# Oregon Conservation Strategy Technical Supporting Document: Methodology for Updating the Strategy Habitat Map

Originally produced by: Institute for Natural Resources, Oregon Biodiversity Information Center (referred to as ORBIC throughout this document), 2015

Edited: Oregon Department of Fish and Wildlife, Oregon Conservation Strategy Revision team (ODFW)

Last edited: June 28, 2016

# Background

## Establishing Strategy Habitats in 2006

In the original Oregon Conservation Strategy (released in 2006), Strategy Habitats were initially determined in a three-step process. First, best available current (2005) vegetation maps were compared to historic vegetation maps from 1850 to indicate vegetation types experiencing high degrees of loss since European settlement in Oregon. Second, similar vegetation types were grouped into "habitats", which were then evaluated for conservation value and historic importance at the ecoregional scale; emphasizing the amount of remaining habitat being managed for conservation values, known limiting factors and potential issues impacting habitats, ecological similarity of habitats, and the importance of each habitat to Strategy Species. Finally, the habitats determined to be of the most conservation concern throughout the state were defined as Strategy Habitats, designated by Ecoregion.

**Table 1. 2006 Strategy Habitats and their designated Ecoregions.**

| Habitat | Ecoregion | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BM | CP | CR | EC | KM | NBR | WC | WV |
| Aspen Woodlands | X | | | | | X | | |
| Coastal Dunes | | | X | | | | | |
| Estuaries | | | X | | | | | |
| Natural Lakes | X | X | X | X | X | X | X | X |
| Grasslands | | X | X | | X | | X | X |
| Late Successional Mixed Conifer Forests | | | X | | X | | X | |
| Oak Woodlands | | | X | X | X | | X | X |
| Ponderosa Pine Woodlands | X | | | X | X | | | |
| Riparian and Flowing Water Habitats | X | X | X | X | X | X | X | X |
| Sagebrush Habitats | X | X | | | | X | | |
| Wetlands | X | X | X | X | X | X | X | X |

## Mapping Strategy Habitats in 2006

*From the 2006 Oregon Conservation Strategy:* A vegetation map was created at a 30-meter pixel resolution using the NatureServe Ecological System Classification. Ecological systems are major habitat types defined by their ecological processes (e.g., fire, hydrology) and environmental components (e.g., soils, geology), which create a mosaic of characteristic plant communities and associated wildlife species (Comer et al. 2003). This classification identifies approximately 115 ecological systems in Oregon.

The vegetation map was put together using the most detailed local vegetation maps available, gathered from local land management agencies, including national forests (Deschutes, Fremont, Malheur, Mt. Hood, Ochoco, Siuslaw, Umatilla, Wallowa-Whitman, and Winema), BLM districts (Burns, Lakeview, Prineville, and Vale), national parks (Crater Lake, John Day Fossil Beds), SSURGO (USDA 1:24,000 soils mapping), and some regional mapping efforts including the Coastal Landscape Assessment and Modeling Study (CLAMS), the Interagency Vegetation Management Project (IVMP), new 2004 data from

the Sage Map USGS project and the R6 Potential Vegetation Modeling project. This information provided the initial vegetation information, and the habitat modeling further refined the analysis.

A map of the historic vegetation of Oregon was compiled using detailed coverage based on the General Land Office's surveyor's notes from the 1850's where they have been developed, primarily in the Willamette, Umpqua and Rogue Valleys, along the coast and in the Columbia Basin ecoregion, and from a regional coverage of forests, developed in the 1930's by H.J. Andrews and the U.S. Forest Service. The vegetation types in these historic maps and coverages were reclassified into the proper ecological system types.

ORBIC used the Davis Index to calculate scores for ecological system and wildlife habitat classifications. The Davis Index ranks habitats based on historic habitat losses based on the change from the historic and existing maps and amount of remaining habitat managed for conservation values. This approach is similar to the Oregon GAP project, which identified as priorities those habitat types that have lost significant acreage since European settlement and are underrepresented in the existing network of conservation lands in the state.

## Revising Strategy Habitats in 2015

The 10-year revision of the Strategy focused on incorporating updated information related to Strategy Habitats, with limited edits to the list of Strategy Habitats. Rather than undergo a new analysis into habitat changes, efforts were instead placed in defining and mapping Strategy Habitats into additional ecoregions, slight changes to Strategy Habitat definitions to more accurately reflect ODFW management practices, and incorporating new science into an updated Strategy Habitat map. New ecoregions were assigned to Strategy Habitats through an ODFW internal review and discussions with ODFW staff and the Strategy Stakeholder Advisory Committee.

For more information and details on Strategy Habitat descriptions, liming factors, and recommended approaches, refer to the Oregon Conservation Strategy, Strategy Habitats: http://oregonconservationstrategy.org/strategy-habitats/.

**Table 2. 2015 Strategy Habitats and their designated ecoregions.**

| Habitat | Ecoregion | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BM | CP | CR | EC | KM | NBR | WC | WV |
| Aspen Woodlands | X | | | X | | X | | |
| Coastal Dunes | | | X | | | | | |
| Estuaries | | | X | | | | | |
| Flowing Water and Riparian Habitats[1] | X | X | X | X | X | X | X | X |
| Grasslands | X | X | X | | X | | X | X |
| Late Successional Mixed Conifer Forests | X | | X | X | X | | X | |
| Natural Lakes[2] | X | X | X | X | X | X | X | X |
| Oak Woodlands | | | X | X | X | | X | X |
| Ponderosa Pine Woodlands | X | | | X | X | | | |
| Sagebrush Habitats | X | X | | X | | X | | |
| Wetlands[3] | X | X | X | X | X | X | X | X |

Additional Ecoregion designations in 2015 are indicated in red.

1) Previously referred to as Riparian Habitats only, this habitat now includes all flowing freshwater and riparian areas as a single Strategy Habitat.
2) Natural Lakes is essentially replacing the 2006 Strategy Habitat "Freshwater Aquatic Habitats", since flowing freshwater is now included as a Strategy Habitat alongside riparian habitats.
3) Includes all freshwater wetland types (except Natural Lakes): ponds, marshes, wet prairies, vernal pools, bogs, swamps, etc.

# Updating Oregon Conservation Strategy Habitat Map

## Overview

To support the 10-year Strategy update, the Institute for Natural Resources (INR) ORBIC at Portland State University used best available data and analyses to update the data and mapped extent and distribution of the Strategy Habitats. Information sources utilized within this effort include local, regional and statewide improved vegetation datasets, which are more current and accurate than those used within the initial 2006 Strategy Habitat maps, as well as more localized and site-specific surveys and analyses, when available. The objective was to comb existing data sources and use the most up-to-date and highest resolution maps available in Oregon.

Work was completed by INR's staff:

- Science staff: Jimmy Kagan [Vegetation], Sue Vrilakas [Botany], Eleanor Gaines [Zoology], John Bauer and John Christy [Wetlands], Eric Nielson and Bo Zhou [Remote Sensing/Vegetation]
- GIS staff: Jane Rombouts, Jesse Downing and Joe Bernert

This document includes detailed descriptions for all data input layers used, and methodology of producing all 2015 Strategy Habitat map layers, including a final compiled dataset. Unless otherwise described, the data input layers used were first converted into a 30m pixel raster GIS dataset, which were then compiled into the final Strategy Habitat map.

