Wildlife Conservation in the Willamette Valley's Remnant Prairie and Oak Habitats: A Research Synthesis

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Submitted to the
Interagency Special Status/Sensitive Species Program
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Executive Summary

Oregon white oak (*Quercus garryanna*) and prairie plant communities of Oregon's Willamette Valley are one of the most imperiled vegetation types in North America, yet few studies have been conducted on wildlife in these plant communities. The primary goal of our synthesis is to help guide future conservation and restoration efforts of these important wildlife habitats in the Willamette Valley. We synthesize relevant research and discuss future research and monitoring challenges and needs. We identify several species that are strongly associated with these habitat types in the Willamette Valley, and highlight their ecology and conservation. Our synthesis is intended for managers and researchers working to improve oak and prairie habitats for wildlife in the Willamette Valley. The project was sponsored by the Interagency Special Status Sensitive Species Program (ISSSSP) of the Pacific Northwest Regional Office of the U.S. Forest Service and Oregon/Washington State Office of the Bureau of Land Management. Oak and prairie habitats are managed as wildlife habitat by the Eugene and Salem Districts of the Bureau of Land Management in Oregon and this synthesis is intended to help guide their efforts as well as other efforts to restore oak and prairie vegetation communities for wildlife habitat in the Willamette Valley.

Despite the large loss of oak and prairie plant communities in the Willamette Valley, there have been surprisingly little research conducted on the ecology of wildlife in these habitats. What was most striking to us in our review was the large number of in-depth studies of butterfly response to restoration and the paucity of studies of vertebrates that went beyond distributional surveys. Almost all of the vertebrate studies remained descriptive, without understanding potential consequences under different management scenarios. Several studies on Fender's blue butterfly seemed particularly valuable as a model for linking field studies with management. Developing management-oriented models can provide useful heuristic tools for identifying research needs.

The lack of experimentation and formal sampling designs in most of the studies on vertebrates that we reviewed highlights the differences with studies conducted on butterflies and restoration in the Willamette Valley. The majority of studies on vertebrates have used informal sampling approaches to investigate habitat associations at relatively small spatial scales. Understanding habitat relationships to guide restoration is difficult and traditional approaches may not be as useful as other approaches that may involve case studies, adaptive management, and indicator variables that respond to smaller-scale changes from restoration.

Research on how vertebrate wildlife responds to restoration in the Willamette Valley is challenging for four primary reasons: (1) disconnect of spatial scale of restoration and animal use patterns, (2) the high variability within and among restoration units and the typical lack of control (non-restored) areas, (3) the extremely high variability of numerous elements of habitat characteristics at the spatial scale of the landscape, making it difficult to detect larger scale patterns, (4) time lags of restoration activities and habitat response, and (5) the existence of non-habitat factors that affect bird occurrence and abundance in the restored areas.

Almost all of the guidance for monitoring wildlife species has been an emphasis on developing standardized methods for estimating numbers of individuals in a given population. To make valid inferences on how wildlife responds to the relatively small areas that are being restored, a paradigm shift will need to occur. Identifying the mechanisms of why species respond to restoration of prairie and oak habitats in the Willamette Valley and thoughtfully applying this understanding to the monitoring program may allow for insightful evaluations of restoration success.

Our synthesis includes life history summaries and management recommendations for 11 vertebrates and one insect species. The species we selected for individual accounts have been the focus of much of the recent effort to restore upland habitats in the Willamette Valley.

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Chapter 1 Introduction

Oregon white oak (*Quercus garryanna*) and prairie plant communities of Oregon's Willamette Valley have declined in area to <10% of their pre-settlement extent due to conversion to agriculture, a fire-suppression mediated succession to dense hardwood or Douglas-fir dominated forest, and urban and suburban development. Indeed, only remnants of these once vast plant communities remain today. Some of the remaining areas of these vegetation communities occur on the Eugene and Salem Districts of the Bureau of Land Management in Oregon. To facilitate the conservation and management of rare and/or declining species on these habitats, the Interagency Special Status Sensitive Species Program (ISSSSP), an interagency program of the Northwest Regional Office of the U.S. Forest Service and Oregon/Washington State Office of the Bureau of Land Management, supported a synthesis of existing research on wildlife response to restoration. This document provides a synthesis and summary of work conducted on wildlife habitat relationships in oak and prairie vegetation communities in the Willamette Valley.

Numerous efforts are focused towards restoring oak plant communities in the Valley. A key goal of such restoration is to improve function as wildlife habitat. Wildlife species associated with Oregon white oak plant communities and prairies (see Section 2, *Grassland and Oak Woodland Plant Communities*) are an important indicator for demonstrating successful restoration. Our comprehensive synthesis of existing research was motivated by the need to understand how wildlife species respond to habitat restoration at different spatial scales, and to explore possible disconnects between assumed and realized wildlife responses.

Although similar oak habitats and prairies occur elsewhere in the Pacific Northwest, the focus of the synthesis is the Willamette Valley of Oregon. The Willamette Valley historically had one of the most expansive areas of oak habitats and prairies in Oregon and has undergone the greatest loss of these habitats. In addition, there is great interest in the conservation and restoration of these plant communities in the Willamette Valley (Floberg et al. 2004, USFWS 2008), making this synthesis timely and relevant to restoration efforts on both private and public lands, such as the Eugene and Salem Districts of the BLM. Our focus on the Valley is also biological—the region is sufficiently unique to justify specific management strategies and focal points of specific future research. Despite the profound interest from public agencies and private landowners, little research has been conducted on wildlife in Oregon white oak and prairie habitats in Oregon.

The primary goal of our synthesis is to help guide future conservation and restoration efforts of these important wildlife habitats in the Valley and assist ISSSSP with their mission of managing species that are rare and/or declining in order to maintain viable populations. We synthesize relevant research, highlight gaps in our understanding of wildlife response to restoration of Oregon white oak and prairie plant communities, and discuss the challenges and needs of future research and monitoring. Our synthesis is intended for managers and researchers working to improve and understand oak habitats for wildlife in the Willamette Valley. As part of the synthesis, we summarize key life history traits and management considerations for selected species in the form of species accounts.

Habitat Loss

In North America, prairies and savannas have undergone some of the greatest habitat loss and degradation because of the value of these areas to agricultural production, and more recently, rural residential development. Savannas, defined as ecosystems with a continuous grass or forb ground cover and scattered trees, occupy over 50 million acres in North America, from the southeastern long-leaf pine savannas to the extensive oak savannas of California (McPherson 1997). The underlying soils of many savanna and grassland areas have proved enormously productive for agricultural production, including livestock grazing. Savanna ecosystems in particular have received very little research despite their occupying one-third the world's land mass (McPherson 1997). In many parts of North America, however, there has been renewed interest in oak savannas and their associated prairies and oak woodlands. This new interest is largely due to the recognition of the value of these ecosystems to numerous plant and animal species (Altman et al. 2001, Standiford 2002, Apostol and Sinclair 2006), and the extensive loss in acreage and native vegetation composition (McPherson 1997), making the types among the most imperiled in North America (Noss et al. 1995).

The renewed interest in oak woodlands, savanna, and prairie ecosystems is nowhere more apparent than in the Willamette Valley of Oregon. In the Willamette Valley, upland prairie ecosystems often transition to oak savannas (1-2 trees/acre; ODFW 2006) and oak woodlands (here generally defined as >30% cover and >50 trees/ha [Agee 1993:351, Sinclair et al. 2006]). All of these ecosystems have undergone enormous losses in the Willamette Valley, for the reasons typical of grasslands and oak savannas elsewhere: agricultural and urban development (Floberg et al. 2004, Apostol and Sinclair 2006). Although such widespread losses are easily seen, more subtle is the alteration of remnant habitats due to changes in the disturbance regime and introduction of invasive plant species. The disruption of broad-scale burning that was once commonly applied by Native Americans has led to landscapes increasingly dominated by climax vegetation communities (Apostle and Sinclair 2006) and higher densities of woody plants. These changes are not surprising given the very dynamic nature of these ecosystems whose community structure and composition are very much dependent on fire (Agee 1993, Abrams 1995, Wilson et al. 1995, Agee 1996, Hosten et al. 2006, Sinclair et al. 2006). Furthermore, the introduction of non-native pasture grasses and ornamental plant species has dramatically altered the species composition of many oak and prairie habitats.
Oak savanna and upland prairie habitats have been reduced in total acreage and patch size. Indeed, the historic records suggest that almost the entire Valley was a mosaic of lowland and upland prairies and savanna (Wilson et al. 1995, Altman et al. 2001:262, Hulse et al. 2002), in contrast to the sparse distribution of mostly small remnant patches that exists today. The most recent estimates of area that these plant communities occupied prior to Euro-American settlement include about 1,000,000 acres of prairie,

with approximately 1/3 wet prairie and 2/3 upland prairie, 500,000 acres of oak savanna, and 400,000 acres of oak woodlands (Altman et al. 2001, ODFW 2006, Sinclair et al. 2006). All of the estimates are apparently derived from maps Christy et al. (1998) created from historic records. Recent estimates of upland prairie and oak savanna suggest approximately 2,000-3,000 acres remain (Altman et al. 2001), with most prairies <50 acres in size (Sinclair et al. 2006). Wilson et al. (1995) and ODFW (2006) report less than 1% of upland prairie remaining in an extremely fragmented distribution. Estimates of oak woodlands suggest they have been reduced to 7% of their former area (approx. 28,000 acres remaining; ODFW 2006). The subtle gradations from prairie to oak savanna to oak woodland also make classification of these habitats difficult, and as such, the precise quantification of loss.

Although estimates of acreage for each habitat type vary for historic and recent time periods, it is clear that there has been dramatic loss of prairie and oak habitats in the Willamette Valley. Further, most of the remaining acreage of oak habitats is privately owned, consistent with the overall ownership patterns in the Willamette Valley (ODFW 2006), where approximately 96% of land is in private ownership (ODFW 2006:235). This makes conservation strategies more challenging due to the multiple ownerships and rapid rate of current and projected development. These factors are largely responsible for the selection of these habitats as Priority Habitats under the Oregon Conservation Strategy (ODFW 2006).

Future Threats

An important source of further loss and habitat degradation of prairie and oak habitats in the Willamette Valley is through changes in plant composition and structure resulting from lack of fire and increasing dominance by introduced plant species (Apostle and Sinclair 2006). The loss of fire and the difficulty of restoring fire to the landscape because of the ownership patterns and concerns over air quality is one of the key threats. Many examples demonstrate the succession to conifer forest initiated by environmental conditions that favor conifers in the absence of fire (e.g., Chiller et al. 2000).

The other obvious primary threat to oak and prairie habitats, particularly oak savanna, is the loss from urban and agricultural development. The human population in the Willamette River Basin has been predicted to double from 1990 to 2050 (Hulse et al. 2002:85; Baker et al. 2004). Such growth will undoubtedly affect oak and prairie habitats and their potential for restoration for many of the sensitive wildlife species. Although human population growth and changes in land uses do severely threaten oak and prairie habitats, there may be opportunities for increased acreage of these habitats if growth occurs along conservation trajectories (Fig. 4 in Hulse et al. 2004). How changes in the distribution of oak and prairie flora and their associated wildlife by climate change represent an important consideration for long-term management of these ecosystems.

Wildlife Species

One of the motivating forces for the conservation of oak habitats in North America has been the rich diversity of wildlife species. In the Willamette Valley, many species are associated with these habitat types but only a few are restricted to these types. There is an impressive diversity of mammals in the Willamette Valley, including two endemic species. Within the Willamette Valley, 62 species of mammals were known to occur prior to Euro-American settlement in the 1850s (Verts and Carraway 1998), and of these almost all of them regularly use oak habitats. Almost 40 native bird species regularly use grasslands and savannas and over 80 species use oak woodlands in the Valley (O'Neil et al. 2001, Marshall et al. 2003). Of the 12 extant species of amphibians native to the Valley, most have an opportunistic association with prairies and savannas (9 species) or woodlands (10 species). Similarly, of the 15 native species of reptiles that occur in the Valley, all of them use woodland habitats opportunistically and 14 species have a similar association with grasslands (O'Neil et al. 2001). Only 3 species are closely associated with grasslands (including prairies) and savannas, including two native turtles and the rarely seen Northern Pacific rattlesnake (*Crotalus viridis oregonanus*) (Nussbaum et al. 1983, St. John 2002). Fourteen species associated with oak and prairie habitats in the Valley are listed as Special Sensitive Status species under the ISSSSP (Table 1). Without question, the invertebrate fauna remains the least well understood group of animals in the Willamette Valley. Pre-settlement grasslands of the Valley were probably inhabited by thousands of invertebrate species. Wilson et al. (1998a) estimated that more than 1100 species of arthropods were associated with upland prairies. Many invertebrate species remain undescribed, particularly moths, with numerous species associated with oak habitats in the Willamette Valley (Miller and Hammond 2007, Moldenke 2009, Ross 2009).

Spatial Scale – Landscape Considerations

Perhaps the greatest challenge for conservation of wildlife species associated with oak and prairie habitats in the Willamette Valley is the paucity of understanding the areal requirements of each species, both in extent of habitat and the spatial pattern of its distribution. Predictions of how wildlife responds to various conservation strategies requires an understanding of the spatial scale of habitat elements. Work by Schumaker et al. (2004) explored how wildlife may respond to future alternatives of the landscape in the Willamette Valley, under the assumption that breeding habitat is limiting the populations of each species. The modeling work by Schumaker et al. (2004) represents the only study we are aware of that specifically addressed landscape-scale assessments of wildlife in the Willamette Valley. The study by Schumaker and his colleagues highlights the lack of empirical estimates that can be used to predict how restoration on a large scale may affect wildlife species. Schumaker's study often relied on single estimates for demographic and movement rates usually from areas outside the Willamette Valley. Further, that they were able to find demographic estimates for only 17 of the 279 species highlights the paucity of such detailed natural history data. Importantly, their methodology and results provide a logical pathway for identifying potentially sensitive parameters, generating hypotheses, and testing them with empirical data (see Chapter 5, *Future Directions*).

Conservation Actions

Interest in the loss of oak habitats in the Willamette Valley parallels that of oak conservation initiatives elsewhere in the United States. Conservationists have responded to this loss by an exemplary effort for protection and restoration of these habitats. Outreach efforts in Oregon have increased and include publication of three landowner management guides for restoration of oak and prairie habitats in the Willamette Valley (ODFW 2000, Campbell 2004, Vesely and Tucker 2004). Workshops conducted by outreach specialists have further supported restoration of oak and prairie habitats. With the large effort towards conservation, including restoration of these habitats, there is now an opportunity to evaluate the most efficient practices that improve conditions for wildlife, both from the individual parcel as well as the Willamette Valley as a large landscape.

The Synthesis

Conservation of wildlife, from butterflies to birds, is a key goal of oak and prairie habitat restoration yet little is known of the response of wildlife to restoration efforts. As a first step towards understanding how wildlife responds to large- and small-scale efforts, this document provides a synthesis of existing information on wildlife associations in these habitat types in the Willamette Valley. We identify several species that are strongly associated with these habitat types in the Willamette Valley including species listed under ISSSSP, and highlight their ecology and conservation (see Chapter 6, *Species Accounts*). From our synthesis of existing literature, we highlight limitations of research and monitoring approaches, and suggest alternative directions for future efforts (see Chapter 5, *Future Directions*).

Chapter 2 Vegetation Trends and Distribution in the Willamette Valley

The distribution of grasslands[1] and Oregon white oak woodlands has shifted across the Pacific Northwest for thousands of years as climatic conditions and fire regimes have changed. Several studies have investigated the late-Quaternary relationships among climate, fire, and vegetation patterns in the Willamette Valley and Puget Trough using pollen and charcoal analysis (Barnosky 1985, Worona and Whitlock 1995, Walsh 2008, Walsh et al. 2008). This research indicates that during the late-glacial period (14,300-13,100 years before present), the climate was colder and drier than today and that vegetation in the Valley lowlands was dominated by open forests of lodgepole pine (*Pinus contorta*) and spruce (*Picea; Barnosky 1985, Walsh et al. 2008*). As the climate warmed during the early Holocene Epoch, forest composition shifted toward Douglas-fir (*Pseudotsuga menziesii*), true-firs (*Abies* spp.) and red alder (*Alnus rubra*) and fire return intervals became shorter. Summer droughts became more prolonged and frequent with low-intensity fires maintaining extensive areas of *Quercus* savanna across the lowlands by the mid-Holocene (ca 7,500-6,500 years before present; Barnosky 1985, Walsh 2008). Approximately 5000-6000 years ago, the regional climate began cooling, winters became wetter, and fire activity decreased. In the southern Puget Trough and higher elevations at the margins of the Willamette Valley, this shift in climate and fire regime fostered a transition in landcover to forests dominated by Douglas-fir and western red cedar (*Thuja plicata; Walsh 2008*). However, the advance of conifer forests was forestalled in the Valley because of fires regularly set by the Kalapuya People to promote the growth of food plants and to enhance game habitat (Boag 1992, Walsh 2008).

An analysis of Government Land Office (GLO) records indicate that approximately 1,000,000 acres of prairie and 500,000 acres of savanna extended across the Willamette Valley when early Euro-American settlers arrived in the region (Alverson 2006, Sinclair et al. 2006). During the last 150 years, most of the Willamette Valley grassland area has been lost to a combination of ecological and anthropogenic forces. Humans have transformed prairies and savannas to agricultural lands and urban developments. Where semi-natural areas have persisted, suppression of Native American burning has allowed trees to encroach upon grasslands, and oak-dominated woodlands have transitioned toward later-successional (usually conifer-dominated) forests (Habeck 1961, Towle 1982). The invasion of non-native plant species began with the introduction of agriculture in the Valley and non-native plants are now found in every part of the Valley.

Grassland Composition and Structure

Because of the long history of settlement and land use in the Willamette Valley and its subsequent disruption to native plant communities, the floristics of pre-settlement grasslands and woodlands are not well understood. Prairie and savanna vegetation of the Willamette Valley was generally dominated by perennial bunchgrasses and forbs. Approximately one third of pre-settlement prairies in the Willamette Valley were dominated by wet-habitat plant community associations and the remainder by upland

[1] Including both prairies and savannas

communities (Sinclair et al. 2006). Today, approximately 375 species of vascular plants are strongly associated with prairies and savannas in the Willamette Valley (E. Alverson, The Nature Conservancy, unpublished data).

Common grasses or grass-like plants that were likely to be widespread on upland sites prior to European settlement were Roemer's fescue (*Festuca roemeri*), California oatgrass (*Danthonia californica*), blue wildrye (*Elymus glaucus*), slender wheatgrass (*Elymus trachycaulus*), California brome (*Bromus carinatus*), foothill sedge (*Carex tumulicola*), and Lemmon's needlegrass (*Achnatherum lemmonii*) (Franklin and Dyrness 1988, Wilson et al. 1998a). Wet prairies in the region are commonly dominated by tufted hairgrass (*Deschampsia cespitosa*), California oatgrass, Sierra rush (*Juncus nevadensis*), western rush (*Juncus occidentalis*), creeping spikesedge (*Eleocharis palustris*), meadow barley (*Hordeum brachyantherium*) or a mix of these species (Wilson et al. 1998b, E. Alverson unpublished data).

Most plant diversity on prairies and savannas was represented by perennial and annual forbs. Frequently occurring upland forbs include: Tolmie's star-tulip (*Calochortus tolmei*), Menzie's larkspur (*Delphinium menziesii*), ookow (*Dicholostemma congestum*), Virginia strawberry (*Fragaria virginiana*), spring gold (*Lomatium utriculatum*), lupines (*Lupinus* spp.), tarweeds (*Madia* spp.), western buttercup (*Ranunculus occidentalis*), rose checkermallow (*Sidalcea virgata*), American vetch (*Vicia americana*), and prairie violet (*Viola praemorsa*), (Franklin and Dyrness 1988, Wilson et al. 1998a, Alverson, unpublished data). Common wet prairie forbs include: narrowleaf onion (*Allium amplectens*), common camas (*Camassia quamash*), common woolly sunflower (*Eriophyllum lanatum*), Willamette gumweed (*Grindelia integrifolia*), cutleaf silverpuffs (*Microseris laciniata*), beauty cinquefoil (*Potentialla gracilis*), straightbeak buttercup (*Ranunculus orthorhynchus*), Oregon saxifrage (*Saxifraga oregana*), meadow checkermallow (*Sidalcea campestris*), Hall's aster (*Symphyotrichum hallii*), mule's-ears (*Wyethia angustifolia*), and death camas (*Zigadenus venenosus*) (Wilson et al. 1998b, Alverson, unpublished data).

Most of the common grasses dominating Willamette Valley prairies and savannas are of low-stature (average height = 20 cm), although there are exceptions (e.g., blue wildrye max. height 140 cm, tufted hairgrass max. height 150 cm). Prairie communities display little vertical stratification, but are characterized by a high degree of horizontal spatial complexity (Wilson et al. 1998a, Wilson et al. 1998b). Spaces between individual bunchgrasses may be occupied by forbs, bryophytes, lichens or remain bare soil. Even slight variation in topography can cause abrupt changes in species composition and result in a mosaic of discrete vegetation patches. Wilson et al. (1998b) also describes a "pedestal" topography characteristic of wet prairies in which bunchgrass and other dominant plants grow from small mounds elevated as much as 20 cm above the lower ground level. Seasonal flooding may submerge much of the ground in winter, while the "pedestals" remain above water, causing the differentiation of fine-scale micro-habitats.

Savanna communities are typically composed of the same range of plant species that characterize upland prairies, but also support low-densities of trees, either as scattered individuals or in small, widely spaced patches. Oregon white oak and California black oak (*Quercus kelloggii*; in Lane County only) were common elements of savannas, but approximately 50% of savanna communities also contained a conifer component: usually Douglas-fir, and to a lesser extent, ponderosa pine (*Pinus ponderosa*).

Oak Woodland Plant Communities

Only two species of true oaks (genus *Quercus*) are native to the Willamette Valley. Oregon white oak is widely distributed throughout the physiographic province, while California black oak reaches its northernmost extent in northern Lane County west of Junction City (McDonald 1969, Stein 1990). Although *Quercus* woodlands can conceivably exist as climax communities in western Oregon (Franklin and Dyrness 1988), almost all contemporary woodlands dominated by Oregon white oak or California black oak occur in an early successional state because of their recent origin and the continuous history of human disturbance upon the landscape of the Willamette Valley (Thelineus 1968). Thelineus (1968) estimated that most of the "forest-form" Oregon white oaks on his study sites originated *circa* 1862, approximately 20 years after a peak of settlement activity in the region and the beginning of suppression of annual prairie fires by Native Americans. However, it is still common to observe "open-form" oaks, a legacy of pre-settlement prairies, scattered within woodland stands.

Oregon white oak grows well on both xeric sites and inundated floodplains. The species also occurs on highly productive soils, but is usually excluded by faster growing trees in the absence of fire or other disturbance (Stein 1990). Thelineus (1968) described four *Quercus* woodland plant community associations in the Willamette Valley. The *Oregon white oak/California hazel/sword fern* community is found on moderate to steep sheltered slopes. The *Oregon white oak/western serviceberry/snowberry* community is associated with exposed ridges and slopes. The *Oregon white oak/mazzard cherry/snowberry* community is found on level sites and slopes. The most xeric woodland sites support the *Oregon white oak/poison-oak* community. Kagan et al. (2004) identified a fifth *Quercus* community association occurring in the southern Valley not described by Thelineus (1968), *Oregon white oak-California black oak/poison oak*. Other common tree species found in dominant positions in oak woodland canopies include Douglas-fir, big-leaf maple, grand fir, and Pacific madrone (Thelineus 1968).

The four Oregon white oak communities distinguished by Thelineus (1968) vary in vegetation structure. Among all four types, the *Oregon white oak/California hazel/sword fern* community has the greatest density of large-diameter trees, especially the open-form type. Large tree frequency and basal area decrease in *Oregon white oak/western serviceberry/snowberry* and *Oregon white oak/mazzard cherry/snowberry* communities, and are lowest in the *Oregon white oak/poison-oak* community. However, the *Oregon white oak/poison-oak* community typically contains the greatest numbers of sapling and pole-size trees.

Many prairie grasses and forb species will occur in the understory of oak savannas and open woodlands. Blue wildrye (*Elymus glaucus*), California fescue (*Festuca californica*), and Alaska oniongrass (*Melica subulata*) are the most common native grasses in oak woodlands. Characteristic or frequently occurring forbs of oak woodlands include Nuttall's toothwort (*Cardamine nuttallii*), shooting star (*Dodecatheon hendersonii*), Oregon fawn lily (*Erythronium oregonum*), woods strawberry (*Fragaria vesca*), tough-leaved iris (*Iris tenax*), peavines (*Lathyrus* spp.), celery-leaf licoriceroot (*Ligusticum apiifolium*), sweet cicely (*Osmorhiza berteroi*), and Pacific sanicle (*Sanicula crassicaulis*).

Chapter 3 Wildlife Communities

Our knowledge of wildlife communities in pre-settlement Willamette Valley grasslands and oak woodlands is largely conjectural, based on accounts of Native Americans, explorers, and early settlers. Bailey (1936), Boag (1992), and Boyd (1999) provide insights to Native American hunting practices and observations by early European visitors and settlers. But most of the anecdotal observations were of game species, predators, and other large- to medium-size mammals of economic importance. To develop a more comprehensive list of vertebrate diversity associated with grasslands and oak woodlands, we utilized a well known wildlife-habitat relationships (WHR) model that describes associations between 743 wildlife species and 32 aquatic and terrestrial habitats in Oregon and Washington (O'Neil et al. 2001). Using this model and geographic range maps of wildlife species, we estimate that 97 native vertebrate species use Willamette Valley grasslands and 159 species use woodland habitats for feeding and reproduction. Our methods and the resulting list of species are reported in the Appendix.

Mammals

Of the 62 native species of mammals that currently or recently occur in the Willamette Valley physiographic province (Verts and Carraway 1998), 31 native species demonstrate at least a general association with grassland habitats (Appendix). However, very few species are specially adapted to life on prairies or savannas given the relatively simple vegetation structure that is characteristic of these habitats and the lack of hiding cover adequate for medium- and large-size mammals. Only four species are reported to be closely associated with grasslands in the Willamette Valley: the deer mouse (*Peromyscus maniculatus*), camas pocket gopher (*Thomomys bulbivorus*), gray-tailed vole (*Microtus canicaudus*), and red fox (*Vulpes vulpes*; O'Neil et al. 2001). The camas pocket gopher and gray-tailed vole are both endemic to the Willamette Valley, including into Clark Co, Washington in the case of the gray-tailed vole. The historic distribution of the red fox in western Oregon remains ambiguous. A range map included in Bailey (1936) shows native red foxes to be distributed throughout the western Cascades and Oregon Coast Range, but absent from the Willamette Valley. Their presence on the contemporary landscape may result from deliberate introductions (Verts and Carraway 1998) or from a range expansion of native populations facilitated by the removal of a major predator/competitor, the gray wolf (*Canis lupus*).

The relatively greater plant species richness and structural complexity of woodland habitats compared to grasslands fosters greater wildlife diversity in the former. We estimate that 50 native mammalian species use oak or mixed oak/Douglas-fir woodlands in the Willamette Valley for feeding and breeding (Appendix). Numerous mammals take opportunistic advantage of mast crops, tree cavities, and other special attributes of oak stands, but only three species demonstrate a close affinity for pure oak stands or the oak component within mixed stands: the California vole (*Microtus californicus*), western gray squirrel (*Sciurus griseus*), and Columbia white-tailed deer (*Odocoileus virginianus leucurus*; O'Neil et al. 2001).

Human activities have had significant impacts on the composition of mammalian communities in the Willamette Valley. At the time of Euro-American settlement (mid-nineteenth century), Roosevelt elk commonly foraged in Valley grasslands until they were driven to less disturbed forest areas in the foothills (Boag 1992). Explorers and pioneers regularly observed grizzly bears (*Ursus arctos horribilis*) and gray wolves in the Willamette Valley, but their persecution by settlers raising livestock led to the extirpation of these large carnivores early in the state's history. Grizzly bears were last observed in approximately 1845 and the final records of gray wolves in the Willamette Valley were of 13 individuals from Lane, Linn, and Clackamas Counties taken for bounties during 1913-1914 (Bailey 1936).

Two other mammalian species now occur only in localized populations. The black-tailed jackrabbit (*Lepus californicus*) was once widely distributed across grasslands of the Willamette Valley (Bailey 1936), but since at least the 1990s are rarely observed (Verts and Carraway 1998). Nevertheless, there have been several recent sightings in southwest Benton County (R. Anthony, Oregon Cooperative Fish and Wildlife Research Unit, pers. comm.; J. Hagar, U.S. Geological Survey, pers. comm.). The Columbian white-tailed deer was reportedly common on prairies and savannas at the time of European settlement, but only relict populations currently exist in Clatsop, Columbia, and Douglas Counties (Verts and Carraway 1998). The species is believed to have been extirpated from the Willamette Valley (O'Neil et al. 2001).

Three species of mammals closely associated with grasslands or oak woodlands (i.e., camas pocket gopher, western gray squirrel, and Columbian white-tailed deer) have been conferred special status under federal or state laws and/or administrative rules because of declining populations or increased level of threat (Table 1).

Several non-native, mammalian species have become widespread in uplands in the Willamette Valley. Eastern gray-squirrels (*Sciurus carolinensis*) and the house mouse (*Mus musculus*) have been reported to occur primarily in urban areas (Verts and Carraway 1998), whereas the eastern cottontail (*Sylvilagus floridanus*) and Virginia opossum (*Didelphis virginiana*) are common throughout the Willamette Valley, particularly in shrubby vegetation, including within oak and prairie habitats (Verts and Carraway 1998).

Table 1. Species with designated state or federal status closely-associated with Willamette Valley grasslands and Oregon oak woodlands. Status is indicated for populations in Oregon and Washington.

