U.S. Fish & Wildlife Service

Willamette Valley Conservation Study

Strategic Habitat Conservation in Oregon's Willamette Valley

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Executive Summary

Oregon's Willamette Valley, renowned for the high quality of life it affords its residents, is losing part of its natural heritage. Habitat loss and fragmentation coupled with the loss of disturbance regimes that rejuvenated and maintained native habitats has resulted in population declines of many of the valley's sensitive wildlife and plants. Several Willamette Valley species are currently listed under the State or Federal endangered species acts.

There is a long history of partners working together to address these issues, through land-based and educational conservation actions across the valley. To determine where and how the U.S. Fish and Wildlife Service could complement these actions, we worked with the Oregon Department of Fish and Wildlife, and other governmental and non-governmental organizations engaged in conservation efforts in the Willamette Valley to complete a study of land-based conservation needs and opportunities in the valley. For the purposes of this study, land-based conservation includes actions to identify, preserve, restore, and manage terrestrial areas primarily for their wildlife habitat values while promoting nature-based recreational and educational activities where appropriate.

The study concludes that the amount and distribution of lands currently managed for sensitive, native wildlife species is inadequate for depressed populations to recover to a healthy and viable condition across their range in the valley. The study recommends that networks of grasslands, oak woodlands, and riparian habitats in specific areas of the valley—subsets of Conservation Opportunity Areas identified by the Oregon Department of Fish and Wildlife, be provided as safe and secure habitat to allow populations of sensitive native wildlife and plants space and time to recover. Establishing these habitat networks provides an opportunity to reclaim a portion of the valley's natural heritage for current and future generations of Oregonians to experience and enjoy.

Acronyms

Acronym	Full Phrase
BLM	Bureau of Land Management
CCAA	Candidate Conservation Agreements with Assurances
CLI	Climate Leadership Institute
COA	Conservation Opportunity Area
COLT	Coalition of Land Trusts
GIS	Geographic Information System
GLT	Greenbelt Land Trust
NEAT	National Ecological Assessment Team
NWR	National Wildlife Refuge
NWRS	National Wildlife Refuge System
OCCRI	Oregon Climate Change Research Institute
OCS	Oregon Conservation Strategy
ODAS	Oregon Department of Administrative Services
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OPB	Oregon Progress Board
PAD-US	Protected Area Database – United States
PCA	Priority Conservation Area
SHA	Safe Harbor Agreement
SHC	Strategic Habitat Conservation
TNC	The Nature Conservancy
USDC	United States Department of Commerce
USDI	United States Department of the Interior
USFWS	United States Fish and Wildlife Service
UW	University of Washington
WGWC	Western Governors' Wildlife Council
WVCS	Willamette Valley Conservation Study

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Introduction

Oregonians have long recognized the value of the Willamette Valley for people—its abundant clean water, mild climate, and rich soils make the valley an important agricultural center. Its cities and towns, with their high livability standards and close proximity to outstanding recreational opportunities continue to draw new residents. From 1970 to 2010, the population of the counties in the valley grew by about 86 percent—from just under 1.5 million to about 2.7 million. The State of Oregon projects an additional 1.3 million new residents by 2050, an increase of about 178 percent since 1980. The 1.3 million new residents represents a population that is larger than today's combined populations of Portland, Eugene, Salem, Gresham, Hillsboro, Beaverton, Medford, Bend, Springfield, and Corvallis—the ten largest cities in Oregon (ODAS 2013).

In 2000, the State of Oregon published the Oregon State of the Environment 2000 report (OPB 2000). The report was the first scientifically credible, comprehensive assessment of Oregon's environment. Signed by all of Oregon's former governors alive at the time (Hatfield, Straub, Roberts, Atiyeh, Goldschmidt, and Kitzhaber), the report concluded that "*One of Oregon's greatest environmental challenges for this century lies in the Willamette Valley. Transformation of prairies, woodlands, riparian areas, and rivers of the valley has fueled our economic growth for over 150 years. Yet this transformation has left its mark on our environment and a debt to pay. Whether we can improve the ecological health of the valley, measured currently by recovery of salmon and watersheds, while continuing economic growth and development for home and communities will be a stern environmental test.*"

The Willamette Valley constitutes the southern extent of a larger inland ecosystem flanked by the Cascade Mountains to the east and the coastal mountains of Oregon, Washington, and British Columbia to the west. With its prairie and oak components, this system creates a stark contrast to the surrounding landscape dominated by coniferous forests. This uniqueness represents a vital part of Oregon's biodiversity and the valley's natural heritage, featuring a high degree of species and habitat specialization that is far different from that found in the surrounding matrix of coniferous forests (Altman and Stephens 2012).

At the time of Euro-American settlement, which began in earnest only a little more than 150 years ago, the valley was typically described as a landscape dominated by vast open prairies interspersed with solitary oak and pine trees. The open prairies were surrounded by bands of oak woodlands. Closed-canopy coniferous forests were limited to the upper foothills and beyond (Johannessen et al. 1971; Christy and Alverson 2011). The valley's major rivers were lined by wide extents of hardwood forests and shrublands, which experienced flooding on an annual basis (Hulse et al. 2002).

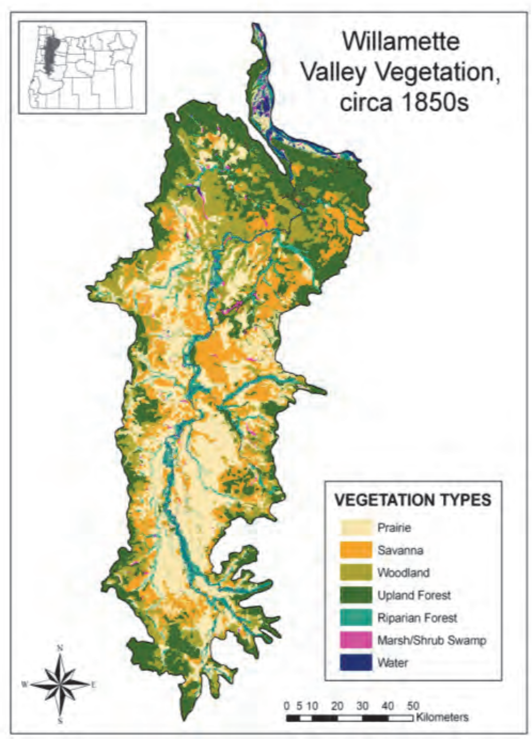

Figure 1. Historical vegetation classes in the Willamette Valley based on General Land Survey Office data, 1851-1910 (Christy and Alverson 2011, used with permission).

For millennia, the prairies were maintained free of encroaching trees and shrubs by frequent, low severity fires set by the native Kalapuya people. Burning increased the distribution and quantity of food that could be harvested by increasing oak and filbert production, stimulating berry and root production (especially in the extensive camas prairies), and concentrating deer for hunting (Taft and Haig 2003, Connolly 2000, Johannessen et al. 1971, Hamman et al. 2011). Annual springtime flooding along the Willamette River rejuvenated and maintained complex riverine and floodplain habitats (Hulse et al. 2002).

As settlers arrived in the valley, malaria and other introduced diseases ravaged the Kalapuya, and as more settlers moved in, the remaining Kalapuya were driven out (Connolly 2000, Taft and Haig 2003). Ranching, farming, and logging practices were introduced (Christy and Alverson 2011) and the practice of annual burning was greatly curtailed (Taft and Haig 2003, Hamman et al. 2011, Johannessen et al. 1971). As burning was curtailed, the habitats changed (Connolly 2000). Oak densities increased and conifers began to invade the open prairies and savannas, which over time, converted to closed-canopy forests (Christy and Alverson 2011, ODFW 2006). As the number of settlers increased, annual flooding posed an ever increasing risk to life and property. To abate the risk, dams were built and revetments were constructed along the river's banks.

Habitat loss and fragmentation is an ongoing issue in the valley. A study of natural area loss conducted across 11 western states used public datasets to assess the degree of human modification to natural areas from 2001 to 2011 (Center for American Progress 2016). The conversion from natural areas to developed areas during this time period in the nine counties of the WVCS sums to almost 61,500 acres (Table 1). (The conversion to development was calculated by county area and so it includes some areas outside of the Willamette Valley Level III Ecoregion, the WVCS study area). Of particular note, however, is that in seven of the nine counties, the annual rate of conversion is much higher than statewide and west-side conversion rates.

In Table 1, figures in **red** are rates of loss higher than the average annual rates, figures in **blue** are lower than average annual rates. For example, the rate of natural area conversion in Washington County was 198 percent higher than the average statewide rate, while the natural areas conversion rate in Lane County was 19.4 percent lower than the combined rates of the 11 western states.

Table 1: Natural Area Development 2001-2011

County	Natural Areas Developed as of 2011 (acres)	Percent of County	Natural Areas Developed 2001-2011 (acres)	Rate of Natural Area Development Compared to:	
				Oregon's Average Annual Rate[1]	Western States Average Annual Rate[1]
Multnomah	119,244	43.3%	3,718	213.5%	232.0%
Washington	175,711	38.0%	6,583	198.0%	215.6%
Yamhill	154,667	33.9%	4,328	87.6%	98.7%
Clackamas	269,447	22.6%	11,734	66.9%	76.7%
Polk	142,438	30.1%	4,124	63.8%	73.0%
Marion	258,597	34.2%	4,779	26.0%	33.4%
Linn	306,171	20.9%	9,479	7.9%	14.3%
Benton	106,150	24.6%	2,223	9.8%	4.6%
Lane	390,050	13.4%	14,508	24.0%	19.4%
Oregon State	8,219,358	13.4%	263,418	-	10.3

1 = Figures in **red** are higher than average annual rates, figures in **blue** are lower than average annual rates.
Source: Center for American Progress, 2016

The ongoing conversion of natural areas and the exclusion of fire and reduced flooding had, and continues to have, a marked effect on the valley’s native habitats and the wildlife they support. The vast prairies, savannas, oak woodlands, and riparian forests and shrublands that once dominated the valley’s landscape are now highly diminished, degraded, and fragmented, and no longer capable of supporting some of Oregon’s iconic wildlife.

Native species and ecosystems may be at an ecological tipping point, as evidenced by the declining populations and range contractions of many native fish, wildlife, and plant species. Twelve species native to the valley are listed under the federal Endangered Species Act (ESA). Many species are extirpated from the valley, and many more are threatened with extirpation including the State Bird of Oregon, the western meadowlark (ODFW 2008). The projected human population growth will only increase the need for additional outputs from the valley’s working landscapes, putting ever more pressure on the limited remaining natural areas.

The Study

The purpose of the Willamette Valley Conservation Study (WVCS) is to assess what will be needed to achieve the conservation of a suite of species that represent native habitats within the Willamette Valley, and how the Service could compliment on-going conservation actions being carried out by private landowners and multiple agencies and nongovernmental organizations across the valley. This study follows the U.S. Fish and Wildlife Service's (Service) Strategic Habitat Conservation (SHC) protocol. SHC is the Service's approach for the efficient conservation of wildlife populations with the overall goal of maintaining landscapes capable of supporting healthy, self-sustaining populations of native fish, wildlife, and plants (USFWS 2008a).

To add a surrogate species approach to conservation in the Willamette Valley, the Service convened a Willamette Valley Strategic Conservation Management Team, comprising many conservation partners active in the Willamette Valley. Surrogate species are "*species that are used to represent other species or aspects of the environment to obtain a conservation objective*" (Caro 2010). Caro noted that species are selected for different reasons: (1) to document the effects of environmental change on biological systems; (2) for use in public relations exercises to promote understanding of environmental problems and (3) to locate areas of conservation significance. The Willamette Valley Surrogate Species Pilot (USFWS 2014) selected species for the first two reasons. The WVCS compliments and builds upon the pilot by selecting species for the third reason—to locate areas of conservation significance.

The WVCS also incorporates and builds upon the Comprehensive Conservation Plans recently completed for the National Wildlife Refuges in the valley (USFW 2011, USFWS 2013a), and the Oregon Department of Fish and Wildlife's (ODFW) Oregon Conservation Strategy (OCS) (ODFW 2006, ODFW 2016). It also incorporates many of the recommendations from other studies and plans that have shaped conservation actions in the valley. These plans are summarized in Appendix A.

The study area is a modified version of the Willamette Valley Level III Ecoregion as defined by Omernik (1987) and the Environmental Protection Agency (1999) (Figure 1.1). The study excluded the portion of the ecoregion in Washington State as well as lands along the Columbia River that are included in other similar studies. The study covers approximately 5,000 square miles, extending 120 miles north to south and ranging from 20 to 40 miles in width. It includes the six largest cities in Oregon (Portland, Eugene, Salem, Gresham, Hillsboro, and Beaverton) as well as portions of Benton, Clackamas, Lane, Linn, Marion, Multnomah, Polk, Washington, and Yamhill counties.

The Willamette Valley Today

Native Species and Habitats

It takes time for species to adjust to changed conditions, and from an ecological and evolutionary standpoint, 150 years is just the blink of an eye. Significant habitat loss and fragmentation coupled with the invasion of noxious, non-native plants and animals and the loss of the fires and floods that rejuvenated and maintained the habitats has had pronounced effects on the wildlife and plants they support, or once supported.

Today, species are still adjusting and for many, the adjustment isn't going particularly well. Evidence of this is found in the fact that there are now 12 species of fish, wildlife, and plants native to the valley whose population numbers are so low that they are listed as threatened or endangered under the federal Endangered Species Act (USFWS 1993a, 1997, 1998a, 2000, 2013b). Two other federally-listed species, the Oregon spotted frog and yellow billed cuckoo, historically bred in the valley, but are now extirpated. Many other species including western meadowlark, Oregon vesper sparrow, and yellow-breasted chat are considered by the State of Oregon to be threatened with extirpation from the valley (ODFW 2008). Grassland-dependent birds have suffered steep population declines and severe range contractions as they adjust to the new realities of the valley (Altman 1999, ODFW 2010). ODFW found that "*In Oregon's Willamette Valley, many grassland species have exhibited steady downward trends in distribution and abundance, with some likely having been extirpated as a breeding species*" (ODFW 2010).

Rather than living in single, large, interacting populations, wildlife inhabiting areas with fragmented habitats are often structured into groups of local subpopulations based on the number, size, and distribution of habitat patches suitable for meeting their life-history requirements (e.g., successful breeding, rearing young, foraging, etc.). A habitat patch is simply a distinct area of a particular vegetation type (e.g., riparian forest, oak woodland). A group of local subpopulations that interact with one another is referred to as a metapopulation (Hanski and Gilpen 1991, Hanski 1998, Akçakaya et al. 2007). Species occurring as metapopulations, depend on a network of habitat patches to occur on the landscape that meet their minimum requirements in terms of number, size, quality, and distribution, to ensure their long-term persistence. If the network of habitat patches meets the requirements, the metapopulation persists. If not, the metapopulation will decline and eventually be lost (Hanski and Ovaskainen 2002).

Based on documented valley-wide population declines and range contractions, it is reasonable to conclude that the valley's current configuration of habitat within which wildlife can breed and raise their young free from other land management conflicts is inadequate for depressed populations of many of its imperiled species to recover and ensure their long-term persistence. By not expressly directing sufficient conservation actions on their behalf, we may be allowing these species to follow Columbian white-tailed deer, Oregon spotted frog, yellow-billed cuckoo, burrowing owls, lark sparrows, and many others as species now extirpated from the valley.

Wintering Canada Geese

On the other side of the population trend ledger are wintering Canada geese, the wintering population in the valley has greatly increased over the past several decades. In the mid-1960s, approximately 15,000-25,000 Canada geese wintered in the Willamette Valley/Lower Columbia River region of

Oregon and Washington (Pacific Flyway Council 2008). The majority of these geese were dusky Canada geese (*Branta canadensis occidentalis*). The Willamette Valley NWR Complex was created during this timeframe, primarily to provide winter forage and sanctuary for dusky Canada geese.

Since then, the dusky Canada goose population has fallen to about half its historic levels (Pacific Flyway Council 2008), while at the same time other subspecies of Canada geese have increased substantially. Currently, an estimated 350,000 Canada geese winter in the Willamette Valley/Lower Columbia River region (USFWS 2014b). The majority of the wintering goose population is comprised of cackling geese (*Branta hutchinsii minima*). Cackling geese breed in western Alaska and historically wintered in California, but beginning in the 1990s, the majority of the cackling geese population shifted from their historic winter range to the Willamette Valley (Pacific Flyway Council 1999). Cackling goose numbers have the potential to increase which would undoubtedly result in increased numbers of geese wintering in the Willamette Valley.

Approximately 6,550 acres of NWRS lands are currently dedicated to providing forage for wintering geese. ODFW manages two state wildlife areas within the Willamette Valley (E.E. Wilson and Fern Ridge) with about 100 acres of those areas provide goose forage. While these lands are managed to provide high quality food and sanctuary, they are far from sufficient to support all of the Canada geese currently wintering in the area (Mini 2012). Private lands, especially grass seed, wheat, pasture, and other grain and forage crops are playing a major role in providing food for wintering geese. However, the provision of these crops comes at a cost to the farming community in the form of crop depredation. Current goose management programs have had varying degrees of success, but even cumulatively, they have not been adequate to limit crop depredation on private lands.

A Changing Climate

A changing climate adds additional uncertainty to the equation. Although climate change is almost certain to affect the Willamette Valley (OCCRI 2010; Schafer et al. 2001), there is uncertainty about the direction and specific consequences it will have to its species and habitats. The University of Washington (UW) studied the potential effects of a changing climate on the Willamette Valley and their results indicate a trend toward warmer and wetter winters, and hotter and drier summers (Michalak et al. 2013).

Climate change can put a species at risk if the climatic conditions within which the species persists (i.e., its climate envelope) moves outside of the species' current geographic range. A climate envelope is modeled by associating aspects of the climate with a species' range to estimate the conditions and identify the areas that are suitable to maintain that species (Araújo and Peterson 2012). If a species' climate envelope shifts outside its current range, the species is at risk. The magnitude of the risk depends on how quickly the climate envelope shifts relative to the species ability to respond.

UW developed climate envelop models for several species of conservation concern in the valley and found that relatively few significant changes are expected. This finding suggests that average projected climate changes do not exceed the range of climate conditions currently tolerated by most of the priority conservation species in the valley (Michalak et al. 2013). Warmer, drier summer conditions leading to increased summer drought may actually benefit the relatively drought-tolerant native prairie and savanna species over the less drought-tolerant tree and other forest species, possibly resulting in prairie/savanna expansion (Bachelet et al. 2011).

This is not to suggest climate change will not adversely affect the valley's sensitive wildlife. Species with limited dispersal abilities, such as the endangered Fender's blue butterfly may not be capable of redistributing to new areas with suitable conditions if their current locations become unsuitable. The combination of decreased summer flow volumes in rivers and streams and increased air temperatures will almost certainly lead to increases in summer water temperature (OCCRI 2010) which could have profound effects on a wide range of species, including aquatic insects, fish, and amphibians.

In a study of grassland bird reproduction in shortgrass prairies, Conrey et al., (2016) found increased nestling mortality following very hot days and droughty days. Large storm events also resulted in increased nestling mortality. Across the 10 years of their study, they found lower survival rates during warmer and drier breeding seasons compared to average conditions. Hotter and drier summers are forecast for the Willamette Valley and short-term (3-month) droughts will be increasingly more likely (Jung and Chang 2011). The extent to which grassland bird populations are affected by these changes remains to be seen, but species with low population numbers are already at an increased risk of extirpation and anything that reduces juvenile survival rates only magnifies that risk.

Perhaps one of the greatest threats to the Willamette Valley due to the changing climate is the likely immigration of people (climate migrants or climate refugees) to the valley, over and above the already anticipated rapid population growth. The Climate Leadership Initiative of the University of Oregon's Institute for a Sustainable Environment (CLI 2008) predicted that global climate change could bring an influx of climate refugees to the Pacific Northwest. While it is difficult to estimate the extent to which this would change projected population growth in the valley, the need for planners and policymakers to take migration trends into account is a recognized necessity (City of Portland and Multnomah County 2015, ODOT 2012). A review of climate change data and studies pertinent to the valley is provided in Appendix B.

Connecting People with Nature

National wildlife refuges in the Willamette Valley currently provide wildlife-orientated outdoor recreation and education opportunities to approximately 500,000 visitors a year (USFWS 2013a). Additionally, dozens of other federal, state, and local providers own or manage a wide range of nature-based recreation facilities (e.g., parks, trails, open spaces) across the Willamette Valley. The pressure on these facilities is expected to increase as the valley's population increases. But not only is the valley's population increasing, it is aging and becoming more ethnically diverse (OPRD 2008). These changes will place new pressures and demands on natural areas and the natural systems that support wildlife and wildlife related recreation.

Nature-based recreation and education results in important economic benefits as well. The hundreds of thousands of valley residents spending dollars on nature-based recreation support local communities and aid in their economic development (Whelan et al. 2008, Carver and Caudill 2013). A recent study of the demographics and economic impacts of birding based on the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (USDI and USDC 2011) estimated that 892,000 Oregonians or about 23 percent of the state's population participated in bird watching activities. On a national scale, 46.7 million birders spent about $41 billion on trips and equipment, creating 666,000 jobs and generating $31 billion in employment income and $13 billion in local, state, and federal tax revenue. An economic analysis of shellfish harvesting, hunting, fishing, and wildlife viewing across the state of Oregon prepared for ODFW and Travel Oregon (Dean Runyan Associates 2009), found that in 2008, hunting, fishing, and wildlife viewing resulted in expenditures of about $128,000,000 in the Willamette Valley, which creates ancillary economic benefits as the dollars flow through local economies.

The Crucial Role of Private Landowners

The overwhelming majority of the valley's remaining habitat, as well as needed restoration opportunities, occur on private lands. To date, the linchpin of much of the applied conservation efforts within the valley has been the cultivation and maintenance of relationships with private landowners by the valley's agency and non-governmental organization (NGO) conservation practitioners. These relationships are based upon genuine collaboration and cooperation on the part of all parties involved. These principles are employed on both small and large conservation actions ranging from targeted invasive species management up to the acquisition of lands or easements from private landowners wanting to protect the conservation values on their properties in perpetuity.

The implementation of these types of voluntary conservation partnerships has contributed in no small part to many successful outcomes for the conservation of the valley's sensitive, native wildlife over the past decade and half. While there are myriad examples that could be highlighted which demonstrate how positive private/public collaborations are changing the face of conservation in the Willamette Valley, three examples represent current collaborative conservation efforts.

A multi-year collaboration by numerous private landowners, public agencies, and non-governmental organizations (NGOs), led to a true Willamette Valley success story—the recovery and delisting of the Oregon chub—the first fish species to be delisted in the nation. Private landowners played a crucial role by restoring chub habitat on their lands, participating in the introduction of chub, and managing their lands to perpetuate chub populations in secure habitats.

Another multi-year effort involving several dozen private landowners, public agencies, confederated tribes, and non-governmental organizations throughout Polk and Yamhill Counties are restoring and protecting Oregon white oak habitats in the northern part of the valley. These private landowners have enrolled their lands in various voluntary conservation partnerships that directly benefit listed species and migratory birds in decline. These partnership-driven collaborations cost effectively leverage limited public resources for the direct benefit of the valley's native wildlife and plants while at the same time, supporting working lands and local economies.

In the southern part of the valley along the lower Coyote Creek riparian corridor, federal agencies and non-governmental organizations have cultivated strong relationships with private landowners through voluntary, nonregulatory programs to restore and protect nearly 450 acres of unique oak-dominated floodplain forest and remnant native prairie meadows. Combined with 530 acres of federally managed lands, these efforts are directly contributing to recovering Bradshaw's lomatium as well as benefiting many other sensitive species.

These success stories highlight the crucial role of private landowners and public/private cooperative efforts in protecting and restoring the valley's native habitats. These efforts not only benefit wildlife and their habitats, but the diverse local communities (and associated economies) enmeshed within this landscape, through large and small restoration efforts aimed at recovering listed species, conserving migratory bird populations, and connecting people with nature. This partnership approach is the fabric of conservation delivery in the valley and future conservation success will continue to be based on cooperative public/private partnerships.

Strategic Habitat Conservation

The USFWS adopted SHC as its approach for the efficient conservation of wildlife populations with the overall goal of maintaining functional landscapes capable of supporting self-sustaining populations of native fish, wildlife, and plants (USFWS 2008a). Functional landscapes are lands and waters with the properties and elements required to support desirable populations of fish and wildlife, while also providing human society with desired goods and services, including food, fiber, water, energy, and living space (USFWS 2012).

SHC is an iterative process of developing and refining a conservation strategy, making efficient management decisions, and using research and monitoring to assess accomplishments and inform future iterations. The SHC process is a cycle involving biological planning, conservation design, conservation delivery, and outcome-based monitoring (USFWS 2008a). This study sets the stage for efficient conservation delivery by completing the first two phases of SHC—Biological Planning and Conservation Design.

As per SHC protocols, we worked with ODFW and other governmental and non-governmental organizations engaged in conservation efforts in the Willamette Valley to select a suite of species to represent the valley's native terrestrial habitats of concern, established population objectives for those species, and determined a spatial distribution of habitat needed to achieve the population objectives. Then, we used the conservation network design optimization algorithm Marxan (Ball and Possingham 2000) to identify priority areas of the valley within which the habitat objectives could be achieved. Each step is descried below with greater detail provided in Appendices D, E, and F. A list of governmental and non-governmental organizations we worked with is provided in Appendix K.

Biological Planning

Biological Planning involves goal setting, selecting species as conservation targets, and establishing quantifiable population objectives for the selected species.

Selecting Conservation Targets

Because it is impractical to develop conservation prescriptions for all species present in a study area as large as the Willamette Valley, we selected a subset of species to represent the valley's native habitats. This was done under the assumption that by implementing management strategies that support the ecological conditions favored by the targets, the conditions for a larger set of species characteristic of that habitat would also be supported (USFWS 2012).

As with the Strategic Conservation Management in Oregon's Willamette Valley (USFWS 2014), we used as the basis for selecting species, the valley's strategy habitats described in the Oregon Conservation Strategy (ODFW 2006). Those habitats are grasslands (including oak savanna), oak woodlands, riparian, and wetlands (including all freshwater wetlands and wet prairie). The WVCS used those habitats, but divided them slightly differently based on available GIS vegetation data layers that allowed us to take a finer look. We separated oak savanna from grasslands and divided riparian habitats into forest and shrubland constituent parts and selected species to represent those parts. Wetlands were represented within wet prairies and riparian areas. Descriptions of these priority habitat types are in Appendix C.

We convened a group of wildlife biologists with expertise in the valley to score and rank a list of species that could potentially represent the habitat types against a set of ecological and management criteria that assessed a species' ability to represent the larger suite of species dependent on the same habitat types. A detailed description of the species selection process is provided in Appendix D. The list of the species selected to represent habitats (conservation targets) is in Table 2.

Table 2: Conservation Targets

Species	Habitat
Western meadowlark Oregon vesper sparrow	Prairie (upland and wet)
Western bluebird	Oak savanna
Slender-billed white-breasted nuthatch	Oak woodland
Yellow warbler	Riparian hardwood forest
Yellow-breasted chat	Riparian shrublands

Western Meadowlark

Western meadowlark (*Sturnella neglecta*), the State Bird of Oregon, was selected to represent grassland habitats of the Willamette Valley Upland Prairie and Savanna and Willamette Valley Wet Prairie systems (NatureServe 2011; see Appendix C) and the species dependent upon those habitats. They are ground-nesting, grassland obligates that are far more likely to nest in large blocks of habitat (>300 acres) than smaller grassland fragments (Altman 1999). ODFW recommends maintaining large expanses of grassland and minimizing disturbance during the breeding season (April 15-July 15) as an important conservation action for western meadowlarks in the valley (ODFW 21016).

Western meadowlark were once described as "*probably the most widely distributed and among the most abundant of the permanent resident birds"* (Gabrielson and Jewett 1940), but recent surveys of grassland birds in the Willamette Valley documented that over a 12-year time frame (1996-2008) western meadowlark suffered a 60 percent decrease in relative abundance (the mean number of individuals tallied at each sample station) and a 30 percent decrease in the number of areas in which meadowlarks were detected (ODFW 2010). These results are reflected by the Breeding Bird Survey which documented a 10 percent decline per year from 1966 to 2007, the last year data are available for the valley (Sauer et al. 2008). This 10 percent decline per year equates to an overall population loss of about 98 percent since the mid-1960s. ODFW now considers the once common State Bird of Oregon as threatened with extirpation from the valley (ODFW 2008).

Oregon Vesper Sparrow

The Oregon vesper sparrow (*Pooecetes gramineus affinins*), another ground-nesting, grassland-dependent species, is one of four subspecies of vesper sparrow (Jones and Cornely 2002). It is endemic to the Willamette Valley. In the 1930s, it was described as an "*abundant summer resident in the Willamette Valley*" (Gabrielson and Jewett 1940), but now has "*nearly vanished from western Oregon*" (Csuti et al. 2001). Breeding Bird Surveys indicate they have declined about 8.6 percent per year since the mid-1960s or by about 97 percent overall (Sauer et al. 2008). ODFW considers Oregon vesper sparrow as being imperiled with extirpation from the valley (ODFW 2008), and recommends maintaining grassland habitats and reducing or avoiding mechanical operations during their nesting season from mid-May to mid-July as important conservation actions for the Oregon vesper sparrow (ODFW 2016).

Western Bluebird

The Western bluebird (*Sialia mexicana*) was selected to represent the oak savanna component of the Willamette Valley Upland Prairie and Savanna system (NatureServe 2011; see Appendix C). In the 1930s, western bluebirds were so common in western Oregon that "*it vies with the robin for first rank as a dooryard bird*" (Gabrielson and Jewett 1940). These cavity-nesting birds have since suffered precipitous population declines due to habitat loss and degradation, and avian competition for nesting cavities from species such as the non-native European starling (Marshell et al. 2003). Recent range contractions and extirpations have been documented in mainland British Columbia, Vancouver Island, the San Juan Islands, north Puget lowlands, and the Long Beach Peninsula (Rich et al. 2004, Guinan et al. 2008, Altman 2011), although they have recently been reintroduced in the San Juan Islands. Western bluebirds in the Willamette Valley are now separated from the rest of the species range (Keyser et al. 2004). ODFW recommends maintaining or restoring grassland and oak savanna habitat with both snags and live trees with large, dead branches to improve availability of nest cavities as important conservation actions for the western bluebird (ODFW 2016).

Slender-billed White-breasted Nuthatch

The slender-billed white-breasted nuthatch (*Sitta carolinenses aculeate*) was selected to represent North Pacific Oak Woodlands (NatureServe 2011; see Appendix C) and species dependent on that habitat. It is a small, cavity-nesting, passerine closely associated with Oregon white oak woodlands of the Willamette Valley (Hagar 2003). Described in the 1930s as being a "*regular resident of the Willamette Valley*" and "*a common bird throughout most of its territory*" (Gabrielson and Jewett 1940), they have also experienced both range contractions and population declines with extirpations documented in western Washington (Grubb and Pravosudov 2008, Rich et al. 2004). ODFW recommends maintaining large oaks containing cavities and implementing controlled burns where possible to maintain oak tree dominance and prevent conifer encroachment as an important conservation action for the slender-billed white-breasted nuthatch (ODFW 2016).

Yellow Warbler

Yellow warbler (*Setophaga petechia*) was selected to represent riparian hardwood forests of the North Pacific Lowland Riparian Forest and Shrubland system (NatureServe 2011; see Appendix C) and the other species dependent upon that habitat. They breed most commonly in riparian, deciduous thickets including cottonwood gallery forests (Lowther et al. 1999). They were once the most conspicuous breeding warbler in Oregon, but declined precipitously before the advent of the Breeding Bird Survey (BBS) (Gabrielson and Jewett 1940, cited in Marshall et al. 2003). Since the mid-1960s, the population declines have been attributed to the loss of riparian habitat and cowbird parasitism (Marshall et al. 2003, Rich et al. 2004).

Yellow-breasted Chat

Yellow-breasted chat (*Icteria virens*) were selected to represent riparian shrublands of the North Pacific Lowland Riparian Forest and Shrubland system (NatureServe 2011; see Appendix C) and the other species dependent on that habitat such as the willow flycatcher, another bird of regional conservation concern (USFWS 2008). In the 1930s, yellow-breasted chat were a "*common summer resident and breeding species in tangled thickets of stream bottoms throughout the state, except coastal counties*" and "*a common species in Jackson and Josephine Counties in the upper Rogue, along the Umpqua in the vicinity of Roseburg, and throughout the Willamette Valley*" (Gabrielson and Jewett 1940). But that is far from the current condition, as ODFW now considers yellow-breasted chat as being threatened with extirpation from the valley (ODFW 2008). The BBS documents a population decline of 3.2 percent per year from 1966 to 2007 (Sauer et al. 2008), equating to a loss of 76 percent of the 1960s population. ODFW recommends restoring large, dense thickets of native-shrub dominated riparian areas as an important conservation action for yellow-breasted chat (ODFW 2016).

Other Species of Conservation Concern

While the list of species the biologists scored included bird, mammal, amphibian, fish, and plant species, only bird species were selected. Birds have long been used as surrogates of air quality (e.g., the canary in the coal mine) and are often used as surrogates for biodiversity because they are well known and studied, their population trends can correlate with those of other taxa (Gregory et al. 2008), and monitoring their responses to management actions provides a measure of the effectiveness of the action (Stephens et al. 2011).

Identifying networks of priority conservation areas on the basis of birds alone has been found to perform well in representing overall species diversity, but the overall effectiveness of the network design can be improved by adding other taxa, especially range-restricted taxa (Larsen et al. 2012). We did that by including other species of conservation concern that require special management needs that would not necessarily be met through a network design based solely on the selected bird species. These species face unique threats, limited range, legal mandates, or other special circumstances. The list of other species of conservation concern is in Table 3, and descriptions of the species are available in Appendix E.

Table 3: Other Species of Conservation Concern

Birds	**Plants**
Streaked horned lark	Bradshaw's lomatium
Invertebrates	Golden paintbrush
Fender's blue butterfly	Kincaid's lupine
Taylor's checkerspot butterfly	Nelson's checker-mallow
	Willamette valley daisy

Establishing Biological Objectives

Biological objectives represent a measurable expression of a desired outcome and serve as one of the basis for estimating how much habitat is needed to be maintained based on the current state of knowledge related to habitat suitability, territory size, population viability, and probability of occurrence in suitable habitat (USFWS 2008a).

More than 15 years ago, Altman (1999) proposed a landbird conservation strategy of protecting, restoring, and managing suitable habitat in proximity to existing populations, providing habitat for the populations to grow and for dispersers to establish new subpopulations on newly restored habitat

(Altman 1999, ODFW 2010). This strategy, focusing initial efforts near remaining populations and radiating out from them influenced the development of this study.

SHC is an objectives-based planning protocol, requiring us to develop quantifiable objectives for the selected species. We chose to develop population objectives and convened panels of researchers and biologists with expertise in each of our conversation target species and asked them what would reasonable population objectives be, that when realized, would indicate that the species were well on the road to recovery.

Our conservation targets fell into two broad categories: those that are rare and imperiled, with very small and fragmented populations that have suffered steep, long-term declines (the grassland, oak savanna, and riparian shrubland species) and those with somewhat larger, though still relatively small populations, and less certain population trends (the oak woodland and riparian forest species).

For the rare and imperiled species (western meadowlark, Oregon vesper sparrow, western bluebird, and yellow-breasted chat), our expert panel suggested a long-term population goal of 6,000, which when met, would convey a high probability for long-term persistence (Traill et al. 2007, Reed et al. 2003). For the species with somewhat larger populations (slender-billed white-breasted nuthatch and yellow warbler), the panel agreed that a long-term, aspirational goal that increased the population by 50 percent over 50 years would indicate they were recovering and would be consistent with the goals of the North American Landbird Conservation Plan (Rich 2004).

We stepped-down the long-term aspirational goals to shorter-term population objectives, which we used to determine habitat objectives. To do that, we calculated the annual growth rate needed for each species, to meet the long-term goals over a 50-year time frame and then applied that rate to the current population estimate for 10 years. Current population estimates, goals, and objectives are provided in Table 4. A detailed description of how we set population objectives is provided in Appendix E.

Table 4. Population Estimates and Objectives

Conservation Targets	Current Population Estimate*	Short-term Population Objective	Long-term Population Goal
Western meadowlark	1,200	1,656	6,000
Oregon vesper sparrow	550	887	6,000
Western bluebird	2,000	2,490	6,000
Slender-billed white-breasted nuthatch	12,100	13,447	18,150
Yellow warbler	12,400	13,122	18,600
Yellow-breasted chat	900	1,315	6,000

* Population estimate is specific to the Willamette Valley. See Appendix E for a discussion on how they were developed.

Establishing Habitat Objectives

Habitat objectives describe the area and distribution of habitat across a landscape thought to be necessary to achieve population objectives (NEAT 2006). Appendix E provides greater detail about how we developed the habitat objectives.

Terrestrial Habitats

Successful conservation strategies address the factors limiting population growth. For grassland birds, ODFW (2006, 2016) identified the loss and degradation of grassland habitats, nest predation, and nesting failure due to the timing of land management practices occurring during critical nesting times (mid-April to mid-July). The extensive loss of native grasslands has resulted in small and disjunct populations (i.e., disjoined and distinct from one another) that are at increased risk of extirpation, genetic isolation, and barriers to dispersal especially for some amphibians, reptiles, and small mammals. Small patches of habitat cannot satisfy the space requirements for some birds (e.g., western meadowlark), reptiles, and medium to large mammals (Altman et al., 2001). For the riparian birds the loss of large habitat patches and altered disturbance regimes that create suitable habitat conditions are limiting populations (ODFW 2006, 2016). For the cavity-nesting oak species, it is habitat loss along with fewer mature oaks with cavities and competition from nonnative species for those cavities (ODFW 2006, 2016).

The expert panels summarized these factors as an insufficient number, size, and distribution of suitable habitat with long-term commitments to maintain breeding and rearing habitats to ensure long-term persistence. To address this factor, for each species we developed objectives for the number, size, and distribution of a network of core habitat patches—areas of suitable habitat and of sufficient size which contain the properties and elements required for successful reproduction and survival of the targeted species. Within these core habitat patches, wildlife management would be prioritized over other management concerns.

To determine the amount of habitat needed for each network of core habitats, we used the largest and densest known subpopulations of each species in the valley as the reference from which to establish area requirements. These typically occurred on large, single ownership parcels with generally high quality habitat. As most of the landscape outside these ownerships is fragmented and of lower quality we assumed that 50 percent more area would be required compared to the reference to support an equal number of breeding pairs. The fact that territory size varies with habitat quality is well established and has been demonstrated empirically in the valley for grassland birds (Altman 1999, Altman et al. 2011). For species without reference subpopulations we used breeding territory sizes reported in the literature, and increased that size by 50 percent for the reasons given above. We took these acreage amounts and split them into the number, size, and distribution of core habitat patches (the network) needed to support each population objective.

The Wetlands Conservancy mapped wetlands of conservation significance for the Western Governors Association's Crucial Habitat Assessment Tool or CHAT (WGWC 2013). Where the top 50 percent highest ranking wetlands intersected mapped grassland or riparian areas in our GIS landcover database, they became targets for conservation. Wet prairie habitat is included in the grasslands habitats.