A large number of data sources were investigated (**Table 1**), with not all being used in the final product. The following datasets were investigated as potential data sources, with datasets that were not used marked as such:

- Oregon GAP and ReGap Vegetation / land cover databases, last updated in 2008, based on 2006 imagery. http://www.pdx.edu/pnwlamp/oregon-gap-analysis-program
- Gradient Nearest Neighbor (GNN) Vegetation Composition and Structure data, last updated in 2014, based on 2012 imagery. http://lemma.forestry.oregonstate.edu/
- *Landfire Vegetation and Cover data, last updated in December 2014, too late to use for this project. Previously updated in May of 2013, based on 2008-2010 imagery. (not used) http://www.landfire.gov/NationalProductDescriptions21.php*
- Land Cover from 2011 National Land Cover, NOAA Coastal Change Analysis Program, updated in 2013 from 2011 imagery. http://www.mrlc.gov/ and http://coast.noaa.gov/digitalcoast/data/ccapregional
- National Hydrographic Data, constantly being updated, with the most recent update for Oregon published on 3/2015. Dataset used was from the Oregon Framework dataset dated 2012. http://nhd.usgs.gov/data.html
- Various Wetland Databases, most recently updated in 2013. http://oregonexplorer.info/wetlands/DataCollections/GeospatialData_Wetlands
    - Oregon Wetlands Geodatabase http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7BE89EEF3F-ABD7-479E-BD10-A2036B15C64C%7D

- Site specific vegetation mapping from several sources including:
    - *NWHI Oak and Pine Mapping. (http://www.nwhi.org/index/gisdata) (not used)*
    - NPS (parks and monuments), John Day Fossil Bed National Monument Maps from 2010, and the Lewis and Clark National Historic Park Maps from 2012.
    - Historic Vegetation (1938), last updated in 2014. http://www.pdx.edu/pnwlamp/glo-historical-vegetation-maps-for-oregon-0
    - ODFW Land Cover Willamette Valley, last updated in 1998.
    - *Various Potential Natural Vegetation compiled in Integrated Landscape Assessment Program (not used)*
    - *Oregon Land Management and Stewardship (Protected Areas Dataset for the United StatesS), last updated in 2013 (not used)*
- Forest Service Vegetation Data Covers. http://www.fs.fed.us/r6/data-library/gis/ (Example: The Oregon Dunes National Recreation Area map developed from field surveys and air photography in 1993.)
- Site specific field studies (i.e. vegetation plots) and modeled GIS coverages from INR including plot data for Oaks, Pines [i.e. Lost Forest stands], Sagebrush, etc. Modeled coverage for Oaks (Umpqua, Willamette Valley), Sagebrush and tree cover (SE Oregon including Aspen, Riparian and Juniper/other stands and Big and Dwarf Sage), and other habitats.
    - ORBIC Element Occurrence data: provides specific locations for documented sensitive species occurrences
- Ancillary data:
    - Elevation (Digital Elevation Models and LiDAR [including tree heights])
    - Strategy ecoregions
    - Bounding datasets used primarily for buffering: boundary lines, coastlines, hydrography, etc.
- Master Strategy Habitat Raster Grid – All individual Strategy Habitat layers, as well as the final composite, were reprojected, snapped, and classified into a single raster grid format. Based on the Oregon ReGap grid, this includes 30m pixels and the Oregon State Lambert Projection.

The Strategy Habitat data used in the Strategy is provided as interactive data layers within ODFW Compass, and available for download via ODFW's Data Clearinghouse as a composite map portraying the updated extent and distribution of all eleven Strategy Habitats (as defined by their designated Ecoregions). This document describes the detailed methodology for mapping each individual Strategy Habitat, and then the steps taken to produce the final, compiled Strategy Habitat map.

**Table 3. Datasets evaluated and used during production of the 2015 Strategy Habitat map. Datasets used are marked as "Yes"; Datasets evaluated but not used are marked as "Reviewed."**

| Data Layers | Aspen Woodlands | Coastal Dunes | Estuaries | Flowing Water and Riparian | Grasslands | Late Successional Mixed Conifer Forests | Natural Lakes | Oak Woodlands | Ponderosa Pine Woodlands | Sagebrush Habitats | Wetlands |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **General Land Cover/Vegetation Datasets** | | | | | | | | | | | |
| Hydrogrpahy - NHD | | | Yes | Yes | | | Yes | | | | Yes |
| Hydrogrpahy - NHD Plus | | | Yes | Yes | | | Yes | | | | Yes |
| Wetlands | | | Yes | Yes | | | Yes | | | | Yes |
| Updates to the TWC Oregon Wetlands Geodatabase | | | Yes | Yes | | | Yes | | | | Yes |
| ReGAP | Yes | Yes | | Yes | Yes | Yes | | Yes | Yes | Yes | Reviewed |
| INR Sagebrush - All Sage Cover | | | | | | | | | | Yes | |
| LandFire Refresh Maps | | | | | | | | | Reviewed | | |
| National Land Cover Data | | | | | | Yes | | | Reviewed | | |
| Coastal Change Program | | Yes | | | | | | | | | |
| **GNN - Dominant Species** | | | | | | | | | | | |
| GNN - PIPO Atttributes (Basal Area): Xwalk | | | | | | | | | Yes | | |
| GNN /GAP Westside Xwalk (Old Growth Classes) | | | | | | Yes | | | | | |
| GNN - Oaks (Dominant and Size/Cover, except in WV) | | | | | | | | Yes | | | |
| GNN - Aspens (Dominant and Size/Cover) | Reviewed | | | | | | | | | | |
| **Masks** | | | | | | | | | | | |
| Species Distribution Mask (endemic areas) | Yes | | | | Yes | | | Yes | Yes | | |
| Species Distribution Mask Eastside Forests | | | | | | Yes | | | | | |
| Elevation Mask - Alpine (Over 8000 feet) | | | | | | Yes | | | | | |
| Elevation Mask - Alpine (Over 450 feet) | | | | | | Yes | | | | | |

| Data Layers | Aspen Woodlands | Coastal Dunes | Estuaries | Flowing Water and Riparian | Grasslands | Late Successional Mixed Conifer Forests | Natural Lakes | Oak Woodlands | Ponderosa Pine Woodlands | Sagebrush Habitats | Wetlands |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Historic/Potential Covers** | | | | | | | | | | | |
| Historic Vegetation (1938) | | | | | Yes | Reviewed | | Reviewed | Reviewed | Reviewed | |
| Statewide ILAP Existing Vegetation Maps | | | | | | | | | | | |
| Statewide ILAP Potential Vegetation Maps | Reviewed | | | | | Reviewed | | Reviewed | Reviewed | | |
| **Site Specic Themes / Local Data** | | | | | | | | | | | |
| USFS National Forest Maps - Apens (other stands) | Reviewed | | | | | | | | | | |
| INR Willamette Valley Lidar Riparian Vegetation Map | | | | Yes | | | | | | | |
| INR Willamette Valley Lidar tree height distributions | | | | | | | | Yes | | | |
| NHI Oak Maps (Willamette and Mt Hood) | | | | | | | | Reviewed | | | |
| ODFW Willamette Valley Land Cover | | | | | | | | Yes | | | |
| INR Intertwine 5-m Pixel Map | | | | | | | | Yes | | | |
| Lidar SE Oregon Vegetation Height | Yes | | | | | | | | | Yes | |
| INR Coastal Dune Maps | | Yes | | | | | | | | | |
| INR/TNC Sage grouse Habitat Maps | | | | | | | | | | Yes | |
| INR 10m and 30m Tree Distribution Maps | Yes | | | | | | | | | Yes | |
| DLCD Estuaries Map | | Yes | | | | | | | | | |
| Lost Forest Ponderosa Pine | | | | | | | | | Yes | | |
| INR sagebrush 10-m pixel map | | | | | | | | | | Yes | |
| **Regional Quality Control Layers** | | | | | | | | | | | |
| Recent Imagery | Reviewed | Reviewed | Reviewed | Reviewed | Reviewed | Reviewed | Reviewed | Reviewed | Reviewed | Reviewed | Reviewed |

## Aspen Woodlands

Aspen (*Populus tremuloides*) dominated forests and woodlands are widely distributed but generally found in small stands occurring throughout eastern Oregon. However, in the Blue Mountains, East Cascades and the Northern Basin and Range, they are more widespread and particularly significant to many wildlife species.

The Aspen woodland Strategy Habitat map layer was compiled from two primary sources: the revised ReGAP data and INR modeled Aspen habitats in SE Oregon. In 2014, INR developed a high resolution map of tree and tall shrubs over 7 feet tall, in an effort to map the spread of Western Juniper throughout the range of the Greater Sage-grouse. The maps were developed at both the 10 meter pixel and 30 meter pixel scales across the Northern Basin and Range, and the southern portions of the Blue Mountains and the East Cascades. This map of tall trees and shrubs was converted into an Aspen Map using a Random Forest Model trained with additional Aspen plot data. Local Aspen and Vegetation (TEU or Terrestrial Ecological Unit) cover data from the Freemont-Winema, Malheur, Umatilla and Wallowa-Whitman National Forests showing aspen were also examined. Some of the USFS data was older and determined to not accurately represent the distribution of current stands. All of the US Forest Service data used is available at their Ecoshare website (http://ecoshare.info/).

### Methods

The layer is combination of the ReGAP Aspen data and the SE Oregon Aspen model with masks for the two areas.

### Review

The updated LEMMA Gradient Nearest Neighbor (GNN) data was also examined in detailed but was not used since very few samples plots were included in the base data for Aspens, resulting in a map that was not very accurate. It was mapped as a Quality Control layer for verification of the ReGAP and SE Oregon Aspen data to distinguish between the stands entirely dominated by aspen, versus stands which has other species present (i.e. lodgepole pine or Engelmann spruce that have a small aspen component). Using GIS procedures, several masks were created to exclud areas where sample plot data was limited in southeastern Oregon.