Class	Common Name	Scientific Name	Primary Habitat Type[1]	ISSSP[2]	ESA[3]	SOC[4]	OCS[5]
Invertebrate	American acetropis bug	*Acetropis americana*	Grasslands	OR-STR		X	
Invertebrate	Whulge (=Taylor) checkerspot butterfly	*Euphydryas editha taylori*	Grasslands	SEN	C		
Invertebrate	Fender's blue butterfly	*Icaricia icarioides fenderi*	Grasslands	E	E		
Invertebrate	Oregon giant earthworm	*Driloleirus macelfreshi*	Oak woodland, prairie, gallery forests	OR-STR		X	
Reptile	Western pond turtle	*Actinemys marmorata*	Grasslands	SEN		X	X
Reptile	Western painted turtle	*Chrysemys picta*	Grasslands	OR-SEN			X
Reptile	Northern Pacific rattlesnake	*Crotalus viridis*	Grasslands/ Oak Woodlands	NL			X
Bird	Grasshopper sparrow	*Ammodramus savannarum*	Grasslands	OR-SEN			X
Bird	Band-tailed pigeon	*Columba fasciata*	Oak Woodlands	NL		X	X
Bird	Streaked horned lark	*Eremophila alpestris strigata*	Grasslands	SEN	C		X
Bird	Acorn woodpecker	*Melanerpes formicivorus*	Oak Woodlands	WA-SEN		X	X
Bird	Lewis's woodpecker	*Melanerpes lewis*	Oak Woodlands	OR-SEN		X	X
Bird	Oregon vesper sparrow	*Pooecetes gramineus affinins*	Grasslands	SEN		X	X
Bird	Western bluebird	*Sialia mexicana*	Oak Woodlands	NL			X
Bird	Slender-billed nuthatch	*Sitta carolinensis*	Oak Woodlands	WA-SEN			X
Bird	Chipping sparrow	*Spizella passerina*	Oak Woodlands	NL			X
Bird	Western meadowlark	*Sturnella neglecta*	Grasslands	NL			X
Mammal	Columbian white-tailed deer	*Odocoileus virginianus leucurus*	Oak Woodlands	E/SEN	E [6]		X
Mammal	Western gray squirrel	*Sciurus griseus*	Oak Woodlands	WA-SEN			X
Mammal	Camas pocket gopher	*Thomomys bulbivorus*	Grasslands	NL		X	

1 Species-habitat type association based on Altman et al.(2001), O'Neil et al. (2001), and ODFW (2006).

2 ISSSP: Interagency Special Status Sensitive Species Program status: Endangered (E), Strategic in Oregon only (OR-STR), Sensitive in Oregon only (OR-SEN), sensitive in Washington only (WA-SEN), not-listed (NL)

3 ESA: Species designated as endangered (E) or a candidate (C) for listing under the federal Endangered Species Act of 1974.

4 SOC: U.S. Fish and Wildlife Service Species of Concern, from ORNHIC (2007).

5 OCS: Oregon Conservation Strategy Species

6 Columbia River distinct population segment

Birds

Although prairies and savannas do not support as great a diversity of birds as forested areas, the drastic decline in the extent of Willamette Valley grasslands causes great concern among conservationists for the avian communities associated with these habitats. We estimate that 48 native species feed and breed in grasslands (Appendix). Data from the Breeding Bird Survey (BBS) indicate that 15 of these species are experiencing significant population declines in western Oregon grasslands (Altman et al. 2001). Only two species, the common yellow-throat and red-winged blackbird, are increasing in numbers (Altman et al. 2001).

At least six species once present on Willamette Valley grasslands no longer breed in the region or have been entirely extirpated: the sandhill crane (*Grus canadensis*), burrowing owl (*Athene cunicularia*), Lewis' woodpecker (*Melanerpes lewis*), Say's phoebe (*Sayornis saya*), lark sparrow (*Chondestes grammacus*; Altman et al. 2001) and black-billed magpie (*Pica hudsonia*; O'Neil et al. 2001). Two subspecies endemic to western Oregon grasslands, the streaked horned lark (*Eremophila alpestris strigata*) and Oregon vesper sparrow (*Pooecetes gramineus affinins*) were once common in the Willamette Valley (Gabrielson and Jewett 1940), but now only occur in local populations (Altman 2003a, Altman 2003b, Moore 2008a).

We estimate that 87 avian species feed and reproduce in oak/Douglas-fir woodlands (Appendix). Oak woodlands support avian communities that differ from conifer-dominated stands in the Willamette Valley and have a higher proportion of Neotropical migrants (Hagar and Stern 2001). Species that are characteristic of oak woodlands and less common in conifer forests include the western wood-pewee (*Contopus soridulus*), lazuli bunting (*Passerine amoena*), Cassin's vireo (*Vireo cassinii*), and Bullock's oriole (*Icterus bullockii*; Hagar and Stern 2001). In a comparison of bird communities observed in oak woodlands during 1967-68 (Anderson 1970) to observations made at the same sites 28 years later, Hagar and Stern (2001) found that three species, yellow warbler (*Dendroica petechia*), common bushtit (*Psaltriparus minimus*), and chipping sparrow (*Spizella passerine*) were common during the earlier period but were not detected at all during the later survey. Species that had increased in abundance included the Swainson's thrush (*Catharus ustulatus*), Pacific slope flycatcher (*Empidonax difficilis*), and purple finch (*Carpodacus purpueus*). Hagar and Stern (2001) concluded that the principle cause for differences in species composition at the woodland sites were successional changes in the plant community and a resulting increase in tree density and canopy closure.

Non-native bird species that commonly occur in prairie and oak habitats of the Willamette Valley include wild turkey (*Meleagris gallopavo*), ring-necked pheasant (*Phasianus colchicus*), and European starling (*Sturnus vulgaris*).

Ten of the avian species most closely associated with grasslands and oak woodlands have special status designated by federal and/or state agencies (Table 1). Natural history accounts for the three special status species are included in Chapter 6, *Species Accounts*.

Amphibians and Reptiles

A review of geographic range maps in Nussbaum et al. (1983) indicates that 13 species of amphibians are native to the Willamette Valley. As a class, amphibians are not well adapted to hot, arid conditions and most populations can only persist under a tree canopy that moderates extreme temperature fluctuations. Only two amphibian species demonstrate even a general association with grassland habitats in the Willamette Valley (Appendix). The long-toed salamander (*Ambystoma macrodactylum*) and the Pacific treefrog (*Pseudacris regilla*) both deposit eggs in open water, thus require at least seasonally available aquatic habitat in addition to grasslands (Nussbaum et al. 1983). Six amphibian species use Willamette Valley woodlands for feeding and breeding (Appendix). Most of these species demonstrate a closer association with conifer stands and the greater volume of coarse, woody debris they provide compared to pure oak woodlands. The local distributions of most amphibians are more closely correlated with intrinsic site characteristics (e.g. aspect, topographic position) or the presence of special habitat elements (e.g., exposed rock, open water) than vegetation structure (Altman et al. 2001).

Prairies, savannas, and dry, open woodlands are the preferred habitat types for most Willamette Valley reptiles. Fifteen species reportedly use oak/Douglas-fir woodlands for feeding and breeding; all but one of these species (western painted turtle) are also associated with grassland habitats (Appendix). Painted turtles and western pond turtles are associated with grasslands (Gervais et al. 2009, Rosenberg et al. 2009). However, both species of turtles native to the Willamette Valley prefer to nest in areas with sparse vegetation with little or no tree canopy, but are not restricted to any particular vegetation type.

Three species of reptiles (western painted turtle, western pond turtle, and northern Pacific rattlesnake) associated with grassland or oak woodland habitats in the Willamette Valley have been designated as Oregon Conservation Strategy species and of these, both turtles are listed as Sensitive under the ISSSSP (Table 1); no amphibians that use these habitats have been conferred special state or federal status.

Invertebrates

Historical records indicate that at least 24 butterfly species were associated with upland prairies in the Willamette Valley, of which 13 species are extinct or exist only as isolated populations on relict patches of native upland prairie (Wilson et al. 1998a). Characteristic upland species include the checkered skipper (*Pyrgus ruralis*), Sonora skipper (*Polites sonora*), and anise swallowtail (*Papilio zelicaon*). Common *Lepidoptera* of wet prairies include the sheep moth (*Hemileuca eglanterina*) and field crescent butterfly (*Phyciodesss pratensis*; Wilson et al. 1998b). Two of the butterflies most closely associated with prairies of western Oregon are Fenders blue butterfly (*Icaricia icarioides fenderi)* and Taylor's checkerspot butterfly (*Euphydryas editha taylori)*. The former species is federally listed as endangered and the latter species is a candidate for federal listing, and both are listed under ISSSSP (Table 1). Miller and Hammond (2007) report that 32 species of Lepidoptera are closely associated with oak woodland habitats; many of these species are wholly dependent on oaks or related genera (family Fagaceae). Ross (2009) reports on additional species that may be dependent on oak and prairie habitats.

Wet prairies and vernal pools located in grasslands support a rich variety of endemic arthropods that are rarely observed in agricultural fields. The assemblage of *Carabidae* is especially diverse in these habitats (Wilson et al. 1998b). The American Acetropis bug (*Acetropis americana*) is closely associated with tufted hairgrass communities (Wilson et al. 1998b) and is listed by ISSSSP as a Strategic Species in Oregon and by USFWS as a Species of Concern (Table 1), largely because of habitat loss.

Native earthworms were likely an important component of Willamette Valley plant communities prior to invasion by European species (Bailey et al. 2002). The Oregon giant earthworm, *Driloleirus macelfreshi,* was early described as occupying native prairies, and its rarity is often attributed to the loss of this plant community. However, most of the locations where the Oregon giant earthworm has been found (only 15 reported specimens, http://www.xerces.org/oregon-giant-earthworm/) were found in gallery hardwood forests in the Willamette floodplain, and the most recent observation was in a mixed hardwood-conifer floodplain forest (J. Gervais, Oregon State University, pers. commun.). This species is an ISSSSP Strategic Species in Oregon (Table 1; see ISSSSP fact sheet: http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/sfs-icl-driloleirus-macelfreshi-2009-12.doc).

Chapter 4 Research Conducted On Oak and Prairie Associated Wildlife

Despite the large loss of oak and prairie plant communities in the Willamette Valley, the biodiversity that occupies and depends on these habitat types, and the large effort towards restoration and conservation planning for oak habitats in the Willamette Valley, there has been surprisingly little research conducted on the ecology of wildlife in these habitats. Other than research conducted on the federally endangered Fender's blue butterfly, almost no research has been conducted on how wildlife responds to restoration efforts. Our understanding of wildlife relationships in oak and prairie plant communities in the Willamette Valley relies mostly on natural history observations. There have been several syntheses of wildlife in the Willamette Valley. The review conducted by Altman et al. (2001) highlights our understanding of wildlife habitat relationships in grassland and oak habitats.

Most of the work conducted on wildlife in the Willamette Valley has described species occurrence, distribution, and habitat associations. Not surprisingly, that comprised most of the studies conducted prior to 2000, summarized thoroughly in Altman et al. (2001). Most of this work remains unpublished, either as agency documents or theses from graduate studies. Two primary exceptions are a series of detailed studies that include both observational and experimental approaches on the federally listed Fender's blue butterfly and the endemic gray-tailed vole, the latter largely due to the use of this species as a model organism for studies of population ecology (e.g., Wolff et al 1997) and evaluation of pesticides under field conditions (Wang et al. 2001).

In an effort to better understand wildlife habitat-relationships in these plant communities, we summarize previous research that is most relevant for understanding how wildlife may respond to restoration of oak and prairie plant communities in the Willamette Valley, drawing upon the most relevant research in other regions.

Biodiversity Studies

Schumaker et al. 2004: Projecting wildlife responses to alternative future landscapes in Oregon's Willamette Basin. Ecological Applications 14:381-400.

Objective:
Evaluate wildlife response to landscape change throughout the Willamette Valley.

Approach:
The authors evaluated wildlife response to landscape change using two modeling approaches that used vegetation maps of the Willamette Valley that included presumed pre-settlement vegetation, contemporary (1990), and 3 projected changes based on different assumptions about development patterns by the year 2050. The first approach assumed habitat amount is an index of population viability. They ranked habitat

suitability for each species and habitat type based on the literature and expert opinion. Their second approach incorporated spatially-explicit population models whereby individuals populate the simulated landscapes according to demographic rates, which were obtained from the literature and expert opinion. The latter required some understanding of demographic rates and thus were conducted for only 17 of the 279 species evaluated by the habitat approach. Several habitats (e.g., oak savanna, natural grassland) and one species in the population-model approach (western meadowlark) are particularly relevant to our synthesis. Furthermore, the general approach used by the authors could be used specifically to evaluate oak and prairie related wildlife response to various conservation strategies for these habitats.

Results:
The most relevant results for the synthesis are the detailed maps of alternative development patterns that depict the landscape pattern of oak and prairie habitats and their configuration within the matrix of developed areas. In terms of what the authors report, the following are the most relevant results:

1. Based on change in habitat amount and the distribution and ranking of habitat suitability, the landscape model suggest the abundance of reptile species decreased considerably from historic conditions to the 1990 map due to decreases in the area of open habitats, primarily oak savanna, dry shrub, and natural grassland.

2. The western meadowlark, a grassland and prairie species, was one of the 17 species the authors included in their modeling of population dynamics. Not surprisingly, and for the same reasons as for the reptiles, the western meadowlark was predicted to have declined considerably from pre-settlement conditions to the 1990 vegetation conditions, and to have increased the most from the 1990 conditions to the scenario envisioned under a conservation emphasis for 2050. Interestingly, they found that for the meadowlark in particular, the percent change in habitat underestimated the percent change in the population. They speculated that this resulted because of the specific location of habitat change rather than percent change over the entire landscape. Thus, if habitat is added in the vicinity of meadowlarks, then populations can increase at a more rapid rate than that predicted by the average addition of habitat.

Management Implications:
The primary implication of this work for managing oak and prairie habitat to benefit wildlife species is in the authors' modeling approach. The authors' comparison of two fundamentally different modeling approaches will facilitate developing heuristic models of various strategies for conserving oak and prairie habitat.

Avian Studies

Altman 1999: Status and conservation of state sensitive grassland bird species in the Willamette Valley. Unpubl. Report, submitted to Oregon Department of Fish and Wildlife.

Objectives:
The primary goal of the study was to understand the distribution and abundance of grassland bird species and their habitat relationships. Specific objectives included:

1. describe bird communities in Willamette Valley grasslands, including both modified grasslands and remnant prairies
2. locate populations of sensitive bird species and estimate their abundance
3. evaluate area requirements and reproductive success for sensitive species
4. provide a scientific basis for predicting effects on avian communities from habitat restoration strategies

Approach:
Over a two-year period (1996 and 1997), the author used an extensive and intensive survey approach to evaluate the distribution, abundance, territory size, and habitat use of grassland birds in both remnant prairies and agricultural fields, including pasture and Christmas tree farms. Grassland bird species that were designated by Oregon as State Sensitive (Critical) were selected as the target species for the study. These species included: streaked horned lark, western meadowlark, vesper sparrow, grasshopper sparrow, and common nighthawk.

The extensive study was conducted during the breeding season of 1996. A total of 544 point-count stations were established along roads to estimate bird distribution patterns. Counts were supplemented with area searches and off-road transects walked by observers. Selection of sampling points was based on known locations of target species, potentially suitable habitat, the goal of obtaining samples throughout Willamette Valley, and inclusion of remnant prairies. The non-representative selection criteria, as the author noted, limited inferences to only the specific areas sampled. At each point, habitat characteristics were estimated within 100 m. Numerous volunteers surveyed common nighthawks in a different set of locations than the other grassland birds.

Study areas were selected for the intensive sampling to estimate territory size and reproductive success. Territory mapping was used to estimate areal use by the target species. Habitat characteristics were measured within the mapped territory and at each nest site.

Results:
Although the lack of a formal sampling strategy limited the strength of inferences and the generality on distribution patterns in the Willamette Valley, the results suggested the following patterns for the 5 target species:

Streaked horned lark: primarily in central Willamette Valley
Western meadowlark: nearly absent in northern portion of Willamette Valley, highest in southeastern portion of Willamette Valley

Vesper sparrow: similar distribution patterns as western meadowlark but with a few locations in northern Willamette Valley with high abundance

Grasshopper sparrow: there were no detections during the extensive survey effort, but they were detected at some of the intensive study sites. The limited results suggest that this species is most common in the southeastern portion of the Willamette Valley.

Common nighthawk: most observations were near or along the Willamette River and its tributaries. Despite an extensive survey effort, the majority of nighthawks were observed in only a few areas, primarily in grasslands, Christmas tree farms, and lowlands in the historic floodplain.

In addition, the near lack of observations of most target species in wet prairies suggested that the primary habitat association of these species is drier grasslands in the Willamette Valley. The author also noted the higher degree of specialization for vesper sparrows and western meadowlark than the other grassland species. Both species were found more than expected in pasture and cultivated fields (western meadowlark) and in Christmas tree farms that have extensive weeds (Oregon vesper sparrow). Streaked horned larks were most commonly detected in areas with sparse vegetation, including gravel and dirt roads. The author found that western meadowlarks were the most tolerant of the target species for tall grass.

Management Implications:
This study represents the only study that we are aware of on the distribution, abundance, and habitat associations for the grassland bird community in the Willamette Valley. The study provides information on distribution patterns that will facilitate specific management efforts and selecting potential study areas for future research. The estimates of territory size, suggesting larger areal requirements for western meadowlarks than the other target species, provide useful guidelines for management and a basis for further exploration into site- and landscape-scale habitat associations of western meadowlarks.

Anderson 1970: The avifaunal composition of Oregon white oak stands. Condor 72:417-423.

Objective:
The primary objective of the study was to describe characteristics of bird communities in Oregon white oak stands in the Willamette Valley.

Approach:
This was the first study that quantified bird abundance and diversity in Oregon white oak woodlands in the Willamette Valley. The study was conducted between October 1967

and December 1968. Anderson conducted bird surveys at five white oak woodlands. He quantified the abundance and proportional representation for migratory strategies (permanent [year-round], summer, and winter residents) in the bird communities in each woodlot.

Results:
The author found very high densities of birds and a high proportion of Neotropical migrants in the oak stands. No comparisons of vegetation and bird occurrence or abundance were made. Anderson provided a detailed list of species occurrence in each of the 5 stands and seasons, data that Hagar and Stern (2001) were able to compare to their study 3 decades later.

Management Implications:
From the almost four decades that have passed since this work was published, it is clear that the primary implication of this work is in the recognition of the unique bird communities found in Oregon white oak woodlands in the Willamette Valley, and in particular, the high proportion of Neotropical migratory birds. Further, the documentation of the bird community allowed later investigations (Hagar and Stern 2001) into how the bird community changed with time, presumably in response to changes in the vegetation. The paper has been cited frequently to support the idea of the unique bird assemblage in Oregon white oak habitats.

Anderson 1972: Seasonal variations in forest birds of western Oregon. Northwest Science 46:194–206.

Objective: The primary objective of this study was to compare patterns of bird abundance and composition throughout the year in three forest types in western Oregon: oak woodlands, Douglas-fir, and western hemlock.

Approach**:** A stand-level survey of bird abundance was conducted in 10 forest stands on the eastern slope of the Coast Ranges. The author used "sample count" methods along transects in each stand to estimate relative abundance. The author quantified and compared the abundance and proportional representation of migratory strategies (permanent [year-round], summer, and winter residents) across three vegetation types (Oregon white oak, Douglas-fir, western hemlock) and seasons using the same approach as in Anderson (1970).

Results: Oak woodlands had higher species diversity and density of birds than in closed-conifer stands. A majority (69%) of individuals detected in the winter were permanent residents in oak woodlands whereas all of the individuals detected in conifer stands were permanent residents. In spring, winter residents left oak woodlands, presumably to nest in conifer stands. This resulted in summer residents comprising 51-55% of all individuals detected in conifer stands but only 33% in oak woodlands. The majority of summer residents in oak woodlands were Neotropical winter migrants. Species were not confined to one vegetation type. All winter residents detected in oak woodlands were found as permanent residents in the conifer stands. However, species diversity was highest in oak woodlands. The difference in species diversity between oak woodlands and conifer stands was greatest in fall and winter. Diversity was fairly even in all seasons in oak woodlands. Anderson believed the primary difference with the bird communities between the conifer and oak woodland stands was the denser and more diverse understory in the open oak woodlands. As with Anderson's earlier study (1970), he provides a detailed list of species occurrence in each of the stands and seasons, data that Hagar and Stern (2001) were able to compare to their study 3 decades later.

***Management Implications*:**
This research, similar to the author's related paper (Anderson 1970), provides detailed description of bird communities in oak woodlands in the Willamette Valley during the late 1960s. The results of this research demonstrated the unique bird communities of oak woodlands in the Willamette Valley, and how they change seasonally. The paper has been cited frequently to support the idea of the unique bird assemblage in Oregon white oak habitats.

DeMars et al. (In press): Multi-scale factors affecting bird use of isolated remnant oak trees in agro-ecosystems. Biological Conservation.

Objective: The objective of this study was to evaluate hypotheses on how characteristics of individual trees and the surrounding landscape are associated with bird use of isolated remnant oak trees in agricultural settings in the Willamette Valley.

Approach:
The author used a comparative approach to identify multi-scale factors that were associated with the presence of birds on individual "legacy" oak trees during the breeding season in the central Willamette Valley. The author compared avian use of isolated oak trees in three different landscape contexts - croplands, pastures, and oak savanna reserves and ranked the relative importance of four factors thought to influence avian use of individual trees: (1) tree architecture; (2) tree isolation; (3) tree cover in the surrounding landscape; and (4) landscape context.

Results:
Remnant oaks were used by 47 bird species, including a high number of species that typically occur in oak savanna, such as the white-breasted nuthatch. Surprisingly, landscape context was unimportant in predicting frequency of use of individual trees. Tree size and tree cover in the surrounding landscape were the best predictors of avian use of remnant trees. The author's findings demonstrated that avian species associated with oak savannas visit or otherwise use individual legacy trees suggesting that these trees contribute to landscape-level conservation of bird communities in oak habitats in the Willamette Valley.

Management Implications:
The author suggested that legacy oak trees in otherwise agricultural settings act as keystone habitat structures by providing critical resources for avian species that could not persist in otherwise treeless agricultural fields. Because legacy trees are rarely retained in contemporary agricultural landscapes in the United States, retention of existing legacy trees and recruitment of replacement trees will contribute to local and regional conservation goals. The primary implication of this study is illustrating the potential importance of legacy trees in agricultural landscapes, a finding that demonstrates that individual landowners can make positive contributions to protecting biological diversity often associated with oak savanna and woodlands by ensuring large oak trees exist in agricultural production areas.

Drovestski et al. 2005: Streaked horned lark *Eremophila alpestris strigata* has distinct mitochondrial DNA. Conservation Genetics 6:875-883.

Objectives:
The objective of this study was to evaluate the genetic basis for the recognition of the streaked horned lark as a distinct clade.

Approach:
The authors collected blood, egg, or tissue samples from SHL from the northern part of their SHL range and from horned larks of other subspecies from outside the range of the SHL and conducted genetic evaluation by sequencing the complete mitochondrial ND2 gene.

Results:
A total of 32 SHL and 68 horned larks from outside the SHL range were sampled for genetic analyses. Analyses suggested the SHL is a unique and well isolated clade. The SHL sample had low diversity, and all 32 individuals shared the same haplotype; horned larks from elsewhere all had multiple haplotypes.

Management Implications:
Results suggest that SHL have been evolving independently and can be considered a distinct evolutionary unit and not simply a peripheral population of an otherwise well distributed species. The authors argued that the results demonstrating that SHL are genetically unique, isolated from other clades, and have low genetic diversity, provide support for making it a priority for conservation.

Doerge, K. F. 1979: Aspects of the geographical ecology of the acorn woodpecker (*Melanerpes formicivorous*). MS Thesis, Oregon State University, Corvallis, OR.

Objectives:
The goal of the study was to identify factors that contributed to the northern extension of the range of the acorn woodpecker into western Oregon and Washington.
Specific objectives included identifying population and habitat characteristics that were associated with the abundance of acorn woodpeckers in the area of the range extension.

Approach:
The majority of the work was conducted in Benton County, Oregon during 1978. Acorn woodpecker colonies were located by driving through rural areas of the county. Habitat characteristics were compared between occupied (8 colonies) and unoccupied (n=8) oak stands. Site selection criteria for these 8 non-occupied oak stands were not described. The author also surveyed for acorn woodpeckers in areas in which this species was reported and in areas believed to provide suitable habitat. Areas included in this less intense search effort included the Willamette Valley from Corvallis to Portland, in the Columbia Gorge from Portland to Dalles, and in Washington from Longview to Lacey.

Results:
A total of 32 colonies of acorn woodpeckers were located. Of these, the majority (n=18 colonies) were located in Benton County with the remainder observed farther north. The author noted that Lewis' Woodpecker occupied several of the areas along the Columbia Gorge that appeared suitable for Acorn Woodpeckers, but they were not found. In general, the comparison of sites occupied and unoccupied by acorn woodpeckers in Benton County resulted in the following in occupied sites: (1) larger trees and more dead limbs, and (2) greater mean density of trees (minimum size for inclusion not reported). The best predictor of occupancy within oak stands was a greater number of dead limbs >10 cm (minimum size included in study) and greater mean diameter. Estimates of group size and home range were reported.

Management Implications:
The primary importance of this work was in providing one of the earliest estimates of the range extension of acorn woodpeckers in western Oregon and Washington. The characteristics of habitat selection are in general agreement with work that has been conduced from other parts of the species' range. The author suggested that the recent expansion of acorn woodpeckers into the Willamette Valley may have been from the transition from open woodlands and savanna to oak woodlands following the cessation of fire after settlement by Euro-Americans. The author also speculated that the loss of Lewis' woodpecker form the Willamette Valley may have been due to the expansion of the acorn woodpecker's range.

Gumtow-Farrior, D. L. 1991: Cavity resources in Oregon white oak and Douglas-fir stands in the mid-Willamette Valley, Oregon. MS Thesis, Oregon State University, Corvallis.

Objectives:
The basic objective was to enumerate and compare abundance of potential nest cavities in Oregon white oak, Douglas-fir, and mixed oak/fir stands in the mid-Willamette Valley, and to identify patterns within tree size-classes and tree species.

Approach:
Ten stands each of Oregon white oak woodlands, second-growth Douglas-fir, and mixed oak/fir stands were selected within the mid-Willamette Valley. Stand types were further classified into three diameter distribution size classes. Oregon white oak stands were further classified into patch size (≤4ha, >4ha). In total, there were 10 stand types defined and 1 replicate in each of three regions (northern, central, and southern) of the mid-Willamette Valley. Stands were selected from each of these sub-regions based on similarity of stand size, mean tree diameter, and species composition. A suite of measurements to characterize the trees and stands were recorded. Only trees >20 cm dbh were included in tree measurements.

Results:
The key result was that the abundance of cavities per tree was greatest in Oregon white oak trees. On average, Oregon white oak had twice the number of cavities that big-leaf maple contained, and over 30 times that of Douglas-fir. This translated to a much higher number of cavities in Oregon white oak stands, despite the lower tree density compared to Douglas-fir stands. Open-form Oregon white oak trees had a much greater abundance of cavities than closed-form Oregon white oaks. As anticipated, the number of cavities/tree increased with tree diameter. The author found similar results for snags. Importantly, cavities in Oregon white oak trees were similarly abundant in both snags and live trees, whereas in Douglas-fir they were largely restricted to snags. Douglas-fir snags, however, had greater number of cavities than snags of other tree species. The best predictor of presence of excavated cavities was disease and tree diameter. For non-excavated cavities, these factors and the open-form structure were the best predictors. In summary, cavity resources were abundant in Oregon white oak stands, and contained approximately 98% of the cavity resources based on all stands sampled.

Management Implications:
The primary implication of this study was the recognition of the abundant cavities in Oregon white oak stands, which far exceeded that of Douglas-fir and mixed stands. The results suggested that cavities are not limiting bird populations in Oregon white oak stands as long as large-diameter, open-form oaks are present.

Hagar, J. Summary of Bird-Banding Results at W.L. Finley National Wildlife Refuge, 2009. Unpublished report submitted to U.S. FWS.

Objectives:
The primary objective of this case study was to evaluate avian response to management efforts to restore oak woodlands in the mid-Willamette Valley to a more open structure. The specific objectives were to estimate changes in abundance, survival, and productivity of birds following tree and shrub removal treatments.

Approach:
An oak woodland site at William L. Finley NWR was selected as a case study of avian response to restoring a more open structure to oak woodlands through mechanical removal of trees and shrubs. Mist-netting was used to mark and recapture birds to estimate survival rates and to age birds to estimate the proportion of juveniles in the area. Point counts were used to increase the sample of detections to allow estimates of abundance for a greater number of species than mist-netting alone would allow. Point count stations were the same as Hagar and Stern (2001) established in 1994 at this site. Birds were counted at stations during the breeding season in 2004, 2007, and 2008, and captured in mist nests during the breeding season in 1998 to 2002, and 2007-2008 , with plans for continued banding in additional years.

Results:
A total of 60 species were observed during the 2008 field season and a total of 81 species were observed since the project began in 1998. Based on these data and knowledge of migration patterns, Hagar reported that 28 species likely breed at the study site each year. Swainson's thrush was among the most commonly captured in mist nets and ranked fourth for the number of detections during point count surveys. The discrepancy between captures and point counts demonstrates how estimation methods affect inferences on relative abundance estimates. Comparisons of point counts among years suggested that some species may have declined slightly, including 3 species associated with oak woodlands (Cassin's vireo, white-breasted nuthatch, and lazuli bunting). The author hypothesized that these species will increase in abundance in response to removal of trees to restore the open structure of the woodland.

Management Implications:
The study is on-going and will require comparisons pre- and post-treatment to develop management recommendations from this case study.

Hagar and Stern 2001: Avifauna in oak woodlands of the Willamette Valley, Oregon. Northwestern Naturalist 82: 12-25.

Objective: Evaluate bird-habitat relationships in contemporary oak woodlands in the Willamette Valley.