Aquatic Habitats

While instream aquatic habitats were not a specific WVCS target, there have been many recent studies and modeling efforts that identified areas of conservation significance along the valley's rivers and streams. These include anchor habitats—areas with opportunities to reconnect the river to its historic floodplain with limited social impact that were mapped as part of the Willamette Planning Atlas (Hulse et al. 2002) and by the Oregon Watershed Enhancement Board (OWEB 2014); instream cold water refugia (cold points) as mapped by Hulse et al. (2007); and Zone of Influence—locations of revetments that if removed would provide a high degree of fish habitat restoration with limited social impacts that were mapped as part of a U.S. Army Corps of Engineers' study (Hulse et al. 2013). We overlaid these mapped area of conservation significance in our GIS database with our targeted habitat types, and where they intersected, they became additional conservation targets.

Habitat Objectives

The following set of tables provides for each species/habitat combination the recommended number of core habitats patches, total acreage of those patches, and how they should be distributed across the valley. In establishing these habitat objectives, we assumed that providing a secure habitat base capable of supporting 50 percent of each species' population objective would be sufficient to begin to recover the depressed populations, with the remainder of each species' population objective occurring outside of the secure habitat base. This assumption must be tested through assumption-based research and the objectives modified based on the results of that research.

To distribute the core habitat patches, we split the valley into three regions along a north-south gradient (north is north Salem, central is from Salem to Corvallis, and south is south of Corvallis) and stratified the habitat objective across the three zones. To further ensure an appropriate distribution of these core habitat patches, recommendations are given for which Level IV Ecosystem (Omernick 1987) the patches should occur. A detailed discussion of these objectives and the assumptions used to calculate them is provided in Appendix E.

Table 5: Grassland Core Habitat Distribution (*Western Meadowlark*)

Area	**Number of Core Habitat Patches**				**Total Acreage of Core Habitat Patches**			
	Large	**Medium**	**Small**	**Total**	**Large**	**Medium**	**Small**	**Total**
North	0	1	2	3	0	938	1,125	2,063
Central	1	2	4	7	1,313	1,875	2,250	5,438
South	1	2	6	9	1,313	1,875	3,375	6,563
Total	2	5	12	19	2,625	4,688	6,750	14,063

Since the strategy is to begin work in proximity to existing population centers, the network is located mostly in the southern and central parts of the valley reflecting the current and likely historic distribution of western meadowlark in the valley. The vast majority of the network should occur in the three valley lowland Level IV ecoregions.

Table 6: Grassland Core Habitat Distribution (*Oregon Vesper Sparrow*)

Area	Number of Core Habitat Patches				Total Acreage of Core Habitat Patches			
	Large	Medium	Small	Total	Large	Medium	Small	Total
North	0	1	2	3	0	341	409	750
Central	1	2	3	6	477	682	614	1,773
South	2	4	6	12	955	1,364	1,227	3,454
Total	3	7	11	21	1,432	2,386	2,250	6,068

This distribution of the network, focused in the southern and central parts of the valley, reflects the current distribution of Oregon vesper sparrow. Because Oregon vesper sparrow occur more often in the valley foothills rather than the valley floor as western meadowlark do, at least 80 percent of the network should be located in the Valley Foothills Omernik Level IV ecoregion (Omernik 1987).

Table 7: Oak Savanna Core Habitat Distribution (*Western Bluebird*)

Area	Number of Core Habitat Patches				Total Acreage of Core Habitat Patches			
	Large	Medium	Small	Total	Large	Medium	Small	Total
North	1	3	6	10	263	563	675	1,500
Central	2	3	6	11	525	563	675	1,763
South	1	3	5	9	263	563	563	1,388
Total	4	9	17	30	1,050	1,688	1,913	4,650

Reflecting western bluebird distribution in the valley, at least two habitat patches should be located in each of the four Omernik Level IV Ecoregions (Omernik 1987), with the majority located in the Prairie Terraces and Valley Foothills Level IV ecoregions.

Table 8: Oak Woodland Core Habitat Distribution (*Slender-billed White-breasted Nuthatch*)

Area	Number of Core Habitat Patches				Total Acreage of Core Habitat Patches			
	Large	Medium	Small	Total	Large	Medium	Small	Total
North	5	10	20	35	4,500	6,000	6,000	16,500
Central	5	10	20	35	4,500	6,000	6,000	16,500
South	5	10	19	34	4,500	6,000	5,700	16,200
Total	15	30	59	104	13,500	18,000	17,700	49,200

To reflect the current and likely historic distribution of nuthatches in the valley, at least six habitat patches should be located in each of the four Omernik Level IV Ecoregions (Omernik 1987), with the majority located in the Valley Terraces and Valley Foothills Level IV Ecoregions.

Table 9: Riparian Forest Core Habitat Distribution (*Yellow Warbler*)

Area	Number of Core Habitat Patches				Total Acreage of Core Habitat Patches			
	Large	Medium	Small	Total	Large	Medium	Small	Total
North	3	5	11	19	1,620	1,800	1,980	5,400
Central	2	5	11	18	1,080	1,800	1,980	4,860
South	2	5	11	18	1,080	1,800	1,980	4,860
Total	7	15	33	55	3,780	5,400	5,940	15,120

Reflecting the current and likely historic distribution of yellow warblers in the valley, at least two habitat patches should be located in each of the four Level IV Ecoregions, but the vast majority should occur in the Willamette River and Tributaries Gallery Forest Level IV ecoregion.

Table 10: Riparian Shrubland Core Habitat Distribution (*Yellow-breasted Chat*)

Area	Number of Core Habitat Patches				Total Acreage of Core Habitat Patches			
	Large	Medium	Small	Total	Large	Medium	Small	Total
North	1	2	4	7	450	600	600	1,650
Central	1	3	3	7	450	900	450	1,800
South	1	2	3	6	450	600	450	1,500
Total	3	7	10	20	1,350	2,100	1,500	4,950

Similar to yellow warbler habitat, at least two subpopulations should be located in each of the four Level IV Ecoregions, but the vast majority should occur in the Willamette River and Tributaries Gallery Forest Level IV ecoregion.

Other Species of Conservation Concern

Other species of conservation concern require site-specific actions to ensure their conservation. The expert panels recommended conserving specific extant populations of the listed species as the best way to assist in achieving recovery criteria (USFWS 2010a). The areas supporting those populations are included in the final portfolio of important areas for land-based conservation actions. Once a recovery plan is adopted for the streaked horned lark, population and habitat objectives from that plan would be adopted and added to this study. Additional detail regarding biological and habitat objectives for the other species of conservation concern is provided in Appendix E.

Conservation Design

The Service traditionally approached conservation with an emphasis on more, more protection, more restoration, and more management. Recent advances in the field of conservation biology, however, are leading the Service in a new direction—a strategic pursuit of sustainable landscapes. Advances in the fields of conservation planning and design, and landscape and population ecology have replaced the emphasis on "more" to the science of "how much more" and "where" as we consider how best to pursue our mission (NEAT 2006). Conservation Design, element two of the SHC cycle, is predicated on the belief that the potential to affect wildlife populations varies over space in response to site characteristics and landscape context. If it does not, it matters little where habitat is conserved (USFWS 2008a). Conservation design provides the roadmap for element three of the SHC cycle: conservation delivery.

Identifying Priority Areas for Conservation

Prioritizing areas of the Willamette Valley for conservation entails an evaluation of the relative value of one area against another area's ability to meet multiple conservation objectives for species and habitats distributed across hundreds of thousands of acres throughout the 5,000 square-mile Willamette Valley ecoregion. This complexity precludes simple mapping exercises to arrive at an efficient conservation design. To deal with this complexity, we used the conservation network design optimization algorithm, Marxan (Ball et al. 2009). Marxan (and its predecessors SPEXAN and SITES) has been used for terrestrial and marine conservation assessments around the world (Beck and Odaya 2001, Andelman and Willig 2002, Noss et al. 2002, Leslie et al. 2003, Carroll et al. 2003, Floberg et al. 2004, USFWS 2013b, Arid Lands Initiative 2014). A detailed description of Marxan and how it was used is provided in Appendix F.

Because we wanted to prioritize areas where the targeted species occur (i.e., the disjunct populations ODFW (2006) describes), we compiled recent bird observation data (from 2008 to 2013) from numerous sources. These included survey data gathered by the American Bird Conservancy, the Portland Bureau of Environmental Services, the Portland Chapter of The Audubon Society, the Oregon Department of Fish and Wildlife, and The Oregon Chapter of The Nature Conservancy. We also used data from a 2013 vesper sparrow survey (Altman 2013), Breeding Bird Survey data, and vetted eBird observations.

The Maxan analysis identified 76 areas, within which there are recent documented occurrences of the target species and sufficient habitat to create and maintain core habitat patches that would contribute to a network or an extant population of a listed species whose protection would aid in recovering that species. We are calling these areas "Priority Conservation Areas" (PCAs) (Figure 1). The PCAs are embedded within and a subset of the Conservation Opportunity Areas identified by ODFW (2016), which are areas known for their importance for fish and wildlife conservation.

It is important to note that because the minimum amount of land that Marxan either adds to or excludes from the network design is 250-acres (the Marxan model used 250-acre hexagon assessment units), land cover types such as roads and other areas that are unsuitable for wildlife habitat are included in each PCA. Only about 30 percent of the area included in all of the PCAs contains the habitats of concern. Acreage of the various targeted habitat types and the number of PCAs within which they occur is provided in Table 11.

Table 11. Habitat types and acreage within the PCAs.

Habitat type	Acreage	PCAs	Habitat type	Acreage	PCAs
Grasslands	27,907	27	Wetlands of conservation concern	11,491	52
Oak savanna	4,848	27	Anchor habitats	6,471	11
Oak woodlands	49,800	52	Cold points	1,091	9
Riparian forest	27,915	75	Zones of influence	5,113	19
Riparian shrubland	7,283	58			

Wilderness Review

A GIS analysis of the study area was conducted to determine the potential for new wilderness areas. The analysis attempted to find any roadless area of 5,000 acres or greater within the valley, or any roadless areas within the valley that extend beyond the ecoregional boundary that equaled at least 5,000 acres. No such areas were identified.

The 5,786-acre Table Rock Wilderness occurs to the east of the study area about 19 miles southeast of Molalla. Table Rock Wilderness was designated by the United States Congress in 1984 and is managed by the Bureau of Land Management (BLM).

GAP Analysis

With PCAs identified, the next step is to determine to what extent each network already occurs on protected lands, such as the grasslands at W.L. Finley National Wildlife Refuge, riparian habitats at ODFW's E.E. Wilson Wildlife Area, and Metro's Smith and Bybee Wetlands. We used data from the Protected Area Database of the United States (PAD-US), which includes a "gap status" of protected lands. The gap status indicates how the lands are being managed for conservation purposes. A gap analysis typically only considers lands in gap status 1 and 2, which have permanent protection from conversion and a mandated management plan to maintain a primarily natural state, but may be subject to practices that suppress natural disturbances such as wildfire. We used gap status 1 and 2 lands in this analysis, but also included some areas that were not gap status 1 or 2, but are public lands that contain quality habitat, have recent documented occurrences of the targeted species, are of sufficient size, and are governed by management plans that protect wildlife values.

The following series of tables (Tables 12-16) provides a graphical representation of where in the valley network objectives are achieved, where they have been partially achieved, and where no protected areas are of sufficient size suitable for the network. The number in the "Objective" column is the habitat objective (i.e., the number core habitat patches). The number in the "Achieved" column

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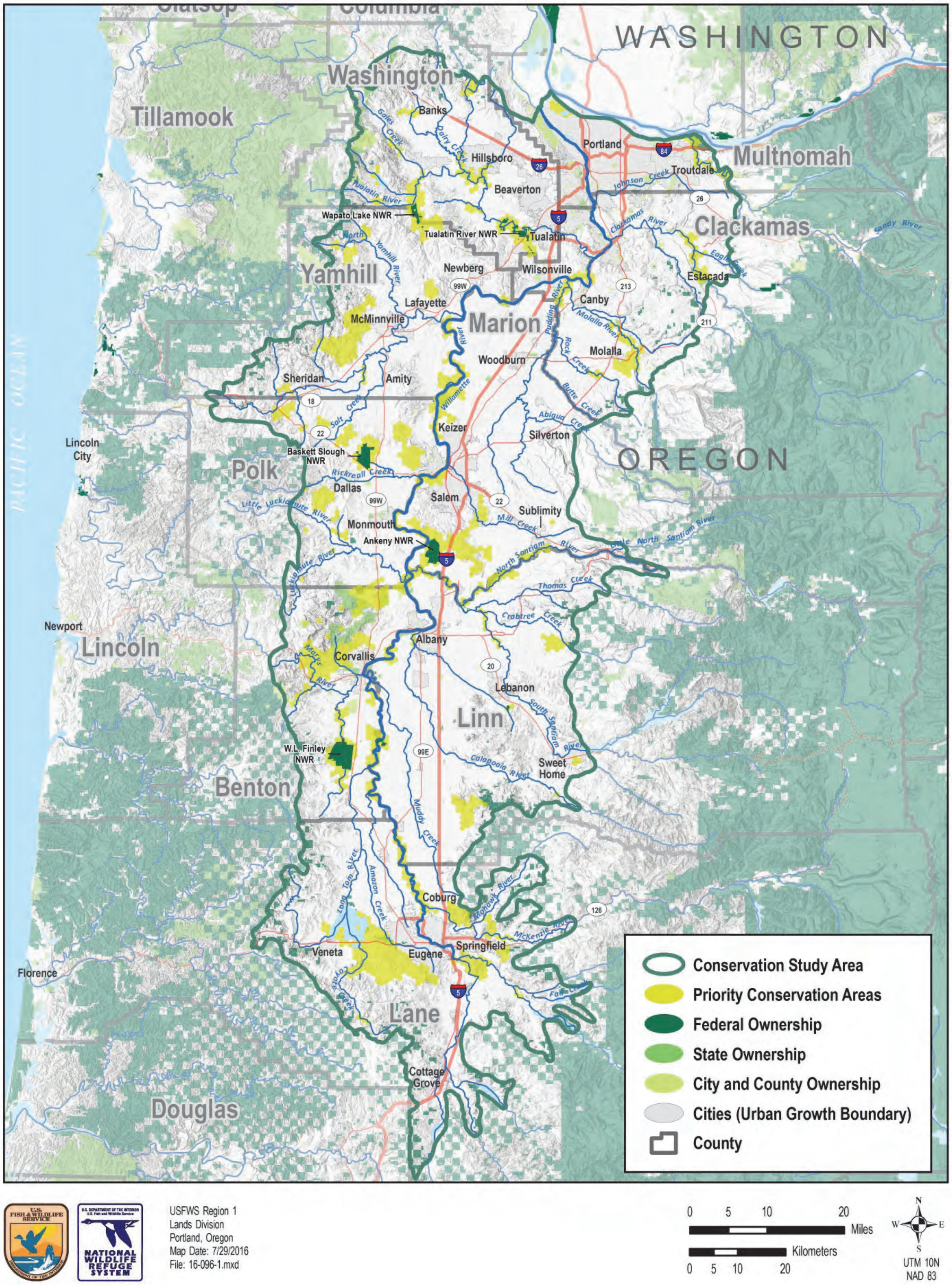
Figure 1. Priority Conservation Area Map



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represents the number of protected areas with suitable habitat and sufficient size to be considered a core patch. The colors differ based on whether the objective has been achieved (green), partially achieved (orange), or no objectives have yet been achieved (purple).

(green)	= Objectives achieved
(orange)	= Objectives partially achieved
(purple)	= No objectives achieved

Table 12: Grasslands (Western Meadowlark and Oregon Vesper Sparrow)

Area	Large		Medium		Small	
	Objective	Achieved	Objective	Achieved	Objective	Achieved
North	N/A	N/A	1	1	2	0
Central	1	1	2	0	4	0
South	1	1	2	0	6	0

Table 13: Oak Savanna (Western Bluebird)

Area	Large		Medium		Small	
	Objective	Achieved	Objective	Achieved	Objective	Achieved
North	1	0	3	0	6	0
Central	2	0	3	0	6	1
South	1	0	3	0	5	1

Table 14: Oak Woodlands (Slender-billed White-breasted Nuthatch)

Area	Large		Medium		Small	
	Objective	Achieved	Objective	Achieved	Objective	Achieved
North	5	1	10	1	20	1
Central	5	0	10	0	20	1
South	5	0	10	1	19	1

Table 15: Riparian Forests (Yellow Warbler)

Area	Large		Medium		Small	
	Objective	Achieved	Objective	Achieved	Objective	Achieved
North	3	1*	5	0	11	2
Central	2	1	5	0	11	0
South	2	1	5	1	11	3

* Sandy River Delta (not GAP Status 1 or 2)

Table 16: Riparian Shrublands (Yellow-breasted Chat)

Area	**Large**		**Medium**		**Small**	
	Objective	**Achieved**	**Objective**	**Achieved**	**Objective**	**Achieved**
North	1	1**	2	0	4	1
Central	1	0	3	0	4	0
South	1	0	2	0	3	1

** Smith and Bybee Wetlands (not GAP Status 1 or 2)

Overall, while portions of the networks are in place, lands protected to date within the PCAs are mostly of insufficient size to meet the objectives for even a small core habitat patch. They do however create a land base from which to build upon to create bigger blocks of habitat. A detailed discussion of the gap analysis is provided in Appendix H.

It is interesting to note that the three National Wildlife Refuges with the most grassland habitat (W. L. Finley, Ankeny, and Baskett Slough) support healthy populations of western meadowlark, and have so for years. Yet populations of western meadowlark and other grassland birds have declined precipitously around them (Altman 1999, ODFW 2010). This highlights the important point that a few widely-spaced “islands” of habitat set aside for wildlife, even though relatively large, do not provide a habitat configuration in terms of amount, distribution, and quality sufficient to maintain, let alone restore the depressed populations of grassland-dependent species across the valley.

Threats Analysis

Understanding potential threats that might render areas of a PCA unusable for conservation is a critical step in developing appropriate conservation strategies (Surasinghe et al. 2012; Groves 2003). A wide variety of agents can threaten the integrity of a PCA, but due to the historic loss and conversion of native habitats and the anticipated surge in population growth, anthropogenic land use changes will likely present a greater challenge to restoring and maintaining biodiversity in the valley than climate change over the course of this century (Wilson et al. 2014). Climate change may actually benefit oak and prairie systems of the valley (Bachelet et al. 2011). Because of that, we focused on the potential for future development as the greatest threat to PCAs.

We used the Development 2050 scenario from the Willamette River Basin Planning Atlas as it reflects a loosening of land use policies that allows market forces freer rein across the valley’s landscape, creating an aggressive development scenario that was judged by project stakeholders to still be within the range of future development considered plausible (Hulse et al. 2002). This scenario mapped areas likely to be converted under loosened land use policies.

We also looked at the projected change in each PCA that would be impacted by exurban development, using data from Theobald (2005). Future patterns of exurban growth were based on historical and current housing density patterns which were used to forecast future housing density projections (Theobald 2005).

Both studies, neither of which include the potential impacts related to an influx of climate refugees, tend to indicate that PCAs, which are almost entirely outside current urban growth boundaries, would not be significantly impacted by future development. Not surprisingly, PCAs modeled to be most affected by future growth tend to be close to urban centers (Portland, Eugene, Corvallis). However, two of those PCAs currently house National Wildlife Refuges with private inholdings, and another supports a population of a listed plant species. That these PCAs are among the most threatened only highlights the need for immediate actions to conserve these valuable places for wildlife. Appendix I provides a detailed description of the Threats Analysis.

Discussion

The WVCS proposes a strategy for protecting and recovering depressed populations of the valley's sensitive native wildlife through the establishment of networks of grassland, oak woodland, and riparian core habitats to be managed primarily for their wildlife values. Concentrating land-based conservation actions within select areas of the valley provides an opportunity to reestablish core habitat areas with enough room and the proper management needed to facilitate population growth and recovery. This would address two of the main factors ODFW (2006, 2016) cites as limiting the populations of sensitive native wildlife in the valley: (1) habitat loss and fragmentation leading to small, disjunct populations, which are at increased risk of extirpation and (2) management conflicts during critical nesting seasons for migratory birds. Concentrating land protection actions in select areas potentially addresses both issues.

The select areas–the PCAs–are almost entirely a subset of Conservation Opportunity Areas (COAs) identified by ODFW (2016). ODFW identified COAs because "*focusing investments on priority landscapes can increase likelihood of long-term success over larger areas, improve funding efficiency, and promoting cooperative efforts across ownership boundaries. Conservation Opportunity Areas are landscapes where broad fish and wildlife conservation goals could best be met. Working in these landscapes can increase the effectiveness of conservation actions at larger scales than can individual projects scattered about the state*" (ODFW 2006). As the PCAs are embedded within ODFW COAs, the COAs delineate potential corridors for terrestrial wildlife movement. The Oregon Conservation Strategy (ODFW 2006) identifies many tools and actions individual landowners can use to maintain or enhance wildlife permeability on their properties.

The PCAs were selected based on the habitat types present and because there are recent documented occurrences of the targeted wildlife species within them, many likely representatives of the small and disjunct populations ODFW (2006) describes. With suitable habitat of sufficient size, distribution, and appropriate management, over time, these small and disjunct populations can grow into larger, connected, and more secure populations. These larger populations can then become sources of individuals to shore up other small and disjunct populations or to establish new populations in nearby but generally unoccupied suitable habitat. Concentrating land protection actions in select areas provides the vehicle to achieve this end as the amount of land thought necessary to recreate core grassland, oak woodland, and riparian habitats is not trivial and protection of individual smaller properties in close proximity to each other can contribute to the creation of larger core patches.

Embedding networks of variable-sized conservation reserves within the matrix of other land uses can also act as a buffer to the effects of climate change by minimizing the distance among reserves to facilitate species migrations (Heller and Zavaleta 2009). Distributing reserves across the landscape also helps safeguard the targeted species against natural catastrophes that could eliminate them from reserves in close proximity to each other and helps conserve the genetic and ecological variation that occurs in species and plant communities across their range (Akçakaya 2000, Bull et al 2007, Groves et al 2002, Lande 1993, Margules and Pressey 2000).

This study provides a blueprint for restoring a landscape structure favorable for sensitive native species of the major habitat types of the valley, but does not address other habitat types such as coniferous forests, instream habitats, or other specialized and local habitats as described by ODFW (2006), all of which deserve conserving. Providing habitat for the WVCS targeted species outside of the PCAs, will of course also be necessary, as those species occur beyond the PCAs. Nevertheless, we believe that working together whenever possible to concentrate land-based conservation actions in close proximity to each other inside the PCAs to create blocks of secure habitat that are distributed across the valley is an important component to the recovery of many of the valley's declining native and sensitive species.

The work being accomplished by The Nature Conservancy, Greenbelt Land Trust, and the Tualatin Basin Partners Work Group provides examples from among the many ongoing efforts in the valley of how this strategy is already being implemented. In cooperation with local landowners, The Nature Conservancy is working to create significant blocks of wildlife habitat and a connectivity corridor from the Yamhill Oaks COA/PCA to Baskett Slough NWR by concentrating its land protection efforts in a few key areas.

By combining TNC's efforts with existing NRCS Wetland Reserve Program easements, a significant grassland/oak core habitat patch is taking shape in the Willamina Oaks COA/PCA. Likewise, Greenbelt Land Trust's efforts at adding to its Bald Hill Farm holding in the Corvallis Forest and Balds COA/PCA is resulting in a significant area of grasslands and oak woodlands that individual purchases could not create alone. Greenbelt Land Trust is not only providing significant wildlife benefits, but creating a nearby access point to nature enjoyed by the residents of Corvallis and the surrounding area.

The Tualatin Basin Partners Work Group, currently comprised of Metro, Clean Water Services, The Intertwine, The Wetlands Conservancy, Columbia Land Trust, and the Service, is focusing conservation efforts along the Tualatin River in an area characterized by relatively small lots. Protection of individual lots in close proximity to each other is resulting in wildlife benefits far greater than the individual pieces could provide alone. Metro is working to secure a wildlife corridor linking Chehalam Ridge to the Wapato Lake NWR. The Work Group is working toward a watershed with clean rivers and streams, robust natural areas, healthy and abundant fish and wildlife populations, and an opportunity for the 2.2 million residents of the Portland-Vancouver-Hillsboro metropolitan area to enjoy and connect to nature. These are a few examples of many conservation organizations which represent many ongoing efforts in the valley that demonstrate how focusing land-based conservation actions in select areas can result in benefits far greater than the sum of the parts.

Recommendations

1. **Complete the network engaging as many partners as possible.**

The partnership approach, long practiced in the valley, is by far and away the best path forward to build upon the lands presently conserved within the PCAs to complete the network. The Strategic Conservation Management in Oregon's Willamette Valley (USFWS 2014) identified many partners that are or could be engaged in reversing the declines of native habitats and species. This includes other federal, state, and local governmental agencies; non-governmental organizations; and most importantly, local landowners. Continuing to build and ultimately completing the conservation network will require contributions from as many partners as possible.

Maintaining close coordination with the Oregon Department of Fish and Wildlife will be critical to the long-term success at developing the network. As the State agency, whose mission is "*to protect and enhance Oregon's fish and wildlife for use and enjoyment by present and future generations*," it is essential that ODFW and the Service be committed to common goals and strategies for restoring the valley's native wildlife and plants.

The WVCS was largely based on achieving the goal of the Oregon Conservation Strategy which is "*to maintain healthy fish and wildlife populations by maintaining and restoring functioning habitats, preventing the declines of at-risk species, and reversing declines in these resources where possible*" (ODFW 2006). Implementing conservation strategies described in this study in lock-step with ODFW is the surest path to success.

The Coalition of Oregon Land Trusts (COLT) is the only association of land trusts in Oregon. COLT focuses on improving and advancing land conservation in the state through increased land trust capacity and coverage, and engagement of stakeholders. With a core value of cooperative partnerships with private landowners, public agencies, and community leaders to achieve land trust goals, COLT and its member organizations is a vital partner in conservation delivery and their participation in developing the network is crucial to successful implementation.

Emerging partnerships such as the Tualatin Basin Partners Work Group and the Pacific Birds Habitat Joint Venture Prairie-Oak Bird Initiative, to name but a few, should also be supported. As noted above, the Tualatin Basin Work Group is developing a coordinated strategy for long-term habitat protection, restoration, and public access along the Tualatin River. The Pacific Birds Habitat Joint Venture is launching a Prairie-Oak Bird Initiative that will address the long-term conservation of prairie-oak birds in the Cascadia ecoregion. The Service should be a key player in these and the many other conservation-based initiatives in the valley.

2. **Develop a plan to implement WVCS findings.**

The Service will use the results of the WVCS to develop a plan to implement aspects of the WVCS best suited for the Service to implement. The plan would include a range of implementation alternatives to be analyzed through a public planning process. The alternatives will present how and where the Service could compliment the work of its partners by identifying areas of the valley where the Service would work with interested landowners wishing to voluntarily collaborate on the conservation of Service Trust resources. The Service calls this process Land Protection or Conservation Planning - which can result in the delineation or description of areas approved for NWRS land protection (conservation) actions, such as acquisition, easements or agreements. It is the long standing policy of the Service to only acquire real property interests on a willing seller basis. The Service will engage local communities and seek public comments on the alternatives.

3. **Evaluate lands for their nature-based recreational and educational opportunities.**

Expanding opportunities for nature-based recreational and educational opportunities is a goal of ODFW, The Intertwine, Rivers to Ridges, COLT, the Service, and many other conservation partners in the valley. Along with evaluating the wildlife values of each parcel offered for protection, an analysis of the site's potential for providing public access to nature-based recreational and educational opportunities should be completed. Parcels that could provide such opportunities should be prioritized over a parcel with similar wildlife values, but without those opportunities.

4. **Incorporate WVCS results into other Service programs.**

The PCAs developed through the WVCS represent the Service's highest priority areas of the valley within which to conduct land-based conservation actions for the benefit of the valley's native wildlife and plants. The Service is creating a cross-programmatic Willamette Valley Landscape Conservation work plan that shows how (and helps us plan how) our combined activities connect to our conservation objectives for the valley. Through this effort, the Service should prioritize landowner assistance and funding opportunities to properties within the PCAs. These programs include the Partners for Fish and Wildlife, Wildlife and Sport Fish Restoration Program, Cooperative Endangered Species Conservation Fund grants (section 6 of the ESA), Habitat Conservation Planning Assistance, and on-going refuge management programs, among others.

5. **Continue to engage in local conservation planning and implementation efforts.**

Local conservation planning efforts are taking place across the Willamette Valley, through Counties, watershed councils, land trusts, and other NGOs. The Service has, and should continue to support these efforts. While each group has its own set of priorities and mandates, typically these efforts share a common goal of restoring and preserving wildlife habitat. The Service should continue its history of engagement in these planning efforts as it has recently done with other conservation partners in Yamhill County, the Lower Calapooia-Santiam, and the Lower North Santiam to look for common ground in each effort's unique goals and objectives to see where there is overlap with the goals and objectives of the WVCS. Common ground leads to coordinated actions.

6. **Develop and facilitate a conservation communication network.**

Several organizations in the Willamette Valley provide communications related to wildlife conservation activities, such as restoration projects, volunteer opportunities, and wildlife-oriented recreation. Forming a "Community of Practice" and network related to conservation communications would contribute to creating and delivering more effective, visible, and clear conservation communications. This network could amplify conservation needs and public opportunities to get involved in programs that are of interest. The Service recommends that a Conservation Communication Network be created for conservation communicators in the valley that would collaborate to craft strategies and messages for both traditional media and evolving social media.

7. **Cooperatively develop Canada Goose management strategies.**

The Service will continue to engage with relevant parties such as ODFW, the Pacific Flyway Council, USDA Natural Resource Conservation Service, Pacific Birds Habitat Joint Venture, Oregon Farm Bureau, Oregon Association of Conservation Districts, Soil and Water Conservation Districts, private landowners, and others to identify and develop land management strategies to support and manage wintering geese and reduce goose depredation impacts to producers. The Service should also continue to coordinate with ODFW on Canada goose hunt program within the Northwest Permit Zone.

8. **Employ every tool in the Service's conservation toolbox.**

Listed below are a variety of habitat conservation tools available to the Service that could be employed to meet the goals and objectives of this study. Should a land protection plan be adopted, it is the policy of the Service to acquire interests in land only from property owners wishing to work with the Service. Landowners within an approved acquisition boundary who do not wish to sell an interest in their property are under no obligation to do so. In all acquisitions, the Service is required by law to offer 100 percent of fair market value, as determined by an approved appraisal that meets professional standards and Federal requirements.

Donations. A donation is a gift of land received from a non-Federal source without consideration or an exchange of value.

Cooperative Management Agreements. The Service can enter into cooperative agreements with other organizations and landowners to improve wildlife habitat management. Cooperative agreements may specify shared responsibilities, or a transfer of funds from the Service to another entity or vice-versa for management purposes. Cooperative agreements may be applied to land under any type of ownership in the valley. The Partners for Fish and Wildlife program is an example of a successful conservation program that relies on Cooperative Agreements.

Conservation Easements. Conservation easements are a type of acquisition where the landowner permanently transfers some, but not all, property rights to the Service as specified by mutual agreement. Under a conservation easement, a landowner would still hold title to the land with certain restrictions on his/her use of that land, spelled out in the easement language. The Service can acquire easements through purchase, donation, or exchange, depending on the terms of the easement. The property owner pays any applicable property taxes.

Fee Title Acquisition. A fee title interest is normally acquired when (1) the fish and wildlife resources on a piece of property require permanent protection that is not otherwise available; (2) the property is needed for development associated with a public use; (3) a pending land use could otherwise harm wildlife habitats; or (4) purchase is the most practical and economical way to assemble small tracts into a manageable unit. Fee title acquisition transfers any property rights owned by the landowner, including mineral and water rights, to the Federal government. A fee title interest may be acquired by purchase, donation, or exchange.

Candidate Conservation Agreements with Assurances. Candidate Conservation Agreements with Assurances (CCAAs) are formal agreements between the Service and one or more parties to address the conservation needs of proposed or candidate species, or species likely to become candidates, before they become listed as endangered or threatened. Landowners voluntarily commit to conservation actions that will help stabilize or restore the species with the goal that listing will become unnecessary. The goal is that actions taken under a CCAA can preclude the need for federal listing. Although a single property owner's activities may not eliminate the need to list, conservation, if conducted by enough property owners throughout the species' range, can eliminate the need to list.

CCAAs may benefit landowners in several ways. First, if the actions preclude listing, the landowner is not regulated by the Endangered Species Act. Second, if the conservation actions are not sufficient and the species is eventually listed, the CCAA automatically becomes a permit authorizing the landowner incidental take of the species. Thus, the CCAA provides landowners with assurances that their conservation efforts will not result in future regulatory obligations in excess of those they agree to at the time they enter into the Agreement. Third, for landowners who want to conserve the species or want to manage habitat on their land, CCAAs provides an avenue to federal or state cost-share programs.

Safe Harbor Agreements. A Safe Harbor Agreement (SHA) is a voluntary agreement involving private or other non-Federal property owners whose actions contribute to the recovery of species listed as threatened or endangered under the Federal Endangered Species Act. In exchange for actions that contribute to the recovery of listed species, participating property owners receive formal assurances from the Service that if they fulfill the conditions of the SHA, the Service will not require any additional or different management activities by the participants without their consent.

Conclusion

The Oregon State of the Environment 2000 report (OPB 2000) issued a challenge to the residents of the Willamette Valley, noting that development over the past 150 years had fueled economic growth, but had come at a cost to the valley's natural environment. The challenge is to improve the ecological health of the valley while continuing economic growth and development. With rapid growth in the Willamette Valley projected, the time is now to address this challenge–to restore and maintain a network of lands across the landscape that will assist in recovering the valley's native fish, wildlife, and plants, while supporting the economic viability of the valley's working landscapes. The future is not inevitable, but rather, what Oregonian's choose to create together.

Oregon residents appear to be up for the challenge. A 2016 survey of Oregonians regarding their attitudes toward fish and wildlife, conducted for the Oregon Legislative Task Force on Funding for Fish, Wildlife, and Related Outdoor Recreation and Education (Responsive Management 2016) found strong support for fish and wildlife conservation in Oregon. Rating on a scale of 0 (not important) to 10 (extremely important), Oregon residents rated strong support for healthy fish and wildlife populations (9.5); for natural areas to exist for enjoying and experiencing nature (9.4); and for ecologically important habitats and lands in Oregon being protected and conserved (9.0). The Service shares and supports these values.

The WVCS identifies important areas within which to conserve, protect, enhance, and manage areas for their wildlife values to improve the ecological health of the valley. The Service is committed to working with all parties to address the critical challenge posed by Oregon's governors in 2000, to improve the ecological health of the valley while continuing economic growth and development for the benefit of today's and future generations of valley residents.

This document continues on the next page.

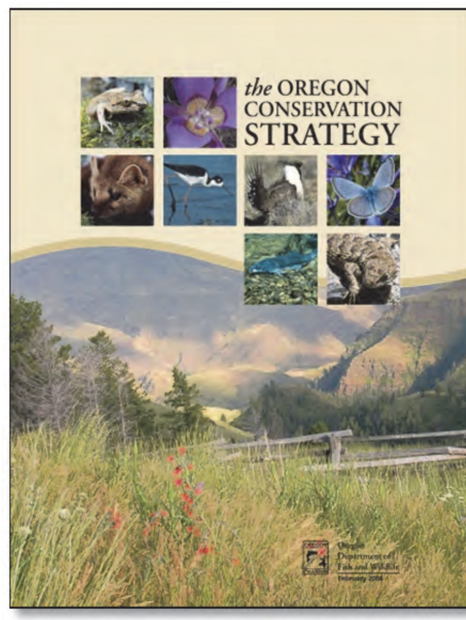
Appendix A. Willamette Valley Conservation Plans

Introduction

There is a long history of conservation planning in the Valley. A review of plans such as the Oregon Department of Fish and Wildlife's Oregon Conservation Strategy (ODFW 2006), the Northwest Power and Conservation Council's (NPCC) Willamette Subbasin Plan (NPCC 2004), the Willamette Restoration Initiative's Willamette Restoration Strategy (WRI 2001), the Pacific Northwest Ecosystem Research Consortium's Willamette River Planning Atlas (Hulse et al. 2002), the American Bird Conservancy's Conservation Strategy for Landbirds in Lowlands and Valleys of Western Oregon and Washington (Altman 2001), the Oregon Biodiversity Project (Defenders of Wildlife 1998), and others reveal a variety of conservation issues as well as opportunities to address the issues.

The Oregon Conservation Strategy

The U.S. Fish and Wildlife Service (USFWS) asked each state to develop a wildlife action plan as part of the State Wildlife Grants Program. In Oregon, that plan is known as the Oregon Conservation Strategy (ODFW 2006). The Oregon Conservation Strategy (OCS) synthesized existing plans, scientific data, and local knowledge into a broad vision and conceptual framework for long-term conservation of Oregon's native fish, wildlife, and habitats. It identified six key conservation issues that affect species and habitats across the state:



- Land use changes;
- Invasive species;
- Disruption of disturbance regimes;
- Barriers to animal movement—aquatic passage and terrestrial corridors;
- Water quality and quantity; and
- Institutional barriers to voluntary conservation.

Climate change has recently been added as a seventh key conservation issue and will be addressed in the second edition of the OCS which is in the process of development.

The OCS notes that land use changes, whether from conversion of native habitats to agriculture or agriculture to more urban uses, results in the direct loss of habitat and an increase in habitat fragmentation, as well as the disruption of natural disturbance regimes such as fire and floods. The disruption has further exacerbated the loss of rare and declining habitats such as upland prairie and riparian bottomland forests that depend on periodic disturbance to maintain themselves on the landscape.

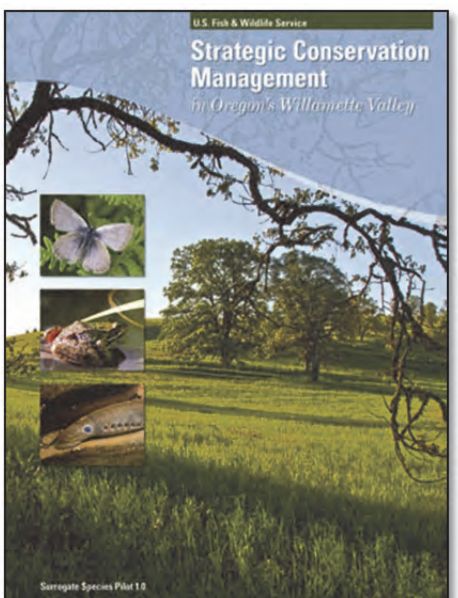
Invasive species cause numerous negative biologic and economic problems. Invasive species can negatively impact food-chain dynamics, degrade habitat conditions, increase the risk of wildfire, and reduce the economic output of private woodlots, farms, and ranches. Invasive species are the second-largest contributing factor of native species becoming at-risk of extinction in Oregon (ODFW 2006).

Barriers to animal movement affect terrestrial species in many ways. Barriers may prevent animals from seasonally tracking food resources or moving between breeding, rearing, and wintering grounds. Barriers may also block daily movements between habitat areas and a water source. The range of many species is currently changing in response to climate change (Chen et al. 2011). Barriers to newly suitable habitat may lead to local extirpations if a species is left in an area no longer suitable.

