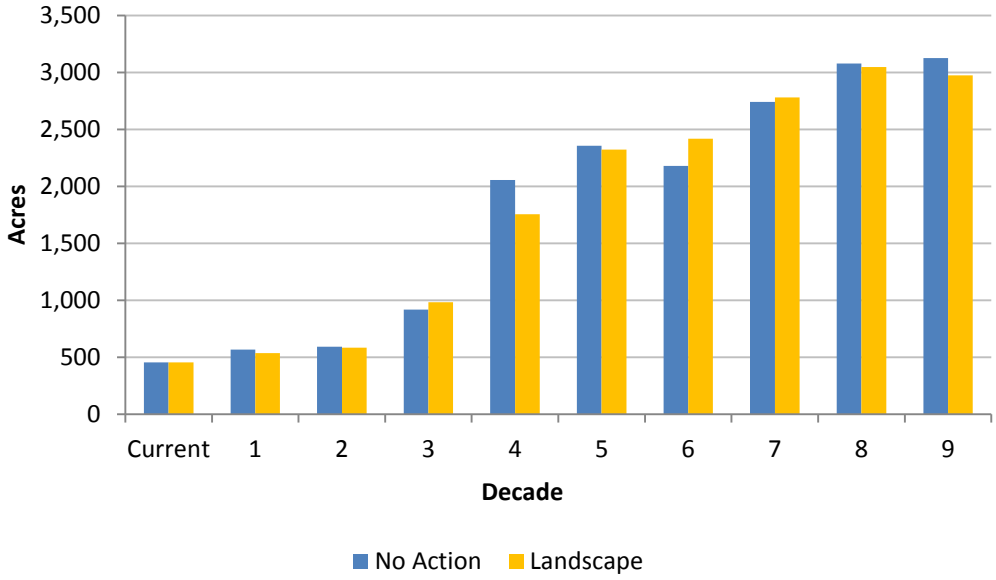


Chart I-47. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Clearwater Landscape, by Alternative

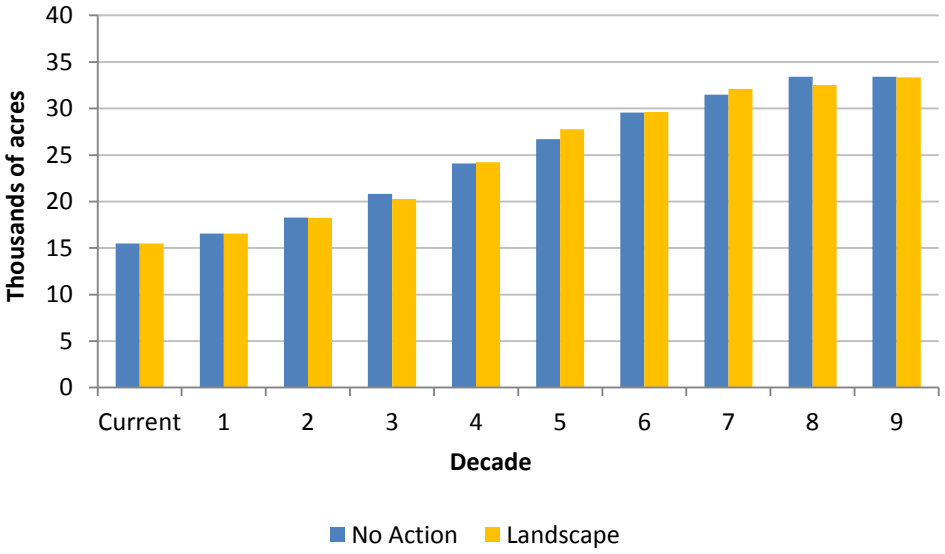


Chart I-48. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Clearwater Landscape, by Alternative

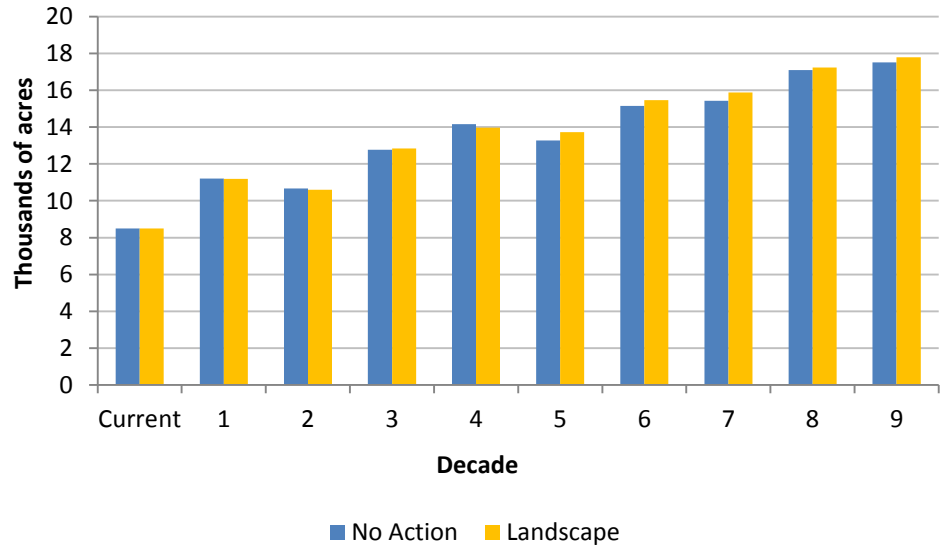


Chart I-49. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Coppermine Landscape, by Alternative

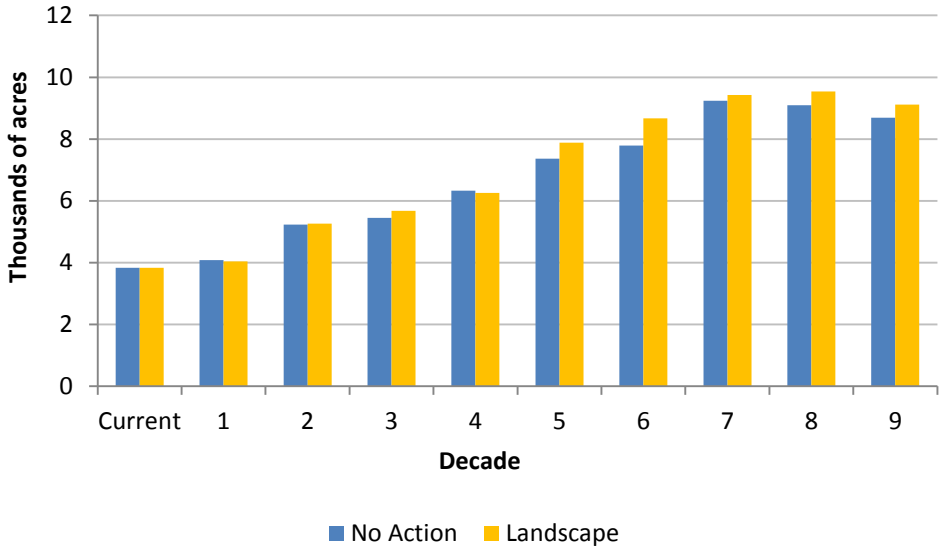


Chart I-50. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Coppermine Landscape, by Alternative

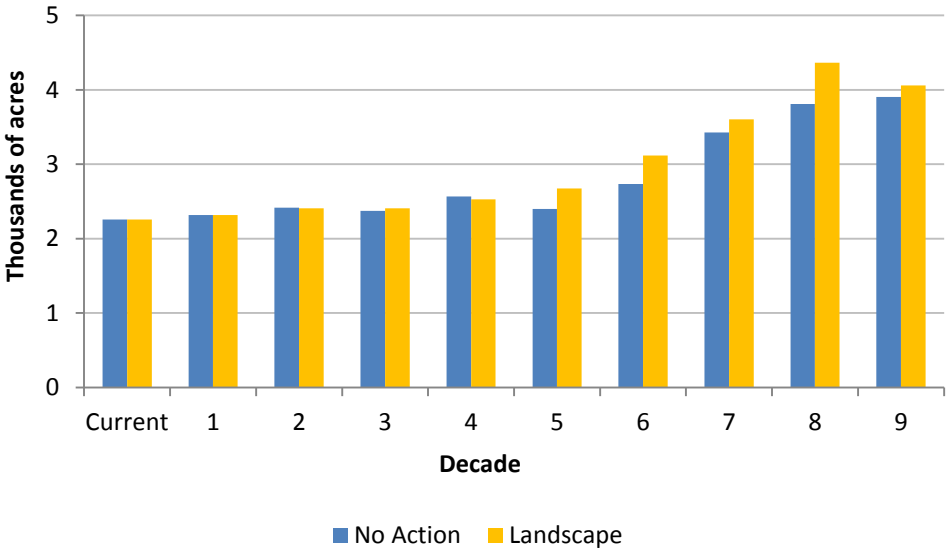


Chart I-51. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Dickodochtedar Landscape, by Alternative

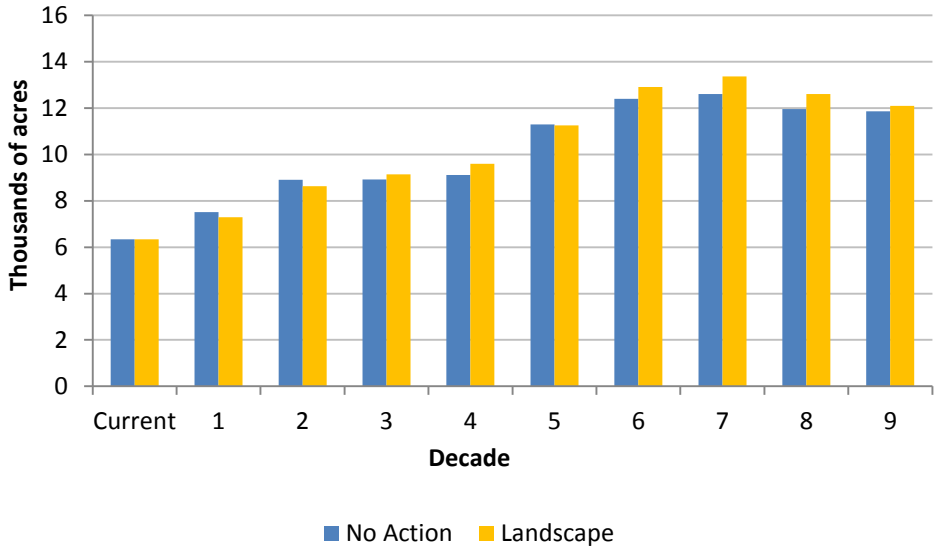


Chart I-52. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Dickodochtedar Landscape, by Alternative

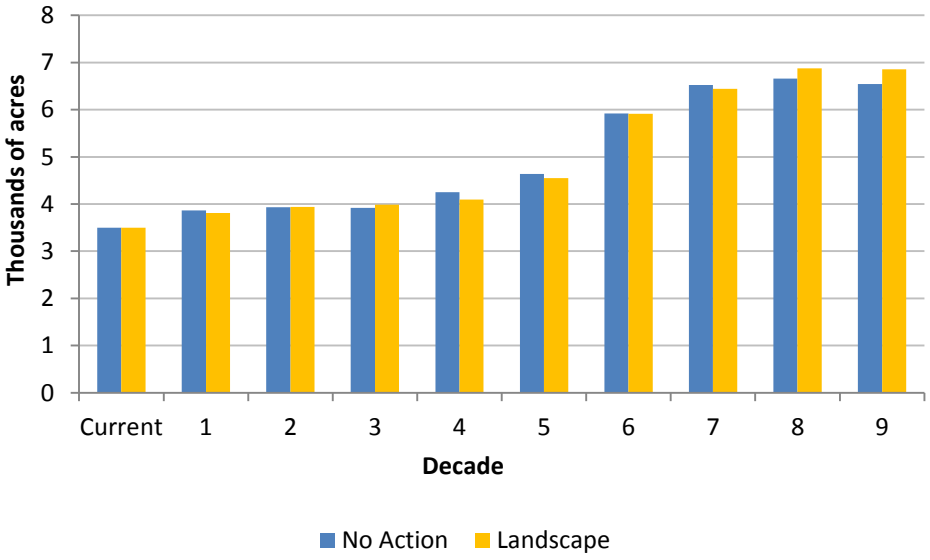


Chart I-53. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Goodman Landscape, by Alternative

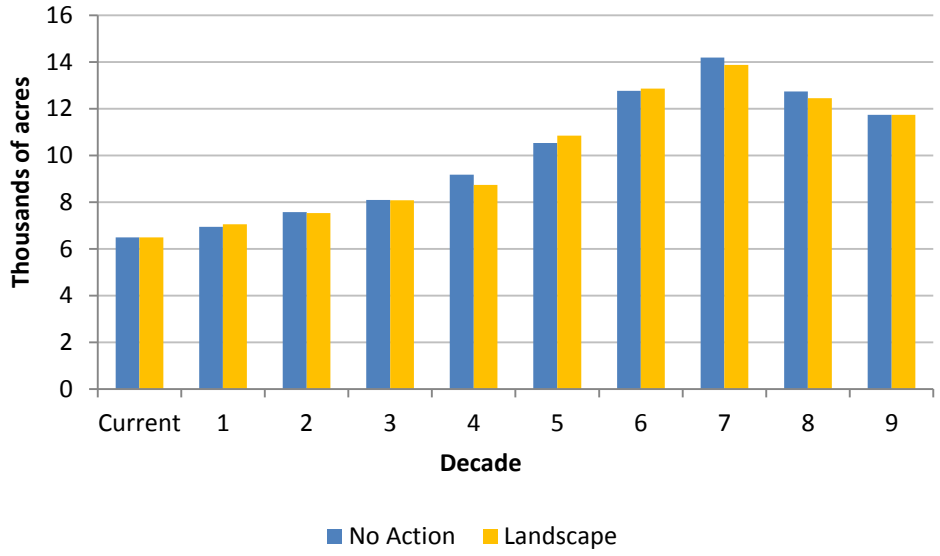


Chart I-54. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Goodman Landscape, by Alternative

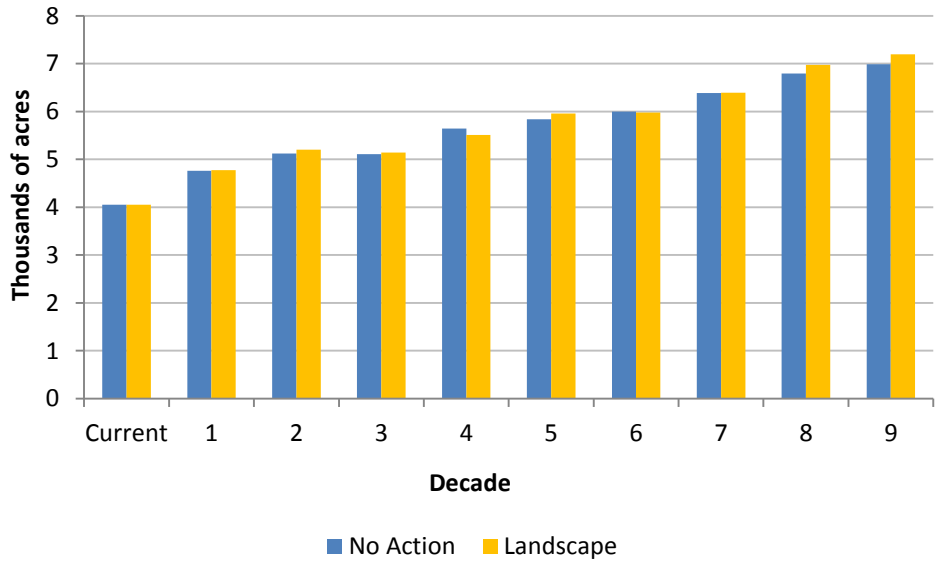


Chart I-55. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Kalaloch Landscape, by Alternative

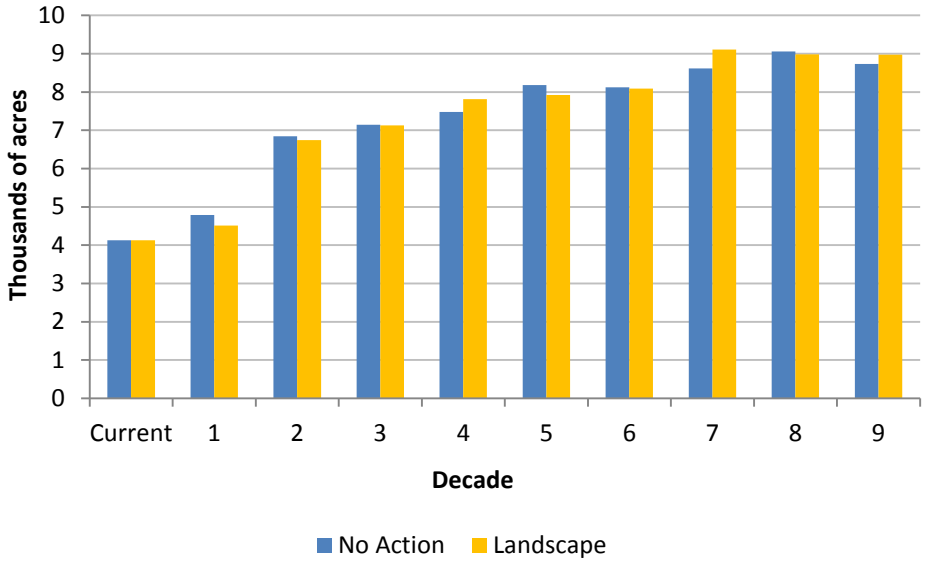


Chart I-56. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Kalaloch Landscape, by Alternative

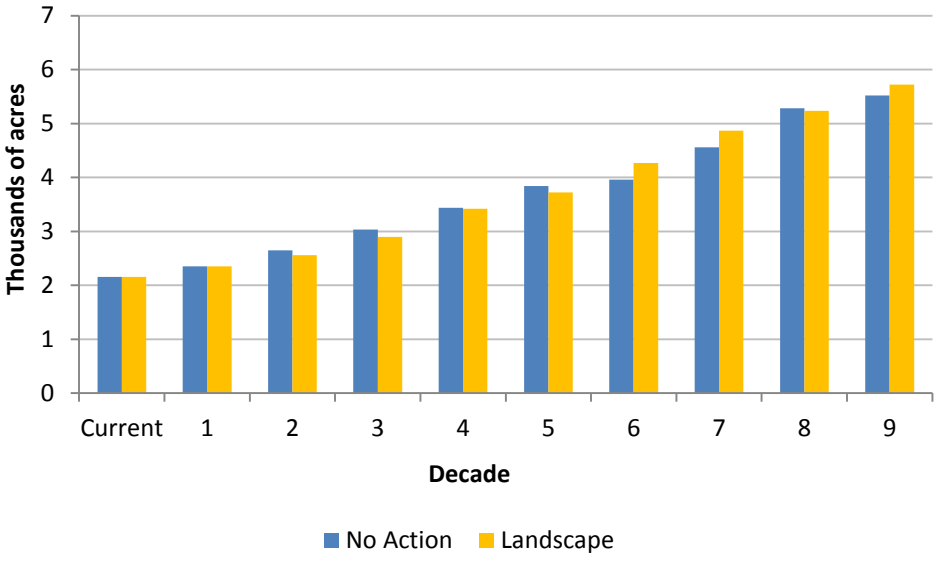


Chart I-57. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Queets Landscape, by Alternative

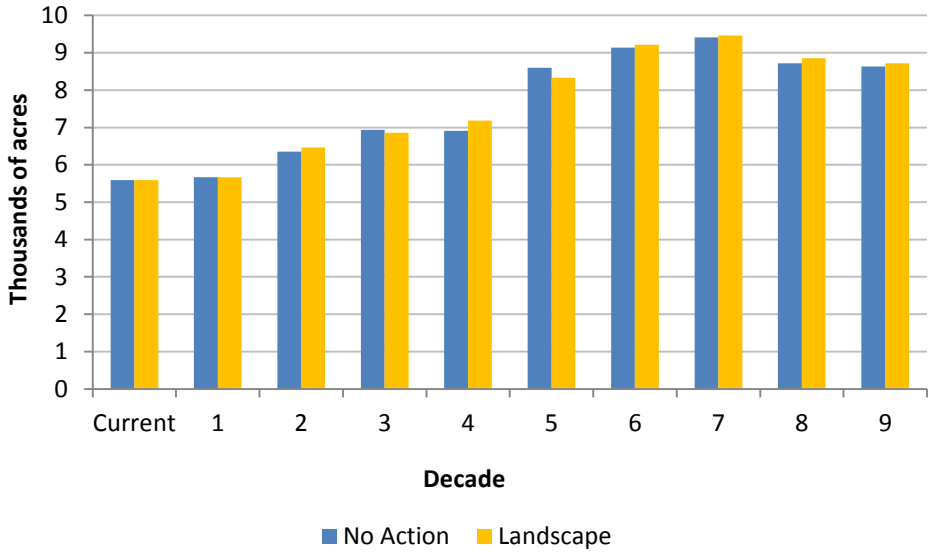


Chart I-58. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Queets Landscape, by Alternative

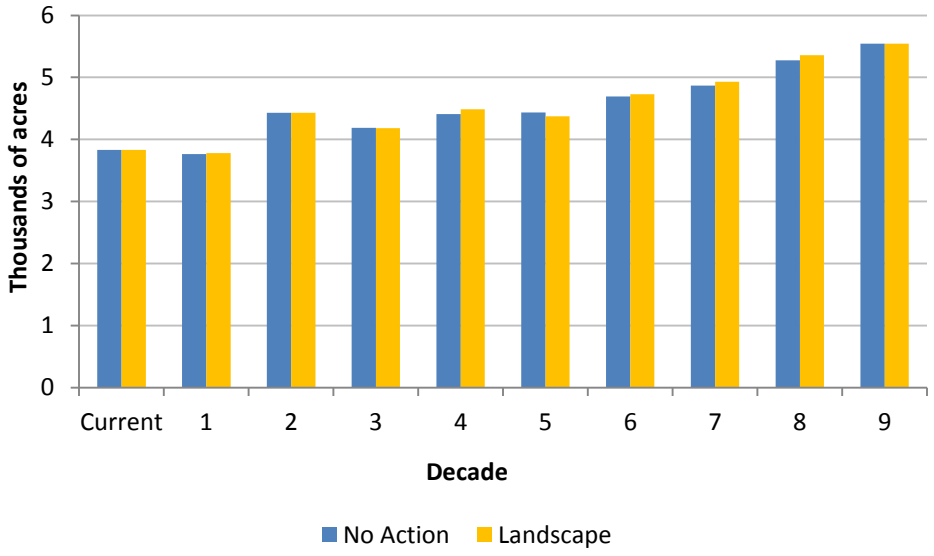


Chart I-59. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Reade Hill Landscape, by Alternative

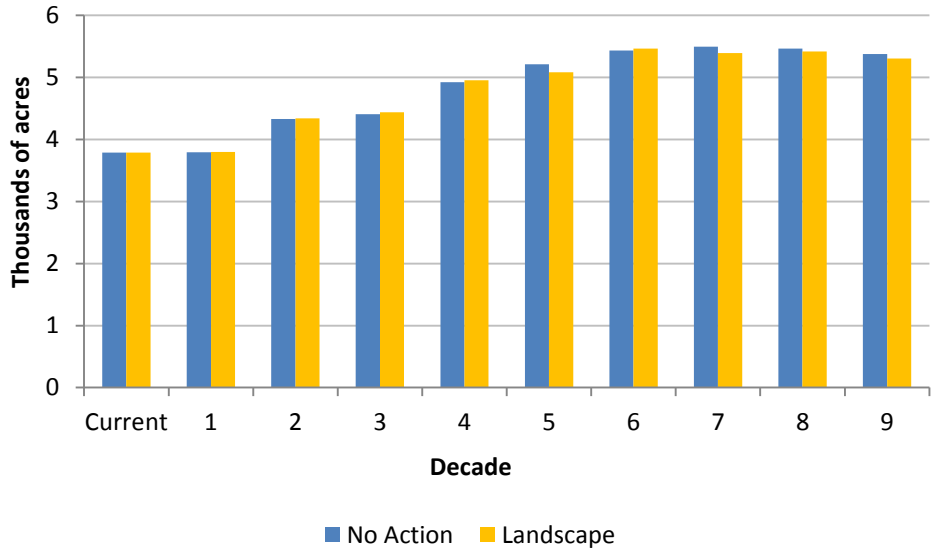


Chart I-60. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Reade Hill Landscape, by Alternative

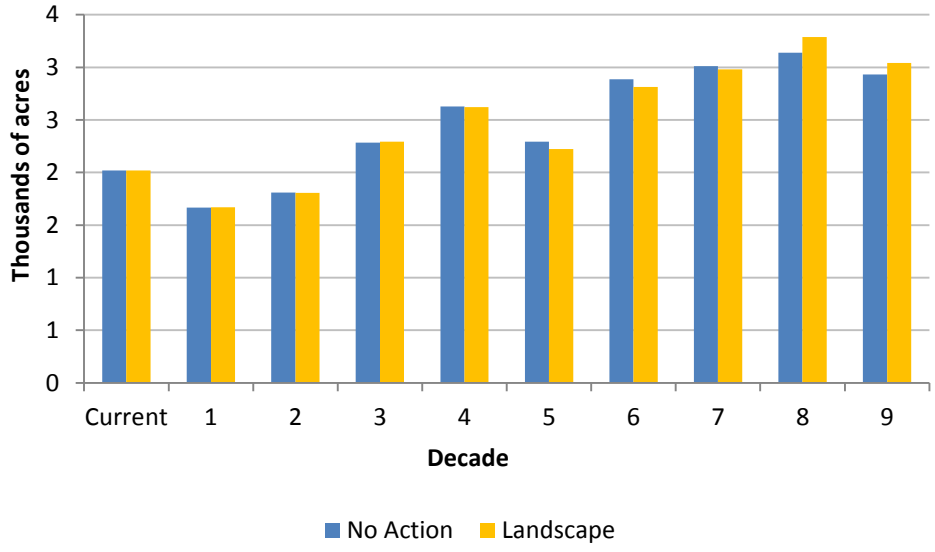


Chart I-61. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Sekiu Landscape, by Alternative

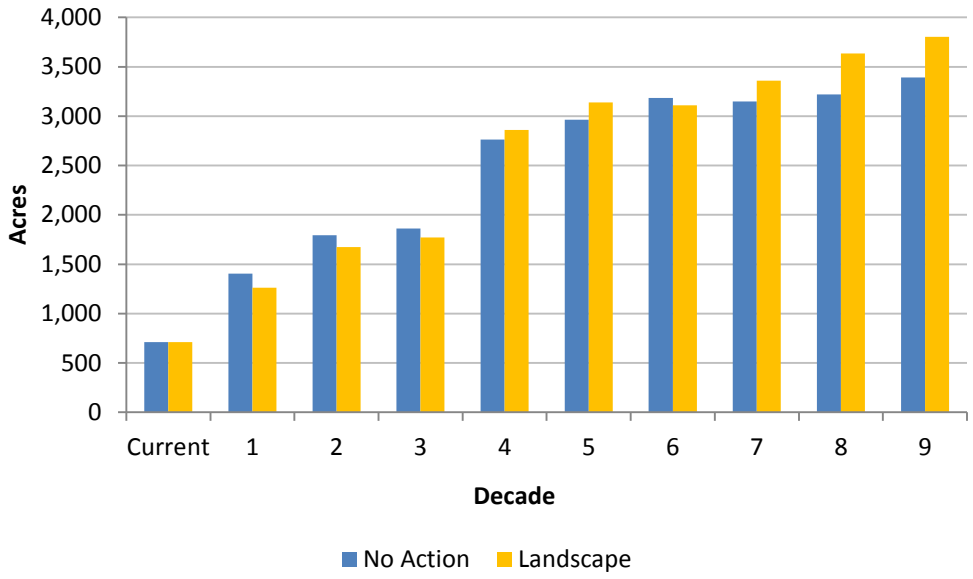


Chart I-62. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Sekiu Landscape, by Alternative

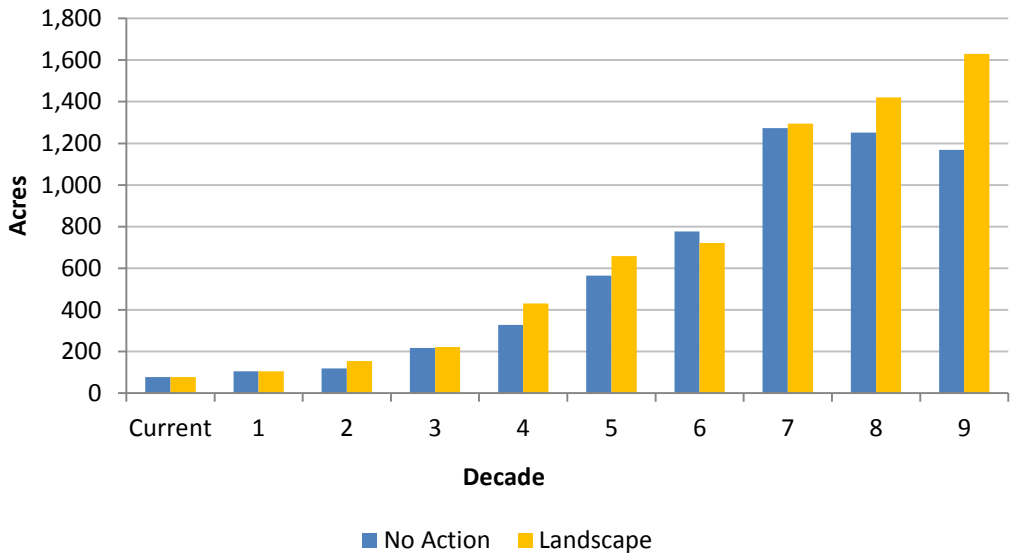


Chart I-63. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Sol Duc Landscape, by Alternative

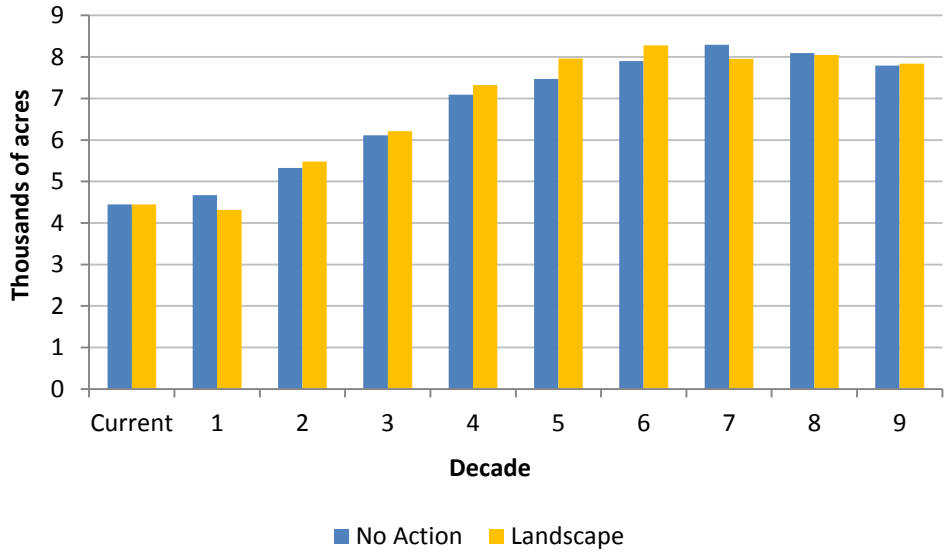


Chart I-64. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Sol Duc Landscape, by Alternative

