STATE OF WASHINGTON November 2005

Status Report for the Mazama Pocket Gopher, Streaked Horned Lark, and Taylor's Checkerspot

by Derek W. Stinson

Washington Department of
FISH AND WILDLIFE
Wildlife Program

The Washington Department of Fish and Wildlife maintains a list of endangered, threatened and sensitive species (Washington Administrative Codes 232-12-014 and 232-12-011, Appendix D). In 1990, the Washington Fish and Wildlife Commission adopted listing procedures developed by a group of citizens, interest groups, and state and federal agencies (Washington Administrative Code 232-12-297, Appendix D). The procedures include how species listing will be initiated, criteria for listing and delisting, public review and recovery and management of listed species.

The first step in the process is to develop a preliminary species status report. The report includes a review of information relevant to the species' status in Washington and addresses factors affecting its status including, but not limited to: historic, current, and future species population trends, natural history including ecological relationships, historic and current habitat trends, population demographics and their relationship to long term sustainability, and historic and current species management activities.

The procedures then provide for a 90-day public review opportunity for interested parties to submit new scientific data relevant to the draft status report and classification recommendation. During the 90-day review period, the Department may hold public meetings to take comments and answer questions. At the close of the comment period, the Department completes the final status report and listing recommendation for presentation to the Washington Fish and Wildlife Commission. The final report and recommendations are then released 30 days prior to the Commission presentation for public review.

The Draft Status Report for the Mazama pocket gopher, streaked horned lark and Taylor's checkerspot butterfly was reviewed by researchers and state, provincial, and federal agencies. This review was followed by a 90-day public comment period from 1 July – 30 September 2005. All comments received were considered in preparation of this final status report. **Send written comments on this report by 1 December to: Endangered Species Section Manager, Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, Washington 98501-1091.** The Department will present the results of this status review to the Fish and Wildlife Commission for action at the 13-14 January meeting in Olympia.

This report should be cited as:

Stinson, D. W. 2005. Washington State Status Report for the Mazama Pocket Gopher, Streaked Horned Lark, and Taylor's Checkerspot. Washington Department of Fish and Wildlife, Olympia. 129+ xii pp.

Cover photos by Chris Chappell (background), John Williams (lark), Bill Leonard (gopher), and Derek Stinson (checkerspot).
Cover and title page illustrations by Darrell Pruett

WASHINGTON STATE STATUS REPORT FOR THE MAZAMA POCKET GOPHER, STREAKED HORNED LARK, AND TAYLOR'S CHECKERSPOT

Derek W. Stinson

Washington Department of Fish and Wildlife
Wildlife Program
600 Capitol Way N
Olympia, Washington

November 2005

TABLE OF CONTENTS

ACKNOWLEDGEMENTS viii
EXECUTIVE SUMMARY ix
Mazama Pocket Gopher ix
Streaked Horned Lark x
Taylor's Checkerspot xi
CHAPTER 1: INTRODUCTION TO WESTERN WASHINGTON GRASSLANDS 1
South Puget Sound Prairies 2
Present Status of South Puget Sound Prairies 7
Prairie Habitat on Fort Lewis 11
McChord Air Force Base 14
Habitat Loss and Fragmentation 14
Habitat Management and Restoration 15
Research 16
Miscellaneous Activities 17
CHAPTER 2. MAZAMA POCKET GOPHER 18
INTRODUCTION 18
TAXONOMY 18
DESCRIPTION 19
DISTRIBUTION 21
North America 21
Washington 21
NATURAL HISTORY 22
Diet and Foraging 22
Behavior, Burrowing and Burrows 23
Reproduction 25
Home Range, Movements and Dispersal 26
Population Dynamics, Longevity, Survival and Mortality 27
Ecological Relationships and Functions 28
HABITAT REQUIREMENTS 31
POPULATION STATUS 32
Washington: Past 32
Washington: Present 35
HABITAT STATUS 42
LEGAL STATUS 44
MANAGEMENT ACTIVITIES 44
Surveys 44
Habitat Management and Restoration 45
Research 45
FACTORS AFFECTING CONTINUED EXISTENCE 45
Adequacy of Existing Regulatory Mechanisms 45
Impacts of Habitat Loss, Fragmentation, and Degradation 46
Airport Management and Development 47
Military Training 47
Trapping and Poisoning 48

CONCLUSIONS AND RECOMMENDATION 48
CHAPTER 3: STREAKED HORNED LARK 49
INTRODUCTION 49
Taxonomy 49
DESCRIPTION 49
DISTRIBUTION 51
North America 51
Washington: Past 51
Washington: Present 52
NATURAL HISTORY 53
Reproduction 53
Movements and Dispersal 56
Diet and Foraging 57
Behavior 58
Longevity, Survival and Mortality 58
HABITAT REQUIREMENTS 59
Breeding Habitat 59
Migration and Winter Habitat 60
POPULATION STATUS 61
North America: all subspecies 61
Streaked Horned Lark: Oregon and British Columbia 61
Washington: Past 61
Washington: Present 62
HABITAT STATUS 64
South Puget Sound Prairie Breeding Areas 64
Coastal Breeding Areas 65
Columbia River Island Sites 65
Land Ownership 68
LEGAL STATUS 68
MANAGEMENT ACTIVITIES 68
Habitat Management and Restoration 68
Research 69
FACTORS AFFECTING CONTINUED EXISTENCE 69
Adequacy of Existing Regulatory Mechanism 69
Habitat Loss and Fragmentation 70
Habitat Degradation and Succession 71
Army Training on Fort Lewis 71
Disturbance, Mortality and Development at Airports and Military Airfields 72
Management of Columbia River Islands 73
Other Human-related Factors 73
CONCLUSIONS AND RECOMMENDATION 74
CHAPTER 4: TAYLOR'S CHECKERSPOT 75
INTRODUCTION 75
TAXONOMY 75
DESCRIPTION 77
DISTRIBUTION 77
North America 77

Washington 78
NATURAL HISTORY 78
Life Cycle 78
Miscellaneous Behavior 81
Movements, Dispersal and Colonization 81
Mortality and Survival 83
Population Dynamics 85
HABITAT REQUIREMENTS 86
Larval Requirements 87
Adult Habitat Requirements 90
POPULATION STATUS 91
Washington: Past 92
Washington: Present 92
HABITAT STATUS 97
Past 97
Present 98
LEGAL STATUS 98
MANAGEMENT ACTIVITIES 98
Surveys 98
Research 98
Miscellaneous Activities 99
FACTORS AFFECTING CONTINUED EXISTENCE 99
Adequacy of Existing Regulatory Mechanism 99
Impacts of Habitat Loss and Fragmentation 100
Habitat Degradation 101
Military Training 102
Recreation and Other Human-related Factors 102
Weather and Climate Change 103
Insecticides and Herbicides 103
Collecting and Research 105
CONCLUSIONS AND RECOMMENDATION 105
LITERATURE CITED 107
PERSONAL COMMUNICATIONS 119
Appendix A . Historical locations for Tacoma pocket gopher (*T. mazama tacomensis*). 120
Appendix B. Streaked Horned Lark Specimens Collected in Washington. 121
Appendix C. Historical populations of Taylor's checkerspot in Oregon and British Columbia now believed extinct. 123
Appendix D. Washington Administrative Code 232-12-011, 232-12-014, and 232-12-297. ... 125

LIST OF TABLES

Table 1.2. South Puget Sound prairie sites with some degree of protection[a] and presence of Mazama pocket gopher, streaked horned lark, and prairie butterflies. 8
Table 1.3. Area (acres) and condition of main prairie areas on Fort Lewis based on Land Condition 11
Mapping data. 11
Table 2.1. General locations and dorsal fur color of 8 described subspecies of Mazama pocket gopher in Washington. 19
Table 2.2. Measurements[a] for three subspecies of Mazama pocket gophers in Washington. 19
Table 2.3. Historical locations in Washington where Mazama pocket gopher populations may be extinct 33
Table 2.4. Locations and recent status of known Mazama pocket gopher populations in Washington. ... 37
Table 2.5. Ownership and condition of land at Mazama pocket gopher sites by subspecies in Washington 43
Table 3.1. Number of singing male streaked horned larks detected during surveys in 1999 and 2000, and estimated number of territories during research in 2002-04. 63
Table 3.2. Locations, ownership, and land use at streaked horned lark nesting areas. 67
Table 4.1. Subspecies of Edith's checkerspots and ranges in Washington. 75
Table 4.2. Larval host plant associations for populations[a] of Taylor's checkerspot. 88
Table 4.3. Nectar sources used by adult Taylor's checkerspot. 91
Table 4.4. The status and survey history for populations of Taylor's checkerspot in Washington[a]. 93

LIST OF FIGURES

Figure 1.1. Location and extent of prairie soils and extant grasslands in the south Puget Sound area 3
Figure 1.2. Western Washington vegetation zones where prairie and oak savannah communities were found.... 4
Figure 1.3. Location and place names used in text for south Puget Sound grassland sites 9
Figure 1.4. Douglas-fir has invaded many remaining historical prairies. 14
Figure 2.1. Range of the Mazama pocket gopher and 8 described subspecies. 22
Figure 2.2. Locations of known extant and historical populations of 4 subspecies of Mazama pocket gopher in Washington. 36
Figure 2.3. Approximate location of extant and extinct populations of *T. m. melanops*. 41
Figure 3.1. Ranges of horned lark subspecies in Washington. 50
Figure 3.2. Historical and current breeding locations of the streaked horned lark in Washington and Oregon, and (inset) hypothesized breeding distribution 52
Figure 3.3. Townships surveyed, historical sites, and current nesting locations detected in Washington, 1999-2000. 62
Figure 4.1. Likely historical range of Taylor's checkerspot; lighter shaded areas represent large gaps in the historical records. 77
Figure 4.2. Annual life cycle and calendar for Taylor's checkerspot in Washington. 79
Figure 4.3. Existing and extinct populations of Taylor's checkerspot in Washington.... 92

LIST OF PLATES

Plate 1. Top: museum specimens (left to right) of *T. m. louiei, melanops, couchi,* and *yelmensis*. Bottom: Mazama pocket gopher (left), showing characteristic incisors, claws, and cheek pouches, in contrast to the side-oriented front claws and pointed snout of Townsend's mole, *Scapanus townsendi* (right). ... 20
Plate 2. Streaked horned lark: nest on Midway beach; week-old chicks on Gray Army Airfield; fledgling on Whites Island; and young of the year or adult males near Portland, Oregon 55
Plate 3. Coastal and Columbia River nesting areas of streaked horned lark in Washington (top: Coffeepot Island, Damon Point; Middle row: Graveyard Spit and Leadbetter Point; Bottom: Whites Island/east end Puget Island, and Midway Beach). 66
Plate 4. Taylor's checkerspot: top left to right, eggs and pre-diapause larva; middle row: post-diapause larvae; bottom: adult. 76
Plate 5. Host plants of Taylor's checkerspot larvae, clockwise from upper left: *Castilleja hispida*, *Collinsia parviflora*, *Plectritis congesta*, and *Plantago lanceolata*. 89

ACKNOWLEDGEMENTS

Ann Potter and Scott Pearson provided valuable information and helpful advice during preparation of the draft. Ann compiled the old and new checkerspot records, and Scott, along with Russell Rogers and Mark Hopey, reviewed the draft lark chapter and provided information and suggestions for improving the report. Mary Linders and Gary Wiles reviewed the entire draft and provided helpful editorial comments. Review and helpful comments on one or more chapters were provided by Robert Beason, Chris Chappell, John Fleckenstein, Jennifer Heron, Jim Lynch, Kelly McAllister, James Miskelly, Robert Michael Pyle, Jon Shepard, Dick Taylor, Mace Vaughan, Gary Wiles, and Gary Witmer. The PhD dissertation and related reports of Ellie Steinberg on the Mazama pocket gopher was also very valuable for the completion of the gopher chapter.

Various individuals at museums graciously provided data from specimens collected in Washington and Oregon, including: Claudia Angle and Craig Ludwig at the Division of Birds, U. S. National Museum, Smithsonian Institution; Phil Unitt, San Diego Natural History Museum; Gary Shugart, Slater Museum, University of Puget Sound; Minh-Tho Schulenberg, Field Museum, Chicago; and Rob Faucett, Burke Museum, University of Washington.

Chris Chappell, WDNR Natural Heritage Program, provided GIS coverages of prairie soils and vegetation and insights into the ecology of prairies past and present. Dick Taylor, WDFW(retired), Jeff DeBell and Florence Caplow, WDNR, Shelly Hall, Olympic National Park, Cheryl Schultz, WSU-Vancouver, Corey Welch, University of Washington, Angel Lombardi and Jeff Foster, Fort Lewis, Sally Alhadeff, Port of Olympia, and Jon Pelham provided information, copies or papers, or otherwise contributed to completion of the report. Andrew Emlen and Kirsten Brennan provided some observation records of larks for the lower Columbia and outer coast. Thanks to Darrell Pruett for the illustrations of gopher, lark and checkerspot. Thanks also to Randy Moore, John Williams, Chris Chappell, Bill Leonard, Dan Grosboll, Rod Gilbert, Mike Walker, Cyndie Sundstrom, and Dave Nunnalee for the use of photographs.

The butterfly records collected over the years by the Evergreen Aurelians was indispensable for the checkerspot report. Kelly McAllister provided gopher and butterfly records, and provided useful insights and suggestions. Mike Walker, WDFW, Dan Grosboll, TNC, James Miskelly at University of Victoria, Dana Ross, and Scott Hoffmann-Black and Mace Vaughan of the Xerces Society all provided additional butterfly records and observations. Anna Schmidt assisted with obtaining gopher photos and observations from her thesis project. Jennifer Brookshier assisted with data records and mapping. The staff at the Geology Library and Diane Mitchell, Kristi MacLean, and Regina Joseph of the Washington State Library assisted with obtaining literature.

EXECUTIVE SUMMARY

Native prairies are among the most endangered ecological communities in North America. Western Washington is generally known for its forests; it is less well known that the south Puget Sound area historically had large expanses of prairie and oak savannahs. These prairies and woodland communities developed during a warm dry period from 10,000 to 7,000 years ago on the droughty, gravelly soils deposited by the Vashon Glacier. In the recent past, glacial outwash prairie still existed on at least 150,000 ac, and grassland and oak woodlands occurred in smaller patches throughout the Puget Trough and south to the Columbia River. Local Native American tribes adapted to use the plants and game of these communities and maintained prairie in the area by burning the vegetation every few years during the last 4,000 years. Since settlement by Euro-Americans, the extent of these prairies has steadily declined with their use for agriculture and the cessation of burning that has allowed succession to Douglas-fir forest. Only about 8% of the original prairie still supports grassland vegetation and about 2-3% is still dominated by native prairie vegetation. In addition to prairies on glacial outwash, native grasslands existed on perhaps 10,000 ac of coastal headlands, islands and rocky balds. Some of the wildlife of prairies, though now locally rare, are little different from abundant and widespread forms found across much of eastern Washington and in grassland communities elsewhere. A few of the wildlife species that inhabited these prairies and grasslands have been genetically isolated from their ancestral stocks for a long period of time and have evolved endemic forms found nowhere else. These unique forms have become rare with their habitat, and some are threatened with extinction. This report summarizes what is known about the natural history and status of three species that have their center of abundance in Washington on the prairies of the southern Puget Sound: the Mazama pocket gopher; streaked horned lark; and Taylor's checkerspot butterfly.

Mazama Pocket Gopher

The Mazama pocket gopher (*Thomomys mazama*) is a regional endemic found only in western Washington, western Oregon and northern California. The subspecific taxonomy of *T. mazama* is in the process of being revised, but in Washington, *T. mazama* is likely represented by 3 surviving subspecies: *T. m. yelmensis* is found on locations scattered on the remnants of prairie in Pierce and Thurston counties; *T. m. couchi* is found on grassland at a few localities near Shelton in Mason County, including the airport; and *T. m. melanops* is found on a few alpine meadows in Olympic National Park in Clallam County. Two additional subspecies that occurred around Tacoma (*T. m. tacomensis*) and in Wahkiakum County (*T. m. louiei*) appear to be extinct. The Washington population of the Mazama pocket gopher became a candidate for federal listing under the Endangered Species Act in 2002. Mazama pocket gophers are known to persist at 27 sites scattered across the southern Puget Sound grasslands and alpine meadows of the Olympics. These may total in the low thousands, but many are small populations on marginal sites that are unlikely to persist. Pocket gophers play an important a role in ecological communities by altering soil structure and chemistry, affecting plant occurrences, and serving as prey for many predators; their burrows provide a retreat for a wide variety of other species, including the western toad.

With the exception of *T. m. melanops* and the apparently extinct *T. m. louiei*, *T. mazama* is a creature of the south Puget Sound prairie landscape. Most gopher populations are restricted to grassland on remnant and former prairie sites. Mazama pocket gophers are not constrained to live on native vegetation and will eat many introduced grasses and weedy forbs. Soil type seems to affect their distribution, because they are absent from most prairies with particularly rocky soils. Habitat loss to succession, agriculture and development has eliminated most of the prairie vegetation, and habitat continues to be lost to residential development. Existing habitat is being degraded by heavy grazing of pastures and the invasion of Scotch broom and other weedy non-native plants.

Half of the known gopher populations are on private lands, where they are threatened by residential development and may be rapidly dwindling due to degraded habitat and high mortality. Pocket gophers may not persist in residential areas due to persecution by trapping, poisoning, and predation by cats and dogs. The last records of the *T. m. tacomensis* were of individuals killed by domestic cats. Gravel mining affects gopher habitat on some private lands. Most occupied habitat on public lands is affected by non-conservation uses including military training and recreation. Gopher populations at airports can be affected by development of airport-related facilities and businesses, and management of airport grassland.

The small size and isolation of most remaining populations of Mazama pocket gopher put them at risk of local extinction, and without increased protection, all but *T. m. melanops* in Olympic National Park could go extinct. Historically, local gopher populations probably exchanged genetic material by individuals occasionally dispersing through intervening oak woodlands and forest; prairie patches where gophers went extinct would eventually be re-colonized. Today, these prairie patches are increasingly surrounded by roads and suburbs that are inhospitable to dispersing gophers. Populations that become extinct are unlikely to be re-colonized without re-introductions.

For these reasons, we recommend that the Mazama pocket gopher be listed as threatened by the State of Washington.

Streaked Horned Lark

The streaked horned lark (*Eremophila alpestris strigata*) is arguably the most distinct subspecies of horned lark. Its historic breeding range included prairies and open grassland habitats in southwestern British Columbia, western Washington, and western Oregon. The center of abundance of the streaked horned lark in Washington was the prairies of southern Puget Sound, primarily in Pierce and Thurston counties. Streaked horned larks have declined with the loss of prairie habitats to development and succession to forest. With the cessation of burning of the prairies by Native Americans, Douglas-fir has spread over much of the prairie and introduced grasses, weeds, and Scotch broom have degraded much of the remainder. Streaked horned larks may have also been restricted to portions of the prairie where the vegetation was short and sparse due to excessive dryness or repeated burns.

There is little information on historical populations. Streaked horned larks were reported to be a "very abundant summer resident of the gravelly prairies near Fort Steilacoom" in the 1850s (Suckley and Cooper 1860). Bowles (1900) estimated that "fully one hundred pairs must have nested" on the Tacoma golf links at the turn of the century. Streaked horned lark breeding in Washington is now limited to only 13 known sites: 6 sites in the south Puget Sound area, 4 sites along the outer coast, and 3 sites on islands in the lower Columbia River. The subspecies has also greatly declined in Oregon and may be extinct in British Columbia. The total breeding population is estimated to be 780, with about 330 birds in Washington and about 450 in Oregon. All remaining nesting sites in the south Puget Sound area are on airports or military bases where grassland has been maintained, but where larks are subject to disturbance and human-related mortality, and where their habitat is threatened with development or incompatible use. Horned larks are among the species most frequently killed by collisions with military aircraft. Columbia River sites are affected by management of the islands, including deposition of dredge spoil, and vegetation manipulation to discourage nesting by Caspian terns. Coastal sites are affected by the spread of European beachgrass and disturbance by recreational activities. Most of the streaked horned larks that breed in Washington winter in Oregon where habitat is being lost to development, buried under fresh dredge spoil, or subject to shifting patterns of agriculture.

Genetic data suggest that the streaked horned lark already suffers from reduced genetic diversity and may

suffer from inbreeding. Given the small number of breeding locations, low population numbers, and the lack of breeding areas free of human-related mortality and disturbance, the streaked horned lark is likely to go extinct without recovery actions.

For these reasons, the Department recommends that the streaked horned lark be listed as endangered in the State of Washington.

Taylor's Checkerspot

Taylor's checkerspot (*Euphydryas editha taylori*), a subspecies of Edith's checkerspot, is a medium-sized butterfly with a striking checkered pattern of orange to brick red, black and cream. It was historically found on grassland habitats at over 70 sites from southeastern Vancouver Island, British Columbia through northwestern Oregon, including about 38 known locations in Washington. The subspecies is now restricted to 1 known population in British Columbia, small populations in 2 areas in Oregon, and a small scattering of 10 populations in Washington. Butterfly populations can be extremely variable from year-to-year. Among 5 or 6 populations that appear to have gone extinct over the last 10 years is one population that was estimated at 7,000 in 1997; it declined precipitously and appeared to be extinct by 2001. Most populations in Washington support no more than a few hundred individuals, and several of these are extremely small and may be on the verge of extinction. The subspecies became a candidate for listing under the federal Endangered Species Act in 2001 (USFWS 2001).