Approach: A stand-level survey of vegetation characteristics and patterns of bird abundance in 9 oak woodlands was conducted in May and June 1994-1996. Comparisons were made in two of the same oak stands that Anderson (1970, 1972) sampled over twenty years earlier. These stands had additional conifer cover than when sampled earlier, allowing an initial evaluation of hypotheses related to conifer encroachment and patterns of bird abundance.

Results:

In comparison with the oak stands that Anderson (1970, 1972) sampled, the authors found that oak stands were more dominated by conifers, but the oak stands retained unique bird communities. Some species found in these stands were uncommon or absent from closed-canopy conifer stands that were sampled in other studies. The authors found 12 species not detected by Anderson, which Hagar and Stern attributed to greater tree density and conifer encroachment because these species are typically associated with conifer stands. Four of these 12 species (Swainson's thrush, Pacific-slope flycatcher, Stellar's jay, and winter wren) were particularly abundant. The authors noted that these species are typically the most common species in closed-canopy conifer forests. Similarly, species associated with more open habitats were absent or less abundant in Hagar and Stern's survey in the 1990s than Anderson's work in the 1960s. Similar to Anderson's studies, Hagar and Stern found a diverse bird assemblage, with a higher a proportion of Neotropical migrants than found in conifer forests.

The oak woodlands in the Hagar and Stern study had a broad range of conditions and ranged from 30-84% canopy cover, providing opportunities to evaluate how such variation affected patterns of bird abundance. In their stand-level comparison of vegetative characteristics with relative abundance of bird species, they reported a unique avian community with 12 species in oak woodlands that were not typically found in closed-canopy conifer stands. The authors hypothesized that that these 12 species were likely to be negatively affected by replacement of oak woodlands by conifers. Based on their correlations of habitat and relative bird abundance, the authors suggested that large diameter trees are important for some species. Because of the dependency of the white-breasted nuthatch on oak woodlands and association with large-diameter trees for cavities, they concluded that this species is the most sensitive to loss of semi-open oak woodlands. The authors point out that the landscapes surrounding the stands they sampled varied greatly and likely affected their results.

Management Implications:

There are three key management implications from this work. The primary implication from this study is the confirmation of the unique avifauna in oak woodlands. The study also provides a description of habitat-relationships of birds in oak woodlands in the Willamette Valley. Another important management implication from the study is the evidence of the importance of large-diameter Oregon white oaks in open woodlands, providing support for management efforts to retain and restore stand structure that allows these large trees to persist.

Johnson and Rosenberg 2006: Granary-site selection by acorn woodpeckers in the Willamette Valley, Oregon. Northwest Science 80:177-183.

Objective: The primary goal was to identify habitat characteristics of trees and the surrounding area that are associated with their use as granaries by acorn woodpeckers in the mid-Willamette Valley.

Approach:
The authors used the typical comparative approach whereby a suite of biotic and abiotic characteristics are measured at and near the focal tree and compared to a randomly selected set of potential granary sites. They used a paired sampling approach at 20 granary sites in Benton County. They defined the granary site as a 12-m radius surrounding the granary and random tree. The 20 granary sites were characteristic of those with acorn woodpecker colonies in the urban-rural interface of Benton County. Sites were open oak woodland or small oak groves, and were often near pasture and grass seed fields.

Results:
Granary sites consistently had greater basal area of Oregon white oak and shorter shrub height than non-granary sites. Oak basal area was almost twice as great at granary than at non-granary plots. Granary trees had larger diameters than non-granary trees. The difference was greatest when compared within a site, suggesting acorn woodpeckers selected for the largest diameter trees rather than a particular size. The authors suggested that the selection for large trees to store acorns, and the large oak basal area surrounding these trees, was a result of selecting granaries in areas of high acorn production.

Management Implications:
The authors' results confirm earlier reports of the importance of large diameter Oregon white oaks within open woodland for acorn woodpeckers. The higher basal area surrounding granaries than non-granary sites together with the open-structured habitat selection, suggests there is a threshold value of the size distribution of oaks that retains the open woodland structure and maximizes acorn production. This study supports the management approach of thinning dense stands to create larger diameter and more productive masting trees. The results of this study can be used as a guide to density management of oak stands for acorn woodpeckers.

Keyser et al. 2004: Life-history variation and demography in western bluebirds (*Sialia mexicana*) in Oregon. Auk 121:118-133.

Objectives:
The objective of this study was to estimate age- and year-specific survival rates for a large population of western bluebirds in residential and rural landscapes in the northern Willamette Valley.

Approach:
The study took advantage of over 1900 nest boxes that have been installed beginning in the 1970s in the northern portion of the Willamette Valley. Volunteers regularly checked nest boxes. Birds were captured and banded. Mark-recapture analyses were used to estimate age- and year-specific survival rates. The study included capture and reproductive data over a 7-year period, from 1995-2001.

Results:
The citizen-science effort, coupled with assistance from wildlife biologists, to monitor nest boxes and capture and mark individuals resulted in one of the largest mark-recapture datasets for passerine birds. The data set included approximately 8,000 marked birds. The authors report age- and year-specific survival and reproductive rates. The predominate patterns were the following: (1) survival rates of adult males (63%) was considerably higher than for adult females (48%), (2) the effect of annual variation in survival was much greater than age effects, particularly for adult females, (3) annual variation in productivity was high, and (4) productivity of females increased with age due largely to increased number of nesting attempts rather than clutch size. These patterns resulted in annual variability being an important driver of the birds' population dynamics. Estimates of population growth rates suggested the population was relatively stable or slightly increasing. Because of the extensive area covered by the nest boxes that were monitored, the authors suggest juvenile survival rates were estimated with apparently little bias because of low emigration from the study area.

Management Implications:
This study demonstrates the large reliance of western bluebirds in the northern Willamette Valley on nest boxes. However, given the estimates of unmarked bluebirds each year, there are clearly a large number of individuals that are nesting in other than the project's nest boxes. Further, the study demonstrates a healthy population of western bluebirds that is apparently either relatively stable or slightly increasing. Finally, the study demonstrates that bluebirds are well adapted to urban and agricultural environments in the Willamette Valley given that nest boxes are available. Because of their adaptability in this environment, western bluebird populations are likely more secure than birds sensitive to urban expansion and agricultural development.

Moore 2008a: Inventory of streaked horned lark (*Eremophila alpestris strigata*) populations on federal, state, and municipal lands in Oregon's Willamette Valley. Unpublished report submitted to U.S. Fish and Wildlife Service.

Objectives:
The objective of this study was to describe the distribution and abundance of streaked horned larks (STHL) on primarily public lands throughout the Willamette Valley and to qualitatively evaluate habitat relationships.

Approach:
The author conducted a survey to identify distribution and abundance of STHL on public lands and municipal areas such as airports and industrial parks within the Willamette Valley during 2006-2008. All areas considered potentially suitable for use by STHL were surveyed by observers searching along transects. Habitat structure was evaluated at each site in which surveys for STHL were conducted. Based on the author's findings from bird and vegetation surveys, areas were scored based upon their ability to contribute to a viable population within the Valley.

Results:
Although STHL do not appear sensitive to plant species composition, vegetative structure is important as is at least some area of bare ground. A mix of bare ground and annual vegetation is selected although larger areas of bare ground will be used by STHL.
The author found that agricultural fields that have sparse grass or fields with a mix of grasses, forbs, and bare ground were most frequently used by STHL.

Management Implications:
This study updates previous understanding of the distribution of the STHL and demonstrates the variability of abundance, with many areas of sparse populations and several areas with large number of individuals. Although density estimates were not reported, they were clearly highly variable. Using a qualitative and subjective assessment, the author ranked areas for their importance to STHL conservation and provided suggestions for site management.

Moore 2008b: Winter diet of streaked horned larks in Oregon. Unpublished Report submitted to U.S. Fish and Wildlife Service.

Objectives:
The objective of this study was to describe the winter diet of STHL in the Willamette Valley.

Approach:
STHL diet was characterized by sampling all accessible habitat parcels in which the author previously found wintering larks in the Willamette Valley. Fecal and soil samples were collected in areas where STHL were observed foraging. Seeds from soil samples were identified to species when possible, and crossed-referenced with fecal samples to document it as a food plant.

Results:
STHL were rarely observed feeding on plants. Based on fecal samples, STHL foraged on very few plant species at a given site, although it is unknown if this was due to lack of diversity of available plant species or from STHL selecting few species at a site. That the dominant seed found in soil samples was almost invariably the species dominant in fecal pellets suggest STHL are foraging on the most abundant seeds and selected seeds in proportion to their availability.

Management Implications:
The results of this study, together with diet studies on horned larks elsewhere, suggests that the diet of STHL will track availability of resources for many grass and forb species. These results suggest that species composition of the fields for food resources may not be as important as selection for sparse vegetative cover given the presence of at least one of these food plants. Because plant species which provide food are often the most abundant senescent plants in a given patch of sparse weedy field, there's good probability of one of them being present in a field of proper structure.

Robinson and Moore, unpubl. ms: Ecology and distribution of streaked horned larks during winter informs their conservation and management.

Objectives:
The primary objectives were to identify STHL winter range, describe their habitat associations during the winter, and estimate population size. Secondary objectives included describing the sub-specific composition of flocks during the winter and estimating site fidelity from one year to the next.

Approach:
The authors conducted surveys in the Rogue, Columbia, and Willamette river valleys and in some coastal areas of Oregon during two winters (2003-04 and 2004-05). The authors surveyed randomly selected study areas using several methods depending on the year. They also conducted surveys in areas outside of the randomly selected areas but that appeared to have suitable habitat. Searches in the Oregon coast were restricted to sites where museum records indicated occupancy in the past. Subspecies composition was evaluated opportunistically, when conditions were most favorable for identification of individuals. Minimum number of STHL at the time of the surveys was determined in the Willamette River and Columbia River valleys by the number observed at point count stations. The authors characterized habitat at each count station in the randomly selected areas. Finally, to estimate site fidelity, sites were revisited ≥ 3 times at all sites where STHL were observed the previous year.

Results:
The largest flocks (<200 individuals) were found in agricultural fields in the Willamette Basin and the Columbia River Valley. Most STHL observed were seen in large flocks and in fields with sparse vegetation and extensive bare ground, but were rarely detected in recently tilled fields. They were detected in sandy dredge spoil, as long as the vegetation was sparse. STHL were not observed in coastal areas nor in the Rogue Valley. Approximately 90% of the Horned Larks observed during winter were STHL. The authors note that point count methods were inefficient for sampling STHL. The authors report low site fidelity in agricultural areas. However, in the Columbia River islands, composed largely of dredge spoil, had sparse vegetation in both years of the study. Vegetation was largely unchanged from year to year, factors which they believed contributed to greater reuse of sites. The authors concluded that they were unable to

estimate abundance but they conservatively estimated 453 STHL based on the number of individuals counted.

Management Implications:
One of the most important implications of the author's work is the documentation that STHL wintered throughout the Willamette and Lower (below Government. Island) Columbia valleys. The authors suggested that management for suitable winter habitats can be easily achieved in the farmed landscape where wintering occurs. They also suggest that the low site fidelity, combined with high mobility that allows STHL to identify ephemeral habitats over a large area, provides conservation opportunities by allowing newly created habitat to be occupied. Winter habitat is often created by timing and location of farming activities, including fallowing fields.

Viste-Sparkman 2005: White-breasted nuthatch density and nesting ecology in oak woodlands of the Willamette Valley, Oregon. M.S. Thesis, Oregon State University, Corvallis.

Objective:
The primary objective of this study was to relate nuthatch density and nest success to habitat characteristics at multiple spatial scales.

Approach:
The author of this comprehensive study used a multiple spatial-scale approach to understand factors that are associated with density of nuthatches and their nest success. The author identified a suite of landscape, stand, and nest tree characteristics that were associated with nuthatch density, nest tree selection, and nest success. The study was conducted within the mid-Willamette Valley during 2003 and 2004, and included woodlands varying from 0.2 – 344 ha, which they classified into three stand types (small woodlands, interior of woodlands, and edges of woodlands). Structural components of the vegetation were measured at multiple spatial scales including (1) woodland stand or grove as estimated from 0.04 ha plots surrounding point-count stations, (2) nest sites (0.04 ha surrounding nests), (3) home range (10 ha), and (4) landscape (within 1-km radius of nest and point transects). Nuthatch densities were estimated at a total of 34 oak woodlands or groves using point transect surveys and distance-based estimation methods.

Results:
A total of 85 nuthatches were detected during the point transect sampling in the 34 oak stands or groves in 2004, and 77 nests were located during the two years. Density estimates were pooled over all stands or patches, resulting in an estimate of 0.14 nuthatches/ha (7.1 ha per nuthatch). Average densities were greatest in small (≤11 ha) groves (0.27 nuthatch/ha), followed by edges of large woodlots (defined as any opening in tree canopy with a minimum diameter of 50m and were thus areas of open grown oaks; 0.12 nuthatches/ha), and lowest in the interior of large woodlots (0.03 nuthatches/ha). Nuthatches were not observed in woodlots <4 ha. Densities increased with increasing

oak cover within 1 km radius, greater edge density within home range scale (10 ha), and density of large (>50 cm dbh) oak trees within 100 m. .

Management Implications:
This study revealed many associations between nuthatches, surround landscape pattern, and vegetation structure surrounding nest sites, all of which provides guidelines for planning oak woodland and savanna conservation strategies that can maintain or improve conditions for nuthatches. Although the study was conducted in woodlands of varying canopy cover, the implications are that open oak woodlands and savanna vegetation structure will favor nuthatches, particularly those areas with large and open-grown oaks and in landscapes with scattered small woodlands.

Mammalian Studies

Weston, S. E. 2005: The distribution of the western gray squirrel (*Sciurus griseus*) and the introduced eastern fox squirrel (*S. niger*) and eastern gray squirrel (*S. carolinensis*) in the north Willamette Valley. MS Thesis, Portland State University, Portland, OR.

Objectives:
The primary objectives were to describe the distribution of western gray squirrels and evaluate the extent to which western gray squirrels occupy sites where they were found in the recent past in the northern portion of the Willamette Valley. A secondary objective was to describe the distribution of non-native squirrels (eastern gray and eastern fox squirrels) in the same region.

Approach:
Surveys were conducted at 65 study sites to detect western gray squirrels and two non-native species, eastern fox squirrel and eastern gray squirrel. Study sites were selected at locations where western gray squirrels were reported currently or historically. Study areas were primarily in Clackamas, Washington, and Yamhill counties. Several approaches were used to locate study areas. First, the author located Douglas-fir/Oregon white oak forest and woodland habitat type as designated by existing habitat maps. Surveys for western gray squirrels were conducted in areas that matched the vegetation type by subjective evaluation. Another approach utilized historical records of western gray squirrel locations. In addition, sites where squirrels were observed by the public or records of sites where squirrels were brought into wildlife rehabilitation centers were included in the set of sites that were surveyed for western gray squirrels. Surveys for squirrels involved repeated visits to the site visually searching for squirrels and listening for auditory signals.

Results:
Western gray squirrels were found at 23 (35%) of the 65 sites, eastern fox squirrels were found at 24 sites, and eastern gray squirrels were observed at one site. A total of 31 western gray squirrels were observed. However, 9 of these were detected when the squirrels were along or crossing a road, suggesting detection may have otherwise been

low within the forested habitat. Western gray and eastern fox squirrels were found together at only 5 sites, but detection and sampling issues (as noted by the author) likely underestimated their co-occurrence. Western gray squirrels were detected in 5 of the 12 historical sites where museum specimens were collected. The author suggested that eastern gray squirrels are found in her general study area only in the Portland metropolitan area.

Management Implications:
The primary implication of this research is the observation that abundance of western gray squirrels may be low in the northern portion of the Willamette Valley. The author noted that western gray squirrels, despite being listed as a sensitive species by Oregon Department of Fish and Wildlife and state-listed as threatened in Washington, is considered a game animal in Oregon and is hunted in the Willamette Valley. A second important management implication of this work is the documentation of the co-occurrence of western gray squirrels and eastern fox squirrels. The author speculated that eastern fox squirrels are expanding their range in the northern Willamette Valley, potentially compromising the distribution of western gray squirrels.

Frank et al. 2006: Mammal mycophagy and dispersal of mycorrhizal inoculum in Oregon white oak woodlands. Northwest Science 80:264-273.

Objectives:
Recognizing that mycorrhizas are essential for regeneration of oak ecosystems, and that many mycorrhizal species associated with Oregon white oak are hypogeous fungi (sporocarps below ground), the authors tested the hypothesis that small mammals disperse fungal inoculum in Oregon white oak ecosystems. A secondary objective was to describe the mycorrhizal species associated with Oregon white oaks.

Approach:
The authors collected sporocarps in an Oregon white oak savanna in southern Oregon. Specimens were collected weekly during April-November 2003 and March-August 2004. Mycorrhizal oak roots were collected from soil samples under sapling and mature Oregon white oak trees. Small mammals were live-trapped under or adjacent to Oregon white oak in the same areas where sporocarps were collected. Fecal pellets were obtained from captured individuals to identify fungal species and their relative abundance in the diet of the small mammals.

Results:
Twenty-one species of sporocarps were collected and 3 mammal species (California voles [*Microtus californicus*], deer mice [*Peromyscus maniculatus*], and harvest mice [*Reithrodontomys megalotis*]) were captured. The fungal communities the authors found in their Oregon white oak study sites differed from conifer forests. Several of these species also occur in conifer forests, but some species were unique to oaks. A total of 12 species of hypogeous fungi were detected in the small mammal pellets, with variation on the species assemblage of fungi collected from each mammal species. The roots of

Oregon white oak saplings were all mycorrhizal, and hypogeous fungi were found on roots from saplings up to 72 m from mature Oregon white oak trees. Saplings farther from mature oaks had mycorrhizas of only epigeous species. The results demonstrate the mutualism of Oregon white oak, fungi, and small mammals.

Management Implications:
This research demonstrates the importance of mycorrhizal associations and dispersal of mycorrhizal inoculum by small mammals for restoration of Oregon white oak ecosystems. The research findings suggest that small mammals improve the regeneration of Oregon white oak. The authors noted that the finding of the inclusion of hypogeous fungi in the mycorrhizal community of saplings distant from mature oaks, and the presence of spores in fecal pellets, suggests small mammals may be important sources of inoculum. Because inoculum is likely essential for regeneration of oaks, small mammal fecal pellets may be useful to obtain an inoculum for reestablishment of oaks.

Reptile and Amphibian Studies

Hoyer 1974: Description of a rubber boa (*Charina bottae*) population from western Oregon.

Objectives:
The primary objective was to describe characteristics of a population of rubber boas from the Willamette Valley.

Approach:
To fill an information gap on detailed description of a rubber boas, and to precisely describe populations within the Willamette Valley, the author captured 338 rubber boas throughout the Willamette Valley, but primarily in Marion and Benton counties, from 1968-1973. Descriptive characteristics measured included gender, mass, and length (total and tail length), head and body scutation, and coloration. Most individuals were released, but some were prepared for museum collection.

Results:
The large sample allowed the author to precisely describe morphological characteristics of rubber boas in the Willamette Valley. In addition to morphological description, the author commented on habitat associations. The author found the species in a broader array of habitats than in previous studies. He found rubber boas in “most habitats except where regular grazing and cultivation is practiced or large areas that undergo periodic flooding” (Hoyer 1974:281), including vacant city lots, grassy fields, and highway and railroad right-of-ways.

Management Implications:
Probably the most significant management implication from this study is in the number of rubber boas the author found and in the broad array of habitats in which he found them common, including degraded areas such as city lots and adjacent to industrial plants. The author suggests the species is fairly common, but difficult to detect.

Hoyer 2001: Discovery of a probable new species in the genus *Contia.* Northwestern Naturalist 82:116–122.

Objectives:
The objective of this study was to provide data for later evaluation in the consideration of a second species of *Contia* in the currently recognized range of *Contia tenuis*, the sharp-tailed snake.

Approach:
The author searched grasslands and coniferous forests with an open canopy in 6 Oregon counties, including the Willamette Valley, and searched in areas near Mendocino, California, the site of the suspected new species of *Contia* that the author previously discovered. Searches were conducted from 170 – 1450 m (reported incorrectly as "km" in the publication). In addition to searches in the field during 1998-1999, the author used museum specimens as well. Measurements made to compare and describe the new form included mass, length (total and tail length), dorsal and caudal scale counts, and recorded head scale configuration and coloration. The author also noted differences in habitat associations.

Results:
The author captured 539 *Contia tenuis* from Oregon and found most individuals in oak-savanna in the Willamette and Rogue valleys. In addition, the author captured 7 individuals of what he considered the new form of *Contia*, 2 in Douglas County and 5 in Medocino County, Ca. The author found the greatest morphological difference between the two forms was the tail length relative to the body length. The new form, which he tentatively called "forest sharp-tailed snake", had a longer relative tail length than the "common sharp-tailed" snake, the proposed name for the previously named form of *Contia tenuis*. The author provides further morphological comparisons between the two forms. In addition, the author suggests the new form of *Contia* is associated with coniferous forest habitat rather than the more open habitat of *Contia tenuis*. Finally, the author cites preliminary genetic studies that are consistent with the hypothesis that the new form of *Contia* represents a distinct species. The author concludes that the status of the new form as a distinct species is tentative, awaiting further research.

Management Implications:
The primary implication of this study is the identification of a potentially distinct species that would split what was considered a single species, *Contia tenuis*, into two species. This could have management ramifications for future conservation planning. This study also demonstrates that sharp-tailed snakes can be quite abundant.

Hoyer et al. 2006: Current distribution and status of sharp-tailed snakes (*Contia tenuis*) in Oregon. Northwest Naturalist 87:195-202.

Objectives:
The primary objective was to re-evaluate the distribution and status of sharp-tailed snakes in Oregon, under the hypothesis that the species is more wide-spread and less vulnerable than previously believed. A secondary objective was to identify possible distributional differences between *C. tenuis* and a purported undescribed species of *Contia*.

Approach:
The authors approached the reevaluation of the distribution of *Contia* in Oregon by first compiling location records and then conducting a field investigation to search for the species in suitable habitats. The authors also conducted field surveys of historic locations. During field surveys, snakes were captured and morphological measurements were made to later separate two potential species of *Contia* in Oregon. Field work was conducted from March to December 1998. Searches were made in grassland or edge of grassland and either brush or forested habitat.

Results:
Through their efforts to compile previous records and obtain previously unreported observations, the authors identified 625 unique observations at 282 different locations. Of these, only 12 new records came from field surveys. Through mapping these new locations, mostly unverified, the range was extended in Oregon from that last reported. *Contia's* range in Oregon includes most of the Willamette Valley, the northern-southern extent of western Oregon, and east of the Cascades in northern Oregon. Sixteen of 59 historical records were included in the locale reports and sharp-tailed snakes occupied all of these sites. Most of the sites that were reevaluated in the Willamette Valley (13 of 17) were occupied by the sharp-tailed snake, demonstrating persistence for over 20 years at these selected sites.

The proposed new species of *Contia* has a distribution largely sympatric with *C. tenuis* in parts of southwest Oregon, but they are believed to occupy different habitats and to differ in their altitudinal distributions.

Management Implications:
The management implications of this work was largely in providing empirical evidence that that sharp-tailed snakes are not as vulnerable as previously discussed in earlier assessments. The authors consider the evidence for a declining population to be weak, and suggest that the reason for the earlier concern was due to very low detectability and

minimal effort to find the snake throughout its range in Oregon, including the Willamette Valley where it was described as “rare and declining” in statewide assessment documents.

Rombough, C. 2008: Herpetofauna of the Coburg Ridge Preserve. Unpublished report to The Nature Conservancy.

Objectives:
The objective of the study was to identify reptile and amphibian species inhabiting the recently established Coburg Ridge Preserve.

Approach:
Through intensive field searches and various sampling methods, reptiles and amphibians were located throughout the Preserve. Direct searching, using visual encounter surveys by searching likely habitat, was the primary method used. Searches were conducted from May – October 2008.

Results:
A total of 13 species of amphibians (4) and reptiles (9) were found within the Preserve. The report provides details of encounters. A western rattlesnake was observed in the rock quarry on the preserve and represents one of the few recent sightings of this species in the Willamette Valley (see Chapter 6, *Species Accounts*).

Management Implications:
This study serves as an initial investigation into the occurrence of amphibians and reptiles on the Preserve and may facilitate future investigations. The occurrence of the western rattlesnake provides further justification for considering special management to increase populations of this presumably once more widespread species in the Valley.

Vesely et al. 1999: Survey of Willamette Valley oak woodland herptofauna 1997-1998. Unpublished report, Pacific Wildlife Research, Inc. Submitted to Oregon Department of Fish and Wildlife.

Objectives:
The primary objective of the study was to identify habitat relationships of reptiles and amphibians in Willamette Valley oak woodlands.

Approach:
The authors selected 10 sites within Yamhill, Polk, Benton, and Lane county that represented a broad range of tree diameter distributions and management histories, were dominated (>50% of basal area) by Oregon white oak or California black oak, and ≥ 25 acres in size. Visual searches, pitfall traps, and cover boards were used to count occurrences of reptiles and amphibians in a set of sample points within each stand. Habitat characteristics were sampled from a set of randomly selected locations. In

addition, landscape characteristics were estimated from cover-type maps within 1-km of the pitfall arrays. Animal occurrence at sample points was compared to vegetative characteristics.

Results:
Habitat characteristics, including stand shape and edge characteristics and landscapes surrounding each stand, varied considerably among the 10 oak woodlands. Seven species of amphibians and 8 species of reptiles were observed at the study sites. Most species were observed at only a few sites; only rough-skinned newts and Pacific tree frogs were detected at > 50% of the stands. Only western fence lizards and rough-skinned newts were observed frequently enough to meet the authors' sample size criteria for species-specific analyses. Other species were pooled for group analyses. Analyses confirmed generally-held understandings of habitat selection. Amphibians were positively related to availability of open water. Reptiles were negatively correlated with canopy cover, being found more frequently in open areas. At the landscape scale, amphibian and reptile occurrence was positively correlated with the area covered by riparian and/or open water habitat, which the authors attributed to the aquatic needs of amphibians and the reptiles' use of clearings often adjacent to open water.

Management Implications:
The primary implication of the work is further recognition of the value of open-structured forest communities for reptiles. Although there are no known species of amphibians and reptiles that occupy only oak woodlands in the Willamette Valley, this study demonstrated the association of reptiles with open-canopy oak woodlands. This study also demonstrated the importance of specific habitat elements for amphibians within oak woodlands in the Willamette Valley.

Invertebrates

Moldenke, A. 2009: Report on Pollination Studies at Coburg Ridge/Mt Baldy. Unpublished report submitted to The Nature Conservancy.

Objectives:
Inventory pollination systems of flora at Coburg Ridge Preserve, with particular attention to native bee pollinators.

Approach:
Searched for plants and their pollinators from mid-May through August 2008 and described plants and pollinators observed at the Preserve.

Results:
A total of 147 species were observed including 75 species of bees. Details of observations and species interactions are provided in the report.

Management Implications:
This study provided a partial inventory of pollinators at the recently established Coburg Ridge Preserve.

Ross. D. 2009: Moths of Coburg Ridge TNC Preserve. Unpublished report to The Nature Conservancy.

Objectives:
The primary objective was to provide a partial inventory of moths in the recently established Coburg Ridge Preserve.

Approach:
The author sampled moths from trap sites at three habitat types at Coburg Ridge Preserve (upland prairie, oak woodland and Douglas-fir forest) from March to October 2008. Moths were sampled with ultra-violet light bucket traps. Moths were brought to the lab for identification and to serve as voucher specimens.

Results:
A total of 253 species were trapped, including 17 considered as regionally rare or of management concern. Over 100 species were represented in the sample by single individuals.

Management Implications:
This study represents one of the few attempts to inventory moth species within oak habitats and upland prairies in the Willamette Valley. The annotated list of species may help managers consider species for special consideration at the Preserve and highlight the diversity of moths, a taxon that presents challenges in species identification. This study represents an initial exploration into the diversity and habitat associations of moths in oak and prairie habitats.

Schultz 1998: Dispersal behavior and its implications for reserve design in a rare Oregon butterfly. Conservation Biology 12:284-292.

Objectives:
The stated objective of the study was to compare the efficacy of corridors versus a "stepping stone" reserve design for Fender's blue butterfly. The study itself addresses movement patterns of butterflies in lupine patches as well as those translocated outside of lupine patches into neighboring fallow fields. The field study does not, however, estimate actual dispersal distances but investigates short distance flight patterns that allowed speculation on long-distance dispersal patterns.

Approach:
The approach the author used to evaluate dispersal of Fender's blue butterfly included field investigations of short distance flight patterns and estimates of adult survival to estimate long distance movements using a correlated random walk model. Movements of Fender's blue butterfly were estimated within patches of Kincaid's lupine and in neighboring fallow agricultural fields located within 200 m of lupine patches. To estimate movements outside of lupine patches, the author translocated Fender's blue butterflies from lupine patches to the fallow field. Similar capture and release methods were used inside of the lupine patches for comparison. Movement patterns were estimated by following individual butterflies and marking their location at least every 20 seconds over <3.5 minutes.

Results:
Observations of Fender's blue butterflies demonstrated greater movement outside of lupine patches, a bias of movement towards lupine patches, and approximately 2.3 hours flight time per day. Although their was directional movement towards lupine, approximately 5% of movements were outside of lupine patches for those that originated in such patches, demonstrating ability to "stray" from patches of their host plant. Using a correlated walk model, the author estimated diffusion rates, and estimated that Fender's blue butterflies potentially could disperse 0.75 km and 2.0 km during its lifetime in lupine and non-lupine habitat, respectively.

Management Implications:
The primary management implication from this work is in reserve design; specifically how far apart habitat patches can be and still allow dispersal between them. The study provides a model-based estimate of lifetime dispersal distances. From this study, dispersal distance of Fender's blue butterfly has been described as 2 km. Despite acceptance of 2 km as a dispersal distance for Fender's blue butterfly, long-distance dispersal has not been empirically estimated. Rather, only data on short-distance movements over a very brief time (<3.5 minutes) were collected. The correlated random walk model used in this study has many assumptions that clearly do not allow confidence in the authors' estimates of long-distance dispersal. Such models are useful as heuristic tools to develop hypotheses on movement, but the use of short-distance movements to make conclusions on long-distance dispersal events may lead to misguided management decisions. The author makes it clear that many assumptions are inherent in the model, but later citations of this work, and the general acceptance of these estimates for dispersal distances of this species, ignore the origin of the dispersal estimates.