As the OCS points out, water quality and quantity are inseparable issues. Adequate flows of cool, well-oxygenated water are directly related to healthy populations of anadromous salmonids and resident fish such as the ESA-listed bull trout (USFWS 1999). This issue may become an even greater priority in the future as a changing climate may affect both the timing and quantity of runoff, leading to reduced summer base flows and warmer stream temperatures (OCCRI 2010).

The OCS contains a suite of goals and actions to address the six key conservation issues relevant to this study, which include:

- Action 1.1. Conserve strategy habitats using voluntary, nonregulatory tools such as financial incentives, conservation easements, landowner agreements, and targeted acquisitions.
- Action 1.2. Encourage strategic land conservation and restoration within conservation opportunity areas.
- Action 1.5. Support local land use plans and ordinances that protect farm and forest lands and other fish and wildlife habitats in urban and rural areas.
- Action 4.2. Maintain and restore habitats to ensure aquatic connectivity and terrestrial corridors in priority areas, such as conservation opportunity areas and urban centers.
- Action 4.6. Identify, maintain, and restore important stopover sites for migratory birds.
- Action 6.3. Improve coordination and delivery of incentive programs to more effectively serve landowners and more strategically address the needs of strategy species and habitats.



Strategic Conservation Management in Oregon's Willamette Valley

The Service's Strategic Conservation Management in Oregon's Willamette Valley (USFWS 2014) initiated a surrogate species approach to conservation. This pilot project identified 10 species to represent the valley's five key habitat types identified by the OCS (ODFW 2006). Some of the species were selected to provide insight regarding the status of other species (e.g., Bradshaw's lomatium and Fender's blue butterfly). Other surrogates (Oregon white oak, black cottonwood, and American beaver) were selected because they represent or determine overall habitat conditions and inferences on other species can be made based on the status and trends of the surrogates. Other species, such as western meadowlark and Pacific lamprey, were selected because they are iconic species and can be used to engage the public and motivate conservation actions. Preliminary biological objectives and priority conservation and monitoring objectives were developed for each selected species. Partners are now engaged in those actions.

Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington

The US Fish and Wildlife Service and cooperating partners developed the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (USFWS 2010). The plan outlines recovery actions for the five listed species at the time Fender's blue butterfly (*Icaricia icarioides fenderi*), Willamette daisy (*Erigeron decumbens*), Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*), Bradshaw's lomatium (*Lomatium bradshawii*), and Nelson's checker-mallow (*Sidalcea nelsoniana*). Each of these species is threatened by the continued degradation, loss, and fragmentation of their native prairie ecosystems. The strategy proposed to achieve recovery of these species is to restore and maintain multiple functional networks of prairie habitat capable of supporting viable populations of each species by protecting, restoring, maintaining, and connecting the remaining fragments of prairie habitats or areas with potential for restoration to prairie habitats within their historical range.

National Wildlife Refuge Comprehensive Conservation Plans

The US Fish and Wildlife Service and cooperating partners developed Comprehensive Conservation Plans (CCPs) for the Willamette Valley NWR Complex (W. L. Finley, Ankeny, and Baskett Slough) in 2011 and for the Tualatin River NWR Complex (Tualatin River and Wapato Lake) in2013. The purpose of each CCP is to specify a management direction for each NWR for the subsequent 15 years. The goals, objectives, and strategies for improving Refuge conditions – including the types of habitats at each Refuge, partnership opportunities, and management actions needed to achieve desired future conditions. The CCP for the Willamette Valley NWR Complex is available at https://www.fws.gov/refuge/William_L_Finley/what_we_do/conservation.html. The Tualatin River NWR Complex CCP is available at https://www.fws.gov/refuge/Tualatin_River/what_we_do/planning.html

US Fish and Wildlife Service Partners for Fish and Wildlife Five-Year Strategic Plan

The Partners for Fish and Wildlife Program initiated work within the Willamette Valley in 1998 with a focus on restoring wetlands close to the existing National Wildlife Refuges. Based upon these initial successes, the program has grown significantly, and has enrolled approximately 250 sites into the program across six counties within what is now referred to as the Willamette Valley Focus Area. In addition to working on a broader geographic scale, the program has broadened its ecological focus from just wetlands to all the historic habitat types of the Willamette Valley with a strong emphasis on sites occupied by federally listed threatened and endangered species. This work has involved not only private landowners, but numerous other local, state, federal, and non-governmental conservation organizations allowing the Partners Program to cost effectively leverage the Service investment, allowing the Program to further the conservation of the valley's native habitats. The Partners for Fish and Wildlife Five-Year Strategic Plan Five-Year Strategic Plan anticipates that the Partner's Program will remain in the vanguard of a coordinated cross-programmatic intra-Service collaborative effort to work with myriad conservation partners throughout the Willamette Valley in the years ahead.

Oregon State of the Environment Report 2000

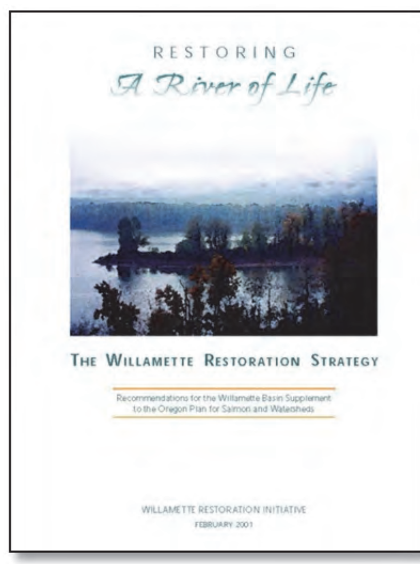
The Oregon State of the Environment 2000 report (OPB 2000) was the first scientifically credible, comprehensive assessment of Oregon's environment. It was developed by a panel of scientists from universities throughout Oregon and was signed by the former governors living at that time (Hatfield (R), Straub (D), Roberts (D), Atiyeh (R), Goldschmidt (D), and Kitzhaber (D)). The Science Panel found that while Oregon had made great strides in resolving some of the critical problems of the past, the State still faces environmental challenges that existing programs and policies may not be sufficient to address. That list of issues included loss of wetlands, degraded riparian areas, depleted fish stocks, and diminished biodiversity.

Specific to the Willamette Valley, the report noted that an estimated 72 percent of the original riparian and bottomland forest is gone, as well as an estimated 99 percent of the valley's wet prairies, 88 percent of upland prairies, and 87 percent of the upland forests at the margins of the valley. The report concludes that this transformation of the valley's landscape "has fueled our economic growth and settlement for over 150 years. Yet this transformation has left a mark on our environment and a debt to pay" (OPB 2000).

Willamette Subbasin Plan

As part of the Columbia River Basin Fish and Wildlife Program, the Northwest Power and Conservation Council (NWPCC) prepared the Willamette Subbasin Plan (NWPPC 2004). Subbasin plans identify priority restoration and protection strategies for habitat and fish and wildlife populations. The Willamette Subbasin Plan identified habitat conversion and human manipulation of channel structure and hydrology as over-arching conservation-related issues in the valley. In the aquatic realm these modifications have blocked access to spawning areas, simplified channels which now lack complex habitat structures required by salmonids, reduced water quality, and changed discharge patterns all of which have resulted in reduced native fish populations. Upland habitat conversion has reduced the extent of native habitats and greatly reduced the abundance of native wildlife. The Plan recommended the following seven priority conservation actions for the subbasin.

- Deal with the dams—change flow regimes and establish fish passage.
- Fix culverts and diversions to allow fish passage.
- Focus on valley and foothills wildlife.
- Restore lowland riparian areas.
- Restore low-cost, high-return areas of the Willamette River floodplain.
- Let the river cool itself by seeping through streamside gravels, alcoves, and islands.
- Ensure that all priority themes above are taken up and supported in an organized way at the local level.

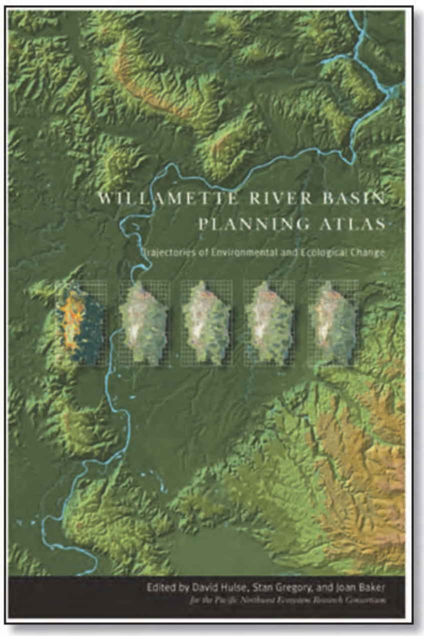


The Willamette Restoration Strategy

The Willamette Restoration Strategy (WRI 2001) was developed by the Willamette Restoration Initiative (WRI), which was established by State Executive Order 98-18, and charged with developing a basin-wide strategy to protect and restore fish and wildlife populations, enhancing water quality, and properly managing floodplains within the context of human habitation and continued growth. The strategy identified many conservation issues in the basin including declining fish and wildlife populations, toxins and wastes in waters, undependable water supplies, and continued habitat destruction. The strategy points out that many natural resources are being used beyond their ability to replenish themselves and population growth and development continue to put pressure on the land and water.

The strategy identified 27 actions to restore the health of the Willamette basin grouped into four focus areas: clean water, water quantity, habitats and hydrologic processes, and institutions and policies. The recommended actions include establishing science-based riparian area protection guidelines; inventorying, mapping, and conserving priority fish and wildlife habitats in the basin; and recognition of the need to create new stewardship pathways for private landowners through agreements and incentives.

Willamette River Planning Atlas



With an additional 1.7 million people expected to live in the Willamette River basin by 2050, the Pacific Northwest Ecosystem Research Consortium (PNERC) developed the Willamette River Planning Atlas (Hulse et al. 2002) which analyzed three future scenarios to depict a plausible range of growth alternatives in the Willamette basin. The alternatives range from more conservation-oriented to more market-oriented. The atlas documented many conservation issues in the valley including significant alterations to river channels and loss of off-channel habitats and floodplains, changes in the timing and quantity of stream discharge, degraded water quality, declines of fish and wildlife populations related to habitat loss, introduced species, contaminants, and direct human disturbance.

The three scenarios modeled in the atlas are Plan Trend, Conservation, and Development. The Plan Trend scenario assumes existing long-term land development plans and policies will be fully implemented. The Development scenario assumes greater emphasis on short-term economic gain in making land and water use decisions and assumes relaxation of land use laws, resulting in fewer restrictions on where intensive land management may occur. The Conservation Scenario projects changes in land and water use patterns to prioritize conservation and ecological restoration.

The land conservation scenario is one of the most significant actions identified in the atlas. The atlas describes lands to be conserved to achieve a naturally functioning landscape and lands to be managed for sustainable production of goods and services compatible with habitat conservation values.

The goal of the PNERC is to: "Understand ecological consequences of possible societal decisions related to changes in human populations and ecosystems in the Pacific Northwest and to develop transferable tools to support management of ecosystems at multiple spatial scales."

Regional Conservation Strategy for the Greater Portland-Vancouver Region

The Intertwine Alliance, a broad coalition of public, civic, private, and nonprofit organizations, developed the Regional Conservation Strategy for the Greater Portland-Vancouver Region (The Intertwine Alliance 2012a) and the companion document, the Biodiversity Guide for the Greater Portland-Vancouver Region (The Intertwine Alliance 2012b) to build a common understanding of the biodiversity of the 3,000 square mile region, define the challenges facing local wildlife and ecosystems, and to offer a vision and framework for protecting and restoring the region's natural systems.

Among the many strategic actions proposed by The Intertwine Alliance, the following are included conserve high-priority lands and protect existing natural areas, protect and acquire biodiversity corridors and core habitats, increase farm and forestland easements to prevent conversion to other uses and support the long-term economic viability of local farm and forestland, restore ecological processes and functions in natural areas, monitor changing conditions and conduct appropriate research, and involve citizens in protecting and managing natural areas. Specifically, the strategy calls for the expansion of the existing natural areas network, by formally conserving or protecting existing intact natural lands and lands with a high restoration potential, and by creating an interconnected system of natural areas, semi-natural areas, and sustainably managed working lands that together can serve multiple purposes and provide multiple functions.

Northern Pacific Coast Regional Shorebird Plan

The Northern Pacific Coast Regional Shorebird Plan (Drut and Buchanan 2000) is one of 11 regional plans tiered to the U.S. Shorebird Conservation Plan, 2nd edition (Brown et al. 2001) reflecting major shorebird flyways and habitats in the United States. The plan notes that the central and southern parts of the Willamette Valley are of regional importance, containing a variety of shorebird habitats, both wetland and agricultural, which support a wide diversity of species and large number of individuals. The Willamette Valley supports flocks of dunlins and common snipes and appears to be the most important wintering area for killdeers in the Pacific Northwest (Paulson 1993). All three are identified as species of high conservation concern due to either declining populations and/or the significance of the valley to the species.

The plan's habitat objectives and management needs for the Willamette Valley include acquisition or protection of agricultural and pasture lands adjacent to Ankeny, Baskett Slough, W.L. Finley, Wapato Lake, and Tualatin River National Wildlife Refuges and additional lands in the central and southern Willamette Valley; and areas adjacent to Jackson Bottom Wetland Preserve near Hillsboro.

Conservation Strategy for Landbirds in Lowlands and Valleys of Western Oregon and Washington

The American Bird Conservancy developed The Conservation Strategy for Landbirds in Lowlands and Valleys of Western Oregon and Washington (Altman 2001) to stimulate and support an active approach to conservation of landbirds in the lowlands and valleys of western Oregon and Washington. Its recommendations are intended to guide land managers' planning efforts and actions and expenditures of government and nongovernment organizations, and stimulate monitoring and research to support landbird conservation.

The plan identified two principal conservation issues affecting landbird populations throughout the Westside Lowlands and Valleys—habitat loss and degradation due directly or indirectly to an expanding population, and extensive private land ownership. Other issues identified include the change and degradation of presettlement vegetation patterns, resulting from the alterations of natural ecological disturbance regimes such as fire and flooding; intensification of farming practices; alteration of hydrological regimes, particularly in riparian habitats; habitat fragmentation; exotic and invasive species; logging oaks and cottonwoods; and other disturbance by humans. The plan proposed a landbird conservation strategy for the valley by protecting, restoring, and managing additional suitable habitat in proximity to existing population centers, providing habitat for dispersers to establish new subpopulations on newly restored habitat. This strategy was adopted by the WVCS.

Pacific Coast Joint Venture Implementation Plan for the Willamette Valley

The Pacific Coast Joint Venture (PCJV) Implementation Plan for the Willamette Valley (Roth et al. 2004) identifies habitat actions in support of four major bird conservation initiatives: the North American Waterfowl Management Plan, Partners in Flight Implementation Plans, the U.S. Shorebird Conservation Plan, and the North American Waterbird Conservation Plan.

The PCJV implementation plan identifies 15 target areas for habitat protection and restoration that provide important wintering and migrating habitat for waterfowl, waterbirds, shorebirds, and landbirds, as well as a suite of other sensitive species. These areas are primarily located along the mainstem of the Willamette River, around the confluence areas of the Willamette's major tributaries; adjacent to national wildlife refuges and Oregon's state wildlife areas and protected areas managed by other state or federal agencies, private nonprofit organizations, and local governments; and in areas with extensive hydric soils that have been converted to other uses.

Oregon Statewide Comprehensive Outdoor Recreation Plan

The State of Oregon's 2008-2012 Statewide Comprehensive Outdoor Recreation Plan (SCORP) entitled Outdoor Recreation in Oregon: The Changing Face of the Future (OPRD 2008), is the State's five-year plan for outdoor recreation. The purpose of the SCORP is to provide information and recommendations to guide federal, state, and local agencies, as well as the private sector, in making policy and planning decisions. The SCORP describes key planning issues such as fewer youth learning outdoor schools and an increasingly aging and diverse population, and makes recommendations to address these issues.

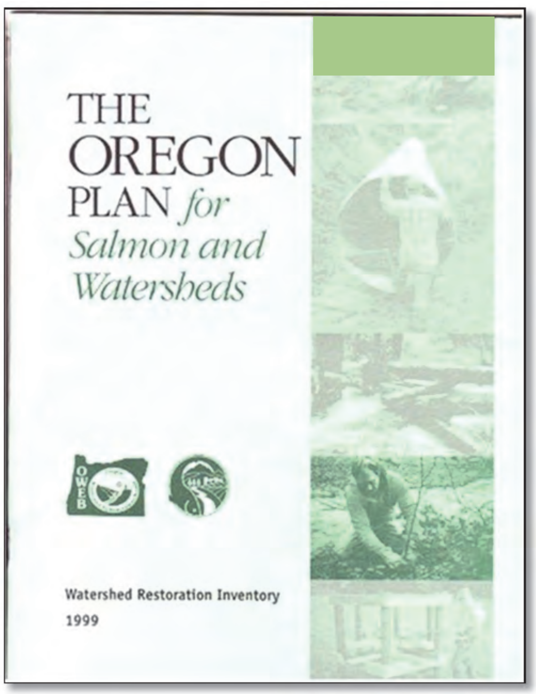
Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment

The Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment (Floberg et al. 2004) was a joint product of The Nature Conservancy, The Nature Conservancy of Canada, Washington's Department of Fish and Wildlife, and the Washington and Oregon Natural Heritage Programs. Similar to the U.S. Fish and Wildlife Service's Strategic Habitat Conservation process, the assessment identified conservation targets, set conservation goals for the targets, and identified most important places for conserving aquatic and terrestrial native species and habitats, including a suite of conservation opportunity areas (COAs) within the valley, by using a spatially-explicit decision support tool (SITES). The results of this project fed directly into the Willamette Valley Synthesis project; a description follows.

Oregon Biodiversity Project

The Oregon Biodiversity Project (Defenders of Wildlife 1998) was a collaborative effort between conservation groups, industry, and government agencies to reduce the risk of future endangered species designations, provide landowners more flexibility in resource management decisions, and establish a process to improve communication among diverse public and private interests. The project conducted an assessment of biodiversity conservation needs at the statewide and ecoregion levels, and identified the Willamette River floodplain, the north Corvallis area, and Muddy Creek (including Finley National Wildlife Refuge) as high priorities for landscape-scale conservation efforts.

Oregon Plan for Salmon and Watersheds



In 1995, the State of Oregon began developing what became known as the Oregon Plan. The original strategy, called the Oregon Coastal Salmon Restoration Initiative, was focused on recovery of coastal coho salmon and improvement of water quality statewide. In 1997, Oregon's Legislature expanded the plan's scope and renamed it the Oregon Plan for Salmon and Watersheds, or the Oregon Plan. The Oregon Watershed Enhancement Board (OWEB) implements the Oregon Plan through a grant program with the goal of restoring and protecting rivers and wetlands, to provide clean water and healthy habitat for native fish, wildlife, and people.

Within the Willamette Basin, OWEB has funded many projects to protect and restore rivers and adjacent riparian areas, improve fish passage, and conserve lands, such as assisting with the McKenzie River Trust's purchase of Green Island at the confluence of the McKenzie and Willamette rivers and the Greenbelt Land Trust's purchase of Harkins Lake in the Willamette River Floodplain. The Harkins Lake project is a great example of landowners coming together to work with our conservation partners within a voluntary, nonregulatory framework, to conserve and restore floodplain functions.

Willamette Valley Synthesis Project

Several of the plans we discussed produced spatially explicit recommendations for where conservation actions should be focused. Not surprisingly, a large degree of overlap exists between the various plans; however, there were significant differences as well. In total, the assessments identified nearly half of the area within the Willamette Valley Ecoregion as a priority for conservation. Responding to the need to get Willamette Valley conservation partners working from the same page, The Nature Conservancy (2012) synthesized these spatially explicit recommendations onto one map. In crafting the synthesis, the following assessments were considered.

- Oregon Conservation Strategy (ODFW 2006);
- Willamette River Basin Alternative Futures Analysis (Hulse et al. 2002);
- Willamette Valley—Puget Trough—Georgia Basin Ecoregional Assessment (Floberg et al. 2004);
- Critical habitat designations and recovery plans for listed species; and
- Oregon's Greatest Wetlands (The Wetlands Conservancy 2005).

This document continues on the next page.

Appendix B. Climate Change

Introduction

Human-driven global climate change is now well underway, with serious implications for a wide range of ecological processes, systems, and species (IPCC 2014). In Oregon, changes in streamflow timing and volume, shifts in timing of life cycle events, and other effects have already been documented, and are likely to intensify in the coming decades. Other probable effects of climate change in Oregon include increasing frequency and severity of wildfires and insect pest outbreaks, loss of estuarine habitat due to sea level rise, increases in harmful algal blooms and oceanic "dead zones," and more (OCCRI 2010). In order to help natural systems adapt to such stressors, resource managers need as much information as possible about likely impacts to particular species, systems, and places.

Climate Change Vulnerability Assessments (CCVAs) have become a key method for understanding these impacts and informing adaptation planning (Glick et al. 2011). CCVAs typically break up vulnerability into three major components: exposure, sensitivity, and adaptive capacity (Figure B1). Exposure represents the external threat to the target system, species, or place from changing climate; sensitivity represents intrinsic qualities that make the target more susceptible to negative impacts from climate change (e.g., a narrow suitable temperature range); and adaptive capacity represents the ability of the target to cope with climate change (Glick et al. 2011).

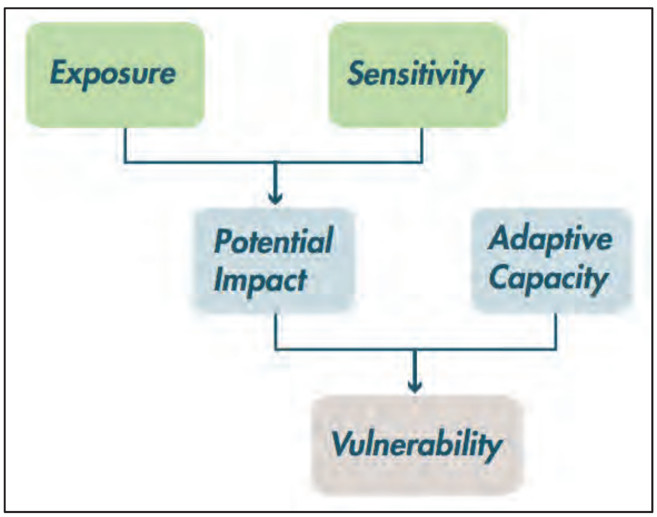


Figure B1. Primary components of climate change vulnerability, from Glick et al. 2011.

A few CCVAs that focused on or included the Willamette Valley have already been conducted. While these studies used an older generation of climate models (CMIP3 [Coupled Model Intercomparison Project Phase 3] rather than the more recent CMIP5), Knutti and Sedláček (2013) demonstrated that CMIP3 and CMIP5 outputs are remarkably similar when differences in emissions scenarios are accounted for, and that spatial climate change patterns in the two generations are very consistent. Because re-running existing analyses with CMIP5 instead of CMIP3 climate data would yield little new information, we chose not to prepare a new CCVA, but rather to summarize the most important existing research. If substantially improved climate projections become available in future years, then new CCVAs should be conducted.

The existing studies that are most relevant to the WVCS are the Pacific Northwest CCVA (PNWCCVA) developed by the University of Washington, which included a Willamette Valley case study (Michalak et al. 2013); The Oregon Climate Assessment Report (OCCRI 2010); and a CCVA for Oregon Conservation Strategy species and areas in the valley (Steel et al. 2011). These studies are summarized below in the "Previous Assessments" section.

Some other key studies describe how winter temperatures have already reduced average snowpack depth and shifted runoff timing and volume in the Willamette Valley, and show that this pattern is very likely to intensify in the coming decades (Chang and Jung 2010, OCCRI 2010). To estimate potential changes in annual flows, seasonal flows, and extreme flow events (both highs and lows) in the valley, Chang and Jung (2010) developed PRMS (Precipitation Runoff Modeling System) models of representative Willamette River sub-basins and calibrated them to a historic period (1973-2006). They then ran these models with future climate inputs from a combination of two emission scenarios and eight downscaled general circulation models (GCMs) for both the 2040s and the 2080s. The results show that the seasonal variation in streamflow will likely increase. Because of decreasing snow pack, increasing winter precipitation, and decreasing summer precipitation, winter flows will be heavier and summer flows lighter. The magnitude and statistical significance of these trends is greater in the higher greenhouse grass emission scenario.

A related study, based on the same PRMS models, showed that short-term (3-month) droughts will be increasingly likely in the lower elevation sections of Willamette Basin (Jung and Chang 2011). Using another hydrologic model, the VIC (Variable Infiltration Capacity) model, the University of Washington Climate Impacts Group also projected reduced summer and increased winter flows in the Willamette basin as the climate warms (OCCRI 2010). Tague et al. (2008) found that the reduced summer flow trend would likely be mitigated in some Cascade Mountain sub-basins with a large groundwater contribution to streamflow, but the WVCS study area is not among these. Additionally, the combination of decreased summer flow volumes and increased air temperatures will almost certainly lead to increases in summer water temperature (OCCRI 2010).

These probable changes in the freshwaters systems of the Willamette Valley could have profound impacts on a range of species, including aquatic insects, fish, and amphibians. Increased water temperatures could also make the Willamette River and its tributaries more vulnerable to invasive aquatic species.

Previous Assessments

University of Washington Climate Change Vulnerability Assessment

The University of Washington (UW) partnered with natural resource managers, scientists, and conservation planners from multiple organizations to conduct a CCVA for the Pacific Northwest. Their goal was to assess the relative (not absolute) vulnerability of species and ecological systems to climate change. The project had multiple components, including downscaling of global climate projections for the Pacific Northwest, models of suitable climate niches for various species under current and projected conditions, a climate sensitivity database for numerous species and ecological system, and models of potential vegetation type under various scenarios. As part of this study, UW conducted a case study for the Willamette Valley, focusing on how land managers could use the PNWCCVA data products to inform management decisions (Michalak et al. 2013). The findings from this document and from the larger study that are most relevant to the WVCS are summarized in Figure B2.

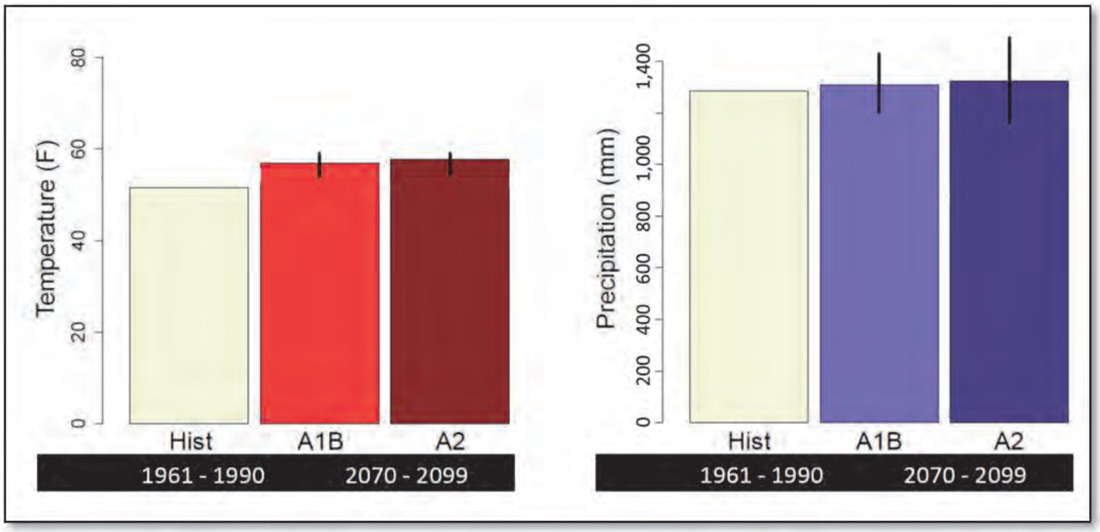


Figure B2. Projected changes in Mean Annual Temperature and Mean Annual Precipitation in the Willamette Valley. The black vertical bars show the 5-model range of projections. Figure modified from Michalak et al. 2013.

Downscaled Climate Change Projections

For the PNWCCVA, UW downscaled five general circulation models, or GCMs (CCSM3, CGM3, GISS-ER, UKMO-HadCM3, and MIROC3.2) using two emissions scenarios developed by the Fourth IPCC Assessment: A2, a relatively high emissions scenario, and A1B, a medium emission scenario (Nakicenovic et al. 2000). The results of these models show good agreement among climate projections for the Willamette Valley. All models agreed that average temperatures will increase in all seasons. Using projections from the ensemble mean based on the A2 (medium-high) emissions scenario, by the end of the century, the mean annual temperature in the Willamette is projected to increase by 6.2°F (individual model projections under the two emission scenarios ranged from 2.7 to 7.9°F by the end of the century).

There is less certainty regarding precipitation. Most (3 out of 5) models project increased annual precipitation, but two models project a decrease. Net annual precipitation based on the ensemble mean of all models is projected to increase 3 percent with individual model projections ranging from -9 percent to +16 percent by the end of the century. Seasonally, the majority of models project warmer, wetter winters and hotter, drier summers. All models consistently project drier summers and there is good agreement that the other three seasons will be wetter.

Species-specific Climate Envelope Models

Climate change puts species at risk by shifting their suitable climate envelopes outside of their current ranges. The magnitude of the risk depends on how quickly a species' climate envelope shifts and on its ability to respond to the change. A climate envelope model uses correlations between key climate variables and species occurrences to identify the region that currently has a suitable climate, then shows where that suitable region will shift to under various future climate scenarios (Araújo and Peterson 2012). Climate envelope models provide an estimate for the exposure aspect of the potential impact formula (Figure B1).

As a part of the PNWCCVA, UW developed climate envelope models for 366 terrestrial vertebrate species (Langdon 2013). Their Willamette Valley case study (Michalak et al. 2013) summarized the outcomes for several species of concern in the ecoregion, and found that relatively few significant changes are expected for those species in the valley (Table B1). A map of results for an example species, the western meadowlark, is shown in Figure 3. Overall, the results suggest that projected average climate changes do not exceed the range of average climate conditions currently tolerated by most of the priority conservation species in the valley. Results indicate stable conditions for Oregon white oak, western meadowlark, yellow-breasted chat, willow flycatcher, slender-billed white-breasted nuthatch, common nighthawk, American beaver, northern red-legged frog, and Townsend's big-eared bat. Only western red cedar and Oregon vesper sparrow showed a contracting envelope in the valley. Purple martins were modeled to expand their range in the valley.

Table B1. Climate niche model results for WVCS focal species.

Species Common Name	Projected Trend in the Willamette Valley
Oregon white oak	Stable in the valley, expanding upslope and east of Cascades
Yellow-breasted chat	Stable in the valley with expansion of range northward
Oregon vesper sparrow	Stable throughout much of its range and expanding to higher elevations but potentially contracting in the valley
Slender-billed white-breasted nuthatch	Stable in the valley and region
Western meadowlark	Stable in the valley and region

There are a few important caveats to these results. First, climate change may lead to increases in the frequency and severity of extreme weather events, such as heatwaves or flooding, and these climate models do not reflect that possibility. Second, these habitat suitability models do not include important ecological processes and interactions such as competition, dispersal, disease, and stochastic events such as fires. Finally, only two future climate models were used; a larger sample of GCMs would provide a fuller picture of the range of possible outcomes.

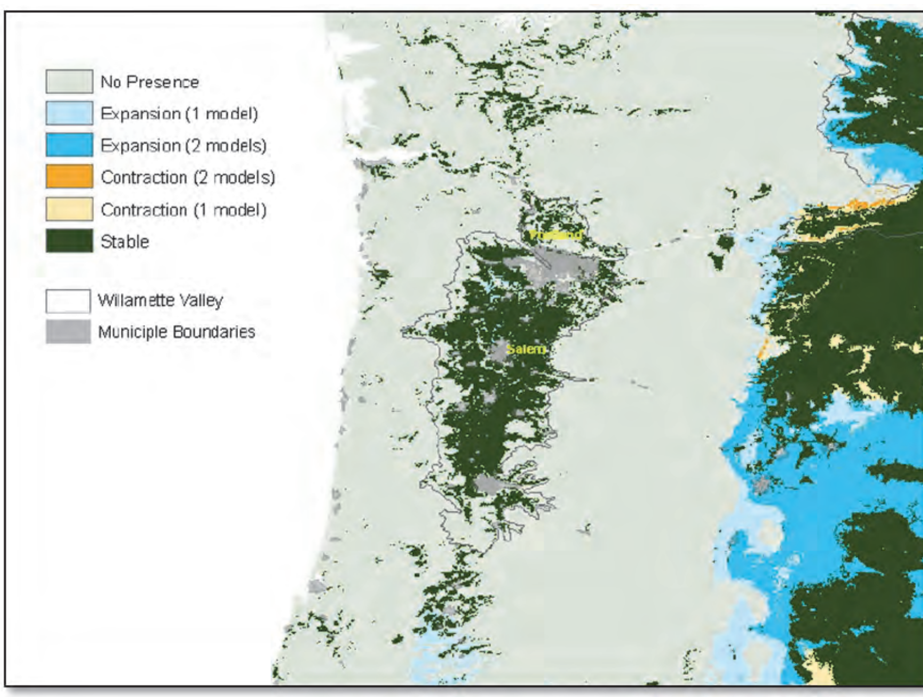


Figure B3. Climate niche modeling results for the western meadowlark. Most of the Willamette Valley was mapped as climatically suitable under both current and future conditions. Figure from Michalak et al. 2013.

Plant Functional Types Model

In contrast to the vertebrate climate niche models, results from the UW's mechanistic vegetation models suggest a much more dynamic future.

They simulated future potential vegetation under climate change in the Pacific Northwest using the Lund-Potsdam-Jena (LPJ) global vegetation model (Sitch et al. 2003). LPJ models the potential distribution of plant functional types (e.g., temperate forests or grasslands) rather than individual species. To do this, it simulates numerous mechanistic processes, such as competition, wildfire, and photosynthesis among other attributes.

Under mild climate change scenarios, the functional vegetation types in the region are projected to remain fairly stable, but with more extreme climate models, substantial shifts in vegetation are projected (Rogers et al. 2011). These changes are largely driven by an increase in summer water stress due to increased temperatures and reduced precipitation during summer, which leads to increases in major fires and thus allows for dramatic shifts in vegetation type. These potential fire-driven vegetation shifts may be avertable via active fuel load management and fire suppression as would likely happen in a developed landscape such as the Willamette Valley.

Land conversion to development and agriculture combined with Douglas fir encroachment has reduced the extent of oak woodlands to a fraction of their historical range (Larsen and Morgan 1998). The UW climate projections suggest that conditions may improve for this species in the Willamette Valley and even in some lower elevation areas adjacent to the Valley. If Douglas fir begins to die back due to increased summer drought or insect pest outbreaks, managers may be able to facilitate transformation to Oregon white oak and prairie systems (Bachelet et al. 2011).

Climate Sensitivity Database

Another relevant component of the PNWCCVA is the Climate Change Sensitivity Database (http://climatechangesensitivity.org/), which provides information about the inherent climate-change sensitivities of habitats and species of conservation concern in the Pacific Northwest. The database provides an estimate for the sensitivity aspect of the potential impact formula (Glick et al. 2011) (Figure B1). The database contains hundreds of records, including numerous species of concern within the Willamette Valley. As part of the ecoregion's case study, Michalak et al. (2013) highlighted several of these species (Figure B4**Error! Reference source not found.**). Two species of frogs have the highest sensitivity (along with relatively high confidence values for that vulnerability score) while many bird species are less sensitive.

There are a few key limitations to the sensitivity database. First, because empirical data on the sensitivities of many species are unavailable, many of the scores are based primarily on expert judgment and are dependent on untested assumptions. Also, the sensitivity database is not spatially explicit, and assumes that each species has a homogenous sensitivity to climate change within the Pacific Northwest.

While western bluebird was estimated to be *sensitive* to the effects of climate change, its climate envelope model suggests that the *exposure* component of the Glick et al. (2011) climate change vulnerability formula (Figure B1) may not be substantial, meaning that the *potential impacts* related to climate change may not be significant. This same situation applies to other species the database rates as sensitive to climate change. The climate envelope models suggest that the average projected climate change in the valley will not exceed the range of average climate conditions currently

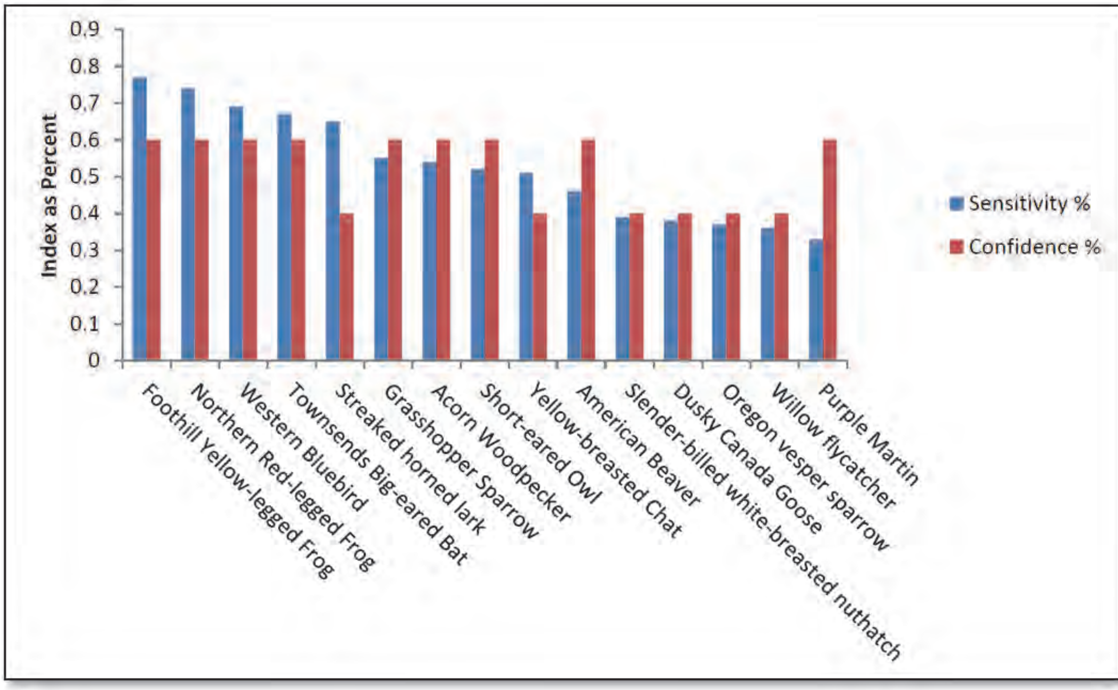


Figure B4. WV species of concern in the UW Climate Change Sensitivity Database. Blue bars indicate percent sensitivity (relative to the maximum possible score), and red bars indicate percent confidence in that score (relative to maximum possible). Figure from Michalak et al. 2013.

tolerated by northern red-legged frog, Townsend's big-eared bat, yellow-breasted chat, slender-billed white-breasted nuthatch, and others, even though they would sensitive to substantial climate changes should those changes occur.

Oregon Climate Assessment Report

The Oregon Climate Change Research Institute (OCCRI) is a network of over 100 researchers associated with the Oregon University System and its partner organizations. In 2007, OCCRI was asked to prepare an assessment of climate change knowledge in Oregon by the State Legislature (HB 3543). In 2010, they published a summary of climate science for the state that describes impacts that have already been documented, likely future effects of climate change, and current knowledge gaps (OCCRI 2010). Some of the assessment's key findings of greatest relevance to terrestrial systems in the Willamette Valley follow.