LandFire data was also reviewed in detail (with the aerial imagery) and was found to be not highly spatially coincident with field plot data. As such, this data was not included.

## Coastal Dunes

Coastal dunes are designated as a Strategy Habitat in the Coast Range Ecoregion, along the ocean where they occur. They include large areas of open sand, open grasslands, shrublands, shorepine woodlands, and forests, including some old-growth forests. The largest coastal dunes occur in the Oregon Dunes National Recreation Area in the central coast, including parts of Lane, Douglas, and Coos Counties, although dunes also occur in Clatsop County, with sand input from the Columbia River, and in Sand Lake in Tillamook County.

The data evaluated for the coastal dunes came from several sources include the NOAA Coastal Assessment Program, GAP and ReGAP, the US Forest Service and local INR mapping projects including the 2011 INR/NPS Lewis and Clark National Historical Park Vegetation Map from Clatsop County.

The largest and best coverage was a polygon vegetation map of the Oregon Dunes NRA, mapped by hand and site visits by the USFS in the 1990's. The vegetation classifications provided from the GAP, ReGAP, and INR datasets included open dunes, forests, shrublands and wetlands. The forest dominated and wetland vegetation types were excluded from this Strategy Habitat layer, as they can be found in other Strategy Habitats, leaving 6 distinct habitat types that were included within Coastal Dunes: Foredune, Grass, Hummocks, Open Sand, Shrubland, and Other.

### Methods

The Oregon Dunes NRA habitat map was evaluated using recent high resolution imagery to determine if it still represented "Coastal Dune" type habitats. Areas and habitat types that did not match up were removed, and remaining types were merged, reprojected from the US Forest Service Albers projection to the Oregon Lambert projection, and converted to a 30m pixel grid (snapped to the standard habitat grid).

A similar vegetation map was made by INR covering much of the dunes in northern Clatsop County, near the mouth of the Columbia, as part of a National Park Service vegetation mapping project in 2012 and 2013 (http://irmafiles.nps.gov/reference/holding/460841, with a more direct link to a slow download included here).

While these two coverages mapped the majority of the dunes in Oregon, there were a number of other small sites that were not included. Additional data that was considered included: the ReGAP map and the 2011 NLCD. A coastal dunes ecological system map from the Zone 2 ReGAP project was particularly useful. The barren areas in both the NLCD and the CCAP coverages were evaluated to account for remaining beaches and open dunes. The resulting dataset included some pixels of barren areas, that were not confirmed as coastal dunes when comparing with imagery. These false areas were limited by applying a 4 mile coastal buffer, which was the smallest buffer from the coastline that was found to not eliminate dune habitats.

### Review

The data was reviewed against aerial imagery and NLCD statewide covers.

## Estuaries

Estuaries represent the water, wetlands and aquatic habitats between the ocean and coastal streams and rivers. The Estuary Strategy Habitat is designated within the Coast Range Ecoregion, and is also discussed within the Oregon Nearshore Strategy.

In Oregon, Estuaries are managed by the Coastal Zone Management Program of the Department of Land Conservation and Development (DLCD), who describes them in this way:

> *"An estuary is defined as a semi-enclosed body of water, connected to the ocean, where salt water is measurably diluted with fresh water from the land. In reality, an estuary - or bay - is a whole lot more. It is a zone of transition between the marine-dominated systems of the ocean and the upland river systems, a zone which yields one of the most biologically productive areas on Earth.*
>
> *Oregon has 22 major estuaries, and many other minor estuaries, along its coast. Most of the larger estuaries have been altered through dredging, filling or diking. Many of the smaller ones have escaped the impacts of civilization and remain in a more natural state. All are important and are covered by Oregon's estuarine management program."*

The data for the estuaries came from a review of various GIS data layers: National Wetlands Inventory, Lower Columbia River Estuary Partnership (LCREP) GIS Layers, Coastal and Marine Ecological Classification Standard (CMECS) GIS data layers, and data included in the Oregon Wetlands Restoration Planning Tool. LCREP and CMECS were decided to have the most accurate classifications of Oregon estuary habit. Data from these sources are best found and viewed at the Oregon Coastal Atlas (http://www.coastalatlas.net/estuarymaps/), developed by DLCD.

The CEMCS Aquatic Database was used to delineate all Oregon estuaries, except the lower Columbia River. Using these data, estuaries were determined to be all tidally influenced lands. INR then added additional areas from the Oregon Wetlands Geodatabase that were classified as aquatic bed or brackish marsh.

Puget Island was used as the boundary for tidal influence on the lower Columbia River. This is consistent with the 2010 Strategic Habitat map, although freshwater tidal influence occurs much further upstream along the Columbia, well into the Willamette Valley Ecoregion. The remaining portion of the Columbia River is included as a Strategy Habitat within the Freshwater and Riparian Habitat. The estuarine areas along the lower Columbia were mapped using the land cover dataset from Lower Columbia River Estuary Partnership (LCREP), obtained from their GIS data download website at: http://www.estuarypartnership.org/resources/search/?f[0]=im_field_resource_type%3A14. Estuaries in this area were determined to be tidally influenced lands, along with lands classified as aquatic bed, mud, sand and water.

### Methods

Estuarine pixels were created by converting all areas mapped within the CEMCS data, and specific categories from the LCREP: Coniferous Wetland Forest-Tidal, Deciduous Wetland Forest-Tidal, Shrub-Scrub Wetland-Tidal, Herbaceous Wetland-Tidal, Aquatic Bed, Mud, Sand, and Water.

## Flowing Water and Riparian Habitats

The data for the Flowing Water and Strategy Habitat is combination of data sources for two components of this Strategy Habitat: the freshwater and aquatic habitats, and the adjacent stream-side vegetation, or riparian habitat.

### Methods

#### *Flowing Water*

The national and Oregon state standard for freshwater spatial datasets is the National Hydrologic Dataset (NHD, http://nhd.usgs.gov/data.html). The NHDPlus v1.0 was used for streams and the larger rivers were added from NHDPlus v2.1. Only perennial, natural waterways were included; and all man-made (canals, ditches, etc.) or intermittent waterways were not included.

The NHD covers Oregon in three regions (R16, R17, and R18). INR compiled data for these three regions and clipped the output to just beyond the Oregon border. Streams were selected from the NHD v1. Wider river segments are categorized in the NHD Area dataset and are represented as double line data (and/or polygon features), and as a result the NHDPlus v2.1 was used for these areas. For both datasets, only those streams and areas categorized with a Description of "Hydrographic Category-perennial" were used.

A portion of the Columbia from east of The Dalles to Hermiston was edited in by hand, and portions of the Willamette and Snake Rivers were only found in the NHD "Waterbody" data set. These areas were added to the NHD data previously described. All resulting line and polygon data were converted to the master habitat raster grid dataset separately and then combined into a single raster layer representing all flowing water.

#### *Riparian Habitats*

The Riparian Layer was developed with multiple datasets, with an emphasis made on using more accurate data where available. It was compiled with the following data: NWI (produced and maintained by USFWS) but obtained for this project from the Oregon Wetlands geodatabase, INR GAP 2008 data, INR Willamette Valley Vegetation Model, and the INR Northern Basin Tree Model. The last two data sets were created using Random Forest Models for the ODFW Strategy Habitat project, and are described in detail later in this document.

Because many riparian habitats are narrow and hard to detect at the 30 meter pixel scale, these were probably the most under-represented areas in the original 2006 Strategy Habitat map. For the 10-year update, the riparian ecological systems from the 2008 ReGAP map for Oregon were first merged with the streamside wetlands from the updated Oregon Wetlands Geodatabase into a statewide riparian habitat map. In the Willamette Valley, where available, these maps were augmented with LiDAR data and a 2010 riparian plot-based map (which was developed by INR for The Nature Conservancy and The American Bird Conservancy). The data from this model was incorporated for the Riparian layer, the following values:

| Code | Class Name | Height Range | Class Description |
|---|---|---|---|
| 15 | Broadleaved tree 1 | 30’ - 70’ | Broadleaved trees less than 70’ tall (e.g., ash); includes some conifers with brightly illuminated canopies |
| 16 | Broadleaved tree 2 | 70’ - 120’ | Broadleaved trees 70-120’ tall (e.g., red alder) |
| 17 | Broadleaved tree 3 | > 120’ | Broadleaved trees over 120’ tall (e.g., bigleaf maple, cottonwood) |

These three datasets (ReGap, Oregon Wetlands, and the Willamette Valley study) were individually converted into the master habitat raster grid format, and then compiled.