Butterfly populations are known to fluctuate dramatically with weather. The critical phases of the life cycle of Edith's checkerspot have often been described as a race by the larvae to develop before their food plants dry out in early summer; larvae that do not mature sufficiently before entering a prolonged diapause which extends through winter, do not survive. Because of this interaction with host plants, local populations sometimes go extinct and the habitat is vacant until being recolonized by dispersing adults. Some populations appear to be dependent on the non-native English plantain or ribwort (*Plantago lanceolata*), a weedy introduced species. Dependence on this species may negatively affect *E. e. taylori* population dynamics and lead to more frequent local extinctions.

Butterflies often occur as metapopulations; metapopulations are collections of smaller subpopulations that occupy patches of habitat, and the patches are successively vacant and occupied as local butterfly extinctions are followed by recolonizations. *E. editha* is a relatively sedentary species and rarely disperses > 5 km. Taylor's checkerspot sites in Washington are located in 4 distinct areas, and may comprise 3 or more metapopulations. Habitat loss has increased isolation of the remaining populations, however, so that many are unlikely to be recolonized when they become extinct. The small size of many populations put them at higher risk of extinction due to fires, disturbance, insecticides, and weather extremes, as well as the potential for reduced survival and reproductive success due to inbreeding.

Several of the largest remaining populations occur on public lands, but most of these lands have uses that can conflict with butterfly conservation, including military training and recreation. Private lands occupied by Taylor's checkerspot are subject to development, agriculture, and gravel extraction that can eliminate habitat. Grassland sites, except where actively maintained, are being degraded by the invasion of Scotch broom, Douglas-fir, and numerous non-native forbs and sod-forming grasses. The remaining populations of Taylor's checkerspot are unlikely to persist without management intervention in the form of habitat restoration and maintenance.

Long-term persistence of isolated populations also requires genetic exchange between subpopulations and recolonization of vacant patches. Maintaining the genetic diversity of populations will require either

restoration of many intervening stepping stones of habitat or physical transport of individual butterflies between patches. The subspecies is unlikely to survive without recovery actions. For these reasons we recommend that Taylor's checkerspot be listed as endangered in the State of Washington.

CHAPTER 1: INTRODUCTION TO WESTERN WASHINGTON GRASSLANDS

Native grasslands have declined dramatically in area in western Washington over the last 5,000 years. Despite a shift in climate regime to moister conditions, the droughty soils and fires set by Native Americans helped maintain prairies in parts of the region. The historical cessation of burning by Native Americans, the spread of Euro-American agriculture, and expanding development have contributed to a rapid reduction in prairie areas in the last 150 years. As these grasslands have declined in area, so have many plant and animal species, including some distinct species or subspecies found nowhere else. Some distinct forms of animals already seem to be extinct in western Washington (e.g., coast gopher snake (*Pituophis catenifer catenifer*)(Leonard and Hallock 1997). This report focuses on 3 of the animals that are among the most distinctive, and endangered wildlife of these habitats: the Mazama pocket gopher (*Thomomys mazama*), streaked horned lark (*Eremophila alpestris strigata*), and Taylor's checkerspot butterfly (*Euphydryas editha taylori*). These 3 species vary in the degree to which they are restricted to native grassland, but all historically had their center of abundance on the dry glacial outwash prairies of the south Puget Sound region. These native prairies are among the most endangered ecosystems in the United States (Noss et al. 1995). The term "prairie" as used in defining the grasslands of the Midwestern U.S. and Great Plains using precipitation, evaporation, and plant associations, may not strictly apply to these grasslands, but the term has long been used for geographic place names and in describing the dry lowland grasslands of the region. The grassland habitats of western Washington include glacial outwash prairie, balds, alpine meadows, coastal dunes, and human created turf and pastures. Smaller grasslands called "balds" formed on shallow soil on bedrock, and typically occur on south or west-facing slopes within an otherwise forested landscape (Chappell et al. 2003). The Westside Grasslands habitat type, as defined by Chappell and Kagan (2001), include glacial outwash prairies, which account for most of the grassland in western Washington, as well as balds. Westside grasslands are characterized by annual average precipitation of 43-140 cm, with moist winters and dry summers, and they experience extreme soil drought in summer (Chappell and Kagan 2001). Grassland sometimes occurs on coastal bluffs where soil is derived from sandy glacial deposits. Balds and grassland on coastal bluffs are more common in the northern Puget Sound region (Chappell et al. 2003).

Annual soil drought on Westside Grasslands eliminated or thinned invading trees and facilitated frequent fires that maintained the prairie vegetation. The grassland environments historically varied depending on hydrology, soil depth and rockiness, and fire history, from sites with luxuriant growth of grass and wildflowers, to sites with scant vegetation and abundant mosses and lichens. Oak savannahs, scattered or sparse oak with a grassland understory, are now rare, but were once common and some were extensive. Micro-topography and its effect on vegetation often creates specific site characteristics selected by species or habitat heterogeneity that can provide refuges for wildlife species during extremes in annual weather. For example, extremely rocky soils may provide the sparse vegetation desired for nesting by horned larks. Topographic relief provides a range of microclimates that can allow butterfly populations to survive a wider range of annual weather.

In addition to the south Puget Sound prairies, these 3 species are found in other grassland types; habitats described by Chappell et al. (2001a) that contain grassland used by 1 or more of the 3 species include Coastal Dunes and Beaches, Coastal Headlands and Islets, and Urban and Mixed Environs. For example, some of the largest remaining populations of Mazama pocket gopher and streaked horned lark are found on mowed grass fields surrounding airports located on historical prairie sites. The pocket gopher also inhabits certain alpine meadows in the Olympic Mountains, and the streaked horned lark nests on sandy coastal spits and dredge spoil islands. Taylor's checkerspot is found on certain grassy balds and estuarine sites, in addition to the prairies. These 3 species favor certain sites because of vegetation or soil characteristics, and none are

found on all the remaining native prairie sites. Conservation of these species will require a challenging hands-on program of prairie protection and restoration and for some a program of translocations to increase the number of populations, and to maintain genetic exchange between isolated populations.

South Puget Sound Prairies

"Our route then continued through most beautiful park scenery, with the prairie now and then opening to view, in which many magnificent pines grew detached. The prairie was covered with a profusion of flowers."

— Charles Wilkes, exploring between the Nisqually and Deschutes Rivers (1844)

The south Puget Sound area historically had extensive prairies on glacial outwash plains with flat or small hilled Mima mound topography originating about 12,000 years ago from the retreat of the Vashon glacier (Kruckeberg 1991, Leopold and Boyd 1999). As the glacier retreated from its southern terminus, it disgorged great quantities of rocks, sand and gravel that accumulated in a plateau (Lang 1961).

The assemblage of plants and animals that make up these prairies today may have become established during a period from about 10,000 years ago until 7,000-5,000 years ago that was warmer and drier than today (Hansen 1947, Washburn 1988, Crawford and Hall 1997). Pollen records in the south Puget lowlands indicate a predominance of oak and prairie vegetation along with alder and Douglas-fir during the period (Brubaker 1991). Prairie and oak habitats may have been much more extensive during this period than they were at European contact, because by 6,000 years ago, grass, oak, Douglas-fir, and alder pollen declined and western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) pollen increased. Subsequent to the dry period, droughty, infertile soil and a high frequency of low intensity fires, most set by Native Americans, maintained the prairies, although the climate otherwise would have produced forest (Crawford and Hall 1997).

Prairies were very important in the economies of some local tribes. Salish peoples periodically burned the prairies to encourage food plants such as bracken (Pteridium aquilinum), common camas (Camassia quamash), and berries (serviceberry, strawberry, and blackberry) (Boyd 1986, Perdue 1997, Leopold and Boyd 1999), and to maintain large herds of deer and elk (Peter 2001). They were said to have burned prairie edges every third spring to encourage the food and medicine plants, and isolate the prairies to prevent prairie burns from causing forest fires (Perdue 1997). The Kalapuyan tribe of the Willamette Valley, Oregon burned the prairies each year primarily in August and September (Boyd 1986). The Nisqually Indians called themselves 'Squallyabsch' which means "people of the grass country" (Carpenter 1986). The Cowlitz Indians have been called a prairie people, as their economy depended on the productivity of the prairies which they enhanced with fire (Leopold and Boyd 1999). Many of the prairie plants were used as food or medicine by the tribes in western Washington (Lombardi 1997, Leopold and Boyd 1999). Frequent burning and the digging of roots may have increased the coverage of forbs versus grasses in parts of the pre-European landscape (Chappell and Kagan 2001).

Recent interest in preserving the remaining prairie habitats has spurred efforts to estimate the historical extent of grasslands in the region. Crawford and Hall (1997) assessed 1,497,000 ac in the south Puget Sound area, that encompassed all or portions of Thurston, Pierce, Lewis, Grays Harbor, and Mason counties, and identified a minimum of 150,000 ac of grassland soil types. The prairies that formed on this plateau of glacial gravels generally have sandy to gravelly, deep, well-drained soils with low water-holding capacity (Crawford and Hall 1997). The gravelly sandy loams, classified in the Spanaway or Spanaway-Nisqually Complex soil series that account for most of the grassland soils, are low in productivity and prone to extreme summer drought. Prairie vegetation also historically occurred on sites with Spana, Nisqually and Carstairs soil series (Crawford and Hall 1997). Grassland

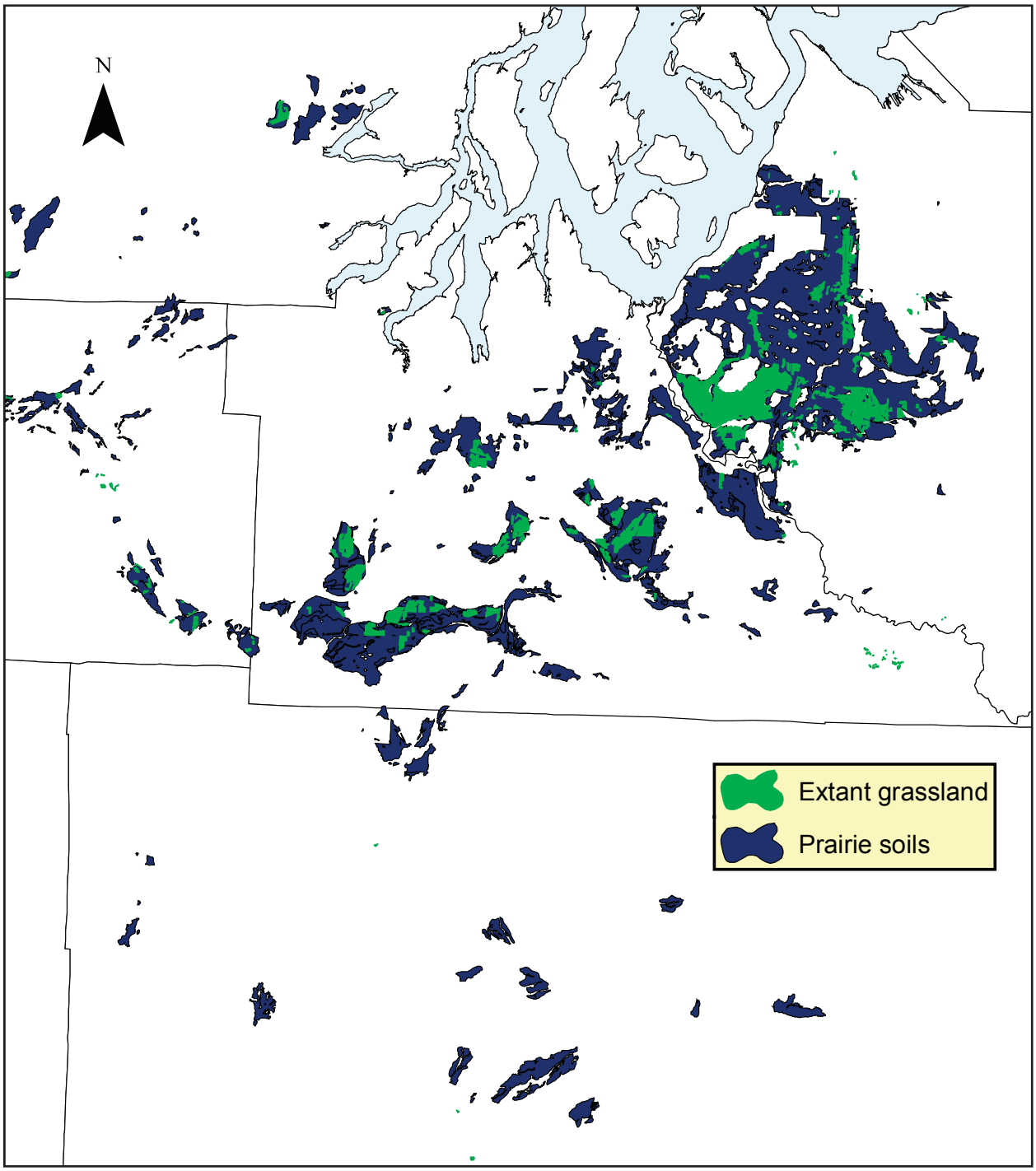


Figure 1.1. Location and extent of prairie soils and extant grasslands in the south Puget Sound area (grassland includes oak savannah and grasslands in a wide range of conditions from native to non-native vegetation; from Washington Natural Heritage Program and Chappell et al. 2003).

soil was not mapped on Shelton or Everett soil series, but some of these sites may have supported prairie vegetation at one time (Crawford and Hall 1997).

Prairies existed on more fertile soils elsewhere, including areas further south in Lewis, Cowlitz, and Clark counties, in addition to the prairies on glacial outwash around the southern Sound (Fig. 1.1). Chappell et al. (2001b) expanded on the work of

Crawford and Hall (1997), and estimated that prior to Euro-American settlement, grassland vegetation occurred on over 180,000 ac of outwash prairies, rocky balds, islands and headlands in the Willamette Valley-Puget Trough-Georgia Basin Ecoregion in Washington. This estimate is based on soil types as mapped by county soil surveys and provides a minimum estimate of dry grassland soils. Chappell et al. (2001b) did not evaluate the urban area of Pierce County because, although some is known to have been historical prairie, it was not covered by the soil survey (C. Chappell, pers. comm.). This estimate also does not include some prairies maintained by Native American burning in wetter areas. For example, Peter (2001) describes an area of 7,000 ac between Hood Canal and the North Fork Skokomish River that was once savannah with a low density of Douglas-fir, and according to local accounts, was regularly burned. Pyle (1989) refers to this area as the "Hoodsport heaths," and Chappell refers to the area as a barrens or shrubby savannah because it is not clear it was dominated by grasses (C. Chappell, pers. comm.). Historical burning of prairies by Native Americans was documented for Whidbey Island, in the Centralia-Chehalis area and on the Quileute Prairie in Clallam County (Agee 1993).

Historical accounts describe the route taken from the Columbia River to Puget Sound, via the Cowlitz River, as being a succession of prairies separated by bands of timber (Lang 1961, Leopold and Boyd 1999). William Tolmie described the prairies as "enameled with a profusion of blue-flowered kamass," and said the Cowlitz and Chehalis prairies "In beauty... far surpass any thing of the sort I have ever beheld" (Tolmie in Leopold and Boyd 1999). Most of the areas where prairies were found is outlined by vegetation zones identified by Cassidy et al. (1997)(Fig. 1.2). The Willamette Valley Zone in Clark County, so named for its ecological and geological affinities to the Willamette River Valley across the Columbia in Oregon, and the Cowlitz River Zone were mosaics of forests, oak savannahs and prairies. Little is known about the vegetative composition of the prairies that occurred in these areas because historically they were among the first parts of the state to be settled (Cassidy et al. 1997). Unlike the glacial outwash plain of Thurston and Pierce counties, gravelly soils were uncommon, facilitating their early conversion to agriculture. More than 99% of the prairies in Clark, Lewis, and Cowlitz Counties have been converted to agriculture and other uses (Caplow and Miller 2004). Caplow and Miller (2004) used soil maps, geographic place names and delineations of prairies from historical General Land Office records to construct maps of historical prairies in Lewis, Cowlitz and Clark counties. They used the constructed maps to survey for populations of rare native plants. They identified 66 historical prairie sites totaling 46,531 ac, and visited at least some portion of 32 of these sites; 23 sites still retained a remnant of prairie species, and 9 supported one or more species of rare plant, often along fencerows or roadsides. No large areas of native prairie vegetation were found. The constructed map did not identify the extent of all historical prairie, because the largest area of prairie vegetation found, a few acres at Lewis and Clark State Park, was not depicted on the map. This site may have once been continuous with the large Lacamas and Cowlitz Prairies complex just to the south that totaled >5,000 ac (Caplow and Miller 2004).

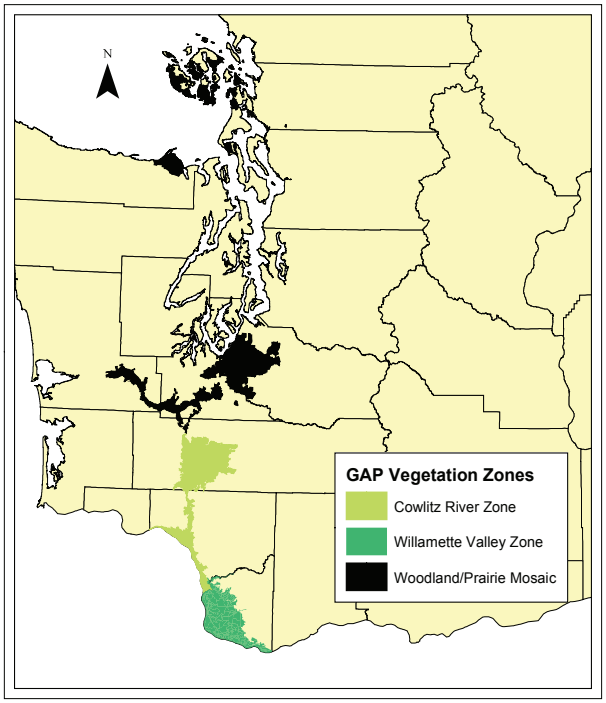


Figure 1.2. Western Washington vegetation zones where prairie and oak savannah communities were found. (Cassidy et al. 1997).

The historical extent of prairie vegetation at other sites in Lewis County that still support some prairie species include: >900 ac at Drews; 1,200 ac at Boisfort Prairie, 1,000 ac at Jackson Prairie, and small meadows at Halfway Creek. Lacamas Prairie in Clark County (4,600 ac) is the only known intact example of a wet prairie in Washington, an 11-ac remnant tufted hairgrass-California oatgrass community (Caplow and Miller 2004). Additional vegetation surveys of these historical prairie sites are planned for 2005-2006.

Mima mounds. Mima mounds are a distinctive feature of some south Puget Sound prairies. These low, regular, rounded mounds average perhaps 6-8 feet in height and 35-50 ft in diameter, and have a density of about 8-10/ac (Washburn 1988, Kruckberg 1991). The mounds contain a bi-convex lens of fine dark soil with a high organic matter content (Mielke 1977). The mounds occur where a layer of fine loose material exists over a harder layer of rock or compacted clay or gravel. Similar mounds, which may or may not be of similar origin, occur on other grasslands in various locations in North America and on other continents. The origins of these mounds have been debated for over 100 years.

Vegetation. The flora of the south Sound prairies has much in common with that of other dry prairies in western Washington near Sequim, in the San Juan Islands, and Whidbey Island. The vegetation often consists of the Roemer's fescue-white-top aster (*Festuca roemeri-Sericocarpus rigidus* synonym *Festuca idahoensis* var. *roemeri -Aster curtus*) community type (Chappell and Crawford 1997, http://www.dnr.wa.gov/nhp/refdesk/communities/index.html), which is considered "critically imperiled because of extreme rarity" and ranked G1/S1, the highest possible ranking for global and state conservation (WNHP 1997). Roemer's fescue, a native bunchgrass, usually covers 30 to 70% of the space in this community type. Bunchgrasses have a caespitose or tussock growth form and spread primarily by seed. The spaces between grass clumps are covered by native forbs, sedges, mosses, and lichens (Chappell and Kagan 2001). Common camas also accounts for significant cover. Other native species typically present include: long-stolon sedge (*Carex pensylvanica*), California danthonia (*Danthonia californica*), and field woodrush (*Luzula campestris*); forbs include woolly sunflower (*Eriophyllum lanatum*), houndstongue hawkweed (*Hieracium cynoglossoides*), white-top aster, cutleaf microseris (*Microseris laciniata*), broadpetal strawberry (*Fragaria virginiana* var. *platypetala*), spikelike goldenrod (*Solidaga spathulata*), early blue violet (*Viola adunca*), prairie lupine (*Lupinus lepidus*), western buttercup (*Ranunculus occidentalis*), yarrow (*Achillea millefollium*), meadow death-camas (*Zigadenus venenosus*), slender cinquefoil (*Potentilla gracilis*), pomocelery lomatium (*Lomatium utriculatum*), and Henderson's shooting star (*Dodecatheon hendersonii*)(Chappell and Crawford 1997). Other species include native bracken, bluebells-of-Scotland (*Campanula rotundifolia*), prairie junegrass (*Koeleria macrantha*), selfheal (*Prunella vulgaris*), and the non-native silver hairgrass (*Aira caryophylla*). Puget balsamroot (*Balsamorhiza deltoidea*) is present on some sites (Chappell and Crawford 1997). Mosses and lichens are sometimes an abundant and diverse component of intact prairie flora (Clampitt 1993). For example, non-vascular cryptogams, primarily mosses, account for >22% cover on Weir Prairie (Tveten 1997). Roadside rock moss (*Racomitrium canescens*) is the most widespread species and can account for a significant part of ground cover. Red fescue (*Festuca rubra*) is a major component of grasslands near salt water, particularly in the north Puget Sound region (Chappell et al. 2003).