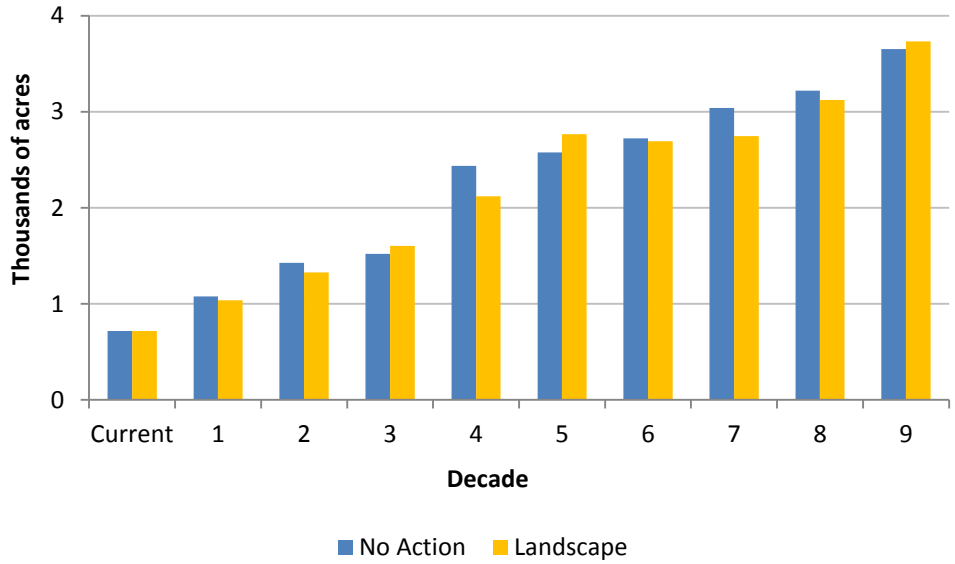


Chart I-65. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 50 to 100 for the Willy Huel Landscape, by Alternative

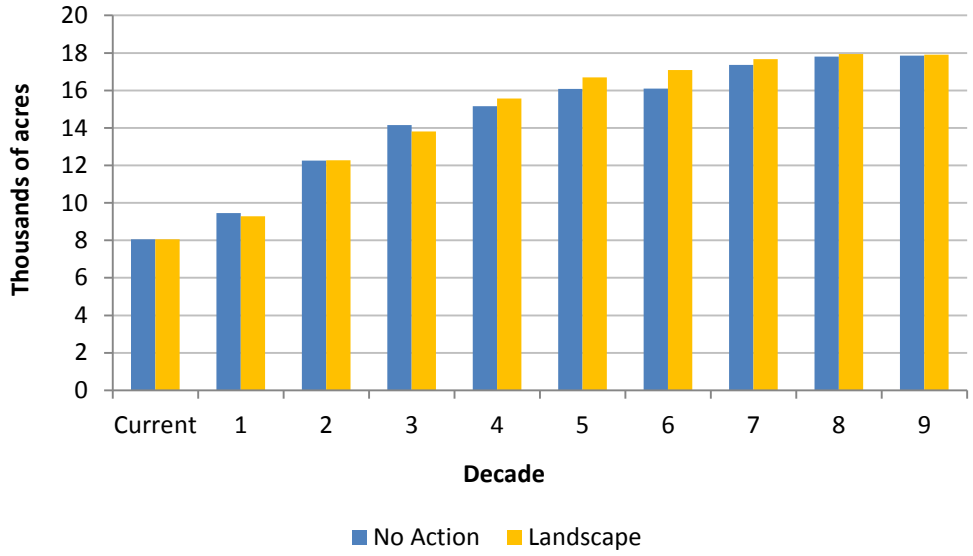
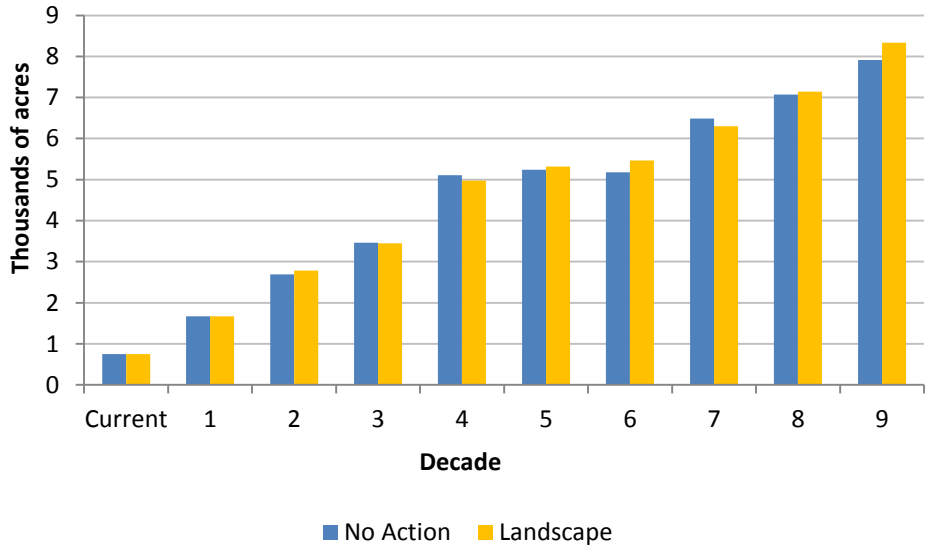


Chart I-66. Acres of Roosting, Foraging, Movement, and Nesting Average Stand Level Model Scores 75 to 100 for the Willy Huel Landscape, by Alternative



Nesting Stand Model Scores

Chart I-67. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Entire OESF, by Alternative

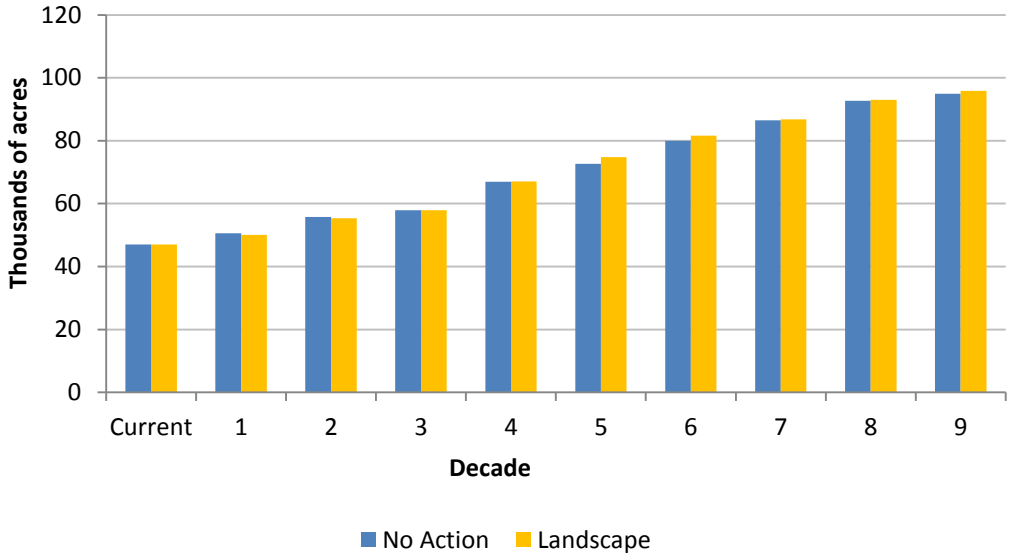


Chart I-68. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Entire OESF, by Alternative

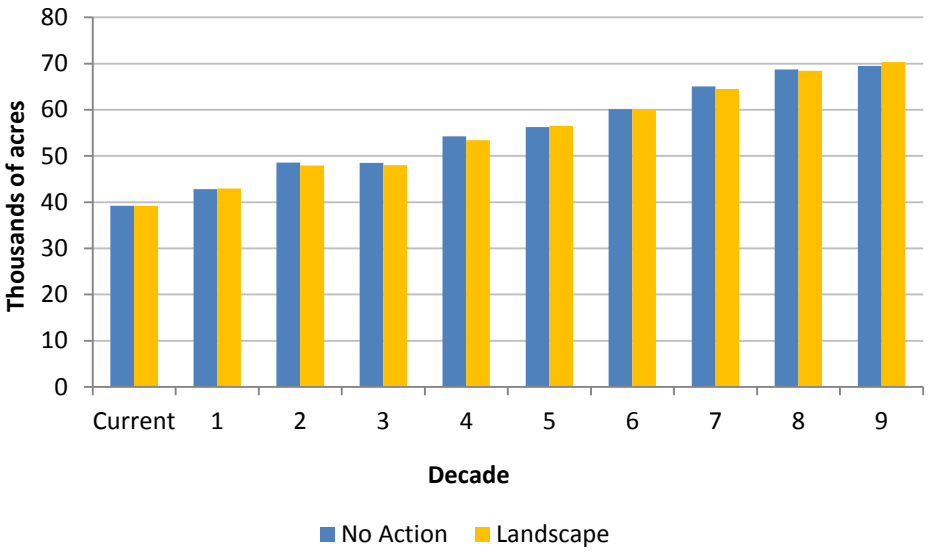


Chart I-69. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Clallam Landscape, by Alternative

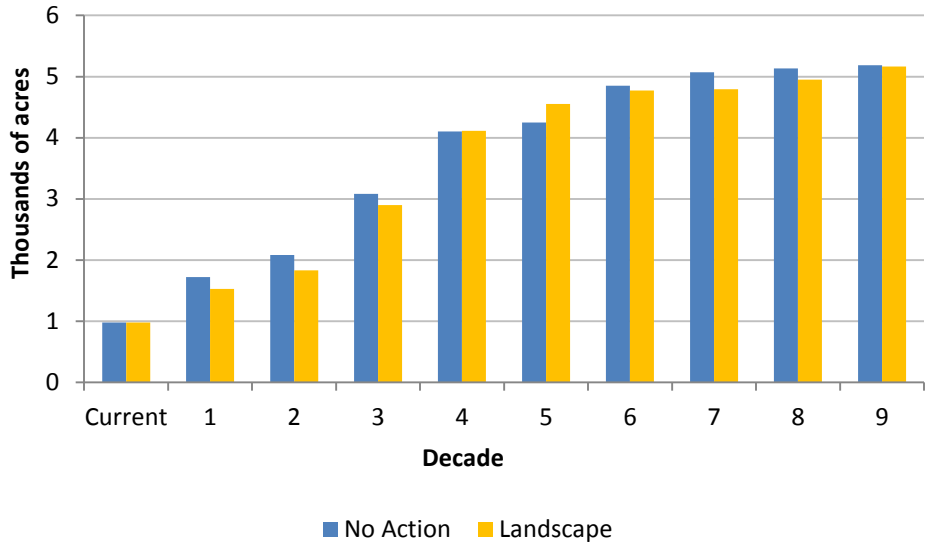


Chart I-70. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Clallam Landscape, by Alternative

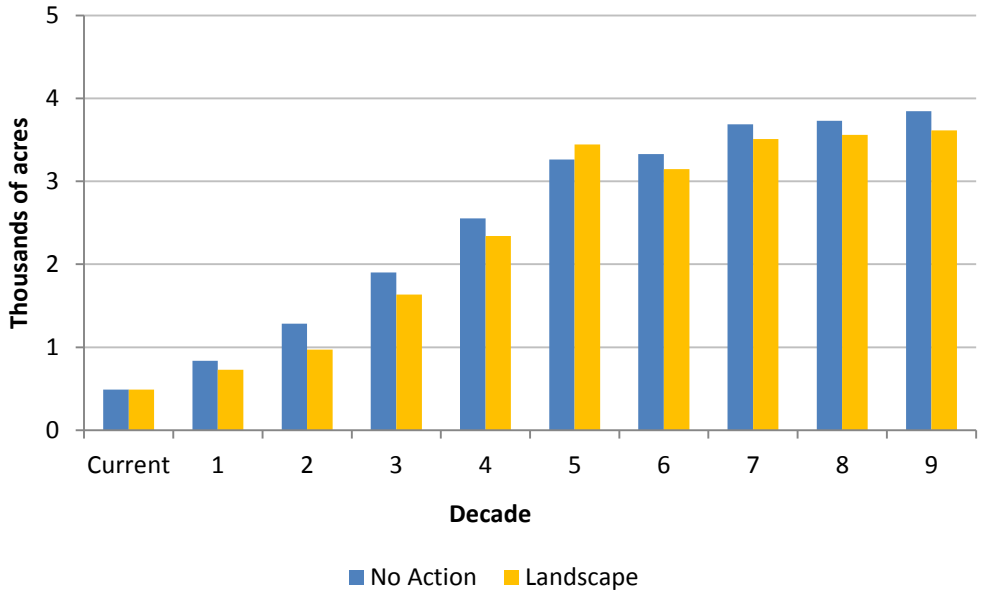


Chart I-71. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Clearwater Landscape, by Alternative

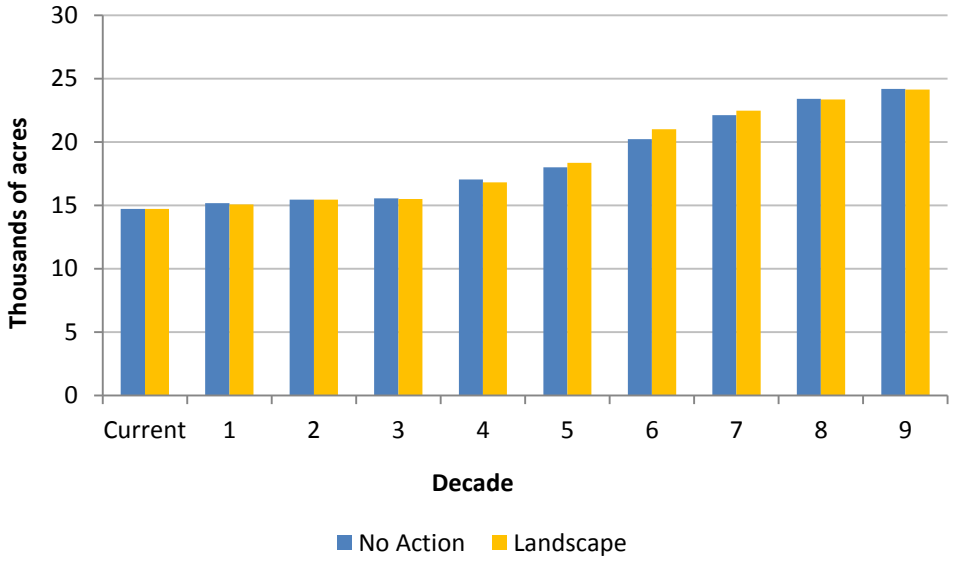


Chart I-72. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Clearwater Landscape, by Alternative

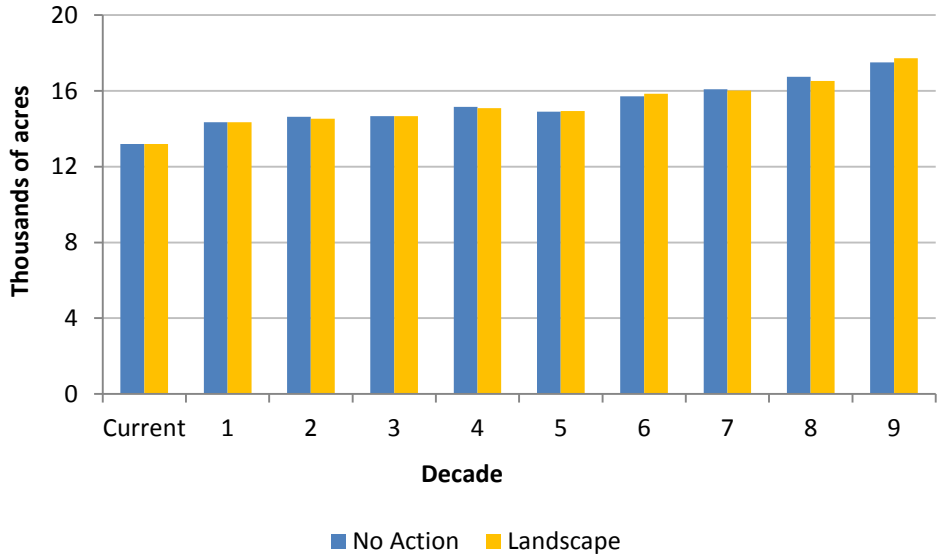


Chart I-73. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Coppermine Landscape, by Alternative

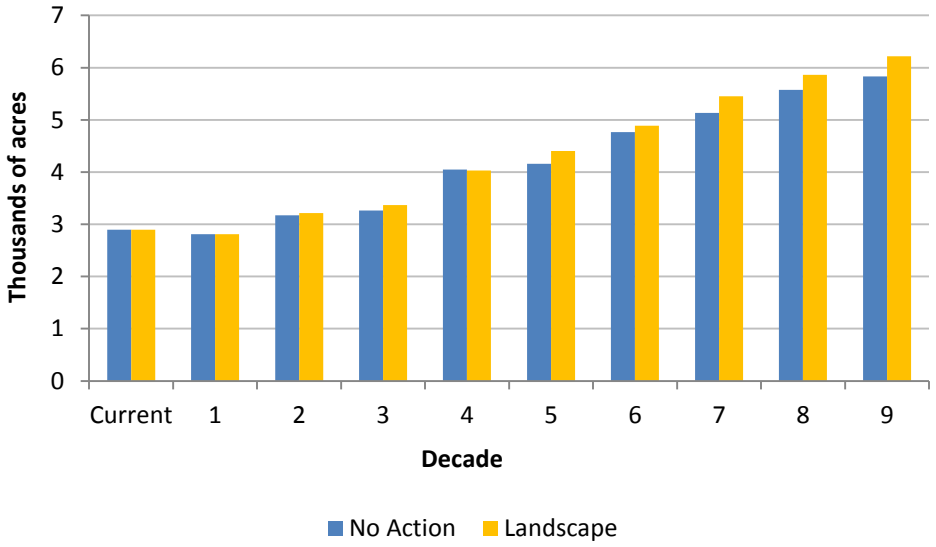


Chart I-74. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Coppermine Landscape, by Alternative

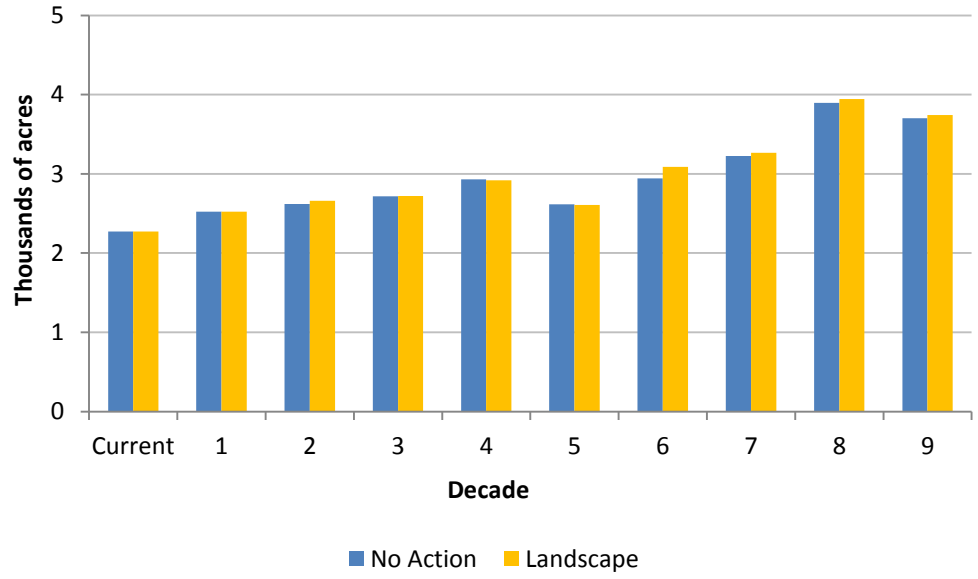


Chart I-75. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Dickodochtedar Landscape, by Alternative

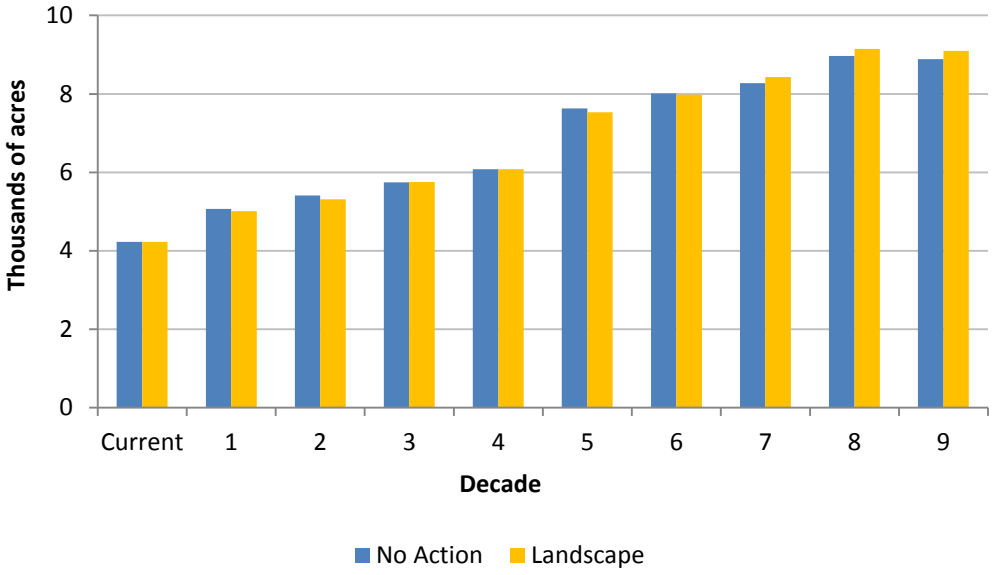


Chart I-76. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Dickodochtedar Landscape, by Alternative

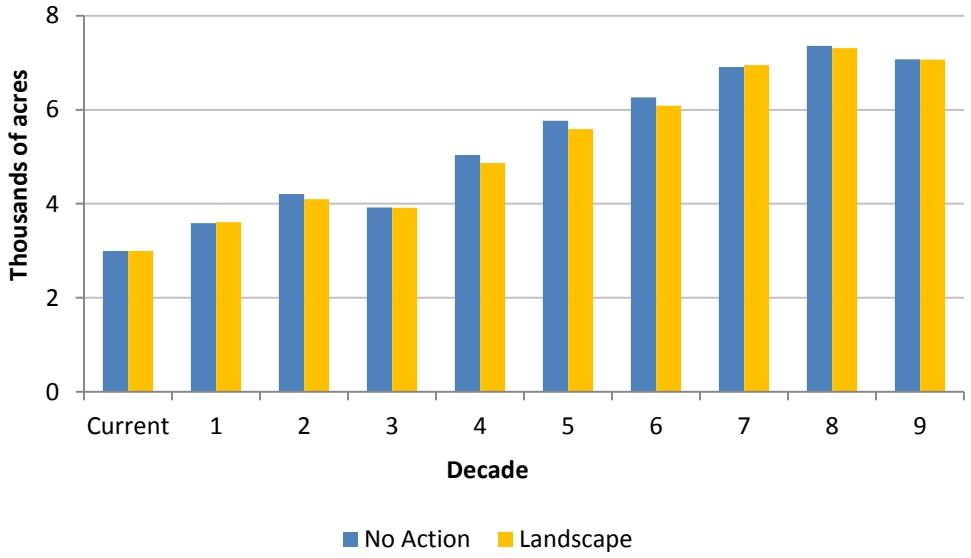


Chart I-77. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Goodman Landscape, by Alternative

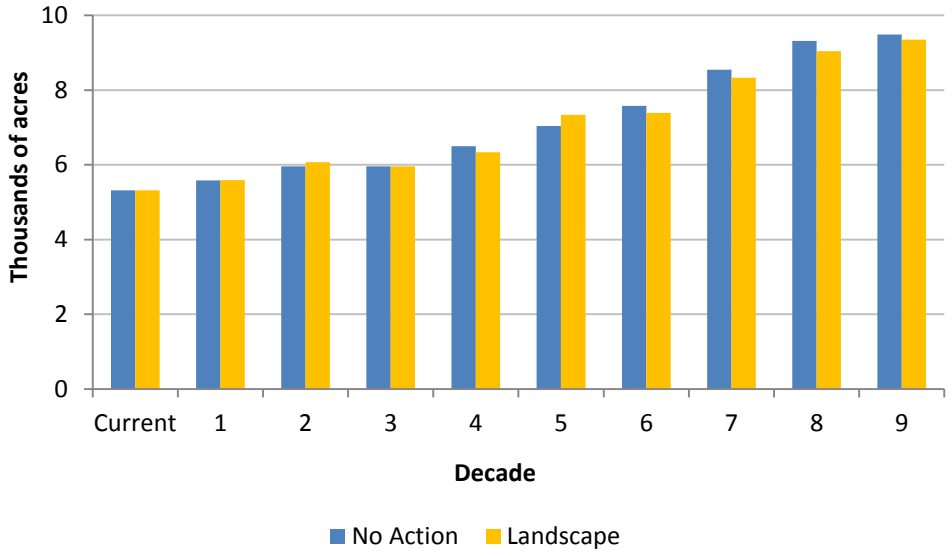


Chart I-78. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Goodman Landscape, by Alternative

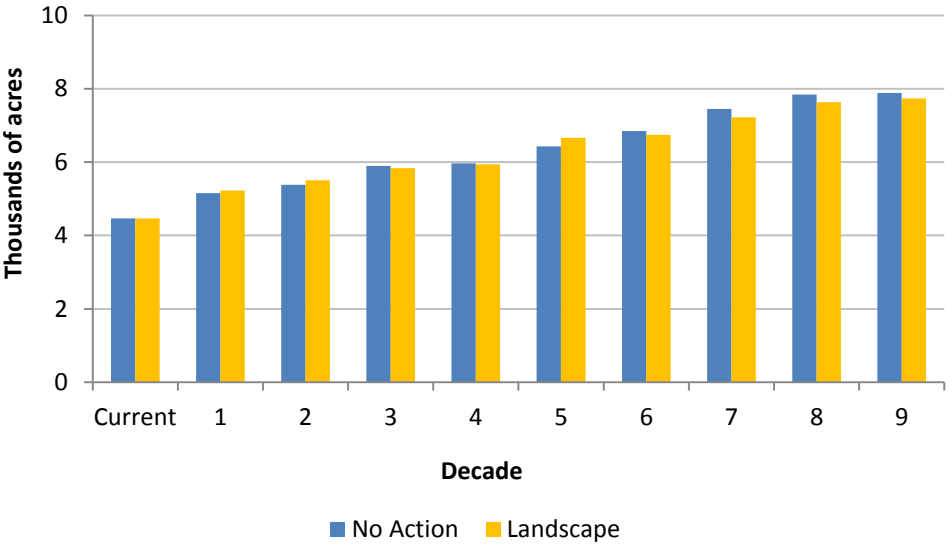


Chart I-79. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Kalaloch Landscape, by Alternative

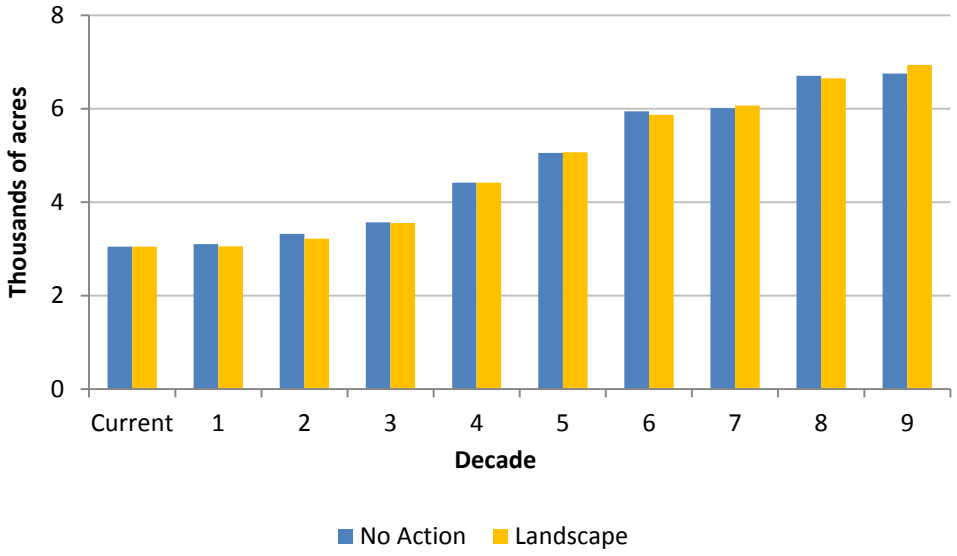


Chart I-80. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Kalaloch Landscape, by Alternative

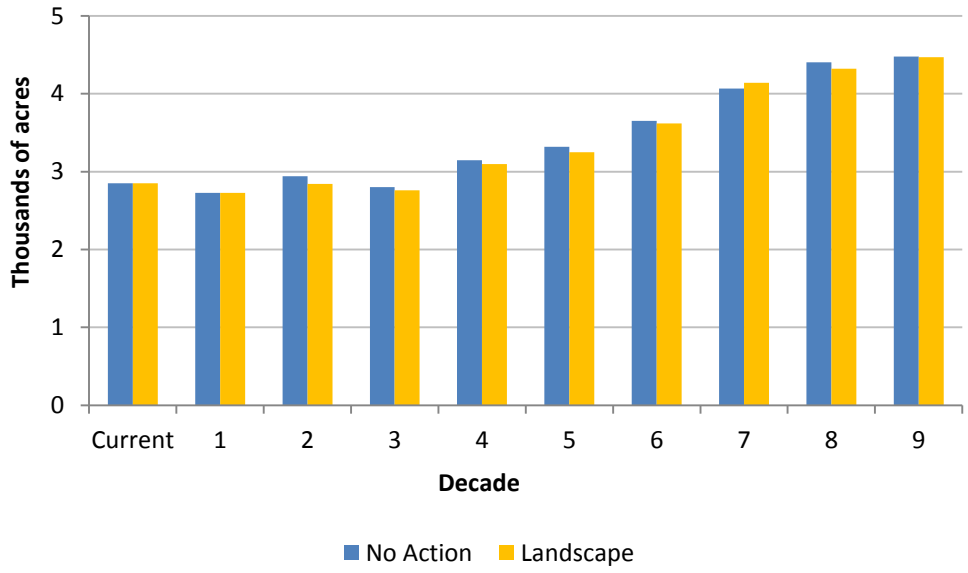


Chart I-81. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Queets Landscape, by Alternative

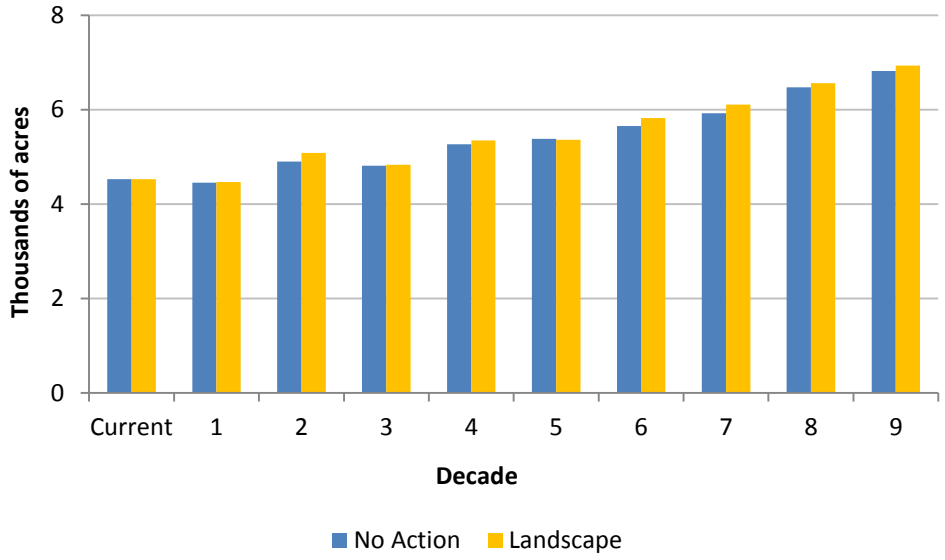


Chart I-82. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Queets Landscape, by Alternative