Schultz and Crone 2001: Edge-mediated dispersal behavior in a prairie butterfly. Ecology 82: 1879-1892.

Objectives:
The primary objectives of the study were to evaluate the response of Fender's blue butterfly to patch boundaries and the effect of these movements on residence times of the butterflies in habitat patches of different sizes.

Approach:
This study used field data collected at the same study site and using the same methods as in Schultz (1998), but extends the modeling work using correlated random walks. Field data were collected on short-distance movement patterns in three landscape categories that facilitated simulating movements (patches of the butterflies' host plant, Kincaid's lupine; habitat outside of patches, and edge habitat as defined by butterfly behavior). Three dispersal models were used to simulate movement and estimate residence time in habitat patches. Results from the computer simulations were compared to field data for residence times; field data did not exist for the other parameters explored with the simulation models. Width of habitat edges were defined as the zone outside of habitat patches at which Fender's blue butterflies modified flight paths. Habitat edge width was estimated from behavioral observations.

Results:
Because butterflies were not marked, the number of different individuals was unknown, but field work resulted in mapping 156 flight paths. Based on behavioral data, edge width varied from 10-22 m. Patterns of movement behavior allowed the authors to simulate larger-scale movement patterns. Simulation models were sensitive to edge behavior. Both edge behavior and variation in movement patterns in the different landscape categories were important factors in model predictions. Predictions of residence times were grossly negatively biased based on comparisons to field-based estimates except for females under a model that allowed for edge-mediated residence times. The difference in predicted and observed behavior motivated the authors to note that "…making assumptions about dispersal that are not grounded in data and using these assumptions to predict effects of fragmentation is potentially dangerous …" (p 1890).

Management Implications:
The primary management implications of this study are two fold. First, estimates of edge width provide insight into how Fender's blue butterfly might be affected by different sizes of habitat patches. Second, the development of the simulation models provided a useful heuristic tool for evaluating different management options. It is important to note, however, the limitations of using the diffusion models to provide realistic estimates of movement patterns. The authors highlight this important limitation of using short-distance movement studies to predict larger-scale events without complementary, even if limited, long-distance dispersal observations.

Schultz and Dlugosch 1999: Effects of declining food resources on populations of the Fender's blue butterfly (*Icaricia icarioides fenderi*). Oecologia 119: 231-238.

Objectives:
The objective of this study was to evaluate the relationship between resource availability and density of Fender's blue butterflies, and ask whether food resources limited the population size of the butterfly.

Approach:
The authors used a comparative approach in assessing correlations between abundance of a suite of metrics of food resources and density of Fender's blue butterfly. To evaluate if resources were limiting population size, the authors assumed that resources that were correlated with density of Fender's blue butterfly were limiting. They incorporated four study sites that were known to represent a broad array of densities of Fender's blue butterfly. Although 60 grids of approximately 12 x 12 m were used to sample resources and butterflies, comparisons were made at the scale of the four independent study areas. The authors sampled what they defined as "coarse resources" and "detailed resources", the former including percent cover of lupine host plants and density of nectar flowers, and the later including density of host plant leaves and quantity of nectar. Based on correlations of the four butterfly populations and the food resources, the authors identify which relationships were the strongest and hence those most useful for future assessments of Fender's blue butterfly habitat suitability.

Results:
As expected, density varied tremendously among the four study areas (36, 44, 96, and 690 Fender's blue butterflies/ha). The Willow Creek study site had almost a 10-fold greater density of Fender's blue than the other sites, which clearly influenced the results of the correlation analysis, especially given there were only four study sites. Ignoring the sensitivity of the results to the Willow Creek study area and the small number of study areas, the authors report that the coarse resources (percent cover of host plants and density of nectar flowers) were not correlated whereas the detailed resources were strongly correlated. Importantly, the study also described the relative use of different species of native and non-native plants as nectar sources. The authors found strong selection of native plants, and provide a detailed assessment of their use.

Management Implications:
Based on the results of the correlation analysis, the authors conclude that assessing habitat for FBB will require measuring density of host plant leaves and quantity of nectar, rather than the more rapidly estimated quantities of percent host plant cover and flower abundance. The authors further suggest that the results indicate that Fender's blue butterfly populations can be increased by increasing abundance of host and nectar plants. Although the primary management implication regarding restoration is supported by numerous studies, the nature of the correlation analysis – a sample size of only four study areas and the much greater density of Fender's blue at one of the four sites - requires caution in interpreting the results, and management implications, of this study.

Schultz and Crone 1998: Burning prairie to restore butterfly habitat: a modeling approach to management tradeoffs for the Fender's blue. Restoration Ecology 6:244-252

Objectives:
The primary objective was to link empirical data with a simulation model to explore and rank prescribed fire strategies to control encroaching shrubs at a Fender's blue butterfly population.

Approach:
The authors incorporated existing data on shrub and butterfly response to rank prescribed fire strategies for managing upland prairies. Recognizing that fire helps maintain and restore Fender's blue butterfly habitat but kills their larvae, the authors used a novel modeling approach to evaluate two important aspects of prescribed fire: proportion of habitat to burn, and the time interval between burns. The simulation models were parameterized with field data collected by other researchers during burns in 1994 and 1996, with response data collected during 1995-1997. The authors explored combinations of proportion of habitat burned (1/8, 1/4, 1/3, and 1/2 of habitat) and time between burns (1-5 years). Importantly, the authors conducted an uncertainty analysis that allowed an evaluation of how the effect of a change in the value of each parameter (e.g., survival rate of Fender's blue butterfly) affected ranking of strategies. This directly allowed for evaluating how further research that provided more reliable estimates would improve the ability to predict the ranking of each management strategy. Through this modeling approach, the authors were able to (1) gain insight into the potential implications of the results from the field experiments that would otherwise be difficult to elucidate, and (2) direct future research that would be most likely to inform burn strategies.

Results:
Predictions from the models suggested that burning 1/3 of the habitat every year maximized the population growth rate of Fender's blue butterfly. Comparison of model results suggested that 8 of 21 burn scenarios met the authors' criteria that 95% of the simulated populations persisted 100 years. However, when the lowest values of the vital rates from the 90% confidence interval were used in the simulation, the outlook was bleak with few cases of persistence for 100 years. The uncertainty analysis suggested that the rank of strategies is most sensitive to rates of habitat change following a burn but not sensitive to demographic rates. This result suggested that although estimates of actual population growth rates of Fender's blue butterflies may be improved, the ranking of burn strategies would be insensitive to improved knowledge on vital rates whereas greater understanding of how habitats responded to burn strategies would substantially impact the ranking of burn strategies.

Management Implications:
Perhaps the most important management implications of this work is in demonstrating how linking results of management experiments with models can facilitate decision making for land managers. Equally important is the demonstration of identifying

research that is most likely to facilitate future decision making. Specifically, this study demonstrated an approach to identify which input variables (e.g., Fender's blue vital rates, response time of vegetation, etc.) are most useful to improve upon in terms of affecting management decision making. From this particular case study, the authors recommend burning on average 1/3 of the habitat each year, and to refine understanding of the response of habitat to prescribed fire. The authors also note that the uncertainty analyses identified how little is known about the persistence of Fender's blue butterflies under different management strategies. The work described here provides a useful approach for incorporating adaptive management to conservation of Fender's blue butterfly.

Schultz and Crone 2005: Patch size and connectivity thresholds for butterfly habitat restoration. Conservation Biology 19: 887-896.

Objectives:
The primary objective was to evaluate the efficacy of two modeling approaches to facilitate the selection of potential restoration sites for Fender's blue butterfly populations.

Approach:
The authors used a modeling approach, and compared the predictions from the models to what they considered a strategy based on conservation "rules of thumb". The authors used a real landscape near Eugene, Oregon and identified 146 potential sites for restoration of Fender's blue butterfly habitat. To develop and fit the models, the authors used a combination of field data on patch occupancy and demography of Fender's blue, and estimates of dispersal based on a model of short-distance movement patterns. Two model approaches were used: incidence function models (using occupancy data) and a spatially-explicit population dynamics model (using dispersal and demography estimates). The authors' "rule of thumb" selection criteria were (1) patches must be close enough that movement among patches occurs, and (2) patch size must be sufficient to sustain populations with only moderate immigration rates. The authors compared the "rule of thumb" selection with those from the two modeling approaches.

Results:
The authors conclude, based on their "rules of thumb" and the results of the two modeling approaches, that selection of patches for restoration should be <1km from existing occupied patches and ≥ 2 ha in size. Given the input values of the parameters, some based on field work (e.g., fecundity) and others extrapolated across scales (e.g., dispersal), it is not surprising that the model results are generally consistent with the authors' "rules of thumb" which were guided by the same parameters and values. Differences in the predictions of the two modeling approaches include a greater importance of connectivity of patches under the dispersal model and that both dispersal and patch size are important for long-term persistence under the incidence-function model. As expected, predicted occupancy decreased with isolation and increased in proportion to size. Perhaps most importantly, the model predicted that the size of

occupied neighboring patches did not influence the probability of occupancy in the patch under consideration. In the 146 potential sites for restoration, the estimated probability of occupancy under the incidence-function model increased with patch size but was only weakly associated with the authors' measure of isolation. With the dispersal/demography model, most patches were predicted to be occupied if within 1 km of occupied patches, but more distant patches were predicted to remain unoccupied over the 25 year simulation. The authors discuss how assumptions of each model result in the different predictions, and emphasize the differences of the models in terms of their time-scales for predictions.

Management Implications:
Perhaps the most important management aspect of this study is in developing and evaluating several tools for assessing potential sites for restoration given a large number of candidates and the limited number that can eventually be restored due to financial limitations. In this sense, the study provides useful tools for linking field data with management. Caution must be used, however, in interpreting the predictions of the model because of the many assumptions that are not well understood, including long-distance dispersal of Fender's blue butterflies which is treated here and elsewhere as if it were directly estimated but it was not.

Severns 2008: Exotic grass invasion impacts fitness of an endangered prairie butterfly, *Icaricia icarioides fenderi*. Journal of Insect Conservation 12:651-662.

Objectives:
The primary objective of this study was to test the hypothesis that tall oat grass reduced reproductive output of Fender's blue butterfly because of the plant's inflorescence that obscured the host plant for the butterfly.

Approach:
Similar to most of the studies on butterflies and habitat modification, the author used an experimental approach at two different spatial scales in several study areas near Eugene, OR during May and June 2004 and 2005. Four paired 1-m radius plots and a single area of approximately 22 x 17 m were used to test hypotheses of response to modification of vegetation structure and spatial scale. In the paired plots, one received the treatment which consisted of clipping the invasive tall oat grass to the same height as native bunchgrasses which are similar in height to Kincaid's lupine. The other plot in the pair served as the control. In the single larger plot, half of the plot received the clipping treatment and the other half served as the control. The author compared reproductive output (number of eggs laid/leaf), location of oviposition in relation to edge of plots, flight behavior including time spent in plots, and frequency of basking in the treated and control areas.

Results:
Relative use of treatment and control plots were consistent with the hypothesized effects of tall oat grass on the behavior of Fender's blue butterfly. Females oviposited more

frequently in the treated plots, resulting in an average of 2.5 times as many eggs/leaf than in control plots. Both males and females basked more frequently in the treated plots, and flew over control than untreated plots more frequently, suggesting avoidance behavior for control plots. Results were similar in the large plot that was divided in half with treatment and control areas, although the effect of reproduction was even greater, with up to 4 times the number of eggs in the treated than in the untreated area. Flight pattern in the large plots suggested Fender's blue butterfly recognized untreated edges; their behavior suggested a "reflective boundary" whereby untreated areas resulted in butterflies changing flight direction, turning back to treated areas. The large plot also received greater proportional use; comparison of behavior in small and large plots suggested the species "missed" smaller plots. The numbers of leaves on Kincaid's lupine, the larval host plants on which eggs are laid, were greater in treated areas, as anticipated given competition for growing space by tall oat grass. Both the greater number of eggs/leaf and the greater number of leaves/plant resulted in much greater density of eggs in treated plots.

Management Implications:
There are clear management implications from this experimental study which clearly established that height of the invasive tall oat grass, at least when a dominant component of the vegetation negatively affects Fender's blue butterflies. The author argues that other plant species whose vegetation affects the availability of Kincaid's lupine to Fender's blue butterfly may have similar affects. That Kincaid's lupine is present in an area does not demonstrate its suitability for Fender's blue butterfly; this study demonstrates that the vegetation structure of neighboring plants can affect the suitability of Kincaid's lupine (and the area in general) for Fender's blue butterfly and affects both colonization and emigration rates of the butterfly. Specifically, this study demonstrates the sensitivity of Fender's blue butterfly to areas with dominance by grasses that extend beyond the height of Kincaid's lupine. Although Kincaid's lupine may be present in an area, dominance by tall oat grass reduced the availability of lupine for the butterfly. Management practices that reduce cover of tall grasses and consider long-term affects to Fender's blue butterflies and their host plants will be beneficial, particularly at larger management units than very small plots.

Severns and Villegas 2005: Butterflies hanging on to existence in the Willamette Valley: a relict population of the Great Copper (*Lyacaena xanthoides* Boisduval). Northwest Science 79: 77-80.

Objectives:
The authors report on the finding of a population of great copper butterflies, a species that prior to this publication were considered extirpated in the Willamette Valley. A secondary objective was to describe habitat associations and life history traits based on the Willamette Valley population that was rediscovered.

Approach:
During a survey of butterflies in a wet prairie reserve near Eugene, Oregon, a population of great copper butterflies was discovered. This prompted a series of behavioral observations on habitat associations and flight period. Male and female voucher specimens were collected.

Results:
During July 2004, great copper butterflies were observed during surveys for other species. Voucher specimens (a male and a female) were collected and deposited at the Oregon State Arthropod collection at Oregon State University. Great copper butterflies were observed in wet prairie habitat in the west Eugene Wetlands complex. The authors estimated, without formal methods, a population of 25-100 adult great copper butterflies within the area surveyed. Based on behavioral observations, the authors observed Willamette Valley gumweed (*Grindelia integrifolia x nana*) were used by the great copper butterflies for nectaring and used willow dock (*Rumex salicifolious*) for oviposition. Numerous observations suggested that the great copper butterflies were indeed selecting these native plant species.

Management Implications:
The key management implications of this study are:
(1) great copper butterflies occur in the Willamette Valley in at least one population and likely others
(2) willow dock and Willamette Valley gumweed, native species to wet prairies in the Willamette Valley, are selected as larval host plants and nectar sources, respectively
(3) additional populations of this species can be more efficiently surveyed now that the habitat associations have been described
(4) based on timing of their life cycles, the authors suggest prescribed fires that are intended to enhance native plants in wet prairies may destroy host plants and their eggs

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York 2002: Relationship between plant and butterfly community composition on upland prairies of the Willamette Valley, Oregon. M.S. Thesis, Oregon State University, Corvallis.

Objectives:
The key objectives of this study were (1) to evaluate if butterfly community structure provided an indicator of the "integrity" (proportion native plant species) of upland prairie; (2) explore the relationship between communities of plants and butterflies, and (3) evaluate host plant and nectar source availability and their relative spatial distribution in relation to selection for host and nectar plants by four uncommon butterfly species.

Approach:
Patterns of abundance and species richness of plant and butterfly species was estimated on 17 prairie remnants that varied from large, highly degraded short-statured plant communities to small, largely native patches of upland prairie. Sampling took place within 40m x 50m macroplots, from June-August 2000, primarily in the central and

southern portion of the Willamette Valley. Characteristics measured included number of flowers and cover of each host and nectar plant species for each butterfly species, and the distance from host plants to the nearest nectar source and nearest host plant. Based on multivariable analyses, three classes of prairie integrity were defined.

To evaluate factors affecting butterfly selection of host and nectar plants, two prairies were selected for intensive study to evaluate factors affecting host and nectar plant selection. Four species of locally uncommon butterflies were selected for intensive observation: Fender's blue, Anise swallowtail, field crescent butterflies, and common-checkered skippers. Nectar and host plant species availability was estimated by quadrat counts during spring 2001. Estimate of spatial factors associated with resource use included distance between nectar sources and host plants, spatial randomness of nectaring and oviposition, and vegetation patterns that characterized used and unused areas.

Results:
The author found there was high variation in both plant and butterfly community structure. Within the macroplots, 15 butterfly species were detected. Eight of the 15 butterfly species detected were uncommon on Willamette Valley prairies and occurred only in small populations. Plant species richness was the most influential factor associated with butterfly species richness. The locally uncommon butterflies that were investigated had specific habitat requirements, which the author speculated contributed to their sparse distribution.

Each butterfly species used a limited number of nectar sources. For the uncommon species evaluated, nectar plant abundance did not differ between areas with and without observed use by these butterfly species. Butterfly species varied in the association of use of nectar plants and the proximity to host plants.

The author provides a detailed evaluation of nectar and host plant use by butterfly species observed at the 17 study sites.

Management Implications:
The results of this study emphasize two key management strategies. First, butterfly species richness was associated with prairie integrity—prairies with a large component of native forbs had the greatest number of butterfly species. Second, even small, degraded sites that really couldn't be called "prairie remnants" because of the near absence of native species, could serve as refuges for locally uncommon butterfly species. The author concluded that the lack of large prairies and the incidence of uncommon species on small and even degraded remnants make it imperative that even small areas be restored and protected. This study also provides guidelines for vegetation management by providing observations and quantification of plant and butterfly species associations.

Research Outside Willamette Valley

Cross 1969: Behavioral aspects of western gray squirrel ecology. Ph.D. Dissertation, University of Arizona, Tucson.

Objectives:
This broad study of the western gray squirrel investigated many aspects of the species ecology in an effort to gain an understanding of the life history of the species in mixed hardwood and conifer forests in southwestern Oregon, near ASTHLand.

Approach:
The author used a variety of techniques, including color-marking, radio tagging, collecting of individuals, and behavioral observations to characterize daily activity patterns, home range, diet, reproductive cycles, age-structure, and habitat use including characterization of dens. The study was largely a broad investigation into the species ecology using a qualitative approach. The study was conducted at two different sites with different vegetation structure and composition and squirrel densities. The study was conducted from Mary 1966-September 1968.

Results:
The mixed oak-conifer site ("Baldy") had a more continuous canopy than the oak dominated site ("Emigrant Lake"), and the former had approximately twice the density of western gray squirrels. Specific results include comparison of home range size between study areas, seasons and gender, and among individuals. Home range size varied considerably, but the majority of individuals had home ranges between 3-18 ha during the duration of the study. Squirrels in the less densely populated study area had greater home range size. Diet was examined from 59 stomachs. The author reported a greater use of hypogeous fungi than previously reported, with a dominance of fungi in the diet during the spring and early summer. Conifer nuts dominated the diet in the fall followed by acorn dominance during the winter. The author provides details on daily activity patterns, den site characteristics, and age-structure based on the individuals collected. The dissertation includes additional life-history details based on the author's behavioral observations.

Management Implications:
The primary importance of this study is the greater understanding of the ecology of this species in mixed hardwood-conifer forests in southwestern Oregon. The study may prove useful for comparisons of squirrel populations from the late 1960s to contemporary periods. The dominance of hypogeous fungi in the seasonal diet broadened the previous understanding of the foraging ecology of western gray squirrels, and provides even greater support for the importance of hypogeous fungi in northwest forests.

Cross and Simmons 1983: Bird populations of the mixed-hardwood forests near Roseburg, Oregon. Oregon Department of Fish and Wildlife Nongame Wildlife Program Technical Report #82-2-05

Objectives:
The primary goal was to evaluate the effects of conversion of mixed-hardwood forests to pasture on the bird community. The specific objective of the study was to estimate abundance and diversity of bird species within a representative sample of these habitat types in the Umpqua Valley.

Approach:
Birds were sampled by point counts within 6 forest and 4 pasture sites. The canopies of the forested sites were dominated by madrone, Oregon white oak, and California black oak. Comparison among sites was qualitative, emphasizing species differences among the ten study sites.

Results:
The study provided detailed description of species composition, relative abundance (based on counts), and estimates of density for species commonly encountered. The researchers found very high variation of counts among the sites in each of the habitat types, and not surprisingly found great differences in species composition between the two types. Using the estimated average differences in the abundance of species in the two types, and the estimated loss of mixed-hardwood forests in the region from 1967 to 1979, the authors estimated change in the avifauna community resulting from conversion of mixed-forest to pasture. The authors compared bird community composition and vegetation qualitatively, restricting their discussion to differences among sites.

Management Implications:
This study provides a detailed description of the bird community in a mixed-hardwood forest in southwestern Oregon that may allow comparisons in the future. The high variation in community composition among the study sites within each habitat type demonstrates the difficulty in predicting bird communities strictly from vegetation type. The predicted changes in the bird community when forests were converted to pastures provided an understanding on how development may affect bird communities in the region.

Manuwal 2003: Bird communities in oak woodlands of south-central Washington. Northwest Science 77:194-201.

Objectives:
The objectives of this study were to compare species composition and relative abundance of bird communities in oak woodland vegetation types and riparian vegetation in south-central Washington.

Approach:
Species richness, composition, and relative abundance were compared among 5 upland oak woodland and one riparian habitat type, all located within Klickitat County, south-central Washington. Oak stands were selected to represent the variability found in Klickitat County, which the authors report had the most extensive oak woodlands remaining in Washington. The five oak woodland types were: large ponderosa pine (hereafter "pine")– large oak, small pine – small oak, large Douglas-fir – large oak, primarily large oak, primarily small oak. The three riparian sites were dominated by black cottonwood and Oregon white oak. Number of individuals of each bird species was counted at point-count stations and was used as an index of relative abundance. Vegetation characteristics were measured at each station. Stations were sampled during spring and early summer in 1995 and 1996.

Results:
A total of 72 bird species were detected at the 18 study areas. Neotropical migratory birds comprised the greatest proportion of species (53 species, 73.6%) detected. The mean number of Neotropical species detected was similar in the riparian and the upland habitat types, with an average of 12 species. Species richness was higher in riparian habitats which the author concluded was due to the greater vertical diversity of vegetation structure and greater edge habitat. Species richness varied considerably within each upland habitat type, contributing to the lack of statistical significance among habitat types. Relative abundance was lower in riparian than upland sites, which the authors noted was inconsistent with most other studies, and suggested that this may have been a result of sampling biases because of the narrow riparian areas that often were smaller than the 50 m radius sampled. The author compared species richness in the oak woodland habitat types he sampled to conifer stands sampled previously and concluded the oak woodlands have much higher species diversity.

Management Implications:
The primary management implication of this work is further confirmation that Oregon white oak woodlands have high avian species richness. Importantly, the author reported the highest bird density and species richness in the small oaks-small pines habitat type, a type that is common on state-owned lands. Despite this conclusion, the upland types did not vary significantly from one another, but importantly had very high variation among sites, regardless of the assignment to one of the five upland habitat types investigated. The author believed this was due to variation in the occurrence of specific habitat elements, including the size, shape, and landscape context of the individual site. This demonstrates the difficulty in conducting research on wildlife response to oak restoration at the spatial scale of the forest stand.

Wilson and Carey 2001: Small mammals in oak woodlands in the Puget Trough, Washington. Northwest Science 75:342-349.

Objectives:
The primary objective was to compare small mammal community composition in different types of Oregon white oak habitats in one of the largest remaining oak sites in western Washington. A related objective was to elucidate habitat relationships of each of the small mammal species both in terms of stand structure and landscape context.

Approach:
The general approach was consistent with many habitat relationship studies of small mammals. The authors selected 22 oak-dominated stands or patches on Ft. Lewis in the Puget Trough, western Washington. The selected sites were typically the largest (8-44 ha). Stands selected were > 4.8 ha and based on earlier studies had a sufficient number of oaks to be inhabited by western gray squirrels. Each site was assigned to one of four vegetation types: oak savanna, oak shrub, oak-conifer, and mixed deciduous. Transects were established at each site, and at each station a series of 15 stations were established. At each station, live traps were set and vegetative characteristics were measured at 10 of the 15 sites.

Results:
A total of 12 species were captured at the 22 study sites. Deer mice and vagrant shrews were the most common. Most sites were oak-conifer mix, and there were several sites of each of the other 3 oak habitat types, most of which had conifer trees present. Abundance of each of the mammal species were highly variable among sites, leading to no clear association of small mammal abundance and oak habitat type. The authors attributed the variability of species abundances among the 22 sites to the high variation of vegetative structure among and within sites. Patterns of small mammal abundance were attributed to understory characteristics, particularly the type and amount of grass and shrub cover. Oak savanna had the lowest abundance of small mammals. Although small mammal species richness was similar to second-growth Douglas-fir stands that were studied in the same region, variation in abundance among stands was much higher in the oak habitats. Mammal community structure in terms of the relative rank of abundance of each species also varied between the second-growth Douglas-fir stands and the oak habitats.

Management Implications:
The characterization of the vegetation in the oak habitats demonstrated the encroachment of Douglas-fir in many of the stands. The comparison of second-growth Douglas-fir to the oak habitats demonstrated that the mammal community could change appreciably with conversion to conifer-dominated stands. However, the results also demonstrated that the small mammal community that was included in the study (that is, susceptible to the types of traps used in the study) are common species in other habitats as well. Furthermore, the high variation among stands or patches of oak habitat rather than

variation among habitat types demonstrated the influence of particular elements of each of the small areas of oak habitats, and probably the landscape context as well.

Response to Restoration

Alexander et al. 2007: Using conservation plans and bird monitoring to evaluate ecological effects of management: An example with fuels reduction activities in southwest Oregon. Forest Ecology and Management 238:375-383.

Objectives:
The primary goal of the study was to evaluate the extent to which abundance of selected bird species would respond to manipulation of vegetation structure in the direction predicted by habitat relationships described in regional conservation plans. The specific objectives were to (1) evaluate changes in abundance of bird species in response to reduction of shrub cover from fuel management in oak woodlands-chaparral in southwestern Oregon, and (2) evaluate the consistency of the response as predicted by the species' affinity with shrub cover as described in bird-habitat relationship models from studies conducted elsewhere.

Approach:
The research took advantage of fuel reduction on lands managed by BLM in a composite vegetation type consisting of oak woodlands and chaparral. A total of 9 treatment and 7 untreated units were included in the study. Units varied from 7-42 ha (untreated) and 11-102 ha (treated). Assignment of which stands were treated was related to goals of fuel reduction and accessibility. Within treated units, some smaller patches of untreated areas remained, increasing the heterogeneity within units. Treated areas had shrub cover reduced by hand-piling, and in most cases involved burning the pile. Treatments were conducted over 5 years (1997-2002). Point-count stations were established in each unit and sampled for birds during the breeding season of 2002 and 2003. Vegetation structure was estimated at each station.

Results:
Generally, abundance of birds did not differ between treated and untreated units consistently during the two years, with most of the results described as inconclusive by the authors. However, for the majority of species that are associated with open areas, the increase in abundance in treated stands was consistent with the predictions based on habitat relationships described in the regional conservation plan. Two of the 13 target species in the regional conservation plan showed responses to treated areas. These two species, the white-breasted nuthatch and the western wood pewee, had higher abundance in the treated units in both years of the study. Although treatments resulted in the desired vegetation structure – a reduction of shrub cover, increased herb cover, and no change in tree density—the authors argue that the lack of a greater number of shrub-associated species responding to the treatments may have been due to the retention of small patches (0.4-1.2 ha) of shrubs throughout the treated areas, insufficient reduction of shrub cover,

the gradual removal of shrub cover over multiple years of the treatments, and the small size of the treatments relative to the territory size of some species.

Management Implications:

This study demonstrates that despite a large effort in attempting to document species responding to restoration, detecting changes is very difficult for bird species due to the often less than ideal experimental conditions, which results in numerous factors that vary among areas compared other than the treatment itself. That, combined with typically small areas, makes detecting changes in bird abundance particularly difficult and thus challenges the ability to conduct adaptive management with the parameters often considered key: animal abundance.

Seavy et al. 2008: Bird community composition after mechanical mastication fuel treatments in southwest Oregon oak woodland and chaparral. Forest Ecology and Management 256:774-778.

Objectives:

The primary objective of the study was to evaluate how the bird community responded to changes in the vegetative structure from removal of shrubs and small trees. The secondary objective was to test the hypothesis that the relatively moderate- to large-scale treatment would have greater effects than a previously conducted study using small-scale treatments.

Approach:

A total of 8 stands of oak woodland - chaparral were selected for comparison of vegetative structure and bird abundance in southwestern Oregon. Stands were selected after treatments. The four selected treated stands ranged from 95-173 ha with some patches of untreated areas remaining. Four untreated stands (52-412 ha) were selected that were most similar to the treatment stands. Small trees (size not given) and shrubs taller than 1 m were masticated to ground level with modified track-mounted excavators. This reduced the average stem density from 40 to 3.3/0.1 ha, and increased woody debris by 16% on average. Approximately 10-15% of each of these stands was left untreated. Treatments were completed in a particular stand during 2000-2003. Vegetation characteristics and bird abundance were estimated at point-count stations. There were 9-25 stations in untreated stands and 16-20 in treated stands. Vegetation and bird abundance were sampled in 2004 (vegetation and birds) and 2005 (birds only), 1-5 years after treatments.

Results:

As anticipated, bird species abundance generally responded to treatments as predicted for species associated with shrubs (decreased in abundance) and open areas (increased in abundance). Several species showed consistent changes in abundance in both years, whereas the responses varied by year for most species, suggesting these species are responding to factors other than what the treatments affected. Responses were greater in this study than the related study where treatments were conducted in smaller areas.

Management Implications:
Together with the companion study (Alexander et al. 2007), these results provide empirical data on the numerical response by birds to mechanical removal of shrub cover at small and moderate to large treatment areas. The authors state that their results suggest treatments designed to maintain shrub-associated birds should be <50 ha and those designed to increase abundance of birds associated with open areas should be >100 ha.