South Puget Sound prairies also host a unique assemblage of animal species, many being endemic races or subspecies not found outside of Pacific coast grassland habitats (Table 1.1). This assemblage includes 6 species of butterflies that are primarily associated with prairies and grasslands (Dunn and Fleckenstein 1997). Endemic forms unique to grasslands or the prairie-oak ecotone west of the Cascades include the streaked horned lark, Oregon vesper sparrow (see Table 1.1 for scientific names), slender-billed white-breasted nuthatch (*Sitta carolinensis aculeata*), coast gopher snake, and Mazama pocket gopher. Several animal species of open habitats that are widespread in shrub-steppe of eastern Washington were once present or more abundant on the prairies and prairie-oak woodland

Table 1.1. Rare species associated with south Puget Sound prairie habitats[a] and their conservation

Common Name	Scientific name	State status[b]	WNHP State Rank[c]	NatureServe Global Rank[c]
PLANTS				
Tall agoseris	*Agoseris elata*	WNH-SX	S3	G4
White–topped aster	*Aster curtus*	WNH-S	S3	G3
Hall's aster	*Aster hallii*	WNH-T	S1	G4
Golden paintbrush	*Castilleja levisecta*	WNH-E	S1	G1
Puget Balsamroot	*Balsamorhiza deltoidea*	-	S2?	G5
Pale larkspur	*Delphinium leucophaeum*	WNH-E	S1	G2
Common bluecup	*Githopsis specularioides*	WNH-SX	S3	G5
Thin-leaved peavine	*Lathryrus holochlorus*	WNH-T	S1	G2
Bolander's peavine	*Lathryus vestitus* ssp. *bolanderi*	WNH-E	S1	G5TNR
Bradshaw's lomatium	*Lomatium bradshawii*	WNH-E	S1	G2
Kincaid's Lupine	*Lupinus sulphureus* ssp. *kincaidii*	WNH-E	S1	G5T2
White meconella	*Meconella oregana*	WNH-TX	S2	G2G3
Great polemonium	*Polemonium carneum*	WNH-T	S1S2	G4
Rose checker-mallow	*Sidalcea malviflora* var. *virgata*	WNH-E	S1	G5TNR
Hairy-stemmed checker-mallow	*Sidalcea hirtipes*	WNH-E	S1	G2
Nelson's checkermallow	*Sidalcea nelsoniana*	WNH-E	S1	G2
BUTTERFLIES				
Puget Blue	*Plebejus icarioides blackmorei*	SC	S2	G5T3
Mardon skipper	*Polites mardon*	SE	S1	G2G3
Taylor's Checkerspot	*Euphydryas editha taylori*	SC	S1	G5T1
Valley Silverspot	*Speyeria zerene bremnerii*	SC	S2S3	G5T3T4
Oregon branded skipper	*Hesperia colorado oregonia*	M	S2	G5T3T4
Sonora skipper	*Polites sonora siris*	M	S2S3	G4T3
VERTEBRATES				
Coast gopher snake	*Pituophis catenifer catenifer*	X	SH	G5T5
Yellow-bellied racer	*Coluber constrictor*	X	S5	G5
Streaked horned lark	*Eremophila alpestris strigata*	SC	S1	G5T1T2
Oregon vesper sparrow	*Pooecetes gramineus affinis*	SC	S1B	G5T3
Sandhill crane	*Grus canadensis*	SE-X	S1B	G5
Mazama pocket gopher	*Thomomys mazama*	SC	S1	G4G5

[a]Does not include other species primarily associated with oak woodlands such as slender-billed white-breasted nuthatch.
[b]WNH = Washington Natural Heritage Program; plant status E = endangered, T = threatened, S = sensitive; SE, SC = state endangered, state candidate; X = probably extinct from south Puget Sound prairies; R = reintroduced to south Puget Sound region (WNHP 1997).
[c]WNH and NatureServe Ranks: Numbers 1-5 indicate degree of conservation concern, with 1 being critically imperiled and 5 being secure; G=global or rangewide status; S=state; T=subspecies rank; NR= not ranked; X=presumed extinct, or locally extinct; B= breeding population; U=status uncertain; Species with 2 ranks (e.g. G2G3) or '?' indicates uncertainty about status.

interface, including western yellow-bellied racer, western meadowlark (*Sturnella neglecta*), common nighthawk (*Chordeiles minor*), western bluebird (*Sialia mexicana*), Lewis' woodpecker (*Melanerpes lewis*), and short-eared owl (*Asio flammeus*) (Leonard and Hallock 1997, Smith et al. 1997, Altman et al. 2001).

Present Status of South Puget Sound Prairies

A recent inventory of prairie sites indicated that of the original 150,000 ac with prairie soils in the southern Puget Sound area, only about 12,500 ac (8%) remain that have >25% native vegetation, and of these only about 2,993 ac (3%) are dominated by native plant species (Crawford and Hall 1997). The inventory found 29 prairie remnants with a mean patch size of 433 (±1,519) ac; however, most of these (19, or 65.5%) were <100 ac. All patch size categories have declined 90%, except the largest category (>10,000 ac), which lost its only patch. Generally, large patches became smaller, and many smaller patches disappeared. The most frequent causes of prairie loss were urban development (33%), conversion or invasion by forest (32%), and conversion to agriculture (30%) (Crawford and Hall1997).

In the mid-1800s, 48% of Fort Lewis was comprised of prairie, oak savannah or woodland (GBA Forestry 2002). Prairie and oak woodland declined by 23,820 ac (58%) through loss to development or forest encroachment (ENSR 2000). Fort Lewis has 20,400 ac of the original 37,400 ac of grassland that existed on that area in 1870; only about 3,000 ac of south Puget prairie remains outside the Fort (ENSR 2000, Altman 2003b). The cessation of burning by Native Americans and active fire suppression has allowed >16,000 ac of prairie on Fort Lewis to succeed to first generation Douglas-fir forest (Foster and Shaff 2003), and an additional 6,500 ac have been lost to development (ENSR 2000). The core of the largest remaining prairie site, 91st Division, is the Artillery Impact Area (AIA), a designation that has produced a mix of prairie conditions from high quality to seriously degraded.

No extensive area of prairie remains as it was prior to 1840 (del Moral and Deardorff 1976, Clampitt 1993). The infertility of south Sound prairie soils prevented the complete conversion to agriculture as occurred on the prairies further south, and the establishment of Fort Lewis in 1917 precluded residential development that would otherwise have occurred. However, fire suppression allowed the prairies to be invaded by Douglas-fir beginning as early as 1850. Large portions of the original prairies were overgrown with forest by 1960 (Lang 1961). Combined with grazing by up to 13,000 head of stock, disturbance for agriculture, military activity, and successive waves of introduced Eurasian plants, all prairie sites have been altered to some degree. Most native grasslands are degraded by exotic grasses and forbs, or have been invaded by shrubs, especially Scotch broom (*Cytisus scoparius*), Nootka rose (*Rosa nutkana*) and common snowberry (*Symphoricarpos albus*) (Chappell et al. 2001b). Scotch broom, perhaps the most invasive exotic, was introduced prior to 1900 at Steilacoom, apparently as an ornamental (Lang 1961). The most common grass invaders include colonial bentgrass (*Agrostis tenuis*), velvet grass (*Holcus lanatus*), sweet vernalgrass (*Anthoxanthum odoratum*), Kentucky bluegrass (*Poa pratense*), and tall oatgrass (*Arrhenatherum elatius*), and the most common forbs include false dandelion or cat's ear (*Hypochaeris radicata*), St. John's wort (*Hypericum perforatum*), oxeye daisy (*Chrysanthemum leucanthemum*) English plantain (*Plantago lanceolata*), sheep sorrell (*Rumex acetosella*), and teesdalia (*Teesdalia nudicaulis*) (Clampitt 1993, Buschmann 1997, Chappell and Crawford 1997, Schuller 1997).

The grasslands around airport runways and taxiways on historical prairies in the area are very important to Mazama pocket gophers and streaked horned larks. Chappell et al. (2003) describe the airport grassland cover type as "…herbaceous vegetation located on and adjacent to airport runways and on soil survey map units that supported presettlement grasslands. These short-stature grasslands are regularly mowed and in some cases have remnant native grassland plant species."

Remaining Puget prairies with native vegetation are rapidly disappearing, and conservation efforts are being focused on managing prairie in and around existing protected areas as well as acquiring the

best and largest remaining sites in private ownership (Table 1.2, Fig. 1.3). The major sites remaining with significant habitat value for grassland wildlife are described below. Some sites also contain valuable oak woodland and wetland habitats.

Scatter Creek Wildlife Area. The 1,140 ac Scatter Creek Wildlife Area (WLA) is located on the historical Mound Prairie that is bisected by Interstate 5 near Grand Mound. The Wildlife Area is inhabited by several butterflies, Mazama pocket gophers, and prairie and oak communities. Scatter Creek WLA contains about 600 ac of degraded prairie, including a Roemer's fescue/white-topped aster community. Some of the prairie habitat is on leased private lands that could be developed. Much of the native prairie has been invaded by Scotch broom and requires broom control activities to maintain the habitat; tall oatgrass has also recently become a serious problem. Intensive recreational use of this site presents additional management conflicts. Rare plants and butterfly habitat have been trampled by horses during specialized dog competitions in which dogs are followed by observers on horseback. The potential impact of pheasant releases on larvae of rare butterflies has not been assessed.

Rock Prairie. Rock Prairie, an area of about 285 ac, is located southwest of Tenino. The area still supports Mazama pocket gophers on a small patch of intact mounded prairie and pastures (Steinberg 1996, K. McAllister, pers. comm.), and the site once supported robust populations of several prairie butterflies (J. Pelham, pers. comm.). It is privately owned and has been degraded by the spreading of waste from large dairies. The addition of nutrients to relatively infertile outwash prairies alters the soil in a way that likely benefits exotic species at the expense of native species (Parker et al. 1997). Open grassland still exists in large parcels, but the potential for restoring native vegetation is unknown.

Rocky Prairie Natural Area Preserve. This 35 ac Natural Area Preserve (NAP) was established in 1990 to preserve a mounded prairie site and its rare plant species and communities, particularly Roemer's fescue/white-topped aster. Rocky Prairie supports one of the best condition native prairie remnants (Schuller 1990). Roemer's fescue/white-topped aster association covers about 80% of the site. It supports several prairie butterflies, and formerly supported Taylor's checkerspots (B. Bidwell, pers. comm.). Prairie restoration activities include the complete removal of Scotch broom and annual maintenance to kill germinating broom seedlings.

Table 1.2. South Puget Sound prairie sites with some degree of protection[a] and presence of Mazama pocket gopher, streaked horned lark, and prairie butterflies.

Name of Area	Management Agency	Area (ac)	Gopher	Lark	Butterflies
Black River-Mima Prairie Glacial Heritage Preserve	Thurston County	1,020[b]			√
13th Division Prairie Research Natural Area	U. S. Army	248			√
Weir Prairie Research Natural Area	U. S. Army	1,193	√		√
91st Division Prairie, Artillery Impact Area[c]	U. S. Army	7,600	√	√	√
Scatter Creek Wildlife Area	WDFW	1,140	√		√
Bald Hills Natural Area Preserve	WDNR	313			√
Mima Mounds Natural Area Preserve	WDNR	445			√
Rocky Prairie Natural Area Preserve	WDNR	35	?		√

[a]The uses allowed vary from non-vehicle military training and dog trials using horses (Fort Lewis and Scatter Creek) to limited research and educational visits (some DNR Natural Area Preserves).
[b] About 550 ac of this preserve has prairie vegetation.
[c] The AIA is closed to all recreational uses and digging; a large portion is closed to vehicles and foot traffic due to the presence of unexploded ordnance.

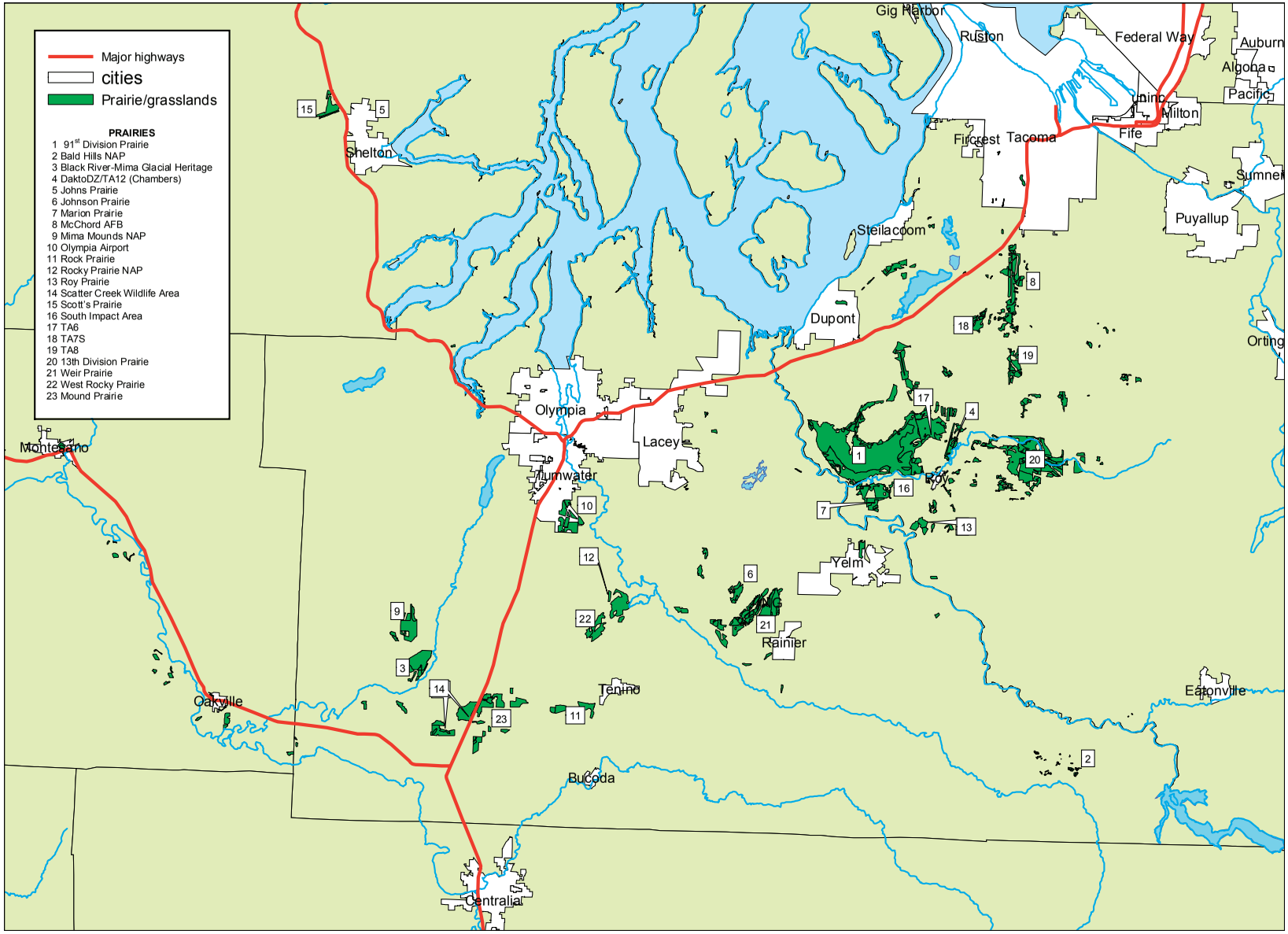


Figure 1.3. Location and place names used in text for south Puget Sound grassland sites (grasslands data from Chappell et al. 2003).

Also, native species, especially Roemer's fescue plugs, were planted after the removal of 100 Douglas firs using a helicopter (S. Pearson, pers. comm.). Other invasive plants that require control include mouse eared hawkweed (*Hieracium pilosella*), Himalayan and evergreen blackberry (*Rubus discolor, R. laciniatus*), cascara (*Rhamnus purshiana*) and tall oatgrass.

West Rocky Prairie/ Beaver Creek. An area called "West Rocky Prairie" north of Tenino includes 300 ac of mounded and terraced prairie, 40 ac of oak woodland, and 300 ac of wetland habitats, and has been identified as a potential state wildlife area. The prairie includes a Roemer's fescue/white-topped aster community and supports several prairie butterflies. Taylor's checkerspot formerly inhabited the site but has not been recorded in recent years. The site is strategically located between other prairie sites and would provide a critical stepping stone. It is one of the most important parcels of Puget prairie remaining in private ownership due to its large size, relatively good condition, and diverse habitat values. Beaver Creek and associated wetlands support the federally threatened water howellia (Howellia aquatilis), and state sensitive Olympic mudminnow (*Novumbra hubbsii*). Seasonally flooded prairie provides habitat for Oregon spotted frogs, and the wetland and oak habitat provides a potential reintroduction site for western pond turtles, western gray squirrel, and slender-billed white-breasted nuthatch. The area is owned by a corporation that has proposed a residential development and gravel quarry for the area. The state is in negotiations with the landowner.

Mima Mounds Natural Area Preserve. Mima Mounds NAP west of Littlerock is a 445 ac preserve established in 1975 to preserve an undisturbed example of mounded prairie and the rare Roemer's fescue/white-topped aster community (DNR 1997). There are also 280 ac of prairie habitat on private lands adjacent to the NAP that support prairie. The preserve supported Taylor's checkerspots and Mardon skippers until recent years. The area was lightly grazed until the 1960s. Restoration has included five controlled burns between 1992 and 1997. The first burn got out of control and burned most of the preserve and may have resulted in the extinction of the local Mardon skipper population (R. M. Pyle, pers. comm.). Portions of the preserve have been burned 3 times, while the northern portion has not been burned. Broom control has also involved mowing, hand pulling, and herbicide applications. In 1996, several hundred Douglas-firs were removed from about 30 ac, and the area planted with Roemer's fescue plugs and some other native species.

Black River-Mima Prairie Glacial Heritage Preserve. This 1,020 ac preserve, owned by Thurston County, includes about 550 ac of Mima mounded prairie that is managed by The Nature Conservancy (TNC) under an agreement with the County (Grosboll and Kelley 1999). This preserve also has and oak woodland. Extensive control of Scotch broom and Douglas-fir has been done and is ongoing. The area combined with Mima Mounds NAP was recently identified as an Important Bird Area in Washington (Cullinan 2001). These two protected areas total 1,500 ac and are separated by < 1 mi of private residential and pasturelands.

Bald Hills. The 313 ac Bald Hills NAP was established in 1985 to preserve rare plant communities. The shallow soil overlying bedrock dries out in the summer creating seasonal soil conditions similar to the droughty soils of outwash prairie, but the balds exist within a matrix of forest. Several other balds with prairie and oak woodland vegetation are located on private lands in the area. The area supports a high density of rare vegetation communities, including grassy balds, and plant species found only on exposed rock outcrop, vernally moist seeps, and oak woodland. The area has very high habitat value for wildlife and at least 39 plant taxa that are not known to occur anywhere else in Thurston County. Private lands containing balds in the area may be at risk of residential development.

Scotts Prairie. This grassland site is at and surrounds the Shelton airport (Sanderson Field) where the DNR Natural Heritage Program mapped 211 ac of "airport grassland." This site is significant for the presence of the Shelton pocket gopher (*T. mazama couchi*) and a small number of nesting streaked

horned larks.

Boisfort Prairie. This former prairie of about 1,200 ac was largely converted to farming in the 19th century. However, a pioneer cemetery, a few roadsides, and a pasture support remnants of native prairie, including several rare plant species and some unusual butterflies and moths (Caplow and Miller 2004). The soil is mostly well drained, but with a few wet swales that support some wet prairie species. Taylor's checkerspot was once recorded here, but now seems to be locally extinct.

Prairie Habitat on Fort Lewis

Fort Lewis, located between the cities of Tacoma and Olympia, is an 86,000 ac U.S. Army reservation, about 20,000 ac of which is grassland. Much of the remaining and best studied south Puget prairie habitat is found on Fort Lewis where the main remaining prairie sites total about 11,339 ac (ENSR 2000, Altman 2003b). Acreages listed in Table 1.3 and in the text may differ depending on whether it was based on soil, existing vegetation, the Training Area boundary, and inclusion of oak woodland (Crawford et al. 1995, Chappell et al. 2003, Altman 2003b).

Weir Prairie. Weir Prairie hosts populations of white-topped aster, Mazama pocket gophers, western toads (Bufo boreas), and butterflies, and contains some of the best examples of native Puget Sound fescue prairie. The 1,193 ac Weir Prairie Research Natural Area consists of Upper Weir Prairie and Lower Weir Prairie, and is protected from the most destructive forms of military training, such as off-road vehicle maneuvers and digging. A large portion of the vegetation on Upper Weir (55%) is in good or fair condition; 30% of Lower Weir and 22% of South Weir are in good to fair condition (Table 1.3). Unauthorized training with tracked vehicles on South Weir in 1996 resulted in extensive damage to the vegetation there. Weir Prairie also receives some negative impacts from horses, motorcycles, and foot traffic during recreational use. Upper Weir is the focus of ongoing prairie restoration work including removal of Scotch broom, prescribed burning, planting of Roemer's fescue and forbs, and road closure and enhancements (Altman 2003b, J. Lynch, pers. comm.).

Table 1.3. Area (acres) and condition of main prairie areas on Fort Lewis based on Land Condition Mapping data (Altman 2003b).