- Summers will be warmer and drier (the ensemble average decrease for summer precipitation is 14% by the 2080s).
- As warm, dry summers increase, forests of all types will be more susceptible to wildfire. In forests west of the Cascades that were historically too cool and moist to burn extensively, heavy fuels loads could drive large fires.
- Climate change will lead to shifts in the distribution and abundance of numerous species of animals and plants.
- Invasive species and insect pests may become more abundant.

University of California, Davis CCVA for the Willamette Valley

In consultation with the Oregon Department of Fish and Wildlife and the Defenders of Wildlife, a group of graduate students from the University of California, Davis assessed the relative climate change vulnerability of the valley's priority species and areas (Steel et al 2011) as defined by the Oregon Conservation Strategy (ODFW 2006). They scored 46 of the valley's 59 strategy species using the Climate Change Vulnerability Index developed by NatureServe (Young et al. 2010), and assessed the relative vulnerability of the valley's 27 COAs (as defined in ODFW 2006) using an index that combined climatic and nonclimatic stressors. They found that birds, on average, were the least vulnerable group of species, and that plants, fishes, and invertebrates tended to be the most vulnerable species in the valley. In their analysis of the COAs, they found that non-climatic factors such as human impact and invasive species had a more significant effect on the overall vulnerability score than did climate change. This suggests, as does Michalak et al. (2013) and Bachelet et al. (2011), that climate change may not be as severe in the valley as in some other areas, and that there are other critical issues that may need to be addresses first, or at least simultaneously.

Climate Change Velocity

Climate change velocity also suggests that, relative to other regions in Western North America (WNA), the Willamette Valley may experience less significant climate change impacts. Climate change velocity, first proposed by Loarie et al. (2009), represents the speed, in kilometers per year, at which an organism would have to move across the landscape in order to maintain constant climatic conditions, which is calculated using a combination of climate change and elevation data.

Climate change velocity is relatively high in areas with little topographic complexity, such as the central Columbia Plateau, because climate is consistent over large areas and organisms would have to travel long distances to find very different climatic conditions.

Conversely, in areas with high topographic complexity (i.e., mountain ranges), climate velocities are relatively low because local conditions change quickly with movement up slope or to different aspects. Near the peaks of mountains, however, the velocity can be extremely high because historical climatic conditions can entirely disappear from the mountain, requiring organisms to move to distant locations to find a suitable climate (Loarie et al. 2009).

Hamann et al. (2014) recently released a set of climate change velocity rasters for WNA using a refined algorithm as well as higher spatial resolution (1 km pixels) than was available in previous climate change velocity datasets. Figure B5 shows two of the Hamann et al. climate change velocity models over most of WNA, with the Willamette Valley outlined in black.

The panel on the left of Figure 5 shows climate change velocity based on 12 biologically relevant climate variables, while the panel on the right shows the velocity of mean annual temperature alone. In both cases, the Willamette Valley has a low exposure to climate change compared to other regions.

Table B2 shows the mean, minimum and maximum values across the entire extent of the datasets, as well as the mean for the Willamette Valley. For temperature climate change velocity, the WNA mean is 9.9 times higher than the valley average, and for multivariate climate velocity, the WNA mean is 3.7 times higher than the valley average. This dataset thus lends further support to the idea, suggested by the UW PNWCCVA, that many of the priority species and systems of the Willamette Valley are less vulnerable to climate change than those in other regions of the Pacific Northwest and WNA.

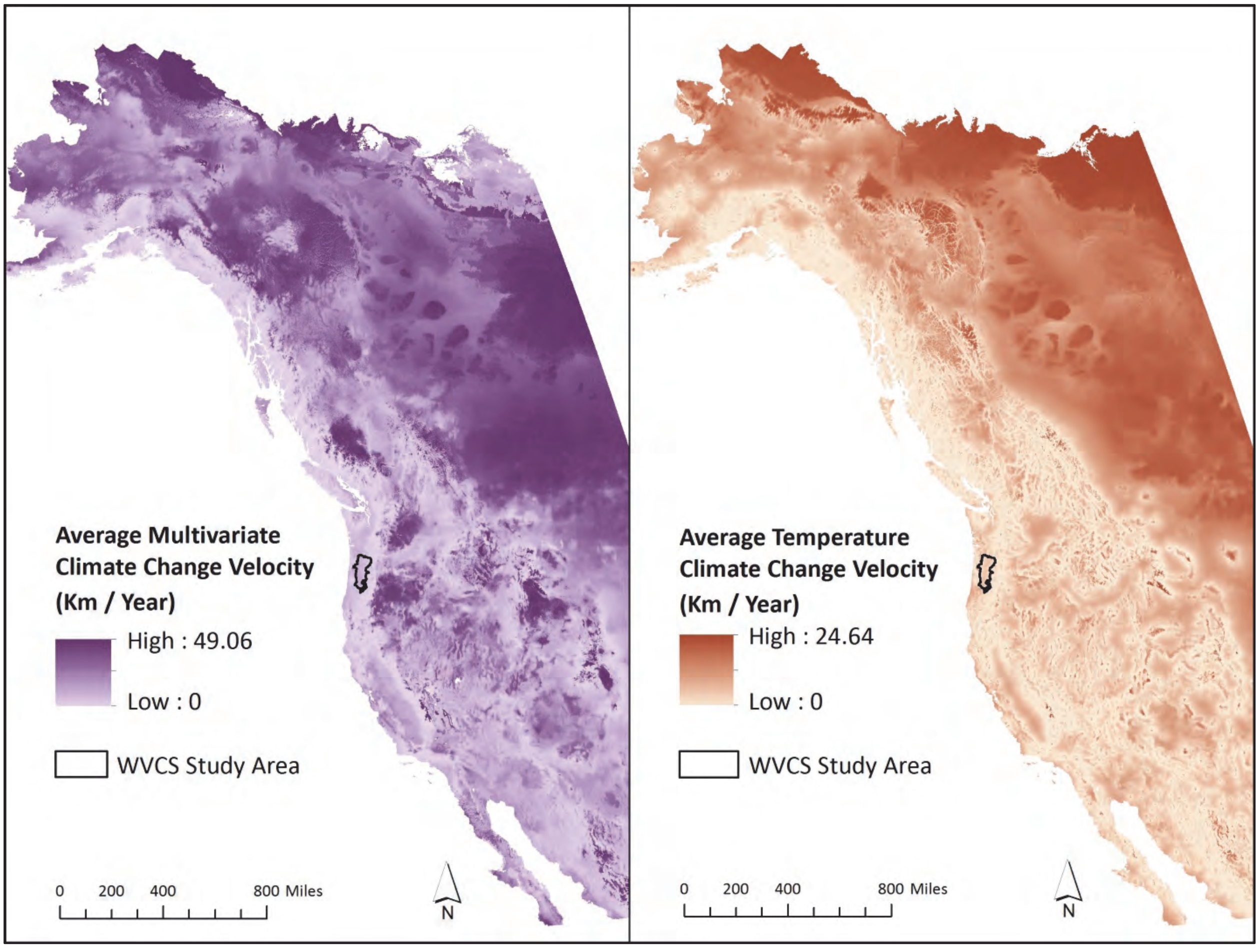


Figure B5. Climate Change Velocity for Western North America from Hamann et al. 2014. Both metrics are based on the differences in mean values for 1961-1990 and 2041-2070, and use the A1B emissions scenario with a 7 GCM ensemble.

Table B2. Statistics for variables shown in Figure B5 over the entire dataset extent (WNA) and the Willamette Valley only.

Values	Multivariate Climate Change velocity (km/yr)	Mean Annual Temperature Climate Change Velocity (km/yr)
Minimum for WNA	0	0
Maximum for WNA	49.06	24.64
Mean for WNA	4.32	2.48
Mean for the Willamette Valley	1.17	0.25

Climate Change Resilience

Just as the Hamann et al. (2014) climate velocity models can serve as a metric of climate change exposure, a recent geospatial analysis by Buttrick et al (2014) developed a model of relative resilience to climate change based on microclimate diversity and permeability that provides a metric of relative adaptive capacity across the landscape. They argue that two variables, microclimate diversity and landscape permeability, are key to climate change adaptation. Areas with high microclimate diversity can serve as climate refugia, increasing the likelihood of species persistence, and good landscape permeability allows organisms to relocate to a more suitable microclimate as their climate envelopes shift across the landscape.

Microclimate diversity is a combination of two indices, both derived from a 30m digital elevation model. The first is the heat load index, a proxy for relative local temperature based on slope, aspect, and latitude, and the second is the compound topographic index, which estimates relative soil moisture potential based on contributing upstream areas and slope. Permeability, which measures how readily terrestrial organisms can move through the landscape, requires a resistance surface as an input layer. Resistance is based on the land cover type of a pixel, with roads and other developed land cover types having high resistance to ecological flows, agricultural pixels having moderate resistance, and natural types having low resistance. Permeability was calculated for each pixel in a resistance surface by testing how well connected a pixel was to other pixels in its neighborhood. Permeability and microclimate diversity were then combined into a single raster model of climate change resilience (Buttrick et al. 2014).

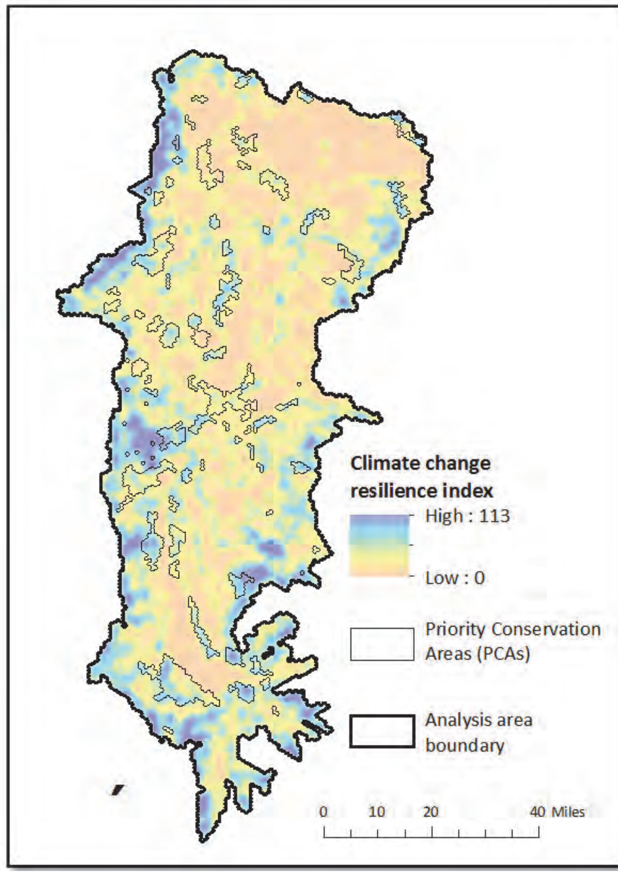


Figure **B**6. Relative resilience to climate change in the Willamette Valley (Buttrick et al. 2014).

To assist with the WVCS, TNC clipped out the Wilmette Valley section of the resilience model, and then calculated the density of pixels that were among the most resilient 40 percent within the valley. The resulting climate change resilience index (Figure 6) provides a depiction of relative climate change resilience across the Valley.

The blue areas in Figure B6 have the highest relative resilience. They are generally at the edges of the valley, where more complex topography allows for high microclimate diversity, and where permeability is higher because of connection to the more intact areas in the mountains that surround the valley. Because most of these blue areas are dominated by Douglas fir forests, which are not priority habits for the WVCS, the PCAs mostly do not overlap with them. The lowest scoring areas of the valley, shown in orange, are in the urban centers and agricultural heartland at the valley bottom. The PCAs mostly do not overlap with these areas, but tend to fall in the middle range of resilience. One exception is the Indian Head Hills area near Coburg, which is more resilient than most of the PCAs. This information could potentially be used to prioritize PCAs with higher resilience for protection, or to identify low resilience areas where “climate smart” management strategies (as described in Stein et al. 2014) may be needed.

Conclusions and Possible Future Research

Taken together, the existing studies suggest that the priority species and habitats of the WVCS are less vulnerable to climate change than many ecosystems and species in the broader region. Some priority habitats, such as prairies, savannas, and oak woodland may actually fare better under predicted climate change conditions (Bachelet et al. 2011). Climate niche models indicate that the WVCS priority bird species are fairly resilient to climate change (Michalak et al. 2013).

This does not mean that climate change will not be a serious issue, but it does imply that protection from other threats such as invasive species and habitat conversion may be equally or more important in terrestrial systems. In aquatic systems, however, climate change impacts will be more severe, and analysis suggests that the valley’s rare plant and insect species may also be vulnerable (Steel et al. 2011).

Because of the relatively low vulnerability of the WVCS species and systems as well as the large body of existing research on Willamette Valley climate change impacts, we concluded that another CCVA was not required at this point. A new region-wide CCVA should be completed when improved data sets become available. For example, if a new generation of regional climate models were developed, it might reduce the uncertainty in precipitation projections or in the frequency of extreme weather events such as flooding and prolonged heat waves (Dulière et al. 2011). Such data would allow for a more definite understanding of the likely effects of climate change on the WVCS priority habitats and species.

Other key uncertainties relating to climate change are its effects on invasive species, large fires west of the Cascades, and the human population growth rate, which may increase if climate refugees are driven out of drought-stricken regions to the south. As new research on these important topics becomes available, their results should be incorporated into Willamette Valley conservation planning and management.

Wapato Lake and surrounding area. USFWS

Appendix C. Priority Habitats

Introduction

The native habitats that species were selected to represent are the declining and in some cases now rare land cover types that were once common across the Willamette Valley. The habitats, identified by the Oregon Department of Fish and Wildlife (ODFW) as "strategy habitats" in the Oregon Conservation Strategy (ODFW 2006), include Grasslands (including oak savanna), oak woodlands, wetlands (including wet prairies), riparian, and aquatic habitats. We used the ecological systems nomenclature of the International Terrestrial Ecological Systems Classification (NatureServe 2011) to identify the following Willamette Valley strategy habitats and ecological systems—Willamette Valley Upland Prairie and Savanna, Willamette Valley Wet Prairie, North Pacific Oak Woodland, North Pacific Lowland Riparian Forest and Shrubland, and Temperate Pacific Freshwater Emergent Marsh. Ecological systems are recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding (Comer et al. 2003).

Some of these systems are endemic to the valley, meaning they are only found in the valley and immediate vicinity. These systems once covered about two-thirds of the valley, but each has experienced dramatic declines since Euro-American settlement began in earnest a little over 150 years ago (Christy and Alverson 2011; Taft and Haig 2003). Conserving and restoring these systems and the native species they host is a constant theme of the Oregon Conservation Strategy (ODFW 2006) and other conservation plans developed for the valley (NWPCC 2004; Floberg et al. 2004; Altman 2001).

Willamette Valley Upland Prairie and Savanna

The Willamette Valley Upland Prairie and Savanna system is endemic to the Willamette Valley and the Puget Trough of Washington State (NatureServe 2011). Prior to settlement, it formed a complex mosaic of varying patch sizes with wet prairies and riparian forests over much of the Willamette Valley. It occurs on well-drained, deep soils and was maintained historically by frequent presettlement low-intensity fires (Johannessen et al. 1971, Christy and Alverson 2011). In the savannas, Oregon white oak (*Quercus garryana*) is the dominant tree species, but as is typical of savanna habitat, trees only occur at low densities, providing less than 30 percent cover. In the absence of disturbance such as fire, conifers invade this system and many historic savannas have converted to forest (Christy and Alverson 2011, ODFW 2006). This process of habitat loss through succession continues to this day. Succession is the process of change in an ecosystem brought about by the progressive replacement of one community by another in a definite order until a stable community (i.e. climax community) is established.

The Willamette Valley Upland Prairie and Savanna system is comprised of five component plant associations (NatureServe 2011) dominated primarily by graminoids, such as California oatgrass (*Danthonia californica*), Roemer's fescue (*Festuca roemeri*), and bearded wheatgrass (*Elymus caninus*). Oregon white oak is the dominant tree species although ponderosa pine (*Pinus ponderosa*) savannas are also present. A plant associations is a vegetation classification unit defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habitat conditions, and physiognomy.

Oak savannas historically covered about 540,000 acres or 17 percent of the valley. Upland prairie was the most extensive prairie type in the valley, covering approximately 707,000 acres or about 22 percent of the valley (Christy and Alverson 2011).

Today, less than one percent of this habitat remains as remnant patches scattered across the valley, making the Willamette Valley Upland Prairie and Savanna one of the most critically endangered ecosystems of the United States (Noss et al. 1995). Oak savanna in Washington, Oregon, and California has been designated by the American Bird Conservancy as one of the 20 most threatened bird habitats in the United States (ABC 2006). Grassland birds are among those that have experienced the steepest population declines in the U.S. (Rosenberg et al., 2016)

Related to this loss has been a substantial decline of wildlife populations dependent on this habitat, resulting in several imperiled species being listed under the Endangered Species Act with more identified as species of conservation concern (ODFW 2008). Altman (2011) documents the extirpation of five prairie-oak bird species from the Willamette Valley since the 1940s: Lewis's woodpecker (*Melanerpes lewis*), Say's phoebe (*Sayornis saya*), short-eared owl (*Asio flammeus*), western burrowing owl (*Athene cunicularia hypugaea*), and lark sparrow (*Chondestus grammacus*).

Plant species native to upland prairie various species of grasses such as California oatgrass (*Danthonia californica*), Roemer's fescue (*Festuca roemeri*), bearded wheatgrass (*Elymus caninus*), Sandberg bluegrass (*Poa secunda*), prairie Junegrass (*Koeleria macrantha*), Lemmon's needlegrass (*Achnatherum lemmonii*), and slender wheatgrass (*Elymus trachycaulus*). Native perennial forbs include Oregon sunshine (*Eriophyllum lanatum*), slender cinquefoil (*Potentilla gracilis*), dwarf checkermallow (*Sidalcea virgata*), lance selfheal (*Prunella vulgaris* ssp. *lanceolata*) and Tolmie startulip (*Calochortus tolmiei*).

Listed species and species of conservation concern associated with the Willamette Valley Upland Prairie and Savanna system include: Fender's blue butterfly (*Icaricia icarioides fenderi* syn. *Plebejus icarioides fenderi*), Taylor's checkerspot butterfly (*Euphydryas editha taylori*), streaked horned lark (*Eremophila alpestris strigata*), western meadowlark (*Sturnella neglecta*), Oregon vesper sparrow (*Pooecetes gramineus affinis*), western burrowing owl, Lewis' woodpecker, band-tailed pigeon (*Patagioenas fasciata*), camas pocket gopher (*Thomomys bulbivorus*), golden paintbrush (*Castilleja levisecta*), Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*), shaggy horkelia (*Horkelia congesta* ssp. *congesta*), Bradshaw's lomatium (*Lomatium bradshawi*), Willamette Valley daisy (*Erigeron decumbens*), peacock larkspur (*Delphinium pavonaceum*), white-rock larkspur (*Delphinium leucophaeum*), and thin-leaved peavine (*Lathyrus holochlorus*).

Western meadowlark/USFWS

Willamette Valley Wet Prairie

Willamette Valley wet prairie/©Steve Gisler, ODOT

At the time of settlement, Willamette Valley wet prairies occurred as a mosaic of emergent marsh, seasonally flooded grasslands, Oregon ash (*Fraxinus latifolia*) swales, and vernal pools. They were a common feature, covering about 340,000 acres or approximately 10 percent of the valley. Wet prairies were maintained on the landscape by a combination of the wetland soil hydrology and frequent low intensity fires.

The Oregon State of the Environment Report 2000 (OPB 2000) estimated that 99 percent of the valley's original wet prairies are gone. Today this system occurs as widely dispersed habitat patches, generally in poor condition relative to historic conditions. They are located primarily on the heavy clay soils of the valley floor that are either perennially saturated or flooded during the winter and early spring (Christy and Alverson 2011).

The Willamette Valley Wet Prairie system is comprised of seven component plant associations (NatureServe 2011), dominated primarily by graminoids, especially tufted hairgrass (*Deschampsia caespitosa),* rushes (*Juncus* spp.), and sedges (*Carex* spp.). Perennial and annual forbs such as common camas (*Camassia quamash* ssp. *maxima*), great camas (*Camassia leichtlinii* ssp. *suksdorfii*), coyote-thistle (*Eryngium petiolatum*), and elegant downingia (*Downingia elegans*) are also commonly found in wet prairies (IAE 2010).

Listed species and species of conservation concern associated with the Willamette Valley Wet Prairie system include northern harrier (*Circus cyaneus*), short-eared owl (*Asio flammeus*), American grass bug (*Acetropis americana*), Bradshaw's lomatium, shaggy horkelia (*Horkelia congesta*), Nelson's checkermallow (*Sidalcea nelsoniana*), racemed goldenweed (*Pyrrocoma racemosa* var. *racemosa*), white-topped aster (*Sericocarpus rigidus*), and Willamette Valley daisy.

North Pacific Lowland Riparian Forest and Shrubland

The North Pacific Lowland Riparian Forest and Shrubland ecological system includes habitats also known as bottomland hardwood forests, gallery forests, wetland or riparian forests, riparian shrublands, and willow shrublands. It occurs from Oregon through Washington and British Columbia and into the temperate lowlands of Alaska. This wide-ranging system is comprised of 57 different plant associations (NatureServe 2011).

At the time of settlement, riparian and wetland forests covered about 240,000 acres, or about 7 percent of the valley. Shrublands covered an additional 13,000 acres, or about 0.4 percent of the valley. These forests and willow-dominated shrublands occur on low-elevation floodplains and lower terraces of rivers and streams. They are generally linear in character following a river or stream, but prior to settlement and subsequent land clearing, could extend up to 10 miles from the Willamette River (Christy and Alverson 2011).

In the Willamette Valley, dominant broadleaf species include bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), Sitka willow

(*Salix sitchensis*), Pacific willow (*Salix lucida* ssp. *lasiandra*), red-osier dogwood (*Cornus sericea*), and Oregon ash (*Fraxinus latifolia*). Conifers tend to increase with succession in the absence of major disturbance such as floods or fires. Riverine flooding and the succession that occurs after major flood events are the primary ecological processes that perpetuate this system. Very early-successional stages can be sparsely vegetated or dominated by herbaceous vegetation.

Listed species and species of conservation concern associated with the North Pacific Lowland Riparian Forest and Shrubland ecological system include willow flycatcher (*Empidonax traillii*), yellow-breasted chat (*Icteria virens*), purple martin (*Progne subis*), yellow-billed cuckoo (*Coccyzus americanus*), western pond turtle (*Actinemys marmorata*), northern red-legged frog (*Rana aurora*), Oregon spotted frog (*Rana pretiosa*), Oregon slender salamander (*Batrachoseps wrightorum*), Nelson's checker-mallow, Oregon giant earthworm (*Driloleirus macelfreshi*), silver-haired bat (*Lasionycteris noctivagans*), Yuma myotis (*Myotis yumanensis*), Camas pocket gopher (*Thomomys bulbivorus*), and white-footed vole (*Arborimus albipes*).

The Oregon State of the Environment Report (2000) estimated that about 72 percent of the valley's original riparian and bottomland forest has been converted to other uses (OPB 2000).

Snagboat Bend provides habitat for western pond turtles, herons, and other species/© Joe Staff

North Pacific Oak Woodland

The North Pacific Oak Woodland system occurs primarily in the Willamette Valley and Washington's Puget Trough. It typically occurs along the ecotone between upland prairie and savanna habitats and conifer-dominated forests found at higher elevations in the valley foothills (Christy and Alverson 2011). An ecotone is a transition area between two systems or plant communities that may be a gradual blending of the communities or a sharp boundary line. This system is comprised of eight component plant associations in which Oregon white oak is either the sole dominant tree species or codominant with Douglas fir (*Pseudotsuga menziesii*) (NatureServe 2011). It is associated with dry, predominantly higher-elevation sites within the valley. These sites likely experienced presettlement low-intensity fires, but stand density and a brushy understory suggest that burning was less frequent in woodlands than in prairie or savanna habitats, but was more frequent than in closed forests (Christy and Alverson 2011). In the absence of fire, succession tends to favor increased shrub dominance in the understory, increased tree density, and increased cover by conifers, especially Douglas fir, with the end result being conversion to a conifer forest and loss of oak woodland habitat (NatureServe 2011).

Prior to settlement, woodlands with an oak component occurred on approximately 330,000 acres or about 10 percent of the valley. Oak was either the dominant species or occurred in combination with Douglas-fir, big-leaf maple, and Ponderosa pine (Christy and Alverson 2011). The Oregon State of the Environment Report (2000) reported that about 87 percent of the upland forests at the margins of the valley have been converted to other uses (OPB 2000).

Common native plant species in oak woodlands include blue wildrye (*Elymus glaucus*), common camas, Pacific blacksnakeroot (*Sanicula crassicaulis*), poison-oak (*Toxicodendron diversilobum*), common snowberry (*Symphoricarpos albus*), and sword fern (*Polystichum munitum*).

William L. Finley National Wildlife Refuge/© Joe Staff

Listed species and species of conservation concern associated with the North Pacific Oak Woodland system include: acorn woodpecker (*Melanerpes formicivorus*), Lewis' woodpecker, olive-sided flycatcher (*Contopus cooperi*), Oregon vesper sparrow, band-tailed pigeon, Oregon slender salamander, Bradshaw's lomatium, and thin-leaved peavine. Red-legged frogs use this habitat during their summer migration from wetlands to upland habitat (IAE 2010).

Great egret at Wapato Lake/© Chuck and Grace Bartlett

Temperate Pacific Freshwater Emergent Marsh

The Temperate Pacific Freshwater Emergent Marsh system includes wetlands dominated by emergent, typically herbaceous vegetation. This system is associated with groundwater discharge or seasonally high water tables. Standing water may be seasonally present, most often during the winter and spring months. In some areas, water table fluctuations occur to a degree that soil surfaces may dry and bare ground may be exposed by later summer. Today, this system mostly occurs as small patches confined to limited areas in suitable floodplain, topographic depressions, or along the margins of ponds and lakes (Rocchio and Crawford 2009).

All larger historical emergent wetlands such as Lake Labish north of Salem, and Lousignont Lake and Wapato Lake near Forest Grove have been drained and converted for agricultural use (Christy and Alverson 2011), however, the historic Wapato Lake is now part of the Wapato Lake National Wildlife Refuge and actions are being planned to restore the historic lakebed. The Oregon State of the Environment Report reported that about 57 percent of the Willamette Valley's original freshwater wetlands have been lost and 44 percent of the valley's historical wetland plant communities are considered imperiled (OPB 2000). And the loss is ongoing. The report noted ongoing wetland loss, citing an Oregon Department of State Lands (ODSL) report that between 1982 and 1994 approximately 6,877acres of wetland (including wet prairie) were lost, despite the State's policy of no net loss of wetlands (OPB 2000). In an updated look, ODSL reported a net loss of an additional 3,960 acres of wetland in the Willamette Valley between 1994 and 2005 (Morlan et al. 2010).

By definition, freshwater marshes are dominated by emergent herbaceous species, mostly graminoids including native and nonnative grasses such as tufted hairgrass (*Deschampsia caespitosa*),meadow foxtail (*Alopecurus pratensis*), western mannagrass (*Glyceria occidentalis*), sedges, rushes, bulrushes (*Scirpus* spp.), and spikerushes (*Eleocharis* spp.). Forbs are also present including beggarticks

(*Bidens* spp.), wapato (*Sagittaria latifolia*), and monkey-flower (*Mimulus spp.*). Trees and shrubs occur peripherally or on elevated microsites and include species such as Oregon ash, alders (*Alnus* spp.), willows (*Salix* spp.), red-osier dogwood (*Cornus sericea*), Pacific ninebark (*Physocarpus capitatus*), and Douglas spirea (*Spiraea douglassii*). Two nonnative, invasive species in particular, reed canarygrass (*Phalaris arundinacea*) and purple loosestrife (*Lythrum salicaria*), can form large, monotypic stands greatly decreasing a wetland's value to native wildlife.

Wetlands play a critical role in meeting the life-history requirements of many native migratory and resident wildlife species. Dabbling ducks such as shovelers, teals, wigeons, and mallards (*Anas platyrhynchos*) feed; and shorebirds such as common snipe (*Gallinago gallinago*), yellowlegs (*Tringa* spp.), sandpipers (*Calidris* spp.), and plovers (*Charadrius* spp.) feed and breed in emergent wetlands. Reptiles such as the western pond turtle, western painted turtle (*Chrysemys picta*); and amphibians such as northwestern red-legged frog, northwestern salamander (*Ambystoma gracile*), and rough-skinned newt (*Taricha granulosa*); are all closely associated with emergent wetlands.

Rivers and Streams

The valley's rivers and streams have been altered considerably since the time of Euro-American settlement and populations of native fish and other aquatic organisms have declined as a result. Listed species include the Upper Willamette and Lower Columbia River evolutionarily significant units (ESUs) of Chinook salmon (*Oncorhynchus tshawytscha*), the Lower Columbia River ESU of coho salmon (*Oncorhynchus kisutch*), the Upper Willamette River and Lower Columbia River ESUs of steelhead trout (*Oncorhynchus mykiss*), Oregon chub (*Oregonichthys crameri*), and bull trout (*Salvelinus confluentus*). Other species of conservation concern include Pacific lamprey (*Lampetra tridentate*), coastal cutthroat trout (*Oncorhynchus clarki* ssp.), and freshwater muscles such as the Oregon floater (*Anodonta oregonensis*). An ESU is a population or group of populations that are substantially reproductively isolated from other conspecific populations and that represents an important component of the evolutionary legacy of the species.

Prior to settlement, the Willamette River from today's Eugene to Albany occurred as a wide swath of braided channels, wetlands, bottomland hardwood forests, and riparian shrublands (Hulse et al. 2002). In places, the forests extended out from the river for up to 10 miles. The valley regularly flooded and the flood water deposited silts and nutrients that over time helped create the valley's exceptional agricultural soils (ODFW 2006). Annual flooding also assisted in the creation and maintenance of the bottomland forests and shrublands as well as creating nesting habitat for the streaked horned lark, a species that prefers to construct its nest on bare ground.

As settlement increased, flooding posed an ever increasing risk to life and property. To abate the risk, dams were built and revetments were constructed along the river's banks. During the period from 1850 to 1995, over 40 percent of the total area of river channels and islands was lost, reduced from 41,000 acres to less than 23,000 acres. More than 25 percent of the total length of all channels was lost, reduced from 355 miles to 264 miles (Hulse et al. 2002). More than one-half of the area of small tributary floodplains and more than one-third of the alcoves and sloughs were lost by 1995 (Hulse et al. 2002).

Between 1941 and 1968, the U.S. Army Corps of Engineers built a system of 13 multi-purpose dams and reservoirs with the primary purpose of flood control. Dams are located on the Tualatin, Long Tom, Santiam, McKenzie, Middle Fork Willamette, and Coast Fork Willamette rivers. Most of the dams do not provide for fish passage and as flood control dams, have greatly affected the frequency and extent of downstream flooding (Hulse et al. 2002).

Bull trout/USFWS

Pidgeon Butte Ridge looking east/© Joe Staff

Appendix D. Selection Criteria

Introduction

Because it is impractical to develop conservation prescriptions for all species present in a study area as large as the Willamette Valley, a subset of species was selected to represent each of the priority habitat types under the assumption that by implementing management strategies that support the ecological conditions favored by the target species, the needs of the larger set of species characteristic of that habitat will also be met (USFWS 2012a).

The goal of the species selection approach was to select species that best represent the priority habitat types and meet practical management considerations. For example, it makes little sense to select a species that well represents a habitat and its associated species, if monitoring that species is so difficult it entails great cost or effort.

The species selection process began by developing a list of species that could represent the habitat types and a list of criteria against which each species would be scored.

Species Selected for Evaluation as Conservation Targets

The initial selection of species to be evaluated was based on their inclusion as focal species in the CCPs for Willamette Valley National Wildlife Refuge Complex and the Tualatin River National Wildlife Refuge (USFWS 2011, USFWS 2013a); the OCS (ODFW 2006); the Conservation Strategy for Landbirds in Lowlands and Valleys of Western Oregon and Washington (Altman 2001); and the

Willamette Subbasin Plan (NPCC 2004); as well as consideration of their distribution and habitat affinities. The initial species list was sent to biologists and scientists with expertise in the valley who would eventually score the species and was adjusted based on comments received. The list of species evaluated for each priority habitat type is provided in Table D1.

Table D1. Species Selected for Evaluation

Prairie	Oak Savanna	Oak Woodland	Riparian Forest	Riparian Shrubland	Wetlands	Riverine
Bradshaw's lomatium	American kestrel	Acorn woodpecker	Brown creeper	Common yellowthroat	Dunlin	Bull trout
Golden paintbrush	Fender's blue butterfly	Band-tailed pigeon	California myotis	Northern red-legged frog	Dusky Canada goose	Chinook salmon
Nelson's checker-mallow	Kincaid's lupine	Black-capped chickadee	Downy woodpecker	Swainson's thrush	Great blue heron	Coastal cutthroat trout
Northern harrier	Lazuli bunting	Chipping sparrow	Swainson's thrush	Willow flycatcher	Northern red-legged frog	Coho salmon
Oregon vesper sparrow	Oregon white oak	Oregon white oak	Red-eyed vireo	Yellow-breasted chat	Oregon chub	Oregon chub
Peacock larkspur	Slender-billed white-breasted nuthatch	Purple finch	Western purple martin	Yellow warbler	Painted turtle	Pacific lamprey
Savannah sparrow	Taylor's checkerspot butterfly	Slender-billed white-breasted nuthatch	Wood duck		Pintail	Red-legged frog
Short-eared owl	Western bluebird	Western grey squirrel	Yellow Warbler		American bittern	Steelhead trout
Streaked horned lark	Western scrub jay	Western wood pewee			Cinnamon teal	Western brook lamprey
Western meadowlark					Lesser yellowlegs	American beaver
Willamette valley daisy					Mallard	Bald eagle
White rock larkspur					Ring-necked duck	
					Sora	

Conservation Target Selection Criteria

The Conservation target selection criteria were developed based on published species selection criteria (Altman 2001, Altman 2010, Altman and Stephens 2012, USFWS 2012) and management considerations (Altman 2010, USFWS 2012). The criteria were reviewed by biologists and scientists familiar with Willamette Valley species and habitats. Comments received were incorporated into the final criteria which are presented below.

Initial Screen

1. The species represents a larger group of species, in that, when conservation actions are directed toward the single species, the actions will also benefit the larger group of species.

Ecological Criteria

2. The species is strongly associated with a particular habitat type, or specific attribute or condition within that habitat type.
3. The species has large spatial needs that can encompass the needs of other species.
4. The species' population dynamics track changes in the larger landscape or ecosystem.
5. Climate change risks to the species are similar in nature and risk level to those of the larger group of species represented.
6. Invasive species, pests, and pathogen risks to the species are similar in nature and risk level to those of the larger group of species represented.

Management Criteria

7. The species can be readily monitored using standard techniques that track progress toward meeting population objectives.
8. Sufficient data exist to model the species habitat relationships and population viability (e.g., habitat suitability, occurrence probability, reproduction, recruitment, and survivorship).
9. The species has public interest or appeal.

Conservation Status

10. The species has special conservation status (e.g. ODFW OCS Strategy Species; Federal ESA; Oregon State ESA; Birds of Conservation Concern [USFWS 2008b] Birds of Management Concern [USFWS 2011b], NWRS strategic growth policy [USFWS 2013d]).

The first criterion was used as an initial screen. If, for an obvious reason, a species was poor at representing the habitat and the larger group of species using that habitat, then it was not scored.

The ecological criteria relate to the species' need for particular habitats and spatial requirements, and whether its population dynamics track changes within those habitats, and how climate change and other future threats might affect the species relative to the larger group the species represents. From a management perspective, we included criteria related to the ease of monitoring, the sufficiency of data to establish population objectives and allow for GIS modeling, and social acceptance of the species.

The conservation status of the species (ODFW 2006, ORBIC 2010) was to be used as a tie-breaker, should applying the selection criteria result in species being ranked equally, but this was never the case.

Evaluation Criteria

In order to provide common and consistent means by which biologists and species experts could rate a species ability to represent a habitat and its associated species, we developed evaluation criteria as the basis for scoring each species. The evaluation criteria are provided below.

Initial Screen

1. A species represents a larger group of species, in that, when conservation actions are directed toward the single species, the actions benefit a group of species, i.e., good indicator species.

- Yes = The species is a habitat specialist with life history requirements that encompass the needs of many native species associated with that habitat.
- No = The species' habitat requirements are too specialized or too general to represent a large group of native species.

Ecological Criteria

2. The species is strongly associated with a particular habitat type.
   - High = The species reaches highest population densities, or greatest recruitment occurs, within a particular habitat type.
   - Medium = The species' population densities or recruitment are similar across a few native habitat types.
   - Low = The species is a habitat generalist, not strongly associated with a particular habitat type.

Because our goal is self-sustaining populations, we were most concerned with identifying the habitat in which recruitment is highest, not necessarily where densities are greatest as the two are not necessarily linked (Van Horne 1983).

3. The species has large spatial needs that encompass the needs of other species.
   - High = A single self-sustaining population of the species requires a large land base.
   - Medium = A single self-sustaining population of the species requires a moderate land base.
   - Low = A single self-sustaining population of the species requires a small land area.

4. The species' population dynamics track changes in the larger landscape or ecosystem.
   - High = Improvements in population dynamics (reproduction, recruitment, and survivorship) can be directly linked to improvements in the habitat type.
   - Medium = Population dynamics are moderately linked to improvements in the habitat type, or nonhabitat factors (e.g., intraspecific competition) equally important to population dynamics.
   - Low = Generalist species whose population dynamics are not linked to changes in a particular habitat type or nonhabitat factors govern population dynamics (e.g., predator/prey relationship).

5. Climate change risks to this species are similar in nature and risk level to those of the larger group of species represented.
   - Yes = The species response to climate change is expected to be similar to the larger community the species represents.
   - No = The species has life history requirements or inherent capabilities (dispersal, food base) that either make the species more or less susceptible to the effects of climate change than that of the larger group the species represents.

6. Invasive species, pests, and pathogen risks to this species are similar in nature and risk level to those of the larger group of species represented.
   - Yes = The species faces threats posed by invasive species, pests, or pathogens also facing the larger community the species represents.

- No = The species faces unique risks related to invasive species, pests, or pathogens not facing the larger community the species represents (such as amphibians and chytrid fungus or bats and white-nose syndrome).

Management Criteria

7. The species can be readily monitored using standard techniques that track progress toward meeting population objectives
   - Yes = The species can be readily monitored using standard techniques that are economical, and do not require specialized equipment.
   - No =The species is difficult or costly to monitor and/or requires specialized equipment.

8. Sufficient data about the species exist (e.g., population objectives, habitat suitability, occurrence probability, reproduction, recruitment, survivorship).
   - High = The species' population objectives have been set locally or local data exists to establish them. Habitat, occurrence, and demographic data exist based on local research.
   - Medium = The species' population objectives must be stepped down from national plans. Habitat, occurrence, and demographic data exist, but are based on research conducted elsewhere.
   - Low = The species population objectives, habitat occurrence, or demographic data are lacking.