Response to Restoration: Studies outside of Oregon

Brawn 2006: Effects of restoring oak savannas on bird communities and populations. Conservation Biology 20: 460-469.

Objective:
The primary objective was to compare bird communities and populations in closed-canopy oak forests to oak savanna and open woodlands in the Midwest USA to provide insight into the response of bird communities to restoration of oak savanna. As a subset of this broader objective, the author sought to identify species that differentiated savanna from closed-canopy bird communities.

Approach:
The study compared bird populations in closed-canopy forests and in stands that had previously undergone treatments to maintain or create open structure.
Bird community structure, density of each species, and reproductive success of a subset of the species were compared between the paired savanna and closed-canopy forests during the breeding season over 3-5 years. Pairing was based on distance.

Results:
A total of 31 bird species were included in their analyses. Of these, 12 were more common in savanna sites, 5 were more common in forests, and 14 were similar in the two habitat types. Although only the red-headed woodpecker was unique to one habitat type, the bird community structure of each habitat type was distinctive. Species that foraged predominately in the canopy and leaf litter were more abundant in forests. Species that had greater abundances in savanna had diverse foraging strategies.

The authors estimated nest success at 795 nests, and of these 13 species had sufficient number of nests for comparative analyses. For most of the 13 species, nest success was greater in savanna than forest. Factors affecting nest success were not measured, but it was assumed that the difference in success between the two habitat types was due to lower predation in savanna for unknown reasons. Bird species that had greater abundance in savanna were those that were typically associated with open habitats, from "old field" to "open woodlands". Although the author reported a distinctive bird community in savanna, he noted that each species was often found in other habitat types, except for the red-headed woodpecker, which the author noted could be labeled an "oak savanna bird". Patch size was not associated with lower abundance for species typical of oak savanna, which the author speculated was due to the relatively small patch size of savanna that existed historically.

Management Implications:
This was one of the few studies that directly addressed how vertebrates may respond to restoration. Several key findings from this study may help inform management of oak savanna in the Willamette Valley. That patch sizes did not seem to affect bird communities or abundance but that vegetation structure did is an important finding. This suggests an important role for remnant or restored savanna habitats, particularly because restoration efforts have not yet been conducted at large scales for oak habitats. Like any study of a diverse fauna, the author noted that some species had lower abundances in savanna, and thus there is a trade-off of prescribed fire and restoration of closed-canopy forests. Given that most of the species that had greater abundances or were characteristic of savanna habitat were of conservation concern, and that species associated with forests were not, the trade-off of restoration was positive for the regional bird fauna. Importantly, although the bird communities were distinctive, only 1 species, the red-headed woodpecker, was unique to the savanna sites sampled.

Davis et al. 2000: Restoring savanna using fire: impact on the breeding bird community. Restoration Ecology 8:30-40.

Objectives:
The primary objective was to evaluate the response of the avian community to restoration of oak savanna in the Midwest USA through a gradient of fire frequency in oak woodlands.

Approach:
Motivated by the often-used reintroduction of fire to restore oak savanna, this study was designed to evaluate changes in the avian community that resulted from prescribed fire, and to link the response to changes in the vegetation structure. More specifically, the author evaluated the ability of oak savanna restoration to provide suitable habitat for a suite of bird species that rely on open habitats and that have been declining in abundance. The study was conducted at an experimental oak woodland restoration site that has been undergoing fire treatments since 1964. . The area of the study site was 210 ha, and was divided into 14 units each receiving one of 7 burn frequencies. Fire frequencies ranged from 0 to 26 times over 32 years.

The study on the effects of restoration treatments was conducted in 7 of the 14 units during 1995 and 1996. One of the two replicates of each burn frequency was selected for estimation of bird abundance and habitat structural parameters. Spot-mapping techniques were used to obtain counts of each bird species in the avian community. Bird species were classified into foraging guilds to test hypotheses not only on species response, but how different guilds responded to changes in the structure of the vegetation.

Results:
As expected, vegetation structure changed with fire frequency. Tree density and leaf area index declined, and the number of snags increased with increasing fire frequency. The bird community differed substantially between unburned and frequently burned plots. The number of species was lower in the unburned treatments in both 1995 and 1996. More importantly, the bird community changed in predictable ways, especially with bird abundance within foraging guilds. Insectivorous birds, associated with the upper canopy were more abundant in less frequently burned plots. Guilds that were more associated with frequently burned plots included insectivorous birds feeding primarily on ground and bark substrates and omnivorous ground foraging species. The species that increased in abundance with fire frequency were those species that require open habitats and were of regional conservation concern.

Management Implications:
This study is one of the few case studies exploring how oak savanna restoration via fire treatments affects habitat suitability for vertebrates. The authors noted that different restoration goals and techniques will likely lead to different results than reported from their study because birds are sensitive to the different shrub layers. The authors noted that the gradual transition from closed forest to savanna resulted in shrub layers and snags that were retained along the entire fire frequency gradient. However, that may not be the case under other treatment approaches, such as mechanical removal of shrubs and trees.

Hartung and Brawn 2005: Effects of savanna restoration on the foraging ecology of insectivorous birds. Condor 107:879-888.

Objective: To understand how conversion from a closed-canopy oak forest to an open woodland or savanna habitat would affect the foraging behavior of insectivorous birds in the Midwest USA.

Approach: Using a subset of the paired sites described in Brawn (2006), the authors compared how insectivorous birds foraged in different foliage layers and selected tree species between the two habitat types.

Results:
In general, the authors found greater selection for oaks in closed-forests, which also had a large number of other hardwood species, particularly maples. As expected, the shrub layer was selected in oak savanna and the canopy layer was selected in the forest habitat. Species-specific patterns were described.

Management Implications:
These findings are consistent with the expectation that floristic composition and habitat structure will change with prescribed fire in ways that will affect the foraging behavior of birds. Prescribed fire in closed-canopy hardwood forests typically opens up the canopy, allowing a rich herb layer to develop, and over time, an abundant shrub cover. The findings from this study confirm the expectation that birds will respond to changes in the development of these vegetation layers from restoration.

Chapter 5 Future Directions

One of the most impressive habitat conservation efforts in Oregon has been the diverse management activities towards restoration of upland prairies and oak savannas in the Willamette Valley. Funding from conservation programs such as the Oregon Landowner Incentive Program and the USFWS Private Stewardship Program have made much of this possible. Many of these programs explicitly require grant applicants to identify wildlife species that are likely to benefit from their project. Furthermore, conservation grant programs often identify improvement of habitats for wildlife as a key goal. But project success is almost always measured in terms of acreage improved or treated; the actual response of wildlife (e.g. change in species occurrence or abundance) is rarely evaluated. Despite this broad interest, few studies have assessed how habitat restoration has affected wildlife in prairies and oak habitats of the Willamette Valley.

What was most striking to us in our review was the large number of in-depth studies of butterfly response to restoration and studies of their autecology and the paucity of studies of vertebrates that went beyond distributional surveys. This is not surprising given that the primary motivation for the butterfly studies was recovery of a federally listed endangered species, the Fender's blue butterfly. From our review, only research on Fender's blue butterfly incorporated a modeling approach to investigate implications of potential management strategies. All of the other studies remained descriptive, without understanding potential consequences under different management scenarios, with the exception of Schumaker's et al. (2004) study on future alternatives of landscape change. The study by Schultz and Crone (1998) seemed particularly valuable as a model for linking field studies with management. Management-oriented models, such as Shultz and Crone (1998) and Schumaker et al. (2004) developed, provide a useful heuristic tool for identifying research needs (see below, *Landscape Models*).

Although there has been very little formal assessment of vertebrate response to restoration of prairie and oak habitats relevant to the Willamette Valley, several studies have been conducted. In Oregon, the work by Alexander et al. (2007) and Seavy et al. (2008) investigated the response of birds to restored oak woodland/chaparral habitats in southwestern Oregon (see Chapter 4, *Research Summaries*). The results of these two studies highlight some of the challenges inherent in conducting studies of vertebrates in small-scale restoration sites, especially when not conducted in an experimental framework. In each of these studies, the authors reported inconsistent results, which they themselves recognized. Alexander et al. (2007) attributed the year-to-year inconsistent results to several attributes related to the difficulty in controlling variability in the vegetation and small spatial-scale of treatments. Seavy et al. (2008), working to remedy the small area issues in the Alexander et al. study, found more consistent results of response to vegetation treatments, but because of different responses between years for many species, Seavy et al. concluded that factors other than vegetation were important. Because of the lack of experimental control, bird response to vegetation modification was difficult to estimate and detect.

In the Midwestern U.S., several studies have been conducted that used either a comparative or experimental approach to evaluate how bird communities responded to restoration. In one of these studies, a comparative approach was used to make inferences on how bird populations respond to modifying closed-canopy forests to oak savanna or open woodland (Brawn 2006). The study provided clear results on the different bird communities that result from the restoration approaches used in the treated areas. Although the numbers of sites were few, results suggested that patch size of restoration was not associated with how bird communities responded.

In another Midwestern study, Davis et al. (2000) conducted a study on bird community response to fire treatments that have been on-going since 1964. Although each burn unit was relatively small (210 ha divided into 14 burn units), Davis was able to detect changes in the bird community with different fire frequencies. Bird communities changed in expected patterns based on the changes in vegetation and bird-habitat relationships.

Research Method

Wildlife-habitat relationship studies that evaluate how restoration of prairie and oak habitats affects wildlife have been conducted along a continuum of what might be described as strengths of inference, from strong inference resulting from experimental studies to a large number of correlative studies lacking formal sampling strategies and resulting in weak inference. Experimental studies have been conducted on the effects of various management treatments on butterflies, including demographic and behavioral responses. There have also been a series of observational studies conducted on associations of butterflies and habitat characteristics as well. In some cases, studies were intensive and focused on detailed autecology at a single study area, and in other studies, broad scale relationships were evaluated at numerous study sites. One study (Schultz and Dlugosch 1999) attempted to incorporate an intensive study approach conducted at multiple study sites to allow inferences on the relationship between plant composition and butterfly density. The experimental studies have provided very strong inference for managing habitat for butterflies in the Willamette Valley. These studies were possible largely because of the small spatial scale of the manipulations that made replication possible and the results were meaningful because the manipulated areas were of sufficient size to be relevant to management. The difference between the spatial scale of the experiment that is logistically possible and the scale that animals respond to is one of the major challenges to effective experimentation (Hairston 1989). This is probably the greatest challenge for meaningful studies on vertebrate response to restoration of prairie and oak habitats in the Willamette Valley.

The lack of experimentation and formal sampling designs in most of the observational studies on vertebrates that we reviewed highlights the differences with studies conducted on butterflies and restoration in the Willamette Valley. The majority of studies on vertebrates have used informal sampling approaches to investigate habitat associations at relatively small spatial scales. Several studies did incorporate statistically valid sampling strategies for investigations on habitat associations. Two of these studies (Viste-Sparkman 2005, DeMars et al. in press) incorporated multiple spatial scales into their analyses, but for the most part the studies have been conducted at relatively small scales.

As a result of the studies conducted, specific habitat associations are now better described, yet how various restoration activities would affect them is less clear. The study conducted by Viste-Sparkman on white-breasted nuthatches provides direction for management, and paves the way for adaptive management to investigate the consequences of modifying habitat. The study on bird use of individual legacy trees (DeMars et al. in press) demonstrated that birds often used isolated legacy trees regardless of whether or not the tree was situated in an oak savanna or in a pasture. However, the study didn't allow strong inference on how birds respond to changes in management, either at the tree or larger spatial scale. Understanding habitat relationships of vertebrates in a manner that can guide restoration is difficult and traditional approaches using correlations of habitat associations with animal abundance may not be as useful as other indicator variables that respond to smaller-scale changes from restoration.

Selection of Indicator Variables

In almost all of the studies of vertebrates that have been conducted in the Willamette Valley that were intended to shed light on habitat associations within prairie and oak habitats, the metric measured was abundance, either as simply occurrence ("presence-absence") or numbers of individuals. This reliance on measures of abundance is perhaps the most limiting aspect of research approaches used to make inferences on how vertebrates respond to prairie and oak habitat restoration. The problem arises because of the small spatial area of each restoration project combined with the relatively large spatial use by vertebrates, resulting in small expected changes in actual numbers even if dramatic improvements in habitat conditions occur. The difficulty in detecting changes in further exacerbated in the Willamette Valley because of the large number of biotic and abiotic factors that contribute to high variation of habitat conditions within and among restoration sites and the variable landscape context within which each restoration site is embedded. These challenges ultimately result in the difficulty in assigning changes in abundance to the restoration method, rather than a plethora of other factors that likely changed at each site. Interestingly, work on butterflies in these similar habitats have measured response to restoration using a variety of metrics, and have not relied on estimates of abundance. These butterfly studies have been very informative and similar approaches need to be attempted with vertebrates. There are numerous journal articles and books that critique indicator variable selection and provide guidance to their selection. First and foremost, it is important for vertebrate biologists to look beyond the traditional call for additional surveys and monitoring of bird abundance in assessing the success of restoration projects for the small acreage of oak and prairie restoration projects that are typical in the Willamette Valley.

Future Research Directions to Help Guide Habitat Restoration

We believe research on how vertebrate wildlife responds to prairie and oak restoration in the Willamette Valley is challenging for four primary reasons: (1) disconnect of spatial scale of restoration and animal use patterns, (2) the high variability of each restoration unit and the typical lack of control (non-restored) areas, (3) the extremely high variability of numerous elements of habitat characteristics at the spatial scale of the landscape, making it difficult to detect larger scale patterns, (4), time lags of restoration activities and habitat response, and (5) the existence of non-habitat factors that affect bird occurrence and abundance in the restored areas. We discuss these challenges in relation to past and future research and identify several key research questions that would be useful for linking research with management.

Patch Size and Landscape Composition

Since restoration efforts are taking place in generally small areas, an assessment of the minimum patch size to which wildlife responds would necessarily be important in guiding restoration efforts (Blann 2006). In addition to simply the size of an individual patch, the functional size of the patch given neighboring patches is equally important, especially in upland prairie and oak savanna vegetation types because of the presumed "naturally" occurring fragmentation that species associated with these habitat types are adapted to. Evaluation of wildlife in such complex landscapes is difficult, particularly in landscapes that have so many other factors that vary among them, including distance to other populations of the wildlife species being evaluated. Future research addressing patch size will probably need to be designed as population studies that go beyond restricting study areas to restoration sites. The knowledge gained from such studies can then be applied to restoration actions as well as landscape planning, particularly with landscape configuration and composition.

Behavioral Changes in Response to Habitat Management

Because of the challenges with spatial scale and lag time of the response of habitat conditions to restoration activities, using behavioral metrics rather than estimates or indices of abundance may result in more consistent results that can provide insights to management. Work on the Fender's blue butterfly provides useful examples for considering measurements of changes in behavior rather than abundance or demographic changes. Furthermore, because behavioral changes can be detected at small spatial scales, opportunities for experimentation and adaptive management are likely greater with behavioral metrics than when abundance metrics are used. Such approaches may also minimize issues with time lags between vegetation change and demographic responses by animals because of the opportunities to manipulate small areas to desired conditions.

Monitoring Wildlife Response to Restoration

A key goal of habitat restoration is to transform existing conditions to allow them to function as wildlife habitat. In particular, the restoration of Oregon white oak habitats has received considerable attention (Hanna and Dunn 1997, Campbell 2004, Vesely and Tucker 2004), and several case studies of restoration have been published (e.g., Apostal and Sinclair 2006). An often-stated objective of restoration efforts is for wildlife conservation, yet this objective is rarely evaluated, thus hampering guidance for improvement. Why hasn't there been more emphasis on effectiveness monitoring and what are the challenges in conducting effective and efficient monitoring of wildlife in these habitats?

The goal of most wildlife monitoring efforts is conceptually simple: to track and detect changes though time in order to direct management to reverse undesired trends.

Although conceptually simple as a stated goal, in reality, designing effective and efficient monitoring programs is difficult (National Research Council 2000, Yoccoz et al. 2001, McComb et al. in press) and may be unobtainable in many situations. One of those situations may prove to be monitoring response of vertebrate wildlife species to restoration of prairie and oak habitats in the Willamette Valley.

Monitoring the numerical response of vertebrate wildlife to habitat restoration is difficult to estimate with precision given the high rates of natural variability and higher sampling variability of biological parameters (Yoccoz et al. 2001), and this is particularly true at small spatial scales (DeSante and Rosenberg 1998, Rosenberg et al. 1999). Vertebrates are often difficult to monitor because of their mobility, difficulty in detecting them, and because of their complex response to changes in their environment (Thompson et al. 1998), all of which makes detecting changes difficult because the statistical power tends to be so low (e.g., Green 1989, Steidl et al. 1997, Steidl and Thomas 2001).

Put Emphasis on Ability to Interpret Results of Monitoring not Sampling Protocols

Almost all of the guidance for monitoring wildlife species has been an emphasis on sampling protocols. To make valid inferences on how wildlife responds to the relatively small areas that are being restored, a paradigm shift will need to occur. It is not the standardization of sampling protocols, such as using point counts in the case of songbirds, which will allow an improved understanding of the efficacy of restoration of these habitats, but rather new ways of considering the mechanisms of how animals respond to changes in habitat. Identifying the mechanisms of why species respond to restoration of prairie and oak habitats in the Willamette Valley and thoughtfully applying this understanding to the monitoring program (e.g., Nichols and Williams 2006) may allow for monitoring the effectiveness of restoration of small areas of habitat. This may also allow for experimental manipulation of habitat at very small scales, similar to the approach of many of the studies of Fender's blue butterfly, and lead to better guidance for management.

Adaptive Management

In many ways the work done on restoration of prairie and oak habitats in the Willamette Valley is a story of case studies. Using case studies to guide management may be a much more fruitful approach in the case of vertebrate use of restoration sites because of all of the challenges to using a more formal research approach (e.g., Schrader-Frechette and McCoy 1993). Incorporating carefully designed case studies in restoration efforts facilitates using an adaptive management approach to learning (Holling 1978, Walters 1986). This approach recognizes that we can learn more about the system as we continue to manage and carefully monitor the effects of each management practices, thus allowing management strategies to be modified to take into consideration the new findings. This type of strategy requires thoughtful consideration of the predictions of restoration effects and sufficient monitoring to ensure feedback to management. In an ideal situation, management is conducted as experiments, and thus has all of the same challenges discussed earlier in terms of detecting changes in small areas. We suggest there is likely a useful approach that takes advantage of the low-cost case study approach, some level of monitoring, and a feedback loop for adaptive management for guiding restoration of prairie and oak habitats in the Willamette Valley. Finding the optimum approach that is both informative and logistically feasible is important before additional research and monitoring efforts are undertaken to understand how vertebrate wildlife respond to restoration in prairie and oak habitats of the Willamette Valley.

Landscape Models to Help Prioritize Restoration

One way to integrate existing data and expert opinion is through heuristic models to facilitate site selection for future restoration work. The modeling work by Schumaker et al. (2004), with further specificity of habitats (e.g., Garmon 2006), provides an approach for conducting modeling work on habitat restoration in the Willamette Valley. Ideally, constructing models that integrates existing data will be most useful as a heuristic tool to help identify the most useful data that will allow more informed decision-making for site selection, and even in the important decision on selection of desired changes of vegetation communities (e.g., oak woodland or oak savanna). In this sense, developing landscape models early in the research planning phase is likely to indicate which parameters are most useful to estimate to provide guidance for restoration work. One of the data gaps that need to be addressed before such modeling work is conducted is a comprehensive database of oak and prairie restoration sites to augment maps of recent vegetation.

Chapter 6 Species Accounts

Twenty animal species that are closely associated with grasslands or oak woodlands in the Willamette Valley have been listed as Oregon Conservation Strategy species because of their declining populations or their vulnerability to habitat loss and other risk factors (See Table 1, Chapter 3). Of these species, 14 are listed as USFS/BLM Special Sensitive Status (SSS) species. We have prepared life history summaries and management recommendations for 12 species, 8 of which are listed as SSS. The species we selected for individual accounts have been the focus of much of the recent effort to restore upland habitats in the Willamette Valley. Information for several species was so sparse (e.g., American acetropis bug, camas pocket gopher) that we did not prepare accounts. We also did not include accounts for two species (i.e., Lewis' woodpecker and white-tailed deer) that have been extirpated from the Willamette Valley, although it's conceivable that these species may once again extend their breeding range into the region should suitable habitat become available.

ISSSP has prepared fact sheets on several species that occur in oak and prairie habitats in the Willamette Valley, and include Taylor's checkerspot, acetropsis bug, and the Oregon giant earthworm. In addition to our species accounts on western pond and painted turtles, ISSSP has developed a fact sheet for western pond turtles and conservation assessments for both turtle species. These documents, and the species accounts we include here, provide summaries of the ecology and management of many of the species of concern in oak and prairie habitats in the Willamette Valley.

ISSSSP Fact Sheets

Taylor checkerspot
http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/20050906-fact-sheet-taylors-checkerspot.doc

Acetropsis bug
http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/20050906-fact-sheet-acetropis-americana.doc

Oregon giant earthworm
http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/sfs-icl-driloleirus-macelfreshi-2009-12.doc

Western pond turtle
http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/sfs-hr-actinemys-marmorata-2009-05.doc

ISSSSP Conservation Assessments

Pond turtle
http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/ca-hr-actinemys-marmorata-2009-11.pdf

Western painted turtle
http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/ca-hr-chrysemys-picta-bellii-2009-09.pdf)

Northern Pacific Rattlesnake (*Crotalus viridis oreganus*)

Conservation Status—The northern Pacific rattlesnake is one of two western rattlesnake (*Crotalus viridis*) subspecies occurring in Oregon. Populations of the northern Pacific rattlesnake in the Willamette Valley are not designated as Sensitive by ISSSSP but are designated as Oregon Conservation Strategy species (ODFW 2006). The subspecies has no federal special status. Willamette Valley populations of *C. v. oreganus* are believed to be threatened by the loss of grassland habitat and a long history of persecution by humans (ODFW 2006).

Systematics & Distribution— The phylogenetic relationships of the western rattlesnake are currently being reconsidered by taxonomists. Up to nine subspecies of *C. viridis* have been previously recognized (Klauber 1996), but recent mitochondrial DNA studies have found evidence of only five divergent populations organized within two major clades that are divided geographically by the Rocky Mountains (Pook et al. 2000, Ashton and de Queiroz 2001). Ashton and de Queiroz (2001) recommend abandoning the traditional classification of subspecies within *C. viridis* and propose recognizing the two major clades as separate species: *C. viridis* to include *C. v. viridis* and *C. v. nuntius*; the remainder of the previously recognized subspecies (including *C. v. oreganus*) as *C. oreganus*. Although the arguments for revising the taxonomy of *C. viridis* by Pook et al. (2000) and Ashton and de Queiroz (2001) are compelling, we have retained the previous subspecies classification and use northern Pacific rattlesnake (*C. v. oreganus*) in this account to remain consistent with the nomenclature currently accepted by the Oregon Department of Fish and Wildlife (ODFW).

The northern Pacific rattlesnake occurs in two disjunct geographic ranges: the southern range that includes the Klamath Mountains physiographic province in northwest California and the major interior valleys of western Oregon (i.e. Rogue, Umpqua, and Willamette Basins); the northern range encompasses the Blue Mountains and the sagebrush-steppe of the Columbia Basin in Washington and British Columbia (St. John 2002). The northern Pacific rattlesnake is distributed along a greater elevational range than any other *Crotalus* subspecies: from sea-level to 6,900 ft in Oregon (Klauber 1996). A second subspecies, *C. v. lutosus* (Great Basin rattlesnake) is distributed throughout much of the Great Basin physiographic province in Oregon, Nevada, and California (St. John 2002). The northern Pacific rattlesnake and Great Basin rattlesnake would both be recognized as the same species (i.e., western rattlesnake) according to taxonomic revisions recommended by Ashton and de Queiroz (2001).

In the Willamette Valley, there is evidence from anecdotal accounts and museum specimens that the northern Pacific rattlesnake once occurred in every county of the province, and was even a nuisance to quarry workers on the banks of the Columbia River (Klauber 1996). However, the species probably has never been widely distributed in the region because of the scarcity of exposed bedrock for over-wintering habitat across most of the valley floor. The subspecies likely was more common in the southern portion of the Willamette Valley (Gordon 1939, St. John 1987). Steep foothills and isolated buttes may have supported localized populations in the northern Valley.

Today, the subspecies has been extirpated from most of the Valley. An extensive survey of amphibians and reptiles in the Willamette Valley conducted in 1984 and 1986-87 detected northern Pacific rattlesnakes at only 6 localities: near Mehama (Marion County); near Lebanon and Brownsville (Linn County); and in the Coburg Hills and near Eugene (Lane County; St. John 1987). The only localities that have confirmed continued presence of the subspecies since 2000 are near Mehama (A. St. John, pers. comm.), Eola Hills (Polk County; anonymous landowner, pers. comm.), and 6 locations in Lane County (B. Wolfer, pers. comm.; A. St. John, pers. comm.). Several *C. v. oreganus* have been captured or killed near Wren (Benton County) since 2007 (K. Harding, pers. comm.), but multiple individuals of *C. v. lutosus* have also been discovered contemporaneously, suggesting a deliberate or accidental release of both subspecies at the locality.

Ecology—The northern Pacific rattlesnake is adapted to a broader range of environments than any other subspecies of *C. viridis*. The subspecies can tolerate conditions at 11,000 ft above sea level in the Sierra Nevada Range, to the coastal redwood belt of northern California, as well as ponderosa pine forests in British Columbia (Klauber 1996). In the Willamette Valley, northern Pacific rattlesnakes are most closely associated with oak woodlands, mixed oak-madrone woodlands, and open stands of Douglas-fir and hardwoods on dry sites (St. John 1987). Rocky slopes, especially with south or west aspects, appear to be a crucial habitat element across the entire geographic range of the subspecies (Klauber 1996).

Seasonal activity radiates from the hibernacula, to which rattlesnakes display strong fidelity (Klauber 1996, Macartney 1985). Hibernacula usually are located in south- or southwest-facing talus slopes or where bedrock is exposed and fissured, permitting rattlesnakes to access underground chambers (Diller and Wallace 1984, Macartney 1985). Most known hibernacula in the Willamette Valley have been in exposed ledges of basalt or sedimentary rock (St. John 1987). In northern California, the subspecies may overwinter in mammal burrows (Fitch 1949). Dozens of rattlesnakes may aggregate in hibernacula and other species of snakes may use the same site (Klauber 1996, Diller and Wallace 2002). In northern Idaho, northern Pacific rattlesnakes typically retreat to hibernacula in mid-October (Wallace and Diller 2001).

Wallace and Diller (2001) reported that the median date at which northern Pacific rattlesnakes emerge from hibernation in Idaho was April 1. In Madera County, CA, rattlesnakes usually emerge in March (Fitch 1949). Upon emergence, rattlesnakes may remain in pairs or aggregations near the hibernaculum for a short period (Fitch 1949). Rattlesnakes then migrate to summer foraging areas following similar movement paths each year (Macartney 1985). Other *Crotalus* species have also been observed using the same travel corridors over multiple years (Neill 1948). In British Columbia, the median maximum distance that northern Pacific rattlesnakes were observed from their hibernaculum was 1.2 km (range 0.29-3.0 km; n=10; Bertram et al. 2001). Foraging habitat may be similar to the rocky slopes that characterize overwintering site, but rattlesnakes may also use meadows, pasturelands, or riparian areas on valley floors (Fitch 1949, Klauber 1996). Rattlesnakes are relatively sedentary within their summer ranges, making occasional, circuitous movements between burrow systems of mammalian prey (Fitch 1949). In Northern California, the average home range was estimated to be 12.2 ha (30 ac) for adult males and 6.5 ha (16 ac) for adult females (Fitch 1949).

Females typically reach sexual maturity during their 4th year in northern Idaho (Diller and Wallace 2002). Females breed biennially in California and northern Idaho (Fitch 1949, Diller and Wallace 2002) and on a triennial cycle in British Columbia (Macartney and Gregory 1988). Mating activity demonstrates a bi-modal, seasonal pattern with peaks occurring soon after emergence from hibernacula in the spring and again in late fall before rattlesnakes move into dens (Diller and Wallace 2002). Young are born live (Fitch 1949). The maximum longevity of northern Pacific rattlesnakes was estimated to be more than 20 years (Fitch 1949).

The diet of adult northern Pacific rattlesnakes is largely composed of rodents; rabbits, birds, and lizards form a minor portion of their diet (Fitch 1939, Macartney 1989). Rodent populations often display regular cycles of abundance, thereby affecting prey availability for rattlesnakes. Diller and Wallace (2002) reported that the reproductive condition of female rattlesnakes was positively related to prey abundance during the previous year.

In California, red-tailed hawks (*Buteo jamaicensis*), great horned owls (*Bubo virginianus*), and coyotes (*Canis latrans*) are reported to be the most significant predators of juvenile rattlesnakes (Fitch 1939). Predation is not believed to be a significant source of mortality among adults (Fitch 1939; Diller and Wallace 2002).

Habitat Management/Restoration—Habitat loss to urban development, agriculture, and rock quarry operations are reported to be among the most widespread and severe threats to the persistence of northern Pacific rattlesnake populations (ODFW 2006, SIRART 2008). However, because of the discomfort most people have about living near rattlesnakes, recruiting volunteer landowners to undertake habitat improvements or other conservation actions to benefit the species will certainly be difficult. Nevertheless, during our research review we became aware of three private landowners in the Willamette Valley that are indeed deliberately leaving rattlesnakes undisturbed on their property.

Given the rarity of the northern Pacific rattlesnake in the Willamette Valley and its purported limited capability to make long-distance movements, habitat restoration projects further than perhaps a kilometer from active hibernacula are unlikely to be colonized for years and will have little effect on improving local population viability in the short term. Educating landowners that live within the home range of known populations as to the objective risks posed by rattlesnakes, as well as measures to minimize human-rattlesnake interactions, is likely to be more useful than habitat restoration projects in unoccupied areas.