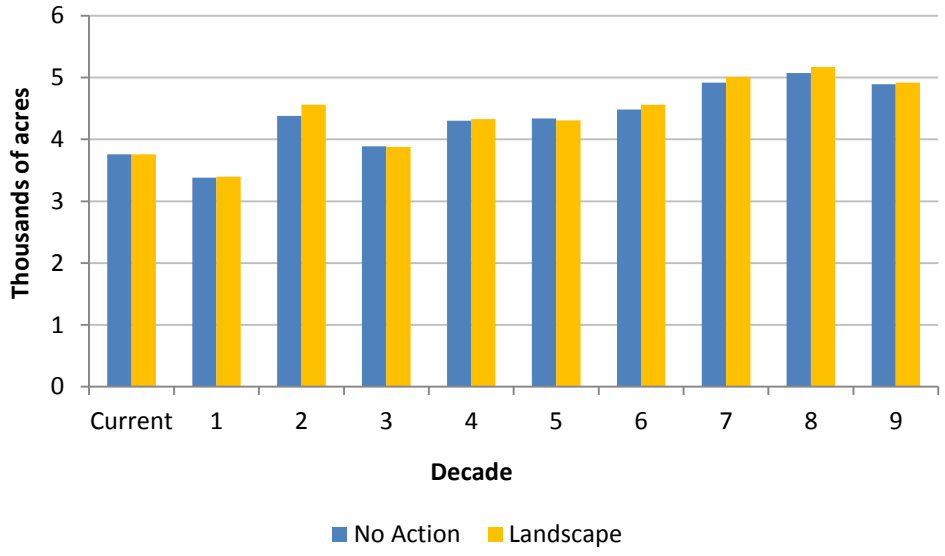


Chart I-83. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Reade Hill Landscape, by Alternative

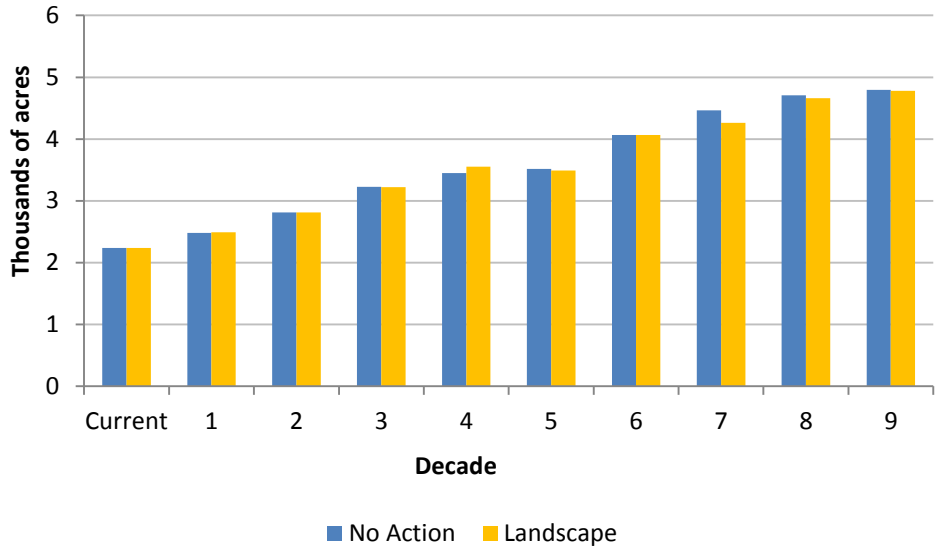


Chart I-84. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Reade Hill Landscape, by Alternative

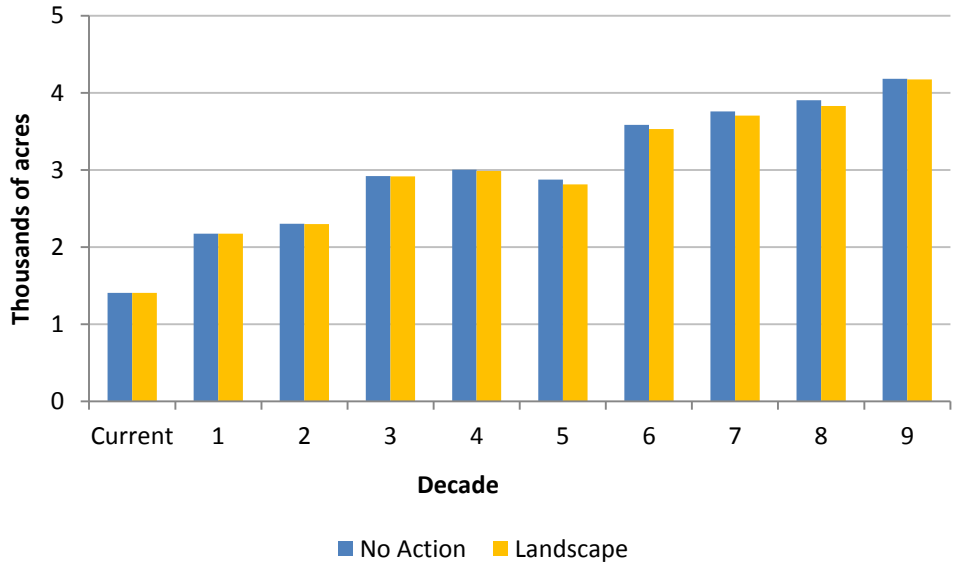


Chart I-85. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Sekiu Landscape, by Alternative

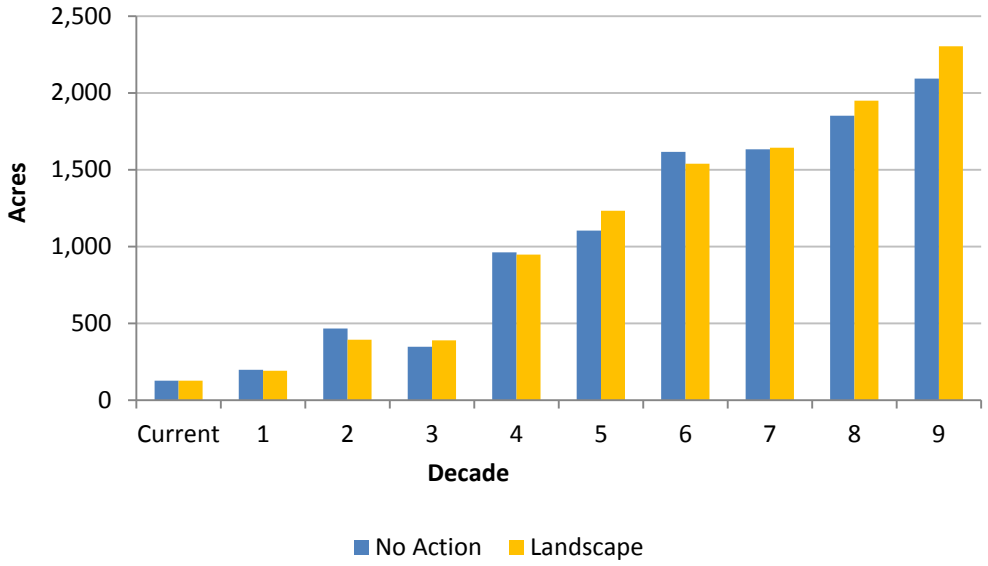


Chart I-86. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Sekiu Landscape, by Alternative

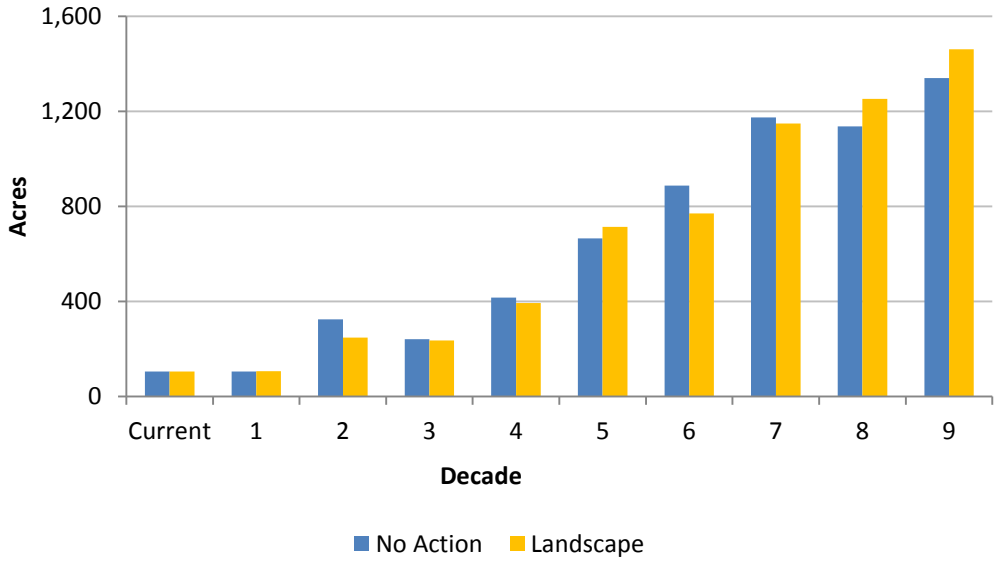


Chart I-87. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Sol Duc Landscape, by Alternative

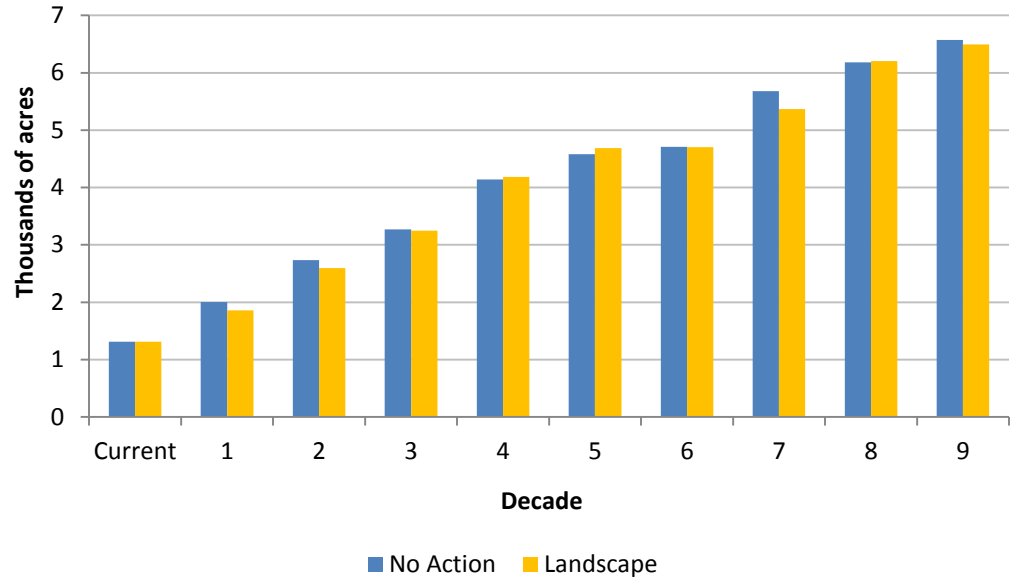


Chart I-88. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Sol Duc Landscape, by Alternative

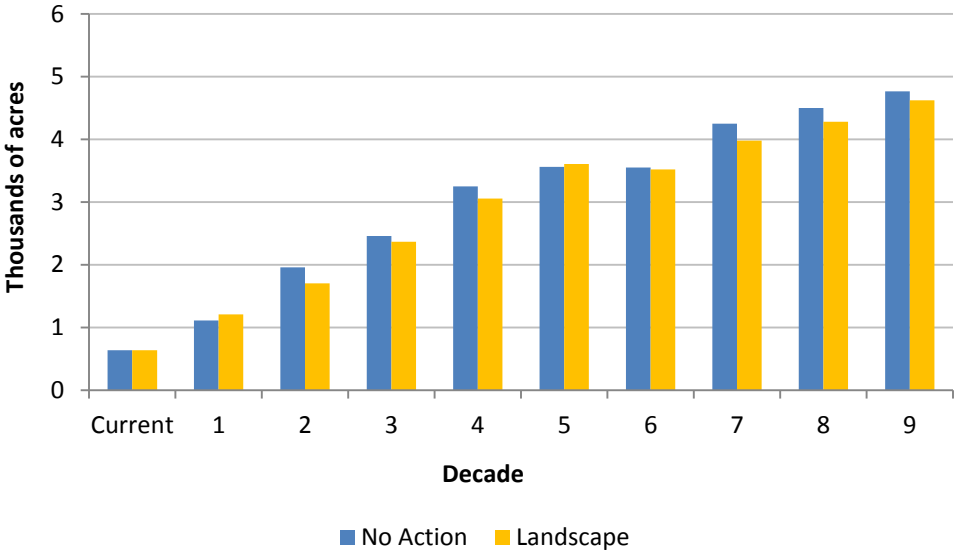


Chart I-89. Acres of Nesting Average Stand Level Model Scores 50 to 100 for the Willy Huel Landscape, by Alternative

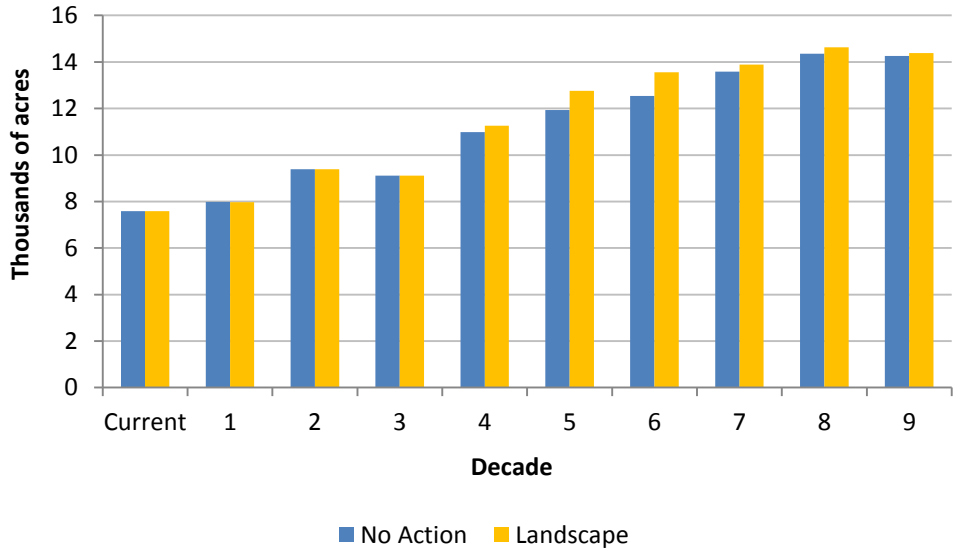
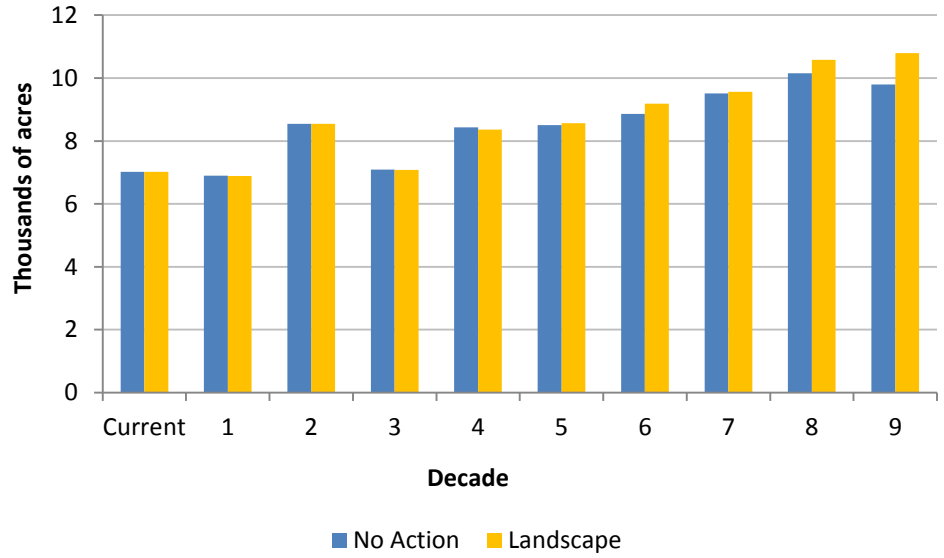


Chart I-90. Acres of Nesting Average Stand Level Model Scores 75 to 100 for the Willy Huel Landscape, by Alternative



Roosting Stand Model Scores

Chart I-91. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Entire OESF, by Alternative

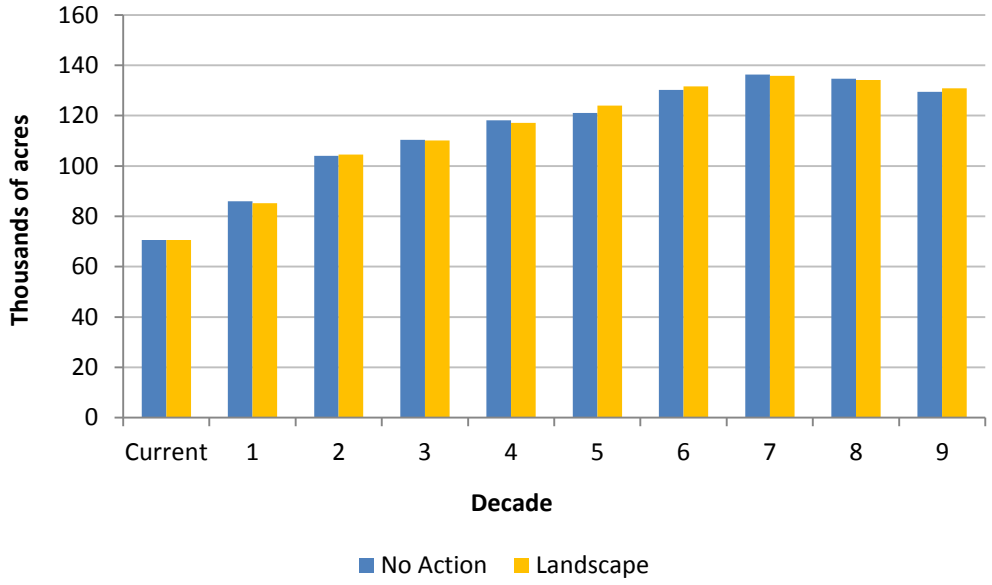


Chart I-92. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Entire OESF, by Alternative

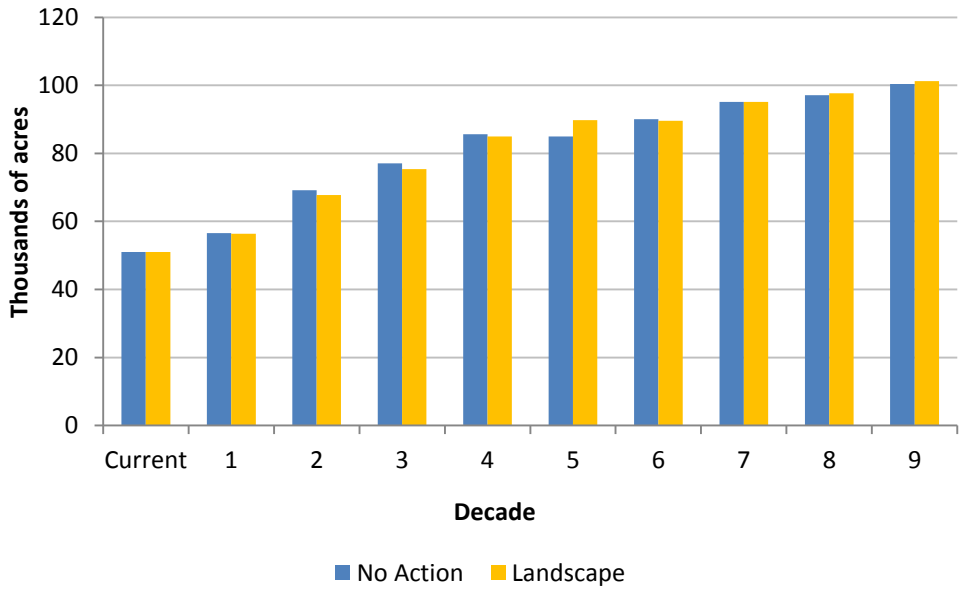


Chart I-93. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Clallam Landscape, by Alternative

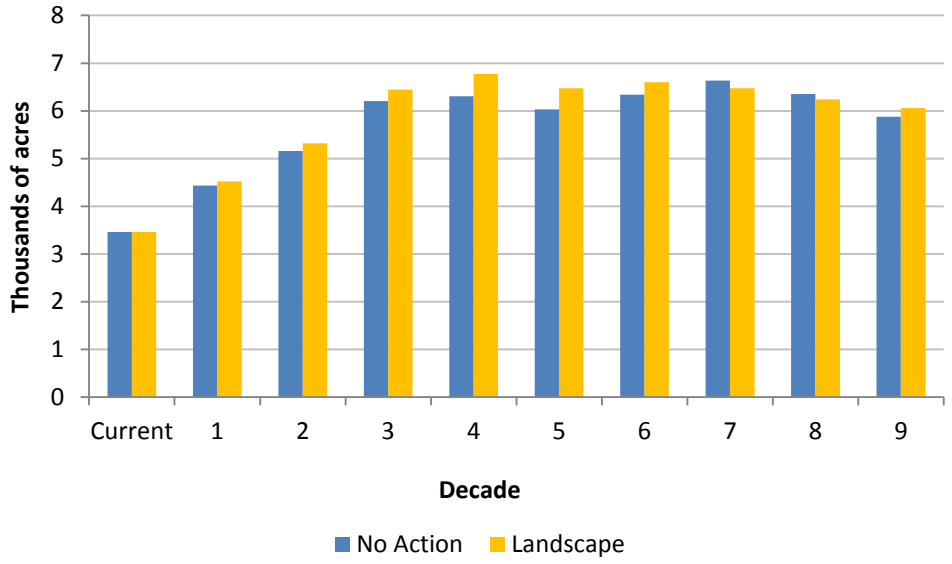


Chart I-94. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Clallam Landscape, by Alternative

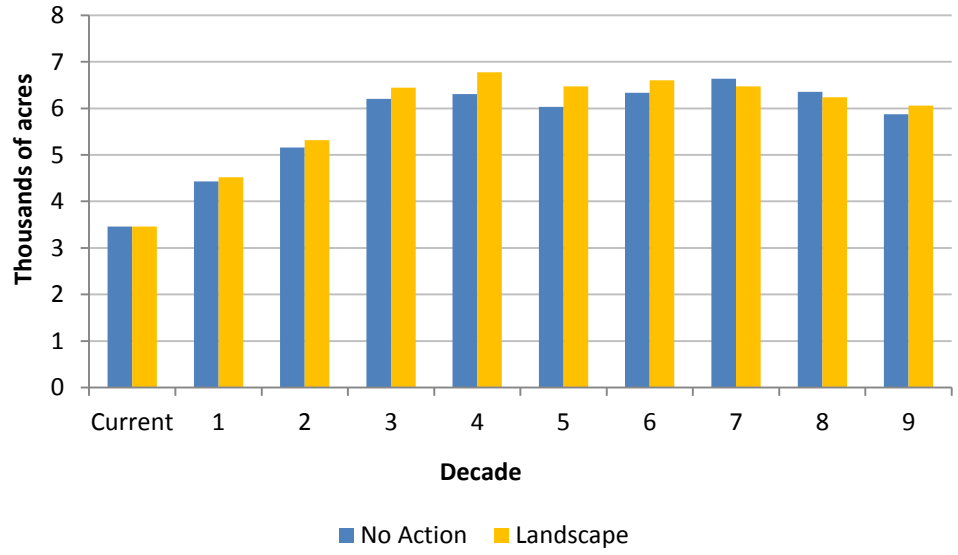


Chart I-95. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Clearwater Landscape, by Alternative

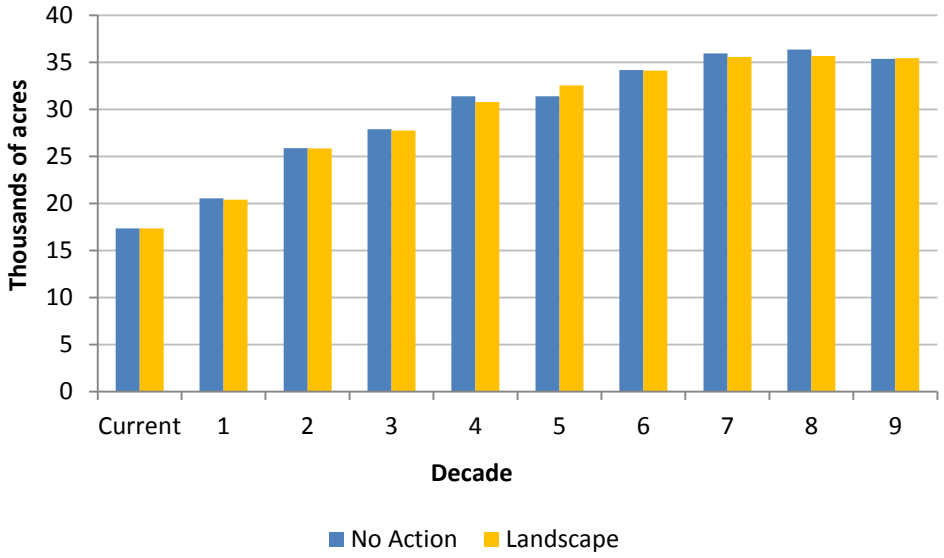


Chart I-96. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Clearwater Landscape, by Alternative

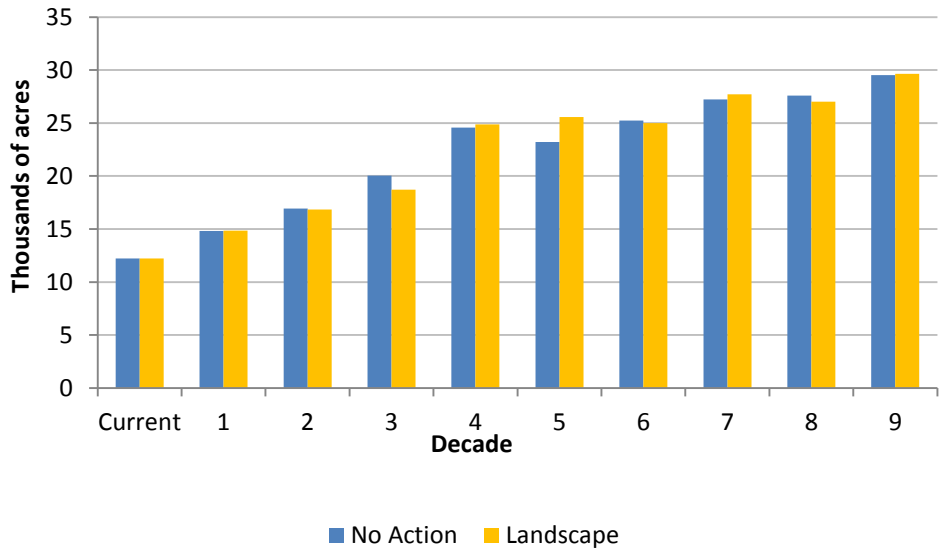


Chart I-97. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Coppermine Landscape, by Alternative

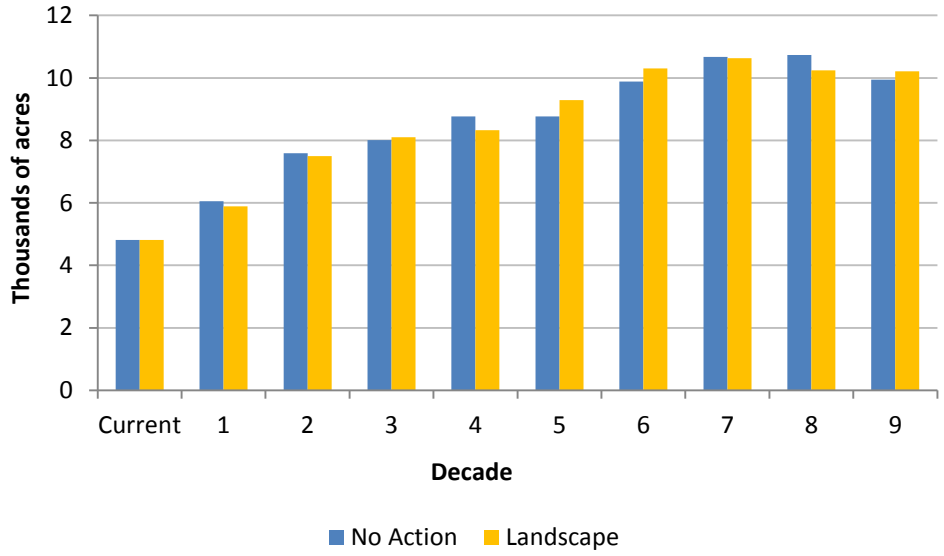


Chart I-98. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Coppermine Landscape, by Alternative

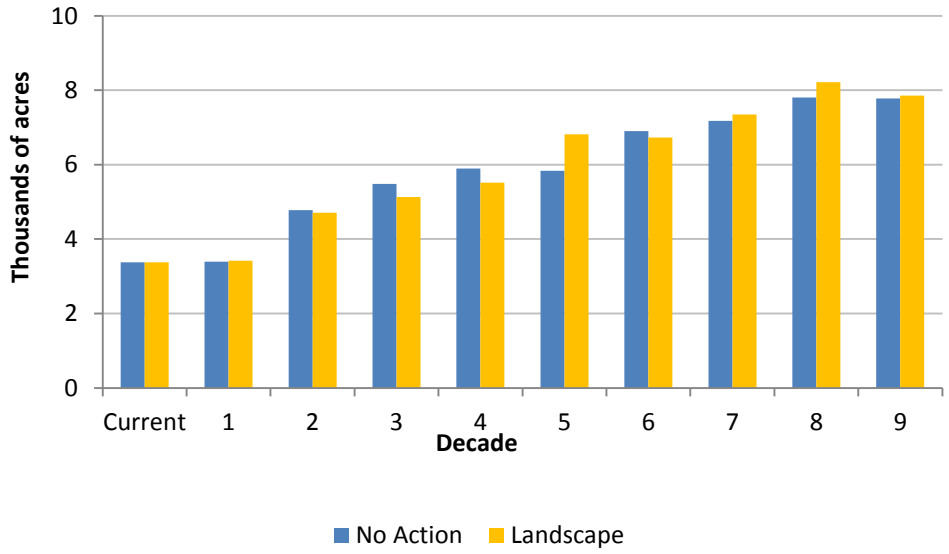


Chart I-99. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Dickodochtedar Landscape, by Alternative

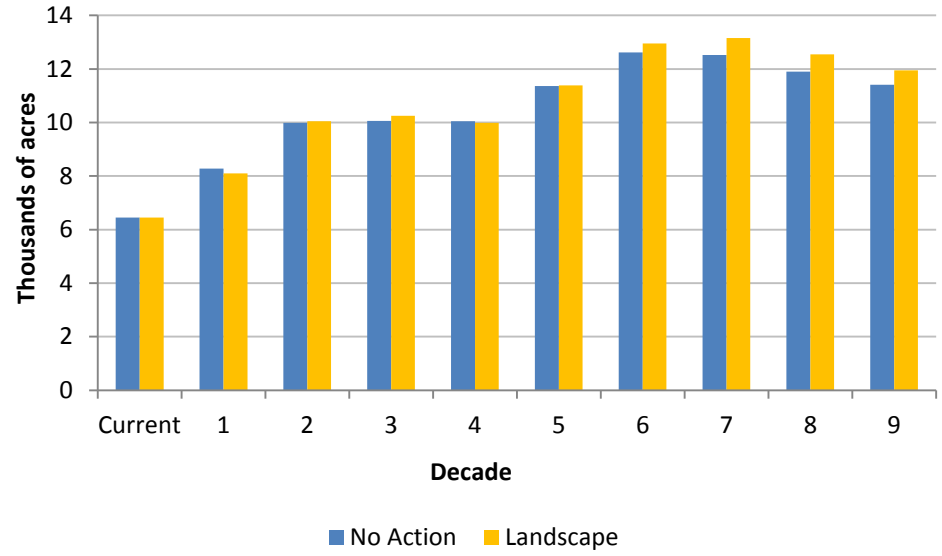


Chart I-100. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Dickodochtedar Landscape, by Alternative