9. Does the species have public interest, and/or appeal?
   - Yes = The species is of interest and supported by the general public.
   - No = The species is not on the public's radar or has negative public connotations.

Species Status

10. The species has special conservation status.
    - High = The species is listed, proposed for listing, or a candidate of conservation concern under the Federal or State Endangered Species Act.
    - Medium = The species is listed as a Bird of Conservation Concern in Bird Conservation Region 5. Declining population trends or local extirpations exist. The species has an initial listing status (Birds of Management Concern, OCS Strategy Species, OR State Sensitive, OR State Vulnerable, etc.).
    - Low = The species has no special status.

Applying the Criteria

Some criteria were split into categories that could be rated as high, medium, or low. Other criteria could be answered with a yes or no. Points were assigned to each categorized criteria based on whether it is rated high (1 point), medium (0.5 points), or low (0 points). Points were assigned to each yes/no criteria based on whether the answer is yes (1 point) or no (0 points). Biologists and scientists were asked not to score a species if they were unfamiliar with it.

A spreadsheet was developed that allowed importance weights to be assigned within the selection criteria categories (ecological and management) as well as assigning importance weights to the categories themselves (ecological criteria could be weighted over management criteria or vice versa). An initial weighting was proposed that weighted ecological criteria 2:1 over management criteria because we wanted to avoid selecting a species that is weak in representing a larger group of species using the same habitat, but was good at meeting management criteria. This weighting scheme was approved by the biologists and was used in determining total scores for each species.

Within the ecological criteria, we weighted habitat association and spatial needs criteria over the climate change and invasive species criteria because the science is more certain on the former two than the potential future response to climate change and other threats. For the management criteria, we weighted monitoring and data availability criteria over the public interest/appeal criterion because the latter criterion required us to estimate public attitudes.

Scores from each biologist and research scientist were combined in a master list. The list was sent back to the group to review for logic and consistency. We then selected one or more species to represent each habitat type based on the scoring.

Results

Species selected to represent each habitat type are provided in Table D2.

Table D2. Species Selected to Represent Habitats

Species	Habitat
Western meadowlark and Oregon vesper sparrow	Prairie
Western bluebird	Oak savanna
Slender-billed white-breasted nuthatch	Oak woodland
Yellow warbler	Riparian forest
Yellow-breasted chat	Riparian shrublands

Willow flycatcher was initially selected to represent riparian shrublands, but data anomalies associated with the Breeding Bird Survey made calculating a Willamette Valley population in riparian shrublands problematic. For that reason, and because their habitat requirements are very similar, yellow-breasted chat was selected to represent riparian shrublands. The Northern red-legged frog was initially selected to represent wetlands, and Chinook salmon were initially selected to represent riverine systems. Data gaps made developing rational population objectives problematic for those species in the Willamette Valley; therefore, we decided to focus on the habitat itself. For that reason, those species were not carried through the SHC analysis. Final scores for each species/habitat combination are provided in Table D3.

Western meadowlark/USFWS

Western bluebird/USFWS

Table D3. Final Scores for all Species/Habitat Combinations

Prairie		Oak Savanna		Oak Woodland		Riparian Forest		Riparian Shrubland		Wetlands		Riverine	
Species	Score	Species	Score	Species	Score	Species	Score	Species	Score	Species	Score	Species	Score
Western meadowlark	0.88	Western bluebird	0.82	Slender-billed white-breasted nuthatch	0.85	Yellow Warbler	0.69	Willow flycatcher	0.75	Northern red-legged frog	0.80	Chinook salmon	0.90
Northern harrier	0.60	Slender-billed white-breasted nuthatch	0.75	Oregon white oak	0.77	Swainson’s thrush	0.63	Yellow warbler	0.74	Great blue heron	0.64	Coastal cutthroat trout	0.87
Bradshaw's lomatium	0.56	Oregon white oak	0.73	Acorn woodpecker	0.75	Downy woodpecker	0.61	Yellow-breasted chat	0.65	Painted turtle	0.61	Coho slamon	0.71
Streaked horned lark	0.56	Lazuli bunting	0.62	Chipping sparrow	0.63	California myotis	0.57	Northern red-legged frog	0.62	Cinnamon teal	0.61	Steelhead trout	0.71
Willamette valley daisy	0.53	Kincaid's lupine	0.56	Band-tailed pigeon	0.58	Western purple martin	0.57	Common yellowthroat	0.52	Pintail	0.59	Bull trout	0.70
Nelson's checker-mallow	0.52	American kestrel	0.53	Western wood pewee	0.57	Wood duck	0.55	Swainson's thrush	0.50	Mallard	0.57	Western brook lamprey	0.66
Golden paintbrush	0.49	Western scrub jay	0.47	Black-capped chickadee	0.53	Red-eyed vireo	0.49			Dusky Canada goose	0.56	Pacific lamprey	0.66
Oregon vesper sparrow	0.49	Fender's blue butterfly	0.46	Purple finch	0.50	Brown creeper	0.44			Oregon chub	0.55	American beaver	0.62
Savannah sparrow	0.49	Taylor's checkerspot	0.23	Western grey squirrel	0.49					Greater yellowlegs	0.55	Bald eagle	0.62
White rock larkspur	0.45									Sora	0.53	Red-legged frog	0.59
Peacock larkspur	0.44									American bittern	0.49	Oregon chub	0.49
Short-eared owl	0.44									Dunlin	0.48		

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Appendix E. Population and Habitat Objectives

Population Objectives

Population objectives represent a measurable expression of a desired outcome. They are expressed as abundance, trend, vital rate, or other measurable indices of population status, based on the best biological information about what constitutes a healthy, self-sustaining population (NEAT 2006). The objectives serve as the basis for estimating how much habitat to maintain based on the current state of knowledge related to habitat suitability, territory size, population viability, and probability of occurrence or average density in suitable habitat (USFWS 2008a).

To set population objectives we assembled panels of research scientists and biologists with expertise in each of our conservation target species, and asked them—what would a reasonable population objective be, that when realized, would indicate that our goal of a landscape capable of supporting healthy, self-sustaining populations had been achieved? We also explored the most important factors limiting the populations of our conservation targets to ensure that those factors were addressed.

Population objectives have already been established for some of our conservation targets in documents such as endangered species recovery plans. We discussed those objectives with our expert panels and updated them if new information warranted a change. For species without published objectives, we considered population status and trends, as described below, in developing population objectives.

Landbirds

The Partners In Flight (PIF) North American Landbird Conservation Plan (Rich et al. 2004), which was ratified by Canada, Mexico, and the United States, established population objectives for landbirds on a continental scale, but they were not stepped-down to any local scale. To do so, we worked closely with our expert panels which included ODFW, the American Bird Conservancy, the Pacific Coast Joint Venture, Fish and Wildlife Service biologists, and others to step-down those continental objectives to the Willamette Valley.

A major challenge in establishing population objectives is to decide on an abundance that would be sufficient to meet the goals for each species. With an overall goal of a landscape capable of supporting healthy, self-sustaining populations, at the very least, the objectives should be sufficient to reduce the risk of extirpation to a very low level. But landbirds provide valuable economic benefits and ecological services that must also be considered. For example, birds provide pest control services by feeding on insects and rodents that harm agricultural crops, they pollinate plants and disperse seeds, and they provide recreational opportunities enjoyed by thousands of the valley's residents, whose spending on bird watching and other recreation supports local communities and aids their economic development (Whelan et al. 2008, Carver and Caudill 2013).

A recent study of the demographics and economic impacts of birding based on the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (USFWS and USDI 2011) estimated that 892,000 Oregonians, or about 23 percent of the state's population, participated in bird watching activities. On a national scale, the 46.7 million birders spent about $41 billion on trips and equipment, creating 666,000 jobs and generating $31 billion in employment income and $13 billion in local, state, and federal tax revenue. With this magnitude of positive benefits, the question then becomes, what population level would be sufficient to allow these species to not only maintain their populations in the valley, but facilitate their provision of economic benefits and ecological services?

To address this question, Partners in Flight proposes a “minimum acceptable abundance” objective by considering three additional questions: How few birds are we willing to accept given their many benefits? How many birds can we afford given the competing demands for the land? And, how will future generations judge the decisions we make today?

ODFW developed a similar type of objective for the Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW and NMFS 2011). That plan has two goals. The first is to achieve delisting objectives. But beyond achieving minimum population levels to allow delisting, ODFW proposes a “*broad sense recovery*” objective which they define as “*Oregon populations of naturally produced salmon and steelhead that maintain a self-sustaining SMU (Species Management Unit) while providing significant ecological, cultural, and economic benefits*.”

We agree that a population objective, once achieved, should result in healthy, genetically diverse populations that are well distributed across their historic range and capable of providing recreational opportunities, economic benefits, and ecological services. An objective that achieves that would align well with ODFW’s goal for the Oregon Conservation Strategy (OCS), which is to “*maintain healthy fish and wildlife populations by maintaining and restoring functioning habitats, prevent declines in at risk species, and reverse any declines in these resources where possible*” (ODFW 2006).

Setting population objectives requires knowledge of the current population size and trend, as well as information on historic baselines to which current populations can be compared (Rich et al. 2004). For example, the 1986 North American Waterfowl Management Plan adopted by the United States and Canada used the abundance of waterfowl in North America during the 1970s, their trends since that time, and the traditional distribution of waterfowl during their various life-cycle periods, as the baseline for establishing population objectives (NAWMPPC 2004). The 1970s populations were considered to be at levels that not only sustained waterfowl on the landscape, but provided valuable recreational opportunities which supported local communities and their economies. By concentrating conservation efforts to achieve the 1986 plan objectives, the 2012 update noted that many waterfowl populations are now substantially larger than they were at the time the original plan was adopted (NAWMPPC 2012).

The North American Landbird Conservation Plan followed a similar approach, adopting a continental goal of restoring landbird population levels to the late 1960s population levels, which are believed to be achievable and realistic for most species (Rich et al. 2004). Adopting a late 1960s baseline population goal accepts the obvious fact that the competing demands on the land means that the extensive loss of native habitats that occurred since European settlement will not be reversed to any significant level, but would restore populations to levels capable of providing greater economic benefits and ecological services. The late 1960s also coincides with the beginning of the Breeding Bird Survey (BBS) across North America, which provides the only consistent data upon which to base measureable population objectives.

With an overall goal of returning landbird population levels to that of the late 1960s as the baseline for establishing population objectives, PIF established four population objective categories which call for: 1) doubling the populations of species suffering severe population declines; 2) a 50 percent increase for species that have undergone moderate declines; 3) maintain or increase populations for

Streaked horned lark/David Maloney, USFWS

species with uncertain or unknown past trends; and 4) maintain populations of species with stable or increasing populations.

For the landbird conservation target species, we set long-term (approximately 50-year) aspirational goals and stepped those down to short-term (10 to 20 year) actionable objectives. As discussed, we considered both the current population size and the long-term population trend in setting population objectives. In doing so it became evident that our conservation target species fell into two broad categories: those currently with very small and disjunct populations, most of which have suffered steep, long-term declines; and those with larger, though still relatively small populations, most of which have experienced less dramatic declines.

The first situation applies to the valley's grassland, oak savanna, and riparian shrubland species (western meadowlark, Oregon vesper sparrow, western bluebird, and yellow-breasted chat). For these species, documented population declines and range contractions support a conclusion that the current network of suitable habitat patches being managed for these species does not meet their minimum requirements in terms of the number, size, and distribution across the landscape to ensure their long-term persistence. Species with somewhat larger populations and less clear population trends are those that represent the oak woodlands and riparian forests (slender-billed white-breasted nuthatch and yellow warbler).

Since population size is a major determinant of extinction risk (Soulé 1986, Traill et al. 2007, Reed et al. 2003, Groom et al. 2006) and species with very small and disjunct populations are at the greatest risk of extirpation, we wanted the objective for the first group to be at an achievable abundance that would infer a low probability of extirpation, or conversely, a high probability of viability over the long run. We explored applying the PIF standard of doubling the population of species suffering severe population declines, but concluded that a mere doubling of current, extremely low populations would still leave these species vulnerable to extirpation in the valley. Our expert panel suggested we consider what a minimum viable population (MVP) would be for these species. An MVP is defined as the smallest population size (abundance) required for a species to have a predetermined probability of persistence for a given length of time (Shaffer 1981, Reed et al. 2003). For example, an

MVP could be set at the minimum number of individuals necessary for a population to have a 95 percent probability of persisting for 100 years, or a 90 percent chance of persisting for 30 generations.

MVPs are determined by conducting a Population Viability Analysis (PVA). A PVA models the combined effects of demographic, environmental, and genetic stochasticity, along with deterministic factors such as habitat loss, in calculating the lowest population abundance necessary for a species to persist over a desired time period (Akçakaya 2000). But because species-specific data are rarely available to complete such in-depth analysis (as is the case for the valley species), two meta-analyses of PVAs were reviewed to determine if a generalized MVP abundance standard could be supported by the published PVAs. A meta-analysis analyzes results from different studies to identify patterns among study results or other relationships that emerge in the context of multiple studies.

In a meta-analysis covering PVAs for 212 species, and implementing a standardization process to make reported MVPs comparable, Traill et al. (2007) was able to derive a cross-species frequency distribution of MVPs with a median of 4,169 individuals (95% CI = 3,577-5,129) and suggested that in lieu of species-specific data, to ensure the long-term persistence of a population, practitioners should "*manage for biologically relevant MVPs [of] at least 5,000 adult individuals whilst addressing the concomitant mechanisms of decline*."

Reed et al. (2003) completed a meta-analysis of PVAs generated for 102 vertebrate species based on actual life-history data. They determined mean and median estimates of MVPs at 7,316 and 5,816 adults, respectively. The 102 vertebrates modeled included 2 amphibians, 28 birds, 1 fish, 53 mammals, and 18 reptiles. They found no significant difference in MVP due to global latitude, taxonomic grouping, or trophic level. Reed et al. (2003) concluded that "*in order to ensure the long-term persistence of vertebrate populations, sufficient habitat must be conserved to allow for approximately 7,000 breeding age adults*."

Western meadowlark/USFWS

But such generalizations regarding MVPs are subject to criticism. Flather et al. (2011) argues that extinction risks are "*often context dependent and manifest from a complex interaction between life-history, environmental context and threat*." They contend that "*MVP estimates both among and within species show striking variation for many reasons. The fundamentally contingent nature of MVPs means that we cannot support a universally applicable MVP threshold*."

With that caveat in mind, and in lieu of PVAs for the species in question, we adopted an interim long-term (~50-year) population goal of 6,000 individuals, the median MVP abundance as determined by the two meta-analyses of PVA models. An aspirational goal of 6,000 individuals for western meadowlark, western bluebird, Oregon vesper sparrow, and yellow-breasted chat is an achievable abundance for the valley that would infer viability over the long-run.

We took a different approach for the two species with somewhat larger populations: yellow warbler and white-breasted nuthatch. Because of the uncertainties of the BBS trend analyses (both have nonsignificant trends with wide 95 percent confidence intervals) contrasted against the certainties and documented loss of the priority habitat types these species were chosen to represent (riparian forest and oak woodlands), we adopted the PIF goal of a 50 percent population increase for both species. Adopting this goal recognizes the trade-off of basing objectives using nonsignificant BBS trends amid contrasting documented declines in the primary habitat type for these species. A 50 percent increase over 50 years equates to a growth rate of just 0.8 percent per year, a slow growth rate, but one that would maintain and slowly rebuild populations and habitats over time, benefiting not just the conservation target species, but the other wildlife species they were chosen to represent.

To determine the shorter-term (10 to 20 years) actionable objectives, we calculated the annual growth rate needed for each of these species to achieve the aspirational population goal over the course of 50 years and applied that rate to the first 10 years. For example, to increase the population of western meadowlarks from their current population of approximately 1,200 to 6,000 over a 50-year period, would require an annual growth rate (λ) of 1.0327 ($1{,}200 * 1.0327^{50} = 5{,}996$). Applying this rate for 10 years yields a 10-year population objective of 1,656 ($1{,}200 * 1.0327^{10} = 1{,}656$).

Current population estimates came from two sources. Estimates for the rare and imperiled species (western meadowlark, Oregon vesper sparrow, western bluebird, and yellow-breasted chat) were developed by the American Bird Conservancy and Pacific Coast Joint Venture, based on multiple surveys and censuses conducted in the valley.

Estimates for the more abundant species (slender-billed white-breasted nuthatch and yellow warbler) were developed by using recent BBS point count data (2003-2013). The methodology for using BBS data is explained in two documents—the Guide to the PIF Population Estimates Database (Blancher et al. 2007) and The Handbook to the Partners in Flight population Estimates Database, Version 2.0 (Blancher et al. 2013).

Bird trend data comes from the Patuxent Wildlife Research Center (Sauer et al. 2008). Trends specific to the Willamette Lowlands are available from the initiation of the BBS in the valley in 1968 until 2007. Beyond 2007, trends were calculated only for entire Bird Conservation Regions (BCRs) making identification of trends specific to the valley far less certain.

Since we are establishing ecoregional population objectives, we recognized the need to account for individuals outside the designated core habitat patches when setting the objectives. To do this we assumed an equal number of birds could be distributed throughout the ecoregion outside the core habitat patches once established. This assumption must be tested through assumption-based research and the objectives modified based on the results of that research.

Listed Prairie Species

Population objectives for prairie species in the valley that were listed under the ESA prior to 2010 are published in the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington

Taylor's checkerspot butterfly/
Ted Thomas, USFWS

(USFWS 2010a). These objectives are expressed in terms of population abundance, trend, and distribution across recovery zones that encompass the study area. The WVCS planning team met with the Recovery Plan authors and others engaged in recovery actions in the valley to determine if the population objectives remain valid. There was general agreement that the objectives remain valid, and those objectives were adopted for this study. Some minor changes were adopted for some of the conservation target species based on new information derived from field monitoring since the Recovery Plan was published in 2010. Suggested changes were adopted and are explained in the discussion of the affected species.

Population objectives for the two recently listed species (streaked horned lark and Taylor's checkerspot butterfly) have not been developed. Recovery plans will be developed for these species in the future. In the interim, we developed population objectives, which will be revised as appropriate once recovery plans are published. As described below, population objectives for Taylor's checkerspot were fashioned after the population objectives developed for Fender's blue butterfly, based on historical distribution in the valley and the metapopulation dynamics exhibited by Fender's blue butterfly.

Habitat Objectives

Habitat objectives describe the area, quality, and distribution of habitat across a landscape thought to be necessary to achieve population objectives (NEAT 2006).

Migratory Landbirds

More than 15 years ago, Altman (1999) proposed a a landbird conservation strategy of protecting, restoring, and managing additional suitable habitat in proximity to existing population centers, providing habitat for dispersers to establish new subpopulations on newly restored habitat. ODFW (2010) suggested that these stabilized population centers could be the source of dispersers to expand the population elsewhere in the valley. This strategy, focusing efforts where the few remaining subpopulations occur, and radiating out from them, influenced the development of the population and habitat objectives.

ODFW (2006) identified the factors that are limiting populations of many of the targeted species. Two important factors are limiting populations of grassland birds in the Willamette Valley. The first is the loss of grassland habitats and the degradation of remaining habitat due to invasive species and the lack of fire, resulting in small, disjunct populations. The second was nesting failure due to the timing of land management practices (mowing, haying, spraying) occurring during critical nesting times (mid-April to mid-July) for these ground-nesting species.

Western bluebirds/George Gentry, USFWS

For the yellow-breasted chat, ODFW (2006) identified the loss of large patches of riparian shrub habitat as an important limiting factor. For the two cavity-nesting species—western bluebird and slender-billed white-breasted nuthatch, habitat loss and degradation along with fewer mature oaks with cavities and competition for those nesting sites as factors limiting their populations.

The expert panels summarized these factors as an insufficient number of core habitat patches—an insufficient number, size, and distribution of suitable habitat being managed free of other management conflicts to support healthy populations across each species historic range in the valley. A core habitat is an area of suitable habitat and of sufficient size that contains the properties and elements required for successful reproduction and survival of the targeted species. Within these core habitats, wildlife management would be prioritized over other management concerns. These core habitat areas would provide safe and secure breeding grounds to allow small, disjunct populations the space and time needed to begin to recover and to eventually become the source of dispersing individuals looking to establish new subpopulations We attempted to address this lack of core habitat areas by developing objectives for networks of suitable habitats to be distributed across the valley.

In areas with highly fragmented habitats such as the Willamette Valley, the lack of source populations can result from the combination of small, disjunct populations coupled with nesting failures where they do attempt to nest (Altman 1999, ODFW 2010). A source population is a population that produces more offspring than is necessary to maintain a stable population size, so the "surplus" individuals disperse to other areas establishing new or augmenting other extent subpopulations (Pashley et al. 2000). Where source populations potentially exist (such as the western meadowlark populations at W.L. Finley and Baskett Slough National Wildlife Refuges), a lack of suitable habitat for the dispersers to establish new territories in areas with a high probability of nest success, limits the ability of these source populations to contribute to population recovery.

To support the current and/or historic distribution of habitat and species distribution, and maintain multiple populations that are geographically spaced to enhance the likelihood of regional population persistence, we developed guidance on how the network should be distributed within the ecoregion. Therefore, the number and distribution of core habitat patches was uniquely determined for each species to reflect the variability of each species ecology, population size, area requirements, and patterns of historic and current habitat distribution and fragmentation, relative to latitudinal divisions (north to south) and also by Level IV ecoregions (Omernik 1987). The objective of a minimum number of core habitats distributed across the northern, central, and southern portions of the valley reflects the current and historic distribution of the priority habitats in the valley. For example, within the Willamette Valley, prairie habitat was historically and is currently unequally distributed south to north, so we adjusted the distribution of core habitats accordingly.

We distributed core habitats across three zones: north (north of Salem), central (Salem to Corvallis), and south (south of Corvallis); and also by Level IV ecoregions (Omernik 1987). The four Level IV ecoregions are the Portland/Vancouver Basin, Willamette River and Tributaries Gallery Forest, Prairie Terraces, and Valley Foothills.

The use of variable sized core habitat patches reflects the local realities of habitat availability and land ownership within the Willamette Valley. While the population objectives could theoretically be achieved with only a few large core habitat patches, the fewer number of patches would necessarily be more isolated from one another and other potentially suitable habitat patches, which would compromise their functionality as source populations. A greater number of core habitat patches distributed across the historic range of the species would better fulfill this critically important role. The distribution of core habitat patches within the ecoregion was based on knowledge of each species historic patterns of distribution and an assessment of current occupancy.

To determine the amount of habitat needed to meet landbird population objectives, we used the largest and densest known subpopulations of each species in the valley as the reference from which to establish area requirements. These subpopulations typically occurred on large, single ownership parcels with high quality habitat. As most of the landscape outside these ownerships is fragmented and of lower quality, we assumed that more area would be required to support an equal number of breeding pairs outside of these ownerships and increased the amount of area needed from the highest density examples by 50 percent to establish core patch size objectives. The fact that territory size varies with habitat quality is well established (O'Connor et al. 1999) and has been demonstrated empirically in the valley for grassland birds (Altman 1999, Altman et al. 2011). For species without reference subpopulations we used breeding territory sizes reported in the literature, and increased that size by 50 percent for the reasons given above.

Assumptions/Rationale

Assumptions used in determining population and habitat objectives for each of the targeted landbird species are provided below.

Western Meadowlark

Western meadowlark/© John and Karen Hollingsworth

The population estimate is based on data from ODFW (2010), Altman et al. (2011), and observations from extensive reconnaissance throughout the Willamette Valley. For the purpose of calculating a population estimate, a breeding season male detection was considered a pair. We also assumed that there was a second female for 25 percent of the males.

The North American Breeding Bird Survey (BBS) reports a statistically significant declining population trend of -10.0 percent per year (95% confidence interval [CI] -19.4 to -0.6) from 1966-2007, the latest year trends were calculated for the Willamette Lowlands (Sauer et al. 2008). This equates to an overall population decline of over 98 percent, the highest rate of decline among all grassland bird species in the valley.

The habitat objective for the area needed per core habitat patch is based on the documented territory size of the western meadowlark at Baskett Slough NWR and at the Willamette Floodplain Research Natural Area at the W.L. Finley NWR. Baskett Slough NWR supports 15-20 territories on approximately 500 acres of mixed quality upland prairie and agricultural fields. W.L. Finley NWR supports 25-35 territories on approximately 600 acres of mostly highly suitable wet prairie habitat (Altman et al. 2011). Thus, we assumed 20 territories per 500 acres and increased that size by 50 percent to correct for habitat quality outside these reference populations.

Based on habitat characteristics and western meadowlark breeding requirements, a single large subpopulation of 30-40 breeding pairs would require a habitat patch of about 1,313 acres. A medium-sized subpopulation of 20-30 breeding pairs would require a habitat patch of about 938 acres, and a small subpopulation of 10-20 breeding pairs would require a 563-acre habitat patch.

Oregon Vesper Sparrow

The population estimate for Oregon vesper sparrow is from Altman (2016) based on. For the purpose of calculating a population estimate, a singing male is considered a pair. From 1968 to 2007, the BBS reports a statistically significant declining population trend of -8.6 percent per year (95% CI -32.4 to 15.2) (Sauer et al. 2008). This equates to an overall population decline of 97.5 percent.

The objective for area needed for a core habitat patch is based on populations at Bald Hill Farm and the Oregon State University Beef Ranch, both near Corvallis. These areas support 10 and 12 pairs respectively, on pastureland, the habitat type with the highest densities in the Willamette Valley. There are approximately 10 pairs on 200 acres at Bald Hill Farm and 12 pairs on 200 acres at the OSU Beef Ranch. Thus, we assumed 11 pairs per 200 acres, and after correcting for habitat quality, assumed 11 pairs per 300 acres.

Based on the existing population size, territory size, and habitat suitability and availability, a single large subpopulation of >15 pairs would require a habitat patch of about 477 acres. A medium-sized subpopulation of 10-15 pairs would require a habitat patch of about 341 acres. A small subpopulation of 5-10 breeding pairs would require a 205-acre habitat patch.

Western Bluebird

The population estimate for western bluebird is derived from the past 10 years (2003-2012) of Breeding Bird Survey relative abundance data specific to the Willamette Valley, following the process described by Blancher et al. (2013) and corrected for BBS survey habitat representation and nontarget habitat biases.

Breeding bird survey results specific to the Willamette Valley are not available, so we relied on BBS trend calculated for the Southern Pacific Rainforest Region (i.e., western Washington and Oregon, and northern California). The reported trend for that region is -1.2 percent per year. As the Southern Pacific Rainforest Region includes areas far less impacted than the Willamette Valley, we estimate that the reported trend underestimates the decline in the Willamette Valley by an unknown degree.

Western bluebirds defend a relatively small breeding territory, ranging from one to several acres (Csuti et al. 2001). For this analysis, we used a conservative breeding territory of five acres. The area needed for a core habitat patch is based on increasing this approximate territory size by 50 percent in lieu of a reference high density population.

Based on territory size, and habitat suitability and availability, a single large subpopulation of 30-40 pairs would require a habitat patch of about 263 acres. A medium-sized subpopulation of 20-30 pairs would require a habitat patch of about 188 acres. A small subpopulation of 10-20 breeding pairs would require about a 113-acre habitat patch.

Slender-billed White-breasted Nuthatch

The population estimate for slender-billed white-breasted nuthatch is derived from the past 10 years (2003-2012) of Breeding Bird Surveys’ relative abundance data specific to the Willamette Valley, following the process described by Blancher et al. (2013) and corrected for BBB survey habitat representation and nontarget habitat biases.

From 1968-2007, the BBS reports a nonstatistically significant population trend in the Willamette Lowlands of -3.0 percent per year, (95% CI -22.5 to 16.5) (Sauer et al. 2008).

The slender-billed white-breasted nuthatch defends territories of various sizes ranging from a few acres to nearly 100 acres depending on habitat conditions (Csuti et al. 2001). For this analysis, we used a conservative home-range figure of 10 acres. The area needed for a core habitat patch is based on increasing this approximate territory size by 50 percent in lieu of a reference high density population.

Based on habitat characteristics and breeding requirements, a large subpopulation consisting of 50 pairs or more, would require about a 900-acre habitat patch. A medium subpopulation of 30-50 pairs would require about a 600-acre patch, and a small population of 10-30 pairs would require about 300 acres.

Yellow Warbler

The population estimate for the yellow warbler is derived from the past 10 years (2003-2012) of Breeding Bird Survey (BBS) relative abundance data specific to the Willamette Valley following the process described by Blancher et al. (2013) and corrected for BBS habitat representation and nontarget habitat biases.

The BBS reports a nonstatistically significant population trend for the Willamette Lowlands of +2.5 percent per year from 1968-2007 (95% CI -16.9 to 21.9) (Sauer et al. 2008).

Yellow warblers defend territories of various sizes ranging from a few acres to nearly 100 acres depending on habitat (Csuti et al. 2001). For this analysis, we used a conservative home-range figure of three acres. The area needed for a core habitat patch is based on increasing this approximate territory size by 50 percent in lieu of a reference high density population.

Based on habitat characteristics and breeding requirements, a large subpopulation consisting of 100-140 pairs would require about a 540-acre habitat patch. A medium subpopulation of 60-100 pairs would require about a 360-acre patch, and a small population of 20-60 pairs would require about 180 acres.

Yellow-breasted Chat

The population estimate for yellow-breasted chat is from the American Bird Conservancy based on available data from multiple riparian bird surveys, anecdotal observations, and professional knowledge.

From 1968-2007, the BBS reports a non-statistically significant population trend for the Willamette Lowlands of -2.4 percent per year (95% CI -10.7 to 6.0) (Sauer et al. 2008).

The objective for the area needed for a core habitat patch is based on a high density population at the State of Oregon's EE Wilson Wildlife Area, near Corvallis. The area supports approximately 30 pairs in 300 acres of high quality shrubland habitat. Thus, after correcting for habitat quality outside of this high-quality reference habitat, we assumed 30 pairs could be supported on 450 acres of typical riparian shrubland habitat in the valley.

Based on habitat characteristics and breeding requirements, a large subpopulation consisting of 25-35 pairs or more, would require about a 450-acre habitat patch. A medium subpopulation of 15-25 pairs would require about a 300-acre patch, and a small population of 5-15 pairs would require about 150 acres.

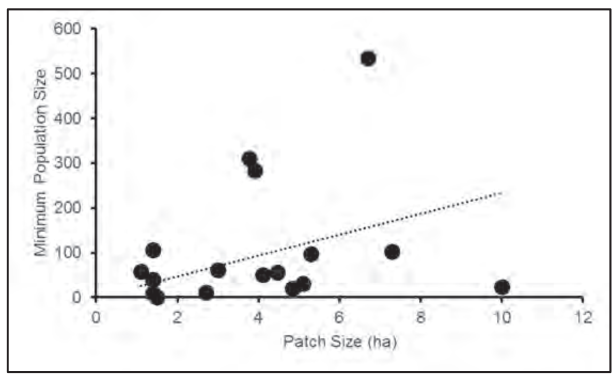
Listed Prairie Species Habitat Objectives

The Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (USFWS 2010a) does not include habitat objectives per se. For the listed plant species we met with the authors of the Recovery Plan, and others actively engaged in restoration of these imperiled species, to explore how much habitat would be necessary to meet the population objectives. With specific populations already targeted, the panel agreed that sufficient prairie habitat would be identified for the targeted grassland species (western meadowlark and Oregon vesper sparrow) and additional habitat objectives for the plant species was not warranted.

For Fender's blue butterfly (FBB) we examined the linear relationship between prairie patch size and minimum FBB population size, from the past five years (2009-2013) of 17 occupied FBB sites across the Willamette Valley. Most functioning networks consist of three subpopulations. To meet delisting criteria most recovery zones would need to support three or four functioning networks with each network needing to support a minimum of 400-1,000 butterflies, or approximately 130-330 butterflies per subpopulation (if each subpopulation is expected to support 1/3 of the population).

Using linear regression, we investigated the significance of the relationship between prairie patch size and minimum Fender's blue butterfly population size. Using this relationship we calculated the minimum patch size range needed by dividing the area required to support a minimum of 130-330 butterflies per subpopulation and a minimum of 400-1,000 butterflies per network.

We found a significant relationship between prairie patch size and minimum Fender's blue butterfly population size over the past five years ($F = 10.35$, $p = 0.006$, $R^2 = 0.33$). Each hectare (ha) of prairie habitat translates to approximately a minimum FBB population of about 23 adults (10 per acre). A Fender's blue butterfly population that would likely contribute to delisting would require between 14.1 and 35.3 acres (5.7 and 14.3 ha) of prairie habitat per subpopulation or a total between 42.3 and 105.3 acres (17.1 and 42.6 ha) of prairie habitat per functioning network.



Due to the lack of any similar information for Taylor's checkerspot butterfly, we adopted the Fender's blue butterfly standard for Taylor's checkerspot.

Wetlands

Oregon's Wetland Conservation Strategy (ODSL 1995) recommended that planning efforts should be made to identify priority wetlands, based on functional value and regionally representative wetland types for restoration and protection. The Willamette Valley and the Willamette Greenway were identified by the Oregon Department of State Lands (ODSL) as priority regions for wetland restoration and acquisition due the significant historical loss of wetlands, water quality issues, presence of rare wetland plant communities and species, threats due to urbanization, and landowner interest (ODSL 1995). This same approach, protecting priority wetlands, was recommended in the Strategic Conservation Management in Oregon's Willamette Valley (USFWS 2014).

To identify priority wetlands, we used spatial data provided by The Wetlands Conservancy which was the same data set that was used to identify wetlands of conservation concern for the Oregon portion of the Western Governors Association's Crucial Habitat Assessment Tool or CHAT (WGWC 2013). The CHAT scored and prioritized the conservation value of wetlands of conservation value by sub-watershed (Hydrologic Unit Code 8 [HUC-8]). By design this approach resulted in wetlands scoring high for conservation value in each subwatershed, and did not consider how they would score compared to wetlands across the entire Willamette Valley ecoregion. Using the same ecological attributes and weighting scheme as was used to identify wetlands of conservation value for the CHAT, the Wetlands Conservancy also mapped the conservation value of wetlands across the entire ecoregion resulting in a map that identified the wetlands of greatest conservation value across the entire ecoregion, rather than individual subwatersheds. We intersected the wetlands map with our vegetation map and targeted those wetlands that intersected our priority habitats for conservation (e.g., riparian forests and shrublands, wet prairies).

Rivers and Streams

There have been many recent studies and modeling efforts of the Willamette River and its major tributaries that identify areas of conservation significance. The studies and areas include the following: The Willamette River Planning Atlas (Hulse et al. 2002) which projected and analyzed alternative futures in the basin and identified areas of high restoration potential; mapping of the 2-year floodplain along the mainstem Willamette River (River Design Group 2012a); the Middle Fork and Coast Fork (River Design Group 2012b) and lower McKenzie River (River Design Group 2013); the U.S. Army Corps of Engineers' study that identified priority revetments for removal (Hulse et al. 2013); mapping of cold water refugia along the mainstem (Hulse et al. 2007); mapping of "anchor habitats" by the Oregon Watershed Enhancement Board (OWEB 2014); and mapping of Conservation Opportunity Areas by ODFW (2006) and TNC (2012).

The studies and conservation plans—summarized in Appendix A, all link the simplification of channel complexity and armoring along the Willamette River mainstem with the resultant loss of side channels, alcoves, and off-channel refugia as major contributors to the decline of aquatic organisms in the Willamette Valley (ODFW 2006, Hulse et al. 2002, NPCC 2004, WRI 2001, OPB 2000). The Pacific Lamprey Assessment and Template for Conservation Measures (Luzier et al. 2011) identified stream and floodplain degradation, primarily the extensive channelization and loss of side channels as a threat that ranked high for both scope and severity for Pacific lamprey in the Willamette basin. To address these issues, The Upper Willamette River Conservation and Recovery Plan for Chinook salmon and steelhead (ODFW and NMFS 2011), consistently recommends both the protection of intact riparian areas, floodplains, and high-quality off-channel habitats; and the restoration of areas to improve the amount, complexity, diversity, and connectivity of riparian, confluence, and off-channel habitats, as important actions to assist in the recovery of listed salmonids. Of course, these habitats are also important for terrestrial species as well, providing critical life history elements.

The mainstem Willamette River and its major tributaries primarily serve as migration corridors and larval and juvenile rearing habitat. Therefore, the project team decided to focus conservation efforts on habitat features important to these life-cycle phases. We used a number of different data sources to assist in identifying priority areas for riverine conservation. The Willamette River Basin Planning Atlas (Hulse et al. 2002) prioritized areas for restoration, based on an analysis of the potential to restore channel complexity and floodplain forests, and the presence of sociocultural constraints, such as human population density, property value, transportation infrastructure, and the presence of prime agricultural soils. Areas of high restoration potential with low sociocultural constraints were prioritized and mapped. We included these areas as conservation targets in the Marxan model.

The U.S. Army Corps of Engineers completed a study that prioritized revetments for removal or modification to restore natural river function (Hulse et al. 2013). That study mapped the area along 72 revetments whose hydrology during a 2-year recurrence interval flood would likely be influenced as a consequence of revetment removal or modification. These areas were termed zones of influence. Of the 72 zones of influence studied, 15 were identified as priority areas because they occur in areas previously prioritized for restoration by the Willamette River Basin Planning Atlas. We included those 15 priority zones of influence where they intersected with priority habitat types as conservation targets in the Marxan model.

The Oregon Watershed Enhancement Board (OWEB) and the Willamette Special Investment Partnership (Willamette SIP) focus on two core geographic regions for investments in protecting and restoring the Willamette River—the historic meander corridor of the Willamette mainstem (including the first few river miles of the Coast and Middle Fork Willamette rivers); and seven selected tributary subwatersheds (OWEB 2014). Along the mainstem, the Willamette SIP targets major tributary confluences and river sections where there are opportunities to reconnect the river to its historic floodplain. These areas are called Anchor Habitats. Anchor Habitats were one of the data layers used in developing the Synthesis Map of Conservation Opportunity Areas (TNC 2012), and where they intersected priority habitat types, the Anchor Habitats were included as targets in the Marxan model.

Floodplains inundated by a 2-year storm event have been mapped along the Willamette River from Eugene to Oregon City (River Design Group 2012a); the Middle Fork and Coast Fork of the Willamette River (River Design Group 2012b); and the McKenzie River below Leaburg Dam (River Design Group 2013). The Middle Fork analysis area extends 17 miles from Dexter Dam downstream to the confluence with the Coast Fork. The Coast Fork analysis area extends from two miles downstream of the Highway 58 Bridge to the confluence with the Middle Fork. Floodplain inundation mapping was completed to gain a better understanding of river corridor connectivity and to identify potential opportunities for protecting floodplain resources and restoring impaired habitats. We used the intersection of floodplain inundation maps with priority habitat types as targets in the Marxan model.

This document continues on the next page.

Appendix F. Marxan

Introduction

The Willamette Valley Marxan analysis was designed to identify in an integrated and efficient manner and building upon lands already conserved, key areas of the valley within which a network of core habitat patches could be established and threatened and endangered populations conserved. This process entailed evaluating thousands of areas throughout the entire Willamette Valley, to identify areas that could meet multiple conservation goals. This complexity makes it nearly impossible to select a highly efficient conservation network design, relying solely on expert knowledge. To deal with this challenge, we identified Priority Conservation Areas (PCAs) using the conservation network design optimization algorithm Marxan (Ball and Possingham 2000). Marxan (and its predecessors SPEXAN and SITES) has been used for many terrestrial and marine conservation assessments around the world (e.g., Beck and Odaya 2001, Andelman and Willig 2002, Noss et al. 2002, Leslie et al. 2003, Carroll et al. 2003, Floberg et al. 2004, USFWS 2013, Arid Lands Initiative 2014).