Prairie	Poor (0-30%)[a] acres (%)	Fair (31-50%) acres (%)	Good (51-100%) acres (%)	Total acres
Weir Prairie - Lower Weir	308 (70)	69 (16)	63 (14)	440
Weir Prairie - South Weir	109 (78)	23 (16)	9 (6)	141
Weir Prairie - Upper Weir	246 (45)	76 (14)	225 (41)	547
Subtotal - Weir Prairie	663 (59)	168 (15)	297 (26)	1,128
Johnson Prairie	161 (73)	36 (16)	24 (11)	221
13th Division - TA 14	1,275 (88)	150 (10)	31 (2)	1,456
13th Division - A 15	368 (70)	97 (18)	59 (11)	524
Subtotal - 13th Division Prairie[c]	1,643 (83)	247 (12)	90 (5)	1,980
Marion Prairie	181 (87)	19 (9)	8 (4)	208
91st Division Prairie[b]	1,018 (15)	4,944 (72)	859 (13)	6,821
Training Area 6	759 (87)	95 (11)	23 (3)	877
Training Area 7S	100 (97)	3 (3)	1 (1)	104
Total	4,525 (40)	5,512 (49)	1,302 (11)	11,339

[a]The percent of native vs. non-native grasses; these categories are used by the Integrated Training Area Management program in its Land Condition Trend Analysis monitoring on Fort Lewis.
[b]91st Division estimates from Crawford et al. (1995), and likely includes TA6, as well as oak community types.
[c]Does not include a small amount of prairie in TA13.

Johnson Prairie. Johnson Prairie is about 194 ac of native and semi-native grassland and is one of the highest quality Puget prairies. It supports a high diversity of plants and butterflies and is used by Oregon vesper sparrows and western toads and a substantial population of Mazama pocket gophers (Steinberg 1995, Remsburg 2000). The site contains several kettle depressions that were formed by chunks of ice left by the retreating glacier, leaving holes filled with meltwater. These kettles no longer contain ponds, but have moist conditions that allow native plants to flower later in the summer and support a high diversity of forbs and butterflies (Remsburg 2000). Johnson Prairie is part of the Rainier Training Area of Fort Lewis and has received less military training activity than other prairie sites due to its distance from the main part of the Fort. Past activities were primarily foot maneuvers, parachuting, and limited vehicle use (Remsburg 2000). No tracked or wheeled vehicle use is allowed off established roads, because the site is designated a Secondary Research Natural Area. It sustained some damage to soil and vegetation during a recent incursion by a Bradley tracked vehicle (Altman 2003b), that resulted in significant restoration to that section of the prairie (J. Lynch, pers. comm.). It is frequently used for hunting, horseback riding, and off-road driving. Civilian recreational impacts are an increasing concern because off-road vehicle use has increased in recent years. Most of the Scotch broom on the site was treated with herbicides in the fall of 1998. Prescribed burns were conducted on portions of the area in 1996 and 2002, and some supplemental planting of prairie species has also been done (Altman 2003b). Mowing and enhancement plantings are ongoing (J. Lynch, pers. comm.).

91st Division Prairie. The 91st Division Prairie (about 6,960 ac), west of Roy in Pierce County is the largest remaining prairie in the South Puget Sound area. The eastern and western ends have heavy use ranges that have been damaged by vehicles and exercises, and the core is an artillery impact zone (AIA), a small portion of which has a high percent cover of bare ground. Access to the AIA is restricted due to the presence of unexploded ordnance, so there is no impact from vehicles or training, and grassland is maintained by occasional wildfires. The periphery of the impact zone contains some of the highest quality prairie sites with high plant diversity, butterflies, and at least one area provides habitat to Mazama pocket gophers, streaked horned larks, and Oregon vesper sparrows (Altman 2003b). The high quality sites include large patches of Puget balsamroot, harsh paintbrush (*Castilleja hispida*), sickle-keeled lupine (*Lupinus albicaulis*), and nineleaf lomatium (*Lomatium triternatum*). In the core of the AIA, soil disturbance by explosive ordnance and relatively frequent wildfires have maintained a grassland, but the native bunchgrass has largely been replaced in some areas by introduced forbs such as *Hypochaeris radicata* and annual grasses, particularly *Anthoxanthum odoratum* (Tveten 1997).

Training Area 6. This area (835 ac) is just northeast of the 91st Division Prairie. It is mostly "semi-native grassland"(Chappell et al. 2003) and is heavily impacted by tank, artillery, and other training. The area retains grassland, but native species are probably only a minor component, and 87% is in poor condition (Altman 2003b). It was once used for nesting by streaked horned larks, but they have not been seen there in recent years.

Marion Prairie and South Impact Area. The name "Marion Prairie" generally refers to 186 ac of grassland remaining in Training Area (TA) 18 north of Yelm. Crawford et al. (1995) used the term to also include about 486 ac of grassland in the South Impact Area to the north. Based on soils, Crawford et al. (1995) estimated that the area once had about 956 ac of prairie. The area supports populations of white-topped asters, Mazama pocket gophers, and Oregon vesper sparrows, although only 13% of the vegetation is in fair or good condition. Marion Prairie is heavily used for training and is subject to excavations for artillery fire bases. The South Impact Area has rifle ranges, but is not subject to excavation (J. Lynch, pers. comm.). The condition of this area was greatly impacted by a training event in 1996; its condition has continued to decline since that time (Altman 2003b). Only 2 species of butterfly, ocre ringlet (*Coenonympha tulia*) and great spangled fritillary (*Speyeria cybele*), were observed there in 2003 (Morganweck and Dunn 2003).

13th Division Prairie. The 13th Division Prairie includes TA14, TA15, and prairie habitat at the north end of TA13. This site is the second largest remnant prairie at about 2,014 ac (tallied from Chappell et al. 2003), and supports a nesting population of streaked horned larks (Pearson and Hopey 2004). The area also supported Taylor's checkerspots until recently, but none have been found in surveys for several years (Hays et al. 2000). Portions of the ground are highly disturbed by tracked vehicles creating open ground attractive to horned larks. About 29% of TA 15 is still in fair or good condition, but TA 14 has an extensive network of dirt roads, is heavily used for training, and only 12% of it is in fair or good condition (Altman 2003b). A small part of TA 13 is grassland, some of which is good quality prairie, including one area near SR 507 that is staked off from vehicular training (Altman 2003b). TA 15 includes the 13th Division Prairie Research Natural Area (248 ac), where only walking maneuvers are permitted (Remsberg 2000). Much of TA 15 is subjected to a lower level of activity except a portion of high quality fescue prairie that is mowed for landing helicopters. The 13th Division Prairie has been subject to regular authorized and unauthorized recreational uses, including dog training, horseback riding, model airplane flying, Boy Scout camping, and pheasant hunting. Butterfly surveys have noted a decline in numbers and diversity in TA15 in recent years (Remsburg 2000, Ressa 2001). Seasonal restrictions of organized events have recently been imposed to help protect nesting streaked horned larks (Pearson 2003). Some restoration work has been conducted in protected areas of the prairie, and portions of the area are regularly mowed.

DaktoDZ/TA12. This area, sometimes called Chambers Prairie, includes about 145 ac near Chambers Lake in the western portion of TA 12 north of Roy, between the Burlington Northern Railroad track and Chambers Lake. This area is highly disturbed and mostly in poor condition with areas of bare ground and Scotch broom. Only 1 common wood nymph (*Cercyonis pegala*) was observed during a 2003 survey (Morganweck and Dunn 2003).

Training Area 7S. This area of about 100 ac is north of the small arms Central Impact Area, and adjacent to McChord AFB. It has been used for wheeled and tracked vehicle maneuver training and gravel extraction. Recreational uses include pheasant hunting and horseback riding, including an unauthorized jumping course. Almost 97% is in poor condition with non-native vegetation predominant (Altman 2003b). The condition of this site has declined with invasion by Scotch broom in the last 10 years (Altman 2003b). The most productive site for butterflies during the late 1970s and 1980s is now a gravel pit (Morgenweck and Dunn 2003). It still supports harsh paintbrush and Puget balsamroot, and surveys in 2003 detected 7 butterfly species, but none were rare prairie-dependent species. It previously supported Taylor's checkerspot, Puget blue and great spangled fritillary butterflies.

Training Area 8. TA8 has been heavily used for training and is characterized by disturbed low quality habitat, with a significant amount of bare ground (Altman 2003b, Morganweck and Dunn 2003). Chappell et al. (2003) classified two thirds of the 330 ac area as shrubland (i.e. Scotch broom). It also receives heavy recreational use. This prairie was in fairly good condition until 1996 when it was designated for tracked vehicle training (Altman 2003b). This area includes habitat of the last remnant population of western gray squirrels in western Washington (Altman 2003b) and it formerly hosted Taylor's checkerspot. There is a small staked area where vehicles are excluded to protect white-topped aster.

Miscellaneous Fort Lewis sites. There are a few other smaller prairie or grassland sites mentioned by Altman (2003b). Gray Army Airfield supports nesting by streaked horned larks (Pearson 2003). Pipeline Prairie extends along both sides of a pipeline right-of-way in TA 23. Prairie-Oak Preserve has received native grass and forb plantings and yearly Scotch broom control; it is used as an educational site. Scouts Out Prairie north of 91st Division Prairie was prescribe burned in 2004. Scotch broom on Spurgeon Creek Rd Prairie was mowed in 2004, and enhancement plantings are planned. These grasslands have received increased attention in recent years for their potential to provide conservation opportunities or alternative training areas (Altman 2003b, J. Lynch, pers. comm.).

McChord Air Force Base

McChord Air Force Base (AFB) is located on an area of historical prairie and oak woodland. There are no large areas of native prairie vegetation remaining on the base, but there are extensive areas (425 ac) of "airport grassland" surrounding the runways that are used for nesting by streaked horned larks. There are also some smaller areas of oak savannah, the largest being 18.5 ac (Chappell et al. 1999). McChord supported large numbers of Taylor's checkerspot in the 1950s, but few butterflies of any species were recorded during 1995 and 1996 surveys. TNC began mowing the south approach zone in 1998.

Habitat Loss and Fragmentation

Trends in the human population suggest that available habitat and the quality of habitat will continue to decline without protection and careful management of conflicting uses. The human population in Washington is expected to increase from the current 5.6 million to 7.7 million by 2020, and may double to 11 million by the mid-21st century (equivalent to adding 29 new cities the size of Tacoma or Spokane; WDNR 1998). From 1970 to 1995 the amount of land devoted to houses and businesses doubled in the central Puget Sound region.

Prairie habitat continues to be lost, particularly to residential development. In the south Puget Sound area, over 90% of the original grassland has been destroyed and perhaps only 2-3% remains that is not dominated by exotic vegetation. As the habitat patches become smaller, fewer, and farther apart, the likelihood of each patch continuing to support grassland-dependent species declines as intervening habitat patches are lost.

Habitat Degradation and Succession

The fire regime established and perpetuated by native Americans maintained the south Puget Sound prairies for the past 4,000 years, or more. Fire suppression allows succession by both native and exotic flora, and without vegetation management the native prairies will disappear. Fire suppression allows fire-sensitive species to invade and allows an unusual build-up of fuels that can lead to very hot fires that harm the normally fire-tolerant native species (Tveten 1997). The largest remaining prairies (91st Division and 13th Division) are maintained by both prescribed and accidental fires, but large portions of these areas are also subject to disturbance during military training.

Douglas-fir. Fire suppression allows Douglas-fir to invade and overwhelm prairie (Fig. 1.4). Disturbances such as grazing and vehicle traffic may accelerate colonization by Douglas-fir because Douglas-fir seed germination is enhanced by disturbance that increases mineral soil contact, while native plants may decline with the loss of the moss carpet. In addition to the natural succession that occurs with fire suppression, Fort Lewis had an active program to encourage a Douglas-fir monoculture from the mid-1960s until 1994 (Perdue 1997). Prairie preserves where Doug-fir control has been conducted in recent years include Johnson Prairie and Weir Prairie RNA on Fort Lewis, Mima Mounds and Rocky Prairie NAP, Thurston County's Glacial Heritage Preserve, and Scatter Creek WLA (Dunn 1998). Fort Lewis has about 16,300 ac of coloniza-

Figure 1.4. Douglas-fir has invaded many remaining historical prairies.

tion forest on areas that were formerly prairie (Foster and Shaff 2003).

Scotch broom. Scotch broom is the most visible invasive species that can rapidly cover prairies. Scotch broom is a nitrogen fixer, that is, it has symbiotic bacteria in nodules on its roots that alter atmospheric nitrogen into forms that remain in the soil and is then available to plants. This changes the normal soil nutrient content of the prairies, which are normally low in nitrogen. Other exotic species may benefit from the addition of nitrogen to the soil, but native species are not adapted to take advantage of the increased nutrient level (Parker et al. 1997). Parker et al. (1997) state that Scotch broom invasion results in a decline in native species diversity, but it is not clear whether this results from competition for light, water, and nutrients, or from the facilitation of invasion by other aggressive species via nitrogen dynamics. Scotch broom germinates and grows rapidly when a seed source is available. Ecosystem disturbance is believed to facilitate invasion by exotic plants by increasing the availability of safe sites for seed germination (Parker 2002). Parker (2002) investigated the potential role of disturbance in Scotch broom invasion on south Puget Sound prairie. Neither burning, nor scraping off the biological soil crust increased invasion by broom. She concluded that the glacial outwash prairie ecosystem is readily invaded by Scotch broom and that simply reducing disturbance would not stop broom invasion (Parker 2002).

Scotch broom is killed through burning, hand pulling, or herbicide, but control requires an ongoing program because the plants produce an abundance of seeds that remain viable in the soil for several decades. A 4-inch layer of soil and litter beneath a Scotch broom plant can contain >2,000 seeds (Swift 1996). Regular mowing can prevent Scotch broom seed production. Fire often stimulates germination of broom seeds in the soil, so a second burn, or herbicide is needed to kill the abundant seedlings. Portions of the Artillery Impact Area on Fort Lewis are broom free, indicating that frequent burning prevents broom establishment, but this can also impact native species. All control methods can be detrimental to native species if not well planned. Horned lark nests can be destroyed by spring burning or mowing; butterflies and sensitive plants can be harmed by herbicides or burns. Non-native insects have been introduced in the area for the biological control of Scotch broom, including a seed weevil (*Apion fuscirostre*), a shoot tip moth (*Agonopterix nervosa*), and a twig mining moth (*Leucoptera spartifoliella*). Although these insect agents have not stopped the spread of Scotch broom, they stress the plants and reduce seed production. They are slow acting, however, and are not expected to produce quick and dramatic results (Dunn 1998). Research is ongoing in the Pacific Northwest, and in New Zealand and Australia where Scotch broom is also a pest, to identify other biological control agents.

Other invasive weeds. There is an abundance of invasive exotic plants that degrade native prairies in the south Puget Sound region. These include sod-forming grasses that spread throughout the region in part because they were more tolerant of heavy historical grazing than the native bunchgrasses (Mack and Thompson 1982). These rhizomatous grasses form dense sods that are impenetrable for many native prairie species, including forbs that would normally occupy the spaces between clumps of Roemer's fescue (Dunn 1998). The presence of exotic invasive grasses and forbs, in addition to Scotch broom, complicates control and restoration because some methods that eliminate broom, such as burning, may favor exotic forbs or grasses, such as colonial bentgrass and velvetgrass (Schuler 1997, Dunn 1998). Selective herbicides, such as Poast®(sethoxydim) and Fusilade® (fluazifop), that kill grasses, but not fine-leaved fescues, such as the native F. roemeri, may prove useful in controlling exotic grasses on prairie sites (Dunn 1998, Grosboll and Kelley 1999).

Habitat Management and Restoration

Prairie restoration. Various agencies and organizations have been involved in developing methods of restoring and maintaining native prairie vegetation. The U.S. Army has identified several goals for the management of grasslands on Fort Lewis. Three overall goals identified in the prairie management plan are: no net loss of open landscapes for military training; no net reduction in the quantity or quality

of moderate- and high-quality prairie; and viable populations of all prairie-dependent and prairie-associated species (Altman 2003b). Related goals are to: 1) stop and reverse the encroachment of Douglas-fir into grassland habitats; 2) control Scotch broom; 3) restore the grassland/forest ecotone; 4) maintain/augment habitat features for grassland dependent species; 5) restore training damaged grassland; and 6) inventory and monitor grassland habitats (ENSR 2000:145). Strategies to accomplish these goals include the commercial or pre-commercial harvest of Douglas-fir from prairie and oak woodland and the burning, mowing, and cutting of Scotch broom. The U.S. Army/DOD has had a prescribed burning program for 7,400 ac of prairie and oak woodland on Fort Lewis since the early 1980s. Portions of the area are subjected to spring, or sometimes fall, burns on a 3-5 year rotation (Tveten 1997, Tveten and Fonda 1999). Burns to remove Scotch broom are done on about 1,500 –3,000 ac annually, with primary focus on the larger grasslands. In addition, Scotch broom is mowed on about 1,000 ac annually. The management objective for grassland sites that receive intense and repeated training is to maintain vegetative cover. These sites may be rehabilitated using a non-native seed mix, because the objective does not entail restoring a high quality native prairie (Altman 2003b). Fort Lewis is also leading a multi-agency effort to develop a regional protocol for assessing the ecological quality of prairies (J. Foster, pers. comm.)

The Nature Conservancy of Washington has been working with Fort Lewis on prairie habitat enhancement and invasive species control under a cooperative agreement since 1992 (J. Lynch, pers. comm.). TNC has been assisting with Scotch broom control and conducting research and management experiments on restoration methods (Dunn 1998). TNC has also been working with the U.S. Air Force/DOD on McChord Air Force Base since 1994 on projects for prairie and oak woodland restoration (Rogers 2000). The early focus of these projects has been control of Scotch broom, but with the eventual goal of restoring the historical appearance and habitat function. TNC of Washington is also involved in habitat restoration with Thurston County on Black River-Mima Prairie Glacial Heritage Preserve (Grosboll and Kelley 1999). TNC is also removing Scotch broom on several private parcels in a corridor between Mima Mounds NAP and the Glacial Heritage Preserve with a grant from the Landowner Incentive Program (LIP). TNC is also using LIP funds to hand pull Scotch broom and seed drill Roemer's fescue plugs on Weir Extension.

WDFW restoration work on Scatter Creek WLA has thus far been focused on Scotch broom control, but tall oakgrass has become a serious problem in the last few years and has also required attention. Other actions include selective removal of Douglas-fir, management experiments with herbicides, fire, and soil nitrogen reduction. Washington Department of Natural Resources removed Douglas-fir and planted native prairie species on Rocky Prairie NAP with a grant from the U.S. Fish and Wildlife Service (Davenport 1997). They have also conducted prescribed burning at Mima Mounds NAP (Schuller 1997).

Other prairie restoration efforts include recovery planning for golden paintbrush, listed as Threatened under the federal Endangered Species Act. The recovery plan calls for establishing additional populations of golden paintbrush throughout its historical range (USFWS 2000, Caplow 2004).

Research

South Puget Sound prairies, particularly those on Fort Lewis, have been the focus of several recent and ongoing studies. The Natural Heritage Program of WDNR conducted an inventory of historical and existing prairie and oak woodland sites based on soil types, and added to existing information describing native prairie vegetation (Chappell and Crawford 1997, Chappell et al. 2001b, Chappell et al. 2003, Caplow and Miller 2004). Cooperative research was recently conducted on the propagation of prairie plants; cooperators included WDNR, USFWS, University of Washington's Center for Urban Horticulture, and TNC (Davenport 1997, Drake and Ewing 1997, Robohm 1997, Schuller 1997). The Center for Urban Horticulture, in cooperation with the U. S. Army, conducted experimental plantings of F. roemeri on Fort Lewis in 1994-95 to re-vegetate disturbed sites and investigate prairie restoration methods (Robohm 1997). Studies of the effects

of fire and military training on prairie vegetation on Fort Lewis have also been conducted with support of the Army, TNC of Washington and the WDNR Natural Heritage Program, and grants through the University of Washington (Clampitt 1993, Tveten 1997, Tveten and Fonda 1999, Parker 2002). The results of these studies are presented in Dunn and Ewing (1997).

Additional completed or ongoing studies since the publication of Dunn and Ewing (1997) include: Native Grassland Mapping Study by the Land Condition Trend Analysis (LCTA) program, initiated in 1997; Native Grassland Propagation Study to determine the most effective means of re-vegetating maneuver lands (Dunn 1998); Hydroseeding and Drill Seeding Project by TNC began in 1998; Effects of Tracked Vehicles on Grasslands (1998-2002) to study the effects of M1A1 tanks on soils and vegetation of prairie and grasslands, by Colorado State University, Center for Ecological Management of Military Lands and contractors; and the White-topped Aster Study, initiated in 1997 by LCTA, TNC and the University of Washington to investigate the demographics of Aster curtus and effects of disturbance and management options for maintaining viable populations of A. curtus on Fort Lewis (ENSR 2000). Kaye (2001) reported progress of research on the propagation of golden paintbrush. Dunwiddie and Pearson (2004) monitored the response of golden paintbrush to a controlled burn. TNC has been testing and improving Scotch broom control techniques and strategies (Dunn 2003).

Miscellaneous Activities

Conservation planning. Fort Lewis, McChord AFB, WDFW, TNC, the Port of Olympia, and Pierce and Thurston counties are developing a Candidate Conservation Agreement with the USFWS to address land use and management issues and the conservation needs of federal candidate species in the south Puget Sound region. Strategic Goal # 8 in the Fort Lewis Sustainability Plan is to "Recover all listed and candidate federal species in the South Puget Sound Region" (Department of the Army 2003). The habitat on Fort Lewis, and the Army's commitment to species recovery will be extremely important for the conservation of the prairie species. TNC completed the South Puget Prairies Site Conservation Plan in 2002. Recent and ongoing recovery actions for candidate species are outlined in a TNC report (Warren and Dunn 2005). The Washington Natural Heritage Program is leading a multi-party group to develop a conservation plan for Boisfort Prairie in Lewis County.