There was an effort to improve the riparian representation in SE Oregon using an approach called Nested Texture Model (NTM). This method starts with image textures derived from aerial photographs and spectral information from satellite images, combined with other supporting data (topography, climate, etc.). Historical vegetation data from different sources (e.g., H. J. Andrews, General Land Office (GLO), Soil Survey Geographic (SSURGO), BLM, Oregon Gap analysis), were used as guidelines to manually digitize hardwood training plots as input to the classification model. The resulting hardwood model was then separated into two classes: Aspen (dominate hardwood species in the study area) and Riparian, defined as a 45 meter buffer of the national hydrology dataset (NHD) ‘Flowline’ data (Environmental Law Institute, 2003).

The Northern Basin NTM aspen/riparian model was compared to the GAP 2008 riparian layer, using Landsat imagery to estimate the accuracy of both. It appeared the in some areas the NTM aspen/riparian model was better than GAP data, while in other places, GAP data captured riparian the NTM aspen/riparian model missed. Combining data from both GAP and the NTM aspen/riparian model produced the best riparian representation.

## Grasslands

Grasslands vary widely in Oregon, including Willamette Valley prairies, forb-rich coastal headlands, Palouse prairies in Umatilla Counties, canyon grasslands found throughout central and northeastern Oregon, and sandy grasslands with needle-and-thread and sometimes prickly-pear in Wasco and Morrow Counties. Historically, Grasslands were most important in the Willamette Valley, Columbia Plateau, and Blue Mountains ecoregions, where they occupied many thousands of acres. In all these areas, most grasslands have been lost, making the remaining habitats especially significant. Grasslands are Strategy Habitats in these three ecoregions, as well as the Coast Range, Klamath Mountains, and West Cascades, where they occupy small but diverse areas important to many plants and wildlife species.

Information available to map Grasslands is limited. Statewide datasets were available from the ReGAP data and statewide historical vegetation data. However, the ReGAP data did not represent the small, remnants grasslands in the Willamette Valley, where Grassland signatures collected by Remote Sensing can be especially similar to agricultural fields and pastures. Therefore, non-vegetation datasets were needed to create the updated Grasslands Strategy Habitat map for the Willamette Valley Ecoregion.

### Methods

With the exception of the Willamette Valley, the Grasslands Strategy Habitat map was primarily developed using ReGAP and historic vegetation. The method included developing a statewide historic vegetation grassland map, and then highlighting ReGAP grassland categories that were found within the historic grassland areas. In central Oregon ecoregions where Sagebrush Habitats are also designated as Strategy Habitats, Sagebrush data was used to remove grasslands that represented sagebrush habitats, currently without sagebrush.

The historic vegetation map was used to assure that temporary grasslands, such as those grasslands which resulted from a clearcut, mapped within the ReGAP existing vegetation coverage were not included in the final Grassland Strategy Habitat map. The historic primary grassland categories include:

- Alkaline grasslands and seasonal wetlands
- Basin wild rye
- Bluebunch wheatgrass
- Coastal headland
- Idaho fescue
- Needle-and-thread grass
- Needle grass
- Prickly pear grassland
- Roemer fescue
- Sandberg bluegrass
- Tufted hairgrass
- Alpine tundra-barren

The ReGap Grassland Ranking numbers are presented in the following table with the lower numbers representing ecological systems more distinctly composed of grasslands, and higher numbers reflecting

mixed grassland with wetlands, shrubs or other components. In general, the numbers 1-4 were used to attribute the Strategy Habitats, while those ranked as 5 were not.

**Table 4. Grassland habitat categories used from ReGap.**

| Grassland Rank | Habitat |
|---|---|
| 1 | California Serpentine Barren |
| 1 | Westside Lowland Prairie and Savanna |
| 1 | Grassland Steppe |
| 1 | California Serpentine Barren |
| 1 | Northern California Coastal Grassland |
| 1 | Eastside Foothill - Canyon Dry Grassland |
| 1 | Semi-Desert Grassland |
| 1 | Eastside Plateau and Mountain Valley Grassland |
| 1 | Palouse Prairie |
| 1 | Westside Grass Bald or Bluff |
| 2 | Recently Burned Grassland |
| 3 | Siskiyou Mountains Serpentine Savanna and Chaparral |
| 4 | Montane - Alpine Meadow |
| 4 | Montane - Alpine Meadow |
| 4 | Westside Montane Grassland |
| 4 | Eastside Subalpine Grassland |
| 4 | Montane - Alpine Meadow |
| 4 | Cascades  Alpine and Subalpine Dry Grassland |
| 4 | Rigid Sagebrush, Buckwheat or Bluegrass Scabland |
| 5 | Big Sagebrush - Bunchgrass Steppe |
| 5 | Harvested Forest - Grass Regeneration |

### *Willamette Valley Grasslands*

The initial review of mapped grassland coverage indicated that several known areas of important grassland habitat in the Willamette Valley were not included in the initial Strategy Habitat map.  For the Willamette Valley Ecoregion, grasslands were instead identified by integrating three additional data sources:

1) Element Occurrence areas mapped in the ORBIC database for Willamette Valley species whose habitat occurs in or around grasslands. This included rare grassland-endemic Willamette Valley at-risk species, as well as other grassland species with mapped occurrences. Sixty-seven species (Table 5) were used, with a total of 560 unique occurrences (or areas) in the valley. These Element Occurrence polygons were converted to the master Habitat raster format. From these areas, any locations that were also mapped in the 2011 National Landcover Dataset (NLCD) as pasture, developed or urban, developed agriculture, or forested areas were removed.

**Table 5. Grassland habitat species, whose Element Occurence areas were used to map grassland habitats in the Willamette Valley.**

| Scientific Name | Common Name |
|---|---|
| *Acetropis americana* | American grass bug |
| *Allium unifolium* | One-leaved onion |
| *Ammannia robusta* | An ammannia |
| *Ammodramus savannarum* | Grasshopper sparrow |
| *Branta hutchinsii leucopareia* | Aleutian Canada goose |
| *Bruchia flexuosa* | Moss |
| *Carex gynodynama* | Hairy sedge |
| *Carex retrorsa* | Retrorse sedge |
| *Castilleja levisecta* | Golden paintbrush |
| *Cicendia quadrangularis* | Timwort |
| *Contia tenuis* | Sharptail snake |
| *Delphinium leucophaeum* | White rock larkspur |
| *Delphinium oreganum* | Willamette Valley larkspur |
| *Delphinium pavonaceum* | Peacock larkspur |
| *Driloleirus macelfreshi* | Oregon giant earthworm |
| *Elanus leucurus* | White-tailed kite |
| *Elodea nuttallii* | Nuttall's waterweed |
| *Enemion stipitatum* | Dwarf isopyrum |
| *Ephemerum crassinervium* | Moss |
| *Eremophila alpestris strigata* | Streaked horned lark |
| *Erigeron decumbens* | Willamette Valley daisy |
| *Eucephalus vialis* | Wayside aster |
| *Euphydryas editha taylori* | Taylor's checkerspot (butterfly) |
| *Falco peregrinus anatum* | American peregrine falcon |
| *Fluminicola virens* | Olympia pebblesnail |
| *Gomphus kurilis* | California clubtail dragonfly |
| *Hemphillia glandulosa* | Warty jumping-slug |
| *Horkelia congesta* ssp. *congesta* | Shaggy horkelia |
| *Hypotrachyna revoluta* | Lichen |
| *Lathyrus holochlorus* | Thin-leaved peavine |
| *Leptogium teretiusculum* | Lichen |
| *Lomatium bradshawii* | Bradshaw's lomatium |
| *Lupinus oreganus* | Kincaid's lupine |