Translocation of individuals to habitat strongholds has been used as a conservation strategy for a number of species-at-risk in the Pacific Northwest, including the Columbia basin pygmy rabbit, western pond turtle, and Fender's blue butterfly (Campbell et al. 2006). Short-distance translocation of western rattlesnakes has been investigated and is reportedly effective for maintaining small populations when appropriate habitat is provided and conflict areas are carefully managed (Brown et al. 2009). To our knowledge, translocation has not been proposed to conserve the northern Pacific rattlesnake in the Willamette Valley, but the approach would seem to merit study given the serious declines of rattlesnake populations in the region.

Non-Habitat Limiting Factors—
Persecution by humans has been the greatest threat to the northern Pacific rattlesnake and other *C. viridis* populations since European settlement. Individuals were systematically hunted and killed during annual "rattlesnake round-ups" that were held in many communities and hibernacula have been routinely destroyed by landowners on whose property they were located (Klauber 1996).

Rattlesnakes can be attracted to warm road surfaces to thermoregulate and road-related mortality is reported to be among the most serious threats to rattlesnake populations (SIRART 2008). It is also suspected that mechanized farming practices (e.g, tilling, crop harvesting) may also cause significant mortality (SIRART 2008).

The presence of large herds of livestock may also have had a deleterious effect on rattlesnake populations during the early settlement of the Willamette Valley. There is anecdotal, but widespread evidence that western rattlesnakes emigrate from intensively grazed areas, although it is unclear whether rattlesnakes are responding to vegetation changes, livestock activity, or both (Klauber 1996). During the late-nineteenth century, livestock numbers in the Willamette Valley increased dramatically. For example, it is estimated that there were 90,000 sheep and more than 30,000 hogs in Polk and Marion Counties by 1900 (Blok 1973). Livestock herds were largely unconfined on the landscape during the settlement period and hogs had a particularly severe impact on native habitats and wildlife (Boag 1992).

Repeated handling of rattlesnakes during the course of scientific studies may cause significant loss of mass in individuals (Fitch 1949) and was hypothesized to cause a serious decline in survival during a long-term population study conducted in Idaho (Diller and Wallace 2002).

Western Pond Turtle (*Actinemys marmorata*)

Conservation Status— The western pond turtle is classified as an ISSSSP Sensitive Species and an Oregon Conservation Strategy (OCS) Species (ODFW 2006) and as a Sensitive-Critical species in OR (ODFW 2008). In Washington, it is classified as a State Endangered Species (Hays et al. 1994), and in California it is listed as a Species of Special Concern. It is considered a Species of Concern by USFWS; a petition for listing under the ESA was found not warranted (USFWS 1993). Factors cited as limiting western pond turtle populations predominately include loss of wetland and adjacent upland habitat for nesting, and lack of juvenile recruitment due to high nest and hatchling predation (Hays et al. 1994, Bury and Germano 2008, Rosenberg et al. 2009). Natural Heritage Global Rank: G3G4 (not immediately imperiled); Oregon State Rank: S2 (imperiled).

Systematics & Distribution— Two subspecies of western pond turtles have been recognized. The northwestern pond turtle (*Actinemys marmorata marmorata*) occupied the range from northern California north to Washington and the southwestern pond turtle (*Actinemys m. pallida*) occupied the southern portion of the range, from San Francisco Bay south to Baja California (Seeliger 1945). Although recent research is in disagreement with delineation of clades, there is general agreement that northern populations show sufficient genetic differentiation from southern populations to be considered a distinct clade (Spinks and Shaffer 2005), and all of the populations in Oregon belong in the northern clade (reviewed in Rosenberg et al. 2009).

The range of the western pond turtle includes northwestern Baja California, Mexico, north to Puget Sound of Washington, restricted with few exceptions to areas west of the Sierras and the Cascade Mountains. In Oregon, the western pond turtle is most abundant in the drainages of the Willamette, Umpqua, Rogue and Klamath but occurs in lowland aquatic habitats throughout western Oregon (Rosenberg et al. 2009). In the Willamette River Basin, western pond turtles are most abundant south of Salem (Holland 1993, 1994; Adamus 2003), consistent with findings in the late 1930s and 1940s (Graf et al. 1939, Evenden 1948). Given both historical and recent understanding of distribution and abundance, the core of the range in Oregon has not contracted but some local populations have declined, especially in urban areas (Rosenberg et al. 2009).

Ecology—Western pond turtles (WPT) are found in both intermittent and permanent aquatic habitats. They inhabit moving water environments including sloughs, streams, and large rivers where deep pools exist, and still bodies of water including human-made ponds, irrigation canals, small lakes, reservoirs, marshes, as well as in oxbow lakes formed from larger rivers (Bury and German 2008, Ernst and Lovich 2009). From the few hatchlings that have been observed outside of the nest, shallow and slow moving waters may be habitat requirements (Rosenberg et al. 2009). WPT inhabit relatively remote landscapes (e.g., Reese and Welsh 1998b), rural (Holland 1994, Adamus 2003), and urban (Spinks et al. 2003) environments throughout its range. WPT spend considerable time on land for overwintering, basking, dispersal, and searching for nesting sites (Bury and German 2008, Ernst and Lovich 2009). Adults may spend up to 7 or more months of the year on land, with the majority of the time spent at overwinter refugia (Reese and Welsh 1997, Rosenberg et al. 2009). WPT have been reported to travel up to 1.4 km (Ryan 2001) from their aquatic habitats to overwinter sites, but most movements to overwinter sites are <200m (Rosenberg et al. 2009). Western pond turtles overwinter e at the bottom of the substrate of aquatic habitats, in undercut banks along streams, or in terrestrial refugia typically buried under 5-10 cm of leaf litter (Rathbun et al. 1992, Holland 1994, Reese and Welsh 1997, Rathbun et al. 2002, Vander Haegen et al. unpublished ms). Shrubby, open, and forested environments have all been used by WPT, although access to some solar radiation is important (Rathbun et al. 1992, Holland 1994, Rathbun et al. 2002). Oak savannas and upland prairies would provide the appropriate habitat if within approx. 200 m of water, and historically may have been a commonly used habitat type for nesting and overwintering.

Western pond turtles require terrestrial habitats for nesting. Nest habitat is usually nearly adjacent to or within 50 m of aquatic habitat in areas with compact soil and sparse vegetation consisting of primarily bare areas, grass, and/or forbs (Reese and Welsh 1997, Rathbun et al. 1992, Holland 1994, Rathbun et al. 2002). Suitable nest habitat near aquatic environments may often be limited (Holland 1994), particularly in urban settings (Spinks et al. 2003).

In Oregon, female western pond turtles construct and lay eggs from May – August, with most nesting conducted from June to mid-July (Rosenberg et al. 2009). Nests are shallow, approximately 7-12 cm below the surface (Ernst and Lovich 2009). Several clutches may be laid in a season, and some years an individual may not nest (Ernst and Lovich 2009). Clutches contain 1-13 eggs (Ernst and Lovich 2009), but averaged 7 in a study that included over 50 nests in the Willamette Valley (Holte 1998). Young hatch typically in 90-120 days (Lucas 2006, Bury and Germano 2008), and is related to temperature (Ernst and Lovich 2009). Although hatchlings may emerge in the fall, most overwinter in their natal nest, emerging the following spring (Rosenberg et al. 2009). Thus, many western pond turtles spend nearly a year on land from the egg stage to emerging as hatchlings, indicating important management considerations at their nest areas. Western pond turtles are sexually mature by 5-9 years (males) and 7-10 years (females), and may live up to 40 years or more (Bury and Germano 2008).

Western pond turtles are omnivorous and opportunistic feeders. Animal matter constitutes the majority of the diet, including larvae of aquatic insects, earthworms, mollusks, and crustaceans, and vertebrates such as tadpoles, frogs, and small fish. Plankton are common in many of the habitats where western pond turtles occur and this may be an important nutrient source (Bury 1986). Observations of western pond turtles scavenging fish and wildlife carcasses suggest that western pond turtles have a very opportunistic diet (Rosenberg et al. 2009).

Habitat Management/Restoration— There are several key issues that management and restoration activities could modify to improve conditions for western pond turtles. Factors limiting populations are not well understood. However, in some areas road mortality, area and quality of nest habitat, elevated nest and hatchling predation, and poor aquatic conditions may be most limiting. Competition and disease transmission from introduced pet turtles remains an important threat, especially near urban areas. Management actions that have been recommended (Rosenberg et al. 2009) include:

- Provide sparse vegetation structure adjacent to aquatic habitat for nesting within 200 m of aquatic habitat; remove all woody plants in designated nesting areas and maintain good solar exposure
- Provide shallow water habitats with abundant aquatic vegetation for hatchling rearing habitat
- Maintain and increase deep pools in streams
- Provide open or open-woodlands for over-wintering within 200m of stream and river habitats
- Consider juxtaposition of terrestrial and aquatic habitat in relation to roads and recreation uses to minimize negative effects
- Manage recreation to minimize disturbance near turtle-use areas
- Remove invasive turtle species and improve education to eliminate releases of pet turtles

Non-Habitat Limiting Factors— Introduced species of turtles, usually released from the pet trade (Rosenberg et al. 2009) are a threat due to potential transmission of disease and increased competition for limited resources. Introduced smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*), and bullfrogs (*Rana catesbeiana*) have been speculated to cause declines in western pond turtles through predation of hatchlings but we are not aware of any studies that evaluated the magnitude of the predation and there is no evidence that these species are causing declines in western pond turtle populations (Rosenberg et al. 2009).

Western pond turtles live in many aquatic environments that are known to have high levels of contaminants, including major rivers that go through urban centers (e.g., Willamette River), and impoundments such as waste water treatment ponds and effluent ponds from lumber mill operations. A large number of contaminants were found in eggs collected near Fern Ridge Reservoir in the Willamette Valley, including organochlorines, PCBs, and metals (Henny et al. 2003). There is a potential for contaminants to affect the population dynamics of western pond turtles, particularly in areas subject to high contaminant loads.

Survey Methods— The two primary methods of surveys are trapping and visual surveys. Trapping surveys require permits and may harm turtles and should only be conducted by trained personnel and when the objectives of the study require capture. Most surveys for western pond turtles have used one or more protocols for visual surveys that were developed by the Interagency Western Pond Turtle Working, with the most recent iteration of the protocols reported in 2001 (Bury et al. 2001). Horn (2001) evaluated the protocols and concluded that the maximum number of turtles observed during any of 6 replications of visual surveys at 3 sites ranged from 40.3 % to 53.5% when compared to population estimations from captures. Standardized protocols using count data from either trapping or visual surveys will be limited in their rigor to allow for factors that affect the ability to detect turtles in a broad array of habitats and conditions, and this needs to be considered before designing and conducting population surveys. Given the difficulty in detecting western pond turtles, particularly in some habitats and especially for younger age-classes, it is important to recognize that occupancy can be confirmed, but that the lack of detections may not indicate the absence of turtles.

Western Painted Turtle (Chrysemys picta bellii)[1]

Conservation Status—The western painted turtle is listed as an ISSSSP Sensitive Species in Oregon and is an Oregon Conservation Strategy Species (ODFW 2006) and as a Sensitive-Critical species (ODFW 2008). It has no special status in the state of Washington. The species is listed as a U.S. Fish and Wildlife Service Species of Concern. The Natural Heritage Global Rank is G5 (demonstrably widespread), and the Oregon State Rank is S2 (imperiled). Factors cited as limiting western painted turtle populations in Oregon include loss of wetland and adjacent upland habitat for nesting, threats from roads and recreation especially in urban centers, and lack of juvenile recruitment due to high nest and hatchling predation (Gervais et al. 2009).

Systematics & Distribution —Western painted turtles have traditionally been divided into four subspecies, *C. picta dorsalis*, *C. picta martinata*, *C. picta picta*, and *C. picta bellii*. These subspecies have been differentiated based on geographic range and morphological characteristics; the subspecies overlap extensively in parts of their range and interbreed where they co-occur. A recent proposal has been made to recognize *C. picta dorsalis* as *C. dorsalis* (Starkey and others 2003) which would result in no longer recognizing sub-specific status of populations in Oregon. Painted turtle taxonomy remains controversial (Ernst and Lovich 2009).

Western painted turtles are the most widespread turtle species in North America, occurring across a broad swath of the North American continent. The western painted turtle, *C. picta bellii*, ranges west across southern Canada from Ontario to British Columbia and south from Missouri to Idaho (Ernst and Lovich 2009). A small band of its range juts into northern Oregon, restricted to the northern Willamette Valley south to Salem and east into central- and northeastern Oregon, primarily within the Columbia Basin (St. John 2002). Other reported locations within Oregon may be released pet turtles or their progeny (Gervais et al. 2009).

Ecology—Western painted turtles occupy slow-moving or still, shallow water including sloughs, ponds, small lakes, canals, and streams. Aquatic vegetation either at the surface or emerging from the water, and a soft, muddy substrate are also characteristics of good turtle habitat, and basking sites in the form of rocks, logs, or emergent banks are also required. Sparsely vegetated land near water is needed for nesting. Soil type is highly variable, but nests are frequently found on land with southern exposure. Hatchlings typically spend their first winter in the nest, emerging in spring to move into their aquatic habitat. Hatchlings seem to require shallow aquatic habitat, but little specific information is available.

In western Oregon, overwintering in a state of semi-dormancy does not always occur, but when it does, they overwinter in either aquatic (buried in mud) or terrestrial (buried under debris and/or soil) environments, with predominant use of shallow aquatic habitats (Hayes et al. 2002, Gervais et al. 2009).

[1] **Contributed from Jennifer Gervais, Oregon Wildlife Institute**

The primary use of terrestrial habitats by western painted turtles is for nesting. Western painted turtles nest near aquatic habitat, usually within 100 m and often much closer and sometimes nearly adjacent to their aquatic habitat (Hayes et al. 2002, Ernst and Lovich 2009, Gervais et al. 2009) Flood plains, shrubby fields, roadsides, pastures, and open beaches have all been used as nesting habitat (Ernst and Lovich 2009). A broad range of substrates are used for nesting in Oregon, including compact soils and recent fill composed primarily of gravel and sand (Ernst and Lovich 2009, Gervais et al. 2009). Nests are often as shallow as 7 cm (Ernst and Lovich 2009).

Sexual maturity has been estimated at 4-5 years in males and 7-9 years in females (Wilbur 1975, Congdon et al. 1992, Hayes et al. 2002). Painted turtles court and mate from March into June, and courting behavior is also seen in the fall (Gibbons 1968b). The nesting season in Oregon is similar to western pond turtles with most nests constructed during June and July (Hayes et al. 2002). Western painted turtles lay large clutches with a mean of 11 eggs and ranging from 4-23 eggs (Ernst and Lovich 2009). Several clutches may be laid in each breeding season. Some females in northern populations may not breed each year (MacCulloch and Secoy 1983), and this is likely true in Oregon. Laying of several clutches per year is typical where it has been studied (Ernst and Lovich 2009), and probably occurs in Oregon. Incubation takes approximately 60-80 days, depending on environmental conditions (Ernst and Lovich 2009). Young turtles hatch in the fall, but spend the winter in the nest in most parts of the species' range (Breitenbach et al. 1984). In the mild climate of western Oregon, emergence from overwintering occurs most typically in March and April (Gervais et al. 2009), similar to western pond turtles (Rosenberg et al. 2009). From the time of laying to spring emergence, western painted turtles may have spent almost a year on land before entering aquatic habitats, highlighting the importance of consideration to both aquatic and terrestrial habitats for conservation of western painted turtles.

Western painted turtles are omnivorous and eat fish, crayfish, tadpoles, amphipods, insects, carrion, and plant matter are also consumed (MacCulloch and Secoy 1983, Ernst and Lovich 2009). Adult turtles in Michigan in one site appeared to be feeding almost entirely on aquatic vegetation based on stomach contents, whereas stomachs from another site frequently contained earthworms, fish, and snails (Gibbons 1967). Their flexible diet probably allows them to occupy diverse aquatic habitats.

Habitat Management/Restoration—Major threats to western painted turtles in Oregon are loss of wetland and adjacent upland habitat, including the degradation of nest areas from invasive plants that increase cover, particularly Himalayan blackberry (*Rubus armeniacus* or *R. discolor*). Populations in urban centers are particularly vulnerable to road mortality and disturbance from recreation near aquatic areas. Road mortality may be a significant problem, particularly for female turtles seeking nest sites. Provision of nesting habitat that is free of human disturbance and close to water is important. Turtles are notoriously wary while basking, and providing basking sites that are away from human disturbance may also be very beneficial, especially to urban populations. Habitat management to give basking and nesting turtles some distance and visual screening from disturbance by human recreationalists and their companion animals may improve both survival and reproduction.

Non-Habitat Limiting Factors—Little is currently known regarding mortality factors for hatchlings, although researchers and conservationists have suggested that introduced bass (both smallmouth and largemouth), and bullfrogs (*Rana catesbeiana*) may have a substantial impact on hatchling survival in Oregon. These introduced species coexist naturally through much of the western painted turtle's range, although the interactions among these species in Oregon are unknown. Likewise, the impact of nest predation by raccoons, coyotes, skunks, and other animals that have adapted to more urban environments is not well understood but have been noted to be at times particularly high and may threaten some populations (Gervais et al. 2009). Determining if nesting and hatchling mortality are causing significant population-level impacts will inform whether taking steps to reduce these sources through nest exclosures or head starting are worthwhile investments of time and funding dollars.

Introduced turtles pose a threat to native populations through the potential for disease transfer and reduction of the genetic integrity through interbreeding when painted turtles are released particularly from unknown genetic stock. Prevention of captive releases by well-meaning members of the public through educational outreach is likely the best response to these threats. Similarly, collection of wild turtles, particularly from isolated urban populations, could affect population viability. Again, the best prevention may be public education.

Survey Methods—Survey methods are similar for both of Oregon's native turtle species. There are two primary methods of surveys-- trapping and visual surveys. The primary limitations of trapping surveys are the commitment of great effort per area and the potential harm to turtles, the latter being the reason that permits are required from Oregon Department of Fish and Wildlife. Trapping should only be conducted by trained personnel and when the objectives of the study require capture. It is important to ensure that methods are sufficiently rigorous to meet the stated objectives of the survey. Survey protocols have been developed for western pond turtles (Bury and others 2001) and applied to western painted turtles (Gervais et al. 2009). In an evaluation of survey protocols for western pond turtles, 40 to 53% of the number of turtles estimated from population estimates were observed during any of 6 replications of visual surveys (Horn 2001). Standardized protocols using count data from either trapping or visual surveys will be limited in their rigor to allow for factors that affect the ability to detect turtles in a broad array of habitats and conditions, and this needs to be considered before designing and conducting population surveys. It is important to recognize that occupancy can be confirmed, but that the lack of detections may not indicate the absence of turtles.

Western Gray Squirrel (Sciurus griseus)

Conservation Status—The western gray squirrel is classified as an ISSSSP Sensitive Species in Washington, and is an Oregon Conservation Strategy (OCS) Species as well as a game animal (ODFW 2006), however the species has no federal special status. In Washington, the western gray squirrel is designated as a state threatened species (WDFW 2009). Factors limiting western gray squirrel populations include habitat loss and fragmentation (Ryan and Cary 1995a; ODFW 2006), predation by domestic cats (Verts and Carraway 1998), competition from introduced squirrel species (Ryan and Cary 1995a), changes in woodland structure due to fire suppression (ODFW 2006), and road-related mortality (Ryan and Cary 1995a, Verts and Carraway 1998).

Distribution— The geographic range of the western gray squirrel extends from the coastal mountains near the Mexico-California border, north along the Sierra Nevada range and along the coast to the southern Cascades (Verts and Carraway 1998). In Oregon, the western gray squirrel occurs throughout the Willamette Valley, southwest Oregon, the Columbia Gorge, foothills of the western Cascades, and lower elevations of the eastern Cascades (Verts and Carraway 1998).

Ecology—In western Oregon, western gray squirrels are strongly associated with *Quercus* woodlands and conifer forests in which Oregon white oak co-occurs (Verts and Carraway 1998). Dalquest (1948) stated that the occurrence of western gray squirrels in Washington is primarily regulated by the spatial distribution of Oregon white oak, the only true oak (*Quercus* spp) that occurs in the state. In contrast, Ryan and Carey (1995b) failed to detect western gray squirrels in pure stands of Oregon white oak at Fort Lewis, Washington, but found that the frequency of stand use was correlated with the species-richness of trees and shrubs that produce large seeds and fruits.

The geographic distribution and life history characteristics of true oaks probably prevent western gray squirrels and other vertebrates from becoming overly dependent upon acorn crops as a food source in the Willamette Valley. Oregon white oak is the only acorn-producing species across most of the Valley (scattered populations of California black oak occur in Lane County) and its acorn production exhibits high inter-annual variation in abundance and synchronicity across large geographic areas (Coblentz 1980, Ryan and Carey 1995a, Peter and Harrington 2009). High yields of mast may only occur once every 3 to 6 years (Ryan and Carey 1995b), thus posing a significant limit to any wildlife species that specializes in feeding upon acorns. Coblentz (1980) speculated that a poor mast crop in the Willamette Valley during 1978 affected the abundance of western gray squirrels in the region.

Besides acorns, the diet of western gray squirrels in Oregon is composed of seeds from Douglas fir (*Pseudotsuga menziesii*) Sitka spruce (*Picea sitchensis*), grand fir (*Abies grandis*) and pines (*Pinus* spp); as well as berries, leaf buds, and tree sap (Bailey 1936; Maser et al. 1978). Hypogeous fungi (i.e., truffles) may comprise a large proportion of their diet during spring and summer (Cross 1969, Stieneck and Browning 1970). The mutualistic relationship with ectomycorrhizal fungi is essential to the growth of Oregon white oak, thus by dispersing mycorrhizal inoculum, small mammals play a crucial role in the regeneration of oak trees (Frank et al. 2008). Western gray squirrels were not one of the species tested in the southern Oregon study by Frank et al. (2008), but squirrels seem likely dispersers of mycorrhizal inoculum among Willamette Valley oaks given the prominence of truffles in their diet.

Western gray squirrels at Fort Lewis exhibited a preference for woodland patches >8 ha in area than smaller patches (stands ranged between 0.4 – 48 ha) and for woodlands within 0.6 km of water (Ryan and Carey 1995b). Larger woodlands probably offer more abundant resources and a greater number of travel routes for arboreal species; therefore the preference for larger patches by squirrels in Washington is also likely to hold for Willamette Valley populations, although this hypothesis remains untested. Ryan and Carey (1995b) did not offer any underlying reason for the increased frequency of squirrel occurrence they observed near watercourses. Three explanations seem possible: 1) there maybe a greater diversity and abundance of food plants in riparian areas than in uplands, thus riparian areas are capable of supporting greater population densities of squirrels, 2) trees and shrubs along water courses may provide travel corridors across otherwise impermeable landscapes, and/or 3) western gray squirrels may have a high physiological demand for water, which requires individuals to visit drinking water sources frequently. All three explanations seem plausible to us, but so far remain unexamined.

There is little information about the reproduction of western gray squirrels from Oregon. Pregnant females have been collected from Benton County (Verts and Carraway 1998) and southwest Oregon (Cross 1969) during March. Foster (1992) found females in estrus from January to March and in June in northeast Oregon. Females typically produce only one litter per year in the Pacific Northwest (Ryan and Carey 1995a). Western gray squirrels use tree cavities as dens and also construct stick nests, called dreys. Dreys are usually constructed near the stem and in the upper-third of the tree. Conifers and hardwoods are used for denning (Foster 1992).

Cross (1969) reported that summer home ranges of female western gray squirrels in southwestern Oregon ranged between 2.1 – 26.1 ha (3.3 – 42.0 ac; n = 3) and between 3.2 – 13.7 ha (5.1 – 22.0 ac; n = 3) for males. In a northeast Oregon study, Foster (1992) reported that home ranges of females ranged between 2.6 - 9.9 ha (4.2 to 16.0 ac; n = 3) and between 4.6 – 7.8 ha (7.4 - 12.6 ac; n = 4) for males. Winter home ranges are almost always smaller in area than summer home ranges (Cross 1969, Ryan and Carey 1995a, Linders et al. 2004).

Habitat Management/Restoration—In the Willamette Valley, Oregon white oaks and California black oak (in Lane County only) are perhaps the single most important habitat element of gray squirrels. Acorns and hypogeous fungi specifically associated with oaks are crucial components of their diet. Branches of mature oaks also are also the most available substrates for cavity nests used by gray squirrels on some landscapes. Annual acorn production varies greatly, so maintaining a diversity of food plants will ensure a consistent supply of food during all seasons.

In Washington, the western gray squirrel is listed as a state threatened species and is afforded special protection during forestry operations (Vander Haegen et al. 2004). The following guidelines have been established in Washington to protect gray squirrels (Vander Haegen et al. 2004):

- Protect all squirrel nests and nest trees
- Maintain a no-cut buffer within 50 feet of each nest tree
- Retain at least 50% canopy coverage within 400 feet of each nest tree
- Maintain habitat connectivity among nests, water sources, and foraging habitat by retaining/creating arboreal travel corridors.
- Retain all oaks whenever possible
- Avoid logging, road building, or other noisy activities within 400 ft of all nest trees during the western gray squirrel breeding season (1 March – 30 September).

Vander Haegen et al. (2004) found that likelihood of occupancy was much greater at sites where operators complied with the above guidelines than at sites where guidelines were not followed. Although Oregon forestry operators are not restricted in stands occupied by gray squirrels, the Washington guidelines offer a reasonable, voluntary approach to protecting the species during oak restoration treatments or timber harvests.

Non-Habitat Limiting Factors— Predators of western gray squirrels include the northern goshawk (*Accipiter gentilis*), red-tailed hawk (*Buteo jamaicensis*), great-horned owl (*Bubo virginianus*), bobcat (*Lynx rufus*), common gray fox (*Urocyon cinereoargenteus*; Ingles 1947), coyote (*Canis latrans*; Cross 1969) and domestic cat (*Felis catus*; Verts and Carraway 1998). Ingles (1947) stated that he did not believe predators were a significant factor limiting gray squirrel populations in California, but we did not find research comparing rates of mortality among different sources anywhere across the geographic range of the species.

Western gray squirrels compete against a large number of other native species for food and den sites, including the scrub jay (*Aphelocoma coerulescens*) and Steller's jay (*Cyanocitta stelleri*, Verts and Carraway 1995), Lewis woodpecker (*Melanerpes lewis*; Cross 1969, Foster 1992), acorn woodpeckers (Ingles 1947, Cross 1969), Douglas' squirrel (*Tamiasciurus douglasii*), and California ground squirrel (*Spermophilus beecheyi*; Ingles 1947). Ingles (1947) speculated that competition with Douglas' squirrels limited the upper elevational range of western gray squirrels in the Sierra Nevada range of California. In Oregon, western gray squirrels potentially compete against two introduced squirrels: the eastern gray squirrel (*Sciurus carolinensis*), and eastern fox squirrel (*Sciurus niger*; Verts and Carraway 1995, Weston 2005). The former species is more adaptable to urban areas and able to produce two litters a year when food is abundant (Foster 1992; Ryan and Carey 1995), characteristics that are likely to permit the eastern gray squirrel to displace the western gray squirrel across extensive areas of the Willamette Valley in the future.

Vehicles were recognized as a major source of mortality as early as the mid-1940's (Ingles 1947). Of 81 western gray squirrels studied at Ft Lewis, 13 were killed on roads (Ryan and Carey 1995b). The importance of road mortality to population viability has not been investigated, but because of the demonstrated high mortality in some areas, road mortality is an important threat to consider for conserving this species in the Willamette Valley, especially near urban or high-use recreation areas.

Outbreaks of notoedric mange maybe a significant source of mortality during some years. Cornish et al. (2001) reported that no squirrels initially captured in Klickitat County, Washington during winter 1998 appeared to have mange, but 59% of squirrels captured in the same study area during August 1998 – July 1999 had contracted the disease; 42% of affected squirrels died. Squirrels may have been predisposed to contracting mange because of poor nutrition that was a consequence of acorn crop failure. Transmission of the disease may have been inadvertently facilitated by repeated trapping using contaminated equipment (Cornish et al. 2001).

Human Disease—In California, the western gray squirrel has been implicated as the primary vertebrate reservoir of Lyme disease (*Borrelia burgdorferi*), which is can be transmitted to humans through infected ticks of the species *Ixodes pacificus* and *Dermacentor occidentalis* (Lane et al. 2005). Nevertheless, infection rates among ticks in California and Oregon remains low (5-6%; Stafford 2007). Western gray squirrels in northern California also were found to have the highest rate of exposure among rodent species tested for *Anaplasma phagocytophilum*, an emerging and potentially fatal disease in humans and wildlife. Gray squirrels also host ticks that are capable of transmitting the *A. phagocytophilum* to humans (Nieto and Foley 2008).

Survey Methods— Bayrakgi et al. (2001) compared four different methods for determining presence or density of western gray squirrels: 1) visual surveys along transects, 2) calling surveys, 3) trapping, and 4) infrared camera stations. The authors reported that visual surveys were effective in their study, but may be less so on landscapes where population densities are very low. Calling surveys were ineffective for detecting squirrels. However, the investigators used recordings of eastern squirrels which may have failed to elicit responses from western gray squirrels. Bayrakgi et al. (2001) did not capture a single western gray squirrel after 8,002 trap nights. However, other investigators have had better success (Cross 1969, Linders 2000). The expense, permitting process, and technical expertise required for mammal live trapping precludes the use of these methods for most effectiveness monitoring efforts. Bayrakgi et al. (2001) found that baited camera stations were useful for detecting the presence of gray squirrels and more cost-effective than visual surveys.

Acorn Woodpecker (*Melanerpes formicivorus*)

Conservation Status—The acorn woodpecker is listed as an ISSSSP Sensitive Species in Washington, and is an Oregon Conservation Strategy Species (ODFW 2006). The species has no special federal status. Threats to the continuing viability of this species in the Willamette Valley include the loss of large Oregon white oaks and competition from European starlings for tree cavities (ODFW 2006).