Habitat acquisition. The area informally called "West Rocky Prairie" is the largest and best remaining south Puget Sound prairie in private hands. WDFW has secured some funding and hopes to acquire 600 ac of this area that includes prairie, oak woodland, and wetlands. WDFW also anticipates acquiring a 40 ac private inholding at Black River-Mima Prairie Glacial Heritage Preserve. TNC is acquiring an easement on 127 ac called Weir Extension adjacent to Weir Prairie. TNC recently received a donation of a conservation easement on 613 acres of the Cavness ranch on Frost Prairie south of Tenino. WDNR has funding to expand Mima Mounds Natural Area Preserve and is working with local landowners. Acquisition efforts require the presence of willing sellers, as well as available funding.

CHAPTER 2. MAZAMA POCKET GOPHER

INTRODUCTION

The Mazama pocket gopher, *Thomomys mazama*, is a small endemic pocket gopher found only in western Washington, western Oregon and northern California. *T. mazama* was formerly more widespread on south Puget prairies, but has become increasingly rare as suitable habitat has been lost to development or degraded by Scotch broom and succession to forest. The apparent extinction of a race once found in Tacoma, *T. m. tacomensis*, suggests that suburban development may be incompatible with persistence of pocket gopher populations. The Washington Department of Fish and Wildlife added four subspecies of Mazama pocket gopher to the state Candidate list in 1991; these were subsequently replaced with the entire species *T. mazama* in 1997. The list of state Candidate species is comprised of species to be reviewed for possible listing as endangered, threatened or sensitive.

TAXONOMY

The Mazama pocket gopher (*Thomomys mazama*), also known as the western pocket gopher, is a member of the family Geomyidae, a family of New World fossorial rodents that is closely related to the Heteromyidae (pocket mice, kangaroo mice, kangaroo rats) (Verts and Carraway 1998). The genus name *Thomomys* is derived from the Greek words *thomos* ("heap") and *mys* ("mouse") (Maser et al. 1981). The species is named after Mount Mazama, the volcano that exploded about 6,000 years ago producing Crater Lake, Oregon, the type locality for the species (Hall 1981, Robbins and Wolf 1994).

The great variability in color and morphology in pocket gophers has resulted in a complex and confusing taxonomy, with about 35 species and 300 described subspecies (Baker et al. 2003). The genus *Thomomys* was generally accepted in 1857. The western Washington populations now recognized as *T. mazama,* were listed as *T. douglassi* after Baily (1915) revised the genus. Goldman (1939) included the western Washington subspecies in *T. talpoides*, as did Dalquest and Scheffer (1942). However, morphology and fur coloration, which were the basis for the original subspecific designations (Table 2.1), are now considered highly variable traits in pocket gophers and have minor value in determining taxonomic status (Steinberg and Heller 1997, Baker et al. 2003). The morphology of individuals is affected by their environment. For example, nutritional quality of available vegetation affects body size and skull characteristics (Patton and Brylski 1987, Smith and Patton 1988). Johnson and Benson (1960) established that, with the exception of the Brush Prairie pocket gopher (*T. t. douglassii*) from the vicinity of Vancouver, all western Washington forms belonged in *T. mazama*, and not *T. talpoides*. They found that the only reliable morphological character that could be used to differentiate *T. mazama* forms from *T. talpoides*, even in juveniles, is the size of the baculum, or penis bone. The bacula of adult *mazama* measure 20-31 mm and 10-17 mm in *talpoides* (Johnson 1982). The resulting taxonomic revision placed the described subspecies *melanops, yelmensis, tacomensis, couchi, glacialis, pugetensis, tumuli*, and *louiei* of Washington, as well as 7 subspecies from Oregon and California, into *T. mazama* (Hall 1981).

Steinberg (1995, 1999) recently re-examined 5 of the 8 *T. mazama* subspecies in Washington using differences in the mitochondrial gene, cytochrome-b. She determined that the subspecies *glacialis*, *pugetensis*, and *yelmensis* exhibited no differences in this gene and believed that combining them would better reflect distinct evolutionary units. She was unable to find extant populations of *tumuli*, *tacomensis*, or *louiei* and did not evaluate their genetics. Steinberg and Heller (1997) expect that the taxonomy will eventually be changed so that only *yelmensis* is retained to represent *glacialis*, *pugetensis*, *tumuli*, and *tacomensis*. This would leave four subspecies, *T. m. melanops, T. m. couchi*, *T. m. louiei*, and *T. m. yelmensis*, in Washington (Plate 1).

Table 2.1. General locations and dorsal fur color of 8 described subspecies of Mazama pocket gopher in Washington.

Subspecies	Locations	County	Typical dorsal fur color[c] (from Verts and Carraway 2000)
T. m. tacomensis[ab]	Tacoma and Steilacoom vicinity, possibly southeast to Puyallup.	Pierce	Reddish tan
T. m. glacialis[a]	Prairie S of Roy	Pierce	Light yellowish brown
T. m. yelmensis	Yelm vicinity prairie; N of Rochester; Vail vicinity	Thurston	Light brown
T. m. tumuli[a]	Rocky Prairie, N of Tenino	Thurston	Blackish brown
T. m. pugetensis[a]	Prairie habitat S of Olympia	Thurston	Blackish brown
T. m. couchi	Shelton vicinity	Mason	Reddish tan
T. m. louiei[b]	Cathlamet Tree Farm,	Wahkiakum	Black, some dark brown individuals
T. m. melanops	Olympic National Park, alpine meadows	Clallam	Reddish brown

[a]These subspecies may be combined with and assume the designation of *T. m. yelmensis* (Steinberg 1999).
[b]These subspecies or populations may be extinct.
[c]Fur color can not reliably be used to distingiush between subspecies; with the exception of black louiei specimens, most individuals are reddish brown with minor variations from that theme.

DESCRIPTION

Mazama pocket gophers are small (body ≈5.5 in) fossorial rodents with short-necked stocky bodies, narrow hips, and short legs (Table 2.2). They have cheek pouches that open on the sides of their mouth, which can be turned inside out like pants pockets, and are used for transporting food. Among North American mammals, they share this characteristic with pocket mice (*Perognathus* spp.) and kangaroo rats (*Dipodomys* spp.) (Baker et al. 2003). Their prominent chisel-like incisors are rootless and grow continuously (Chase et al. 1982). Pocket gophers close their lips behind their incisors so that their teeth can be used for tunneling without getting soil in their mouths. They have small ears and small bead-like eyes. Their front feet are equipped with strong claws and their digits and palms are bordered with a fringe of stiff bristles (Verts and Carraway 1998). Their tails are short (≈2.5 in) and nearly naked.

T. mazama is a relatively small pocket gopher, similar in size to *T. talpoides*, the species commonly found in eastern Washington. Male *T. mazama* average 10 – 20% heavier and 5% longer. The camas

Table 2.2. Measurements[a] for three subspecies of Mazama pocket gophers in Washington (from Booth 1947, Dalquest 1948, and Witmer et al. 1996).

Subspecies	Sex	n	Total length (mm) mean (range, ±SD, if given)	Tail length mean in mm (range, SD, if given)	Hind foot length mean in mm (range, SD)	Mass (g, ±SD)
T. m. melanops	Unsexed	5	212 (210-216)	71 (67-74)	28 (26-29)	-
T. m. couchi	Male	13	196	55	27	87
	Female	9	191	53	27	79
T. m. yelmensis[b]	Male	27	222.7 (±7.4)	59.1 (±5.1)	29.1 (±1.6)	139.1 (±14.2)
	Female	30	207.0 (±7.1)	50.1 (±5.5)	27.3 (±1.3)	111.0 (±17.9)

[a]Measurements can not be reliably used to distinguish between subspecies.
[b]*T. m. yelmensis* measurements from Witmer et al. (1996); these populations were traditionally considered *T. m. pugetensis*.

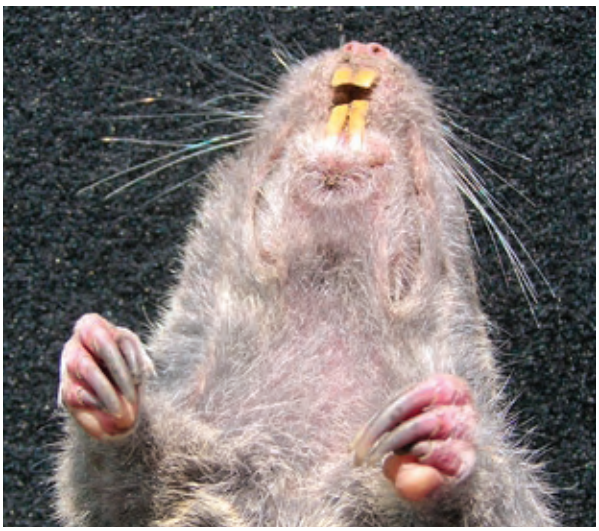


Plate 1. Top: museum specimens (left to right) of *T. m. louiei, melanops, couchi,* and *yelmensis*.
Bottom: Mazama pocket gopher (left), showing characteristic incisors, claws, and cheek pouches, in contrast to the side-oriented front claws and pointed snout of Townsend's mole, *Scapanus townsendi* (right).

pocket gopher (*T. bulbivorus*) and Townsend's pocket gopher (*T. townsendii*) in Oregon weigh 2-4 times as much as *T. mazama* or *T. talpoides* (Verts and Carraway 1998). Verts and Carraway (1998) state that the pelage of *T. mazama* in Oregon "ranges from pure black with purplish and greenish overtones to brown to hazel to yellowish hazel"on the dorsal (top) surface, and "from lead-colored to buff to ocherous" on the ventral surface; the face is "lead-colored to black" and the feet and end of tail are usually white. Johnson and Benson (1960) noted that the western Washington specimens "agree well" with those in Oregon. They state that *T. mazama* skins are generally red brown, compared to the yellow brown and gray/brown shades of *T. talpoides*, and the dark patches behind the ears are more obvious in *T. mazama* (Table 2.1, Plate 1). The subspecies *louiei* exhibited more melanism than the other Washington forms, and contained the only black specimens from Washington. An entirely black subspecies (*T. m. niger*) occurs near the coast of central Oregon.

Confusion with moles. Moles (family Talpidae) are insectivores and lack the prominent gnawing teeth exhibited by rodents (Plate 1). Moles also have a pointed snout and front claws that differ substantially from pocket gophers. Since both moles and pocket gophers are seldom seen above-ground, most people only see the evidence of their digging. The mounds of pocket gophers are easily confused with those of moles, and Maser et al. (1981) note that in Oregon moles are sometimes locally called "gophers" even where pocket gophers do not occur. Gopher mounds can sometimes be distinguished from mole mounds by their shape. Moles generally push soil up from vertical shafts creating circular volcano-like mounds. Pocket gophers, however, push soil out from inclined lateral tunnels typically creating fan-shaped mounds. Where snow accumulates in winter, pocket gophers are active under the snow and will fill snow tunnels with discarded soil, which are seen as sinuous ropes of earth on the surface of the ground when the snow melts in spring.

DISTRIBUTION

North America

Pocket gophers are found across most of the United States, with the exception of the northeastern states, and from central Alberta south to Panama (Chase et al. 1982). Pocket gopher ranges generally do not overlap because one species will competitively exclude the other (Chase et al. 1982, Verts and Carraway 2000). They are never represented by more than one species at any one site, although in a few locations two species occur within 100 yards of each other (Walker 1955). The pocket gopher commonly seen in eastern Washington is the Northern pocket gopher, *Thomomys talpoides*, which is the most widely distributed species in North America. *T. talpoides* also occurs on the western slope of the Cascades in subalpine meadows in Pierce, King, Skamania and Whatcom counties (Johnson and Cassidy 1997). It is represented in western Washington lowlands only by the Brush Prairie pocket gopher (*T. t. douglassii*), an isolated subspecies in the vicinity of Vancouver in Clark County (Johnson and Cassidy 1997). Mazama pocket gophers are restricted to western Washington, western Oregon and a portion of northern California (Fig. 2.1).

Washington

Mazama pocket gophers are patchily distributed in open non-forested habitats in parts of western Washington (Fig. 2.1). Their center of abundance is on the south Puget Sound prairies of Pierce, Thurston, and Mason counties. The species is also found on subalpine meadows of the Olympic Mountains, where the subspecies *T. m. melanops* apparently persisted through the Pleistocene glaciations (Steinberg 1999). Another isolated subspecies, *T. m. louiei*, was described from forest clearings near Cathlamet, Wahkiakum County, in 1950, but has not been seen in recent years and may be extinct. The population described as *T. m. tacomensis* may also be extinct (Steinberg 1996a).

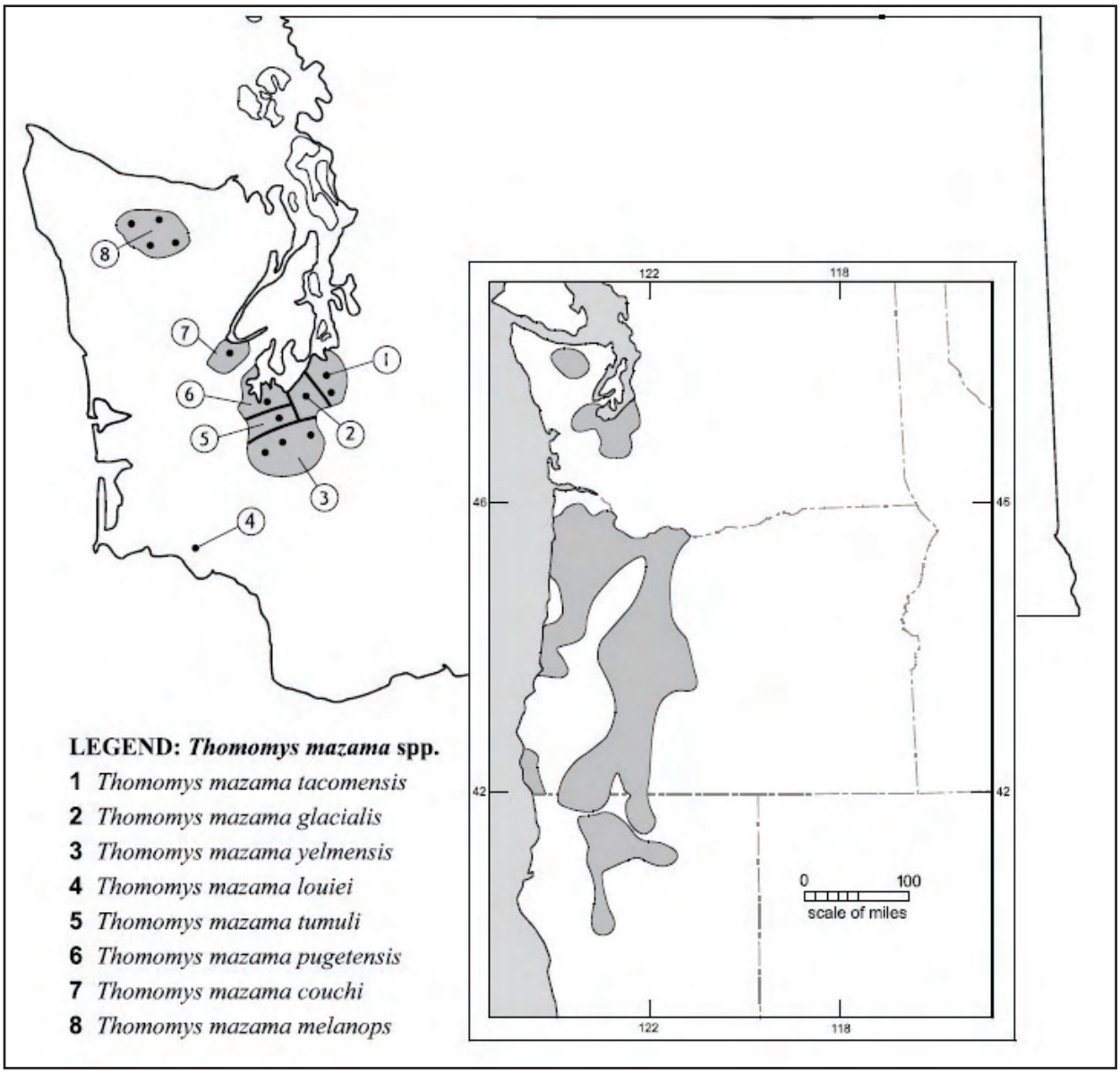


Figure 2.1. Range of the Mazama pocket gopher and 8 described subspecies; Steinberg's (1999) DNA analysis may result in combining subspecies 1-3, 5 and 6 (figure modified from Hall 1981).

NATURAL HISTORY

Diet and Foraging

Pocket gophers eat a wide variety of roots and above-ground plant parts. Maser et al. (1981) state that *T. mazama* are particularly fond of bulbs, such as wild onion and wild garlic, and also eat clover (*Trifolium* spp.), lupines (*Lupinus* spp.), false dandelions (presumably *Hypochaerus radicata*), and grasses. Maser has observed *T. mazama* foraging in the evening on the surface close to their burrows (Maser et al. 1981). He states:

> "Gophers quickly cut off vegetation, cram as much as possible into their cheek pouches, and disappear underground. They frequently reappear in a short time to continue gathering food. The food that is carried into a burrow is undoubtedly deposited in a storage chamber....I have not seen one of these gophers take time to eat while it is exposed on the ground." (Maser et al. 1981:173).

While trapping *T. mazama* on the south Puget Sound prairies in 1941, Victor Scheffer found food caches of roots of cat's ear (*Hypochaeris radiata*),

Gairdner's yampah (*Perideridia gairdneri*), bracken (*Pteridium aquilinum*) and camas bulbs (Scheffer 1995). Dalquest (1948) contains a photo of a food cache 2 liters in volume, composed mostly of quackgrass (*Agropyron repens*).

In a Ponderosa pine/ bitterbrush /needlegrass community in Oregon, Burton and Black (1978) reported that the annual diet of *T. mazama* consisted of aboveground parts of forbs and grasses (40% and 32%, respectively) and 24% roots. Agoseris (*Agoseris heterophylla*), microsteris (*Microsteris gracilis*), and blue-eyed Mary (*Collinsia parviflora*) were eaten in March and May; knotweed (*Polygonum douglasii*), nama (*Nama densum*), groundsmoke (*Gayophytum diffuseum*), and willow-weed (*Epilobium paniculatum*) were frequently eaten in July and September. Common thistle (*Cirsium vulgare*), lupine (*Lupinus leucocephallus*) and violets (*Viola purpurea*) were frequently eaten in summer, while lupines and mulleins (*Verbascum thapsus*) were eaten in winter. Grasses, especially mountain brome (*Bromus carinatus*), were eaten most heavily during the dormant season. Needlegrass (*Stipa occidentalis*) was heavily used during the growing season and early winter (Burton and Black 1978). In July, when all forbs were most abundant, perennial forbs were preferred over grasses, and grasses were preferred over annual forbs. Feeding preferences seemed to change with availability, but the most succulent plants available were the most preferred. Woody plants were least preferred and were a minor component (4%) of the annual diet, eaten mostly in winter. Gopher damage accounted for less mortality to pine seedlings than lack of moisture or frost heaving. Where gardeners use root cellars for storage, pocket gophers were said to "carry off several bushels" of potatoes or turnips (Scheffer 1931).

In a fallow field and a Christmas tree farm in western Washington, food cache chambers usually contained a single type of root, often thistles (*Cirsium* spp.) or Scotch broom (Witmer et al. 1996). Scotch broom is probably not a preferred food, since gophers are absent where Scotch broom is abundant (Steinberg 1996a).

T. mazama, likely show a strong preference for dandelions (*Taraxicum officinale*) as *T. talpoides* do. Dandelions decreased 94% in mountain rangeland due to foraging by *T. talpoides* where sheep grazing had been excluded (Keith et al. 1959, Laycock and Richardson 1975). Vaughan (1974) reported that when snow still partly covered the ground, roots made up 36% of the diet of *T. talpoides*, but they were not eaten when aboveground plant matter was abundant.

Behavior, Burrowing and Burrows

Maser et al. (1981) describe pocket gophers as "pugnacious," probably referring to their territorial behavior in excluding other gophers from burrows. Their burrow system is synonymous with their territory except during the breeding season when territoriality seems to be more relaxed. Witmer et al (1996) reported that at least 5 of 32 burrow systems during February-April contained an adult pair. Gophers are believed to be generally solitary except when breeding and when females have litters, and exclude other gophers from their burrows. Territories of *T. talpoides* are re-established by September and remain mutually exclusive until the following spring (Chase et al. 1982). Despite being aggressive toward other gophers, Chase et al. (1982) characterized gophers as being more docile than most small rodents when handled.

The behavior and burrowing activities of *T. mazama* are likely very similar to *T. talpoides* and *T. bottae*, which have received more research attention. Pocket gophers are adapted to a fossorial life and spend most of their time in their burrow systems. In order to facilitate movements in tunnels, pocket gophers have narrow hips. They are able to run backwards almost as fast as forward (Maser et al. 1981). One pocket gopher dug 146 m of tunnel in 5 months, though the ground was frozen for 2 of those months (Richens 1966). The gopher created 0-14 mounds per day for a total of 161 mounds. One *T. talpoides* was able to construct 152 cm of tunnel per minute through snow (Marshall 1941). Andersen and MacMahon (1981) reported that *T. talpoides* seems to burrow at a relatively constant speed in a given soil type. Under field conditions gophers burrowed at an average speed of 1.5 cm/min (range 0.8 – 2.5), but stopped completely when the soil was frozen

or saturated (Andersen and MacMahon 1981). An adult *T. talpoides* released on compacted clay-loam burrowed 3 cm/min for at least 15 minutes (Richens 1966). When digging, gophers loosen soil with their claws, and their teeth when necessary, and push the dirt backwards under their body. While digging, they periodically turn around within the diameter of their own body and push the soil to the surface or into an unused burrow with their front feet and head (Chase et al. 1982). Soil is pushed out in one direction, creating the fan-shaped mounds typical of gophers, or under snow cover it is packed into tunnels in the snow. Old nest material, rejected food, and fecal material all remain in the burrow system among unused chambers or abandoned and plugged burrows (Chase et al 1982). Unlike other rodents, pocket gophers maintain a sealed burrow system, plugging the entrances with a few inches to a foot of soil (Dalquest 1948).