Based on user-specified inputs, Marxan creates conservation designs that satisfy key principles of systematic conservation planning, including efficiency, complementarity, representativeness, and adequacy (Ardron et al. 2010). The Marxan algorithm quickly arrives at near-optimal conservation designs that meet user goals (e.g., 5,438 acres of western meadowlark habitat in the central valley) while minimizing user-specified constraints (e.g. estimated cost in dollars, total acreage, or more abstract constraints such as the level of human impact). Marxan also seeks to minimize the total outer perimeter of the conservation network in order to create a less fragmented solution. All of these factors (goals, constraints, and fragmentation) are considered by Marxan's objective function.

Marxan works by first generating a random initial conservation network design, then altering it slightly and testing the new version against its objective function. It iterates through this process millions of times to allow Marxan to thoroughly explore the enormous problem space. Early in the process, Marxan will sometimes move toward a design with a poorer objective function score. This approach, known as simulated annealing, is critical in helping the algorithm avoid this from happening (Game and Grantham 2008) so that more efficient solutions can eventually be achieved.

There are a few key limitations to Marxan. The quality of its network design is dependent on the quality of the data used (e.g., landcover types, threatened and endangered species locations). For instance, there may be unmapped populations of listed species that could contribute to recovery that Marxan cannot factor into its network design. Marxan cannot factor in landowner interest, or pre-existing stakeholder and political conflicts (Ardon et al. 2010). As land-based conservation actions are dependent on landowner interest, significant opportunities may fall outside of the final network design.

Before running Marxan, several methodological and conservation decisions had to be made. We needed to define the size and shape of Marxan planning units, select conservation features, choose data layers to represent the selected conservation targets, define which constraints or costs should be minimized, and calibrate Marxan parameters. After running the model, we also had to refine the boundary of the Marxan solution based on expert knowledge, as is recommended by Game and Grantham (2008). The remainder of this appendix describes how these decisions were made.

Planning Units

Marxan requires that all input data layers be aggregated to polygon planning units (PUs) that seamlessly cover the analysis area. In other words, a spatial database is developed that includes, for each PU, the total acreage of each Marxan target as well as a "constraint" score. These PUs are the building blocks of the conservation network, and their geometry can greatly influence Marxan outputs. It is possible to use PUs that are based on natural ecological divisions like watersheds, or political divisions like land ownership parcels, but their irregular sizes and edge lengths can lead to selection biases and so regular grids are preferred. In this case, we chose a grid, and selected hexagons instead of squares because squares often result in overly rectilinear conservation designs.

Marxan PU resolution should generally be no finer than the conservation target data can support and no coarser than is useful for management decisions (Ardon et al. 2010). We identified 250 acres as an appropriate PU size given uncertainty in the input data, and subdivided the 3,200,000-acre study area into a grid of 13,388 hexagons comprised of 250 acres each.

Locking In Special Areas

Marxan allows for some PUs to be "locked in" so that they are always included in the final conservation network design. This is useful for areas that are of key importance to a particular fine filter target, which may not have enough overlap with other targets to be picked up by the Marxan algorithm. It can also be appropriate to lock in areas that are already part of the conservation network, so that the solution builds off existing protected areas. For the Willamette Valley analysis, we locked in PUs representing both coarse and fine filter targets and portions of the existing conservation estate.

We locked in 31 PUs (4,750 acres) for key populations of endangered plants (Bradshaw's lomatium, Kinkaid's lupine, and the Willamette daisy), using shapefiles provided by Rebecca Currin (USFWS) in 2014. We locked in 103 PUs (25,750 acres) for the Taylor's checkerspot and Fender's blue butterflies. The Taylor's checkerspot population location data were provided by Richard Szlemp (USFWS) in 2013, and Fender's blue locations data were provided by Tyler Hicks (Washington State University) in 2013. Experts on the endangered plants and butterflies in the valley agreed that locking in these fine filter targets was appropriate and sufficient.

We also locked in two key bird areas delineated by Bob Altman of the American Bird Conservancy. One is the Indian Head Hills area near Coburg in the South Willamette Valley, which has a high density of declining grassland birds. The other is an area of pastures near Molalla where vesper sparrow and western meadowlark observations have occurred nearby. Including the bird areas added 31 PUs, or 4,750 acres. Finally, we locked in 159 PUs (39,750 acres) that intersected the approved boundaries for the National Wildlife Refuges in the valley.

Locking Out Areas Outside Oregon Department of Fish and Wildlife Conservation Opportunity Areas

In the fall of 2015, the Oregon Department of Fish and Wildlife (ODFW) finalized an update to their Conservation Opportunity Areas (COAs). ODFW also used Marxan to identify priority areas. They had a different suite of target species and habitats than the WVCS, but to the degree possible, we wanted the WVCS PCAs to be a subset of the ODFW COAs while still meeting WVCS conservation objectives. In order to accomplish this, we "locked out" all PUs that did not have any intersection with the ODFW COAs, unless they were already locked in as previously described. Marxan never includes locked out PUs in its solutions regardless of how much target habitat they contain.

Marxan was able to identify an efficient design almost entirely within the ODFW COAs with the notable exception of particular subpopulations of threatened and endangered species the recovery team locked-in to the final design. Because the ODFW COAs and the WVCS PCAs were created using different PUs, there is some mismatch in their edges. Overall, 91.0 percent of the area of the final PCAs falls within the area of ODFW COAs, providing a highly consistent map of important areas for conservation actions in the valley.

Data Layers Representing Conservation Targets

The priority habitats for the WVCS are prairie (wetland and upland), oak savanna, oak woodland, riparian forest, and riparian shrublands. The Oregon Conservation Strategy (ODFW 2006) was the basis for selecting these habitats, which are described in Appendix C.

After deciding on target habitats, we had to identify the best available spatial data representing the location of these habitats in the Willamette Valley. Numerous Land Use/Land Cover (LULC) layers are available in the valley, including the National Land Cover Dataset (NLCD), The Coastal Change Analysis Program (C-CAP) Land Cover layer, LANDFIRE Current Vegetation Class, the Northwest Habitat Institute (NWHI) vegetation layer, and others. Each dataset has its strengths and weaknesses, and so we decided to combine all relevant layers into a single spatial database. To do this, a Landsat image from 2010 was broken up into polygons with distinct spectral signatures using eCognition, producing about 250,000 polygons. Because these polygons were often too large to capture wetlands, which were important to this study, we also incorporated a modified version of the National Wetlands Inventory (NWI). This data layer, which was developed by the Institute for Natural Resources in Portland, Oregon, was essentially "burnt in" to the eCognition polygon layer, and the NWI attributes of these wetland polygons were used to assign their vegetation class.

The other polygons were assigned vegetation classes based on agreement among existing LULC maps and other ancillary information such as LiDAR-derived vegetation height. The final product was a set of polygons that covered the entire study are, each with a vegetation type assignment based on multiple datasets. The dataset was also hand edited in 2014 after field visits revealed that some areas that were mapped as pasture had been converted to vineyards or Christmas tree farms. Because these high structure agriculture types are easy to detect with high resolution imagery, many of these errors could be caught and corrected in the office.

The composite vegetation layer had 20 different vegetation classes (Table F1). Some of these classes directly corresponded to our priority habitats, and were used as Marxan Targets. However, because true prairie habitat is now very rare in the valley, we chose to represent prairie with landcover types that are fairly compatible with grassland-dependent species, and can support our target species well, with minor changes in management (e.g., delaying haying of pasture until after chicks have fledged). These vegetation classes include unmanaged pasture, grasslands within protected areas, and pasture/hay. Together, these classes comprised the prairie target habitat in the Marxan model. To avoid prioritizing prairie habitat that was never historically open, we only targeted these areas when they overlapped with historical prairie or savanna as defined by the 1951 historical vegetation map of the Willamette Valley (Christy and Alverson 2011). We also did not target oak savanna areas that were not historically open.

Table F1. Classes in the composite vegetation layer prepared for this study, with their correspondence to Marxan target habitats

Vegetation Class	Corresponding Marxan Target Habitat
Cultivated Agriculture	Not a target
Deciduous Forest	Not a target
Developed/High Intensity	Not a target
Developed/Low Intensity	Not a target
Developed/Medium Intensity	Not a target
Developed/Open Space	Not a target
Grassland/Herbaceous in Protected Areas	Grassland
Harvested Forest - Regeneration	Not a target
High Structure Agriculture	Not a target
North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest	Not a target
North Pacific Oak Woodland	Oak Woodland
Oak Savanna	Oak Savanna
Pasture/Hay	Prairie
Riparian Forest	Riparian Forest
Riparian Shrubland	Riparian Shrubland
Scrub/Shrub	Not a target
Seed/Sod Grass	Not a target
Temperate Pacific Freshwater Emergent Marsh	Not a target
Unconsolidated Shore	Not a target
Unmanaged Pasture	Grassland
Water	Not a target

Although the oak woodland target habitat was directly represented in the composite vegetation layer, there are not enough acres of oak-dominant woodland in the valley to meet population objectives for the target species (slender-billed white-breasted nuthatch). There are, however, many acres of woodlands which are dominated by other types of trees but that also include a sizable minority of oak trees. Because these areas could be restored to oak woodland with active management (e.g., removal of conifers), we chose to include them in the oak woodlands Marxan target. This gave Marxan more flexibility when satisfying oak woodland goals, and thus allowed for a more efficient solution.

Stacked Targets

In many cases, not all parts of a habitat's distribution area are equivalent in terms of conservation delivery. For example, planners might value all patches of a particular habitat type, but recognize that patches over a certain size are likely to be more functional than smaller patches. Thus, they might favor large patches of this habitat when creating a network design, while accepting smaller patches when they are needed to meet acreage goals or when they overlap with other important targets. In order to give Marxan a similar preference for certain subsets of a target (e.g., larger patches), "stacked targets" can be used. This essentially means that although all of a habitat distribution is targeted by Marxan, those areas with special attributes that make them more valuable are targeted twice and are more likely to be included in the final conservation network design. In a Marxan analysis in the Columbia Plateau (ALI 2014), for example, stacked targeting of shrub steppe patches over 500 acres in size allowed Marxan to favor these areas while still selecting smaller patches as needed.

In the Willamette Valley, stacked targets were used for all habitat types (Table F2). For each priority habitat, in order to select areas where the targeted species are known to occur, we favored areas that were within 2 km of a recent observation (5 years or less) of the habitat's target species. In the case of prairie habitat, because our broad definition included such a large acreage of agricultural lands that could potentially be managed to support grassland species as well, we only targeted those areas that were within 2 km of either a recent western meadowlark or vesper sparrow observation.

Table F2. Marxan targets and their acreage goal levels. Goal levels were capped at 70% of available acreage. The "base" habitats are shown in bold, and their "stacked targets" are nested beneath them in italics. Each subsection of the valley (North, South, and Central) had unique targets (see Executive Summary and Appendix E for more information).

	Target	Habitat acreage goals based on population targets	Available habitat (acres)	Marxan acreage goals (capped at 70% of available)
North Valley	Oak Savanna in historically open areas	1,500	3,371.8	1,500.0
	within 2km of a recent western bluebird observation	1,500	235.2	164.6
	Prairie* in historically open areas	2,813	79,820.0	**
	within 2km of a recent vesper sparrow observation	750	8,984.6	750.0
	within 2km of a recent western meadowlark observation	2,063	9,948.9	2,063.0
	Oak Woodland	16,500	63,574.8	16,500.0
	within 2km of a recent white-breasted nuthatch observation	16,500	13,513.6	9,459.5
	Riparian Forest	5,400	46,014.2	5,400.0
	within 2km of a recent yellow warbler observation	5,400	10,497.6	5,400.0
	that intersects anchor habitats with high restoration potential	5,400	1,756.9	1,229.9
	that intersects Willamette floodplain segments with cold points	5,400	172.3	120.6
	that intersects wetlands with high WGA CHAT scores	5,400	4,237.6	2,966.3
	that intersects areas with high suitability for revetment removal	5,400	1,920.8	1,344.6
	Riparian Shrubland	1,650	11,460.0	1,650.0
	within 2km of a recent yellow-breasted chat observation	1,650	758.3	530.8
	that intersects anchor habitats with high restoration potential	1,650	495.6	346.9

	Target	Habitat acreage goals based on population targets	Available habitat (acres)	Marxan acreage goals (capped at 70% of available)
	that intersects Willamette floodplain segments with cold points	1,650	76.5	53.5
	that intersects wetlands with high WGA CHAT scores	1,650	1,684.7	1,179.3
	that intersects areas with high suitability for revetment removal	1,650	350.7	245.5
Central Valley	Oak Savanna in historically open areas	1,763	3,176.7	1,763.0
	within 2km of a recent western bluebird observation	1,763	1,144.7	801.3
	Prairie* in historically open areas	7,211	76,253.3	**
	within 2km of a recent vesper sparrow observation	1,773	8,610.3	1,773.0
	within 2km of a recent western meadowlark observation	5,438	15,060.2	5,438.0
	Oak Woodland	16,500	41,655.5	16,500.0
	within 2 km of a recent white-breasted nuthatch observation	16,500	15,016.7	10,511.7
	Riparian Forest	4,860	24,319.0	4,860.0
	within 2 km of a recent yellow warbler observation	4,860	9,751.7	4,860.0
	that intersects anchor habitats with high restoration potential	4,860	2,070.8	1,449.5
	that intersects Willamette floodplain segments with cold points	4,860	266.5	186.5
	that intersects wetlands with high WGA CHAT scores	4,860	3,712.1	2,598.5
	that intersects areas with high suitability for revetment removal	4,860	2,464.2	1,724.9
	Riparian Shrubland	1,950	5,187.4	1,950.0

	Target	Habitat acreage goals based on population targets	Available habitat (acres)	Marxan acreage goals (capped at 70% of available)
	within 2 km of a recent yellow-breasted chat observation	1,950	936.3	655.4
	that intersects anchor habitats with high restoration potential	1,950	430.3	301.2
	that intersects Willamette floodplain segments with cold points	1,950	80.4	56.3
	that intersects wetlands with high WGA CHAT scores	1,950	829.2	580.4
	that intersects areas with high suitability for revetment removal	1,950	536.2	375.3
South Valley	Oak Savanna in historically open areas	1,388	5,965.1	1,388.0
South Valley	within 2 km of a recent western bluebird observation	1,388	757.8	530.4
South Valley	Prairie* in historically open areas	8,748	113,398.8	**
South Valley	within 2 km of a recent vesper sparrow observation	2,185	23,411.6	2,185.0
South Valley	within 2 km of a recent western meadowlark observation	6,563	32,772.5	6,563.0
South Valley	Oak Woodland	16,200	54,061.7	16,200.0
South Valley	within 2 km of a recent white-breasted nuthatch observation	16,200	15,981.1	11,186.8
South Valley	Riparian Forest	4,860	32,417.1	4,860.0
South Valley	within 2 km of a recent yellow warbler observation	4,860	11,200.5	4,860.0
South Valley	that intersects anchor habitats with high restoration potential	4,860	3,370.6	2,359.4
South Valley	that intersects Willamette floodplain segments with cold points	4,860	634.9	444.4
South Valley	that intersects wetlands with high WGA CHAT scores	4,860	5,772.9	4,041.0

	Target	Habitat acreage goals based on population targets	Available habitat (acres)	Marxan acreage goals (capped at 70% of available)
South Valley	that intersects areas with high suitability for revetment removal	4,860	1,701.0	1,190.7
	Riparian Shrubland	1,500	6,486.4	1,500.0
	within 2 km of a recent yellow-breasted chat observation	1,500	1,411.3	987.9
	that intersects anchor habitats with high restoration potential	1,500	1,156.7	809.7
	that intersects Willamette floodplain segments with cold points	1,500	275.6	192.9
	that intersects wetlands with high WGA CHAT scores	1,500	1,622.1	1,135.5
	that intersects areas with high suitability for revetment removal	1,500	369.3	258.5

* As was described above, the Prairie target includes Grassland/Herbaceous in protected areas, Pasture/Hay, and Unmanaged Pasture.

** Because the 10-year Prairie acreage goals can easily be met in areas near western meadowlark and vesper sparrow observations, we did not target prairie that was further than 2 km from an observation.

To identify areas near existing breeding populations, we compiled recent bird observation data from numerous sources. These included survey data gathered by the American Bird Conservancy, The Portland Bureau of Environmental Services, the Portland Chapter of The Audubon Society, the Oregon Department of Fish and Wildlife, and The Oregon Chapter of The Nature Conservancy. We also used data from a vesper sparrow survey conducted by Bob Altman in 2013, some incidental vesper sparrow observation also provided by Bob Altman, Breeding Bird Survey data, and vetted eBird observations.

Because we wanted to focus on areas that currently or very recently had breeding populations, we only used breeding season records from 2008 to 2013. Breeding season was defined as May-June, but for the resident species (western meadowlark and slender-billed white-breasted nuthatch) we also used the last half of April, and for the migrant species (yellow warbler, western bluebird, vesper sparrow, and yellow-breasted chat) we included the first half of July.

In addition to favoring habitat near recent occurrences of the associated target species, we also used several other stacked targets for riparian forests and shrublands. Aquatic habitats were not directly targeted in this analysis, but we did favor riparian areas that could provide benefits to aquatic systems while still meeting terrestrial habitat goals. We did this by configuring Marxan so that it preferred to meet acreage goals for riparian targets in places where they overlapped with existing aquatic priority areas (Table F2).

These existing aquatic priority areas included the following GIS layers: sections of the Willamette River floodplain with high restoration potential and low social impact from the Willamette River Planning Atlas (Hulse et al. 2002); the Willamette River's 2-year floodplain (River Design Group 2012a); layers from a US Army Corps of Engineers' study that identified priority revetments for removal (Hulse et al. 2013); cold water refugia (Hulse et al. 2007); "anchor habitats" mapped by the Oregon Watershed Enhancement Board (OWEB 2014); and wetlands of conservation concern identified by The Wetlands Conservancy for the Western Governors Association's Crucial Habitat Assessment Tool or CHAT (WGWC 2013). We overlaid these areas of conservation significance with the riparian forest and shrubland habitat layers, and the areas of intersection became targets for conservation.

Setting Goal Levels

Marxan requires specific goals levels for each target. They can either be a percent of the total distribution or specific acreage goals. For this analysis, acreage goals were identified for target habitats by estimating the amount of land required to support resilient populations of their particular target species. This process is described in Appendix E.

For all targets, we capped the goals at 70 percent of the total available distribution. Targeting more than that can cause Marxan to include every PU that has even a very small portion of the target in the solution, which leads to inefficient designs.

Constraint Layer

Marxan uses a constraint layer in order to optimize the selection of spatial units (This is called the cost layer in the Marxan documentation, but the term constraint is preferred here because this analysis does not rely solely on an economic cost layer, and so referring to cost can be misleading). The constraint layer allows it to favor PUs that are less constrained in their ability to meet conservation goals (though Marxan may still select highly constrained PUs if they are essential to meet a goal). To prepare the constraint layer, we identified a set of variables that can limit the landscape's ability to meet conservation goals, and then compiled the best available spatial data for each of these factors. We then used different combinations of the variables to develop three alternative constraint layers. One of the constraint layers represented environmental integrity, another represented socioeconomic constraints, and the third was designed to make Marxan favor areas inside the Synthesis Conservation Opportunity Area (COA) polygons developed by the Oregon Chapter of the Nature Conservancy (TNC 2012).

The environmental integrity constraint layer is based on two variables: Land Use/Land Cover (LULC) types, and the number of highway miles in a PU. The social constraints layer combines three variables: land cost, actively farmed prime agricultural farmland, and tax lot size. The Synthesis COA layer considers the location of the PU relative to the location of COA. All constraint variables are described in detail below.

Integrity Factors

Land Use/Land Cover

The LULC cover types were based on the same composite vegetation layer that we used for target habitats, described above. Each cover type was scored for its general wildlife value on a scale of 1 to 10, with the best cover type(s) receiving a 1 and the worst cover type(s) receiving a 10 (Table F3). All of the target habitats (e.g., prairies, oak woodlands) received a score of 1. Developed areas, high intensity agriculture, and grass seed fields were scored high for their wildlife constraints, meaning that Marxan would attempt to avoid those areas.

Table F3. LULC types in the Willamette Valley and their wildlife conservation value scores.

Land Use/Land Cover	Score
Cultivated Ag	8
Deciduous Forest	5
Developed/High Intensity	10
Developed/Low Intensity	8
Developed/Medium Intensity	10
Developed/Open Space	5
Grassland/Herbaceous	1
Harvested Forest – Regeneration	8
High Structure Ag	10
North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest	5
North Pacific Oak Woodland	1
Oak Savanna	1
Pasture/Hay	5
Riparian Forest	1
Riparian Shrubland	1
Scrub/Shrub	1
Seed/Sod Grass	8
Temperate Pacific Freshwater Emergent Marsh	1
Unconsolidated Shore	1
Unmanaged Pasture	3
Water	5

Road Density

Negative effects of roads on ecosystems and species have been well documented. These effects include, but are not limited to, “mortality…, modification of animal behavior, alteration of the physical environment, alteration of the chemical environment, spread of exotics, and increased use of areas by humans” (Trombulak and Frissell 2000). Based on expert opinion, however, small, secondary roads were not considered to be a constraint on our target avian species because they can easily and safely cross them. Further, the breeding territories of some of these species are known to include secondary roads, and their behavior does not appear to be affected by such roads. Only state highways were considered to be constraining in this analysis.

We calculated the number of highway miles per PU, then linearly scaled this variable from 1 to 10 to create an index of highway density. We scaled all constraint variables from 1 to 10 so that variables with large ranges (e.g., tax lots) would not have excessive influence on the final index value and model results. All things being equal, Marxan will favor PUs with the lower highway density index over PUs with similar biological attributes but with a higher highway density index.

Social Factors

Prime Agricultural Farmland

For reasons discussed above, we wanted Marxan to avoid prime farmland as much as possible. An area is designated as prime agricultural farmland based on its soil type. We mapped actively farmed areas with prime agricultural farmland soils, and then calculated the percent of this land use type in each PU. If a PU was 100 percent actively farmed prime agricultural farmland, then it was given a score of 10 (highly constrained; to be avoided). If it had none of these areas, it was assigned a value of 1 (not constrained, to be favored).

Tax Lot Size

Favoring PUs with larger average lot sizes over PUs dominated by small lots makes it easier to achieve habitat objectives, because cobbling a large number of small parcels together is generally inefficient and logistically complex. Using county tax lot data for all areas in the Willamette Valley outside of Urban Growth Boundaries (UGBs), we calculated the average tax lot size within each PU. We then linearly scaled and inverted these values to generate a tax lot size index, where PUs with the smallest mean lot size had a score of 10, and those with the largest had a score of 1. PUs inside UGBs were assigned the maximum value of 10.

Land Value

We also used appraised land values compiled from county tax lot data in our constraints layer. When land value is used as a constraint, Marxan will essentially attempt to minimize the purchase price of lands selected while still meeting the conservation goals. Mean land value was calculated for each 250-acre PU in areas outside UGBs. The mean was about $25,000 per acre, with a range of less than $500 to well over $1 million per acre. Marxan will avoid higher land cost areas if it can achieve conservation goals on lower cost land. We assigned the PUs a cost score based on the average land value (Table F4).

Table F4. Constraint scores derived from average cost per acre for each PU. The most expensive PUs are the most constrained (10), and the cheapest are the least constrained (1).

Mean Price per Acre ($)	Score	Mean Price per Acre ($)	Score
0-10,000	1	>50,000-60,000	6
>10,000-20,000	2	>60,000-70,000	7
>20,000-30,000	3	>70,000-80,000	8
>30,000-40,000	4	>80,000-90,000	9
>40,000-50,000	5	>90,000 or in UGB	10

Synthesis Conservation Opportunity Areas

We used conservation priority areas identified in a previous multi-partner analysis as a third constraint layer. These areas were mapped by the Oregon Chapter of The Nature Conservancy (TNC), which worked with conservation partners to produce a synthesis of the major Willamette Basin planning efforts. These prior planning efforts included: TNC's Willamette Valley–Puget Trough–Georgia Basin Ecoregional Assessment (Floberg et al. 2004); the Pacific Northwest Ecosystem Research Consortium's Willamette River Basin Alternative Futures Analysis (Hulse et al. 2002); the ODFW's Oregon Conservation Strategy (ODFW 2006); critical habitat designations and recovery plans for listed species; and Oregon's Greatest Wetlands as delineated by The Wetlands Conservancy (2005).

The TNC analysis found a large degree of overlap between the plans, but significant differences as well. The effort resulted in the development of a Willamette Basin Synthesis Map of Conservation Opportunity Areas (COAs).

These COAs represent the shared priorities of many key partners in the Valley, and we wanted to take advantage of this valuable product while allowing Marxan to select areas outside the Synthesis COAs if they had especially high conservation value. We chose not to constrain the solution to only those PUs that intersected the Synthesis COAs, as we did with the updated ODFW COAs, because the Synthesis COAs have a smaller footprint in the WVCS analysis area (972,916 acres vs. 1,168,872 in the ODFW COAs) which would make it harder for Marxan to efficiently satisfy WVCS objectives in these areas.

In order to keep the new design mostly within the Synthesis COAs while giving Marxan some flexibility, we made areas outside of COAs more constrained than areas within Synthesis COAs. Each PU outside of a Synthesis COA was scored with a 10 (constrained by the absence of a COA), and a PU wholly within a Synthesis COA received a score of 1 (not constrained). PUs that span a Synthesis COA boundary were scored by the percent of the PU outside the Synthesis COA. For example, if 80 percent of the PU was outside the COA, it received a score of 8.

Factor Weights

For constraint layers made of combinations of variables, relative weights were assigned to the individual factors. Larger weights (coefficients) were assigned to those factors believed to be more important in constraining an area's ability to meet conservation goals than other factors. Weights used in the Marxan analysis are shown in Table F5.

Table F5. Weights for the variables rolled up into the landscape integrity and socioeconomic constraint indices

Landscape Integrity Variables	Weight (0-1)	Socioeconomic Variables	Weight (0-1)
LULC	0.7	Land Cost	0.4
Highway Miles	0.3	Lot Size	0.3
Landscape Integrity Total	1	Prime Farmland	0.3
		Socioeconomic Total	1

Combining All Constraints

Because Marxan works with only one constraint layer, the three constraint layers (Integrity, Social, Synthesis COAs) were rolled up into a single index of combined constraints. Landscape Integrity and Socioeconomic constraints were each given a weight of 0.3 and the COAs constraint layer was given a weight of 0.4, for a total of 1. The combined constraints index is a linear combination of all the constraint factors (Table F6). These were calculated for each PU and scaled from 1 to 10, multiplied by the coefficients in the table below, then added together. The coefficients are the individual factor weights multiplied by the weight given to the category of constraint. For example, the coefficient for land use/land cover cost is 0.21 [0.7 (individual factor weight) * 0.3 (landscape integrity weight)].

Table F6. Factor weights used in combined constraint index

Constraint	Weight
Landscape Integrity	
Land use/land cover	0.21
Length of highway in PU	0.09
Social Factors	
Land Cost	0.12
Lot Size	0.09
Prime agricultural soils	0.09
Synthesis COAs	0.4
Total	1

Calibrating Marxan

After selecting the targets, constraint layer, and goal levels, the Willamette Valley Marxan model was calibrated to ensure that it was consistently finding very good solutions. For Marxan, a lower objective function score is better than a higher score as it indicates that a particular conservation design is obtaining the required goals efficiently. Parameters that require calibration are: the number of iterations, the boundary length modifier, the range of the constraint layer, and the species penalty factor. The effect of these parameters on Marxan solutions and the calibration procedures are described below.

Calibrating the Number of Iterations

During a single run, Marxan iterates through millions of different conservation network designs, evaluating each one. By adjusting the number of iterations per run, users can give Marxan more or less time for the runs to converge on spatially similar, near-optimal solutions. The design problem that Marxan solves can vary greatly in complexity, depending on the number of PUs and the number of targets. The more complex the problem is, the more time is required to attain very low-scoring solutions in most runs. To be sure that the number of iterations was high enough for Marxan to achieve converging and low-scoring solutions, eight versions of the model, differing only in this parameter, were run 100 times each(Table F7).

As the number of iterations was increased, the score went down; this indicates that the model was finding better solutions when given more time. The range in scores also decreased, meaning that the 100 runs became more consistent with each other. Range over mean is a useful metric—when it levels off (Figure F1), it indicates that further increases to the number of iterations will not improve consistency and scores, and would thus add processing time with little benefit. Based on this analysis, we used 20 million iterations per run in the Willamette Valley Marxan analysis.

Table F7. Marxan number of iterations calibration results. Each row summarizes 100 runs.

No. of Iterations	Min Score	Max Score	Mean Score	Range	Range/ Mean	Processing Time
2.5 million	8,994,336.3	8,994,964.9	8,994,602.0	628.6	0.0070%	4 mins and 16 secs
5 million	8,994,068.5	8,994,402.7	8,994,221.2	334.2	0.0037%	6 mins and 49 secs
7.5 million	8,993,945.8	8,994,272.5	8,994,077.4	326.7	0.0036%	8 mins and 52 secs
10 million	8,993,904.6	8,994,158.3	8,994,021.0	253.7	0.0028%	11 mins and 5 secs
15 million	8,993,842.1	8,994,045.3	8,993,938.7	203.1	0.0023%	14 mins and 43 secs
20 million	8,993,784.5	8,993,990.1	8,993,890.9	205.6	0.0023%	19 mins and 51 secs
25 million	8,993,764.6	8,993,948.8	8,993,855.5	184.2	0.0020%	23 mins and 45 secs
30 million	8,993,765.9	8,993,922.7	8,993,829.9	156.8	0.0017%	29 mins and 9 secs

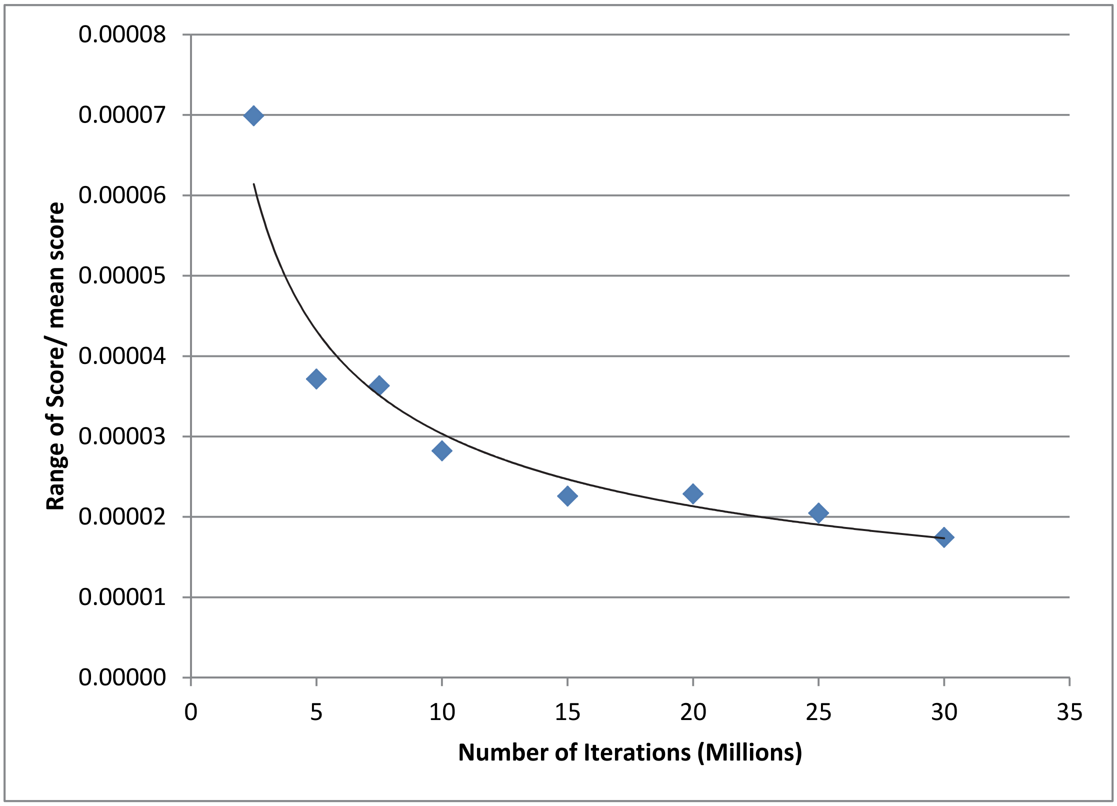


Figure F1. Change in range/mean of scores with number of iterations. The black line is a power equation fitted to the blue points with an R^2 value of 0.954.

Calibrating the Boundary Length Modifier

Another important Marxan parameter is the Boundary Length Modifier (BLM). It controls the level of spatial clumping in the solution. If the BLM is set to 0, then solutions will be formed with no regard to their overall pattern, and are typically very dispersed. As the BLM is increased, Marxan's solutions become more clumped and connected, because the algorithm favors PUs adjacent to those already selected over equally valuable PUs that are isolated from previously selected ones. This is a key parameter because, as was previously discussed, fragmented systems can create undesirable conditions for wildlife and can make management more difficult and costly.

To calibrate this parameter, we ran multiple versions of the model that differed only in their BLM values (Figure 2). As the BLM values (point labels) decrease, the total boundary length (y-axis) increases and the total constraint (x-axis) of the solutions increases. Based on this chart as well as maps of the solutions at each BLM setting, we decided on a BLM value of 0.3, which produced a solution with a moderate overall constraint score that also appeared reasonably unfragmented on the map.

Calibrating the Species Penalty Factor

The Species Penalty Factor (SPF) is a multiplier for each Marxan target that determines a scoring penalty if Marxan fails to meet user goals for that target (Game and Granthem 2008). Although it is called the *Species* penalty factor, this parameter also applies to habitat types and other targets. According to Ardron et al. (2010), Marxan is considered to be performing best when all target goals

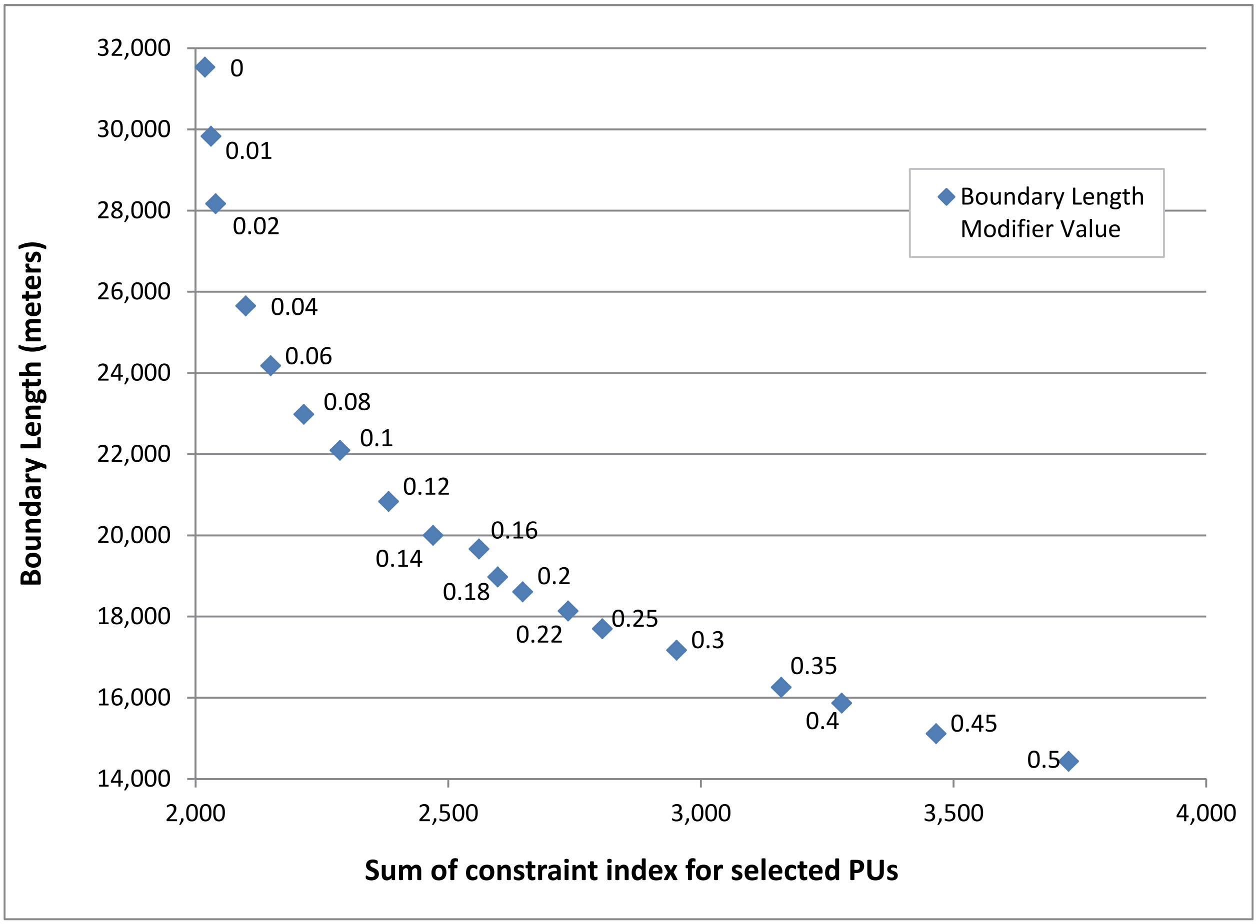


Figure 2. Changes in total boundary length and total cost of the solution as the boundary length modifier value changes. BLM values are shown beside each data point.

are met in 70-90 percent of runs. Using an SPF of 100 for all targets as a somewhat arbitrary starting value, we found that all goals were met in about 89 percent of Marxan runs, which falls in the desired range. Thus, an SPF of 100 for all Marxan targets seemed appropriate and further calibration was not required.

Refinement of Marxan Outputs

We ran Marxan with the acreage goals from Table F2 and all parameters specified above. Due to the complexity of the problem (there are $2^{13,388}$ possible network designs), Marxan is unable to guarantee finding the single design that minimizes the objective function to the maximum extent possible (Ardon et al. 2010). To increase our confidence that the final design was a very good solution, we completed 100 runs, each with 20,000,000 iterations. Marxan then selected as the “best solution” the single most efficient network design (i.e., the design with the best objective function score) out of the 100 runs tested. During these 100 runs of 20 million iterations each, 2 billion alternative conservation network designs were evaluated. We used the best solution from these runs as the basis for our PCAs. To create draft PCAs, we merged contiguous PUs into single PCAs. The result was a set of 136 PCAs ranging in size from single, isolated PUs (250 acres each), to 137 merged, contiguous PUs (34,250 acres).