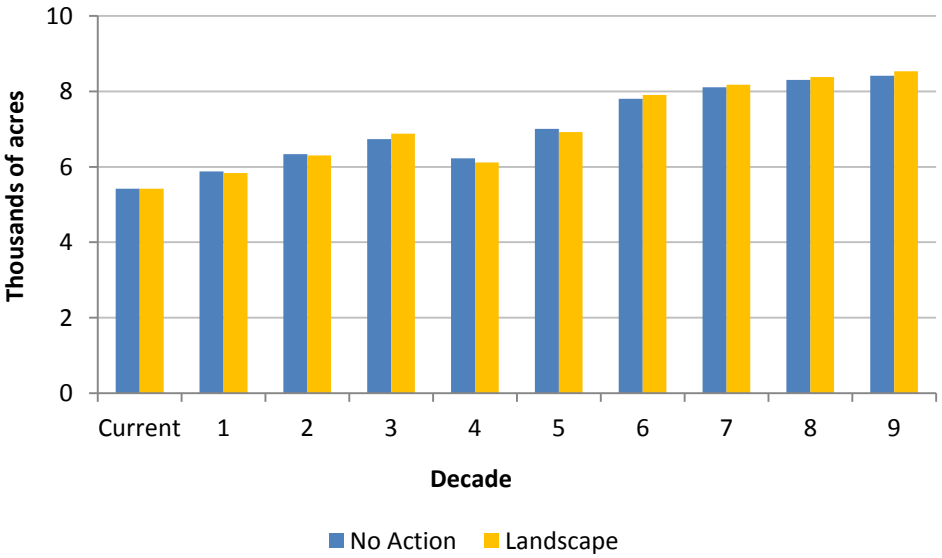


Chart I-101. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Goodman Landscape, by Alternative

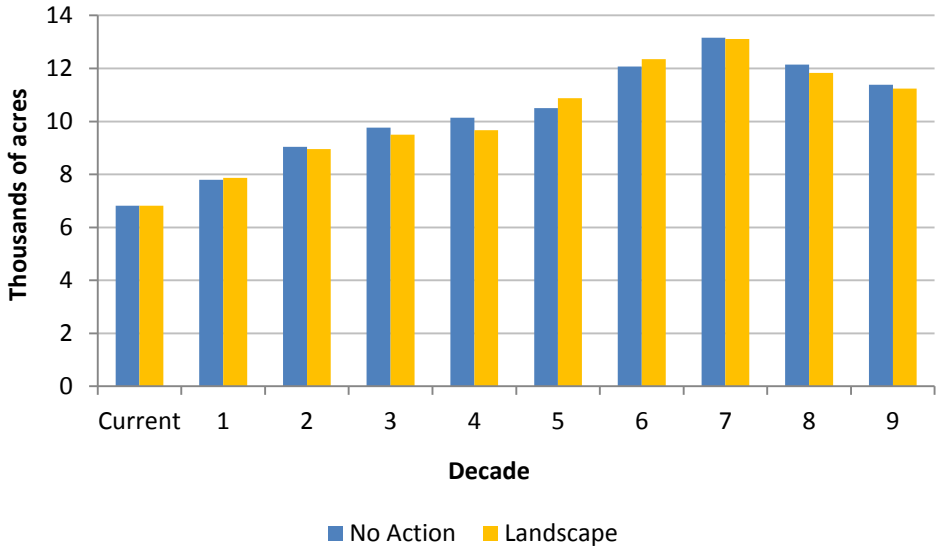


Chart I-102. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Goodman Landscape, by Alternative

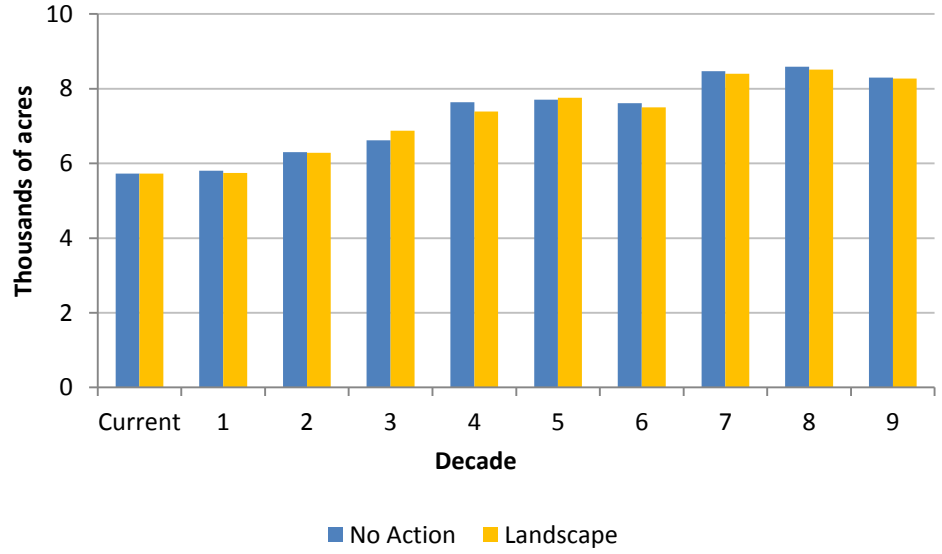


Chart I-103. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Kalaloch Landscape, by Alternative

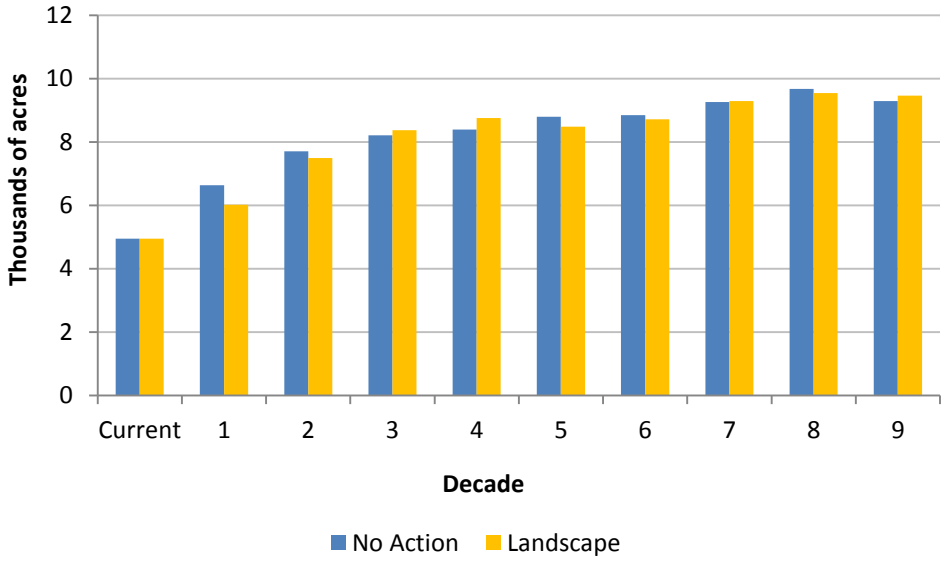


Chart I-104. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Kalaloch Landscape, by Alternative

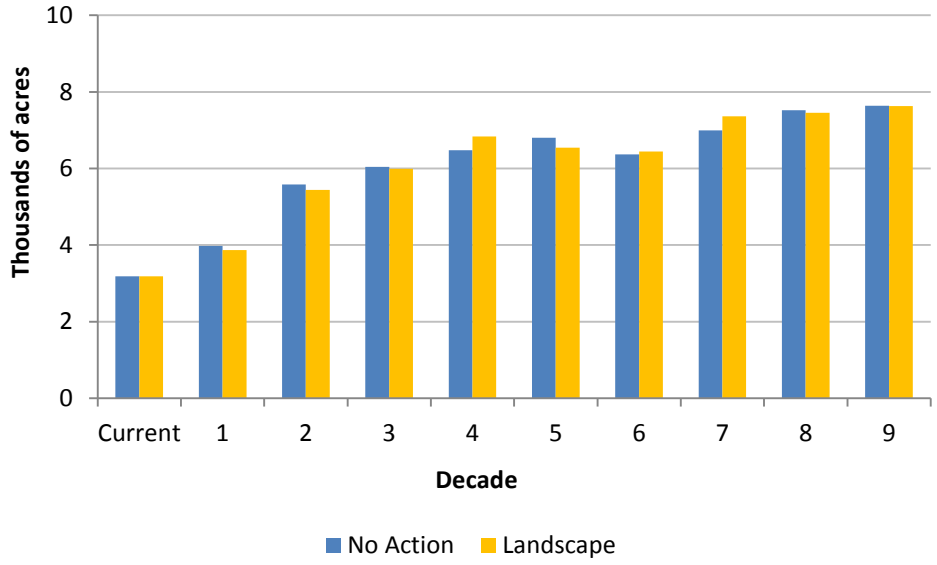


Chart I-105. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Queets Landscape, by Alternative

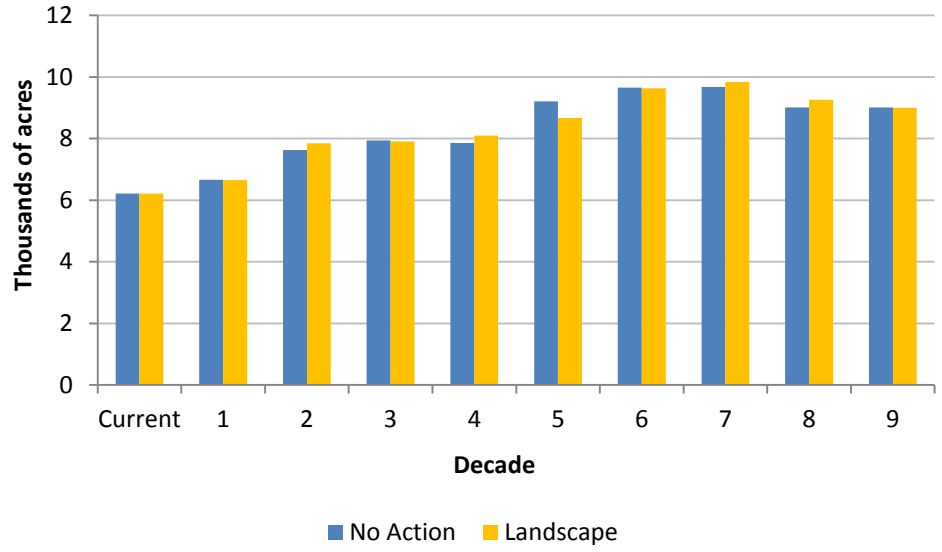


Chart I-106. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Queets Landscape, by Alternative

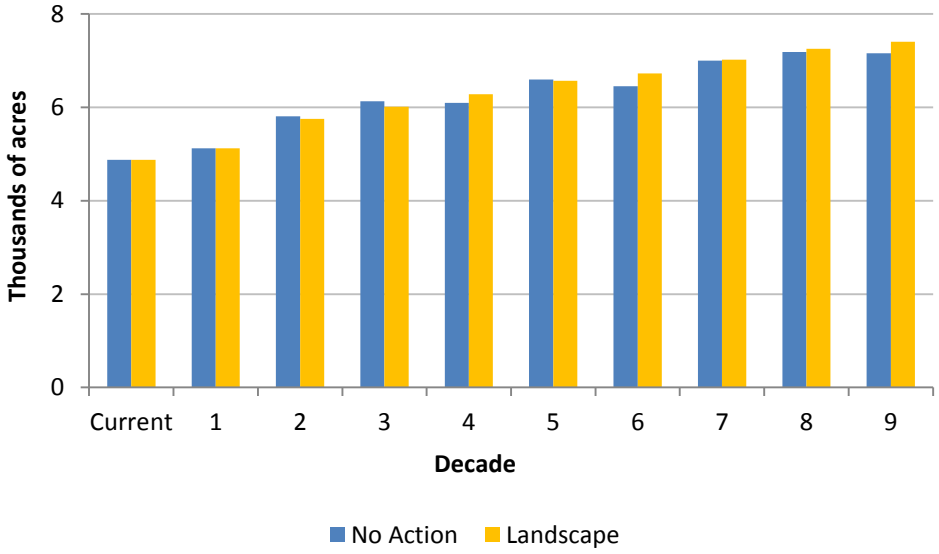


Chart I-107. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Reade Hill Landscape, by Alternative

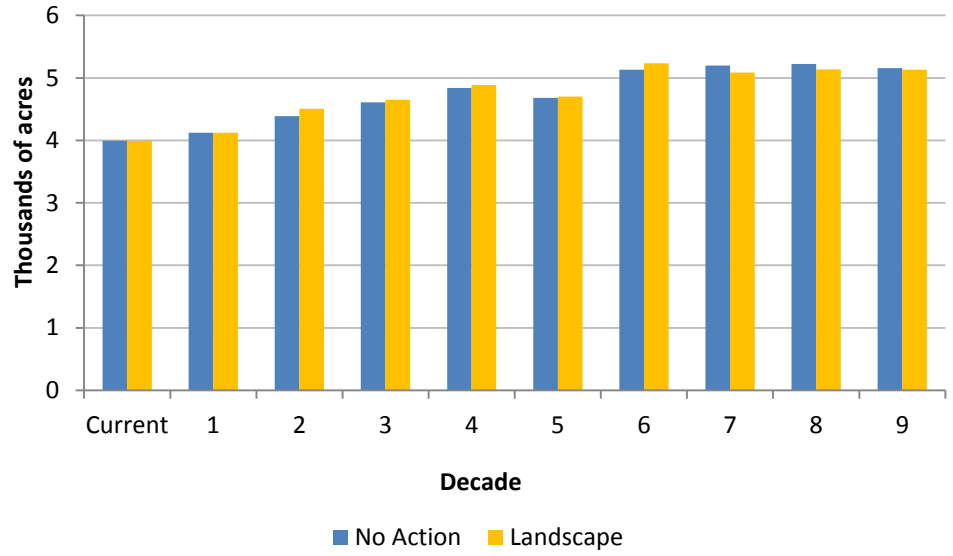


Chart I-108. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Reade Hill Landscape, by Alternative

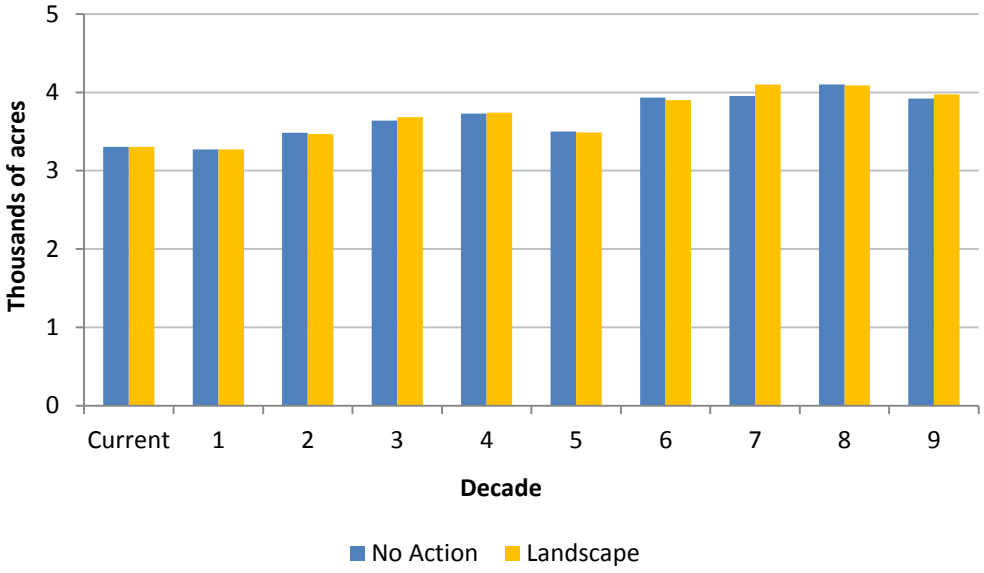


Chart I-109. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Sekiu Landscape, by Alternative

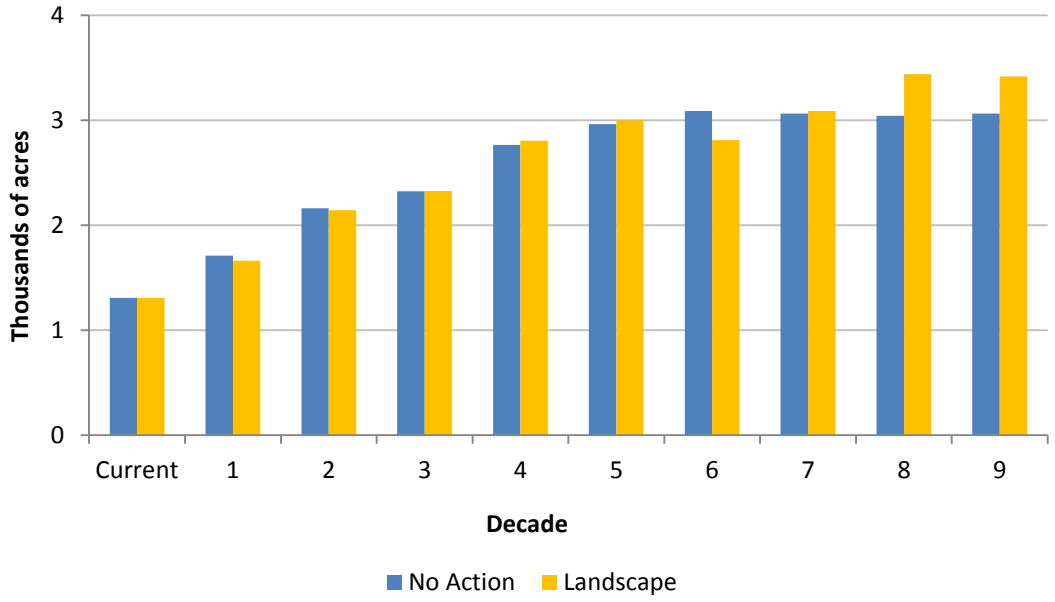


Chart I-110. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Sekiu Landscape, by Alternative

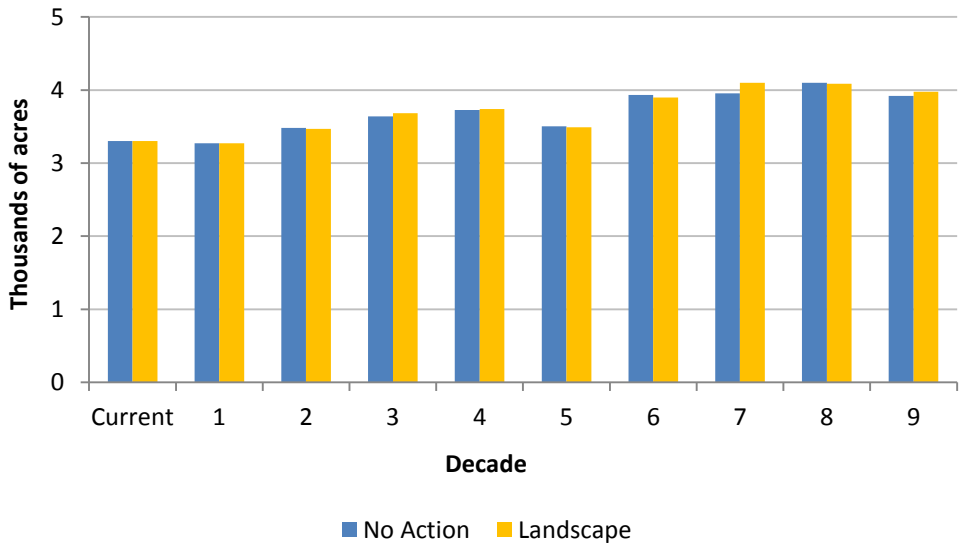


Chart I-111. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Sol Duc Landscape, by Alternative

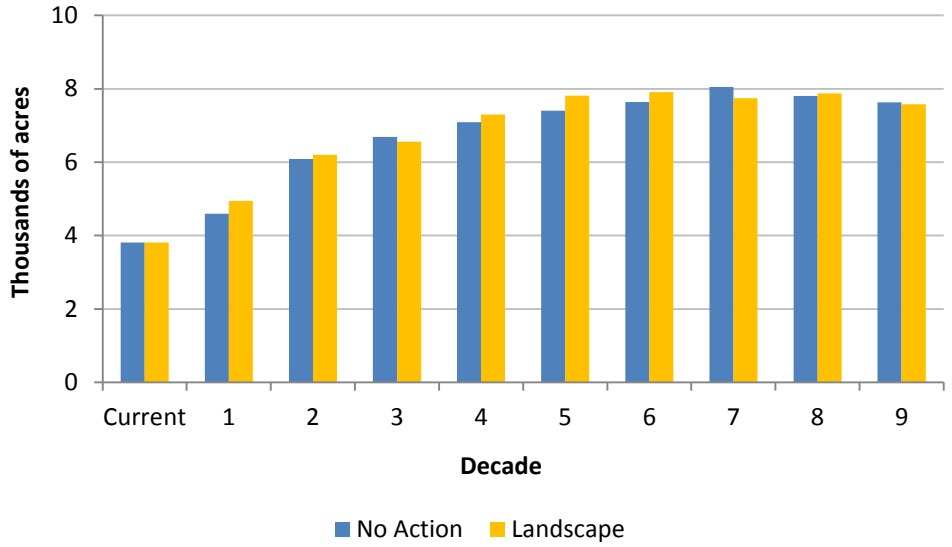


Chart I-112. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Sol Duc Landscape, by Alternative

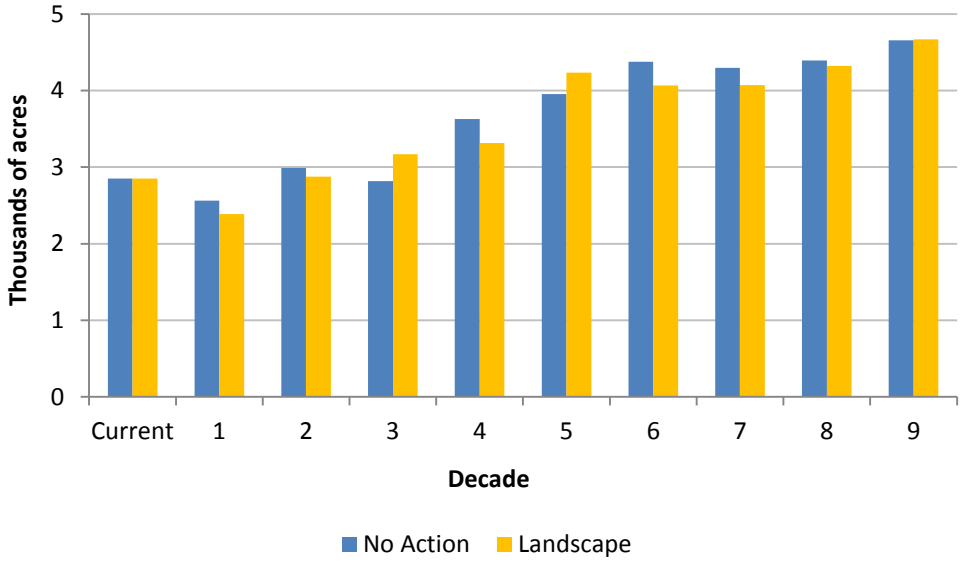


Chart I-113. Acres of Roosting Average Stand Level Model Scores 50 to 100 for the Willy Huel Landscape, by Alternative

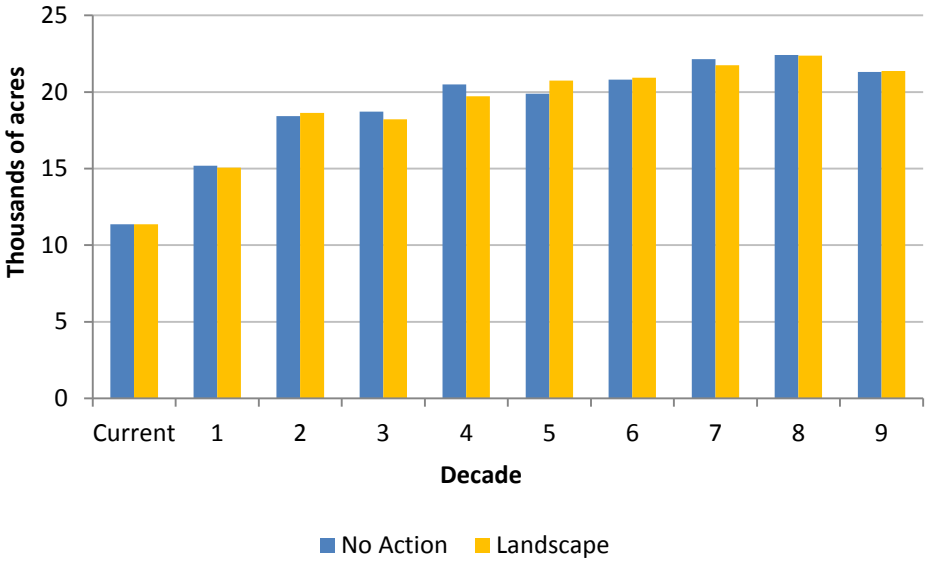
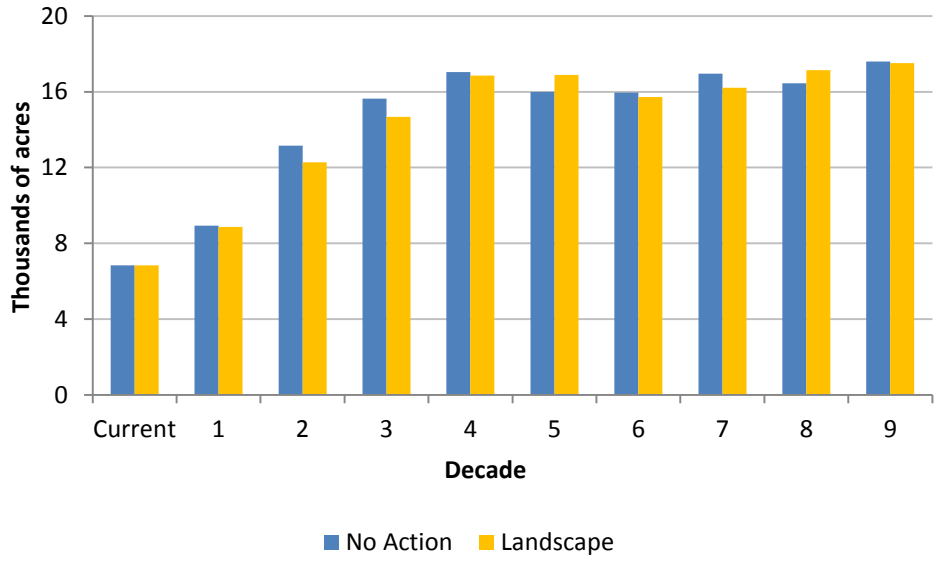


Chart I-114. Acres of Roosting Average Stand Level Model Scores 75 to 100 for the Willy Huel Landscape, by Alternative



Foraging Stand Model Scores

Chart I-115. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Entire OESF, by Alternative

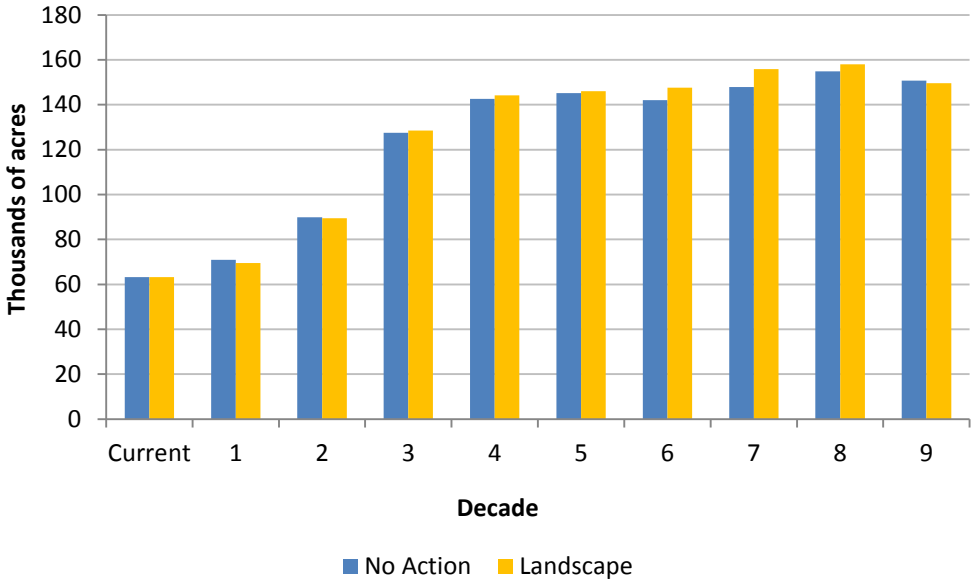


Chart I-116. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Entire OESF, by Alternative

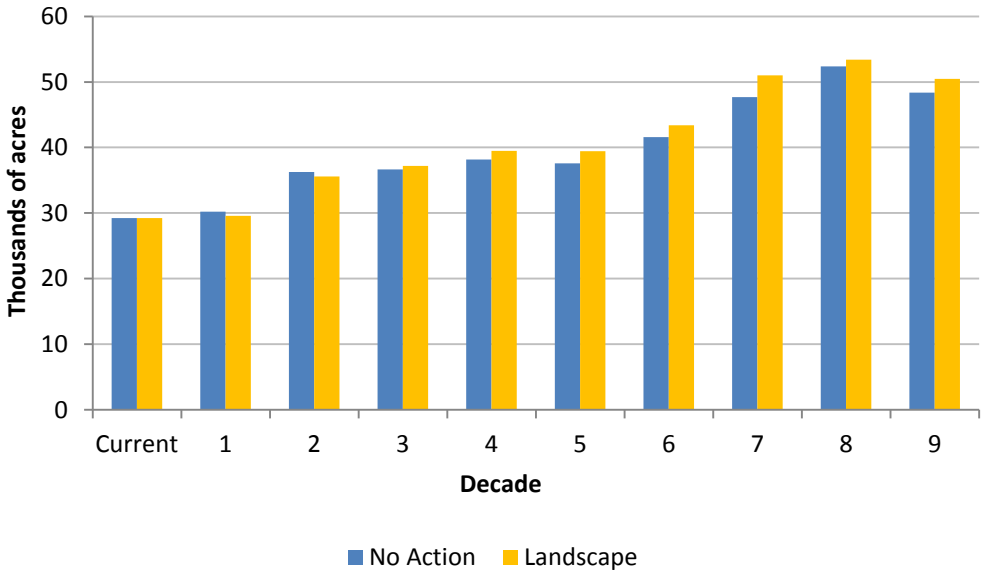


Chart I-117. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Clallam Landscape, by Alternative