| Scientific Name | Common Name |
|---|---|
| *Melanerpes lewis* | Lewis's woodpecker |
| *Mimulus tricolor* | Three-colored monkeyflower |
| *Montia howellii* | Howell's montia |
| *Myotis thysanodes* | Fringed myotis |
| *Navarretia willamettensis* | Willamette navarretia |
| *Odocoileus virginianus leucurus* | Columbian white-tailed deer |
| *Orobanche californica* ssp. *californica* | California broom-rape |
| *Physcomitrella patens* | Moss |
| *Physella hordacea* | Grain physa (snail) |
| *Plebejus icarioides fenderi* | Fender's blue (butterfly) |
| *Pooecetes gramineus affinis* | Oregon vesper sparrow |
| *Preissia quadrata* | Liverwort |
| *Progne subis* | Purple martin |
| *Prophysaon vanattae* pop. 1 | Spotted tail-dropper |
| *Pseudephemerum nitidum* | Moss |
| *Pyrrocoma racemosa var. racemosa* | Racemose pyrrocoma |
| *Rhyacotriton variegatus* | Southern torrent salamander |
| *Rorippa columbiae* | Columbia cress |
| *Rotala ramosior* | Toothcup |
| *Scirpus pendulus* | Drooping bulrush |
| *Sclerophora peronella* | Lichen |
| *Sericocarpus rigidus* | White-topped aster |
| *Sidalcea campestris* | Meadow checker-mallow |
| *Sidalcea hirtipes* | Bristly-stemmed sidalcea |
| *Sidalcea nelsoniana* | Nelson's sidalcea |
| *Sisyrinchium hitchcockii* | Hitchcock's blue-eyed grass |
| *Speyeria zerene bremnerii* | Valley silverspot (butterfly) |
| *Sullivantia oregana* | Oregon sullivantia |
| *Taraxia ovata* | Golden eggs |
| *Tuber quercicola* | Fungus |
| *Vespericola* sp. 2 | Bald hesperian (snail) |
| *Viola praemorsa* ssp. *praemorsa* | Upland yellow violet |
| *Wolffia borealis* | Dotted water-meal |
| *Wolffia columbiana* | Columbia water-meal |

2) Known grasslands that are protected and managed areas within the Willamette Valley were digitized, including government owned lands such as Wildlife Refuges and Wildlife Areas, grassland protected areas identified in the 2010 Oregon Heritage Plan

(http://www.oregon.gov/oprd/HCD/SHPO/docs/shpo_preservation_plan-2005.pdf), and selected sites owned by the Oregon Department of Transportation that are identified by Heritage Seedlings as areas for native grass seed collections. These areas were compiled into a single GIS layer, converted to raster, and then all pixels identified as herbaceous or pasture/meadow landcover types in the 2011 NLCD were maintained.

3) Raster coverages developed by INR in 2013 representing areas modeled as potential habitat for three species of federally listed, endemic plant species which occur primarily in grasslands in the Willamette Valley. These speces included *Lomatium bradshawii* (Bradshaw's desert parsley), *Lupinus oreganus* (Kinkaid's lupine), and *Erigeron decumbens* (Willamette daisy). The models were inductive species models, developed at 10 meter pixel scales for the entire range of the species in Oregon, using all available data, including NAIP, Landsat imagery, soils, elevation, topography, climate and other data. The models are continuous probability grids, and only the pixels with high probability of the species occurring were used to inform the location of Willamette Valley grasslands. As was the case with the other two datasets, the 2011 NLCD was used to remove forested, developed, and other pixels.

The results of these three datasets were combined to develop the Willamette Valley Grasslands Strategy Habitat map, which was then clipped to the Willamette Valley Ecoregion, and compiled with the grassland maps from other ecoregions to form a single, statewide map.

### Review

A detailed review of additional vegetation datasets included the ILAP Arid land covers, the Potential Natural Vegetation covers for eastern Oregon, LandFire and others. The land ownership and management data from PADUS was also reviewed, focusing on areas managed specifically for grasslands in Oregon (i.e. Zumwalt Prairie). However, these reviews did not lead to any significant changes in grassland coverage.

## Late Successional Mixed Conifer Forest

The Late Successional Mixed Conifer Forest Strategy Habitat represents the older forests found throughout the state. Only the OSU – PNW Research Station, Landscape Ecology, Modeling, Mapping & Analysis (LEMMA, http://lemma.forestry.oregonstate.edu) data was used, as it represents the best available and most current data in Oregon. The LEMMA data included information developed using a Gradient Nearest Neighbor (GNN) imputation methodology (http://lemma.forestry.oregonstate.edu/data), with the most recent information created for the range of the Northern Spotted Owl.

The data was evaluated and adjusted to be consistent across the state. Specifically, in western Oregon, the GNN data is used to represent old growth forest, while in eastern Oregon the GNN data is used based on the age dominance and stand type. The Old Growth Structure Index (OGSI) is defined for 200 year old tree stands, developed by LEMMA, and identified a few old growth areas that were assigned to other Strategy Habitats. For example, the GNN data OGSI identified over 200,000 acres of Ponderosa Pine which was included in the Ponderosa Pine Strategy Habitat cover, and over 50,000 acres of Canyon Live Oak which was included in the Oak Woodland Strategy Habitat coverage).

### Methods

The old growth areas were primarily determined from the GNN data, but ReGap data was also used for evaluating community associations and GNN stand ages and to build cross walks. Masks were used to distinguish the Blue Mountains and southern Oregon mountain areas and to distinguish the eastside and west-side communities.

The primary parameters used from the GNN were the OGSI and age of the dominant stand. Since the majority of the data falls within the range of the Northwest Forest Plan (NWFP), similar parameters recently used in the 20-year report for NWFP Effectiveness Monitoring (Ray Davis et al., in review) could be used in this analysis. This analysis takes into account differences among ecoregions, like lower productivity and smaller trees east of the Cascade crest. There are two age thresholds available for OGSI: an 80-year threshold, and a 200-year OGSI threshold. In discussions with ODFW staff specializing in forest ecology, it was determined that the optimal threshold to use would be 200 years, as this age range would provide the highest possibility of providing the optimal structure and characteristics for Late Successional Mixed Conifer Forests.

**Table 6. The primary categories in re-GAP used in Western Oregon cross walk.**

| Percent of Veg | Percent of old | Total Statewide Acres | Acres Old Growth | Oregon Community Name | Habitat Name | Sort Field | OldMap |
|---|---|---|---|---|---|---|---|
| 23% | 20% | 2,596,998 | 598,007 | Dry-site Douglas-fir - Western Hemlock | Western Oregon Douglas-fir Hemlock Forests | 1 | 1 |
| 27% | 18% | 2,017,313 | 543,002 | Moist-site Western Hemlock - Douglas-fir | Western Oregon Douglas-fir Hemlock Forests | 1 | 1 |
| 10% | 2% | 580,908 | 60,559 | Westside Douglas-fir or Madrone | Western Oregon Douglas-fir Hemlock Forests | 1 | 1 |
| 23% | 11% | 1,504,472 | 339,605 | White Fir Mixed Conifer | Siskiyou Mixed Conifer Forests and Woodlands | 2 | 1 |
| 18% | 6% | 990,700 | 180,116 | Southwestern Oregon Incense Cedar - Douglas-Fir Mixed Conifer | Siskiyou Mixed Conifer Forests and Woodlands | 2 | 1 |
| 6% | 0% | 91,361 | 5,708 | Lower Montane Serpentine Conifer | Siskiyou Mixed Conifer Forests and Woodlands | 2 | 1 |
| 17% | 6% | 1,065,904 | 183,426 | Mixed Evergreen Hardwood - Conifer Forest | Mixed Hardwood-Conifer Forests | 3 | 1 |
| 11% | 4% | 1,189,078 | 130,169 | Big Leaf Maple - Douglas-fir | Mixed Hardwood-Conifer Forests | 3 | 1 |
| 42% | 7% | 519,878 | 217,766 | Pacific Silver Fir | Silver Fir - Mountain Hemlock Montane Forests | 4 | 1 |
| 31% | 5% | 501,126 | 157,869 | Mountain Hemlock | Silver Fir - Mountain Hemlock Montane Forests | 4 | 1 |
| 31% | 2% | 181,115 | 55,423 | Red Fir | Silver Fir - Mountain Hemlock Montane Forests | 4 | 1 |
| 45% | 1% | 40,462 | 18,205 | Moist-site Western Hemlock - Silver Fir | Silver Fir - Mountain Hemlock Montane Forests | 4 | 1 |
| 2% | 0% | 274,054 | 6,550 | Dry-site Montane - Subalpine Spruce - Fir | Subalpine Forests and Woodlands | 5 | 1 |
| 7% | 1% | 318,278 | 22,791 | Sitka Spruce | Coastal Spruce, Port Orford Cedar or Redwood Forests | 7 | 1 |
| 24% | 0% | 59,413 | 14,483 | Coast Redwood or Port Orford Cedar | Coastal Spruce, Port Orford Cedar or Redwood Forests | 7 | 1 |
| 15% | 1% | 235,755 | 35,617 | East Cascades Mixed Conifer | Mixed Conifer Forests | 9 | 1 |
| 3% | 0% | 252,303 | 8,818 | Recently Burned Forest | Burn | 16 | 1 |