Because Marxan is a decision support tool, designed to guide the selection of an efficient conservation reserve, its output should never be interpreted as "The Answer" (Ardon et al., 2010) An external review is recommend as a "reality check" of the results. We conducted that check and based on expert knowledge of the valley, we made some minor refinements to this Marxan solution. We reduced fragmentation by deleting isolated PCAs that were made up of only 1 or 2 PUs, unless they had been locked in for rare plants or butterflies. This removed 50 PUs (12,500 acres). We also removed two PUs (500 acres) that had almost no intersection with either the TNC Synthesis or the revised ODFW COAs and included only riparian habitat.

To ensure we came very close to meeting our goals, we then replaced much of the habitat from the deleted PCAs by adding PUs to the design. We selected several PUs, at the edges of existing PCAs, that had a high habitat density. We also enhanced connectivity in the design by adding PUs between PCAs that were separated by only one or two PUs, as long as there was some habitat in the intervening PUs. Finally, we added in PUs containing several key places in the existing conservation estate that were not included in the solution. These included the Chahalpam Wildlife Area, near Stayton, OR, as well as the Trappist Abbey near Lafayette, Oregon. In total, we added 43 PUs back in (10,750 acres) to the Marxan solution. The final conservation design includes 76 PCAs made up of 1,273 PUs (318,250 acres).

Appendix G. Priority Conservation Areas

Introduction

Conservation partners working in the Willamette Valley have completed several major planning efforts that identified areas within the valley that provide, or could provide with restoration, significant benefits for water quality, watershed health, wildlife habitat, species conservation, and other environmental values (Appendix A). These planning efforts differed in goals, methodologies, and scope, but many produced spatially explicit recommendations for where conservation work should be focused. In total, these assessments identified almost half of the Willamette Valley Ecoregion as a priority for conservation.

The Nature Conservancy (TNC) worked with conservation partners to synthesize the findings of the major Willamette Basin planning efforts to produce the Willamette Basin Synthesis Map of Conservation Opportunity Areas (COAs). In developing the Oregon Conservation Strategy, the Oregon Department of Fish and Wildlife also mapped COAs. COAs are defined by ODFW as "*landscapes where broad fish and wildlife conservation goals could best be met*" (ODFW 2006). They were established because "*focusing investments on priority landscapes can increase likelihood of long-term success over larger areas, improve funding efficiency, and promoting cooperative efforts across ownership boundaries*" (ODFW 2006). There is a high degree of overlap between the two mapping efforts. These COAs are recognized by conservation partners in the valley as providing a spatially-explicit strategic framework within which to focus conservation actions. The Service supports and is committed to working within this strategic framework.

Priority Conservation Areas

Because the Service's goals are a subset of the goals of the various planning efforts, the Service identified a subset of COAs to focus actions that could best meet the goals of the WVCS. The Maxan analysis identified 76 areas, within which, our habitat objectives could be met (see Figures 1, 2, and 3). We are calling these areas Priority Conservation Areas (PCAs).The PCAs lay almost entirely within the boundaries of the previously identified COAs. Only when we identified an important population of a threatened or endangered species (a fine-filter target) beyond an existing COA does a PCA occur outside of a previously mapped COA.

PCAs were typically named after the name of the Willamette Valley Synthesis COA (TNC 2012) in which the PCA is located. In some instances, multiple PCAs are within a single large COA. When this happened, we added a location modifier such as "north" or "south". In some instances, a PCA spans more than one COA. When that happened, we included both COA names, such as Finley NWR/Muddy Creek, separating the 2 COA names with a slash (/). In a few instances new names were developed to clarify the location of the PCA.

Table G1 provides the name for each PCA, its size (acreage), the County within which it is located, and a brief description of the conservation targets present. Federally listed species are followed by their listing status (LE = Listed Endangered, LT = Listed Threatened). If the PCA includes designated Critical Habitat (CH) for the species, the acronym 'CH' follows the listing status. As objectives were developed for the southern, central, and northern sections of the valley, the PCAs are identified by color which section they occur (South PCAs 1-17, Central 18-45, North 46-72).

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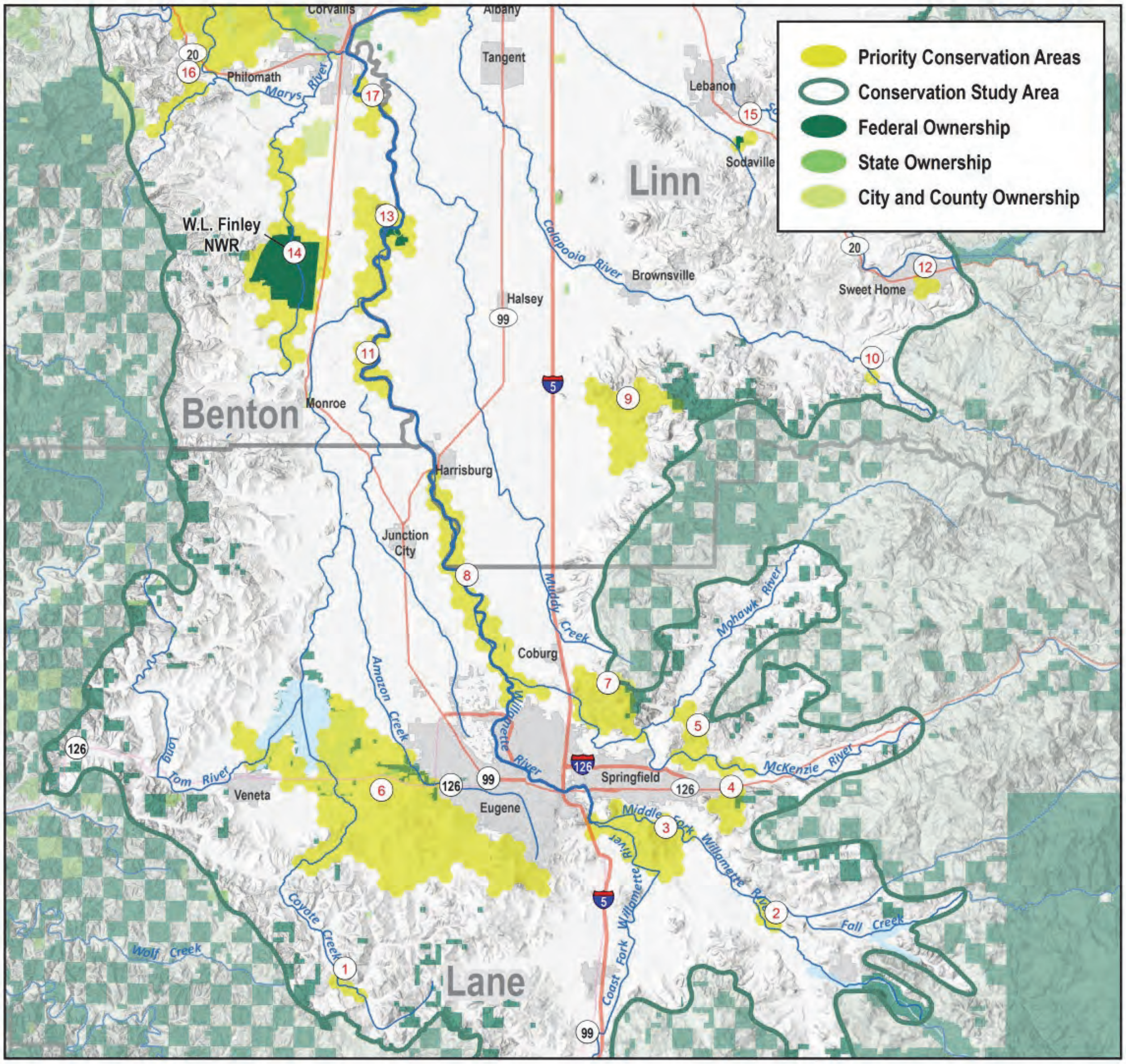
Willamette Valley Conservation Study

Figure 1. Priority Conservation Area Map South Zone



PCA ID	Name	Acreage
1	Upper Coyote Creek	750
2	Coast Fork Willamette River	750
3	Middle Fork - Coast Fork Confluence/ Mount Pisgah	7,000
4	Lower McKenzie Oaks	1,750
5	Lower McKenzie River	3,500
6	West Eugene - Spencer Creek/ Coyote Creek	37,500
7	Coburg Hills (south)	5,250
8	McKenzie-Willamette Confluence / Harper's Bend Horseshoe Bar	9,000
9	Coburg Hills (north)	6,500

PCA ID	Name	Acreage
10	Calapooia Oak Savanna	250
11	Ingram Island	2,500
12	Sweet Home Lomatium Site	750
13	Long Tom-Willamette Confluence	6,750
14	Finley NWR/Muddy Creek	13,750
15	Oak Creek Prairie and Savanna	500
16	East Slope Mary's Peak	1,750
17	Stahlbusch-John Smith Islands	1,750

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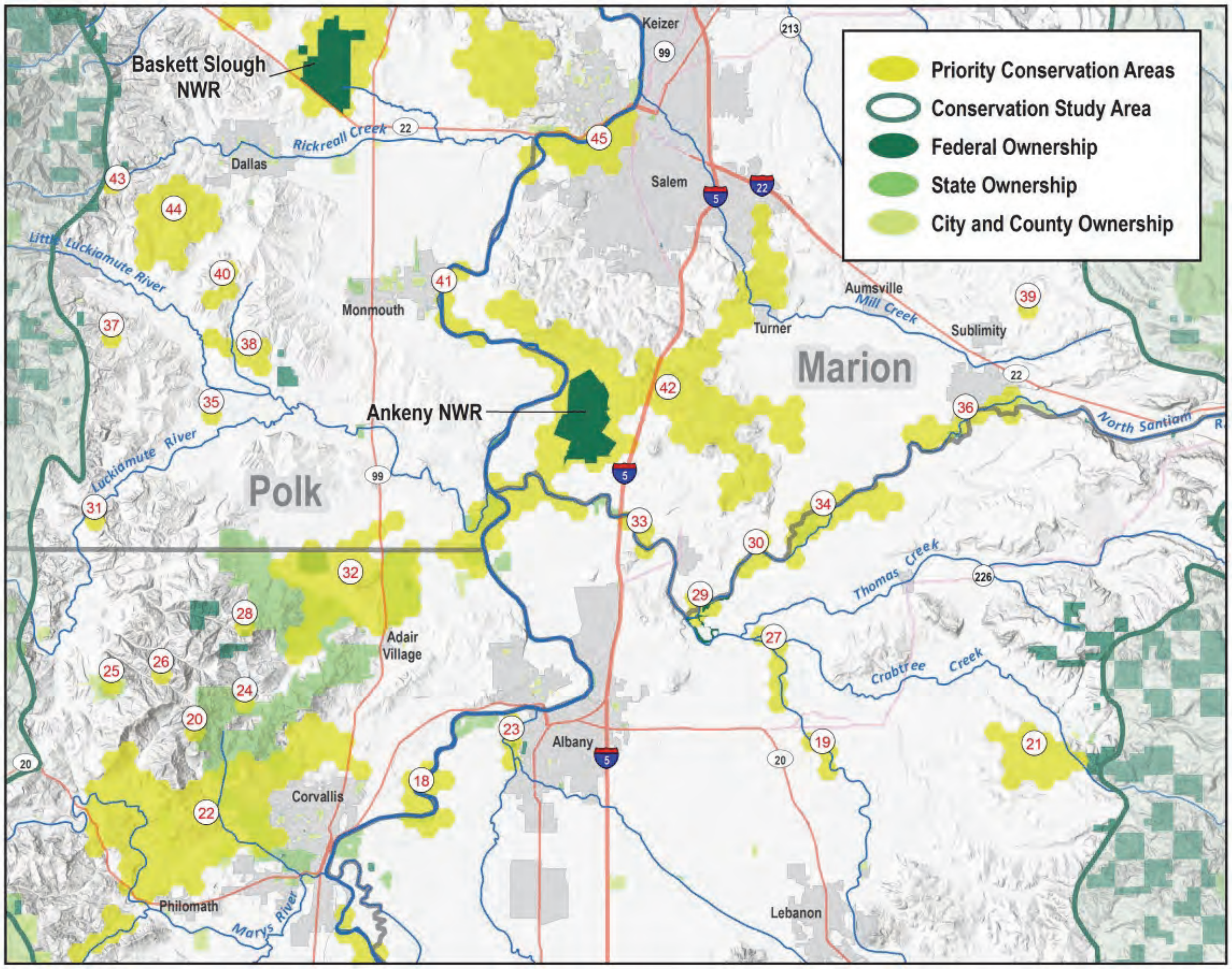
Willamette Valley Conservation Study

Figure 2. Priority Conservation Area Map Central Zone



PCA ID	Name	Acreage
18	Bowers Rock-Truax Island	2,250
19	South Santiam (south)	750
20	Corvallis Area Forests and Balds (TCB-1)	250
21	Golden Valley - Richardson Gap	3,250
22	Corvallis Area Forests and Balds (south)	18,750
23	Lower Calapooia River	750
24	Corvallis Area Forests and Balds (TCB-2)	250
25	Corvallis Area Forests and Balds (TCB-3)	250
26	Corvallis Area Forests and Balds (TCB-4)	250
27	South Santiam (north)	1,250
28	Corvallis Area Forests and Balds (TCB-5)	250
29	Santiam Confluences (2)	750
30	Santiam Confluences (3)	750
31	Luckiamute River (TCB-1)	250

PCA ID	Name	Acreage
32	Corvallis Area Forests and Balds (north)	9,500
33	Santiam Confluences (1)	750
34	Santiam Confluences (4)	3,250
35	Luckiamute River (TCB-2)	250
36	Santiam Confluences (5)	2,250
37	Upper Lukiamute (FBB)	250
38	Habeck Oaks (south)	1,250
39	Beaver Creek-Upland Larkspur	250
40	Habeck Oaks (mid)	750
41	Willamette Mainstem Section 6 Connectivity Area	1,500
42	Ankeny NWR-Salem Hills	28,000
43	Black Rock (TCB)	250
44	Habeck Oaks (north)	4,500
45	Minto Island	3,500

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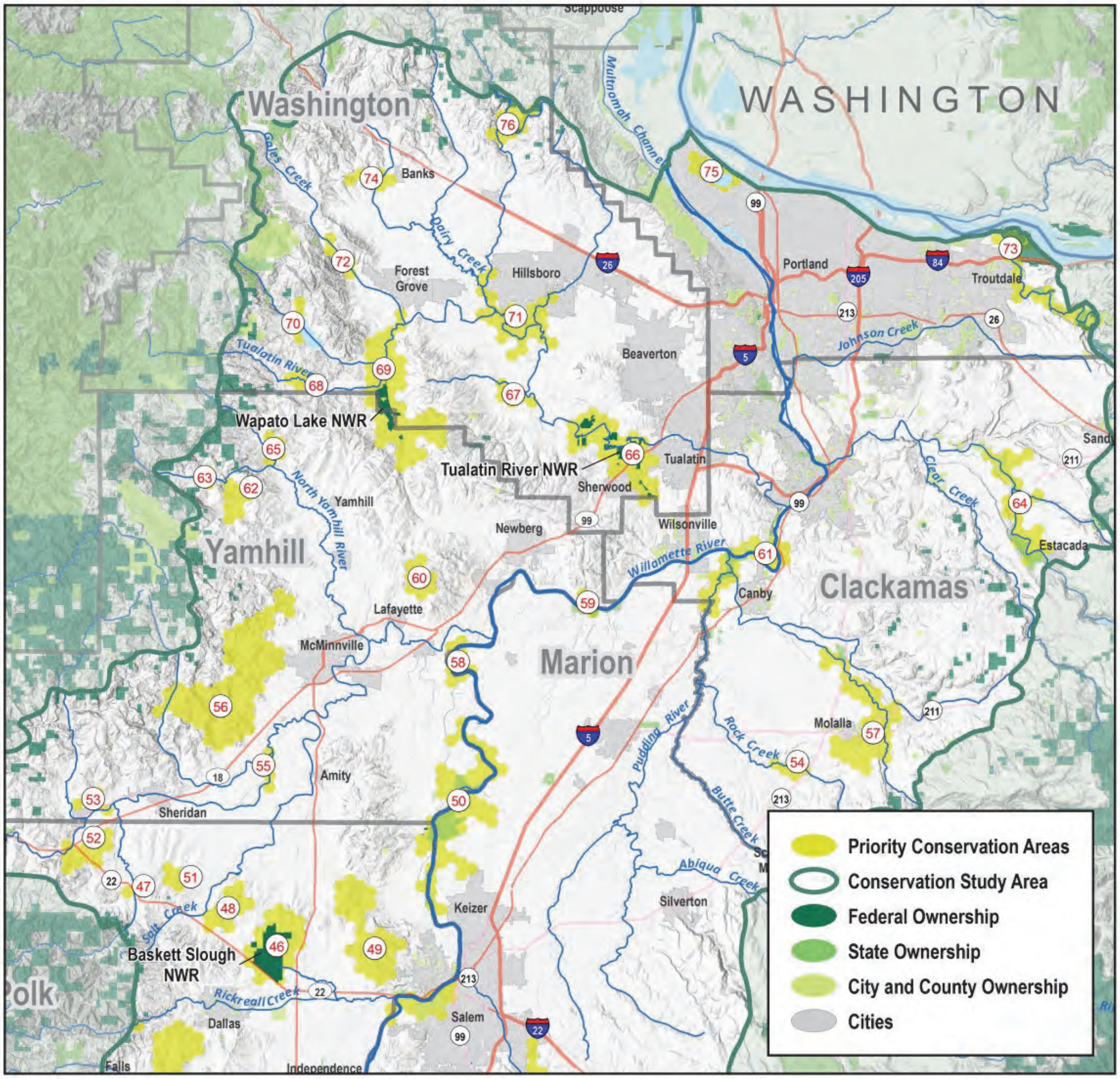
Willamette Valley Conservation Study

Figure 3. Priority Conservation Area Map North Zone



PCA ID	Name	Acreage	PCA ID	Name	Acreage	PCA ID	Name	Acreage
46	Baskett Slough NWR (east)	7,000	57	Mollala River and Grasslands	8,750	68	Taulatin Headwaters	1,000
47	Mill Creek	500	58	Grand Island (north)	2,250	69	Wapato Lake NWR/ Ribbon Ridge	12,500
48	Baskett Slough NWR (west)	3,000	59	Champoeg	1,000	70	Scoggins Valley (north)	1,250
49	Eola Hills	8,000	60	Trapist Abbey	2,250	71	Jackson Bottoms Area	6,500
50	Grand Island (south)	13,500	61	Pudding-Mollala Confluence	5,250	72	Gales Creek	1,250
51	Red Prairie	1,250	62	Oak Ridge/ Moore's Valley (east)	2,250	73	Sandy River Delta	6,250
52	Willamina Oaks (south)	3,000	63	Oak Ridge/ Moore's Valley (west)	750	74	Banks Swamp	1,500
53	Willamina Oaks (north)	1,250	64	Clackamas River	6,250	75	Smith and Bybee Wetlands	2,250
54	Rock Creek	1,250	65	Mount Richmond	1,250	76	McKay Creek - Red Slide Hill	2,500
55	South Fork Yamhill River	1,000	66	Tualatin River NWR	8,750			
56	Yamhill Oaks	17,750	67	Tualatin River	1,500			

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Table G1. Priority Conservation Areas.

Priority Conservation Area	Size (acres)	County	Primary Conservation Targets Present
		Southern Section	
1. Upper Coyote Creek	750	Lane	This small, riparian-focused PCA is located along the headwaters of Coyote Creek near the Territorial Highway north of the town of Crow. It contains riparian forests and shrublands and wetlands of conservation significance.
2. Coast Fork Willamette River	750	Lane	Located along the Coast Fork of the Willamette River from the north end of Elijah Bristow State Park to the Fall Creek confluence, this PCA contains riparian forests and shrublands known to support conservation target species and wetlands of conservation significance.
3. Middle Fork - Coast Fork Confluence/ Mount Pisgah	6,500	Lane	Large PCA that includes TNC's Confluence Preserve, Buford Park, and Mount Pisgah. Mount Pisgah is an Audubon Society designated Important Bird Area. Targeted habitats include grasslands, oak savanna and woodlands, riparian forests, shrublands, and wetlands of conservation significance that support sensitive species and a regionally significant population of Bradshaw's lomatium (LE). Riparian areas include anchor habitat and zones of influence.
4. Lower McKenzie Oaks	1,750	Lane	Located east of Springfield and south of Highway 126, this PCA contains large stands of oak woodlands that support the slender-billed white-breasted nuthatch.
5. Lower McKenzie River	3,500	Lane	Located along the Lower McKenzie River at Mohawk Creek, this PCA contains oak woodlands, and riparian forests and shrublands that are wetlands of conservation significance.
6. West Eugene - Spencer Creek/Coyote Creek	37,500	Lane	Located west of Eugene, this very large PCA includes the ecologically significant West Eugene Wetlands and ODFW's Fern Ridge Wildlife Area. The PCA abuts the Fern Ridge Reservoir, which is an Audubon Society designated Important Bird Area. The grasslands, oak savannas and woodlands, riparian forests and shrublands, and wetlands create rare habitats that support many sensitive species. ESA listed species include Willamette daisy (LE, CH), Fender's blue butterfly (LE, CH), and Kincaid's lupine (LT, CH).
7. Coburg Hills (south)	5,250	Lane	Located along the southern extent of the Coburg Hills, this PCA contains grasslands, oak savanna, and oak woodlands that are known to support conservation target species. Grassland habitats support Fenders blue butterfly (LE, CH).

Priority Conservation Area	Size (acres)	County	Primary Conservation Targets Present
8. McKenzie-Willamette Confluence / Harper's Bend Horseshoe Bar	8,750	Lane Linn	Large riparian-focused PCA located along the mainstem Willamette River north of Eugene. PCA contains riparian forests and shrublands, wetlands, zones of influence, cold points, and anchor habitat. McKenzie River Trust's Green Island is located in this PCA.
9. Coburg Hills (north)	6,500	Linn	Located along the northern extent of the Coburg Hills, this PCA is a stronghold for Oregon vesper sparrow. It contains grasslands, oak savanna, and oak woodlands. The PCA also supports an important population of Kincaid's lupine (LT).
10. Calapooia Oak Savanna	250	Linn	Small PCA located along the upper Calapooia River that includes McClun Wayside County Park. The PCA supports an important population of Willamette daisy (LE) and includes oak and riparian forest habitats.
11. Ingram Island	2,500	Benton Linn	Riparian-focused PCA located along the mainstem Willamette River between Corvallis and Eugene. Greenbelt Land Trust's Harkins Lake property is located here. The PCA contains riparian forests and shrublands, wetlands of conservation significance, and important salmonid habitat elements (zones of influence, cold points, and anchor habitat).
12. Sweet Home Lomatium Site	750	Linn	Small PCA, located south of Highway 20 near Sweet Home that includes the City's Hobart Nature Reserve. The PCA includes an important population of Bradshaw's lomatium (LE) and supports riparian forest and shrublands that are wetlands of conservation significance.
13. Long Tom-Willamette Confluence	6,750	Benton Linn	PCA includes the Long Tom and Willamette River confluence along with the Snagboat Bend Unit of the W.R. Finley NWR. Targeted habitats include riparian forests and shrublands that support conservation target species, wetlands of conservation significance, and important salmonid habitat elements (zones of influence, cold points, and anchor habitat).
14. Finley NWR /Muddy Creek	13,750	Benton	Large PCA centered on the W. L. Finley NWR, an Audubon Society designated Important Bird Area. The PCA includes many WVCS targeted species and habitats including grasslands, oak savanna and woodlands, riparian forests and shrublands, wetlands of conservation significance, and important populations of all conservation target species, including species listed under the ESA: streaked horned lark (LT, CH), Kincaid's lupine (LT), Nelson's checkermallow (LT), and Willamette daisy (LE, CH). The Refuge contains an experimental population of golden paintbrush (LT) and a 366-acre

Priority Conservation Area	Size (acres)	County	Primary Conservation Targets Present
			patch of wet prairie within the Willamette Floodplain Research Natural Area-the largest contiguous patch of wet prairie remaining in the valley.
15. Oak Creek Prairie and Savanna	500	Linn	Small PCA along Oak Creek south of Lebanon and Highway 20, that supports a regionally significant population of Bradshaw's lomatium (LE).
16. East Slope Mary's Peak	1,750	Benton	Located southwest of Corvallis along the Alsea Highway (Hwy 34) and Greasy Creek, the grasslands of this PCA support western meadowlark and important populations of Fender's blue butterfly (LE) and Kincaid's lupine (LT). Scattered oak woodlands occur along the hillslopes.
17. Stahlbusch-John Smith Islands	1,750	Benton Linn	Riparian focused PCA along the mainstem Willamette River east of the Corvallis Airport. The PCA supports riparian forests and shrublands, wetlands of conservation significance, and important salmonid habitat elements (zones of influence, cold points, and anchor habitat).
Central Section			
18. Bowers Rock-Truax Island	2,250	Benton Linn	Riparian focused PCA along the mainstem Willamette River between Albany and Corvallis that includes riparian forests and shrublands, wetlands of conservation significance, and important salmonid habitat elements (zones of influence, cold points, and anchor habitat).
19. South Santiam (south)	750	Linn	Located along the South Santiam River south of Highway 226, this PCA contains riparian forests and shrublands that are known to support conservation target species, wetlands of conservation significance, and zones of influence.
20. Corvallis Area Forests and Balds (TCB-1)	250	Benton	Small PCA that is thought to have once provided habitat for the Taylor's checkerspot butterfly (LE), and potentially could again.
21. Golden Valley - Richardson Gap	3,250	Linn	Located just south of the Santiam River in the eastern part of the valley, this PCA supports grasslands, large patches of oak woodlands and scattered oak savanna.
22. Corvallis Area Forests and Balds (south)	18,750	Benton	Located west and southwest of Corvallis, this large PCA supports many WVCS sensitive species targets and includes grasslands, oak savanna and woodlands, riparian forests and shrublands, and wetlands of conservation significance. The PCA supports important populations of Willamette daisy (LE, CH), Fender's blue butterfly (LE, CH) and Kincaid's lupine (LT, CH) and hosts one of Oregon's two known extant populations of Taylor's checkerspot butterfly (LE, CH). Jackson-Frazier

Priority Conservation Area	Size (acres)	County	Primary Conservation Targets Present
			Wetlands, Fitten Green Natural Area, Greenbelt Land Trust's Bald Hill Farm and Lupine Meadows, and other conservation areas are located in this ecologically significant PCA.
23. Lower Calapooia River	750	Benton Linn	Located just west of Albany, this riparian-focused PCA includes riparian forests, wetlands of conservation significance, and important fish habitat elements (cold points and anchor habitat).
24. Corvallis Area Forests and Balds (TCB-2)	250	Benton	Small PCA that is thought to have once provided habitat for the Taylor's checkerspot butterfly (LE), and potentially could again.
25. Corvallis Area Forests and Balds (TCB-3)	250	Benton	This PCA is centered on Beazell Forest, which supports one of Oregon's two known extant populations of Taylor's checkerspot butterfly (LE).
26. Corvallis Area Forests and Balds (TCB-4)	250	Benton	Small PCA that is thought to have once provided habitat for the Taylor's checkerspot butterfly (LE), and potentially could again.
27. South Santiam (north)	1,250	Linn	This riparian-focused PCA located along the South Santiam River north of Highway 226 includes the confluence with Crabtree Creek, riparian forests and shrublands, wetlands of conservation significance, and zones of influence.
28. Corvallis Area Forests and Balds (TCB-5)	250	Benton	Small PCA that is thought to have once provided habitat for the Taylor's checkerspot butterfly (LE), and potentially could again.
29. Santiam Confluences (2)	750	Marion Linn	Located at the confluence of the North Santiam and the South Santiam, this PCA includes the confluence with Edgar Slough, riparian forests known to support yellow warbler, riparian shrublands, and wetlands of conservation significance.
30. Santiam Confluences (3)	750	Marion Linn	Located along the North Santiam River just north of Jefferson Scio Drive, this PCA contains a large patch of riparian forest and shrubland that includes wetlands of conservation significance. An important population of Kincaid's lupine is located in this PCA.
31. Luckiamute River	250	Polk	Located in the northern section of Kings Valley west of Corvallis, this PCA includes oak woodlands and grasslands that once provided habitat for the Taylor's checkerspot butterfly (LE), and potentially could again with proper management.

Priority Conservation Area	Size (acres)	County	Primary Conservation Targets Present
32. Corvallis Area Forests and Balds (north)	9,500	Benton Polk	Located north and northeast of Corvallis, this PCA supports grasslands, oak savanna and woodlands, riparian forests and shrublands, wetlands, and listed species: Fender's blue butterfly (LE) and Kincaid's lupine (LT).Taylor's checkerspot butterfly (LE) is thought to have once inhabited this area. The PCA includes ODFW's E. E. Wilson Wildlife Area, an Audubon Society designated Important Bird Area and a stronghold for yellow-breasted chat.
33. Santiam Confluences (1)	750	Marion Linn	Located along the Santiam River just east of I-5, this PCA contains a large patch of riparian forest that supports yellow-breasted chat, wetlands of conservation significance, and zones of influence.
34. Santiam Confluences (4)	3,250	Marion Linn	Located along the North Santiam River south of the town of Marion, this PCA includes Wiseman Island and its significant stands of riparian forests and shrublands that support both yellow warbler and yellow-breasted chat. Also contains large wetlands of conservation significance.
35. Luckiamute River (TCB)	250	Polk	Small PCA that is thought to have once provided habitat for the Taylor's checkerspot butterfly (LE), and potentially could again.
36. Santiam Confluences (5)	2,250	Marion Linn	Located along the North Santiam River south of Stayton, this PCA includes large patches of riparian forest and shrublands that support targeted species and wetlands of conservation significance.
37. Upper Lukiamute (FBB)	250	Polk	Small PCA that is thought to have once provided habitat for the Taylor's checkerspot butterfly (LE), and potentially could again.
38. Habeck Oaks (south)	1,250	Polk	Located south of the Monmouth Highway east of the intersection with Kings Valley Highway (Hwy 223), this PCA includes portions of Cooper Creek and includes large stands of oak woodlands and oak savanna known to support targeted species. Riparian forests occur along Cooper Creek.
39. Beaver Creek-Upland Larkspur	250	Marion	This small PCA located east of Sublimity contains grasslands that support important populations of Willamette daisy (LT, CH) and Bradshaw's lomatium (LT).
40. Habeck Oaks (mid)	750	Polk	Located north of the Monmouth Highway (Hwy 194) and east of Kings Valley Highway (Hwy 223), this PCA includes oak woodlands and savanna that support western bluebird and slender-billed white-breasted nuthatch.
41. Willamette Mainstem	1,500	Marion Polk	This riparian-focused PCA is along the Willamette River just west of Ankeny NWR. It contains riparian forests and

Priority Conservation Area	Size (acres)	County	Primary Conservation Targets Present
Section 6 Connectivity Area			shrublands, wetlands of conservation significance, and zones of influence.
42. Ankeny NWR-Salem Hills	28,000	Marion Polk	PCA includes the grasslands, riparian forests and shrublands, and wetlands of the Ankeny NWR, an Audubon Society designated Important Bird Area. PCA also includes the Santiam and Little Luckiamute confluences with the Willamette. Oak savanna and woodlands on the Salem Hills support an important slender-billed white-breasted nuthatch population. Ankeny NWR supports Nelson's checkermallow (LT) and streaked horned lark (LT, CH). Salmonid habitat elements occur along the Willamette and Santiam rivers (zones of influence, cold points, and anchor habitat).
43. Black Rock (TCB)	250	Polk	Small PCA that is thought to have once provided habitat for the Taylor's checkerspot butterfly (LE), and potentially could again.
44. Habeck Oaks (north)	4,500	Polk	Located southeast of Dallas and west of Kings Valley Highway (Hwy 223), this PCA includes large patches of oak woodlands and savanna known to support western bluebird and slender-billed white-breasted nuthatch.
45. Minto Island	3,500	Marion Polk	This PCA includes both Hayden Island and Minto Island with its ~1,200-acre Minto-Brown Island Park. Riparian forests and shrublands are known to support targeted species. The islands also include wetlands of conservation significance, and important fish habitat elements (zones of influence and anchor habitat).
Northern Section			
46. Baskett Slough NWR (east)	7,000	Polk	PCA centered on Baskett Slough NWR, an Audubon Society designated Important Bird Area. Grasslands, oak savanna and woodlands support western meadowlark, Oregon vesper sparrow, western bluebird, and slender-billed nuthatch. Baskett Slough NWR prairies support the largest population of the endangered Fender's blue butterfly (LE, CH) within its range along with Kincaid's lupine (LT), Willamette daisy (LE, CH), and streaked horned lark (LT, CH). The PCA provides important migratory bird wintering areas and stopover sites, and includes the Mud Slough area east of the Refuge which is an Audubon Society designated Important Bird Area.
47. Mill Creek	500	Polk	Located along Mill Creek at Highway 22, grasslands of this small PCA support an important population of Fender's blue butterfly (LE, CH) and Kincaid's lupine (LT, CH).

Priority Conservation Area	Size (acres)	County	Primary Conservation Targets Present
48. Baskett Slough NWR (west)	3,000	Polk	Located west of Baskett Slough NWR, north of Highway 22, and east of Van Well Road, this PCA includes grasslands and oak woodlands known to support targeted conservation species such as western meadowlark, Oregon Vesper sparrow, and slender-billed white-breasted nuthatch.
49. Eola Hills	8,000	Polk	Located in the Eola Hills east of Baskett Slough NWR, this PCA contains large patches of oak woodlands that support targeted species such as the slender-billed white-breasted nuthatch and western bluebird. Grasslands support western meadowlark.
50. Grand Island (south)	13,500	Marion Yamhill	This large, riparian-focused PCA is located west of Kaiser and extends north (downstream) along the Willamette River to include Willamette Mission Park and the confluence of Lambert Slough. The PCA includes large patches of riparian forests and shrublands that are known to support targeted conservation species. Also includes wetlands of conservation significance and important salmonid habitat elements (zones of influence, cold points, and anchor habitat).
51. Red Prairie	1,250	Polk	Located north of Highway 22 and east of Red Prairie Road, this PCA contains grasslands and oak woodlands known to support western meadowlark, Oregon vesper sparrow, and slender-billed white-breasted nuthatch.
52. Willamina Oaks South	3,000	Polk	Located at the junction of Highways 18 and 22, this PCA includes grasslands and oak savanna and woodlands. A large complex of protected grasslands and oak woodlands is located within this PCA which includes TNC's Noble Oaks Reserve.
53. Willamina Oaks North	1,250	Yamhill	Located north of Highway 18 near the intersection with Highway 22, this PCA of oak savanna and woodlands supports important populations of Fender's blue butterfly and Kincaid's lupine.
54. Rock Creek	1,250	Clackamas	Riparian-focused PCA located southwest of Mollala, just west of Highway 213. Riparian forests support targeted species. PCA also includes riparian shrublands and wetlands of conservation significance.
55. South Fork Yamhill River	1,000	Yamhill	Riparian-focused PCA located west of Amity and north of Highway 153 with riparian forests that support targeted species. PCA also includes wetlands of conservation significance.
56. Yamhill Oaks	17,750	Yamhill	Large PCA located in Yamhill County north of Highway 18 that contains large patches of oak woodlands known to support targeted species. PCA also includes grasslands,

Priority Conservation Area	Size (acres)	County	Primary Conservation Targets Present
			oak savanna, riparian forests and shrublands known to support targeted species. Grasslands and savanna support important populations of Fender's blue butterfly (LE, CH) and Kincaid's lupine (LT, CH). TNC's Yamhill Oaks Reserve is in this PCA.
57. Mollala River and Grasslands	8,750	Clackamas	PCA includes grasslands known to support western meadowlark and Oregon vesper sparrow. Riparian forests and wetlands of conservation significance occur along the river.
58. Grand Island (north)	2,250	Yamhill	Located west of St. Paul along the mainstem Willamette River, this riparian-focused PCA includes riparian forests known to support targeted species. The PCA also includes wetlands of conservation significance and zones of influence.
59. Champoeg	1,000	Yamhill	Spanning both sides of the Willamette River, this PCA includes Champoeg State Park and includes riparian forests and shrublands. Oak woodlands known to support the slender-billed white-breasted nuthatch are found along the hillsides.
60. Trapist Abbey	2,250	Yamhill	Located north of the town of Lafayette, this PCA includes the oak woodlands of Our Lady of Guadalupe Trappist Abbey and other nearby woodlands. A conservation easement protects the Abby's oak habitat.
61. Pudding-Mollala Confluence	5,250	Clackamas	This PCA includes the lower reach of the Pudding River, its confluence with the Molalla River, and the Molalla and Willamette River confluence. Molalla River State Park is located here. Large riparian forests and shrublands support conservation target species. PCA includes large wetlands of conservation concern and anchor habitat. Oak woodlands occur along the south-facing hills north of the Willamette River.
62. Oak Ridge/ Moore's Valley (east)	2,250	Yamhill	Located west of the Oak Ridge Road and Fairdale Road intersection, this PCA supports large patches of oak woodlands. Grasslands support an important population of Fender's blue butterfly (LE, CH) and Kincaid's lupine (LT, CH).
63. Oak Ridge/ Moore's Valley (west)	750	Yamhill	Located just west of PCA 62, this PCA includes large patches of oak woodlands. The North Yamhill River flows through this PCA.
64. Clackamas River	6,250	Clackamas	Located west of Highway 211 and north of Estacada, this PCA includes grasslands and riparian forests known to support conservation target species including western meadowlark and Oregon vesper sparrow. Wetlands of conservation significance occur in the riparian forests.

Priority Conservation Area	Size (acres)	County	Primary Conservation Targets Present
65. Mount Richmond	1,250	Yamhill	This PCA is located along Turner Creek near its confluence with the North Santiam River. Grasslands support a population of Fender's blue butterfly (LE). Oak woodlands occur along the hillsides.
66. Tualatin River NWR	8,750	Washington	PCA is centered on the Tualatin River NWR, an Audubon Society designated Important Bird Area. The PCA contains grasslands, oak woodlands, riparian forests, and wetlands of conservation significance.
67. Tualatin River	1,500	Washington	Located upstream of the Tualatin River NWR, this PCA includes the riparian habitats of the Tualatin River and Burris and Christensen creeks, which are wetlands of conservation significance.
68. Tualatin Headwaters	1,000	Washington	Located south of the town of Cherry Grove along the headwaters of the Tualatin River, this PCA includes riparian forests and shrublands known to support conservation target species. Oak woodlands occur along the hillsides.
69. Wapato Lake NWR/ Ribbon Ridge	12,500	Washington Yamhill	This PCA is centered on the wetland habitats of the Wapato Lake NWR and the oak woodlands of Ribbon Ridge. Wapato Lake NWR contains wetlands of conservation significance.
70. Scoggins Valley	1,250	Washington	Located west and south of Henry Hagg Lake, the grassland habitats of this PCA support important populations of Kincaid's lupine (LT) and the northernmost known population of Fender's blue butterfly (LE).
71. Jackson Bottoms Area	6,500	Washington	This PCA, located in the mid- Tualatin River watershed, includes the 650-acre Jackson Bottom Wetlands Preserve, an Audubon Society designated Important Bird Area. The PCA includes riparian forests and shrublands and wetlands of conservation significance.
72. Gales Creek	1,250	Washington	Located northwest of Forest Grove along Gales Creek, this PCA includes the confluence with Kelly Creek, riparian forests and shrublands, and wetlands of conservation significance.
73. Sandy River Delta	6,250	Multnomah	PCA includes the Sandy River Delta and the riparian habitats of the lower Sandy River to Metro's Oxbow Regional Park. The Delta is located near Troutdale at the confluence of the Sandy and Columbia rivers. The US Forest Service manages the delta. The delta includes grasslands, riparian forests and shrublands that support conservation target species as well as wetlands of conservation significance.