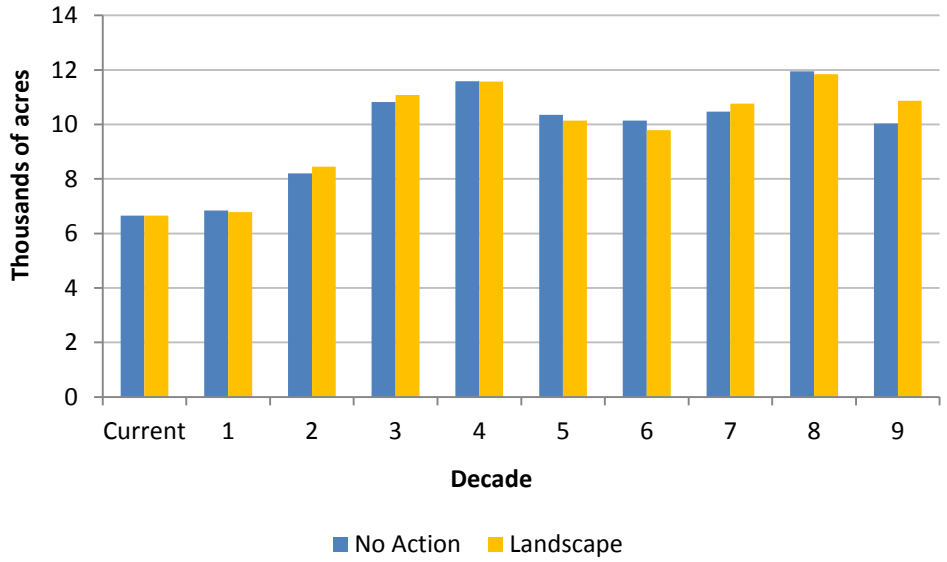


Chart I-118. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Clallam Landscape, by Alternative

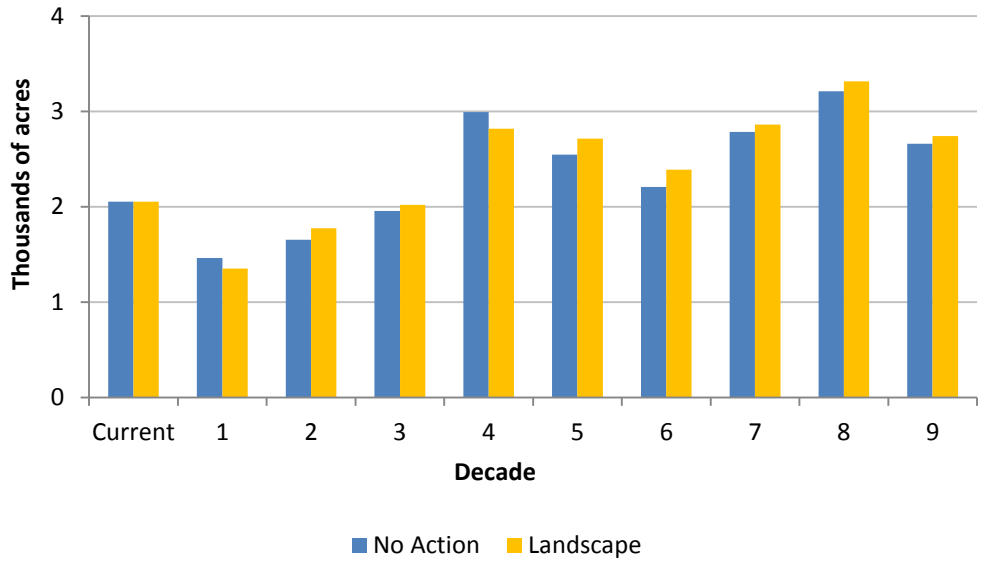


Chart I-119. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Clearwater Landscape, by Alternative

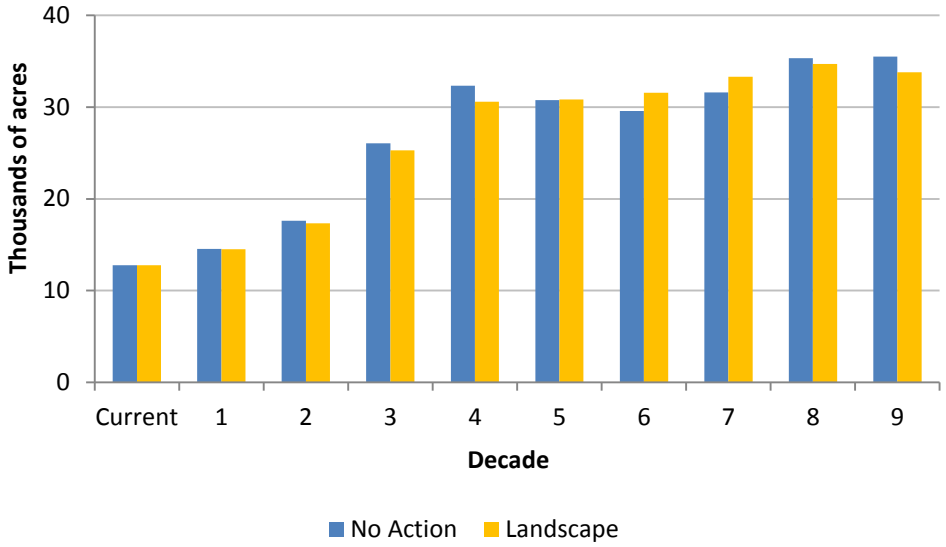


Chart I-120. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Clearwater Landscape, by Alternative

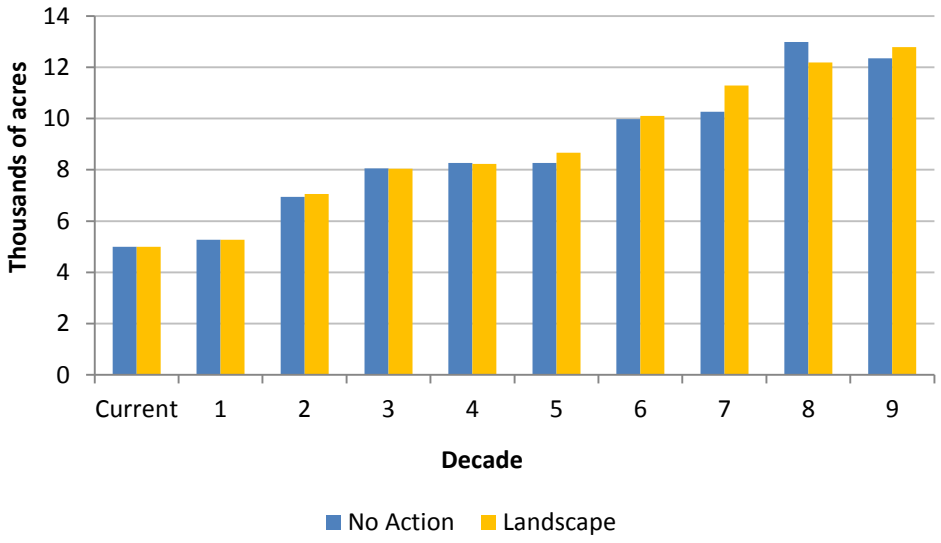


Chart I-121. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Coppermine Landscape, by Alternative

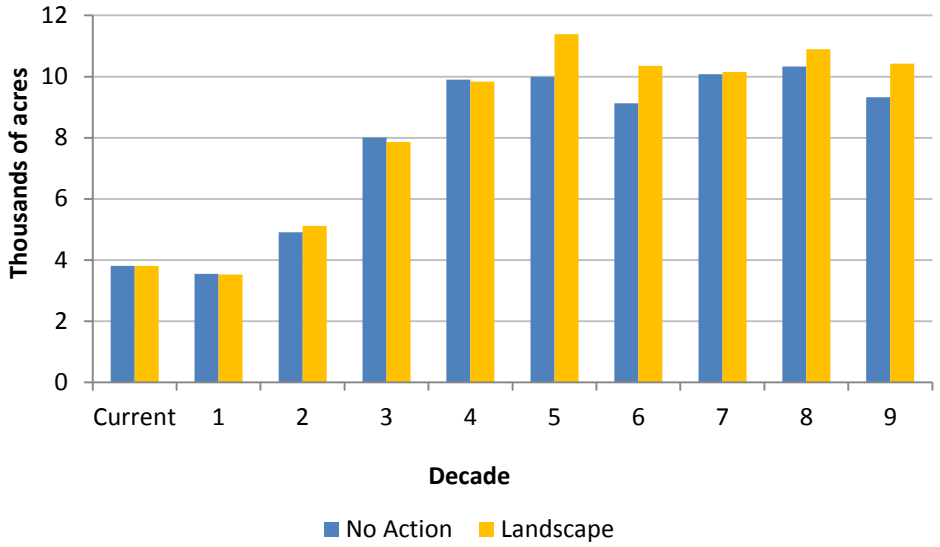


Chart I-122. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Coppermine Landscape, by Alternative

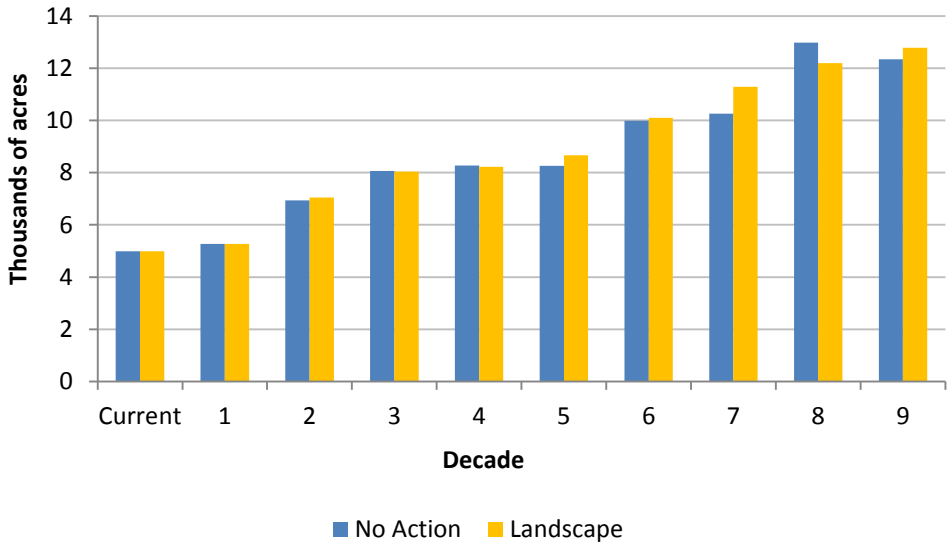


Chart I-123. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Dickodochtedar Landscape, by Alternative

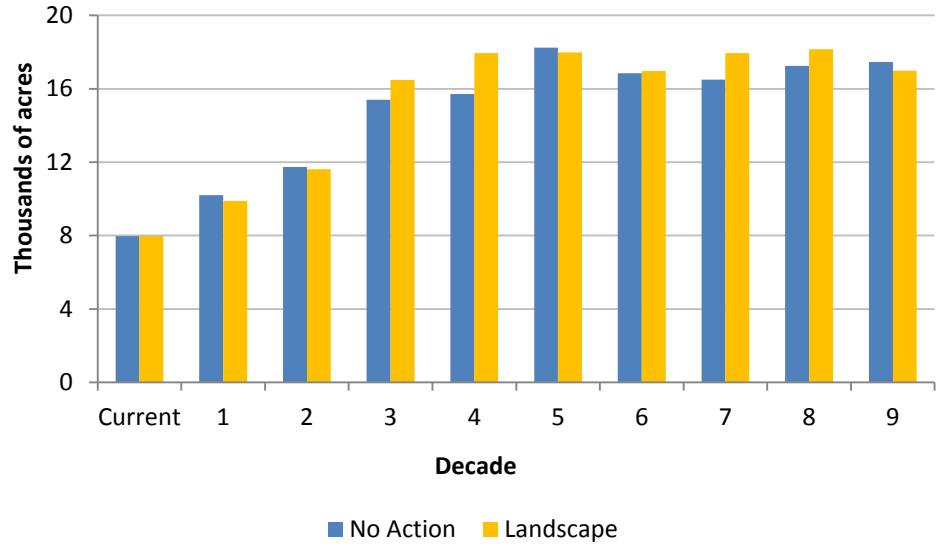


Chart I-124. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Dickodochtedar Landscape, by Alternative

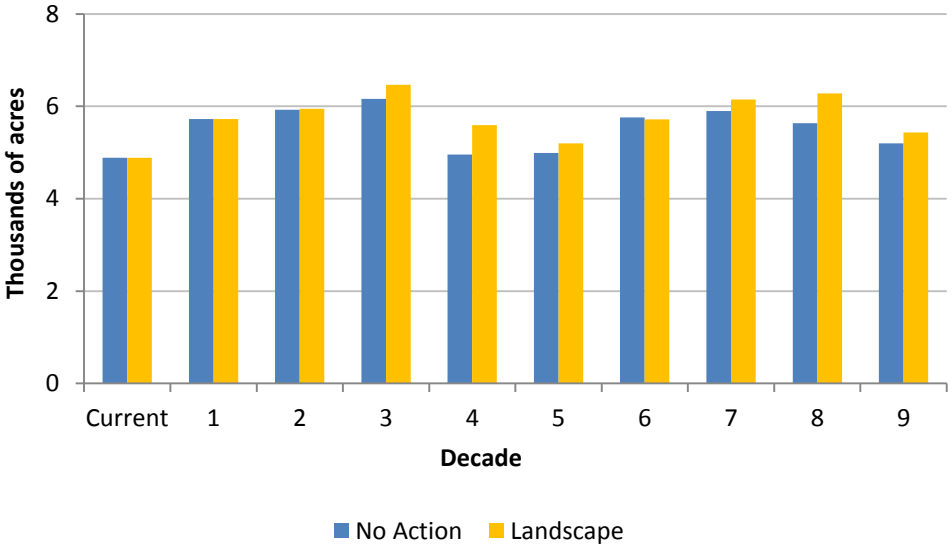


Chart I-125. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Goodman Landscape, by Alternative

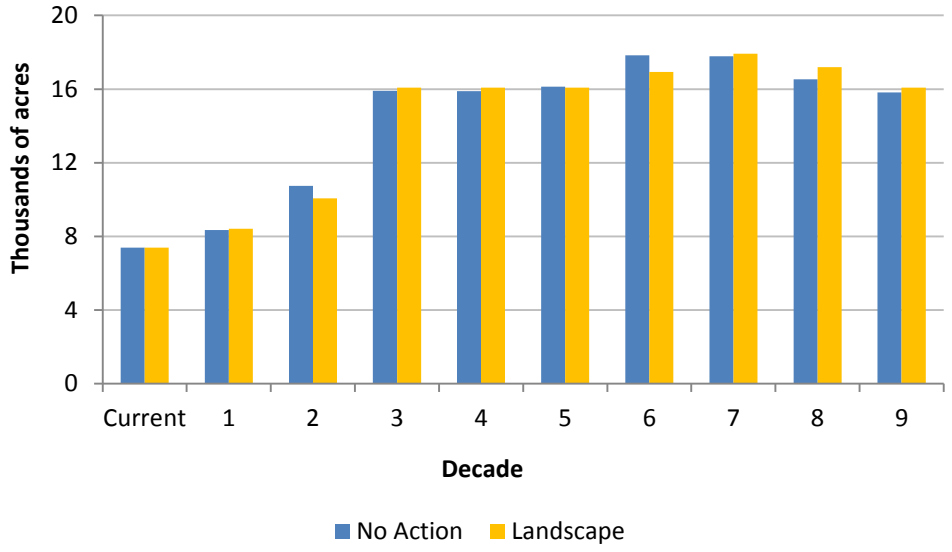


Chart I-126. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Goodman Landscape, by Alternative

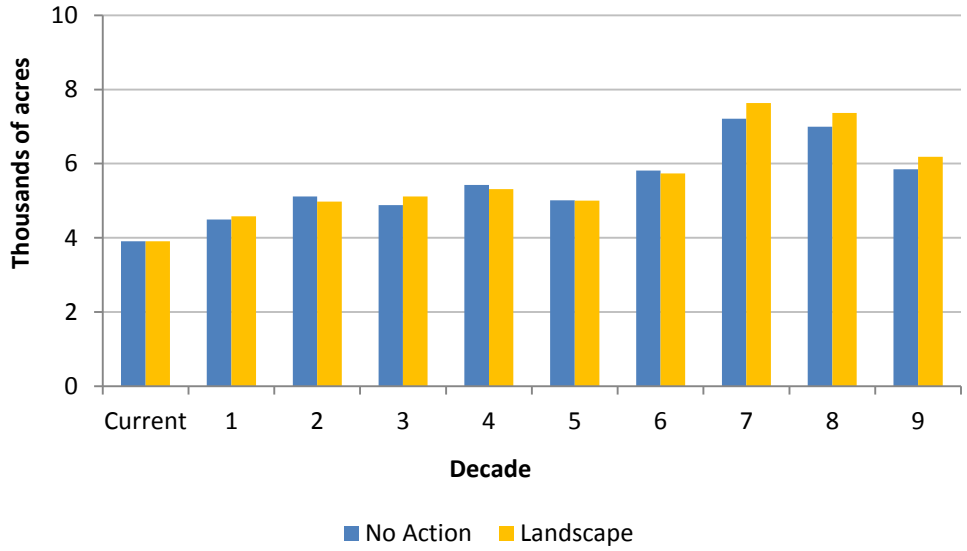


Chart I-127. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Kalaloch Landscape, by Alternative

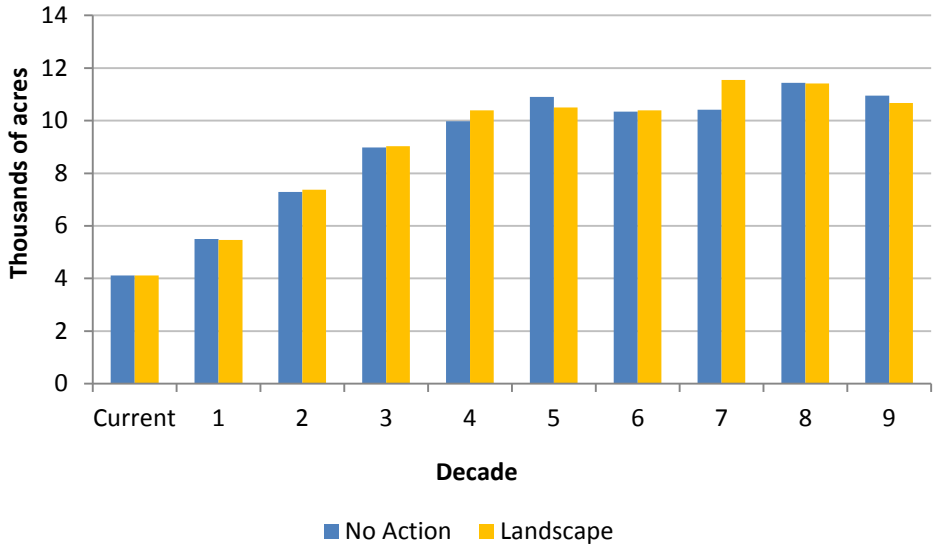


Chart I-128. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Kalaloch Landscape, by Alternative

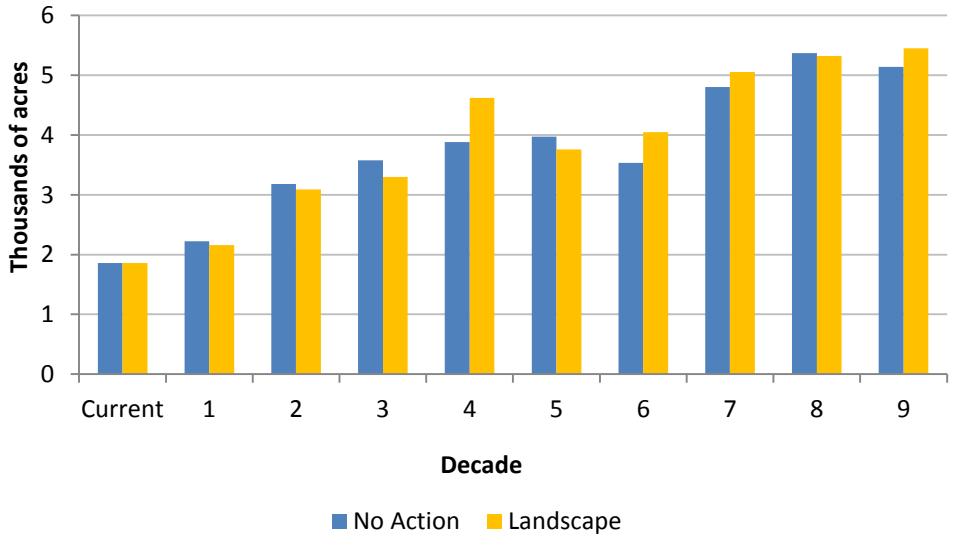


Chart I-129. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Queets Landscape, by Alternative

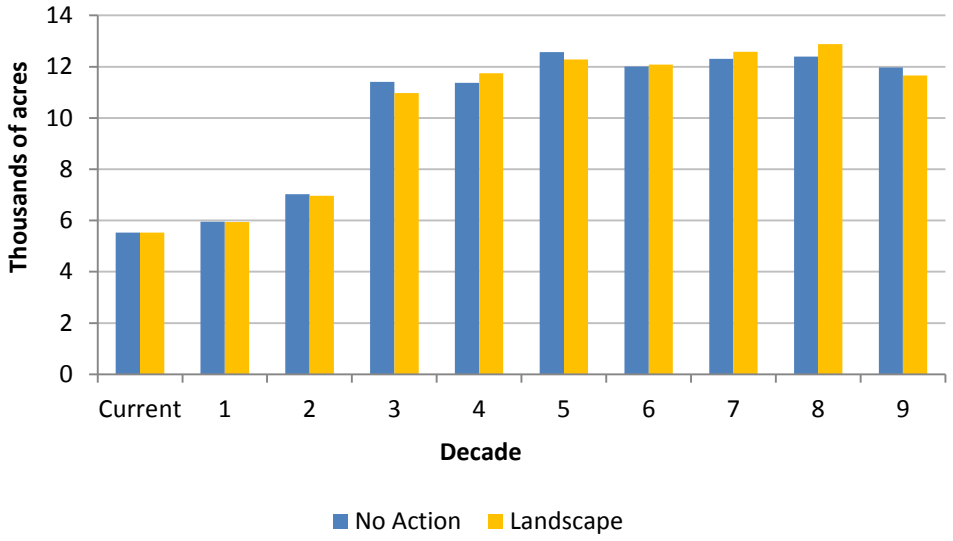


Chart I-130. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Queets Landscape, by Alternative

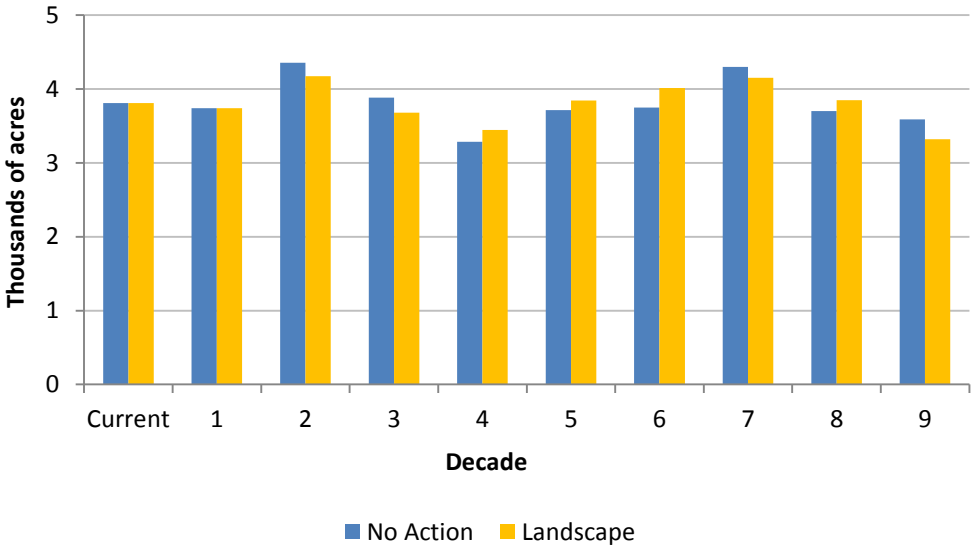


Chart I-131. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Reade Hill Landscape, by Alternative

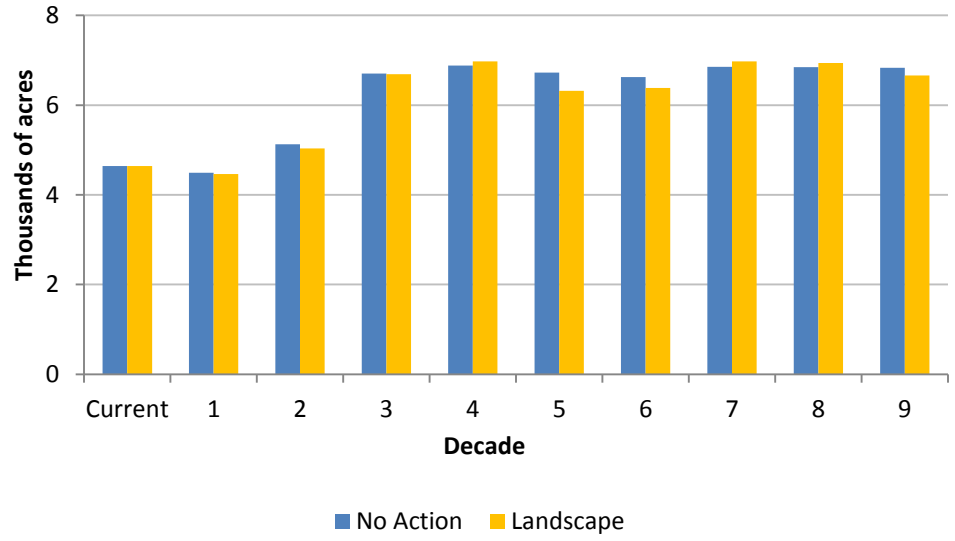


Chart I-132. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Reade Hill Landscape, by Alternative

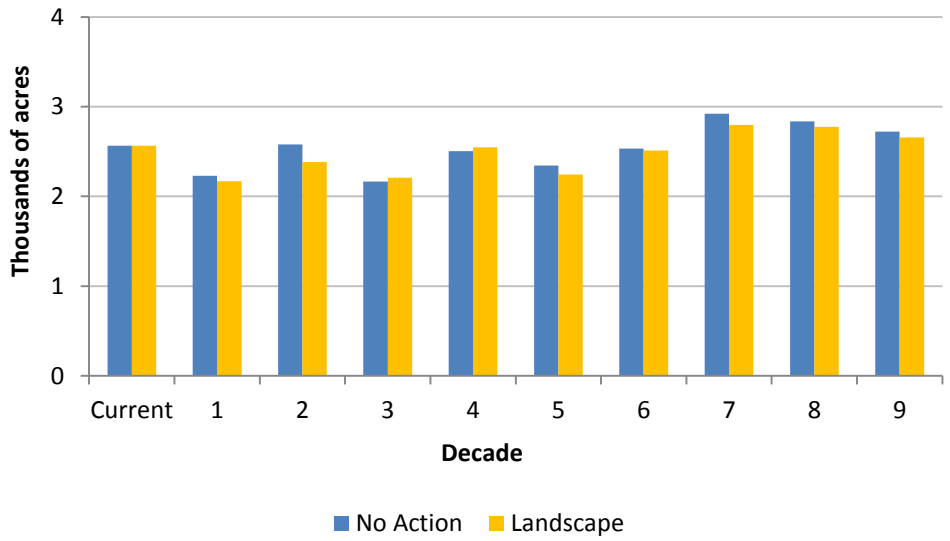


Chart I-133. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Sekiu Landscape, by Alternative

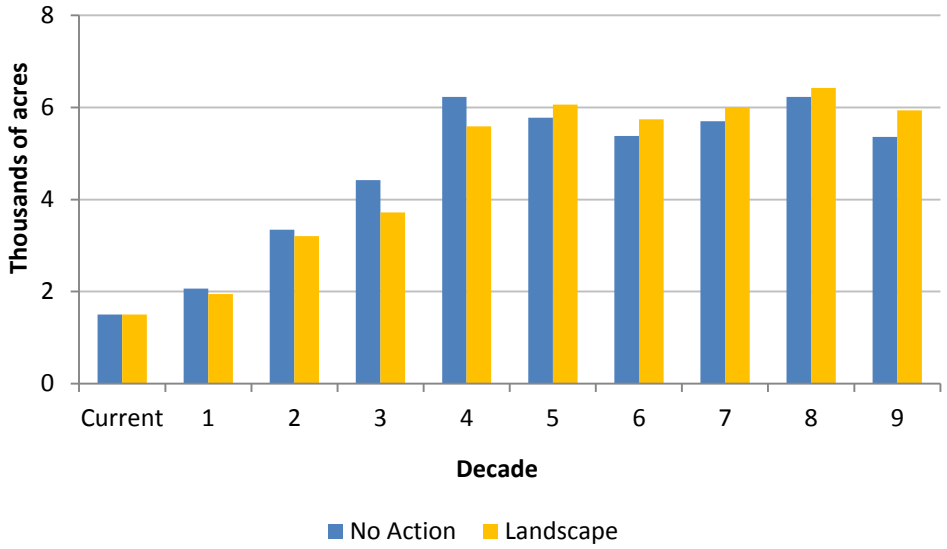


Chart I-134. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Sekiu Landscape, by Alternative

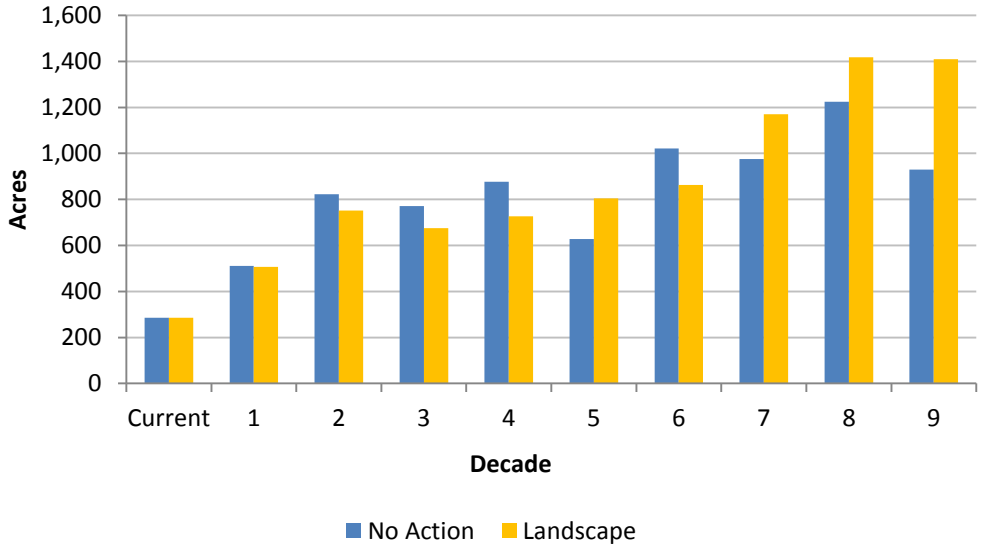


Chart I-135. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Sol Duc Landscape, by Alternative

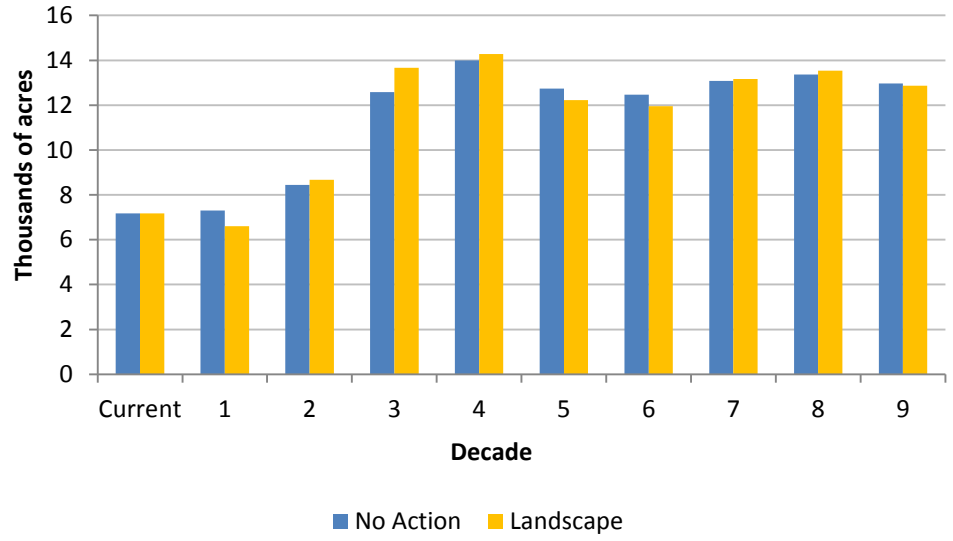


Chart I-136. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Sol Duc Landscape, by Alternative