The remaining association had very small percentages of old growth and smaller uncommon associations. A data review of the spatial correspondence of the GAP and GNN data indicated the following categories needed to be excluded (all representing between 1,000 up to 110,000 acres [the larger areas were in harvested forest / Regeneration). These were excluded from old growth:

- Ponderosa Pine (included in its own conservation strategy)
- Mixed California Black Oak – Conifer (used in Oak Coverage)
- Red Alder or Bigleaf Maple (riparian vegetation category)
- Oregon White Oak - Ponderosa Pine (used in Oak Coverage)
- California Subalpine Woodland
- Subalpine Woodland and Parkland
- Westside Lowland Riparian (largely included in the riparian habitat coverage)
- California Lowland Riparian (largely included in the riparian habitat coverage)
- Lodgepole Pine on Pumice, Ash or Barren Soil
- Lodgepole Pine on Normal Soil
- Westside Montane Riparian (largely included in the riparian habitat coverage)
- Westside Forested Swamp or Wetland (largely included in the wetlands coverage)
- Oregon White Oak (represented in the Oak habitat coverage)
- Western Juniper
- Harvested Forest - Tree Regeneration
- California Montane Woodland and Chaparral
- Wooded Lava Flow
- Developed, Open Space (Roads, Parks, Golf Courses, Open Space)
- Water

Since the OGSI parameter is less accurate in defining old growth in the eastern Oregon ecoregions, the GNN dominant stand age and dominant species was primarily used to define old growth (i.e. over 200 years). East of the Cascade crest, the age of the dominant tree, in conjunction with the basal area, the estimate of stand age and canopy cover were examined and a crosswalk was compiled for mapping old growth. Specific species associations were excluded from east side old growth: Juniper, Remnant stands, and Ponderosa Pine (to be in the Ponderosa Pine Woodlands Strategy Habitat). About 300,000 acres of old growth were identified initially in Eastern Oregon, although one third of the area was excluded because it is covered in juniper, while another third exists in remnant stands. The primary eastern Oregon old growth includes true firs, Douglas fir, larch, and various pines species.

### Review

The data was compared to stands and mapped categories in ReGAP, Land Fire and the recent NLCD Coverage. Then NLCD was comparable for the forest stand data but GNN offered a more complete picture of the stands. Recent images were also evaluated in conjunction with data from the Monitoring trends and Burn Severity GIS databases (for fire perimeters, data available from http://www.mtbs.gov/)

## Natural Lakes

Natural Lakes refer to naturally occurring bodies of water that are larger than 20 acres. The Natural Lakes Strategy Habitat map was developed using NHD data, with a concerted effort made to remove man-made reservoirs, although some smaller reservoirs may still be included in the final results. Water bodies smaller than 20 acres have been classified as ponds, so were also removed from this Strategy Habitat. Ponds are represented in the Wetlands layer, and described in this document as a Palustrine Unconsolidated Bottom wetland.

### Methods

The Lakes layer was created using NHDPlus v2.1 Waterbody data. NHD data covers Oregon in portions of three regions (R18, R17, and R16). The following feature types were extracted from all waterbodies, clipped to the BLM Oregon boundary, and merged into one shapefile to represent NHD Waterbody data for Oregon.

**Table 7. Waterbody features used within the Natural Lakes Strategy Habitat map.**

| | | |
|---|---|---|
| LAKE / POND | 39004 | Hydrographic Category \| perennial |
| LAKE / POND | 39009 | Hydrographic Category \| perennial; Stage \| average water elevation |
| LAKE / POND | 39010 | Hydrographic Category \| perennial; Stage \| normal pool |
| LAKE / POND | 39011 | Hydrographic Category \| perennial; Stage \| date of photography |
| LAKE / POND | 39012 | Hydrographic Category \| perennial; Stage \| spillway elevation |

NHD has a separate Reservoir dataset, but many reservoirs are represented in the selected subset of Waterbody data. First, any feature with the word 'reservoir' in the GNIS name category was removed. Additional reservoirs were then selected by visual identification and removed. Some smaller water bodies that are technically reservoirs may be retained.

Any feature smaller than 20 acres was removed.

Malheur Lake is a combination of classifications. Selection based on FCODEs resulted in a patchwork of polygons for this region. Also, what appears to be a river path cuts through the western portion. This area was simplified to a single polygon representation via a manual edit. Portions of the Snake and Willamette River are classified as 'Lake/Pond' and in the NHD 'Waterbody' dataset. These were removed from the 'Lakes' layer and added to the 'Flowing Water and Riparian' layer, as described in the Flowing Water and Riparian Habitats section.

## Oak Woodlands

Oaks comprise forests, woodlands and savannas which occur throughout the Willamette Valley and Klamath Mountains ecoregions, extending east through the Columbia River Gorge to the east side of Mount Hood, and through the Klamath River valley to the Klamath Basin. Oregon white oak (*Quercus garryiana) is* the most important tree in these habitats, although from Eugene south, California black oak (*Quercus kellogii*) is also part of the Oak Strategy Habitat, as are the more local canyon live oak (*Quercus chrysolepis*) woodlands and savannas of the southern Siskiyou Mountains.

The Oak Woodlands Strategy Habitat map was compiled from several data sources for different areas in the state including: GNN data in the East and West Cascades and Klamath Mountains ecoregions, Willamette Valley data compiled from ODFW and detailed Lidar datasets, and an INR-TNC oak mapping project from the Umpqua Valley.

### Methods

In the Klamath Mountains, West Cascades, and East Cascades ecoregions, sufficient Oak habitat plots were available to create the Oak Strategy Habitat map using Gradient Nearest Neighbor (GNN) analysis. First, pixels where GNN attributed with a forest type of "Quercus" were selected, and then from that selection set pixels with basal area of oak > 8 and canopy cover of oak species greater than any other tree species were extracted. The only exception was in the Umpqua Valley area of the Klamath Mountains, where a 2010 detailed Umpqua oak map had previously been developed by INR and TNC. For this cover, we included only areas mapped as oak woodlands, and largely excluded the very open oak savannas and the madrone dominated areas.

In the Willamette Valley Ecoregion, numerous sources were evaluated in detail including comparing several sources from Northwest Habitat Institute (NWHI), US Forest Service, ReGAP, local INR data and field samples/plots and others. The ODFW Willamette Vegetation data set (1998) appeared the best when compared to photos and plot data. The data was compared to the detailed PVT and historic maps, and as a result results were expanded to incorporate all oak coverage with a buffer of 90 meters (approximately 3 pixels). Additionally all INR Oak plot samples were included. Although it is from 1998, the ODFW Land Cover data is provides accurate mapping of the Oak Woodlands Strategy habitat within the Valley and for differentiating oaks from very similar stands of deciduous trees. The oak areas were then extracted using Willamette Valley lidar data, focusing on trees ranging from roughly 30 to 90 feet. ReGap Oak classifications were used in areas which were not mapped using the higher resolution, lidar based database. These were locations at elevations above the Willamette Valley data towards and into the Coast Range, as well as an area on the southwest Oregon coast.

GNN data for oaks in southern Oregon provides over 200 sample plots, compared to the Willamette Valley, which has less than 40 samples in an area that is over twice as large. This demonstrates the geographic bias in the distribution of the samples in plots. Eastside sampling (near Mount Hood and south) are of moderate sample size and appear to agree with other data sources including mapped oak stands from field surveys.

There were not enough plots to apply the GNN analysis in the Willamette Valley Ecoregion. Additionally, the ReGAP remote sensed classification also had misclassifications, due to limited data availability when

the ReGAP map was made and the spatial resolution of 30 meter pixels (compared with the detailed image-based classification which uses the higher resolution lidar and NAIP data).

### Review

Additional oak woodlands related databases and maps were reviewed, including NWHI data and USFS data from the Willamette Valley ecoregion. These data sets contain mapped White Oak and Ponderosa Pine stands within the Willamette Valley. The data was created using field data collection and LANDSAT image interpretation. Field mapping, from May 2000 to October 2006, was used to classify areas accessible and/or visible from public roads. The coverage incorporates the selected strata classifications for vegetation type, structural conditions, size, and canopy. When compared with current NAIP photography, the spatial resolution of the polygons shows deficiencies due to the low resolution of LANDSAT based imagery used at the time when this data set was created, and as such were not used in the development of the final map.

## Ponderosa Pine Woodlands

Ponderosa Pine forests and woodlands are a critical resource for the economy and wildlife throughout Oregon. These fire dependent forests are especially of concern in the East Cascades and Blue Mountain Ecoregions, where they are one of the dominant forest types, as well as in the Klamath Mountains ecoregion, where they provide habitat for many Strategy Species.