The extensive burrow systems of pocket gophers have shallow tunnels with laterals for foraging at the surface, and deeper tunnels with chambers for nests, food caches and deposition of fecal pellets. Cox and Hunt (1992) reported that mounds are deposited on the surface by *T. bottae* primarily when gophers are expanding the main tunnel and the quantity of soil is more than can be stored in unused tunnels. When short surface-access tunnels where excavated, the soil was more often deposited in unused tunnels or chambers, and surface mounds were not produced. *T. mazama* tunnels are 3.8- 4.4 cm in diameter, and the shallow ones are 10-25 cm below the surface (Witmer et al. 1996, Verts and Carraway 1998). Witmer et al. (1996) reported that deeper tunnels averaging 141 cm (range 119-150 cm) are also dug. Nest chambers are about 25 cm in diameter and are lined with dry grass. Scheffer (1931) noted that the nests of 4 burrow systems were found at depths of 66, 75, 86 and 91 cm, and Witmer et al. (1996) found nests at an average depth of 88.5 cm (range 48-150 cm, n=12). Five food caches were about 23 cm in diameter at an average depth of 52.8 cm (range 36-72 cm), and were often located 30-60 cm from a nest (Witmer et al. 1996). Food caches usually contained a single type of food cutting. Andersen and MacMahon (1981) calculated that one *T. talpoides* food cache contained about a 13 day supply of food for an adult gopher. The burrow systems of reproductive male *T. bottae* were longer, covered more area, and were more linear than those of females and nonreproductive males (Reichman et al. 1982). However, the spacing between and within burrow systems did not vary by sex, reproductive condition, or study site; burrow systems consisted of basic building units with equal branch lengths and equal distances between branch points. Burrow system length was inversely related to plant productivity. Plant production was approximately twice as great at one study site, and average burrow system length was half that of the other study site (Reichman et al. 1982).

One system of foraging tunnels of *T. mazama* in Oregon occupied an area 12 x 20 ft, or <20.5 m^2 (Walker 1949). Late winter- early spring home ranges in Washington reported by Witmer et al. (1996) ranged from 47-151 m^2 (0.01 – 0.03 ac; n = 8). Ingles (1965) indicated that burrow systems of *T. monticola* ranged from 22 m^2 for young animals to 222 m^2 for older animals. Burrow systems seem to be a valuable resource and systems that become vacant are quickly occupied by gophers from adjacent territories or dispersing subadults (Verts and Carraway 1998, Witmer et al. 1996, Engeman and Campbell 1999). Reichman et al. (1982) indicated when a *T. bottae* was removed, its burrow was taken over by another gopher within hours or minutes, suggesting the gophers were aware of the presence and perhaps the position of their neighbors.

Thomomys pocket gophers adjust their annual cycle of activity to the seasonal changes of weather, soil and plant growth where they occur (Cox and Hunt 1992). Mound building by *T. mazama* in Washington appears to be highly seasonal, with increased activity associated with fall rains (D. Stinson, pers. obs., K. McAllister, pers. comm.). Cox and Hunt (1992) reported that *T. bottae* burrowing activity increased with early winter rains in southern California because it created soil conditions favorable to digging and to growth of herbaceous plants, and was associated with increased reproductive activity. Gophers did not expand their burrow systems when the soil was saturated. Wight (1918) reported that *T. mazama* in Oregon tunneled 4.8 times faster in soft, moist soil and in hard-baked soil. Miller (1948, 1957)

reported that production of surface mounds by *T. bottae* at two locations in California was highest when soil moisture was 9 –19% and 15-17%, and he assumed that this moisture level provided the easiest digging conditions. Seasonal increases in mound building by *T. bottae* in Arizona seemed to be related to availability of preferred foods and movements of males seeking mates (Bandoli 1981); precipitation was not a major factor influencing burrowing activity, but the study area did not have a dramatic seasonal difference in precipitation as occurs in western Washington. Activity is reduced in summer when the soil becomes hot and dry (Chase et al. 1982, Cox and Hunt 1992). Periods of inactivity during the hottest part of the summer suggest that gophers aestivate, but this has not been documented (Cox and Hunt 1992, Baker et al. 2003).

The ability to capture pocket gophers in pitfall traps (Verts and Carraway 1998; D. Stinson, personal observ.), and their frequent occurrence in the diets of predators indicate that they appear on the surface more frequently than do moles. In captivity, *T. talpoides* spent an average of 2.7 h on the surface per day (Proulx et al. 1995). Marsh and Steele (1992) state that gophers rarely venture more than 12-18 inches from their foraging burrows and retreat immediately if disturbed. Scheffer (1931) and Vaughan (1974) noted that surface activity occurs mostly at night, although Maser et al (1981) reported they are occasionally seen foraging abroad on warm overcast days. Cox and Hunt (1992) noted that the digging of surface-access tunnels was not correlated with soil moisture, but was related to accessing seasonally available foods. Using radio telemetry, Andersen and MacMahon (1981) found that *T. talpoides* in a subalpine study area were active about 50% of each day. Pocket gophers do not normally drink, but get required moisture from their food. Pocket gophers do not hibernate but remain active in winter. Where the ground becomes frozen and covered with snow, gophers tunnel through the snow; snow tunnels allow gophers to feed on above-ground shrubs covered by snow without danger of predation (Chase et al. 1982).

It is not known if pocket gophers vocalize in the wild. Aside from occasional murmurs or squeeks in captivity, *T. bottae* was generally silent (Howard and Childs 1959). Individuals did, however, seem to signal each other by clicking their teeth together. Gophers do squeal with anger when annoyed, and squeak when in pain.

Reproduction

Mazama pocket gophers attain sexual maturity by the breeding season after their birth, when approaching 1 year of age. In *T. bottae*, 35% of females are able to breed in their first year, but this has not been observed in *T. mazama*. The mating system of pocket gophers seems to be one of "female choice," based on recent genetic evidence and the fact that in most species the larger male can not fit in the smaller tunnels of the female (Steinberg 1996a); the large males can only mate with females that are willing to enter the males' tunnel systems. Pocket gophers are also thought to be polygynous based on at least 2 cases of males siring litters from >1 female, and sex ratios that favor females by as much as 4 to 1 (Daly and Patton 1986, 1990, Steinberg 1996a). One male *T. bottae* inseminated 5 females (Patton and Feder 1981). However, Witmer et al. (1996) observed a nearly 1:1 sex ratio in *T. mazama*. Reichman et al. (1982) reported that *T. bottae* seemed to be serially monogamous. He found 4 instances of males and females sharing a common deep nest between their burrow systems and the males did not share a nest with any other neighboring female. T. H. Scheffer recorded the breeding condition of 313 male and 312 female Mazama pocket gophers near Olympia and noted embryos from 17 March to 15 June (Scheffer 1931, 1938). A female collected in Oregon by Walker (1949) on 21 March was not reproductively active, but one collected 10 April was in breeding condition, and another contained embryos on 3 July. Scheffer (1938) reported that the mean litter size for 312 females was 5.0 and saw no evidence that gophers in Washington have more than one brood of pups per year. Walker (1949) also stated that only one litter was produced each year by *T. m. niger* in Oregon. Some other gopher species (e.g., *T. bottae*) are known to have >1 brood per year (Chase et al. 1982). Scheffer suggested that the gestation period may be about 28 days, but it may be similar to that observed in captive *T. talpoides*, about 18 days (Andersen 1978). The

constricted hip structure of pocket gophers does not inhibit pupping because the pubic symphisis in females is permanently absorbed during the first breeding cycle through the action of ovarian hormones (Chase et al. 1982).

Growth and development. The growth of juvenile *T. mazama* has not been described, but probably mirrors that of the similar-sized *T. talpoides* reported by Andersen (1978). In four litters of 5, pups were blind and had a mean birth weight of 3.6 g. They were hairless and the eyes were visible as dark spots under the skin. By day 17, pups ate solid food and moved about the cage actively. At day 26, the eyes and ears were open. Pocket gophers are believed to be weaned around 35-40 days and at day 39 their cheek pouches were used to carry food (Chase et. al 1982). *T. talpoides* may disperse from natal burrows at about 2 months, because in captivity fighting among siblings had increased to the point where they had to be separated (Andersen 1978). Pups grow rather rapidly, gaining about 2 g/day for the first 40 days, and most attain adult weights of 90-100 g by 4-5 months of age (Andersen 1978).

Home Range, Movements and Dispersal

Home range size and density. Territory sizes vary widely with habitat quality and reproductive status. Using radio-telemetry, Witmer et al. (1996) estimated that the late winter-early spring home range of *T. mazama* on a fallow field averaged 108 m^2 for 4 males (range 73-143 m^2), and 97 m^2 for 4 females (range 47-151 m^2). Andersen and MacMahon (1981) found that most adult *T. talpoides* only made small shifts (10-15 m) in their home range over the course of a year. Burrow length, perimeter, and home range size were all greater for reproductive male *T. bottae* than for females or nonreproductive males (Reichman et al. 1982).

Smallwood and Morrison (1999) reviewed 100 density estimates of pocket gophers from 32 studies. The estimates averaged 53 $\pm$ 49 gophers/ ha, but varied 415 fold from 0.94 to 390/ha in part because of a 1000-fold difference between the largest and smallest study areas. Smallwood and Morrison (1999) pointed out that the conventional study method is to estimate density for a dense cluster of gophers; as the study plot size is increased, more gopher-free area is included and estimated density decreases. A model based on study area size and female body mass predicted a density of 26 (range 22 to 30) gophers/ha assuming a female mass of 127 g. Smallwood and Morrison (1999) noted that densities should not be compared among species, populations, or localities without defining the estimate to spatial scale.

Movements. Adult pocket gophers are relatively sedentary. The mean distance between captures of *T. talpoides* in Colorado was 28 m for juvenile males, 18 m for juvenile females, and 11 m for adults; the maximum movement was 101 m, and 64 m in 24 hours (Hansen 1962). Vaughan (1963) reported that a *T. talpoides* crossed 61 m of inhospitable barren wash by tunneling through snow. He released *T. talpoides* into a field where resident gophers had been removed, and the average movement was 239 m (range 15-790 m, n=13). Nearly 40% of young *T. talpoides* moved >150 m and roughly 19% moved >300 m. Andersen and MacMahon (1981) found that a few immature gophers make long distance (>100 m) movements. In homing experiments, 10 of 11 released animals returned to their territory through existing tunnel systems in the territories of other gophers (Howard and Childs 1959). One female returned using existing burrows from a distance of 200 m.

Dispersal. Dispersal of sexually maturing individuals is the result of an innate drive (Chase et al. 1982), and they are not necessarily driven out by the mother. Some subadults settle in or near the natal burrow system for some time, but others disperse to establish their own burrow system or assume ownership of one left vacant. Scheffer (1931) noted that excavation of burrows seemed to show that some young dispersed by plugging off a portion of the parental burrow system and expanding lateral tunnels. In a study of *T. bottae*, dispersal was common but 63% of gophers caught as juveniles and adults were recruited within 40 m of their presumed natal territory, 20% had moved 40-100 m, 11% moved 100-200 m, and 6% moved 200-300 m (Daly and Patton 1990).

Young pocket gophers often disperse above ground

(Chase et al. 1982). Vaughan (1963) reported that gophers dispersed from introduction sites by burrowing in the soil or the snow, but that young usually dispersed above ground from parental burrows. Daly and Patton (1990) also reported that pitfall trapping demonstrated that much of the dispersal in *T. bottae* occurred above ground. Most dispersal movements of *T. bottae* occurred in the spring and summer before they reached sexual maturity, and juvenile females began dispersing in spring soon after they were weaned (Daly and Patton 1990). Most gophers that disperse far from their parental home range are males, as is typical in small rodents. Six individuals dispersed between 90 - 122 m, but many probably moved further, beyond the study plot (Howard and Childs 1959, in Chase et al. 1982). Once pocket gophers have established a territory, they generally remain there, although they will shift their home range in response to seasonally wet soils. Dispersal in a study of *T. bottae* was sufficiently common that vacant habitats within a few hundred meters were rapidly colonized (Daly and Patton 1990).

Population Dynamics, Longevity, Survival and Mortality

Population dynamics. Pocket gopher populations are reported to undergo occasional extreme fluctuations (Case et al. 1982) and are characterized by local extinction and recolonization (Baker et al. 2003). Territoriality and extreme weather may influence pocket gopher populations more than any other factors. Extreme winters are known to nearly wipe out the young of the year and produce dramatic population drops. Flooding of burrows can expose many gophers to predators on the surface. Although Andersen and MacMahon (1981) recorded significant mortality of gophers from weasel predation, they believed that weather was the most important mortality factor in their subalpine study area because it restricted burrowing and therefore the acquisition of food, caused mortality from hypothermia, and increased susceptibility to parasites. They hypothesized that year-to-year variation in numbers may be unrelated to population density until a threshold is reached, above which the density is maintained by territorial behavior. Low elevation populations may be regulated by density dependent factors such as territorial behavior more often than alpine populations that are subject to more severe weather.

Longevity and survival. Pocket gophers are not long-lived and most live only a year or so. Based on zonation lines in mandibles, Livezey and Verts (1979) reported that none of 127 *T. mazama* were >3 years old and only 6 (4.7%) were >2 years old. In Colorado, of 78 marked *T. talpoides*, 14 were recaptured 1 year later, and only 2 survived for 3 years (Hansen 1962). The maximum lifespan reported for pocket gophers is 5 years of age for males and at least 4 years for females (Case et al. 1982). The mean life span of 330 *T. bottae* in a 5-year study was about 13.6 months for males and 18.3 months for females, and 96% were 2 years old or less when last captured (Howard and Childs 1959). Daly and Patton (1990) reported that of adult *T. bottae* tagged in 1 year, only 19% of males survived to the following year, compared to 31% for females. In a 4 year study in Utah, annual adult survival of *T. talpoides* was >28%, 18%, 23%, and 70% (Andersen and MacMahon 1981); juvenile survival from weaning through the first winter was comparable to adult annual rates.

Traps and poison. Where they are perceived to be a problem, trapping and poisoning by humans can take the greatest toll on gophers. Pocket gophers can be a pest in agricultural fields and sometimes affect survival of conifer seedlings (Barnes et al. 1970, Marsh and Steele 1992, J. DeBell, pers. comm.). Pocket gophers (*Thomomys* spp.) may account for more damage to regenerating conifers in western forests than all other animals combined (Engeman and Witmer 2000), and various jurisdictions paid bounties on pocket gophers in the early 20th century (Yakima Daily Republic, 7 June 1924, Maser et al. 1981). Mazama pocket gophers in Washington were used in a rodenticide experiment as recently as 1995 (Witmer et al. 1996). Link (2004) discusses methods of controlling gopher damage to plantings.

Predation and parasites. Predation does not seem to affect gopher populations as much as habitat quality, food availability, and weather extremes (Anderson and MacMahon 1981, Baker et al. 2003). Although predation is not believed to prevent population

increases, it is probably the most frequent source of mortality of gophers that reach dispersal age. Long-tailed weasels (*Mustela frenata*), coyotes (*Canis latrans*), bobcat (*Lynx rufus*), spotted owls (*Strix occidentalis*) and house cats are known to prey on Mazama pocket gophers (Scheffer 1931, 1932, Nussbaum and Maser 1975, Toweill and Anthony 1988a, Toweill and Anthony 1988b, Forsman et al. 2001). Other predators probably include red-tailed hawks (*Buteo jamaicensis*) (Witmer et al. 1996), great horned owls (*Bubo virginanus*), and dogs (Scheffer 1932, Maser et al. 1981, Chase et al. 1982). Gopher snakes (*Pituophus catenifer*) prey on pocket gophers, but they are now probably extinct from western Washington (Leonard and Hallock 1997, Altmann et al. 2001). Forsman et al. (2001) indicated that *T. mazama* occurred, although rarely, in the diet of spotted owls in the Olympics. Other known predators of pocket gophers that may prey on *T. mazama* include: red fox (*Vulpes vulpes*), skunks (*Mephitis mephitis* and *Spilogale gracilis*), northern goshawk (*Accipiter gentilis*), kestrel (*Falco sparverius*), barn owl (*Tyto alba*), and long-eared owl (*Asio otus*) (Maser et al. 1981, Chase et al. 1982). Pocket gophers are most vulnerable when feeding near or on the surface, or when moving soil out of their burrows (Baker et al. 2003). Avian predators may be the most successful at catching gophers; in a Colorado study, gophers accounted for 7.4% of the diet of red-tailed hawks and 71.4% of the diet of barn owls (*Tyto alba*) (Douglas 1969).

Two species of flea and several species of chewing lice have been identified in *T. mazama* (Walker 1949, Whitaker et al. 1985, Hellenthal and Price 1989). Parasites have not been reported to cause mortalities in *T. mazama*, but Andersen and MacMahon (1981) reported botfly larvae (*Cuterebra* sp.) and helminthes parasites contributed to mortalities in a subalpine *T. talpoides* population.

Ecological Relationships and Functions

> "...not only the character of the vegetation but the distribution and abundance of several small mammals and the local patterns of movements of migrating birds were seemingly strongly influenced by the activities of pocket gophers. Without this rodent the structure of the subalpine community would be considerably different than it is today, whereas the loss of any other small mammal would probably have a relatively minor effect."
>
> T. A. Vaughan (1974)

Pocket gopher effects on soils and plants. Mielke (1977) reviewed the influence of gophers and other fossorial rodents on soil and plant growth, and described the interaction between bison and fossorial rodents. He suggested that the activities of fossorial rodents may provide an explanation for the genesis of North American prairie soils. Pocket gophers are known to make a relatively large contribution to energy transfers in mountain meadow communities (Anderson and MacMahon 1981). Pocket gophers have an impact on ecological communities by altering soil structure and chemistry, and plant occurrences (Hobbs and Mooney 1991, Reichman and Seabloom 2002, Canals et al. 2003). Their burrowing activities may turn 3-7 tons of soil per acre every year, mixing organic matter with the subsoil and speeding soil-forming processes (MacMahon 1999). Richens (1966) estimated that the actions of 30 gophers on one acre could collectively move >38 tons/year. In some prairie ecosystems, pocket gophers have been found to be important in maintaining plant species richness and diversity (Martinsen et al. 1990). The soil moving activities of gophers seem to increase the abundance of the forbs that they eat. Gophers redistribute soil nutrients and create bare ground creating a more patchy distribution and greater average availability of light and soil nitrogen (Huntly and Inouye 1988). On abandoned agricultural fields (old-field) in Minnesota, the abundance and proportional abundance of annuals and forbs were 8.5 and 7.7 times greater and plant species diversity was 4.7-47.8% higher where gophers (*Geomys bursarius*) were present than where they were absent (Huntly and Inouye 1988).

In California grasslands, pocket gopher (*T. bottae*) activity decreased the establishment of the invasive exotic, barbed goatgrass (*Aegilops triuncialis*) (Eviner and Chapin 2003). Goatgrass coexisted with other plants where gophers were active, but it completely dominated areas without gophers. Gophers apparently dug burrows in clumps of goatgrass where the fibrous root system increased burrowing efficiency; this led to high mortality of

goatgrass through the burial of plants. In contrast, Stromberg and Griffin (1996) reported that germination and establishment of native perennial grasses were reduced compared to exotic annual grasses in coastal California grasslands.

Laycock and Richardson (1975) reported the effects of *T. talpoides* on vegetation and soil of subalpine grassland that was protected from grazing for 31 years. They found that where gophers were present in an exclosure, noncapillary porosity, organic matter, total nitrogen, and total phosphorous were higher and bulk density was lower than where gophers were absent. These changes may have resulted from the burial of organic material by mounds, the decay of unused food caches, and the distribution of gopher excrement in the burrow system (Laycock and Richardson 1975). The soil backfilled by gophers into old burrows is less compacted than the surrounding matrix (Reichman and Seabloom 2002). Dalquest (1948) noted that pocket gophers were pestiferous in newly planted alfalfa, but once established, alfalfa seemed to benefit from gopher activity. He based this on an apparent correlation between alfalfa growth and gopher activity and abundance, and the observations of farmers who forbade him from collecting gopher specimens from their established alfalfa fields (Dalquest 1948). Reichman and Smith (1985) investigated the effect of pocket gophers on vegetation and reported that gophers seemed to reduce plant biomass above their burrow systems by one third. They did not think that gophers increased plant growth, but rather that gophers choose the most productive portions of a field. However, Murphy et al. (2004) report that *Plantago* spp. growing on soil tilled by *Thomomys bottae* were larger and exhibited delayed senescence, thereby benefiting the butterfly larvae present. Andersen and MacMahon (1981) estimated that *T. talpoides* consumed 30% of the annual primary productivity represented in belowground biomass of forbs in a subalpine meadow. However, fertilized old-field plots from which gophers were excluded showed lower and more variable plant biomass than similar plots available to gophers (Huntly and Inouye 1988). Gopher activity also resulted in a net increase of 5.5% in primary productivity on shortgrass prairie (Grant et al. 1980).

Andersen and MacMahon (1985) reported that the mound building activities of *T. talpoides* in areas buried by volcanic tephra by Mt. Saint Helens led to changes in local plant community composition and dynamics. Gophers increased the nutrient content of surface soils and increased the rate of succession. A long-term increase in surface nutrients may also occur in other communities where surface nutrients are exhausted by plant growth or leaching (Huntly and Inouye 1988). In contrast, on Minnesota old-fields where soil nitrogen decreased with soil depth, gophers decreased the rate of plant succession by favoring pioneer species and causing mortality to tree seedlings (Huntly and Inouye 1988).