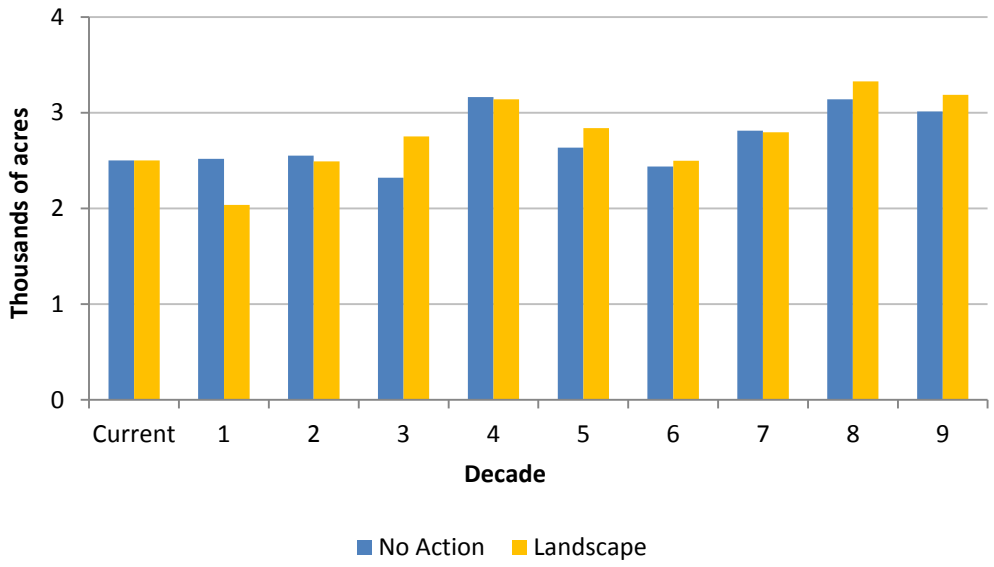


Chart I-137. Acres of Foraging Average Stand Level Model Scores 50 to 100 for the Willy Huel Landscape, by Alternative

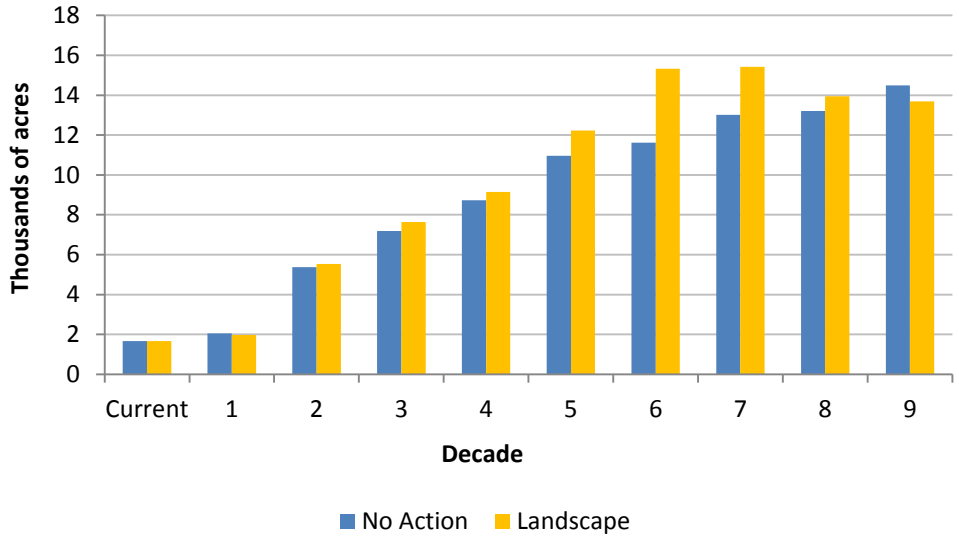
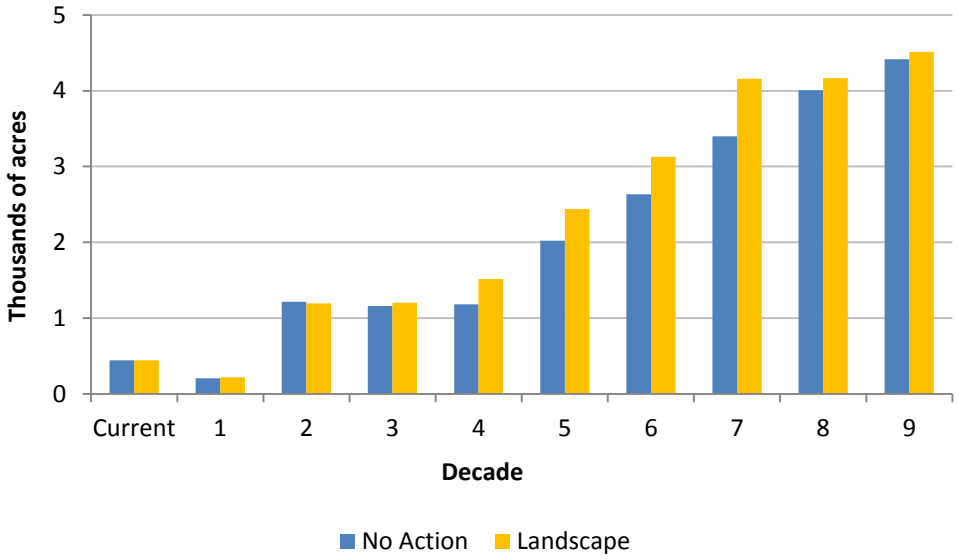


Chart I-138. Acres of Foraging Average Stand Level Model Scores 75 to 100 for the Willy Huel Landscape, by Alternative



Movement Stand Model Scores

Chart I-139. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Entire OESF, by Alternative

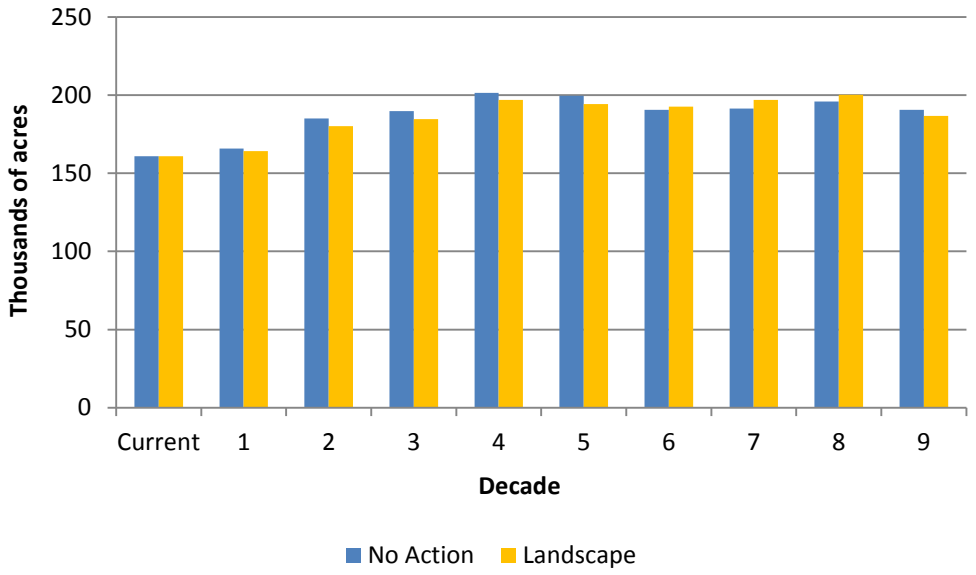


Chart I-140. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Entire OESF, by Alternative

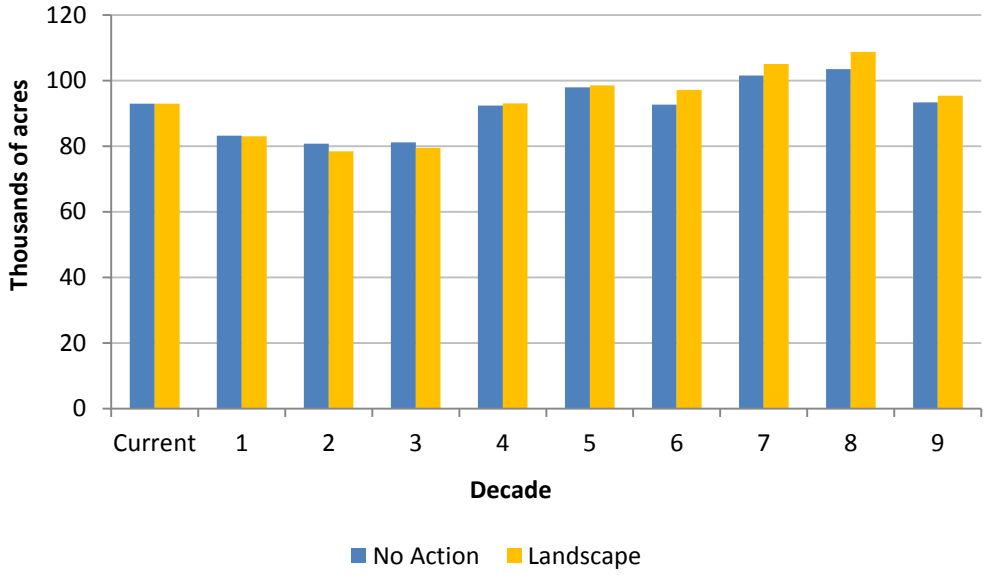


Chart I-141. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Clallam Landscape, by Alternative

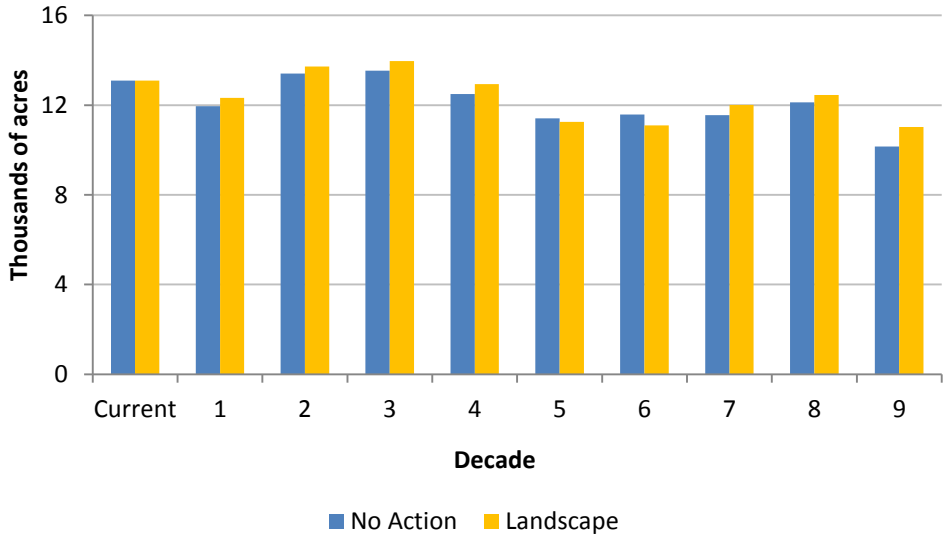


Chart I-142. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Clallam Landscape, by Alternative

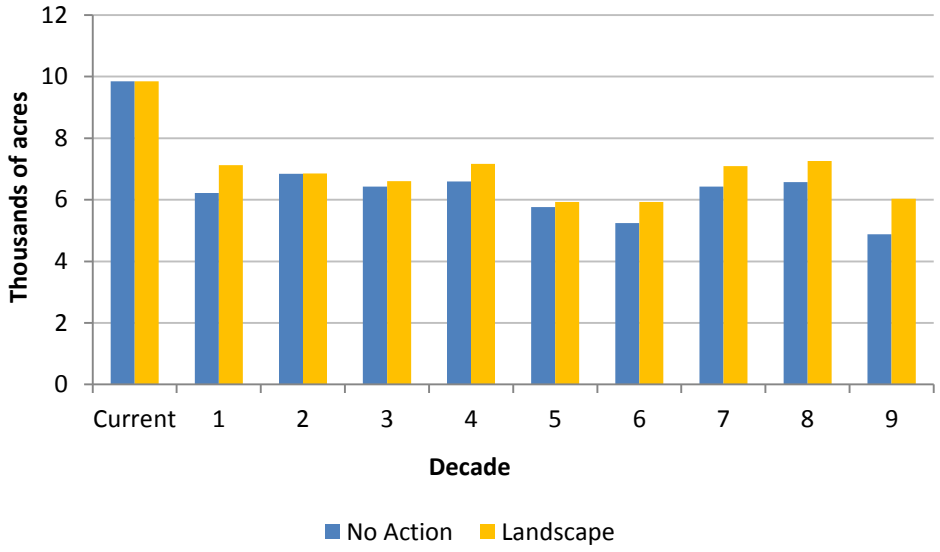


Chart I-143. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Clearwater Landscape, by Alternative

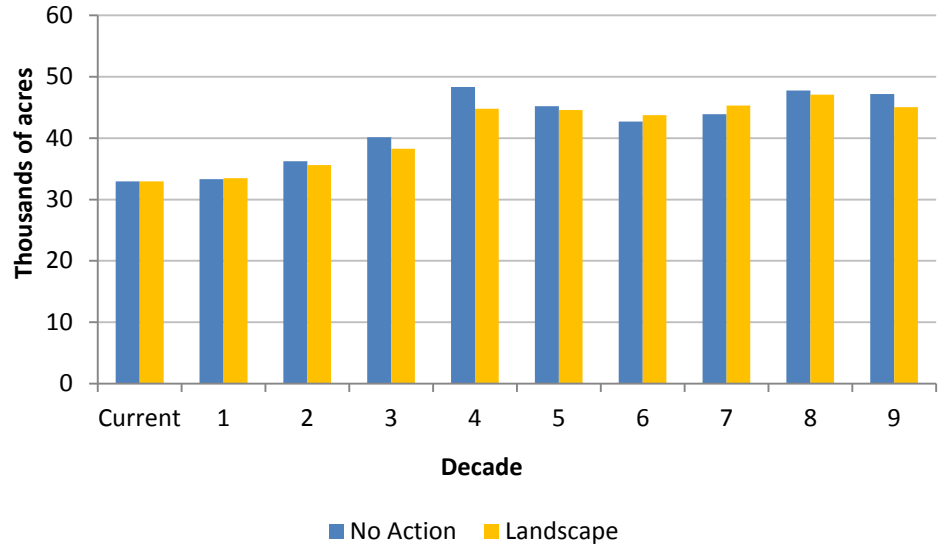


Chart I-144. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Clearwater Landscape, by Alternative

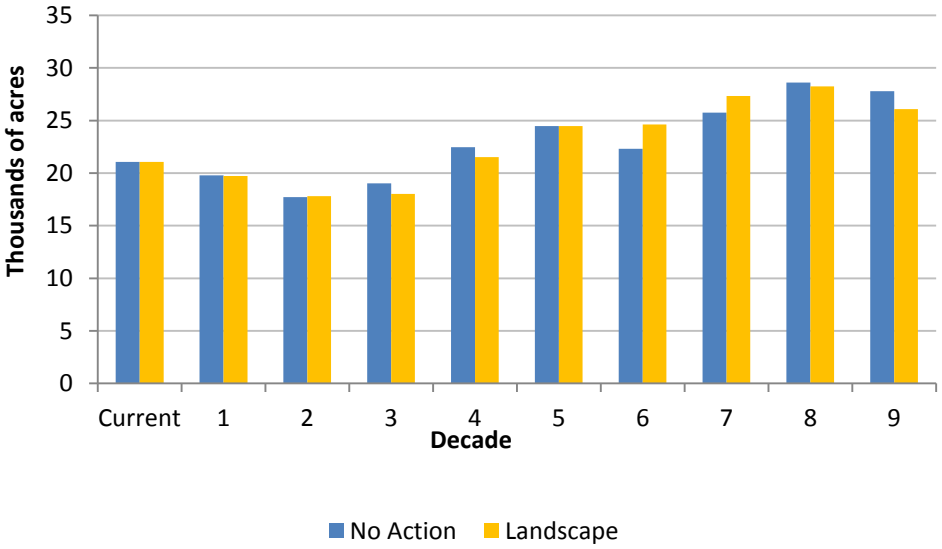


Chart I-145. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Coppermine Landscape, by Alternative

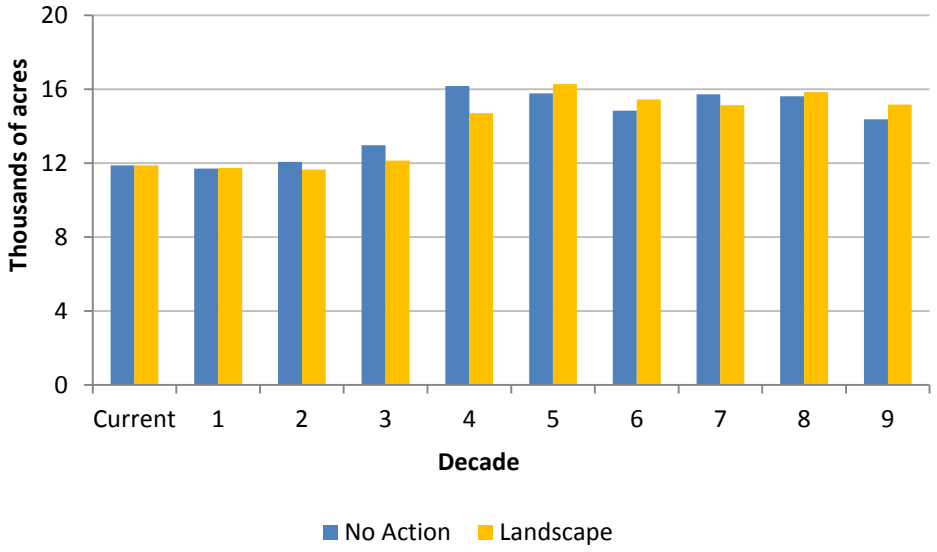


Chart I-146. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Coppermine Landscape, by Alternative

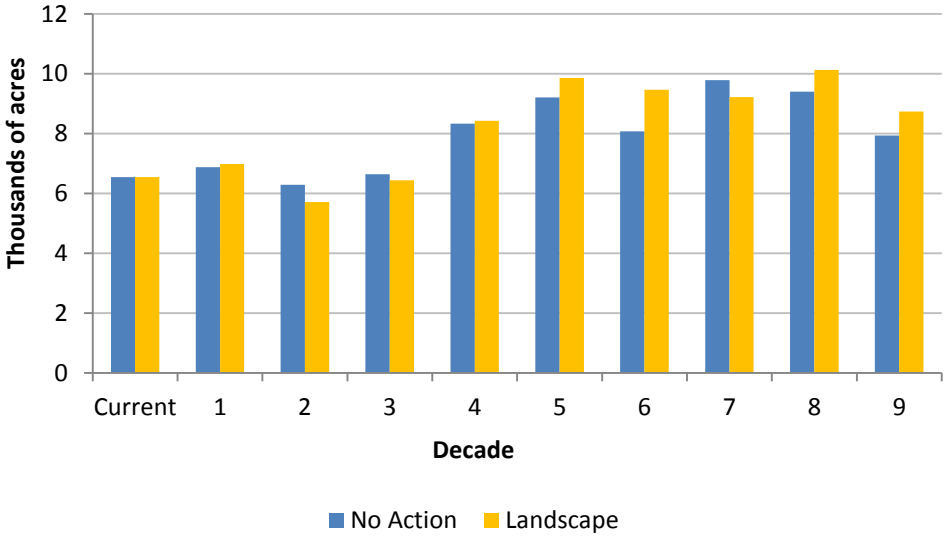


Chart I-147. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Dickodochtedar Landscape, by Alternative

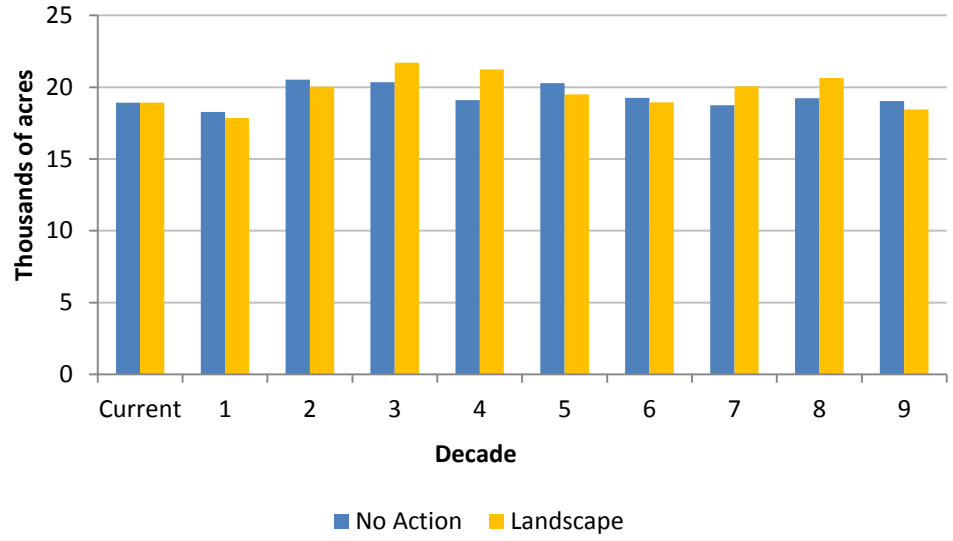


Chart I-148. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Dickodochtedar Landscape, by Alternative

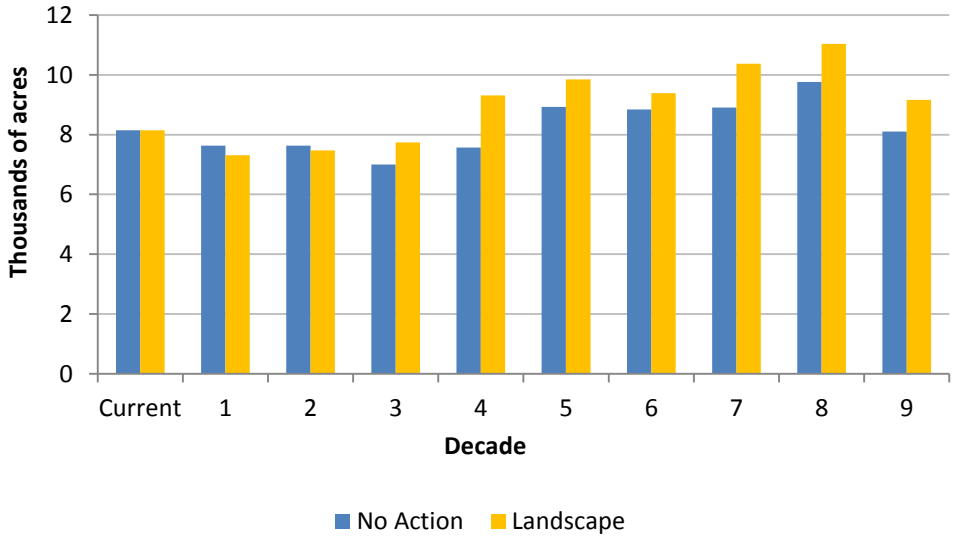


Chart I-149. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Goodman Landscape, by Alternative

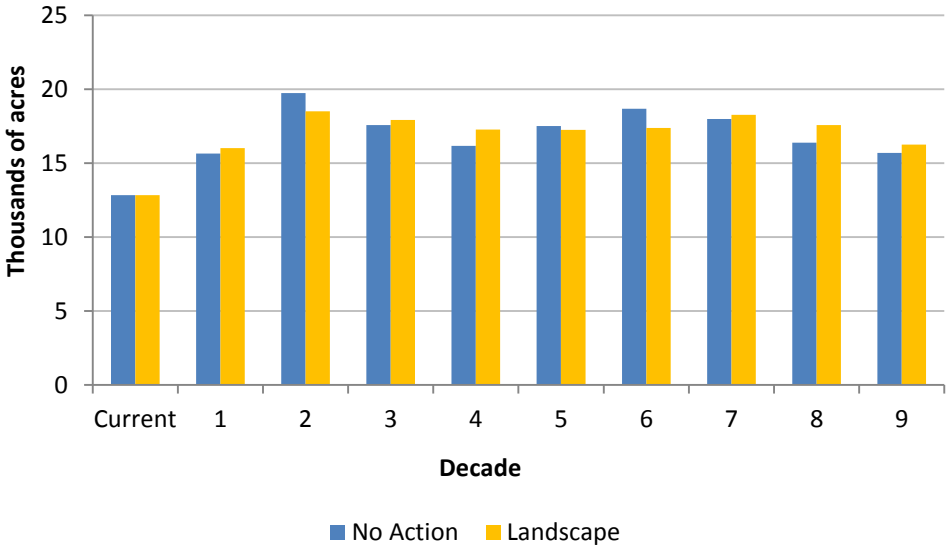


Chart I-150. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Goodman Landscape, by Alternative

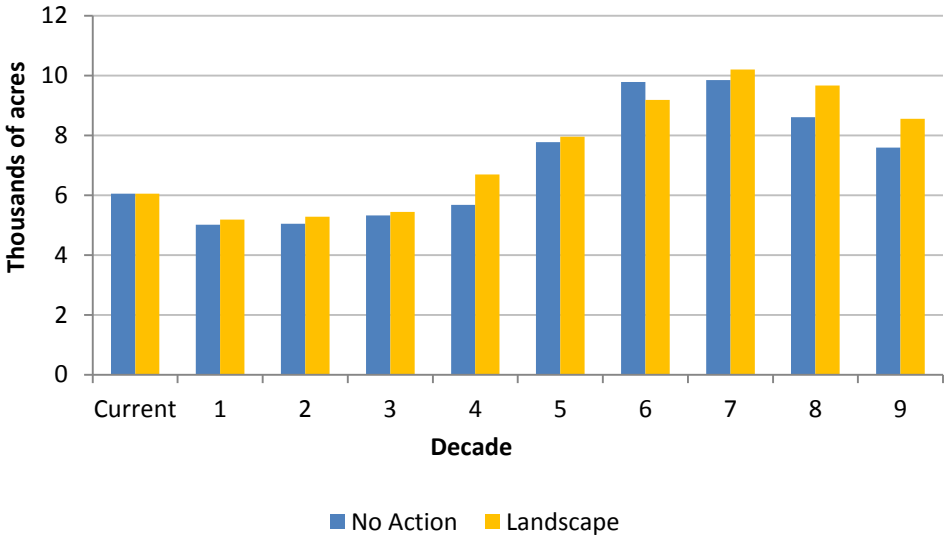


Chart I-151. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Kalaloch Landscape, by Alternative

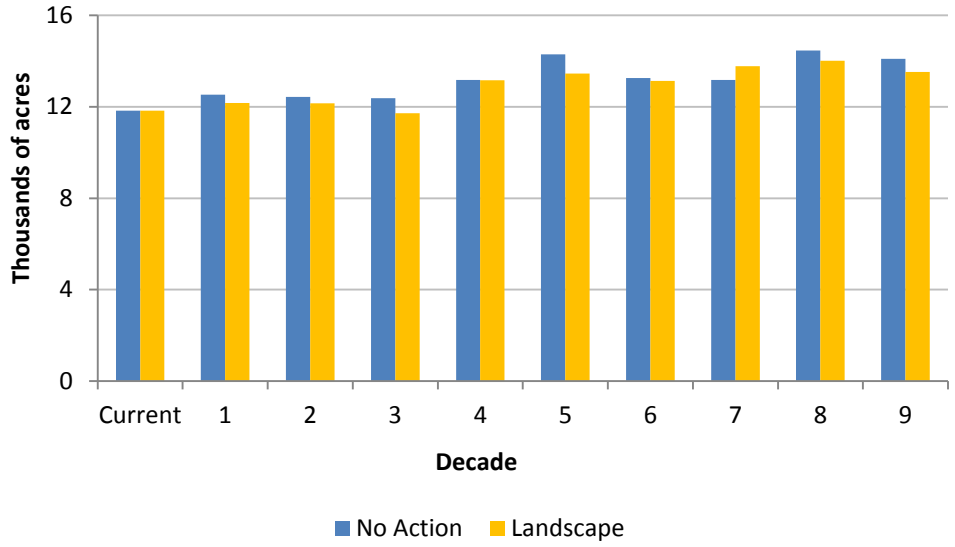


Chart I-152. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Kalaloch Landscape, by Alternative

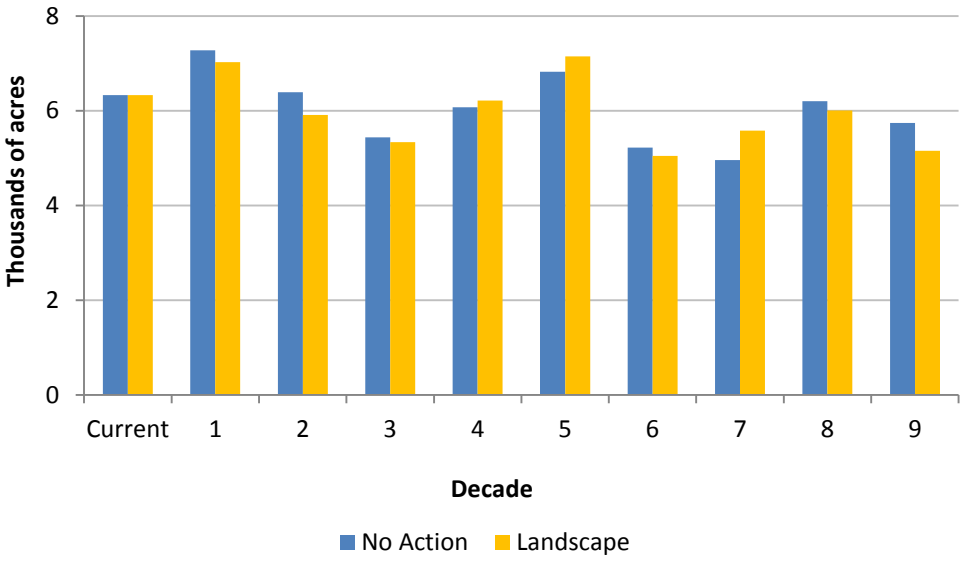


Chart I-153. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Queets Landscape, by Alternative

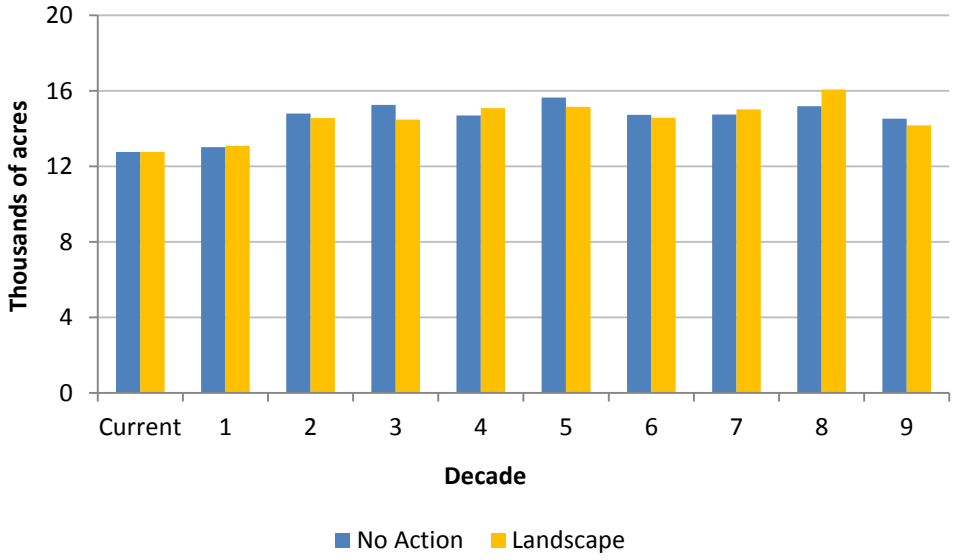


Chart I-154. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Queets Landscape, by Alternative