74. Banks Swamp	1,500	Washington	Banks Swamp (also known as the Killin Wetlands) is an Audubon Society designated Important Bird Area. The PCA is located along Highway 6 west of Banks and contains an important remnant of the Willamette Valley scrub-shrub marsh present before settlement. The PCA contains riparian forests and shrublands that support yellow warbler and large wetlands of conservation significance.
75. Smith and Bybee Wetlands	2,250	Multnomah	Located near the confluence of the Willamette and Columbia rivers within the City of Portland, this PCA is centered on Metro's 2,000-acre Smith and Bybee Wetlands Natural Area. The PCA includes riparian forests and shrublands, wetlands of conservation significance, and seasonal mud-flat habitats. It provides important migratory bird wintering area and stopover site.
76. McKay Creek - Red Slide Hill	2,500	Washington	Located along McKay Creek north of the city of North Plains, this riparian-focused PCA also includes the East Fork McKay Creek. Riparian forests along the creeks create large wetlands of conservation significance.

LE = Listed Endangered; LT = Listed Threatened; CH = Critical Habitat (Designated)

Wetland/ USFWS

Appendix H. Gap Analysis

Introduction

The purpose of a gap analysis is to compare priority areas for conservation against the amount and distribution of protected lands within the planning area. Priority areas that are not adequately represented in the portfolio of protected lands represent a "gap" in the conservation area network (Margules and Pressey 2000, Groves 2003). Identifying gaps is an important step in systematic conservation planning. The purpose of the gap analysis conducted for this study was to compare the amount and distribution of protected lands within PCAs against the habitat objective, to determine if a given objective is satisfied by the current configuration of protected lands. The difference between what is already protected and the habitat objective represents a gap in meeting WVCS conservation objectives.

In order to make sure we were working with the most up-to-date information, we contracted with the Institute for Natural Resources (INR) to update the Protected Area Database of the United States (PAD-US). Administered by the U.S. Geologic Survey, PAD-US is the official inventory of protected open space in the United States. INR contacted federal, state, and local agencies and land trusts active in the Willamette Valley, to update their inventory of protected lands and their gap status. Reporting is voluntary and land protection is ongoing, so there cannot be 100 percent assurance that all protected lands are included.

We used the updated data in completing the gap analysis. PAD-US data includes a "gap status" of protected lands. The gap status indicates how the lands are being managed for conservation purposes. A gap analysis typically only considers lands in gap statuses 1 and 2, which identify the lands in permanent protection from conversion with a mandated management plan, to maintain a primarily natural state the lands, however, may be subject to practices that suppress natural disturbances such as wildfire. Gap status 3 lands have permanent protection, but may be subject to extractive activities such as logging or mining, and as such, do not convey an appropriate level of protection needed to meet the Service's conservation goals for the valley. We used gap status 1 and 2 lands in this analysis, but also included some areas that were not gap status 1 or 2, but are public lands that contain quality habitat, are of sufficient size, and are governed by management plans that protect wildlife values.

Sustaining a diversity of healthy populations over time requires conserving a sufficient variety and amount of habitat and building an ecologically-connected network of conservation areas to allow the movement of species in response to climate change. Adequate protection, therefore, cannot be measured just by the amount of acres under conservation status anywhere in the valley, but rather by securing the habitat objectives—the number, size, and distribution of habitat patches under some form of conservation status that prioritizes management for the conservation target species.

The discussion, just as the population and habitat objectives, is broken-down into the northern part of the valley (north of Salem, PCAs 46-76), the central part of the valley (Salem to Corvallis, PCAs 18-45), and the southern valley (south of Corvallis PCAs 1-17).

Grasslands

North

In the northern part of the valley, the objective is to manage 2,813 acres of core grassland habitat for western meadowlark, Oregon vesper sparrow, and other grassland dependent species. This habitat should be distributed across the northern valley in order to support three subpopulations of western

Streaked horned lark/© Joe Staff

meadowlark (one medium subpopulation [20-30 breeding pairs on 938 acres], and two small subpopulations [10-20 breeding pairs on 563 acres each]).

About 1,970 acres of grassland habitat within the northern PCAs is currently protected. This represents about 70 percent of the total objective, but these grasslands are found primarily in only two PCAs: Baskett Slough National Wildlife Refuge (Refuge) (east) [PCA 46], which has the vast majority of protected grasslands (1,740 acres) and represents about 89 percent of the protected grasslands; and Tualatin River National Wildlife Refuge [PCA 67] (207 acres). A third site has less than 20 acres of protected grasslands. The habitat at Baskett Slough Refuge meets the objective for the single medium core patch. No other area has sufficient protected grasslands to satisfy the small core patch objective.

Important PCAs for additional grassland conservation include additional areas around the Baskett Slough Refuge (east and west) [PCAs 46 and 48] to benefit from a potential source population of western meadowlarks on the Refuge, Eola Hills [PCA 49], and the Molalla River and Grasslands [PCA 57]. In the Molalla area, establishing a protected core habitat patch could be an important step in recovering these species in the northern part of the valley. The Yamhill Oaks [PCA 56] has over 2,000 acres of grassland habitat, but there are no recent documented occurrences of western meadowlark or Oregon vesper sparrow so this area is not an immediate priority area for grassland birds.

Center

In the central part of the valley, the objective is for 7,211 acres of core grassland habitat be managed for western meadowlark, vesper sparrow, streaked horned lark, and other grassland dependent species The habitat should be distributed in order to support seven subpopulations, comprised of one large subpopulation of western meadowlark (30-40 breeding pairs on 1,313 acres), two medium subpopulations (20-30 breeding pairs on 938 acres each), and four small subpopulations (10-20 breeding pairs on 563 acres each).

There are currently approximately 2,900 acres of protected grassland habitat within the central PCAs, or about 40 percent of the overall objective. These are found in only two PCAs: 2,434 acres at Ankeny NWR-Salem Hills [PCA 42] and 469 acres at Corvallis Area Forests and Balds (south) [PCA 22]. Ankeny NWR/Salem Hills [PCA 42] has almost 87 percent of the protected grassland habitat within the PCAs in this part of the valley.

Protected lands within Ankeny NWR-Salem Hills [PCA 42] meet the habitat objective for the large core habitat patch. Protected areas in the Corvallis Area Forests and Balds (south) [PCA 22] and the Corvallis Area Forests and Balds (north) [PCA 32] provide building blocks for achieving additional habitat objectives for either small or medium core patches.

Priority areas for grassland birds include Ankeny NWR-Salem Hills [PCA 42] and Corvallis Area Forests and Balds (south and north) [PCA 22 and PCA 32].

South

In the southern part of the valley, the objective is for 8,745 acres of core grassland habitat to be managed for western meadowlark, vesper sparrow, streaked horned lark, and other grassland-dependent species. This habitat should be distributed in order to support 9 subpopulations, consisting of 1 large subpopulation of western meadowlark (30-40 breeding pairs on 1,313 acres acres), 2 medium subpopulations (20-30 breeding pairs on 938 acres each), and 6 small subpopulations (10-20 breeding pairs on 563 acres each).

There are currently approximately 3,147 acres of protected grassland habitat within the southern PCAs, or about 36 percent of the overall objective. These protected grasslands occur in 4 of the southern PCAs.

Finley NWR/Muddy Creek [PCA 14] has the largest block of protected grasslands (2,544 acres) which is about 93 percent of the total protected. Two other PCAs each have less than 400 acres of protected grasslands. These are West Eugene-Spencer Creek/Coyote Creek [PCA 6] (399 acres); Coburg Hills (south) [PCA 7] (157) acres; and Middle Fork-Coast Fork Confluence/Mount Pisgah [PCA 3] (47 acres).

Finley NWR/Muddy Creek [PCA 14] meets the habitat objective for the large core habitat patch and is the only area that meets any of the habitat objectives.

Important PCAs for additional grassland conservation include Finley NWR/Muddy Creek [PCA 14]; West Eugene-Spencer Creek/Coyote Creek [PCA 6]; Middle Fork-Coast Fork Confluence/Mount Pisgah [PCA 3]; and Coburg Hills (north) [PCA 9].

Oak Savanna

Very little oak savanna remains in the valley today and very little of that is protected.

North

In the northern portion of the valley, the objective is for 1,500 acres of core oak savanna habitat to be managed for the western bluebird and other oak savanna wildlife. This acreage should be distributed in order to support 10 subpopulations of western bluebird, consisting of 1 large subpopulation (20-30 breeding pairs on 263 acres); 3 medium subpopulations (20-30 breeding pairs on 188 acres each); and 6 small subpopulations (10-20 breeding pairs on 113 acres each)

Very little oak savanna is currently protected in the north part of the valley with protected areas found in only two PCAs to any extent: Eola Hills [PCA 49] has 105 acres and Baskett Slough NWR (east) [PCA 46] has 32 acres.

While no PCA has sufficient protected oak savanna to meet a habitat objective, Eola Hills [PCA 49] is close to meeting the requirements for a small core habitat patch.

Important PCAs for additional oak savanna conservation include Baskett Slough NWR (east) [PCA 46] and Eola Hills [PCA 49]. Yamhill Oaks [PCA 56] has over 1,000 acres of mapped oak savanna, by far the most of any PCA, but no observations of western bluebird have been recorded there over the past five years, making oak savanna conservation in this PCA a somewhat lower priority.

Center

In the central part of the Willamette Valley, the objective is for 1,763 acres of core oak savanna habitat to be managed for the western bluebird and other oak savanna wildlife. This habitat should be distributed in order to support 11 subpopulations of western bluebird consisting of 2 large subpopulations (30-40 breeding pairs on 263 acres each); 3 medium subpopulations (20-30 breeding pairs on 188 acres each); and 6 small subpopulations (10-20 breeding pairs on 113 acres each)

Only 2 central PCAs have any protected oak savanna habitat. Corvallis Area Forests and Balds (north) [PCA 32] has 234 acres and Corvallis Area Forests and Balds (south) [PCA 22] has 56 acres.

Habitat protected in ODFW's E.E. Wilson Wildlife Area within the Corvallis Area Forests and Balds (north) [PCA 32] satisfies the acreage objective for a small core habitat patch.

Important PCAs for additional oak savanna conservation include Ankeny NWR-Salem Hills [PCA 42]; Corvallis Area Forests and Balds (south [PCA 22] and north [PCA 32] sections); Golden Valley – Richardson Gap [PCA 21]; and Habeck Oaks (south) [PCA 38].

South

In the southern part of the valley, the objective is for 1,388 acres of core oak savanna habitat to be managed for the western bluebird and other oak savanna wildlife. The habitat should be distributed in order to support 9 subpopulations of western bluebird, consisting of 1 large subpopulation (20-30 breeding pairs on 263 acres); 3 medium subpopulations (20-30 breeding pairs on 188 acres each); and 5 small subpopulations (10-20 breeding pairs on 113 acres each).

In the southern part of the valley, protected oak savanna occurs in only 3 PCAs. The greatest amount is 132 acres in the Coburg Hills (south) [PCA 7]: followed by 55 acres in the Finley NWR/Muddy Creek [PCA 14]: and 24 acreas in the West Eugene-Spencer Creek/Coyote Creek [PCA 6].

Habitat protected in the Coburg Hills (south) [PCA 7] satisfies the objectives needed for a small core habitat patch.

Important PCAs for additional oak savanna conservation include Finley NWR/Muddy Creek [PCA 14]; West Eugene-Spencer Creek/Coyote Creek [PCA 6]; and Coburg Hills (north [PCA 9] and south [PCA 7]).

Oak Woodlands

North

In the northern section of the valley, the objective is for 16,500 acres of core oak woodland habitat to be managed for the slender-billed white-breasted nuthatch, and other oak woodland wildlife. Habitat should be distributed in order to support 35 subpopulations of the slender-billed white-breasted nuthatch, consisting of 5 large subpopulations (50 breeding pairs or more on 900 acres each), 10 medium subpopulations (30-50 breeding pairs on 600 acres each), and 20 small subpopulations (10-30 breeding pairs on 300 acres each).

There are approximately 2,617 acres of protected oak woodland habitat in the northern PCAs, representing about 16 percent of the habitat objective. Three PCAs each have more than 200 acres of protected habitat: Eola Hills [PCA 49] has 1,249 acres; Trappist Abbey [PCA 60] has 495 acres; and Baskett Slough NWR (east) [PCA 46] has 430 acres. Willamina Oaks South [PCA 52] with 151 acres and Yamhill Oaks [PCA 56] with 186 acres contribute to the total.

Eola Hills [PCA 49] satisfies the habitat objectives for a large core habitat patch. Trapist Abbey [PCA 60] satisfies the habitat objectives for a medium core patch although there are no recent documented occurrences of the slender-billed white-breasted nuthatch at the Abbey. Baskett Slough NWR (east) [PCA 46] satisfies the objectives for a small core patch.

Priorities for additional conservation include the Yamhill Oaks [PCA 56], Eola Hills [PCA 49], Trapist Abbey [PCA 60], Baskett Slough NWR (east [PCA 46] and west [PCA 48]), Willaminia Oaks South [PCA 52], and Wapato Lake NWR/Ribbon Ridge [PCA 69].

Center

In the central part of the valley, the objective is for 16,500 acres of core oak woodland habitat to be managed for the slender-billed white-breasted nuthatch and other oak woodland wildlife. This habitat should be distributed in order to support 35 subpopulations, consisting of 5 large subpopulations (50 pairs or more on 900 acres each); 10 medium subpopulations (30-50 pairs on 600 acres each); and 20 small subpopulations (10-30 pairs on 300 acres each)

There are about 555 acres of protected oak woodland habitat in the central part of the valley, which accounts for just a little over 3 percent of the habitat objective. These acres occur in just 4 PCAs. Corvallis Area Forests and Balds (south) [PCA 22] with 462 acres is the only PCA with greater than 300 acres of protected oak woodland. None have greater than 600 acres. There are two PCAs that each have less than 50 acres: Ankeny NWR-Salem Hills [PCA 42] has 50 acres; and Corvallis Area Forests and Balds (north) [PCA 32] has 40 acres.

Protected areas within Corvallis Area Forests and Balds (south) [PCA 22] meet the objectives for a small core habitat patch. Protected oak woodlands occur on Fitton Greem and at Bald Hill Farm. Efforts to connect these habitats could result in a medium or large core habitat patch.

Important PCAs for additional oak woodland conservation include Corvallis Area Forests and Balds (south [PCA 22] and north [PCA 32]), Ankeny NWR-Salem Hills [PCA 42], Habeck Oaks (mid) [PCA 40], and Golden Valley–Richardson Gap [PCA 21].

South

In the southern part of the valley, the objective is for 16,200 acres of core oak woodland habitat to be managed for the slender-billed white-breasted nuthatch, and other oak woodland wildlife. Habitat should be distributed in order to support 34 subpopulations of slender-billed white-breasted nuthatch, consisting of 5 large subpopulations (50 pairs or more on 900 acres each), 10 medium subpopulations (30-50 pairs on 600 acres each), and 19 small subpopulations (10-30 pairs on 300 acres each).

There are about 1,620 acres of protected oak woodland habitat in the southern PCAs of the valley. There are only two protected areas within the PCAs with greater than 400 acres of protected oak woodland habitat in each: Finley NWR/Muddy Creek [PCA 14] has 708 acres and Coburg Hills (south) [PCA 7] has 491 acres. Other areas contributing oak woodland habitat include West Eugene-Spencer Creek/Coyote Creek [PCA 6] has 230 acres, and Middle Fork-Coast Fork Confluence/Mount Pisgah [PCA 3] has 189 acres. An additional PCA has less than 5 acres of protected oak woodland.

Protected habitat within Finley NWR/Muddy Creek [PCA 14] satisfies the habitat requirement for a medium core patch and Coburg Hills (south) [PCA 7] satisfies the requirement for a small core patch.

Priority areas for additional oak woodland conservation include West Eugene-Spencer Creek/Coyote Creek [PCA 6]; Finley NWR/Muddy Creek [PCA 14]; Lower McKenzie River [PCA 5]; and Middle Fork-Coast Fork Confluence/Mount Pisgah [PCA 3].

Riparian Forest

North

In the northern section, the objective is for 5,400 acres of core riparian forest habitat to be managed for the yellow warbler and other riparian forest wildlife. Habitat should be distributed in order to support 19 subpopulations, consisting of 3 large subpopulations (540 acres each), 5 medium subpopulations (360 acres each), and 11 small subpopulations (180 acres each).

Approximately 765 acres of protected riparian forest occur within the northern PCAs. Three PCAs have over 100 protected acres each: Tualatin River NWR [PCA 66] has 209 acres; the Sandy River Delta [PCA 73] has 962 acres; and the Banks Swamp [PCA 74] has a little over 100 acres.

The Sandy River Delta [PCA 73] is comprised of two sections: the Wild and Scenic River section upstream of the delta, and the delta itself. Protected areas within the delta meet the requirements for a large core patch, and protected areas in the Wild and Scenic River section meet the requirements for a small subpopulation. While the delta does not have GAP 1 or 2 status according to PAD-US, it is managed by the Sandy River Management Plan (USFS 1995), which proposes adequate management of the delta's habitat values to consider it protected. Protected riparian forests on the delta meet the requirements for a large core habitat patch.

Tualatin River NWR [PCA 66] meets the criteria for a second small core patch.

Priority PCAs for additional riparian forest conservation include Grand Island (south) [PCA 50], which has less than 3 of its 2,300 acres of riparian forest in conservation status; Pudding-Mollala Confluence [PCA 61]; Tualatin River NWR [PCA 66]; and Mollala River and Grasslands [PCA 57].

Center

In the central section of the valley, the objective is for 4,860 acres of core riparian forest habitat to be managed for the yellow warbler and other riparian forest wildlife. This habitat should be distributed in order to support 18 yellow warbler subpopulations, consisting of 2 large subpopulations (540 acres each), 5 medium subpopulations (360 acres each), and 11 small subpopulations (180 acres each).

Approximately 1,120 acres of riparian forest are protected within the central PCAs, representing about 23 percent of the objective. Ankeny NWR-Salem Hills [PCA 42] has 574 acres, and is the only PCA with more than 180 protected acres. Other PCAs with protected riparian forest of any consequence, include Corvallis Area Forests and Balds (south) [PCA 22] with 139 acres; and Corvallis Area Forests and Balds (north) [PCA 32] and Santiam Confluences (5) [PCA 36] each with just under 100 acres. Three PCAs have from 50 to 80 acres protected each: Bowers Rock-Truax Island [PCA 18]; Minto Island [PCA 45]; and Santiam Confluences (2) [PCA 29].

Protected riparian forest in Ankeny NWR-Salem Hills [PCA 42] meets the objective for 1 of the 2 large core habitat patches. No other PCA has a sufficient quantity of protected riparian forest to meet any other habitat objective.

Priority areas for additional conservation include: Ankeny NWR-Salem Hills [PCA 42]; Bowers Rock-Truax Island [PCA 18]; Corvallis Area Forests and Balds (north [PCA 32] and south [PCA 22]); Minto Island [PCA 45]; and the Santiam Confluences PCAs [PCAs 29, 30, 34, and 36].

South

In the southern section of the valley, the objective is for 4,860 acres of core riparian forest habitat to be managed for the yellow warbler and other riparian forest wildlife. Habitat should be distributed to support 18 subpopulations of yellow warbler, consisting of 2 large subpopulations (540 acres each), 5 medium subpopulations (360 acres each), and 11 small subpopulations (180 acres each).

There are approximately 2,520 acres of protected riparian forest habitat within the southern PCAs, or 52 percent of the habitat objective. There are four PCAs with greater than 180 acres of protected bottomland hardwood forests each: Finley NWR/Muddy Creek [PCA 14] has about 990 acres; West Eugene-Spencer Creek/Coyote Creek [PCA 6] has 888 acres; Middle Fork-Coast Fork

Confluence/Mount Pisgah [PCA 3] has 242 acres; and McKenzie-Willamette Confluence/Harper's Bend-Horseshoe Bar [PCA 8] has 230 acres.

Finley NWR/Muddy Creek [PCA 14] has sufficient protected riparian forest to meet the objectives for 1 large core habitat patch. Protected habitat distribution in West Eugene-Spencer Creek/Coyote Creek [PCA 6] satisfy the requirements for 1 medium and 1 small core habitat patches. McKenzie-Willamette Confluence/Harper's Bend-Horseshoe Bar [PCA 8] and Middle Fork-Coast Fork Confluence/Mount Pisgah [PCA 3] meet the objectives for 2 additional small core patches.

Priority PCAs for riparian forest conservation include: Finley NWR/Muddy Creek [PCA 14]; McKenzie-Willamette Confluence/Harper's Bend-Horseshoe Bar [PCA 8]; West Eugene-Spencer Creek/Coyote Creek [PCA 6]; Middle Fork-Coast Fork Confluence/Mount Pisgah [PCA 3]; Long Tom–Willamette Confluence [PCA 13]; and Ingram Island [PCA 11].

Riparian Shrubland

North

In the northern section of the valley, the objective is for 1,650 acres of core riparian shrubland habitat to be managed for the yellow-breasted chat and other riparian shrubland wildlife. Habitat should be distributed to support 7 subpopulations, consisting of 450 acres for 1 large subpopulation, 300 acres each for 2 medium subpopulations, and 150 acres each for 4 small subpopulations. Approximately 238 acres of riparian shrubland have been protected within the northern PCAs, representing 14 percent of the objective. Metro's Smith and Bybee Wetlands [PCA 75] with about 630 acres of shrubland and the Sandy River Delta [PCA 73] with 216 acres have the most shrubland habitat in the north part of the valley. Banks Swamp [PCA 74] has 90 acres of protected shrubland. Banks Swamp (also known as Kilian Wetlands) is recognized by the Audubon Society as an Important Bird Area. Metro has been actively engaged in protecting this important site.

Three other PCAs have from 20-45 acres of protected shrubland habitat: Tualatin River NWR [PCA 66] has 43 acres; Pudding-Mollala Confluence [PCA 61] has 21 acres; and Trapist Abbey [PCA 60] has 20 acres protected.

Smith and Bybee Wetlands [PCA 75] which does not have GAP 1 or 2 status according to PAD-US, is managed by the Smith and Bybee Wetlands Natural Area: Comprehensive Natural Resource Plan (Metro 2012) which conveys adequate protection of the resource values and is considered to meet the requirements for a large core habitat patch.

Protected habitat on the Sandy River Delta [PCA 73] satisfies the requirements for a small core patch.

Important PCAs for additional riparian shrubland conservation include Grand Island (south) [PCA 50] where almost none of the mapped 636 acres of riparian shrubland is protected, Pudding-Mollala Confluence [PCA 61]; Tualatin River NWR [PCA 66]; and Mollala River and Grasslands [PCA 57].

Center

In the central section of the valley, the objective is for 1,950 acres of core riparian shrubland habitat to be managed for yellow-breasted chat and other riparian shrubland wildlife, that is distributed to support 1 large subpopulation (450 acres); 3 medium subpopulations (300 acres each); and 4 small subpopulations (150 acres each).

There are only about 205 acres of protected riparian shrubland habitat within the central PCAs, or about 10 percent of the objective. No PCAs have greater than 100 protected acres of riparian shrubland. Only 4 PCAs have more than 10 protected acres: Corvallis Area Forests and Balds (north) [PCA 32] has 96 acres which includes ODFW's E.E. Wilson Wildlife Management Area; Ankeny NWR-Salem Hills [PCA 42] has about 48 acres; Corvallis Area Forests and Balds (south) [PCA 22] has about 35 acres; and Minto Island [PCA 45] has a little over 10 acres. No other PCA has more than 10 acres of protected habitat. None of the PCAs meet any of the habitat objectives.

Priority PCAs for riparian shrubland conservation include Ankeny NWR-Salem Hills [PCA 42]; Bowers Rock-Truax Island [PCA 18]; Corvallis Area Forests and Balds (north [PCA 32] and south [PCA 22]); Minto Island [PCA 45]; and Santiam Confluences [PCAs 29, 30, 33, and 34].

South

In the southern section of the valley, the objective is for 1,500 acres of core riparian shrubland habitat to be managed for yellow-breasted chat and other riparian shrubland wildlife. Habitat should be distributed to support 6 subpopulations of yellow-breasted chat, consisting of 1 large subpopulation (450 acres), 2 medium subpopulations (300 acres each), and 3 small subpopulations (150 acres each).

Approximately 510 acres of riparian shrubland are protected within the southern PCAs, primarily within 3 PCAs: Finley NWR/Muddy Creek [PCA 14] with 184 acres; West Eugene-Spencer Creek/Coyote Creek [PCA 6] with 214 acres; and McKenzie-Willamette Confluence/Harper's Bend Horseshoe Bar [PCA 8] with 56 acres. Two other PCAs each have between 10-50 acres of protected riparian shrubland habitat.

Finley NWR/Muddy Creek [PCA 14] meets the objectives for 1 of the 3 small core patches. Protected riparian shrublands in the West Eugene-Spencer Creek/Coyote Creek [PCA 6] are too scattered to be considered a core habitat patch. With additional efforts, small, medium, or large core habitat patches could be protected. No other areas are close to meeting the objectives.

Priority areas for additional riparian shrubland conservation include: Finley NWR/Muddy Creek [PCA 14]; West Eugene-Spencer Creek/Coyote Creek [PCA 6]; McKenzie-Willamette Confluence/Harper's Bend Horseshoe Bar [PCA 8]; Middle Fork-Coast Fork Confluence/Mount Pisgah [PCA 3]; Ingram Island [PCA 11]; and Long Tom-Willamette Confluence [PCA 13].

Discussion

Overall, there are not enough lands being managed for the targeted species to meet all of the objectives for any targeted species/habitat combination.

Yellow breasted chat/USFWS

The following series of tables provides a graphical representation of where in the valley objectives have been achieved, where they have been partially achieved, and where no protected areas are of sufficient size to meet any of the objectives. The number in the "Objective" column is the subpopulation/habitat patch objective. The number in the "Achieved" column is the number of subpopulations/habitat patches secured under some form of habitat protection.

Table H1. The Status of Achieving Habitat Protection Objectives in the Willamette Valley

Grassland						
Section	Large		Medium		Small	
	Objective	Achieved	Objective	Achieved	Objective	Achieved
North	N/A	N/A	1	1	2	0
Center	1	1	2	0	4	0
South	1	1	2	0	6	0
Oak Savanna						
Area	Large		Medium		Small	
	Objective	Achieved	Objective	Achieved	Objective	Achieved
North	1	0	3	0	6	0
Center	2	0	3	0	6	1
South	1	0	3	0	5	1
Oak Woodland						
Area	Large		Medium		Small	
	Objective	Achieved	Objective	Achieved	Objective	Achieved
North	5	1	10	1	20	1
Center	5	0	10	0	20	1
South	5	0	10	1	19	1
Riparian Forest						
Area	Large		Medium		Small	
	Objective	Achieved	Objective	Achieved	Objective	Achieved
North	3	1*	5	0	11	2
Center	2	1	5	0	11	0
South	2	1	5	1	11	3
Riparian Shrubland						
Area	Large		Medium		Small	
	Objective	Achieved	Objective	Achieved	Objective	Achieved
North	1	1**	2	0	4	1**

Center	1	0	3	0	4	0
South	1	0	2	0	3	1

* Sandy River Delta (not GAP 1 or 2)
**= Objective met by lands not currently rated as GAP Status 1 or 2. See text for explanation.

(green)	= Objectives achieved
(orange)	= Objectives partially achieved
(red)	= No objectives achieved

Appendix I. Threats Analysis

Introduction

Estimating the level of threat that a priority area might be converted to some other land use rendering it unsuitable for conservation is an important step in systematic conservation planning (Margules and Pressey 2000). Understanding potential threats is a critical step in developing appropriate conservation strategies, and identifying the Priority Conservation Areas (PCAs) most threatened with conversion and thus in most need of urgent attention (Surasinghe et al. 2012; Groves 2003).

Threats analyses require peering into the future which always adds an element of uncertainty. Unpredictable changes to land use laws further cloud the situation, as has been the recent history in Oregon and the Willamette Valley. Passage of Senate Bill 100 in 1973 marked a milestone for land use planning in Oregon. It required every city and county to prepare a comprehensive plan in accordance with a set of general statewide planning goals. The planning goals covered a wide range of topics including preservation of agricultural lands (Goal 3), forest lands (Goal 4), and open spaces, scenic and historic areas, and natural resources (Goal 5). Over the ensuing years, three ballot measures to overturn SB 100 were rejected by the voters.

In 2004, Oregon voters passed Ballot Measure 37 which allowed property owners whose property value had been reduced by environmental or other land use regulations enacted after they became owners of the property to claim compensation from state or local governments. In lieu of compensation, the measure provided that the government responsible for the regulation may choose to “remove, modify or not apply” the regulation. Thousands of Measure 37 compensation claims were filed, but because municipalities could not afford the compensations costs, the land use laws were typically waived unleashing new developments in areas current laws would not allow.

In 2007, Oregon voters passed Ballot Measure 49 which modified Measure 37 to give landowners with Measure 37 claims the right to build homes as compensation for land use restrictions imposed after they acquired their properties. It also allowed claimants to transfer homebuilding rights upon sale or transfer of the property. While Measure 49 significantly pared back Measure 37, one only has to drive the back roads of the Willamette Valley to readily see the steady fragmentation of farmlands and wildlife habitat resulting from Measures 37 and 49. The point here is that that the laws and rules passed by one generation may be repealed by the next adding uncertainty to any threats analysis. When factored in conjunction with a steady increase in land values this suggests some degree of urgency to develop additional conservation capacity within the Willamette Valley.

A wide variety of agents can threaten the integrity of core priority areas, but due to the historic loss and conversion of native habitats and the anticipated surge in population growth (ODAS 2013), anthropogenic land use will likely present a greater challenge to restoring and maintaining biodiversity this century, than climate change (Wilson et al. 2014). Because of that, we focused on the potential for future development to occur within priority core areas as the main threat facing unprotected PCAs. An analysis of this type requires the development of alternative future scenarios that may play out over time in the planning area. We focused on two analyses conducted by others. The first is the projected future developed for the Willamette River Basin Planning Atlas (Hulse et al. 2002), and the second is projected exurban housing impacts (Theobald 2005).

Willamette River Basin Planning Atlas

As described in the Willamette River Basin Planning Atlas: Trajectories of Environmental and Ecological Change (Hulse et al. 2002), the Willamette River basin was the subject of an extensive study of potential alternative futures that, over a 30-month period, involved a broad cross-section of stakeholders including lay and professional citizen groups, agriculture, industry, and scientists. This broad cross-section of stakeholders created, mapped, and evaluated a set of three land use scenarios for the year 2050: Plan Trend, Development, and Conservation (Hulse et al 2004). All three futures assume a doubling of the 1990 human population by 2050 (Baker et al. 2004), consistent with growth projections for the valley (ODAS 2013).

The Plan Trend 2050 scenario represents the valley's expected landscape in 2050 if current land use policies are implemented and recent trends continue. Development 2050 reflects a loosening of land use policies that allows market forces freer rein across all components of the valley's landscape, but still within the range of what stakeholders considered plausible. Conservation 2050 places greater emphasis on ecosystem protection and restoration, reflecting a plausible balance among ecological, social, and economic considerations as defined by the stakeholders (Baker et al. 2004).

These alternative future scenarios represent the most in-depth, stakeholder vetted scenarios for the valley in existence. The scenarios are spatially and temporally explicit, with projections provided by decade until the year 2050. The results are presented in the Willamette River Basin planning Atlas (Hulse et al. 2002), and further described in Ecological Applications, a peer-reviewed scientific journal (Baker et al. 2004). The scenarios and supporting metadata are available at http://www.fsl.orst.edu/pnwerc/wrb/access.html. Because this analysis is about potential development threats to identified core priority areas, we focused our analysis on the Development 2050 scenario.

Since 1973, Oregon has maintained a strong statewide land use planning program. The foundation of the program is a set of 19 Statewide Planning Goals that express the state's policies on land use and related topics, such as the protection of natural resources, scenic and historic areas, open spaces, farmland, and forests; and provide an orderly and efficient transition from rural to urban land uses.

Under Oregon law, each of the state's cities and metropolitan areas created an urban growth boundary (UGB) around their perimeters, which is a land use planning line to control urban expansion onto farm and forest lands beyond the UGB. Land inside the UGB is designated for urban uses. The location of a UGB is revised periodically, in order to maintain a 20-year supply of land to meet population and employment growth projections.

Under Plan Trend 2050, new development occurs only within designated UGBs and existing rural residential zones. But because of the projected population growth, the amount of urbanized land, plus land influenced by rural development, increases, but by less than 25 percent. Rural residential zones are projected to be completely built-out by 2020. UGBs are expanded by 11 percent (51,000 acres).

Under the Development 2050 scenario, new development occurs at lower densities over a larger rural area, leading to the fragmentation and conversion of agricultural fields. UGBs expand by 29 percent (129,000 acres) and the areas influenced by rural structures increases by 68 percent (121,500 acres).

Projected Land Use Modifications

We also looked at the projected percentage of change in each PCA that would be functionally modified by human land use (e.g., exurban housing growth, infrastructure) by 2050, using data from

Theobald (2005). Forecasted patterns of exurban growth were generated by the Spatially Explicit Regional Growth Model, which used historical and current housing density patterns to develop a simulation model that forecasts future housing density patterns and projections (Theobald 2005).

Results

To complete the threats analysis, we intersected land cover maps developed for the Development 2050 scenario and changes in exurban growth, with the map of PCAs. We calculated the percentage of increase in developable land use types from 2010 to 2050 within each PCA for the Development 2050 scenario, and from 2010 to 2020 for the exurban housing development scenario, and plotted the results on scatter charts. The charts were divided into quadrats (Threat Levels 1-4) based on the amount of targeted habitat types within the PCA and the increase in developable land use types:

- Threat Level 1: PCAs with greater than (>) 2,000 acres of combined targeted habitat and >10 percent of the land is located within future development land use zones.
- Threat Level 2: PCAs with less than (<) 2,000 acres of combined targeted habitat but with >10 percent of the land located within future development land use zones.
- Threat Level 3: PCAs with >2,000 acres of combined targeted habitat, but with <10 percent of the land located within future development land use zones.
- Threat Level 4: PCAs with <2,000 acres of combined targeted habitat, and with <10 percent of the land located within future development land use zones.

PCAs that have none of their lands impacted by projected development are not included in the results.

Development 2050 Scenario

The analysis of the Development 2050 scenario revealed that none of the PCAs fall within Threat Level 1. Only seven PCAs fall within Threat Level 2, and 14 PCAs fall within Threat Level 3. These PCAs are identified in Table I1.

Not surprisingly, most of the PCAs under the greatest threat for future development occur close to major urban areas (Portland and Eugene). Two of these PCAs currently house national wildlife refuges and one supports a population of a listed plant species.

Some of the PCAs with multiple wildlife values, such as West Eugene-Spencer Creek/Coyote Creek [PCA 6] and the Corvallis Area Forests and Balds (south) [PCA 21], which provide habitat for most of the targeted wildlife species as well as several listed species are in Threat Category 2. That these PCAs are among the most threatened only highlights the need for immediate actions to conserve these valuable places.

Table I1. PCAs Predicted to be Impacted by Development (2050 Scenario)

PCA ID	PCA Name	Habitat Acres	% Land Cover Developed (2010-2050)
PCAs in Threat Category 2			
72	Gales Creek	155	42.0%
4	Lower McKenzie Oaks	1,391	28.2%
66	Tualatin River NWR	1,357	21.6%
71	Jackson Bottoms Area	918	16.4%

PCA ID	PCA Name	Habitat Acres	% Land Cover Developed (2010-2050)
12	Sweet Home Lomatium Site	54	12.8%
69	Wapato Lake NWR/Ribbon Ridge	1,952	11.3%
5	Lower McKenzie River	1,635	10.3%
PCAs in Threat Category 3			
6	West Eugene-Spencer Creek/ Coyote Creek	19,095	8.5%
57	Mollala River and Grasslands	2,809	6.3%
49	Eola Hills	3,948	5.6%
22	Corvallis Area Forests and Balds (south)	11,063	4.9%
42	Ankeny NWR-Salem Hills	12,477	4.2%
7	Coburg Hills (south)	2,153	3.7%
50	Grand Island (south)	3,316	2.7%
8	McKenzie-Willamette Confluence/Harper's Bend Horseshoe Bar	2,176	1.8%
3	Middle Fork-Coast Fork Confluence/Mount Pisgah	3,129	1.5%
56	Yamhill Oaks	8,529	1.0%
14	Finley NWR/Muddy Creek	6,942	0.2%
46	Baskett Slough NWR (east)	3,356	0.2%
32	Corvallis Area Forests and Balds (north)	3,270	0.2%
9	Coburg Hills (north)	3,271	0.1%

Projected Land Use Modifications

The results of the projected percent change in human land use (e.g., exurban housing growth, infrastructure) by 2050, using data from Theobald scenario largely mimicked those from the Willamette River Basin Planning Atlas. The analysis revealed that none of the PCAs fell within threat category 1 and only a handful of PCAs fell within threat category2. These are all in Washington County, which is expected to grow rapidly over the coming decades. Wapato Lake NWR/Ribbon Ridge [PCA 69] falls within this category.

All of the 14 PCAs with more than 2,000 acres of targeted habitat types fell into threat category 3. None of PCAs is expected to lose more than five percent of their area to exurban housing. Ankeny NWR-Salem Hills [PCA 42] at 4.9 percent loss had the highest predicted loss of these 14 PCAs (Table I2).

Table I2. PCAs Predicted to be Impacted by Exurban Housing Development

PCA ID	PCA Name	Habitat Acreage	Change in Human Land Use (2010-2050)
PCAs in Threat Category 2			
74	Banks Swamp	300	20.7%
72	Gales Creek	156	19.1%
71	Jackson Bottoms Area	918	16.7%
67	Tualatin River	257	15.2%
76	Dairy Creek - Red Slide Hill	173	10.6%
69	Wapato Lake NWR/ Ribbon Ridge	1,953	10.0%

PCA ID	PCA Name	Habitat Acreage	Change in Human Land Use (2010-2050)
PCAs in Threat Category 3			
42	Ankeny NWR-Salem Hills	12,477	4.9%
50	Grand Island (south)	3,316	3.1%
56	Yamhill Oaks	8,529	2.5%
57	Mollala River and Grasslands	2,809	2.0%
49	Eola Hills	3,948	1.0%
8	McKenzie-Willamette Confluence/Harper's Bend Horseshoe Bar	2,176	1.0%
6	West Eugene-Spencer Creek/Coyote Creek	19,095	0.9%
22	Corvallis Area Forests and Balds (south)	11,063	0.9%
3	Middle Fork-Coast Fork Confluence/Mount Pisgah	3,129	0.6%
7	Coburg Hills (south)	2,153	0.4%
46	Baskett Slough NWR (east)	3,356	0.4%
32	Corvallis Area Forests and Balds (north)	3,270	0.2%
14	Finley NWR/Muddy Creek	6,942	0.1%
9	Coburg Hills (north)	3,271	0.0%

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The mission of the U.S. Fish & Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.

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Willamette Valley panorama
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