T. mazama effects on plant diversity. Soil disturbance created by *T. mazama's* mound-building may increase plant diversity on south Puget Sound prairies. Hartway and Steinberg (1997), who compared plant species occurrence on and away from *T. mazama* mounds, found strikingly higher (3X) plant diversity on mounds than off, and a higher diversity of native species (forbs and grasses combined). However, mounds also had much higher diversity of non-native forbs because soil disturbance creates microsites favorable to colonization by early successional/pioneer species, many of which are weedy exotics. The frequency of occurrence of 12 of 35 species analyzed was significantly different on mounds versus off mounds. Native species that benefited from gopher activity included yarrow and white-topped aster, a sensitive species in Washington (WNHP 1997). The pattern was different for each prairie site depending on the surrounding plant community; prairie sites with many exotic species had fewer native species on mounds, apparently because the exotic species effectively exclude the native ones (Steinberg 1996a).

Pocket gopher effects on other animals. Pocket gophers also affect many other animal species. Where abundant, they contribute substantially to the prey base of predators. Vaughan (1974) and Andersen et al. (1980) found that *T. talpoides* accounted for more of the biomass (up to 75% in Colorado) than any other small mammal in subalpine meadow communities. Bevis et al. (1997) reported that *T. talpoides* accounted for 2-13% of the biomass of prey represented in pellets at 6

spotted owl nests on the east slope of the Cascades. *T. talpoides* comprised 72% of the mammalian prey of ferruginous hawks (*Buteo regalis*) in a study in eastern Washington (Richardson et al. 2001), and occurred frequently in pellets of short-eared (*Asio flammeus*), long-eared, and great horned owls in central Oregon (Maser et al. 1970).

Pocket gophers also improve habitat for a variety of species that use pocket gopher burrow systems as retreats, particularly during inclement weather. Using radio telemetry on Fort Lewis, Jim Lynch (pers. comm.) discovered that western toads use *T. mazama* burrows as refuges in summer and sometimes remain underground for weeks. *T. mazama* may similarly provide habitat features for salamanders (especially *Ambystoma macrodactylum*), frogs, lizards, snakes, small mammals, and invertebrates. Vaughan (1961) reported that 22 species of vertebrates used gopher burrows in Colorado. He noted that gopher burrows may have affected the local distribution of tiger salamanders (*Ambystoma tigrinum*) and some reptiles. Vaughan (1961) noted that 15 of 22 (68%) of the terrestrial vertebrates known from a 110 ac study site in eastern Colorado regularly inhabited the occupied or abandoned burrows of pocket gophers. G. Witmer (pers. comm.) believes that it is primarily inactive or abandoned burrows that provide habitat because active burrows are normally plugged by the gopher. Ingles (1965) noted that certain species of arthropods were known only from the nests of pocket gophers. Creation of mounds by pocket gophers may affect the distribution of voles (*Microtus* spp.). In tallgrass prairie, voles sometimes used the break in the grass canopy created by mounds as runways (Klaas et al. 1998). They seemed to avoid areas with higher mound density, however, perhaps due to increased risk to aerial predators.

On a Minnesota old-field, gophers increased the abundance of grasshoppers by providing bare soil for egg deposition and creating greater structural plant diversity; the more open patchy vegetation apparently benefited grasshoppers which need warm, dry conditions and a rich food source (Huntly and Inouye 1988). Ostrow et al. (2002) demonstrated experimentally that browsing of roots by *T. talpoides* influenced the number and distribution of insect herbivores that fed aboveground by affecting nutritional qualities of the host plants. Sucking insects preferred plants that were protected from gophers that graze roots, while chewing insects preferred unprotected plants. Pocket gophers were also affected by the above-ground feeding of insects and seemed to prefer plants with lower densities of nonaphid insects (Ostrow et al. 2002).

Vaughan (1974) reported that the soil deposited by *T. talpoides* in Colorado subalpine habitat provided areas where pioneer plant species (*Viola nutallii*, *Collomia linearis*, and *Polygonum douglasii*) dominated, and were preferred foraging sites for deer mice (*Peromyscus maniculatus*). The annual plants were important foods of voles (*Microtus montanus*), and the seeds were favored food of deer mice and chipmunks (*Eutamias minimus*). Violets, favored by gopher activity, produced an abundant late summer seed crop that attracted large flocks of migrant mourning doves (*Zenaida macroura*) and dark-eyed juncos (*Junco hyemalis*). Vaughan (1974) concluded that the pocket gopher was the dominant mammal of the study area in terms of their effect on the community.

Origin of Mima mounds and prairie soils. The origins of Mima mounds have long been debated. Dalquest and Scheffer (1942) first hypothesized that the activity of pocket gophers was the force responsible for the creation of Mima mounds. Basically, gophers push material toward the center of the mound as they dig outward in their territory which is located in the same place year after year (Cox and Allen 1987, Cox and Hunt 1990). Other hypotheses include various geologic and geofluvial processes (Washburn 1988, Berg 1989). Mima mounds co-occur with burrowing rodents in North America, South America, and Africa; Reichman and Seabloom (2002) consider the burrowing mammal hypothesis for their formation to be the simplest explanation. The gopher hypothesis has been accepted by many ecologists, but the evidence has been insufficient for it, or any other hypothesis, to be more widely accepted. If pocket gophers are responsible for Mima mounds, this would be one of the most dramatic and enduring phenomenon attributable to a small vertebrate animal.

Steinberg (1996a) did not find gopher populations on the largest remaining Mima mound sites in western Washington and reported that the soil seemed very compacted. It is unclear if soil compaction as a result of historical livestock grazing led to local gopher extinction, if the soil is compacted due to the extinction of gophers, if that was the normal condition of the soil at the site. Dalquest (unpubl. field notes, 1940-1941) noted that gophers were absent from some mounded prairies, but were found only on the Mima mounds at other sites. If gophers were present historically on all these prairies, restoring gopher populations to these sites may improve soil conditions and benefit the prairie plant community.

HABITAT REQUIREMENTS

Mazama pocket gophers need open meadows, prairie, or grassland habitat with friable soils that are not too rocky. In general pocket gophers prefer light-textured, porous, well-drained soils, and do not occur in peat or heavy clay soils (Chase et al. 1982). Gophers tend to favor areas with deeper soils (Baker et al. 2003). The highest gopher densities occur in sites with dark, light-textured soils vegetated with grasses and forbs, especially succulent forbs with underground storage structures. The availability of forbs may provide nutrients important for gopher growth and reproduction. Keith et al. (1959) reported that experimental removal of forbs by spraying 2,4 –D reduced *T. talpoides* populations by 87%. Rezsutek and Cameron (1998) reported that spraying 2,4 -D to remove forbs reduced the proportion of reproductive female *Geomys attwateri* and average length of residency of both sexes; body mass was also reduced, albeit not significantly perhaps because most gophers in treated plots were able to obtain forbs off the edge of the sprayed area (Rezsutek and Cameron 1998). Burton and Black (1978) indicated that management practices that stimulate the production of succulent forbs and grasses are likely to improve habitat.

Mazama pocket gophers in Washington occur primarily on grasslands of the glacial outwash plain (Dalquest 1948). Occupied sites in Washington include airport margins, fallow fields, Christmas tree farms, and occasionally clearcuts. Although *T. talpoides* can become very abundant in cultivated fields of alfalfa or other legumes, Dalquest and Scheffer (1944) reported that *T. m. tacomensis* was the only subspecies of *T. mazama* that occurred on cultivated land away from the outwash prairies. They also occur in the fringes of adjacent woodland in Oregon, particularly in ponderosa pine communities, but they are absent from dense forest (Hooven 1971, Verts and Carraway 1998). Provided a source population is available, Mazama pocket gophers may invade an area when the forest cover has been removed; as grass and forbs increase gophers can become abundant for a few years unless or until the area regenerates to forest (G. Schirato, pers. comm.). *T. m. melanops* is found in open parkland and subalpine meadows in the Olympic Mountains (Johnson and Cassidy 1997). *T. mazama* is not found on all of the remaining south Puget Sound prairie sites. They do not usually occur where grassland has been taken over by dense Scotch broom or where the soil is too rocky (Steinberg 1996a). The proportion of soil by weight made up of medium rocks (1 - 2”) correctly predicted the presence or absence of pocket gophers for 8 of 9 sites (Steinberg and Heller 1997). Four of five sites with gophers had soil that was <10% by weight in medium rocks. *T. mazama* also seems to be absent where moles are abundant (Steinberg 1996a). Like *T. talpoides*, *T. mazama* is probably absent from poorly drained meadows with saturated soils (Vaughan 1974). Dalquest (unpublished field notes, 28 Dec 1941) indicated that burrowing by gophers on Rocky Prairie (5 mi north of Tenino) was nearly 100% restricted to the Mima mounds, apparently because the troughs between mounds had soil that was too thin and rocky.

Oak savannah, with widely scattered Garry oak (*Quercus garryana*) and a ground cover of prairie vegetation, was once the most abundant oak community type in the south Puget landscape, but is now nearly gone (Chappell and Crawford 1997). Mazama pocket gophers have not been reported in oak savannah habitat in Washington, but they were probably found in savannah where adjacent to or surrounded by open prairie.

POPULATION STATUS

There are little historical data on Mazama pocket gopher populations in Washington, and little quantitative data on current populations. Most of what we know about the past and present status of populations is limited to distributional information. The Mazama pocket gopher remains widespread and relatively common in western Oregon, with the exception of *T. m. helleri*, an isolated subspecies found only near the mouth of the Rogue River in Curry County. *T. m. helleri* is listed as 'Lower Risk, Near Threatened' on the IUCN Red List and a federal Species of Concern (Verts and Carraway 1998, Yensen 1998). The remaining populations in Washington have restricted distributions and several populations have gone extinct. Many remaining populations are increasingly isolated as prairie is invaded by forest or succumbs to suburban developments.

Washington: Past

Mazama pocket gophers were more widespread when the south Puget prairies were more extensive and less fragmented. The gopher populations in Thurston and Pierce counties extended from the southwestern corner of Thurston County, northeast to Point Defiance in Tacoma, and as far east as Puyallup. The populations were not contiguous, but included several isolated populations that exhibited their own local variations in size and fur color. The population in Tacoma may have been isolated for quite some time (Booth 1947–cites Dalquest & Scheffer 1939). *T. m. couchi* near Shelton and *T. m. louiei* in Wahkiakum County, also seemed to be distinct isolated populations when first described. Dalquest did not find any gophers in 1941 at Buck Prairie or Mooney Prairie, north of McCleary, nor at Mima Prairie 1-2 mi southwest of Littlerock. Steinberg (1999:69) suggests that, based on DNA evidence, *T. m. melanops* in the Olympics may represent a "pre-Pleistocene relict" (i.e. a population that was present before the Pleistocene glaciations).

Walter Dalquest and Victor Scheffer attempted to collect a series of 50 gophers from each of 8 different prairie sites from 1939-1942, and used these specimens for their paper published in 1944. They were unable to capture 50 at some sites; after catching 34 near Vail, Dalquest (unpublished field notes) wrote "I think I have most of the gophers on this prairie." Their efforts to acquire a good sampling of all the forms of gophers at various localities may have actually speeded the extirpation of some local populations. They caught 7 on Lost Lake Prairie, southwest of Shelton, "seemingly the entire population," (Dalquest and Scheffer 1944:314), an assessment that may have been correct, because gophers appear to be extinct there today. Steinberg (1996a) was not able to find gopher activity there, nor at numerous other sites where gophers had been reported historically, although many locations on specimen tags and in field notes are ambiguous as to exact location (Table 2.3). Mike Thorniley, retired animal damage control agent with Washington Department of Game indicated that he trapped gophers in response to damage complaints at several locations during the 1960s-1970s, including Tenino, along Scatter Creek east of Tenino, Bucoda, the south side of Deep Lake near Millersylvania State Park, just northeast of Offutt Lake, and east of Chain Hill (M. Thorniley, corresp. on file). What is known for the subspecies considered legitimate by Steinberg (1999), and *T. m. tacomensis* is summarized below. Known historical locations where they now seem to be extinct are listed in Table 2.3 and Appendix A.

T. m. tacomensis The Tacoma pocket gopher, *T. m. tacomensis*, was first collected at Fort Steilacoom in 1853 by Suckley and Cooper (1860), but was originally described by Taylor (1919) from a specimen collected by G. Cantwell in 1918. It was found in Tacoma from Point Defiance, south to Steilacoom and perhaps as far east as Puyallup. T.H. Scheffer caught gophers on Brookdale Rd southeast of Parkland around 1920, and John Finley reported catching gophers as far east as South Meridian in Puyallup (V. Scheffer, unpubl. notes). Between 1938 and 1962, at least 158 gophers were collected at numerous localities, primarily on the west side of Tacoma in the 1940s (Appendix A). Gophers were apparently becoming harder to find, however, because Murray L. Johnson, who was Curator of Mammals at the Slater Museum, University of Puget Sound in Tacoma from 1948-1983, collected

Table 2.3. Historical locations in Washington where Mazama pocket gopher populations may be extinct.

Population	County[a]	Township/Range/Sec[b]	Year	Notes
T. mazama yelmensis				
2 mi N Rochester	T	T16N R03W S30	1940-41[c] 1996	46 collected by Dalquest. None located (Steinberg 1996a)
Vail, 1 mi W	T	T16N R01E S22	1941	34 collected by Dalquest[c]
Vail, 1 mi E	T	T16N R01E S25	1966	Small number present in pasture S25,NWofNW ("Ruth Prairie")
Vail vicinity	T	T16N R01E	1995	None found at historic locations around Vail, (Steinberg 1996a)
Tenino; 1 mi S Tenino	T	T16N 1W	1938-41[c] 1995	62 coll. by Dalquest in area; Steinberg (1996a) did not find any at Tenino (but did at Rock Prairie)
Littlerock vicinity (2 mi E Mima Prairie, E of Black River)	T	T16N R3W S1	1941 1995	Present (V. Scheffer, field notes Jan 24-25) None found (Steinberg 1996a)
1 and 2 mi W of Rainier	T	T16N R1E S7 & 8	1995	None found (Steinberg 1996a)
Hwy 12 and Sargent Rd.	T	T15N R3W S12	1995	None found (Steinberg 1996a)
Prather Rd/Hwy 99, 0.3 mi N Lewis County line (1954: Grand Mound near railroad)	T	T15N R3W S24 SEofNW	1954 1960 1996	3 collected M.Johnson 6 collected M. Johnson None found (Steinberg 1996a)
Masonic Cemetery, Olympia[d]	T	T18N R02W S38	1953	2 collected by L. Couch
7.3 mi N & 1.3 mi W Tenino[d]	T	T17N R02W S14	1942[c] 1996	36 collected by Dalquest None found (Steinberg 1996a)
T. mazama tacomensis				
TACOMA[e]: several locations in west Tacoma from Pt. Defiance, south to Chambers Creek; also Wapato Hills and Brookdale (see Appendix A for locations)	P	T21N R02E S15, S26, S34 T20N R02E S2,S10,S16, S20,S21 T20N R03E S19	1940-62 1974 1980 1993	158 collected at numerous locations (Dalquest and Scheffer 1944; museum records, Appendix A) Cats killed several gophers at Wapato Hills (WDFW data) M. Johnson had been unable to find any tacomensis in 10 years (WDFW files) No evidence of gophers in the area (Steinberg 1996a)
T. mazama couchi				
Lost Prairie	M	T19N R04W S7	1941 1994	Collected 7, "seemingly the entire population" (Dalquest & Scheffer 1944) None found (Steinberg 1996a)
Johns Prairie	M	T20 R03W S8,S9,S5	1952-53 1992 1994 2004	S8 (6 collected by L. Couch) S5, NW of SE and SWof SW: few mounds in heavy Scotch broom (WDFW data) S9 (Steinberg 1996a) None in recent years (G. Schirato)

Population	County[a]	Township/Range/Sec[b]	Year	Notes
T. mazama melanops				
"Head of Soleduck R." at timberline, (M Johnson interpreted this locality as Soleduck Park); O.N. P.	C	T28 R8W S20 SE	1897	V. Bailey collected type specimen
			1951	None found (Johnson 1977)
Cat Cr at 4500 ft/ High Divide, O. N. P.	C	T28 R8W S28	1921	3 collected G.Cantwell, 1 coll W.T.Shaw
			1930-31	Mounds/tunnels observed (Svihla and Svihla 1933)
			1951	None found (Johnson 1977)
			1976	None found (Johnson 1977)
Bogachiel Peak	C	T28N R8.5W S25	1931	4 collected by Boles and Hibben, Cleveland Museum (Johnson 1977)
			1951	None found (Johnson 1977).
Canyon Cr. divide at head of Bogacheil R., O. N. P. [probably W of Deer Lake]	C	T28 R9W S23/24[?]	1921	3 collected by Shaw (Dalquest & Scheffer 1944)
			1951	None found (Johnson 1977)
T. mazama louiei				
Cathlamet Tree Farm, Huckleberry Ridge	W	T10N R05W S8,S9	1949	9 collected A. Moore (Gardner 1950)
			1956	11 collected in logged burn (M. Johnson)
			1977	None (M. Johnson, notes)
			1986	None found, old burn regenerated to forest (R. Taylor, WDFW)
			1995	None found (Steinberg 1995)

[a]County: T = Thurston; P = Pierce; M = Mason; C = Clallam; W = Wahkiakum.
[b]Township, range, and section locations for historic records were assigned based on locality information given by the source.
[c]Unpublished field notes of W.W. Dalquest and V.B. Scheffer on file at Museum of Vertebrate Zoology, Univ. California, Berkeley.
[d]These populations originally described as *T. m. pugetensis*.
[e]These populations originally described as *T. m. tacomensis*.

only 5 in 1950 and 5 in 1961-1962. Many of the original collection sites succumbed to suburban development, and one site became an extensive gravel mining operation. Johnson (notes on file) indicated in 1980 that he had been unable to find any *tacomensis* for 10 years, although Tacoma area residents turned in a few gophers killed by their cats in 1974 (WDFW data). Steinberg (1996a) found no trace of gophers at several historical locations and potential sites in Tacoma and vicinity. All populations originally assigned to *T. m. tacomensis* may now be extinct.

T. m. melanops. The Olympic pocket gopher was first collected at the head of the Soleduck River by Vernon Bailey in 1897. They were also collected in the 1920s and 1950s on several other subalpine sites in Olympic National Park, including south of Lake Crescent on Happy Lake Ridge, and on meadows between Appleton Peak and Cat Peak (Johnson 1977, Scheffer 1995). Taylor and Cantwell did not find gophers at the heads of the Elwah, Quinault, or Dosewallips rivers in 1921 (Scheffer 1995). Johnson (1977) indicated that gophers were no longer present at the head of Canyon Creek or along the High Divide at Bogachiel Peak and the head of

Cat Creek in 1951 or 1976, but they were found at Appleton Pass, Happy Lake Ridge and Aurora Peak. Johnson (1977) speculated that fire suppression, avalanches, landslides, or weather cycles may have played a role in the local extinctions.

T. m. louiei. Gardner (1950) described *T. m. louiei* from 9 specimens collected in forest openings northeast of Cathlamet, Wahkiakum County. At one time gophers were found within a 2.25 mi^2 area, but none could be found in 1977 (M. Johnson, notes). There was no sign of gophers in 1986 and an old burn where they were once found had regenerated to forest (WDFW unpubl. data). E. Steinberg and R. Taylor were also unable to locate any in 1995, suggesting the subspecies had become extinct (Steinberg 1995). This subspecies contained many black individuals, as do some populations of *T. mazama* in Oregon. The origin and history of this form of pocket gophers may remain a bio-geographical mystery.

Washington: Present

Mazama pocket gophers are known to exist at 27 locations in western Washington (Fig. 2.2, Table 2.4), but many of the populations are very small and isolated due to the loss of habitat. The largest remaining populations are found on Fort Lewis, at the Olympia and Shelton Airports, and possibly in Olympic National Park. Eleanor Steinberg conducted fairly extensive surveys of locations where pocket gophers had been recorded and all sites with intact or restorable prairie based on data from WDNR. She visited: type localities listed in Hall (1981); locations recorded on gopher specimen tags at Slater Museum, University of Puget Sound, and the Burke Museum, University of Washington; and locations in the unpublished field notes of Victor Scheffer and Walter Dalquest. Table 2.4 includes a summary of known extant populations of Mazama pocket gopher based on records on file at WDFW, and recent surveys by Steinberg (1995, 1996a), ENSR (1993, 1994), and Farrell and Archer (1995). Some of these sites are Christmas tree farms, tree nurseries, and pastures where prairies once existed or where timber was clearcut near a source population of gophers.