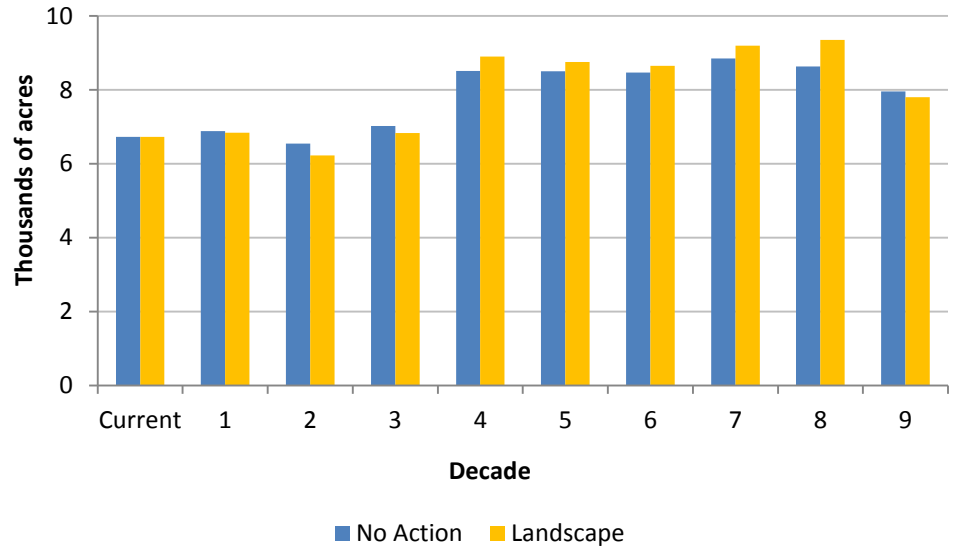


Chart I-155. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Reade Hill Landscape, by Alternative

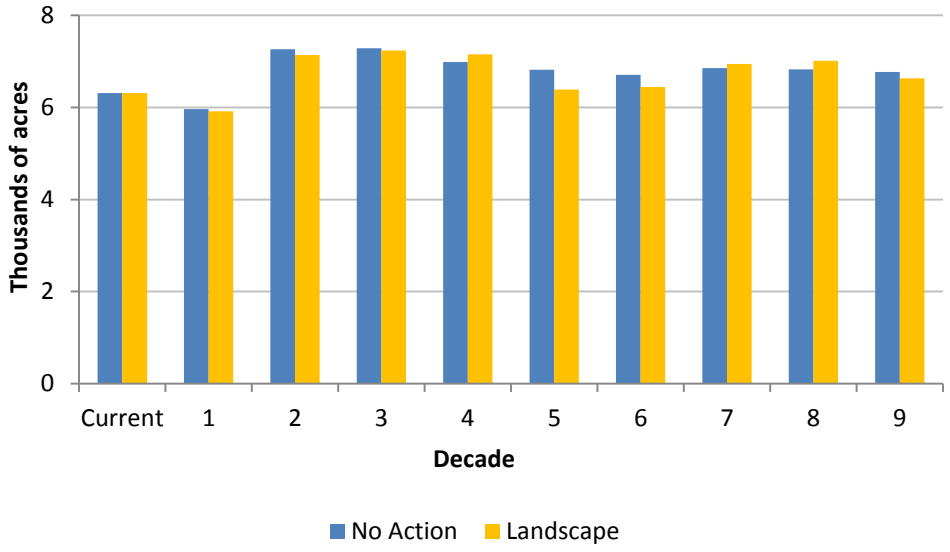


Chart I-156. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Reade Hill Landscape, by Alternative

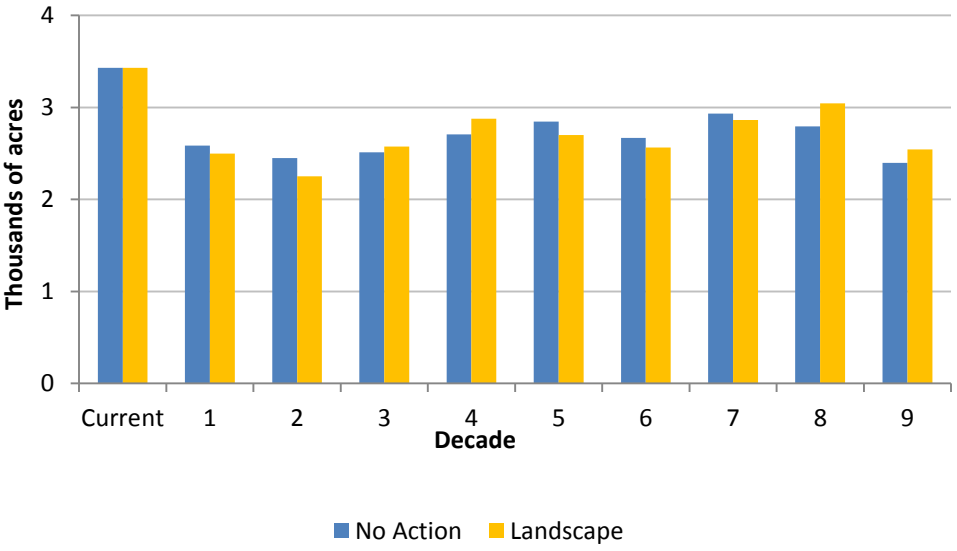


Chart I-157. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Sekiu Landscape, by Alternative

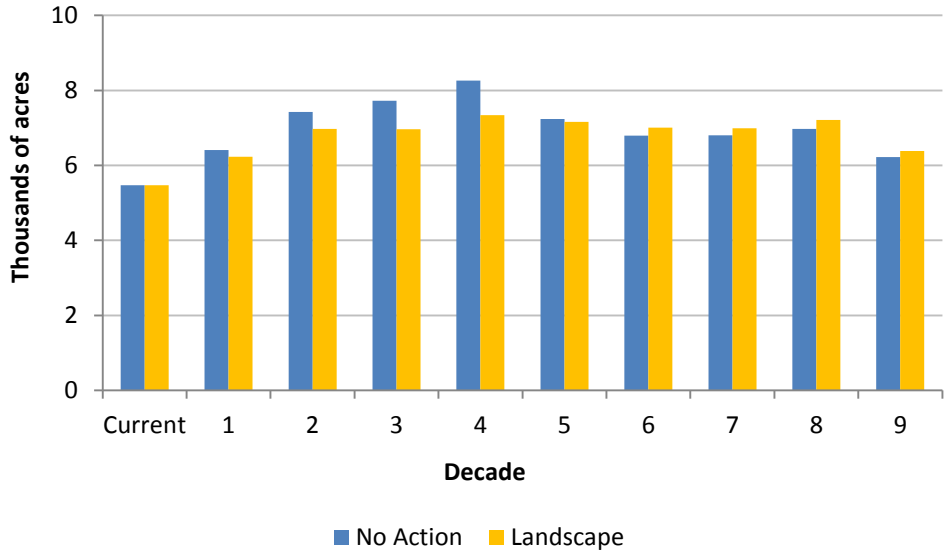


Chart I-158. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Sekiu Landscape, by Alternative

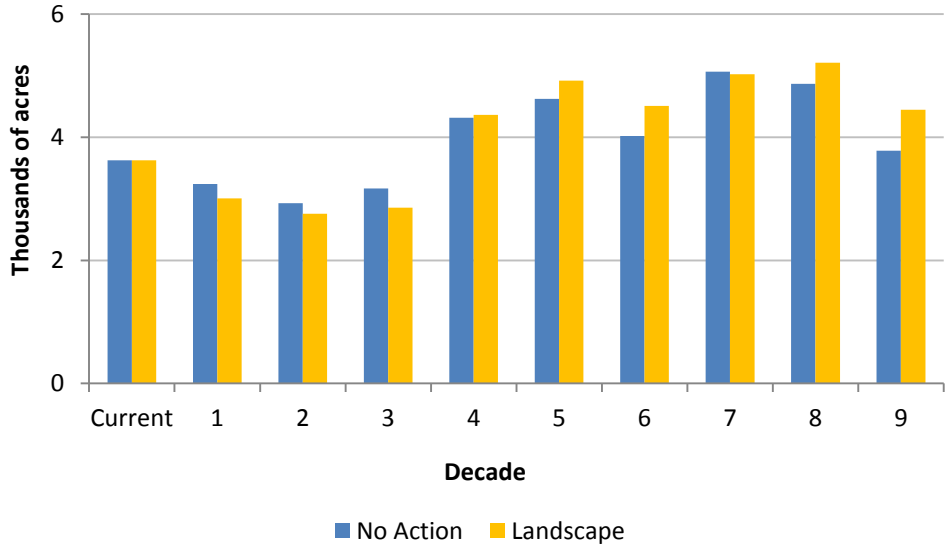


Chart I-159. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Sol Duc Landscape, by Alternative

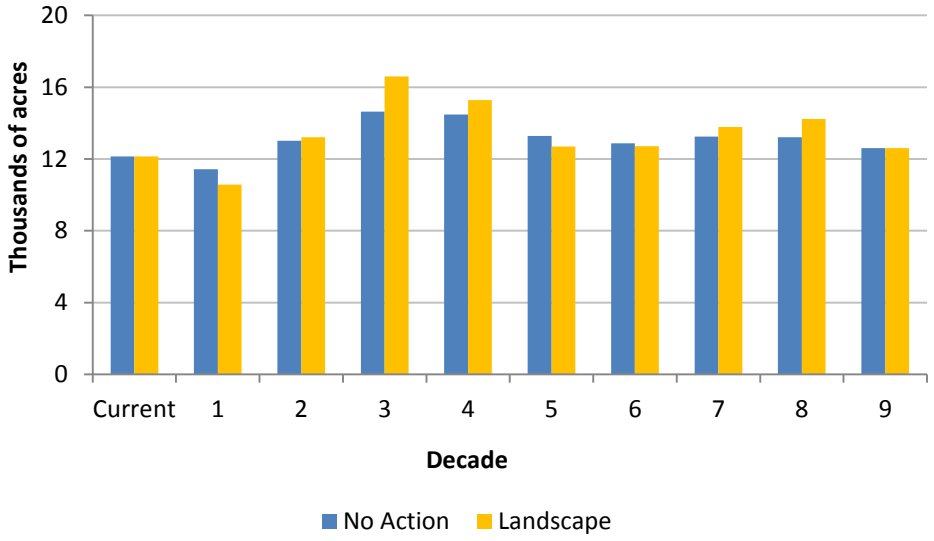


Chart I-160. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Sol Duc Landscape, by Alternative

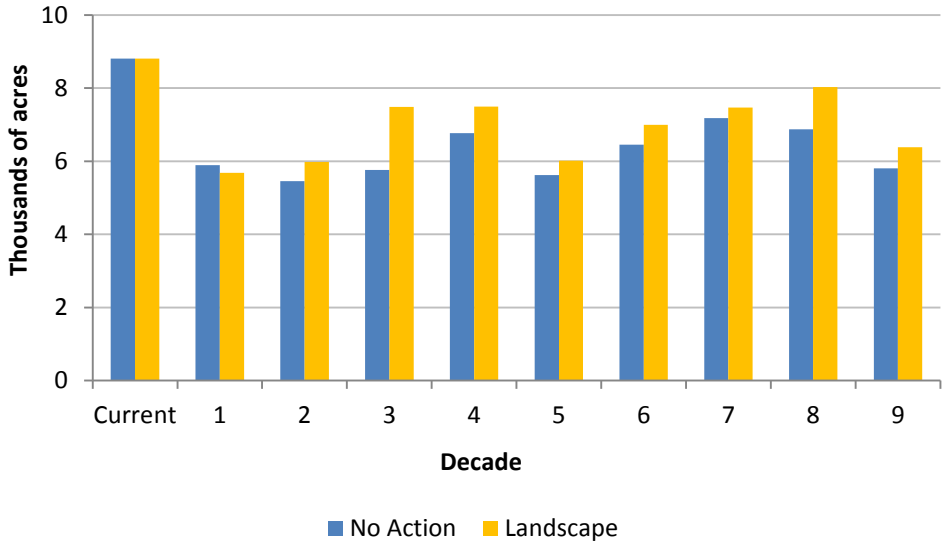


Chart I-161. Acres of Movement Average Stand Level Model Scores 50 to 100 for the Willy Huel Landscape, by Alternative

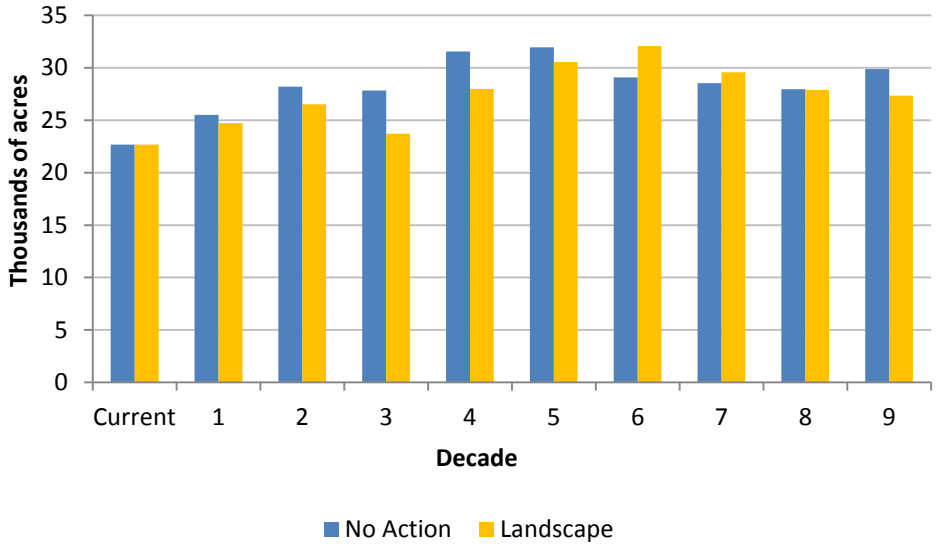
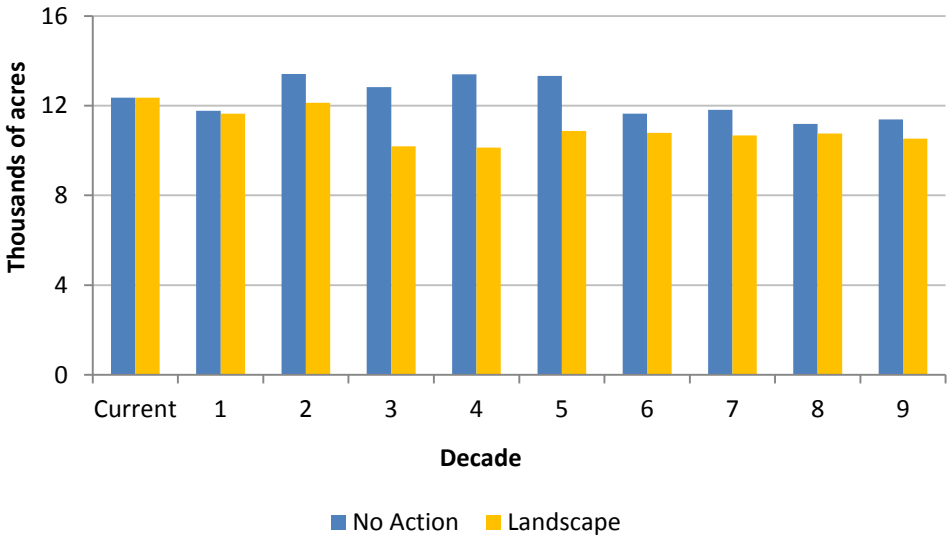


Chart I-162. Acres of Movement Average Stand Level Model Scores 75 to 100 for the Willy Huel Landscape, by Alternative



Description of the Northern Spotted Owl Territory Model

The northern spotted owl territory model is a spatially explicit model that provides an index to the overall capability of the OESF. It estimates the quantity and quality of potential spotted owl territories that theoretically could derive some support from habitat on DNR-managed land in the OESF. The model identifies likely areas where viable northern spotted owl territories could exist. While it is unlikely that actual northern spotted owls will behave as predicted by the model, the model provides an objective, repeatable index that will be used to assess the effects of forest management by comparing the maximum number of potential spotted owl territories supported by the OESF under the No Action and Landscape alternatives in each decade of the analysis period.

The DNR northern spotted owl territory model is based on the movement and territory packing models described in the British Columbia Ministry of Forest and Range Technical Report #038 (Sutherland and others 2007). The modeling assumptions, process, and spatial output are similar to those described in Sutherland and others (2007). The input data, modeling platform, and specific modeling rules are, however, different.

Model Overview

The spatial extent of the model is the entire OESF (all land owners) and all areas within 50,000 feet (approximately 9.5 miles) of the OESF.

The spatial resolution of the model (i.e. the "grain" size at which information can be distinguished spatially) will be at the scale of the Remsoft ID polygon in the analysis model.

The development environment for this model is ArcGIS 9.3.1and Python 2.5.

Input Data

The analysis model projects future forest conditions on DNR-managed lands. The northern spotted owl stand model evaluates forest stands for spotted owl movement, roosting, foraging, and nesting support. DNR then averaged the stand level scores. These average stand level scores are referred to as RFMN (Roosting, Foraging, Movement, Nesting) scores.

On adjacent non-DNR lands the Gradient Nearest Neighbor (GNN) dataset is used as a data source for forest and habitat conditions (Ohmann and Gregory 2002). GNN uses multivariate gradient modeling to integrate data from Forest Service PNW Station Forest Inventory and Analysis program (FIA) field plots with satellite imagery and mapped environmental data. A suite of fine-scale plot variables is imputed to each pixel in a digital map, and regional maps are constructed for many of the same vegetation attributes

available for FIA plots. All GNN map products are grid-based at 30-meter spatial resolution. No future forest conditions were modeled for non-DNR lands.

Modeling Process

The model has three basic assumptions about the viability of a spotted owl territory (the term viability is used in the sense of having the potential to meet the life needs of a spotted owl pair):

1. A territory needs to contain at least 7,400 acres of quality habitat (see the description below for what constitutes "quality" habitat).
2. A territory cannot be larger than 27,300 acres in size.
3. A territory cannot have more than 25 percent of its quality habitat overlapping with other territories.

Using the above assumptions, the model employs a number of spatial-analytical processes to estimate the likely number of viable territories the OESF can support:

1. Estimation of potential nest sites.

    1.1. DNR made the assumption that a nesting score greater than or equal to 50 identifies owl habitat through the spotted owl stand model. Areas that have a mean nesting habitat score greater than or equal to 50 within the analysis are converted to a polygon. These polygons are considered "potential nesting habitat". As described above, the GNN dataset is used on adjacent non-DNR managed lands as a data source for habitat conditions. A similar evaluation of habitat was done on GNN data as to what was done on DNR managed lands. For both data sources, stands had to be less than 3,000 feet in elevation to be considered habitat.

    1.2. 3,000 points are randomly scattered within the polygons defining the potential nesting habitat. Each point must be at least 100 meters apart from another. The purpose of this is to "saturate" the landscape with potential modeled nest sites and where a potential northern spotted owl territory might originate. An additional 74 nest points were added. These 74 points represent actual locations of known northern spotted owls.

2. Calculating raster-based "cost surface" for spotted owl movement.

    For each potential nest site a raster-based "cost surface" is calculated that incorporates two variables:

    2.1. Distance from the nest point accounting for both horizontal and vertical (e.g. topographic) distance. This is commonly known as the "path distance."

    2.2. Assumptions regarding the relative cost associated with moving through different forest types and land cover. For example, the cost of moving through an old growth stand is less than the cost of moving through a recently harvested stand.

3. Estimating the amount of habitat in a potential territory

3.1. In order to determine how much potential habitat is within each increment of "cost" associated with moving out away from the potential nest point, the cost surface raster is overlaid with a habitat raster. The habitat for DNR-managed land are identified through the stand model with RFMN average score greater than or equal to 50 identified owl habitat.

4. Assessing the viability of potential territories

4.1. The overlaid cost/habitat raster is tallied to determine the minimum area (expressed in the incremental cost units) that will provide at least 7,400 acres of habitat (modeling rule #1). If this minimum amount of habitat is acquired before the maximum territory size is reached (27,300 acres according to rule #2), a territory is considered "potentially viable." If the territory exceeds the maximum area of 27,300 acres before acquiring the minimum 7,400 acres of habitat, the territory is considered "non-viable." Depending on the surrounding topography and forest conditions, the territories can be of variable size and shape. The potentially viable territories are then overlaid to determine their overlap percentages with each other. All territories that have at least 25 percent of their habitat area overlapped by other territories are considered for elimination.

4.2. A 'territory quality index" is calculated for each territory as the ratio of the amount of habitat within a territory to the territory size.

4.3. An iterative approach is used to eliminate low-quality territories. One at a time, the territory with lowest habitat to area ratio and highest proportion of its habitat area overlapped by other territories is removed from the list of potentially viable territories until no territories overlap more than 25 percent.

4.4. Randomly, ten percent of the potentially viable northern spotted owl territory (territories that passed model rule #1 and #2) are withheld. The territories are then examined for neighbor overlapping deciding order of habitat density. For example, a territory is "formed", and then the territory with the greatest habitat density is "formed". If they overlap more than 25 percent, the territory with the lower habitat density is eliminated and the territory with the next greatest habitat density is then examined.

5. Steps 4.4 is then repeated 500 times for each time step and management alternative. This allows DNR to:

5.1. Summarize the variation of the acreage, habitat density, spatial configuration, and number of "viable" territories associated with each iteration of randomly placed nest sites. This variation will inform DNR about the uncertainty associated with the model.

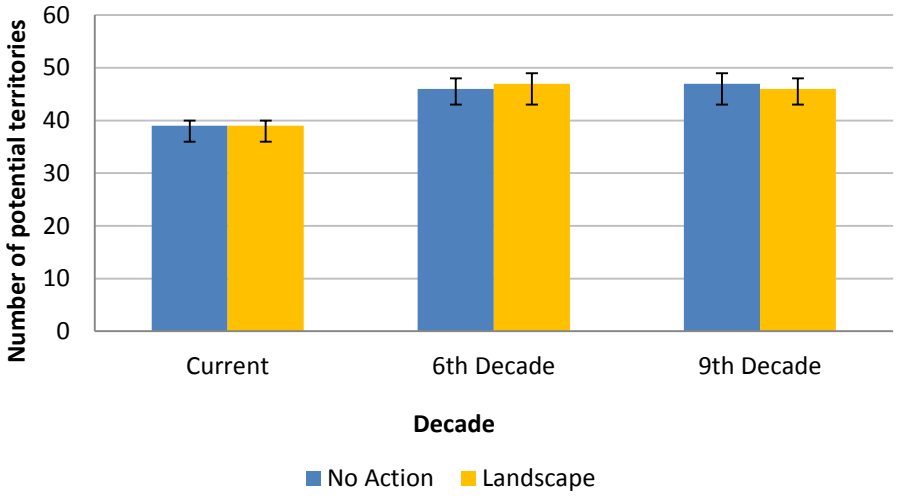
5.2. Due to the random withholding of ten percent of the sample each time, the 500 model runs result in a distribution of the likely number of viable territories. The median of this distribution is used to index the potential for DNR-managed lands in the OESF to support reproductively successful northern spotted owls, at each time step (decade) under each of the alternatives.

Analyses Using the Model Outputs

Potential Viable Northern Spotted Owl Territories

The maximum number of viable spotted owl territories supported by DNR-managed lands in the OESF is compared between the no Action and Landscape alternatives at each time step (each decade).

Chart I-163. Number of Potential Northern Spotted Owl Territories Projected by Territory Model Iterations*



*Error bars show the distribution of the number of territories modeled. The colored bars report the number of territories modeled with the highest frequency.

The likely number of potential territories increases over the planning horizon with little difference between alternatives. The error bars show there is a relatively small distribution around the territory count estimates.

Chart I-164. Distribution of Northern Spotted Owl Territory Quality for Three Time Periods, No Action Alternative

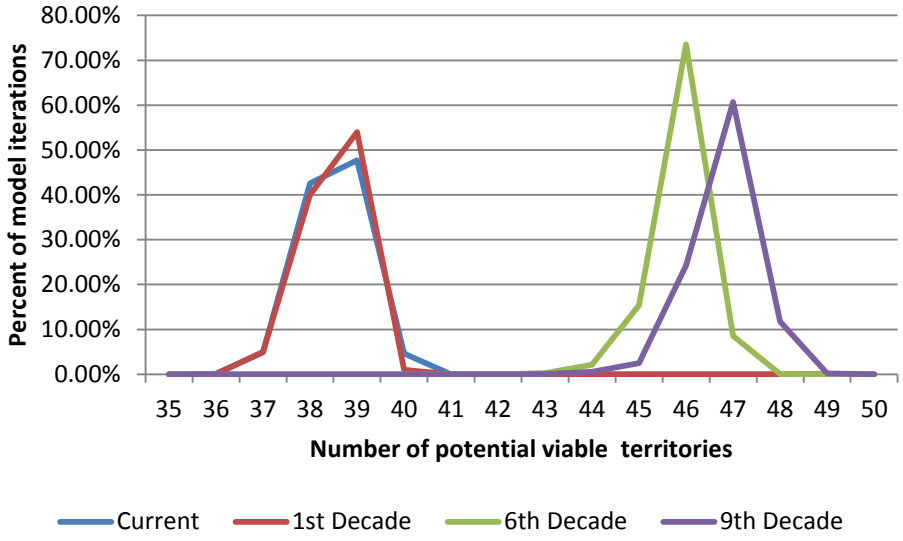
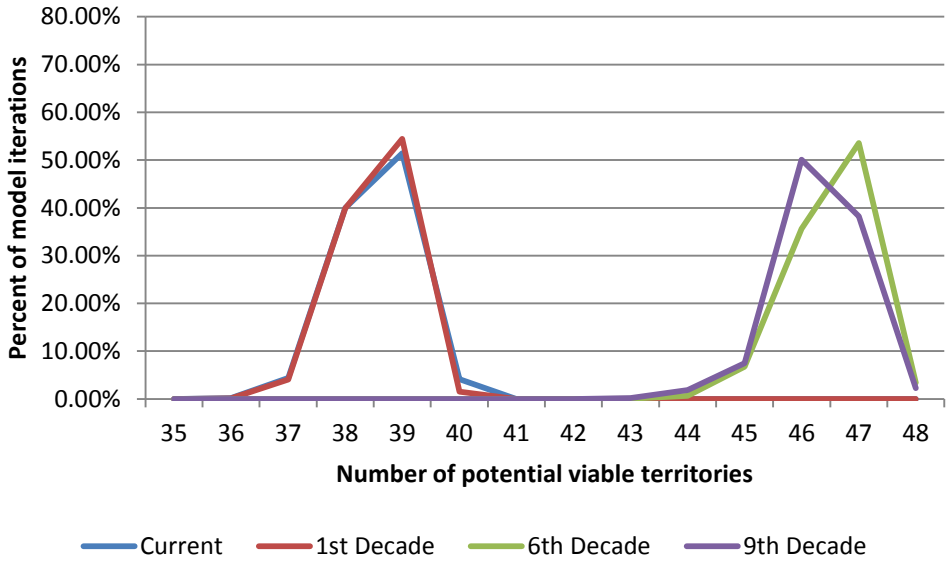


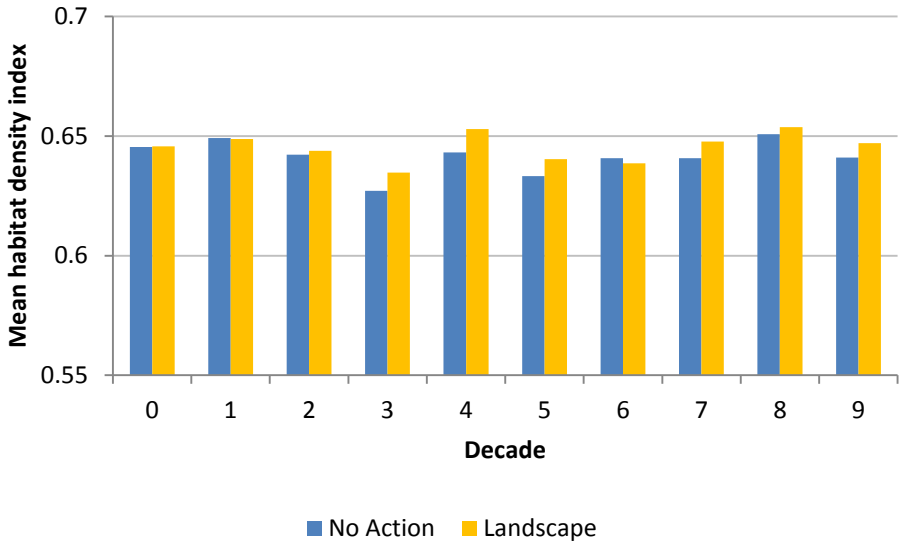
Chart I-165. Distribution of Northern Spotted Owl Territory Quality for Three Time Periods, Landscape Alternative



The distribution of potential territories over time indicates an increase in the capability for potential territory support within the OESF.