Distribution—The geographic range of the acorn woodpecker extends from southern Washington, through western Oregon and California (west of the Sierra Range), New Mexico, Texas, and further south through Mexico and Central America (Koenig et al. 1995). The species is currently a locally common, year-round resident of the Rogue and Umpqua Valleys; a less common resident of the Willamette Valley (Simmons 2003). The present distribution in the Northwest represents a recent range expansion. Acorn woodpeckers were rare north of Eugene, Oregon during the 1940's (Gabrielson and Jewett 1940) and were not regularly observed in Washington until 1995 (Simmons 2003). Koenig and Haydock (1999) suggest that the geographic distribution of acorn woodpeckers is strongly influenced by the local diversity of *Quercus* species: fewer oak species increases the annual probability of acorn crop failure and the subsequent decrease in acorn woodpecker fitness.

Ecology—In Oregon, the species is closely associated with *Quercus* woodlands, ponderosa pine/oak savannas, tanoak woodlands, and southwest mixed conifer/hardwood communities (Simmons 2003). Johnson and Rosenberg (2006) found that the basal area of Oregon white oaks was almost twice as great in stands containing acorn caches created by acorn woodpeckers called granaries (50.1 m^2/ha, SE =4.1 m^2/ha) than stands that did not (27.2 m^2/ha, SE= 3.0 m^2/ha). Eight occupied stands in Benton County, Oregon had a mean tree density of 264 trees/ha (107 trees/ac) and a mean tree diameter at breast height (dbh) of 48.8 cm (19.2 in; Doerge 1978). Stands used by acorn woodpeckers often have less understory shrub cover than unused stands (Hooge 1999, Johnson and Rosenberg 2006).

As the name suggests, the diet of the acorn woodpeckers includes a large proportion of mast, but also contains a significant amount of insects during spring and summer (MacRoberts and MacRoberts 1976). Unlike most other woodpeckers, the acorn woodpecker primarily forages on insects by pursuing them in flight (MacRoberts and MacRoberts 1976). All members of an acorn woodpecker colony participate in collecting acorns and storing them in communal granaries—trees or other wood structures in which acorns (sometimes thousands of them) are fitted into individually drilled holes. Granaries are an important resource for acorn woodpecker colonies, sometimes containing all the available food to supply a colony during winter months. On average, acorn woodpecker colonies in Benton County, Oregon were found to contain 75.2 granaries (Doerge 1978). Acorn productivity is highly cyclical and synchronous within *Quercus* species, a phenomenon that leads to regular failures of mast crops (Peter and Harrington 2009), and imposes limits on the size and distribution of acorn woodpecker populations (Koening and Haydock 1999).

Acorn woodpeckers usually excavate nest cavities in dead branches of live trees (Koenig et al. 1995). Acorn woodpecker territories contain significantly larger numbers of dead limbs than are available in unoccupied areas (Doerge 1978). Tree species commonly used for nesting in Oregon and/or California include Oregon white oak (*Quercus garryanna*), valley oak (*Quercus lobata*), California sycamore (*Plantanus racemosa*), Douglas-fir (*Pseudotsuga menziesii*) and black cottonwood (*Populus trichocarpa*; Hooge et al. 1999, Simmons 2003). The average diameter of nest trees in a coastal California study was 98.3 cm dbh (38.7 in); range 35.6-254.6 cm dbh (14.0-100.2 in; Hooge et al. 1999). The mean outside diameter of the branch at the nest hole was estimated to be 31 cm (12.2 in); range 13.1-144.0 cm (5.2-56.7 in; Hooge et al. 1999). Hooge et al. (1999) reported that mean nest height was 8.3 m (27.2 ft); range 2.3-18 m (7.5-59.0 ft). A single nest cavity may simultaneously contain eggs from multiple female breeders (MacRoberts and MacRoberts 1976). Nest cavities are often used for several years (Koenig et al. 1995). Tree cavities are also used for communal roosting (MacRoberts and MacRoberts 1976), which would seem to be an essential behavior for surviving the winter climate in Oregon.

Acorn woodpeckers live in colonies consisting of breeding individuals and non-breeding helpers (Koenig et al. 1995). Doerge (1978) found that in Benton County, Oregon the average colony size was composed of 4.25 individuals (range 2-8 individuals, n = 8 colonies). Colonies are generally larger in other areas of the species geographic range. Colonies are typically composed of 1-7 breeding males, 1-3 breeding females, and as many as 10 non-breeding helpers (Koenig and Mumme 1987). The small colony sizes observed by Doerge (1978) may reflect the low diversity of true oaks and marginal habitat capability for acorn woodpeckers in the Willamette Valley. Helpers will attempt to seek breeding positions among groups outside of their natal colony. Competition among females is particularly fierce and can lead to violent power-struggles (Koenig et al 2000). In coastal California, estimated dispersal distances range from 0.53–9.57 km (0.33-5.94 mi) for females and 0.22–2.90 km (0.14-1.80 mi) for males (Koenig et al. 2000).

The mean territory size at a site in coastal California (containing multiple territories) was 6.0 ha, range 3.5-9.0 ha (mean 14.8 ac, range 8.7-22.2; MacRoberts and MacRoberts 1976). At the same site, Hooge (1995) estimated that mean home range was 5.5 ± 2.0 SD ha (13.6 ± 4.9 SD ac) for male breeders, 4.9 ± 2.32 ha (12.1 ± 5.7 ac) for female breeders, 13.2 ± 7.6 ha (32.6 ± 18.8 ac) for non-breeding males and 89.3 ± 56.9 ha (220.6 ± 140.5 ac) for non-breeding females. The large variation in home range size between breeding and non-breeding individuals is primarily due to extra-territorial explorations by non-breeders for breeding position vacancies among outside colonies (Hooge 1995). In contrast, Doerge (1978) reported that the mean home range of acorn woodpeckers among her Willamette Valley sites was only 0.69 ha (1.7 ac). Koenig et al. (1995) noted that territory and home range sizes are highly variable for the species and are affected by the spatial pattern of habitat patches.

Habitat Management/Restoration —Few other vertebrates are as closely associated with oak woodlands in the Willamette Valley as the acorn woodpecker. Preserving large-diameter oaks and ensuring the growth of replacement trees are crucial to survival of acorn woodpecker colonies. Tree competition has a pronounced affect on mast crops (Peter and Harrington 2002), and thus influences fall/winter food availability for acorn woodpeckers. As the crowns of individual oaks are shaded by their cohorts or are over-topped by conifers, acorn production decreases. Maintaining adequate spacing between oaks so that the full crown of each tree is exposed to the sun will maximize the mast productivity of the stand. Peter and Harrington (2002) found that tree crown shape was a useful predictor of acorn productivity: trees having full, “mushroom-shaped” crowns were 6 times more likely to be in the highest acorn productivity class than suppressed, “vase-shaped” trees. Prescribed burns conducted to reduce understory shrub cover were found to have a positive, although delayed (6-10 years) effect on acorn productivity (Peter and Harrington 2002). Acorn production is also influenced by tree age. Production is rare in trees <20 years of age, but increases steadily until trees are 60-80 years, then plateaus until trees reach an advanced age (>180 years; Peters and Harrington 2002).

Nest trees, roosting cavities, and granaries are critical elements of acorn woodpecker habitat. Land managers should ensure that these essential sites are identified and protected in occupied territories before conducting tree harvest and stand thinning operations. Additional large (>35 in dbh) oaks should be maintained or recruited as future replacements for nest trees and granaries. Research suggests that live trees with dead, large-diameter (>12 in) branches are especially valuable components of nest habitat.

Habitat managers also should provide sufficient space for acorn woodpeckers to conduct their various life requisite activities. Colonies have been reported to use home ranges smaller than 2 ac, but most research indicates that breeding members of a colony typically defend territories ranging in area between 8-22 ac.

In the Willamette Valley, acorn woodpeckers are distributed in widely-dispersed groups, many of which likely are isolated from one another due to the significant loss of oak woodland habitat (less than 7% of its former extent; ODFW 2006). Habitat managers should insure that restoration projects designed to create habitat for acorn woodpeckers in areas unoccupied by the species are located within range of dispersal (females <6 mi; males <2 mi) from an existing group to maximize the probability that the newly created habitat is colonized.

Non-Habitat Limiting Factors—We failed to find research that investigated the effects of disease, predation, competition, or other limits to acorn woodpecker populations. However, Koening et al. (1995) hypothesizes that predation is probably the greatest cause of mortality in adults. Acorn woodpeckers have been observed protecting eggs, tree cavities, and food resources from numerous other avian and mammalian species, but apparently are nearly always successful defending against predators and competitors by mobbing the intruder (MacRoberts and MacRoberts 1976). Intraspecific competition for nest sites and deliberate destruction of eggs by conspecifics are major causes of egg mortality (Koening and Mumme 1987).

Streaked Horned Lark (*Eremophila alpestris strigata*)

Conservation Status— *Eremophila alpestris strigata* is listed as an ISSSSP Sensitive Species in Oregon and Washington, and has been designated as an Oregon Conservation Strategy (OCS) species and a federal candidate subspecies for listing under the Endangered Species Act (ODFW 2006, USFWS 2009). Factors causing declines are reported to include reduced prairie habitat quality and nest failure due to land management practices such as mowing and spraying (ODFW 2006). Drovetski et al. (2006) estimated the total population size of the streaked horned lark is <800 individuals across the subspecies' geographic range, although this estimate warrants revision because of the recently discovered activity centers in Oregon (Altman, pers. comm.; R. Moore unpublished survey data). Mitochondrial DNA studies indicate that *E. a. strigata* demonstrates remarkably little genetic diversity among populations along the Pacific Northwest coast and has long been isolated from interior subspecies (Drovetski et al. 2006). Given the distinctive genetics of the streaked horned lark and problems of small populations, Drovetski et al. (2006) recommend that actions to ensure the future of the subspecies be a priority.

Distribution— Of the 21 subspecies of *E. alpestris*, three or four are known to breed in Oregon (Altman 2003b). *E. a. strigata* is the only subspecies to regularly breed in the Willamette Valley, but other subspecies over-winter in the region (Moore 2008a). The streaked horned lark is considered an uncommon permanent resident of the central Willamette Valley that is distributed in scattered, localized populations (Altman 2003b). The subspecies was formerly considered common in western Oregon and particularly abundant in Yamhill, Polk, Linn and Benton Counties (Gabrielson and Jewett 1940). Other subspecies of *E. alpestris* remain common in shrub-steppe communities of eastern Oregon (Reinkensmeyer et al. 2007)

Ecology—Horned larks occur in open fields with large patches of bare ground and sparse vegetation, beaches, and foredunes; forests and tall vegetation are avoided (Beason 1995, R. Moore pers. comm.). In the Willamette Valley, Altman (2003b) found that streaked horned larks were absent in fields having grass layer heights >0.6 m (2 ft). However there is evidence that the species will use fields with taller grass if its cover is sparse (R. Moore, pers. comm.). Landcover types used in the Willamette Valley include: native prairie, Christmas tree farms, plowed fields, intensively grazed pastures, mudflats, gravel roads, and grass seed fields of suitable vegetation structure (Altman 1999, R. Moore pers. comm.). In the Columbia River Gorge, areas where dredging spoils have been deposited are occupied by streaked horned larks, however some nests have been destroyed when spoils have been dumped onto nests (Pearson et al. 2008).

A study on an agricultural landscape in Colorado found that that horned larks avoid field edges, but nesting success showed a surprising negative relationship with size of breeding habitat patches (Skagen et al. 2005). However this finding may have been caused by the unique composition of local predator communities (Skagen et al. 2005) and has not been replicated elsewhere.

The diet of adult streaked horned larks is primarily composed of seeds, seedlings of crop plants (e.g., wheat, oaks, lettuce), and insects; adults feed insects to their young (Beason 1995). Moore (2008b) reported that streaked horned larks wintering in the Willamette Valley concentrate their feeding on seeds from only one or two non-native grass or forb species, although the food plants differ among horned lark flocks. The findings were ambiguous as to whether horned larks demonstrated a preference for the non-native seeds taken, or a lack of more preferable alternatives on intensively managed croplands.

The timing of nesting activities in the Willamette Valley is variable, probably in response to weather and environmental factors (Altman 2003b). Eggs have been discovered as early as March 15 (Altman 2003b), but nesting typically does not commence until May 1 (R. Moore, pers. comm.). Eggs have be observed in nests as late as mid-August (R. Moore pers comm.). The nest is constructed on the ground, in a natural depression or one excavated by the female (Beason and Franks 1974). The nest is usually located on the north side of rock or patch of tall plants to protect nestlings from direct sun (Hartman and Oring 2003). Females show very strong fidelity to nest sites (Pearson et al. 2008).

Average territory size in the Willamette Valley is 0.77 ha (1.9 ac, n=3; Altman 1999). Across the geographic range of the species, territory size ranges between 0.3 - 5.1 ha (0.74 - 12.6 ac, Beason 1995). Territories are abandoned in fall and individuals aggregate into winter flocks (Altman 2003b).

Habitat Management/Restoration— Recommendations by Altman (2003), (Moore 2008a), personal communications with R. Moore provide the following guidance for managing streaked horned lark habitats:

- Delay mechanized activities in nesting habitats (including croplands) during nesting and fledging periods (after August15) to avoid egg and juvenile mortality
- Create and/or maintain habitat patches characterized by bare ground or sparse, herbaceous vegetation that remains undisturbed during the breeding season. Herbicides applied prior to the nesting season have been used successfully to prevent the development of dense vegetation around nests (R. Moore pers. comm.)
- Pastures provide some opportunities for nesting; however the grass cover that is typically maintained for livestock forage is too dense for horned lark nesting. Horned larks will opportunistically used over-grazed areas.
- Horned larks can become habituated to aircraft and ground vehicle traffic, but are easily disturbed by foot traffic. Maintain a buffer around nesting areas to exclude human visitors, dogs (*Canis lupus familiaris)*, and domestic cats (*felis catus*) during the nesting season.

Pearson et al. (2006) state that the strong fidelity displayed by females to previously used nest sites decreases the likelihood that the species will colonize restored habitats. Post-fledging juveniles are more likely than breeding adults to discover and utilize new habitat patches, and habitat management areas created near existing populations have a greater chance of being encountered by juveniles.

Non-Habitat Limiting Factors—
Predation is a major cause of mortality among adults and juveniles (Beason 1995); especially by mammals closely-associated with rural residential areas such as striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), feral and domestic cats (), dogs (Altman 2003b) and mice (Peromyscus maniculatus; R. Moore pers. comm.). Significant avian predators include the northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), and red-tailed hawk (*Buteo jamaicensis*),

Mechanized agricultural operations such as mowing, tilling, and spraying has been reported to cause direct mortality of eggs and juveniles (Beason 1995, Altman 2003b). The tendency of streaked horned larks to forage and nest on roadsides causes the species to be vulnerable to traffic-related mortality (Altman 2003b).

Slender-Billed Nuthatch *(Sitta carolinenses aculeata)*

Conservation Status—The slender-billed nuthatch is one of two subspecies of *S. carolinenses* (commonly called the white-breasted nuthatch) occurring in Oregon. Slender-billed nuthatches are listed as an ISSSSP Sensitive Species in Washington, and designated as an Oregon Conservation Strategy species because populations are "low and declining" (ODFW 2006:314). The slender-billed nuthatch has no special federal status in Oregon, but the species is designated as a USFWS species of concern in Washington (USFWS 2009). Factors causing the decline of slender-billed nuthatch populations are reported to be loss of large-diameter oaks and a subsequent reduction in the availability of tree cavities (Hagar 2003), as well as competition for cavity nest sites (Viste-Sparkman 2005).

Distribution—White-breasted nuthatches are a widely-distributed, year-round resident of North America (Grub and Pravosudov 2008). Mitochondrial DNA analysis suggests that the eight recognized subspecies of *S. carolinenses* are organized into four monophyletic clades that have differentiated *in situ* during the fragmentation of the continental Tertiary forest caused by Late Miocene and Pliocene orogeny, and through further population isolation caused by glacial cycles and climatic shifts (Spellman and Klicka 2007).

In Oregon, *S. carolinenses aculeata* is distributed across wooded slopes of the major interior valleys west of the Cascade Range; *S. carolinenses tenuissima* occurs in forested areas east of the Cascade crest (Hagar 2003). Slender-billed nuthatches probably have never been common in the Willamette Valley, at least since European settlement (Gabrielson and Jewett 1940). Today, the subspecies is considered to be rare across most of the Valley, but can be locally common in stands of oak (*Quercus* spp.), mixed oak-conifer woodlands, and nut orchards (Hagar 2003).

Ecology—Today, slender-billed nuthatches are most closely associated with woodlands dominated by Oregon white oak (*Quercus garryanna*) in the Willamette Valley (Hagar 2003). Slender-billed nuthatches also frequently use stands of mature ponderosa pine (Anderson 1976, Contreras 1997), a habitat type that is now exceedingly rare in the Willamette Valley, but was much more extensive on the pre-European landscape (Hibbs et al. 2002). Hagar and Stern (2001) reported a positive relationship between the relative abundance of slender-billed nuthatches and the average diameter of oaks in Willamette Valley woodlands. In another Willamette Valley study, Viste-Sparkman (2005) found that the population density of slender-billed nuthatches was strongly associated with oak canopy cover and the stand frequency of large oaks (diameter breast height >50-cm; >20 in). DeMars (2008) reported that slender-billed nuthatches will use relatively isolated, individual oak trees on agricultural landscapes.

Investigations into the response of slender-billed nuthatches and other subspecies of *S. carolinensis* to patch size and landscape configuration have yielded conflicting findings. In the Willamette Valley, Vista-Sparkman (2005) reported that slender-billed nuthatch density was greater in small oak woodland patches and was positively associated with increasing landscape edge density. Similarly, white-breasted nuthatches were found to be more closely associated with edges rather than interiors of oak woodlands in California (Sisk and Margules 1995). However, studies conducted in Illinois (Blake and Karr 1987) and the Mid-Atlantic States (Robbins et al. 1989) reported that the abundance of white-breasted nuthatches was positively associated with larger woodland patches. In Ontario, the presence of the species was unrelated to the amount or configuration of forest cover on the landscape (Villard et al. 1999). The discrepancy among these findings could be due to sensitivity of the species response to the scale and extent of the study area, as well as to the types of patches and edges (e.g., oak woodland-conifer forest, oak woodland-dry prairie) represented on the study area (Thompson et al. 2002). Vista-Sparkman (2005) posited several ecological explanations for the association between slender-billed nuthatch density and woodland edges—her principle assertion being that oaks near woodland edges grow larger and have more fully-developed crowns than interior trees, attributes associated with greater availability of food and tree cavities.

The slender-billed nuthatch is primarily a bark-forager, using its long bill to probe into bark crevices for insects (Hagar 2003). However, the species will sometimes glean foliage of trees and shrubs for food (Anderson 1976). The greater abundance and diversity of arthropods that has been observed in trees with furrowed bark compared to smooth-barked trees (Jackson 1979) offers a possible explanation for the close-association between slender-billed nuthatch abundance and large-diameter oaks, which are characterized by increasingly fissured bark as trees mature. Insects comprise most of the diet during all seasons of the year; weevils (Coleoptera and Curculionida) reportedly are the most common prey items in the Willamette Valley (Anderson 1976). Plant seeds, especially those of sedge (Cyperaceae), are a minor component of the winter diet (Anderson 1976).

Slender-billed nuthatch pairs hold year-round territories, but defense behavior declines outside of the breeding season (Hagar 2003). Nesting has been observed as early as mid-April in Oregon, but most nesting/rearing activities peak during June (Adamus et al. 2002). Slender-billed nuthatches are a secondary cavity-nester, usually using a tree cavity excavated by a woodpecker. During a 2-year study in the Willamette Valley, 52 out of a total of 77 nests discovered were in Oregon white oak trees (Viste-Sparkman 2005). On average, nest trees were 71 cm diameter breast height (DBH), range 10-137 cm DBH and contained 8.2 cavities per tree (Viste-Sparkman 2005). The average height of nest cavities was 6.1 m (95% confidence interval [CI] 4.9-7.3 m) and branch diameter at the nest cavity averaged 49 cm (CI 43-55 c; Viste-Sparkman 2005). Of 41 nests discovered by Viste-Sparkman (2005) in 2004, 10 were in cavities used the previous year.

No home range or territory size estimates are available for the slender-billed nuthatch. However, a research summary compiled by Grubb and Pravosudov (2008) found that territory sizes for *S. carolinensis* across the US, as well as a Eurasia congener range between 10-40 ha (25-98 ac); territory sizes tending toward the smaller end of the range in closed-canopy forest and larger territories in open woodlands. Our literature review did not reveal any descriptions of natal dispersal

Habitat Management/Restoration—Slender-billed nuthatches reach their highest densities in oak or mixed oak-conifer woodlands. Trees used for nesting are characterized by their large diameter, open-grown form, and multiple cavities in the stem and large branches. Oregon white oak stands occupied by slender-billed nuthatches are characterized by relatively high canopy cover (40-97%) and oak basal area (mean 24 m^2/ha; Viste-Sparkman 2005).

Non-Habitat Limiting Factors— There is surprisingly little information describing sources of mortality or non-habitat limiting factors for such a widespread species. In the Willamette Valley 13 of 25 nests monitored during 2003-2004 failed; of the 13 failed nests, 11 were taken by unspecified predators (Vista-Sparkman 2005). Owls and hawks are assumed to be predators of adult nuthatches (Grubb and Pravosudov 2008)

Western Bluebird *(Sialia mexicana)*

Conservation Status— The western bluebird is not listed under the ISSSSP, but is an Oregon Conservation Strategy species (ODFW 2006), however the species has no special federal status. The western bluebird was previously abundant in Oregon (Gabrielson and Jewett 1940), but only transient individuals were observed in the Willamette Valley by the 1970's (Prescott 1979). An analysis of 1966 – 2007 North American Breeding Bird Survey data from routes in western Oregon shows a slight, non-significant, increasing trend in abundance (Sauer et al. 2008). A long-term demography study conducted in the northern Willamette Valley found bluebird populations to be slightly increasing within the study area (Keyser et al. 2004). Factors limiting western bluebird populations in Oregon are reported to be: loss of savanna habitat, decreased availability of snags on managed forests, declining habitat quality due to invasive plants, competition from non-native birds, and predation by house cats (*Felis catus*; Eltzroth 2003, ODFW 2006).

Distribution—The geographic range of the western bluebird extends from British Columbia and Idaho, south through Washington, Oregon, and California,and includes much of the southwest U. S., and northern and central Mexico (Guinan et al. 2008). Western bluebirds breed throughout the Willamette Valley, but are more common in the foothills of the Coast Range and Western Cascades than the Valley floor (Eltzroth 2003). Some bluebirds from the northernmost portions of the geographic range migrate in winter to Mexico, Arizona, or California, but other individuals (including those in the Willamette Valley) only move to lower elevations near their summer range (Eltzroth 2003, Guinan et al. 2008).

Ecology—In western Oregon, western bluebirds breed in open woodland, oak savannas, along grassland-forest edges, and clearcuts with retained snags and avoids dense forests (Eltzroth 2003, Guinan et al. 2008). Nesting habitat typically has an open understory (Thomas et al. 1979, McGarigal 1993); however, dense shrubs are used as cover during winter (Eltzroth 2003).

Diet during the breeding season is primarily composed of invertebrates, including: grasshoppers (*Orthoptera*), caterpillars *(Lepidoptera*), beetles (*Coleoptera*), and other arthopods (Guinan et al. 2008). During winter, bluebirds forage on fruits and seeds from elderberry (*Sambucus* spp.), mistletoe (*Phoradendron* spp., a common parasite of Oregon white oak), *Rubus* spp., poison oak *(Rhus diversiloba*), and other plants (Guinan et al. 2008).

In the Willamette Valley, nest building begins in late-March or early-April (Eltzroth 2003). The species is a secondary cavity-nester, usually requiring a tree cavity excavated by a woodpecker, but occasionally finding a suitable cavity created by wood decay (Eltzroth 2003). In a study conducted in the Oregon Coast Range, the diameter of nest trees averaged 71 cm (28 in) dbh, range 25-137 cm dbh (9.8-53.9 in dbh) and the average height of the nest cavity was estimated to be 9.2 m (30.2 ft), range 3.6-18.0 m (11.8-59.1 ft; Schreiber and DeCalesta 1992). In western Washington, nest trees averaged 43.9 cm

(17.3 in) dbh; 34.0 cm (13.4 in) diameter at the nest hole, with a mean nest height of 7.0 m (23 ft; Zarnowitz and Manual 1985). Artificial nest boxes are readily used by bluebirds; boxes in mid-day shade are preferred over more exposed sites (Sims 1983). As many as three clutches of 4-6 eggs may be produced during the breeding season (Eltzroth 2003). Non-breeding adults have been observed helping breeding pairs defend nests and feed juveniles (Guinan et al. 2008).

Keyser et al. (2004) estimated the average natal dispersal distance was 7.8 ± 6.48 km SD (4.8 ± 4.02 mi SD) for females (*n* = 225 dispersal events) and 2.3 ± 3.52 km (1.4± 2.19 mi SD) for males (*n* = 196). Females banded in Corvallis, OR traveled significantly farther than males from natal territories to breeding territories: mean male dispersal 3.1 km, range 0–14.5 km (mean 1.9 mi, range 0-9.0 mi, *n*= 68; mean female dispersal 9.0 km, range 0–96.5 km (mean 5.6 mi, range 0-59.9 mi) *n*= 50 (Guinan et al. 2008). Territorial fidelity is high. Keyser et al. (2004) reported that 58% of after hatch year juveniles and nearly 100% of adults known to be alive returned to their previous year breeding site.

There are no reports of home range or territory size from the Willamette Valley, but territory size in Arizona was reported to range from 0.56 ha to 0.79 ha (1.95-1.38 ac; Szaro 1976). Territories in a California study averaged 1.26 ha (3.14 ac; Kraaijeveld and Dickinson 2001).

Habitat Management/Restoration— The following management recommendations for western bluebirds mostly follow those of Guinan et al. (2008), with some additional information summarized from studies in Oregon:

- Maintain >20% combination of short, herbaceous vegetation and/or bare ground in breeding areas
- Manage tree density to maintain open woodland and savanna-type habitat conditions preferred by western bluebirds. In the Western Cascade Range, western bluebirds were most abundant during the breeding season in stands averaging 4 trees/ha (1.6 trees/ac); bluebirds were not detected in stands >20 trees/ha (8 trees/ac; Hansen et al. 1995)
- Monitor and manage for understory vegetation diversity to support an abundance of invertebrate prey
- Retain snags (>10 in dbh) and live trees with large, dead branches (branch diameter >10 in) to improve availability of nest cavities. Aggregated snags and nest trees are preferred over a uniformly distributed pattern
- Add nest boxes to provide a short-term solution where there is limited availability of natural tree cavities for nesting.

Given the high territorial fidelity of western bluebirds, newly restored habitats located near established breeding sites are more likely to be discovered and used by juveniles and unpaired adults than sites beyond the typical dispersal distance (females = 5.6 mi, males = 1.9 mi; Guinan et al. 2008).

Non-Habitat Limiting Factors— Non-native house sparrows (*Passer domesticus*) are a serious competitor for cavity nest sites and are known to destroy bluebird eggs and kill hatchlings; violet-green (*Tachycineta thalassina*) and tree swallows (*Tachycineta bicolor*) also compete for cavities (Eltzroth 2003). Guinan et al. (2008) reported that predation is a major cause of mortality among fledglings and adults in some western bluebird populations. Predators include snakes, rodents, weasels (*Mustela* spp.), feral and domestic cats (*Felis catus*), raccoons (*Procyon lotor*) and Cooper's hawks (*Accipiter cooperii*) (Guinan et al. 2008). Prolonged periods of cold, wet weather have resulted in the loss of eggs and hatchlings and may increase the incidence of disease and parasitism (Eltzroth 2003, Guinan et al. 2008).

Land managers should be cautious about using environmental contaminants on breeding habitats. Bluebirds experimentally exposed to high levels of lead gun shot showed immunological changes and decreased neurological responses compared to a control group (Fair and Myers 2002a). Fair and Meyer (2002b) detected organochlorine pesticide components in 44 of 99 grassland birds that were tested and found greater concentrations, on average, in insectivorous species (such as western bluebirds) than granivores or omnivores. These authors concluded that the effect of contaminants on the fitness of grassland birds will be unclear until longer-term investigations are conducted.

Chipping Sparrow *(Spizella passerina)*

Conservation Status—The chipping sparrow is not listed under the ISSSSP, but is classified by ODFW as a Conservation Strategy Species (ODFW 2006), but the species has no federal special status. Analysis of BBS data indicate a declining trend in detections of the species in Oregon during 1966-2000 (Scheuering 2003). Reported causes for the decline in chipping sparrow populations are loss of open oak woodlands in the Willamette Valley and alteration of historic fire regimes (Scheuering 2003, ODFW 2006).

Distribution— The chipping sparrow occurs in scattered, localized populations throughout the Willamette Valley during the spring and summer, but is more common in shrub-steppe communities of eastern Oregon (Scheuering 2003). Most of the Oregon population probably winters in Arizona, Texas, along the Gulf of Mexico in the U. S., or in northern Mexico (Middleton 1998); however, a few individuals usually remain in the Willamette Valley (Scheuering 2003).

Ecology—Chipping sparrows are most common in open woodlands, savannas, and openings within conifer forests; closed-canopy forests are avoided (Granholm 1988, Scheuering 2003). The species prefers areas with relatively sparse understories, but will forage in nearby shrubs (Granholm 1988). Hagar and Stern (2001) did not detect chipping sparrows in 5 oak woodland study sites that were known to be occupied by the species 27 years earlier (Anderson 1970, Anderson 1972). The authors hypothesized that increased tree density within the stands lessened habitat suitability. DeMars (2008) found that isolated Oregon white oaks on agricultural lands were used with similar frequency by chipping sparrows as individual oaks on savanna restoration sites. Chipping sparrows have been observed using filbert orchards in the Willamette Valley during winter (Scheuering 2003).