The Ponderosa Pine Woodlands Strategy Habitat map was developed using a similar combination of datasets as the other forest Strategy Habitat (Oak Woodlands, Late Successional Mixed Conifer Forests) maps, developed by the OSU/PNW Research Station, Landscape Ecology, Modeling, Mapping & Analysis (LEMMA, http://lemma.forestry.oregonstate.edu), and data developed by the INR for a number of projects. The LEMMA data included information developed using a Gradient Nearest Neighbor (GNN) imputation methodology, that is described in detail at their website (http://lemma.forestry.oregonstate.edu/data), with the newest information created for the range of the Northern Spotted Owl in Washington, Oregon and California.

The GNN data was the primary database used for the Ponderosa Pine Strategy Habitat map. It was reclassified based on the summary statistics for the attribute data related to Ponderosa, specifically the primary forest type and size of the Ponderosa pines in the stand. The Forest type attribute in the data describes dominant tree species (based on basal area) of current vegetation. The Basal Area of *Pinus ponderosa* is expressed in meters$^2$/hectare, and indicates the size of the trees in the stand. Detailed queries of the dominate species and Ponderosa tree sizes where used to create a ranking scheme (outlined below).

### *Methods*

A detailed query was designed to create a set of probabilities to identify locations where ponderosa pine trees are likely to occur or be dominant. The classification and ranking used a set of rules, based on a review of the GNN attributes (and the associated precision of the parameters). The rules were based on:

- Is Ponderosa pine solely the dominant species in the stand or mixed with others species?
    - Areas where Ponderosa pine is the only species are ranked higher than areas where Ponderosa pine exists with other species. The lowest rank would be mixed stands, where Ponderosa pine is the secondary species present.
- What is the size of the trees in the stand?
    - Based primarily on the basal area of the Ponderosa Pines:
        - > 16 high ranking
        - 8 to 16 moderate ranking
        - 3 to 8 lower ranking
        - <3 very low ranking (and excluded if not dominant)
- Other parameters including stand height, age and canopy cover were reviewed and extraneous values were edited from the look up table

The data was reclassified in the GIS and null data and extents were set for additional processing which included masking the study data. The ranking are based on the confidence associated with the parameter estimates:

1 = high probability of Ponderosa Pine and large stands (with Ponderosa pine dominating). This has a FORTYPBA which is equal to Ponderosa pine and tree size as larger (i.e. Ponderosa pine basal area >16 meters$^2$/hectare). These also have average stand age of 113 years. The average height of stand is 15.9 meters and canopy cover (of all live trees) of 43%. Overall, this category has a total pixel count of 2.4 million acres in Oregon. When combined with the GAP data, this group is comprised of over 30% the Ponderosa Pine Oregon Community type. The next largest gap mapping class is the Eastside Douglas fir - Ponderosa Pine Mixed Conifer for only 6% and then Harvested Forest - Tree Regeneration for 4%. This indicates the GNN ponderosa pine category is strongly associated with the ponderosa pine categories in the GAP data and the remaining areas are smaller fragmented land cover classes. Overall, the GNN estimates for the ponderosa pine were almost entirely used to map this Strategy Habitat, as they can be used to represent mature ponderosa forests. The extensive GNN data occurs in the East Cascades, the Blue Mountains and other areas in Oregon. The largest contiguous blocks of the Ponderosa forests are mostly found west and south of Bend in Deschutes National Forest, in the Ochoco National Forest, and near Klamath – Crater Lake area (in the Winema National Forest).

2 = high probability of Ponderosa Pine with moderate forest stands. This group is a combination of two groups. Group One is dominated by only Ponderosa pine (and smaller trees) and Group Two is Ponderosa pine with other species (but larger trees).

Group One contains attributed species as only Ponderosa pine and moderate to larger basal area (Ponderosa pine basal area is 8 to 16 meters$^2$/hectare). Group Two is still dominated by only Ponderosa pine, but also has other species present, such as grand fir (*Abies grandis*) or Douglas fir (*Pseudotsuga menziesi* ), and the Ponderosa pine has a basal area of over 16.0 meters$^2$/hectare. Average stand age for these is 105 years, with an average height of 14.1 meters; yet the average canopy cover is only 27.9%. A total pixel count of the category is 3.0 million acres. This category expands the fringe area identified above and includes more area in the Blue Mountains (i.e. Whitman and Malheur National Forest) including lower elevation locations in the Wallowa Mountains, and areas east of the Siskiyou Mountains.

This category also has a strong spatial correspondence with the Gap Ponderosa pine habitat (Ponderosa Pine and eastside Douglas fir and Ponderosa Pine mixed conifers) with a 30% overlap.

3 = moderate probability of Ponderosa Pine with moderate stand size. This is forest type Ponderosa pine and the basal area is 0.5 to 8.0 meters$^2$/hectare. A total pixel count is only 1.0 million acres. This fills new area adjacent to other groups and starts to pick up area in the western basins (i.e. Klamath in SW Oregon and east side Mount Hood – Warm Springs). It also has small fragments of south facing slopes and other micro areas on the east side (i.e. in Wallowa – Whitman National Forests).

4 = moderate probability of mixed ponderosa. This has forest type of Ponderosa pine and other species from 8 to 16 meters$^2$/hectare. Douglas fir is the most common other species and then grand fir. This has a total pixel count of 1.9 million acres. This fills in areas between above categories.

5 = lower probability of smaller Ponderosa. The forest type is Ponderosa pine and others species with 0.5 to 8 meters$^2$/hectare, with a total pixel count of 1.4 million acres.

6 = lower probability with larger Ponderosa mixed in the stand. The forest type is not ponderosa but it is a secondary species in the stand. The Ponderosa pine size is larger > 16 meters$^2$/hectare (up to 33). This is a small category with a total pixel count of 0.2 million acres.

7 = low probability mixed moderate Ponderosa in stand. The forest type is not predominantly Ponderosa pine but it is in the stand with basal area of 8 to 16 meters$^2$/hectare with a total pixel count of 1.3 million acres.

8 = low probability small Ponderosa in mixed stand. Ponderosa pine is a secondary forest type with small basal areas from 0.5 to 8, with a total pixel count of 2.7 million acres.

All of the ranks were mapped and compared visual to other existing data (from US Forest Service local data, ReGAP data, and aerial photography). Ranks 1 through 4 were maintained within the Ponderosa Pine Woodlands Strategy Habitat map, and ranks 5 through 8 were not included.

**Table 8. Ponderosa pine tankings and pixel counts.**

| VALUE | PIXEL COUNT | PONDEROSA |
|---|---|---|
| 0 | 245889824 | Not Expected to be Present |
| 1 | 6371716 | High Probability - Large Stands |
| 2 | 7151775 | High Probability - Moderate Stands |
| 3 | 2379420 | Moderate Probability - Moderate Stands |
| 4 | 4715657 | Moderate Probability - Mixed Stands |
| 5 | 3544949 | Lower Probability - Small Stands |
| 6 | 280386 | Lower Probability - Mixed Stands with large Ponderosa |
| 7 | 1983067 | Lower Probability - Mixed Moderate Stands |
| 8 | 6051417 | Lower Probability - Mixed small Stands (Secondary) |

All of the data was preprocessed and put into a standard projection (Oregon state Lambert) and converted into the master strategy habitat raster grid format. Primary processing is documented with a Python program in ArcGIS. The following data inputs are used:

1. GNN Base coverage clipped to Oregon
2. GNN Attribute data (containing the imputation data)
3. GNN to Ponderosa pine crosswalk based on conditional queries of the GNN database for Stand type (dominant species) and Ponderosa pine basal diameters.
4. Masking ponderosa pine to major area of distribution
5. Adding in ReGAP ponderosa pine for specific populations (i.e. Lost Forest)

## Review

Numerous existing data sources were reviewed for inclusion and assessing the map. One of the primary databases was the ReGAP data. The primary GAP categories from the overlay indicated the following Ecological System:

- Ponderosa Pine =1
- Eastside Douglas fir - Ponderosa Pine Mixed Conifer = 2
- Harvested Forest - Tree Regeneration =3
- Western Juniper =3
- White Fir Mixed Conifer =3

The first two categories have a very strong spatial association with the Ponderosa Pine Woodlands Strategy Habitat map. The coverages were also compared to the existing ReGap land cover which is the most current land cover data source statewide for Oregon.