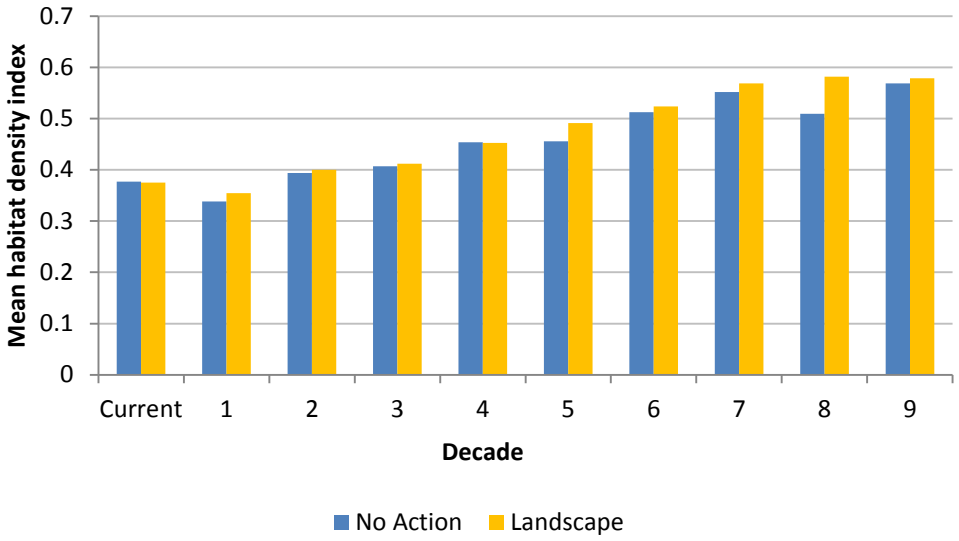
Mean Habitat Quality within Potential Viable Northern Spotted Owl Territories

Chart I-166. Habitat Quality Within Modeled Potential Northern Spotted Owl Territories Across All Ownerships



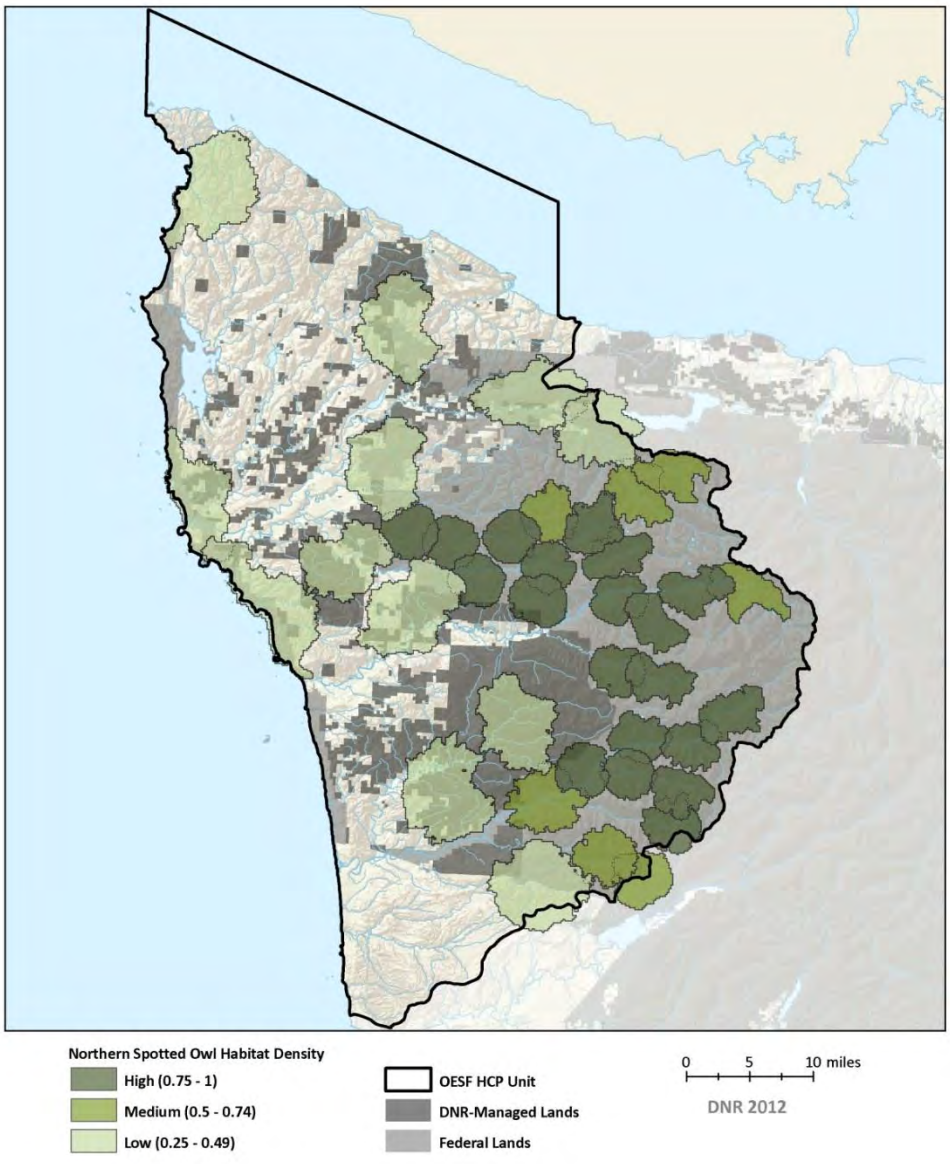
Habitat quality is assessed from the habitat density within territories. This is calculated by the habitat acres divided by territory acres. Habitat quality across all landscapes changed little during the planning horizon, likely due to the influence of the GNN (Gradient Nearest Neighbor) data being modeled as static. By having all non-DNR managed lands not developing over time, it influences the territory quality (Chart I-148). However when evaluating just DNR managed lands (Chart I-149), there is a steady increase in territory quality by both alternatives over the planning horizon. The dip in mean habitat density can also be attributed to new territories being deemed by the model as "viable" but having minimum habitat thresholds.

Chart I-167. Habitat Quality Within Modeled Potential Northern Spotted Owl on DNR Managed Lands



■ Representative Maps of Potential, Viable Northern Spotted Owl Territories Over Time, No Action and Landscape Alternatives

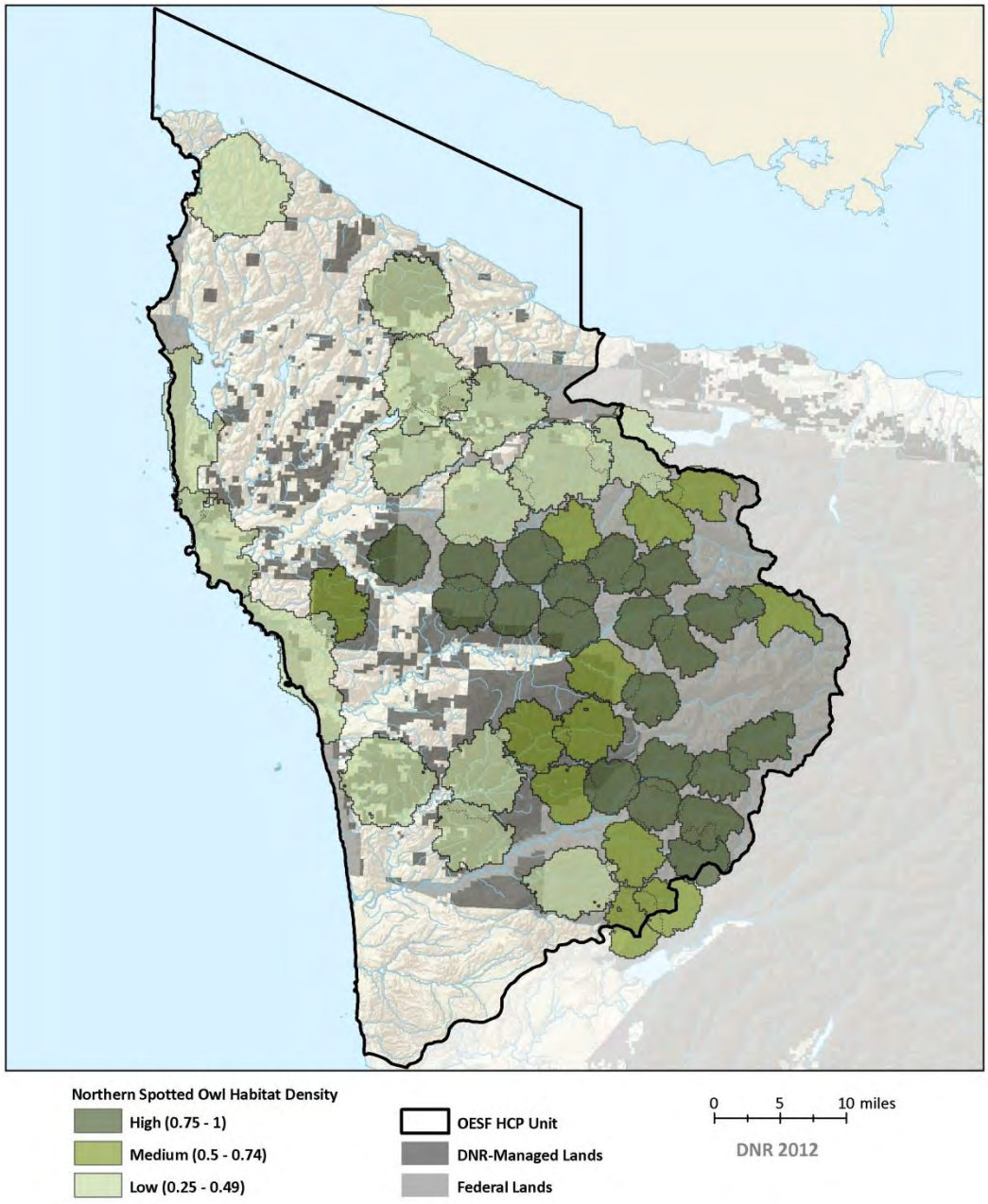
Map I-78. Modeled Potential, Viable Northern Spotted Owl Territories for Decade 1*, No Action Alternative



* Representative map of one iteration (out of 500) showing most frequently predicted number of potential, viable territories for this alternative at this time period. Dark green represents modeled potential, viable territories with high habitat density scores and the potential, viable territories are smaller in size since it takes less area to meet the resource needs of northern spotted owls. Medium green represents modeled potential, viable territories with medium habitat density scores and tend to be larger potential, viable territories. Light green represents modeled potential, viable territories with low habitat density scores and are the largest since it takes more area to meet the resource needs of northern spotted owls.

All potential, viable territories shown on maps are one likely outcome of 500 iterations and are theoretical. They do not reflect where northern spotted owl territories are or will be located, but rather a reflection of the quality and configuration of habitat at different time periods with a set of assumptions for evaluating support of reproducing northern spotted owls.

Map I-79. Modeled Potential, Viable Northern Spotted Owl Territories for Decade 6*, No Action Alternative



* Representative map of one iteration (out of 500) showing most frequently predicted number of potential, viable territories for this alternative at this time period. Dark green represents modeled potential, viable territories with high habitat density scores and the potential, viable territories are smaller in size since it takes less area to meet the resource needs of northern spotted owls. Medium green represents modeled potential, viable territories with medium habitat density scores and tend to be larger potential, viable territories. Light green represents modeled potential, viable territories with low habitat density scores and are the largest since it takes more area to meet the resource needs of northern spotted owls.

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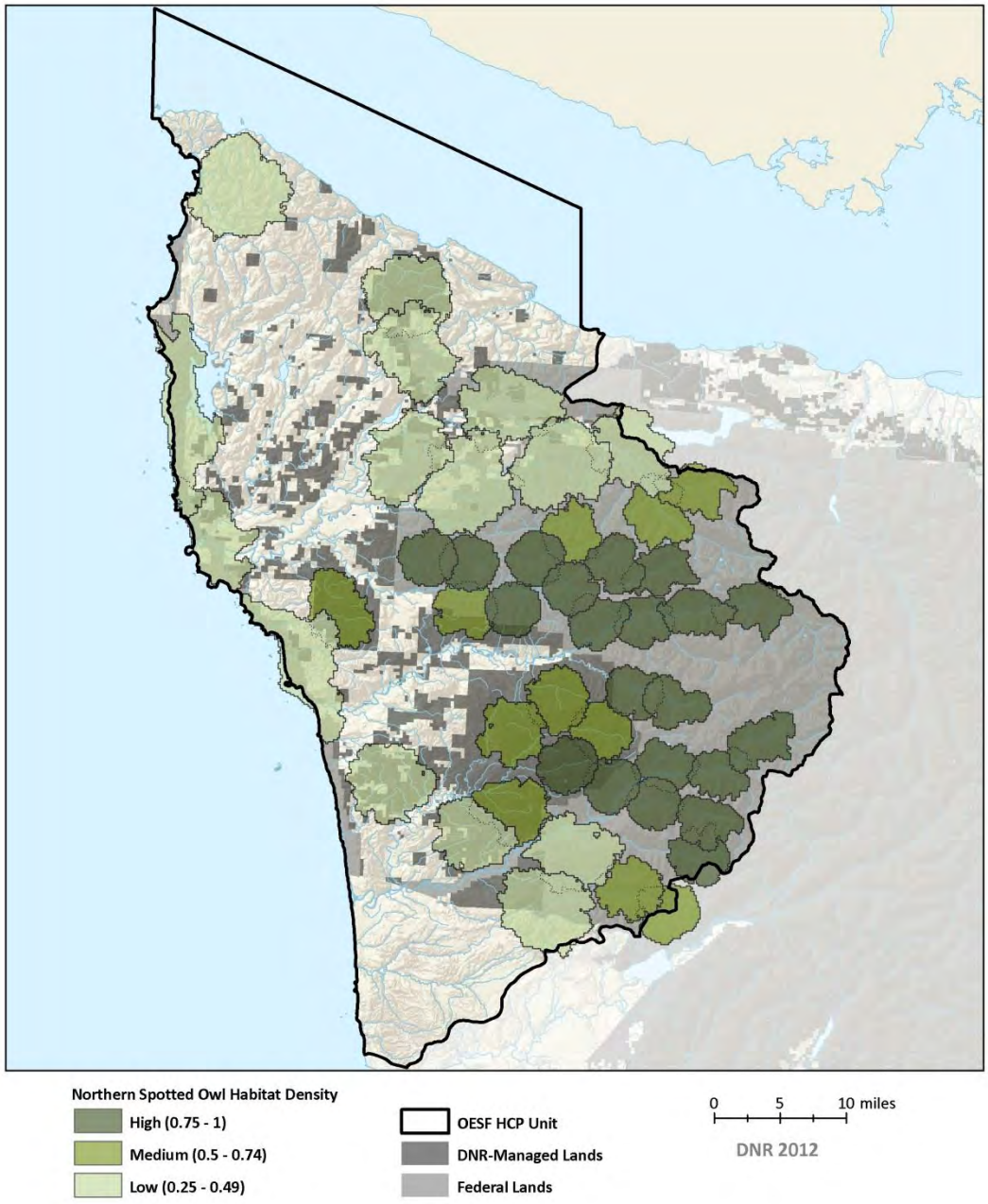
Map I-80. Modeled Potential, Viable Northern Spotted Owl Territories for Decade 9*, No Action Alternative



* Representative map of one iteration (out of 500) showing most frequently predicted number of potential, viable territories for this alternative at this time period. Dark green represents modeled potential, viable territories with high habitat density scores and the potential, viable territories are smaller in size since it takes less area to meet the resource needs of northern spotted owls. Medium green represents modeled potential, viable territories with medium habitat density scores and tend to be larger potential, viable territories. Light green represents modeled potential, viable territories with low habitat density scores and are the largest since it takes more area to meet the resource needs of northern spotted owls.

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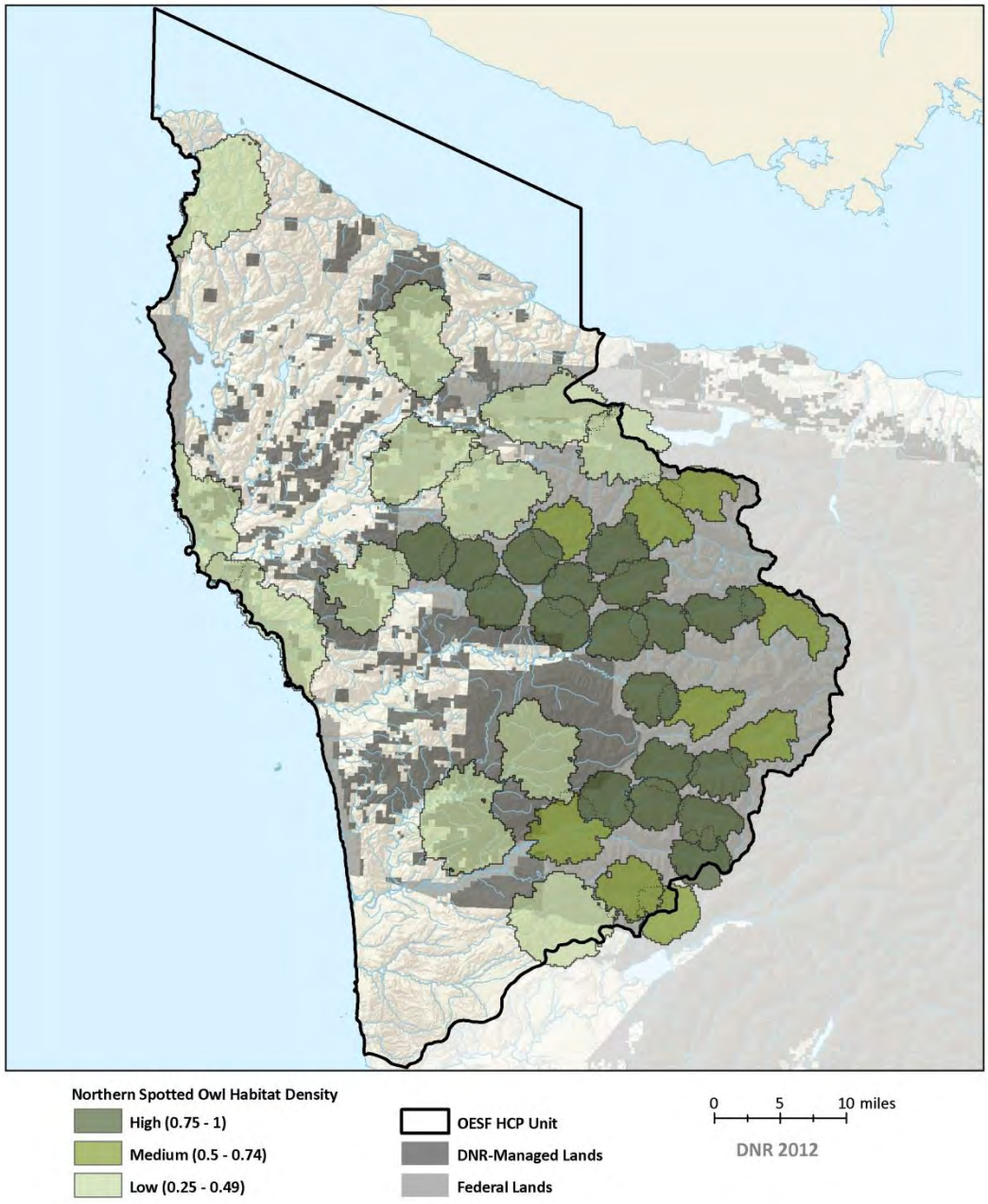
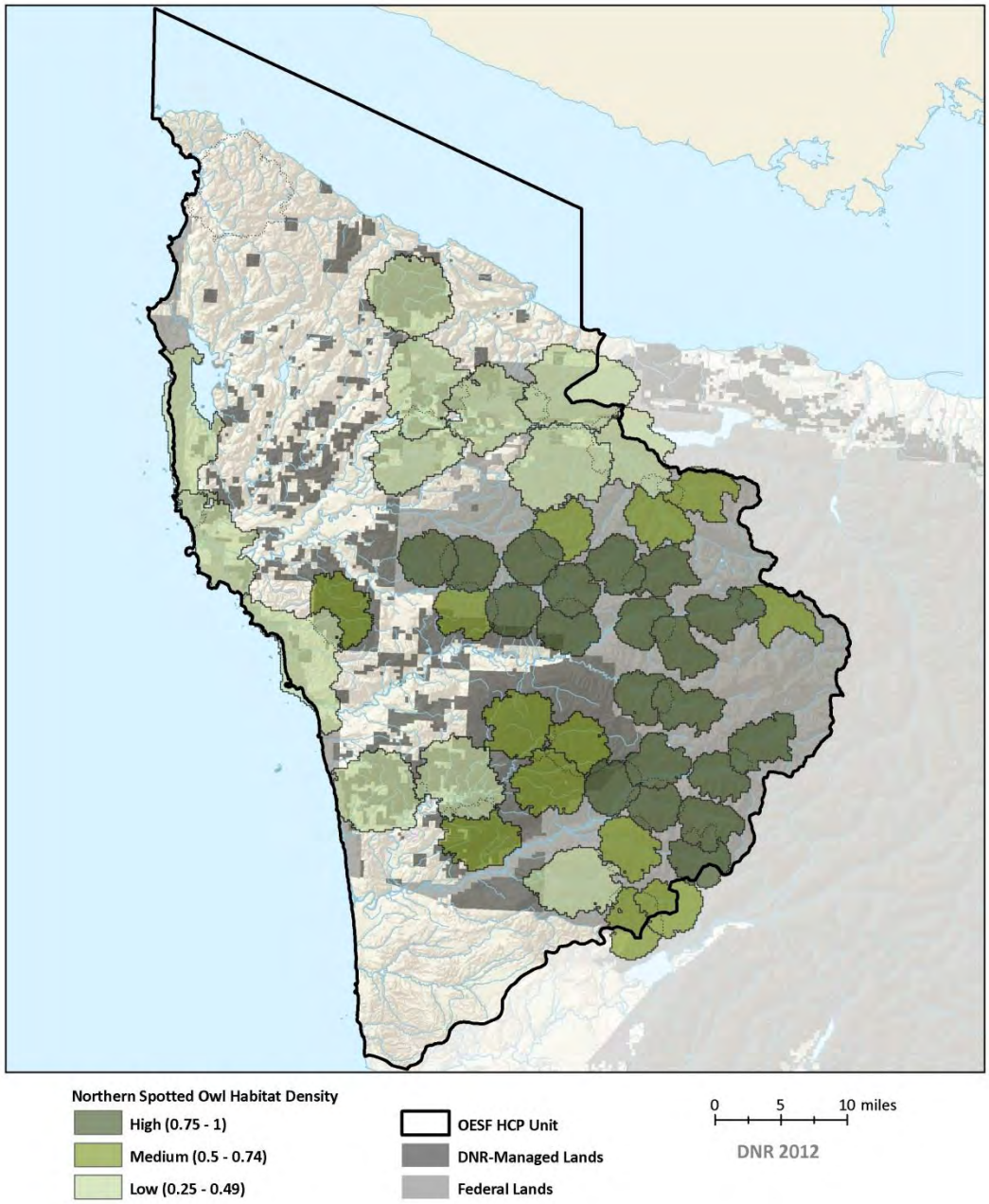
Map I-81. Modeled Potential, Viable Northern Spotted Owl Territories for Decade 1*, Landscape Alternative



* Representative map of one iteration (out of 500) showing most frequently predicted number of potential, viable territories for this alternative at this time period. Dark green represents modeled potential, viable territories with high habitat density scores and the potential, viable territories are smaller in size since it takes less area to meet the resource needs of northern spotted owls. Medium green represents modeled potential, viable territories with medium habitat density scores and tend to be larger potential, viable territories. Light green represents modeled potential, viable territories with low habitat density scores and are the largest since it takes more area to meet the resource needs of northern spotted owls.

All potential, viable territories shown on maps are one likely outcome of 500 iterations and are theoretical. They do not reflect where northern spotted owl territories are or will be located, but rather a reflection of the quality and configuration of habitat at different time periods with a set of assumptions for evaluating support of reproducing northern spotted owls.

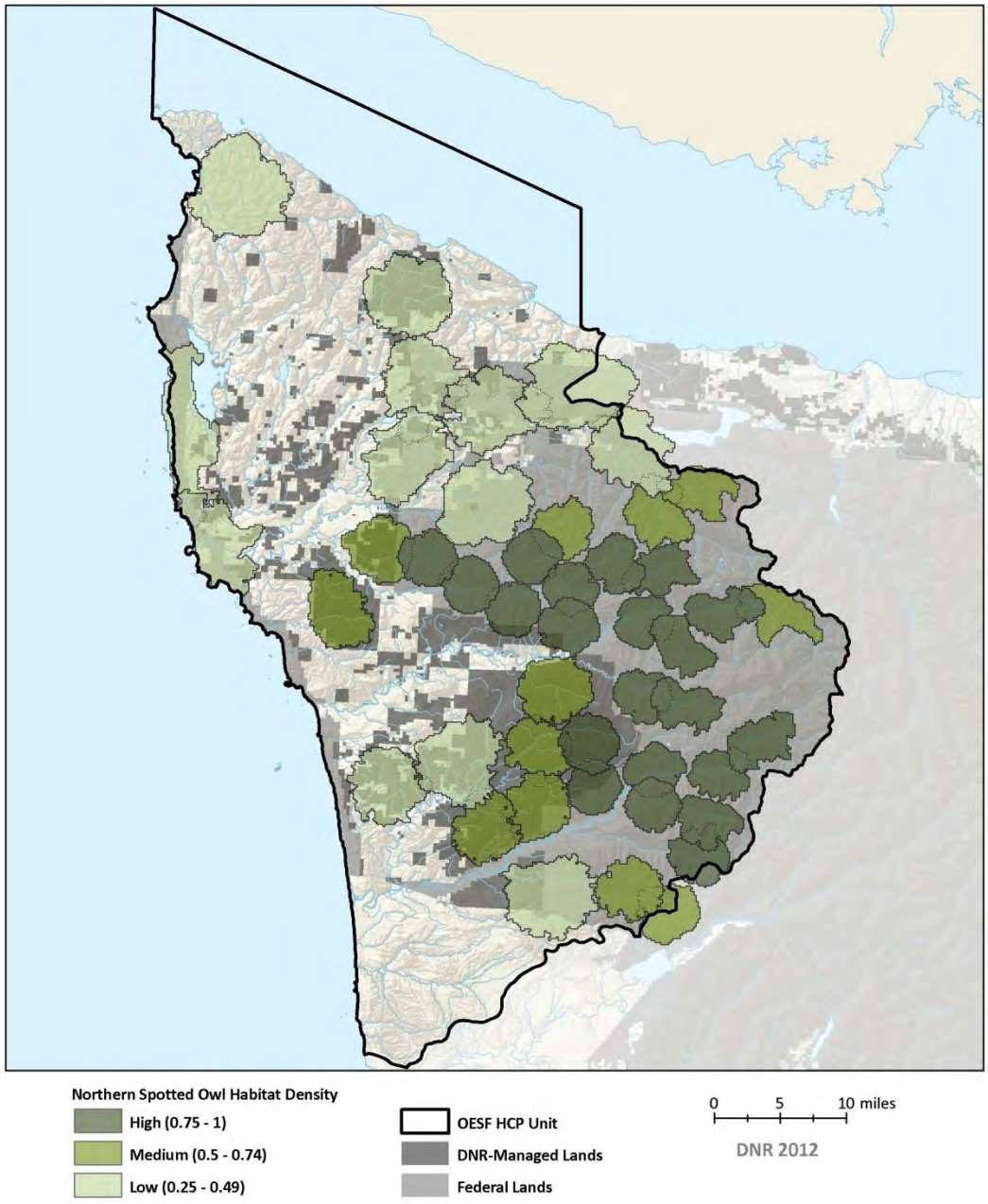
Map I-82. Modeled Potential, Viable Northern Spotted Owl Territories for Decade 6*, Landscape Alternative



* Representative map of one iteration (out of 500) showing most frequently predicted number of potential, viable territories for this alternative at this time period. Dark green represents modeled potential, viable territories with high habitat density scores and the potential, viable territories are smaller in size since it takes less area to meet the resource needs of northern spotted owls. Medium green represents modeled potential, viable territories with medium habitat density scores and tend to be larger potential, viable territories. Light green represents modeled potential, viable territories with low habitat density scores and are the largest since it takes more area to meet the resource needs of northern spotted owls.

All potential, viable territories shown on maps are one likely outcome of 500 iterations and are theoretical. They do not reflect where northern spotted owl territories are or will be located, but rather a reflection of the quality and configuration of habitat at different time periods with a set of assumptions for evaluating support of reproducing northern spotted owls.

Map I-83. Modeled Potential, Viable Northern Spotted Owl Territories for Decade 9*, Landscape Alternative



* Representative map of one iteration (out of 500) showing most frequently predicted number of potential, viable territories for this alternative at this time period. Dark green represents modeled potential, viable territories with high habitat density scores and the potential, viable territories are smaller in size since it takes less area to meet the resource needs of northern spotted owls. Medium green represents modeled potential, viable territories with medium habitat density scores and tend to be larger potential, viable territories. Light green represents modeled potential, viable territories with low habitat density scores and are the largest since it takes more area to meet the resource needs of northern spotted owls.

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References

Anthony, R. G., et al. 2006. Status and trends in demography of Northern Spotted Owls, 1985–2003. Wildlife Monographs 163**:**1–48.

Beak Consultants Inc. 1993. Habitat Conservation Plan for the Northern Spotted Owl on Timberlands owned by the Murray Pacific Corporation. Murray Pacific Corporation. Tacoma, WA.

Carey, A. B. 1995. Sciurids in Pacific Northwest Managed and Old-growth Forests. Ecological Applications 5:648- 661.

Carey, A.B. and M.L. Johnson. 1995. Small Mammals in Managed, Naturally Young, and Old-growth Forests. Ecological Applications 5:336–352.

Courtney, S.P., J.A. Blakesley, R.E. Bigley, M.L. Cody, J.P. Dumbacher, R.C. Fleischer, A.B. Franklin, J.F. Franklin, R.J. Gutiérrez, J.M. Marzluff, and L. Sztukowski. 2004. Scientific Evaluation of the Status of the Northern Spotted Owl. Sustainable Ecosystems Institute, Portland, Oregon.

Crookston, N. L.; Stage, A. R. 1999. Percent Canopy Cover and Stand Structure Statistics from the Forest Vegetation Simulator. Gen. Tech. Rep. RMRS-GTR-24. Ogden, UT: U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 11 p.

Forsman, E.D., R.G. Anthony, J.A. Reid, P.J. Loschl, S.G. Sovern, M. Taylor, B.L. Biswell, A. Ellingson, E.C. Meslow, G.S. Miller, K.A. Swindle, J.A. Thrailkill, F.F. Wagner, and D.E. Seaman. 2002. Natal and Breeding Dispersal of northern spotted owls. *Wildlife Monographs*. 149: 1-35.

Forsman E. D. and A.R. Giese. 1997. Nests of Northern Spotted Owls on the Olympic Peninsula, Washington. *The Wilson Bulletin*. 109(1): 28-41.

Gutiérrez, R.J., M. Cody, S. Courtney, and A.B. Franklin. 2006. The invasion of barred owls and its potential effect on the spotted owl: A conservation conundrum. *Biological Invasion*. 9(2): 181-196.

Hanson, E., D. Hays, L. Hicks, L. Young and J. Buchanan. 1993. Spotted Owl Habitat in Washington: A Report to the Washington Forest Practices Board. Washington Forest Practices Board, Olympia, Washington.

Hershey, K.T., E.C. Meslow, F.L. Ramsey.1998. Characteristics of forests at spotted owl nest sites in the Pacific Northwest. *Journal of Wildlife Management*. 62(4): 1398-1410.

Herter, D.R., L.L. Hicks, H.C. Stabins, J.J. Millspaugh, A.J. Stabins, and L.D. Melampy.2002. Roost Site Characteristics of Northern Spotted Owls in the Nonbreeding Season in Central Washington. Forest Science 48(2):437-446.

North, M.P., J.F. Franklin, A.B. Carey, E.D. Forsman, and T.E. Hamer. 1999. Forest stand structure of the northern spotted owl's foraging habitat. Forest Science45(4):520-527.

Ohmann, J. L., and M. J. Gregory. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest neighbor imputation in coastal Oregon, USA. Canadian Journal of Forest Research 32:725–741.

Olson G.S., E. Glenn, R.G. Anthony, E.D. Forsman, J.A. Reid, P.J. Loschl, and W.J. Ripple. 2004. Modeling demographic performance of northern spotted owls relative to forest habitat in Oregon. *Journal of Wildlife Management*. 68: 1039–1053.

Pierce, D.J., J.B. Buchanan, B.L. Cosentino, and S. Snyder. 2005. An Assessment of Spotted Owl Habitat on Non-federal Lands in Washington between 1996 and 2004.Washington Department of Fish and Wildlife, Olympia, Washington.

Reynolds, K.M. 1999. EMDS Users Guide (Version 2.0): Knowledge-based Decision Support for Ecological Assessment. USDA Forest Service General Technical Report PNW-GTR-470. Pacific Northwest Research Station, Portland, Oregon.

Spies, T.A., Franklin, J.F. 1991. The structure of natural young, mature, and old-growth Douglas-fir forests. In: Ruggiero, L.F., Aubry, K.B., Carey, A.B., Huff, M.H. (Eds.), Wildlife and Vegetation of Unmanaged Douglas-fir Forests. USDA Forest Service General Technical Report PNW-GTR-285, pp. 91–110.

Sutherland, G.D., D.T. O'Brien, S.A. Fall, F.L. Waterhouse, A.S. Harestad, and J.B. Buchanan (editors). 2007. A framework to support landscape analyses of habitat supply and effects on populations of forest-dwelling species: a case study based on the Northern Spotted Owl. British Columbia Ministry of Forest and Range, Victoria, British Columbia Technical Report. Number 038.

Thomas, J.W., E.D. Forsman, J.B. Lint, E.C. Winslow, B.B. Noon, and J. Verner. 1990. A Conservation Strategy for the Northern Spotted Owl: Report of the Interagency Scientific Committee to Address the Conservation of the Northern Spotted Owl. USDA Forest Service, USDI Bureau of Land Management, USDI Fish and Wildlife Service, and USDI National Park Service, Portland, Oregon.

Washington State Department of Natural Resources. 1997. Final Habitat Conservation Plan. Washington State Department of Natural Resources, Olympia, Washington.