Chipping sparrows usually begin arriving in Oregon in late March (Scheuering 2003). Eggs and nestlings have been observed from late-May through mid-July (Scheuering 2003). Nests are constructed in a tree or tall shrub, usually 1-3 m above the ground, (Middleton 1998; Swanson et al. 2004). There is a preference for nesting in conifer saplings when they are available (Reynolds and Knapton 1984, Swanson et al. 2004). Clutch size ranges from 2-7 eggs (typically 4; Middleton 1998).

For most of the year, the diet of the chipping sparrow is composed of seeds from grasses and annual forbs (Allaire and Fisher 1975, Scheuering 2003). Insects (primarily Lepidoptera, Coleoptera, and Orthoptera) are an important component of the species' diet during the breeding season (Allaire and Fisher 1975).

In Montana, chipping sparrow density averaged 13.9±0.75 territories/10 ha (24.7 ac) in open ponderosa pine/Douglas-fir forest with native forb/bunchgrass ground cover (Ortega et al. 2006). Across their geographic range, the territory size of chipping sparrows varies between 0.3 ha (0.5 ac) to 1.6 ha (2.5 ac; Middleton 1998). The return rate of banded chipping sparrows to breeding territories previously established in native ponderosa pine/Douglas-fir plant communities was 56.6%; returns to stands invaded by spotted knapweed averaged 33.8% (Ortega et al. 2006). The authors surmised that reduced breeding success of pairs in knapweed infested territories caused fewer offspring to be produced, leading to fewer returns during following years.

Habitat Management/Restoration—Chipping sparrows would benefit from land management practices that maintain open woodlands and savanna habitats. Gaines et al. (2007) reported significantly greater density of chipping sparrows on restoration sites (treatment: 20% basal area retention, prescribed understory burning) in ponderosa pine/Douglas-fir/bunchgrass habitat than control stands with greater tree density in the same habitat type. Although the species occurs on croplands and managed pastures (DeMars 2008), food availability and breeding success are likely to be greater in habitats that support a higher diversity of native plants and insects (Ortega et al. 2006). Given the breeding site fidelity exhibited by chipping sparrows, restored habitats located in close-proximity to occupied breeding territories have a greater probability of being discovered and used by the species.

Non-Habitat Limiting Factors—
Studies from the western U. S. indicate that predation is the primary cause of nest failure (85% of failed nests, Swanson et al. 2004, Ortega and Ortega 2001). Known nest predators include snakes, common crow (*Corvus brachyrhynchos*), blue jay (*Cyanocitta cristata*, and domestic cat (*Felis catus*; Middleton 1998).

Across most of the U.S., the chipping sparrow is one of the most common species parasitized by brown-headed cowbirds (*Molothrus ater*). In southwest Colorado, 22% of nests were parasitized by brown-headed cowbirds, leading to an increased rate of nest abandonment and reduced clutch size (Ortega and Ortega 2001). In ponderosa pine forests of Colorado, 11.9% of chipping sparrow nests were parasitized (Swanson et al. 2004), although survival or productivity effects were not reported. McLaren et al. (2006) reported a 26% incidence of parasitism in Ontario, Canada. The incidence of parasitism is unknown in Oregon**,** but brown-headed cowbirds are abundant in agricultural landscapes of the Willamette Valley (Patterson 2003).

Oregon Vesper Sparrow *(Pooecetes gramineus affinins)*

Conservation Status—The Oregon vesper sparrow is one of two *Pooecetes gramineus* subspecies occurring in Oregon. The Oregon vesper sparrow is an ISSSSP Sensitive Species in Oregon and Washington, and is designated as an Oregon Conservation Strategy (OCS) species in the Willamette Valley and designated as a subspecies of concern by the U.S. Fish and Wildlife Service (ODFW 2006, USFWS 2009). Limiting factors are reported to be: habitat degradation due to altered fire regimes and invasive species; nest failure due to agricultural practices during breeding season; and predation by domestic cats (*felis catus*; ODFW 2006). Except for one research study (Altman 1997, Altman 1999), all information on *Pooecetes gramineus affinins* from the Willamette Valley is based on anecdotal observations. Therefore many aspects of the subspecies autecology can only be approximated by relying on research conducted on other subspecies of *P. gramineus*

Distribution—*P. g. affinis* is a long distance migrant that breeds west of the Cascade crest in Oregon. A second subspecies, *P. g. confinis* is a summer resident occurring throughout the shrub-steppe east of the crest (Altman 2003a). Northern populations of *P.g. affinis* (including Oregon) winter in southern U.S. to central Mexico (Jones and Cornely 2002). Oregon vesper sparrows were once abundant in the Willamette Valley (Gabrielson and Jewett 1940), but are now rare across most of the region (Altman 1999). The present Willamette Valley population is most common in the low foothills and buttes along the periphery of the Valley (Altman 1997).

Ecology— Across the geographic range of *P. gramineus*, the species occupies a wide variety of grassland and agricultural habitat types including: native prairies and savannas, shrub-steppe communities, hayfields, pastures, and croplands (Jones and Cornely 2002). There is no information describing habitat relationships of the Oregon vesper sparrow prior to European settlement of the Willamette Valley. However, the species' affinity for short stature grasslands across contemporary landscapes suggests that Oregon vesper sparrows were probably most closely associated with native upland prairies and savannas that once extended across the Willamette Valley foothills and dry sites on the valley floor. During the early Twentieth-Century, Oregon vesper sparrows apparently were well adapted to agricultural landscapes in the Willamette Valley. Gabrielson and Jewett (1940) found the species common in "open meadows and farmlands".

During an survey of grassland songbirds of the Willamette Valley conducted in 1996, 95% of Oregon vesper sparrows were detected in lightly grazed pastures and 2-5 year old Christmas tree plantations, although <15% of sampling occurred in those habitat types (Altman 1997). Vegetation structure in habitats occupied by the species is characterized by sparse shrubs (<25% of total cover), grass cover height <30 cm (< 12 in; Altman 1997), and the presence of singing perches above the herbaceous canopy such as trees, tall shrubs, or fence posts (Jones and Cornely 2002).

The diet of Oregon vesper sparrows has not been investigated, but other subspecies of *P. gramineus* feed upon caterpillars and other invertebrates during the breeding season; seeds of grasses and forbs are consumed all year (Berger 1968).

Spring migrants begin appearing in the Willamette Valley during mid-March to mid-April (Altman 2003a). Ground nests are constructed from mid- to late-May, usually at the base of a shrub, tree, or other object (Altman 2003a). In northeast Oregon, grass cover height surrounding the nests of *P. gramineus. confinis* averaged 13 cm, SD =0.07 (5.1 in, SD = 0.28 ; Kennedy et al. 2009). Juveniles typically fledge by the end of June, but occasionally young may not fledge until late July. Average territory size in the Willamette Valley is 1.3 ha; range 0.45-5.3 ha (3.1 ac; range 1.1-13.0 ac; Altman 1999). Approximately 50% of breeders return to territories used previous years (Best and Rodenhouse 1984). We found no information describing natal dispersal for any subspecies of *P. gramineus*.

Habitat Management/Restoration— There has been no published research describing the response of Oregon vesper sparrows to restoration activities in the Willamette Valley. We have largely relied on restoration studies that have examined the effects of habitat changes upon other subspecies of *P. gramineus*.

In general, research across the range of *P. gramineus* has demonstrated that the species is more responsive to differences in vegetation structure than the composition of plant communities. Kennedy et al. (2009) did not find significant differences in nest survival, clutch size or other population parameters across plant communities composed of varying proportions of native/non-native species. In an oak savanna restoration study conducted in Minnesota, vesper sparrow abundance was positively correlated with a gradient of decreasing tree density and a subsequent increase in open grassland (Davis et al. 2000). The short-term abundance (Bock and Bock 1992) and nest density (Pylypec 1991) of vesper sparrows also increased in areas where prescribed burning or wildfire has reduced grass cover height and density; explanations by the authors for the observed effects were increased food availability (i.e., forb seeds) and changes to vegetation structure preferred by vesper sparrows. However in southeast Washington, vesper sparrow abundance had not significantly recovered 7-years after a severe wildfire that altered the habitat type from sagebrush-steppe to grassland dominated by cheatgrass (*Bromus tectorum*), a non-native, invasive species (Earnst et al. 2009).

Today, Oregon vesper sparrows are most likely to be found on the hilly margins of the Willamette Valley, as they probably were prior to European settlement. Dry, upland prairies and pastures are the best candidate sites for restoring Oregon vesper sparrow habitats. Given both the rarity and site fidelity of the species, habitat management areas located near existing breeding territories are more likely to be discovered and used than management areas that are distant from known populations.

Non-Habitat Limiting Factors—
Across the geographic range of *P. gramineus*, predation is reported to be one of the primary causes of nesting failure (Best and Rodenhouse 1984, Altman 1999, Kennedy et

al. 2009). Thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*), striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), and feral and domestic cats (*felis catus*) are reported to be the most serious predators of vesper sparrows (Altman 1999, Grant et al. 2006).

Numerous studies have shown that tilling, hay cutting, and other agricultural practices destroy ground nests of grassland birds (Camp and Best 1994, McMaster et al. 2005). In the Willamette Valley, mechanical operations occurring from mid-May to July 1 are likely to have the most severe impact on nest success and juvenile survival. Agricultural pesticides may reduce the availability of invertebrate prey taken by Oregon vesper sparrows during the breeding season, thereby lowering productivity of the species (Altman 2003a). Different studies have demonstrated both negative and positive results to grazing; the differences are apparently explained by the grass cover density and height resulting from grazing pressure (Jones and Cornely 2002).

Rainfall and weather patterns affect food availability and have been shown to be an important determinant of vesper sparrow nesting success (George et al. 1992).

Western Meadowlark (*Sturnella neglecta*)

Conservation Status— The western meadowlark is not designated as Sensitive by ISSSSP but populations in Oregon are designated as Oregon Conservation Strategy species (ODFW 2006). The western meadowlark is also the State Bird of Oregon. Limiting factors are reported to be: declining prairie habitat quality and nest failure due to land management practices (ODFW 2006). According to USGS Breeding Bird Survey trend data, the abundance index of western meadowlarks in Oregon decreased 1.01% per year between 1966-2008 (Sauer et al. 2008).

Ecology—Seventy years ago, the western meadowlark was reported to be the most widely distributed resident bird in Oregon (Gabrielson and Jewett 1940). The species remains common across much of the Great Basin province in eastern Oregon; populations are scattered among valleys in the western portion of the state (Altman 2003c). The western meadowlark is rare or uncommon in most of the Willamette Valley, but locally more abundant near Coburg Hills and Fern Ridge Reservoir in Lane County (Altman 2003c). The species is more numerous in winter as individuals migrate to the Willamette Valley from Canada and possibly eastern Oregon (Altman 2003c).

Western meadowlarks are most closely associated with native prairie communities, fallow fields, and pastures; cultivated grass fields and hayfields offer marginal habitat in the Willamette Valley (Altman 1999; Davis and Lanyon 2008). Optimum breeding habitats were lightly grazed pastures and fallow fields with grass height 1-3 ft (Altman 1999). The density of grass/forb cover has been shown to affect habitat use by meadowlarks in other regions (Davis and Lanyon 2008), but the preferred density of ground cover vegetation has not been reported from western Oregon. Western meadowlarks avoid areas dominated by woody vegetation (Davis 2004, reported by Davis and Lanyon 2008). Abundance is also negatively affected by urbanization (Bock et al. 1999). Singing perches (e.g. fence posts, trees, large rocks) are reported to be essential habitat elements (Altman 2003c).

Diet is composed mostly of invertebrates (e.g., beetles, weevils, wireworms) during spring; winter diet is mostly seeds (Davis and Lanyon 2008).

In Oregon, nesting begins in April and occurs through July (Gabrielson and Jewett 1940). Two clutches may be produced under good conditions (Altman 1999; reported by Altman 2003c). Nests are constructed on the ground in tall grass. Territory size in the Willamette Valley averages 14.3 ac ([5.8 ha], range 4.8-35 ac [1.9-14.2 ha]); territories are dominated by grass cover types, although intensively managed grass seed fields are not often used (Altman 2003c). Females show a strong tendency to return to the previous years' territory (Davis and Lanyon 2008).

Habitat Management/Restoration— Although habitat relationships of the western meadowlark have not been thoroughly investigated in western Oregon, research on the species from other regions and observational data on habitat use from the Willamette Valley provides some guidance for planning restoration activities. Habitat management areas that restore grassland plant communities with appropriate vegetation structure should benefit western meadowlarks. However, our literature review found no information from native prairie restoration projects in western Oregon to confirm whether meadowlarks demonstrate a positive response to such efforts. Land management activities and human disturbance should be minimized in occupied territories during breeding season to avoid causing adults to abandon nests.

Management areas should be large enough to encompass multiple meadowlark territories. Davis and Lanyon (2008) suggest that woodland edges be minimized in habitat management areas for western meadowlarks. Observational data suggest that meadowlarks avoid breeding in landscapes dominated by cultivated grass seed fields (Altman 1999); habitat restoration planners should locate meadowlark management areas in landscapes that as include as few grass seed fields as practical.

Non-Habitat Limiting Factors— Predation was reported as the most common cause of nesting failure in a Manitoba study (Davis and Sealy 200). Nest predators include: raccoons, ground squirrels, snakes, cats, and canids (Renfrew and Ribic 2003); adult meadowlarks are hunted by numerous species of raptors (Davis and Lanyon 2008). In urban areas and agricultural landscapes of the Willamette Valley, domestic cats are probably an important predator of meadowlarks (Altman 2003c).

Agricultural practices such as tilling, spraying, mowing are reported to cause direct mortality of eggs and nestlings; however meadowlark survival appears unaffected by moderate levels of grazing (Davis and Lanyon 2008). Human activity within meadowlark territories may cause adults to abandon nests (Davis and Lanyon 2008).

Fender's Blue Butterfly (*Icaricia icarioides fenderi*)

Conservation Status—Fender's blue butterfly was listed as endangered under the Endangered Species Act in 2000 (USFWS 2008) and is therefore listed under the ISSSSP. Critical habitat units were designated in 2006 and are located in Yamhill, Polk, Benton, and Lane Counties, Oregon (USFWS 2008). A draft recovery plan for the species was published in September 2008 (USFWS 2008). Threats to the Fender's blue butterfly include loss of prairie habitat to agriculture and urban development, intrusion of woody vegetation into the species' habitat, and altered natural disturbance regimes (USFWS 2008). The total population of the species was estimated to be 3000-5000 individuals in 2003 (Schultz et al. 2003). Population viability modeling by Schultz and Hammond (2003) suggests a high probability of future extinction across much of the species range.

Distribution—Fender's blue butterfly is considered an endemic to the Willamette Valley of Oregon, although its precise historic distribution is not known (Schultz et al. 2003). The species was first collected in 1929, but there are no records of it being observed between 1937-1989 (USFWS 2008). The species is presently known to occur on fewer than 30 sites in Yamhill, Polk, Benton, and Lane Counties (Schultz et al. 2003, USFWS 2008).

Ecology—The life cycle of the Fender's blue butterfly is typically competed within one year. Adults live approximately 2 weeks, during which time a female may lay up to 350 eggs (Schultz et al. 2003). Egg mortality is high; only 1-2 eggs per female will ultimately survive to become adult butterflies (Schultz et al. 2003). Only three species of perennial lupines are known to be used for oviposition and food of larvae: Kincaid's lupine (*Lupinus sulphureus* ssp. *Kincaidii*), longspur lupine (*L. arbustus*), and sicklekeel lupine (*L. albicaulis*; USFWS 2008). All three lupines are closely associated with dry, upland prairies dominated by native bunchgrasses (*Festuca* spp.; Schultz et al. 2003, USFWS 2008). Larvae feed on their lupine hostplants until the plant senesces, at which time the larva enters diapause near the base of the plant. Larvae again become active in March-April of the following year. Once completing larval development, they enter a pupal stage for approximately 2 weeks, and then emerge as adult butterflies in May and June (Schultz et al. 2003). Nectar plants used by adults occur in upland and wet prairies. Plants most commonly used by adult butterflies include: narrowleaf onion (*Allium amplectens*), Tolmie star-tulip *(Calochortus tolmiei*), dwarf checkerbloom *(Sidalcea malviflora* ssp. *virgata*), common wooly sunflower (*Eriophyllum lanatum*), and Oregon geranium (*Geranium oreganum*; Schultz et al. 2003). The rarity of host and nectar plants used by Fender's blue butterfly larvae is one of the most important factors limiting the species population size (Shultz and Dlugosch 1999, Schultz 2001).

Habitat fragmentation and diminishing population connectivity pose a serious threat to the persistence of Fender's blue butterfly. The primary host plant of the species, Kincaid's lupine, is known to occur at fewer than 60 sites, comprising a total area of approximately 160 ha (395 ac; Wilson et al. 2003, USFWS 2008). Historically, patches of Kincaid's lupine probably occurred <0.5 km (<0.31 mi) apart in the Willamette

Valley, but today patches range between 3-30 km (1.9-18.6 mi; Schultz 1998). Given a model-based estimate of the maximum dispersal distance of adult butterflies as 2 km from their natal lupine hosts (Schultz et al. 2003), most populations today are highly isolated and are at risk of genetic and demographic problems associated with small populations (Schultz et al. 2003).

Habitat Management/Restoration— Land management for conserving Fender's blue butterfly has focused on restoring the three primary habitat components of the species: 1) host plants used for oviposition and larval food sources, 2) nectar plants used by adults, and 3) vegetation structure of short-stature, bunchgrass prairies (Schultz 2001). Numerous projects have investigated native plant reintroductions and weed control techniques to increase abundance of host (particularly Kincaid's lupine) and nectar plants (Schultz 2001, Clark and Wilson 2005, Severns 2008, Thorpe et al 2008). Solarization, a soil sterilization technique, has been used to effectively reduce competition from weeds prior to out-planting Kincaid's lupine (Schultz 2001). Herbicides and hand-pulling have also been used with success to control weeds on lands managed for Fender's blue butterfly habitat by The Nature Conservancy (Greg Fitzpatrick pers. comm..). Burning and/or mowing have been used to restore a vegetation structure resembling native prairies and to reduce weeds (Wilson et al. 2003, Thorpe et al. 2008). In all of the techniques noted above, the timing and intensity of treatments was crucial to the success of treatments in the above projects.

Non-Habitat Limiting Factors— Insecticides used to control gypsy moths (*Lymantria dispar*), mosquitoes that are vectors for West Nile Virus (*Aedes vexans*, *Culex* spp.), and agricultural pests pose a threat when applied near areas occupied by Fender's blue butterfly (USFWS 2008). Barry et al. (1993; reported in USFWS 2008) reported that *Btk* (*Bacillus thuringiensis* var. *kurstaki*), a biological agent used to control lepidopteron pests, can drift in toxic concentrations over 3 km from the point of application.

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APPENDIX

Wildlife Associated with Grassland and Woodland Habitat Types in the Willamette Valley

To more fully describe the range of vertebrate diversity associated with grasslands and oak woodlands in the Willamette Valley, we utilized a wildlife-habitat relationships (WHR) model for Oregon and Washington (O'Neil et al. 2001). The habitat classification on which the WHR model is based includes 32 terrestrial and aquatic habitat types that are fully described in O'Neil et al. (2001). The model identifies the degree of association (i.e., closely-associated, generally-associated, or species present) and the type of activity (i.e., feeding, breeding, or feeding and breeding) for each of 743 vertebrate species known to occur in Oregon and Washington at present or historically. The wildlife-habitat associations are based on opinions of wildlife biologists that were convened in expert panels for the explicit purpose of developing the WHR model. We used source data from the model that are located in tables organized in a digitized database that was distributed on CD-ROM media.

To create a list of wildlife that use grasslands and/or oak woodlands, we queried the WHR database for all species that feed and breed in "Westside Grasslands" and/or "Westside Oak and Dry Douglas-fir Woodlands" habitat types described in (O'Neil et al. 2001). The Westside Grasslands habitat type includes wet and dry prairies, savannas, and chaparral habitats. The habitat classification and model structure did not permit us to distinguish species that use only a subset of these four communities. The westside oak and dry Douglas-fir woodland habitat type includes pure *Quercus* woodlands, lowland Douglas-fir stands, and woodlands composed of both oak and conifer elements. Ancillary data in the WHR model identified species that demonstrate a particularly close association the oak component within westside oak and dry Douglas-fir woodlands.

The initial list resulting from our database query included many species that have probably never been present in the Willamette Valley. To refine our initial list we used geographic range maps and locality information from well known authorities for Pacific Northwest herpetofauna (Nussbaum et al. 1983; St. John 2002), birds (Gabrielson and Jewett 1940; Marshall et al. 2003), and mammals (Bailey 1936; Verts and Carraway 1998) to create a final list of wildlife that occur in the Willamette Valley at present or did occur historically. We also inserted one species into the final list that was not included in the output from our database query (e.g., grizzly bear). There is strong evidence that the grizzly bear was present in the Willamette Valley at the time of European settlement (Bailey 1936; Verts and Carraway 1998). Our final list includes 185 species of native and introduced wildlife (Table 1).

Appendix 1-1: Wildlife Species-Habitat Matrix: 185 vertebrate species associated with Willamette Valley grasslands and/or oak habitat types. The matrix includes both native and introduced species that use at least one of these habitat types for feeding and breeding activities. Full descriptions of "Westside Grasslands" and "Westside Oak and Dry Douglas-fir Woodlands can be found in (Johnson and O'Neil 2001). Westside grasslands include wet and dry prairies, as well as savannas. An "**X**" set in bold font in the Oak/Douglas-fir column indicates that the species demonstrates a particularly strong association with the oak component of this habitat type. A "?" indicates that a determination is not possible given existing information.

Class	Common Name	Grassland Associate	Oak/Douglas-Fir Associate	Extirpated	Introduced/ Non-Native
Amphibian	Long-toed Salamander	X	X		
Amphibian	Dunn's Salamander		X		
Amphibian	Western Red-backed Salamander		X		
Amphibian	Ensatina		X		
Amphibian	Clouded Salamander		X		
Amphibian	Pacific Chorus (Tree) Frog	X	X		
Reptile	Western Painted Turtle		X		
Reptile	Western Pond Turtle	X	X		
Reptile	Northern Alligator Lizard	X	X		
Reptile	Southern Alligator Lizard	X	X		
Reptile	Western Fence Lizard	X	X		
Reptile	Western Skink	X	X		
Reptile	Rubber Boa	X	X		
Reptile	Racer	X	X		
Reptile	Sharptail Snake	X	X		
Reptile	Ringneck Snake	X	X		
Reptile	Gopher Snake	X	X		
Reptile	Western Terrestrial Garter Snake	X	X		
Reptile	Northwestern Garter Snake	X	X		
Reptile	Common Garter Snake	X	X		
Reptile	Western Rattlesnake	X	X		
Bird	Turkey Vulture		X		
Bird	White-tailed Kite	X			
Bird	Northern Harrier	X			
Bird	Sharp-shinned Hawk		X		
Bird	Cooper's Hawk		X		
Bird	Red-tailed Hawk	X	X		
Bird	American Kestrel	X	X		
Bird	Peregrine Falcon		X		
Bird	Ruffed Grouse		X		
Bird	Wild Turkey	X	X		X
Bird	Mountain Quail		X		
Bird	California Quail	X	X		
Bird	Killdeer	X	X		
Bird	Common Snipe	X			
Bird	Band-tailed Pigeon		X		
Bird	Mourning Dove	X	X		
Bird	Burrowing Owl	X		X	
Bird	Western Screech-owl		X		

Class	Common Name	Grassland Associate	Oak/Douglas-Fir Associate	Extirpated	Introduced/ Non-Native
Bird	Great Horned Owl	X	X		
Bird	Short-eared Owl	X			
Bird	Northern Pygmy-owl		X		
Bird	Long-eared Owl		X		
Bird	Northern Saw-whet Owl		X		
Bird	Common Nighthawk	X	X		
Bird	Vaux's Swift	X	X		
Bird	Anna's Hummingbird		X		
Bird	Rufous Hummingbird		X		
Bird	Lewis's Woodpecker	X		X	
Bird	Acorn Woodpecker	X	**X**		
Bird	Red-breasted Sapsucker	X	X		
Bird	Downy Woodpecker	X	X		
Bird	Hairy Woodpecker	X	X		
Bird	Northern Flicker	X	X		
Bird	Pileated Woodpecker		X		
Bird	Western Wood-pewee	X	X		
Bird	Say's Phoebe	X			
Bird	Black Phoebe	X			
Bird	Willow Flycatcher		X		
Bird	Hammond's Flycatcher		X		
Bird	Pacific-slope Flycatcher		X		
Bird	Ash-throated Flycatcher	X	**X**		
Bird	Western Kingbird	X	X		
Bird	Cassin's Vireo		X		
Bird	Hutton's Vireo		X		
Bird	Warbling Vireo		X		
Bird	Loggerhead Shrike	X		X	
Bird	Black-billed Magpie	X		X	
Bird	Steller's Jay		X		
Bird	Western Scrub-Jay	X	X		
Bird	American Crow	X	X		
Bird	Common Raven		X		
Bird	Streaked Horned Lark	X			
Bird	Purple Martin		X		
Bird	Tree Swallow	X	X		
Bird	Violet-green Swallow	X	X		
Bird	Cliff Swallow		X		
Bird	Barn Swallow		X		
Bird	Black-capped Chickadee	X	X		
Bird	Chestnut-backed Chickadee		X		
Bird	Bushtit		X		
Bird	Red-breasted Nuthatch		X		
Bird	Slender-billed Nuthatch	X	**X**		
Bird	Brown Creeper		X		
Bird	Bewick's Wren		X		
Bird	House Wren	X	X		
Bird	Winter Wren		X		
Bird	Golden-crowned Kinglet		X		
Bird	Western Bluebird	X	X		
Bird	Swainson's Thrush		X		
Bird	American Robin		X		
Bird	Wrentit		X		
Bird	European Starling	X	X		X
Bird	Cedar Waxwing		X		
Bird	Orange-crowned Warbler		X		
Bird	Nashville Warbler		X		
Bird	Yellow-rumped Warbler		X		
Bird	Black-throated Gray Warbler		X		
Bird	Townsend's Warbler		X		
Bird	Hermit Warbler		X		
Bird	Macgillivray's Warbler		X		

Class	Common Name	Grassland Associate	Oak/Douglas-Fir Associate	Extirpated	Introduced/ Non-Native
Bird	Common Yellowthroat	X	X		
Bird	Wilson's Warbler		X		
Bird	Yellow-breasted Chat		X		
Bird	Western Tanager		X		
Bird	Spotted Towhee		X		
Bird	Chipping Sparrow	X	X		
Bird	Vesper Sparrow	X			
Bird	Savannah Sparrow	X			
Bird	Grasshopper Sparrow	X			
Bird	Song Sparrow	X	X		
Bird	White-crowned Sparrow		X		
Bird	Dark-eyed Junco		X		
Bird	Black-headed Grosbeak		X		
Bird	Lazuli Bunting	X	X		
Bird	Red-winged Blackbird	X			
Bird	Western Meadowlark	X			
Bird	Brewer's Blackbird	X	X		
Bird	Bullock's Oriole		**X**		
Bird	Brown-headed Cowbird	X			
Bird	Purple Finch		X		
Bird	House Finch		X		
Bird	Red Crossbill		X		
Bird	Pine Siskin		X		
Bird	Lesser Goldfinch	X	X		
Bird	American Goldfinch	X	X		
Bird	Evening Grosbeak		X		
Mammal	Virginia Opossum		X		X
Mammal	Vagrant Shrew	X	X		
Mammal	Montane Shrew	X	X		
Mammal	Baird's Shrew		X		
Mammal	Trowbridge's Shrew		X		
Mammal	Shrew-mole		X		
Mammal	Townsend's Mole	X	X		
Mammal	Coast Mole	X	X		
Mammal	Broad-footed Mole	X	X		
Mammal	California Myotis		X		
Mammal	Yuma Myotis	X	X		
Mammal	Little Brown Myotis	X	X		
Mammal	Long-legged Myotis	X	X		
Mammal	Fringed Myotis		X		
Mammal	Long-eared Myotis		X		
Mammal	Silver-haired Bat		X		
Mammal	Big Brown Bat	X	X		
Mammal	Townsend's Big-eared Bat		X		
Mammal	Pallid Bat		X		
Mammal	Brush Rabbit	X	X		
Mammal	Nuttall's (Mountain) Cottontail		X		X
Mammal	European Rabbit	X	X		X
Mammal	Black-tailed Jackrabbit	X		?	
Mammal	Townsend's Chipmunk		X		
Mammal	California Ground Squirrel	X	X		
Mammal	Eastern Gray Squirrel		X		X
Mammal	Eastern Fox Squirrel		X		X
Mammal	Western Gray Squirrel		**X**		
Mammal	Douglas' Squirrel		X		
Mammal	Northern Flying Squirrel		X		
Mammal	Western Pocket Gopher	X	X		
Mammal	Deer Mouse	X	X		
Mammal	Dusky-footed Woodrat	X	X		
Mammal	Bushy-tailed Woodrat		X		

Class	Common Name	Grassland Associate	Oak/Douglas-Fir Associate	Extirpated	Introduced/ Non-Native
Mammal	Gray-tailed Vole	X			
Mammal	Red Tree Vole		X		
Mammal	California Vole	X	**X**		
Mammal	Townsend's Vole	X	X		
Mammal	Long-tailed Vole	X	X		
Mammal	Creeping Vole	X	X		
Mammal	Pacific Jumping Mouse		X		
Mammal	Common Porcupine		X		
Mammal	Coyote	X	X		
Mammal	Gray Wolf	X		X	
Mammal	Red Fox	X	X		?
Mammal	Gray Fox	X	X		
Mammal	Grizzly Bear	X	X	X	
Mammal	Black Bear		X		
Mammal	Raccoon	X	X		
Mammal	Ermine		X		
Mammal	Long-tailed Weasel	X	X		
Mammal	Western Spotted Skunk	X	X		
Mammal	Striped Skunk	X	X		
Mammal	Mountain Lion		X		
Mammal	Bobcat		X		
Mammal	Roosevelt Elk	X	X		
Mammal	Black-tailed Deer	X	X		
Mammal	Columbian White-tailed Deer	X	**X**	X	