Numerous other data were also reviewed. This included LandFire data which was available with mapped data for Ponderosa Pine but our review indicated it was not as accurate, or up to date as the GNN data. One of the data set for potential evaluation was the recently compiled and reviewed data for Ponderosa pine potential natural vegetation compiled as part of the ILAP project. This data had detailed review and input from the regional foresters across the state, including numerous USFS research staff. The Ponderosa pine zone indicated where Ponderosa pine can be expected to grow and not where the existing conditions are present, and as such was not included.

Recent fire perimeters from the MTBS were also reviewed for masking in the Ponderosa pine zone but the review indicated that a majority of recent fires (i.e., the Three sisters Pole Creek fire) were not hot enough to impact the Ponderosa pine but impacted sub alpine and lodge pole more extensively and the dominant vegetation remained in Ponderosa pine where it was mapped.

Numerous existing stand data for USFS and other areas were reviewed but were not consistent for using as a seamless data source. The stand data was used to review and validate data from the model estimates from GNN.

## Sagebrush Habitats

Sagebrush represents one of the most widespread, yet vanishing habitats in Oregon. Once the dominant vegetation type across the Northern Basin and Range, the southeastern portions of the Blue Mountains, and much of the Columbia Basin, the habitat has significantly declined as a result of frequent and severe wildfires, increasing invasive annual grasses, western juniper expansion, and other causes.

The data for the Sagebrush Habitats Strategy Habitat map comes from two primary data sources: the INR sagebrush cover, created in 2014 within the SageCON project (http://orsolutions.org/osproject/sagecon), and ReGap. As INR has developed high resolution, accurate sagebrush maps for the last few years, no other datasets aside from LandFire were reviewed.

### Methods

The INR sagebrush map was created for the range of the Greater Sage-grouse in 2014, using a random forest model and sagebrush data from various data sources including INR Sagebrush field data (2013), BLM AMI (Assessment, Monitoring and Inventory) plot data from 2013, Vale District BLM ESI (Ecological Site Inventory) vegetation and soil field plots from 2012 and 2013. The AIM data and the Vale BLM field plots were available for the map, but to obtain these data individually, they must be requested directly from the BLM.

Two sagebrush maps were made: (1) A map of all sagebrush species present (including Wyoming big sagebrush, basin big sagebrush, mountain big sagebrush, rigid sagebrush, low sagebrush, silver sagebrush, black sagebrush, and early sagebrush); and (2) A map including only tall sagebrush species (Basin, Mountain, and Wyoming Big Sagebrush). Both maps were created with four categories:

1) Not present
2) Trace to 3 percent cover
3) 3 to 10 percent cover
4) Over 10 percent cover

Categories 2-4 that also occurred in areas not historically dominated by forests were included in the final Sagebrush Habitats Strategy Habitat map. The data was compiled at a 10 meter spatial resolution and then aggregated to 30 meter pixels.

INR Sagebrush data was focused within a specific portion of Southeastern Oregon, that was a focal point of SageCON. For areas within the Sagebrush Habitat designated Ecoregions outside of this area, the Columbia Plateau, East Cascades and the northwestern portion of the Blue Mountains ecoregions, ReGap data was used. For these areas, the following ReGap ecological systems were used to identify sagebrush:

- Rigid Sagebrush, Buckwheat or Bluegrass Scabland
- Great Basin Dry Mixed Sagebrush
- Big Sagebrush Shrubland
- Low Sagebrush
- Big Sagebrush - Bunchgrass Steppe
- Mountain Big Sagebrush

- Great Basin Dry Mixed Sagebrush
- Silver Sagebrush

After compiling the INR and ReGap sagebrush data (into the master strategy habitat raster grid format), an additional step was taken to highlight areas that have recently undergone fire. These recently burned areas were added to recognize habitats that, due to recent wildfires, may be lacking actual sagebrush vegetation during this 2015 mapping exercise, but are still areas where sagebrush habitats would normally occur under the right circumstances. The recently burned sagebrush areas were delineated using aerial photography that was collected in 2012 and 2013 summer seasons. Within the publically available dataset, there is no distinction between Sagebrush Habitats and recently burned Sagebrush Habitats. Please contact ODFW for more information, or for access to the recently burned data.

## Wetlands

Wetlands are important habitats characterized by an abundance of water, hydric (wetland) soils, and plants that grow in wetland conditions. They are some of the most biologically rich and productive lands in Oregon.

The data for the Wetlands Strategy Habitat map came from the wetland geodatabase for the state of Oregon. The geodatabase is most easily found by searching for "wetlands" at the Oregon Geospatial Data Portal (http://spatialdata.oregonexplorer.info/geoportal/catalog/main/home.page). The Wetlands Conservancy and INR have cooperated to develop an updated wetlands coverage for Oregon. This map continues to be improved with support from the Environmental Protection Agency. The most recent updates of the wetland coverage were used be used to create the wetland habitat component of the 2015 Strategy Habitat dataset, and is used in a number of wetland planning tools, including the Wetland Restoration Planning tool and the Oregon Rapid Assessment Protocol tool.

### Methods

Wetlands attributed as "potentially restorable" and wetland types included as parts of other Strategy Habitats ("Tidal mud flat" and "Salt marsh/swamp" are included in the Estuaries Strategy Habitat Map; and Rivers and Streams, and Lakes are included in the Flowing Water and Riparian Habitats and Natural Lakes Strategy Habitat maps) were not included in the Wetlands Strategy Habitat Map. All other wetland types ("Palustrine (freshwater)", "Pond", "Playa", "Vernal pool complex", etc.) were extracted from the wetlands geodatabase and rasterized into the master strategy habitat raster grid format.

## Composite Strategy Habitat Map

Each Strategy Habitat was first mapped individually, and then compiled into a single composite 2015 Strategy Habitat map/dataset. Contact ODFW for additional details on how to access the individual Strategy Habitat layers.

Combining these data sets, each of which originate from independent data sources, creates conditions where multiple classifications may exist for any given point (or 30 meter pixel) on the map. The data sources were developed independently of one another and as a result, the combined database creates the potential for multiple habitats to be mapped in a single pixel. For example, Ponderosa Pine and Oregon White Oak often occur together. The maps for each of these forest types were developed separately, and in locations where mixed oak/pine forests occur, pixels have been correctly attributed to both types within each individual Strategy Habitat map. When overlaying the individual Strategy Habitats to create a final composite layer, a methodology was established to determine the prevailing habitat type for any given pixel.

### Methods

All individual Strategy Habitat layers had been aggregated to 30m pixels, projected to the Oregon Statewide Lambert Projection, clipped to the Oregon state boundary, and snapped to the master strategy habitat grid format. Data was compiled into binary covers (1 for data present and 0 for no data) so a composite coverage could be easily built. The composite was created using either a conditional statement, a ranking system to select dominant or most important type in any given pixel, or sometimes both.

Conditional statements were first used to determine prevailing Strategy Habitats among the single species (or species type) forested habitats (Aspen Woodlands, Oak Woodlands, and Ponderosa Pine Woodlands). For these habitats, the GNN data provides a percentage coverage within each pixel. When possible, the highest percentage coverage determined the prevailing Strategy Habitat mapped within that pixel. For example: “A pixel has been labeled as both Oregon white oak and Ponderosa pine. Using the percentage cover of pine and oak from the base GNN data, the species with the greatest cover will be used to attribute the pixel to that Strategy Habitat”.

A ranking system was then used to determine the final prevailing Strategy Habitat to be maintained among all remaining, non-woodland, Strategy Habitats. Data sources that were of a higher precision and accuracy were ranked higher than data sources that were less precise and/or accurate. For example, Estuaries, Wetlands, Natural Lakes, and Flowing Water and Riparian Habitats have the ability to be mapped at a higher precision, and their results were compared to aerial imagery in some locations, ensuring a higher accuracy. These habitats are thus ranked ahead of habitats like Coastal Dunes, Grasslands, and Sagebrush; which are more widespread, dependent on less precise data collection methodologies, and are more difficult to test their accuracy.

**Strategy Habitat Ranking for the Composite Strategy Habitat Map:**

1. Estuaries
2. Wetlands
3. Flowing Water and Riparian Habitats
4. Natural Lakes
5. Ponderosa Pine Woodlands
6. Late Successional Mixed Conifer Forests
7. Aspen Woodlands
8. Oak Woodlands
9. Coastal Dunes
10. Grasslands
11. Sagebrush Habitats

Python programs were used to overlay all individual Strategy Habitat layers, and follow first the conditional statements for forested habitats, and then the ranking system for all habitat layers. The final composite layer was then finalized to include FGDC compliant metadata.