Survey methods. Most of the past and present information about *T. mazama* populations are simple indications of presence/absence, often with notes on relative abundance. Methods of estimating populations are needed to better understand their population dynamics and the viability of local populations. The number of mounds and plugs, or mound systems and the open-hole response has often been used elsewhere as an index to pocket gopher abundance or to estimate local populations. Reid et al. (1966) devised and tested a method using new mounds and sign in 1-ac plots with which they could estimate the early fall population within 10%, but the number of plots required was very high (55) when gopher density was low. Testing of the method involved lethal trapping of all the gophers in the plots, which is not desirable for a species of conservation concern. The mathematical relationship between gopher sign and population size is likely to be different for *T. mazama* and may vary with season and soil type. Smallwood and Erickson (1995) developed an index using fresh mounds or sign that was able to account for 95% of the population, and was more accurate and efficient than the open hole method. They also reviewed other studies, including Reid et al. (1966), and concluded that gopher density could be estimated with plot occupancy with high precision, and with the fresh mound/sign count they developed with fair precision. The number of fresh mounds or sign attributed to each gopher apparently changes little with changes in gopher density (Smallwood and Erickson 1995). They also noted that a problem with the open-hole test is that burrows opened >2 times within a few months were often abandoned. Engeman et al. (1993) compared the results of the use of plot occupancy based on mounds or sign vs. the open-hole method on *T. talpoides* in Idaho. They reported that the open-hole method was more sensitive, because of a lack of activity in the plots. However, their study was conducted in August when gopher activity is likely to be very low. Engeman et al. (1993) leveled all mounds at the start of the test period, which Smallwood and Erickson (1995) believed would bias the results. Engeman et al. (1999) refined the open-hole method to determine the proportion of burrow systems that were occupied (vs. abandoned) for *T. mazama* in clearcut ponderosa pine forest in Oregon. They

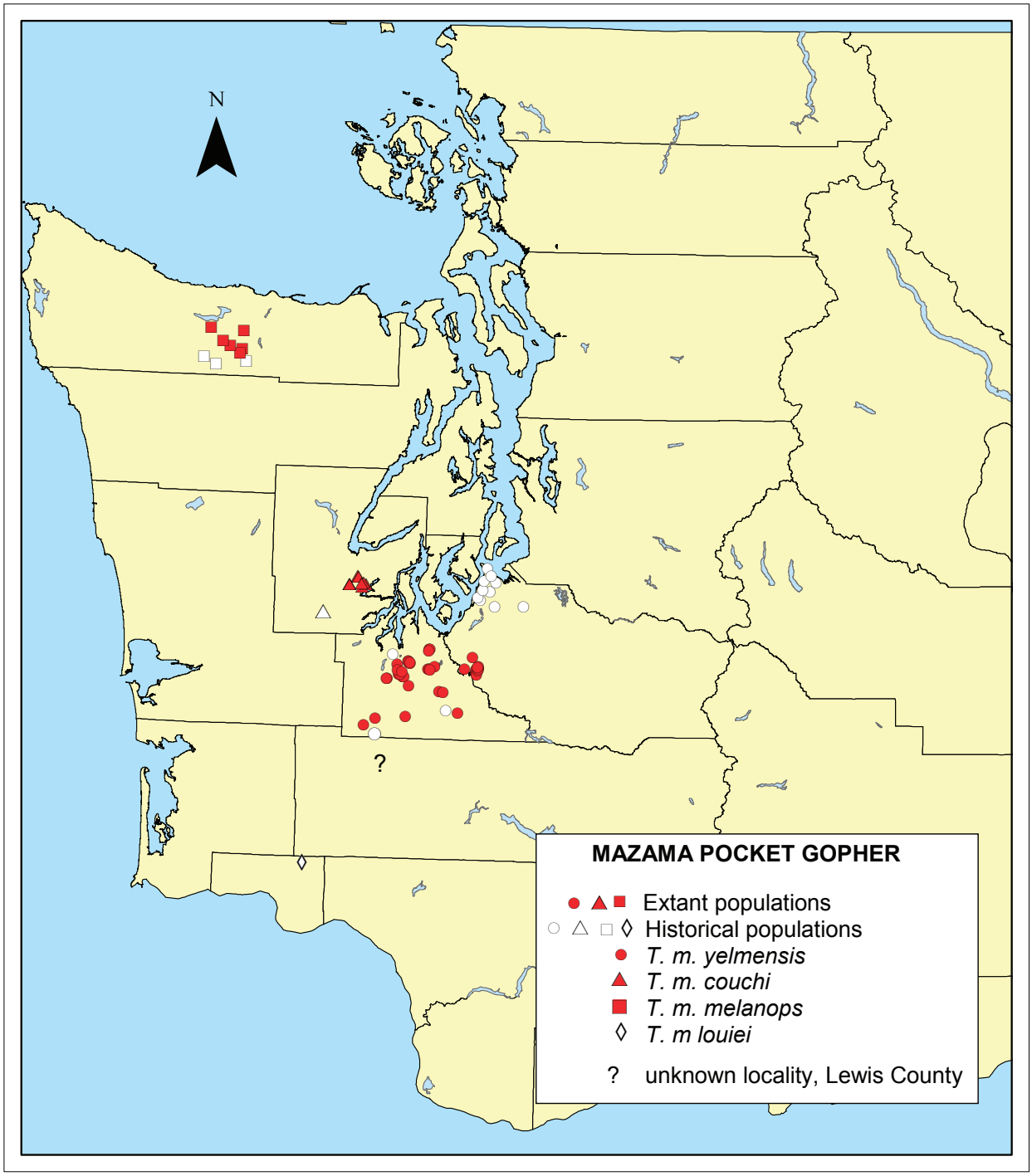


Figure 2.2. Locations of known extant and historical populations of 4 subspecies of Mazama pocket gopher in Washington (subspecies as suggested by Steinberg 1999).

did not evaluate the method for estimating the local population. Variations of these methods have been used to estimate local populations in Washington by ENSR (1993, 1994), Farrell and Archer (1996), and Steinberg (1996a).

T. m. yelmensis. The south Puget Sound populations of *T. m. yelmensis* are scattered among at least 15 sites (Table 2.4); some of these are completely isolated from other sites. Some small occupied sites may be marginal habitat that was colonized when a larger nearby patch of prairie habitat was developed, or are tiny remnants of formerly large populations. There are probably a few

additional populations at locations that have not been documented, for example, gophers occurred sporadically in a residential area of Tumwater west of I-5, until the construction of a subdivision in 2000 (J. Sedore, pers. comm.). In 2003, a single individual was found near the corner of Martin Way NE and Desmond Drive, in Lacey, but there are no known populations in the vicinity (K. McAllister, pers. comm.).

Fort Lewis has relatively large populations of up to a few hundred individuals at Johnson Prairie, Upper and Lower Weir Prairie, Marion Prairie, within the 91st Division Prairie AIA, and on rifle ranges in the South Impact Area. ENSR, a consulting company, conducted surveys on Fort Lewis in 1993, and developed an estimate of the population on Marion Prairie (Training Area 18). Based on the density of burrow systems in sample plots, and assuming a density of 4 gophers/ac for the 108 ac area, they estimated 462 gophers on Marion Prairie and 3,060 gophers on all of Fort Lewis (ENSR 1993). However, Steinberg (1996a) cautioned that the estimate may be grossly inflated because it was based on extrapolation from Marion Prairie, where she detected the highest density of gophers. She found microhabitat differences greatly affect gopher density. She also noted that the timing of estimates

Table 2.4. Locations and recent status of known Mazama pocket gopher populations in Washington.

Population	County[a]	Township/Range/Sect.	Year	Notes
T. mazama yelmensis[b]				
Weir Prairie, Fort Lewis	T	T17N R01E S31 SEofSE S32 SWofSE	1990	Gophers scattered over 80 ac, (WDFW data)
			1993/94	Relatively large population (Steinberg 1996a)
Hannus Rd.SE & powerline	T	T16N R01E S1 SWofNE	1994	Gophers active in prairie habitat (WDFW data)
Johnson Prairie, Fort Lewis	T	T17N R01E S30,31 (?)	1993/94	Relatively large population (Steinberg 1996a)
Rich Rd.&Yelm Hwy, Lacey/ Hewitt Lake	T	T18N R01W S40 NWofSE	1995	Population present (WDFW data; Steinberg 1996a)
			2005	Gophers present , but main site being developed
Kelly's Corner area	T	T17N R01W S11, NWof NE; S2, 39, 41	1966	Mound systems scattered over 40 ac of Christmas tree farm
			2004	Gophers may be extinct at original site, but occur in several locations S of Pattison Lake, including Canterwood Ln and Cate Farm Dr. (K. McAllister, pers. comm.)
Scatter Creek Wildlife Area	T	T16N R03W S36 SWofSW; also possibly S35,47,50,51,41	1996	Small number of mounds found (WDFW data)
			1997	4 collected by E. Steinberg

Population	County[a]	Township/Range/Sect.	Year	Notes
Rock Prairie; 2 mi SW Tenino	T	T16N R02W S47 NWofNE; S 38	1941	22 collected by Scheffer & Dalquest, (notes for 24-25 Jan)
			1995	Small population (Steinberg 1996a)
			2005	Present, Mima Acres Rd (WDFW data)
Rocky Prairie/5 mi N Tenino[c]	T	T17N R01W S30? T16 N R1W S5, 6; T16N R2W S1,12	1941[c]	35 collected by Dalquest on tops of Mima mounds
			1996	No gopher activity evident, but found a dead gopher at Rocky Prairie NAP (Steinberg 1996a)
			2005	Gophers present at NAP (K. McAllister)
James Rd/2.5 mi SE Rochester	T	T15N R03W S09 NWofSE	1954 1976 1995	1 collected by M Johnson; 3 collected by T. Moore; 1 killed by cat; small population among Christmas trees, E and W of Scatter Crk (WDFW data)
Grand Mound; Prather Rd. & Hwy 99	T	T15N R3W S24	1954 1960	3 collected by M. Johnson; 6 collected by M. Johnson (WDFW data)[current status unknown]
Roy Prairie[d] 0.5-2 mi S Roy,	P	T17N R02E S38,39	1942	Type locale for *glacialis*, 50 coll. by Dalquest
			1954	7 collected by M. Johnson
			1966-67	12 collected (R.Taylor)
			1975	8 coll. by Thaeler & Moore in S3
			1983	"Plentiful gopher activity" (M. Johnson)
			1991	Present (M. Johnson/R.Taylor)
			1993	Small population still exists in (Steinberg 1996a)
91st Division Prairie N[d] Fort Lewis	P	T18N R2E S19,30,31,32 T18N R1E S24,25,NEofNE,35,36	1992	Several populations of gophers in the N andS portions of the Artillery Impact Area (ENSR 1993)
			1993/94	Sparse patches of mounds (Steinberg 1995)
Rifle ranges/South Impact Area, Fort Lewis	P	T18N R1E S36,R2E S31 T17N R1E S1,R2E S6,S7	1992	Mounds found in great numbers (ENSR 1993);
			1993/94	locally dense, patchy (Steinberg 1995)
Marion Prairie/ Training Area 18, Fort Lewis[d]	P	T17N R02E S6,7 T17N R01E S1SE	1992	Mounds found in great numbers (ENSR 1993);
			1993/94	locally dense, patchy (Steinberg 1995)

Population	County[a]	Township/Range/Sect.	Year	Notes
Meridian Tree Farm[e]	T	T17N R01W S43 SEofNW	1983	WDNR seed tree farm
			2001	Still present (K. McAllister, pers. comm.)
			2004	Status uncertain (K. McAllister, pers. comm.)
Olympia Airport[e]	T	T17N R02W S10,11,13,14,15	1966-2004	Scattered in suitable areas at airport and vicinity and south of airport (WDFW 1966, 1999, A. Schmidt)
Bush Prairie	T	T17N R02W S03	1939-41	25 collected Dalquest
			1995	Mound system in cleared area for new lane of I-5 S (WDFW data)
			1999	2 collected by USDA on Kirsop Rd.
Lathrop Rd/93rd Av SW & Jones Rd	T	T17 R02W S20 SEofNW	1997	22 trapped at WDNR Webster Tree Nursery
T. mazama couchi				
Shelton Airport (Scott's Prairie)	M	T20 R04W S11,12	1922	8 including type spec. coll. by L. Couch (Goldman 1939)
			1938-1941	48 collected by Dalquest & Scheffer
			1976	5 collected by T. Moore
			1982	14 burrow systems on only 4 ac (M. Johnson/G. Schirato)
			1992	100 burrow systems in south runway areas (Taylor/Schirato)
			1993, 1997	Dense population around runways, in fields around buildings (Steinberg 1996a)
			1995	Farrell & Archer (1995) estimated population of 990
			2003	GeoEngineers, Inc. (2003) observed mound density of 100-200/ac
State penitentiary, Shelton	M	T20N R4W	1996	Mounds reported (Steinberg 1996a)
			2004	Economic and Engineering Services, Inc., (G. Schirato, pers. comm.)
McKewen Prairie	M	T21N R03W S31 NWofSE	1992	A few mounds both sides Brockdale Rd;
			1996	Along McKewen Prairie Rd (S32) (Farrell and Archer 1996)
T. mazama melanops				
Aurora Peak, Olympic National Park	C	T29N R09W	1976	1 collected by M. Johnson (Johnson 1977)

Population	County[a]	Township/Range/Sect.	Year	Notes
Boulder Lake, vicinity, Olympic National Park.	C	T29N R08W	1898	4 collected by D. G. Elliot, Chicago Field Museum
			1930/31	Mounds/tunnels observed (Svihla and Svihla 1933)
			1975	5 collected by T. Moore, M. Johnson
			1993, 1996	Gophers present (Steinberg 1995, 1996b)
Happy Lake and Happy Lake Ridge, Olympic National Park	C	T29N R08W	1898	5 collected by D. G. Elliot, Field Museum, Chicago
			1921	1 collected at 5,500 ft by W. Taylor (Scheffer 1949/1995)
			1974	2 collected by M.Johnson
			1993,	Present (Steinberg 1995, 1996b)
			1996, 1997	5 collected (Steinberg 1999)
Oyster Lake, Appleton Pass, Olympic National Park	C	T28N R08W	1951	Present (Johnson 1977)
			1953	5 collected (Johnson 1977; Slater Museum data)
			1976	Present (M. Johnson 1977)
			1996, 1997	'Heavy gopher activity' on plateaus along ridge E of Oyster Lake (Steinberg 1996b); 2 collected (Steinberg 1999)

[a]County: T = Thurston; P = Pierce; M = Mason; C = Clallam.
[b]There are probably more small populations of T. m. yelmensis; several locations near historical sites have mounds that appear to be gophers, but have not been confirmed (K. McAllister, pers. comm.); additional surveys are needed.
[c]These populations originally described as *T. m. glacialis.*
[d]These populations originally described as *T. m. pugetensis.*
[e]These populations originally described as *T. m. tumuli.*

greatly affects the population estimate because the number of active burrows tripled with the dispersal of young of the year after early summer. ENSR (1994) reported a revised estimate for Marion Prairie of 233 gophers, based on a re-analysis of the same data. They did not offer a new estimate for Fort Lewis, but their revised density estimate of 2.15/ac would result in an estimated maximum of 1,645 gophers if all the known sites on Fort Lewis had the same density as Marion Prairie, which is unlikely. Steinberg's (1996a) observations suggest the total may be much lower than this, and that the largest populations on Fort Lewis may each contain no more than a few hundred animals.

The Mazama pocket gopher population at Olympia Airport has not been estimated, but gophers seem to be scattered over portions of several hundred acres, so may include several hundred individuals (K. McAllister, pers. comm.). Gophers have persisted on Rock Prairie southwest of Tenino, but they may be much less widespread than formerly. Steinberg (1996a) was unable to find any gophers at Tenino, Wetico (southwest of Rainier), and Vail, or on the Mima Mounds Natural Area Preserve, or Black River-Mima Prairie Glacial Heritage Preserve.

T. m. couchi. Shelton pocket gophers persist at the Scott's Prairie/Shelton airport site and perhaps 2 nearby areas. Steinberg (1996a) found no trace of the *T. m. couchi* population at Lost Lake Prairie reported by Dalquest and Scheffer (1944), nor in Shelton Valley, Buck Prairie, Bulb Farm Rd, or in fields or roadsides around Satsop, Elma, and Cedarville. Farrell and Archer (1996) delineated gopher territories at the Shelton airport based on

"mound systems" and then applied a correction factor based on the percent of systems that were re-plugged within 48 hours of being opened (76.6%). This produced an estimate of 990 gophers, but it is unknown how closely their perceived mound systems correspond to actual burrow systems. Smallwood and Erickson (1995) tested the accuracy and precision of survey methods for *Thomomys* pocket gophers including the use of the plugging response, or "open-hole" test. They reported that the use of a 24-hour open hole test (tunnels are opened and monitored for 24 hours for plugging by gophers) accounted for only 68% of the gophers present. Gophers often plugged openings too far inside a tunnel to be detected without digging (Smallwood and Erickson 1995). Most of the mound system counts by Farrell and Archer (1996) occurred in late summer; Steinberg (1996a) indicated that the number of burrow systems may triple between May and July as young of the year disperse. Assuming Farrell and Archer's delineation of burrow systems was reasonably accurate, the spring population at the site may be closer to 200-400. GeoEngineers (2003) counted active mounds in plots on the airport and estimated an average density of 100-200 mounds per acre and there were about 240 ac of occupied habitat. They did not attempt to relate the number of mounds to the number of gopher burrow systems.

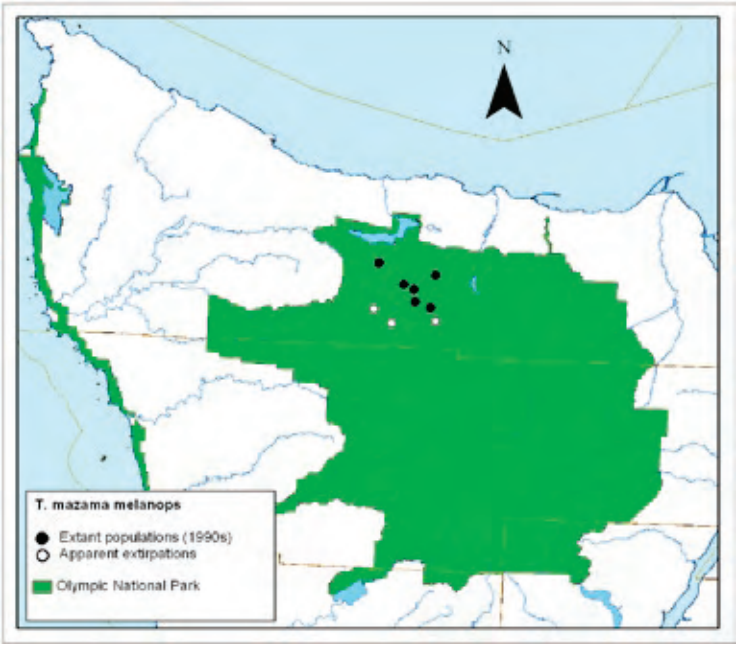


Figure 2.3. Approximate location of extant and extinct populations of *T. m. melanops*.

Farrell and Archer (1996) reported a density of 17.9 mound systems/ac from 2 plots on a regenerating clearcut on McKewen Prairie Rd. Gophers were not present on the site in 1992 shortly after it was clearcut (G. Schirato, pers. comm.), but gophers had colonized the site and in 1995 there was a population of perhaps up to several hundred. The gophers may have reached the site from a road right-of-way that contained a few mounds and was the only adjacent open habitat (G. Shirato, pers. comm.).

T. m. melanops. No complete inventory has been done in Olympic National Park, so it is uncertain how many gopher populations exist there or how many acres are inhabited (Fig. 2.3, Table 2.4). Steinberg noted gophers at Boulder Lake in 1993, and Erika Edwards found gophers at Happy Lake Ridge, Aurora Peak, Boulder Lake and Three Horse Lake, Appleton Pass, and the ridge east of Oyster Lake in 1996 (Steinberg 1996b). Edwards surveyed the Grand Valley and Badger Valley areas (T28N R5W), but found no gophers. Corey Welch, University of Washington is currently conducting research on these populations and may provide a more complete picture of their distribution (C. Welch, pers. comm.).

Summary of current status. Over half of the historically known populations of Mazama pocket gophers in Washington have gone extinct, including at least 2 of the originally described subspecies (*T. m. louiei* and *T. m. tacomensis*). Most surviving *T. mazama* populations are small (<100) and appear to be isolated from other populations. Small populations are unlikely to persist for long without at least occasional demographic and genetic recharge by dispersing individuals from a larger population. The more important information for the persistence of the species and each of the extant subspecies may be the number of large populations (at least several hundred individuals). There are perhaps 3-4 large populations of *T. m. yelmensis* (Olympia Airport, 2

or 3 on Ft Lewis, and possibly Kelly's Corner), 1 large population of *T. m. couchi* (Shelton Airport), and 1 complex of several small populations of *T. m. melanops* in Olympic National Park. No survey method for estimating local populations has been adequately tested for the Mazama pocket gopher, so population estimates must be viewed with caution. Assuming that the number of territories can be estimated with reasonable accuracy by counting apparent mound systems on the surface, then based on past estimates for Fort Lewis and Shelton sites and the descriptions of the abundance of mounds at other known sites, the total of all remaining populations of *T. mazama* in Washington may be between two thousand and five thousand animals. This number includes 3 different subspecies and scattered populations, many of which are isolated. Gopher populations are known to fluctuate year to year, and an increasing number of studies suggest that animal populations of less than a few thousand may not be viable over the long-term (40 generations; Reed et al. 2004). Additional surveys are needed to find any populations that remain undiscovered and to document additional remnant populations in the rapidly developing areas on historical prairies of Thurston and Pierce counties to aid in recovery planning.

HABITAT STATUS

In Washington, the Mazama pocket gopher is primarily a species of the south Puget Sound prairies, so the decline, fragmentation, and degradation of those prairies describe the condition of most of their native habitat (see South Puget Sound Prairies, Chapter 1). Pocket gophers are not found on all the remaining prairie sites, apparently because some have soil that contains too much rock, aggravating the loss of gopher habitat by increasing the isolation of remnant populations. Although gophers are somewhat particular about the soil, they do not seem to be constrained by a need for native prairie vegetation as long as tree and shrub cover is kept out. Mazama gophers sometimes do well in clearcuts (G. Schirato, pers. comm.).

Gophers are found on former prairie sites with non-native grassland at the Olympia and Shelton airports. There may always be grass and forbs that can support gophers surrounding the airport runways, but away from the runways and taxiways, additional construction and development will likely occur. Airports may continue to provide habitat because safety considerations and FAA regulations require that vegetation around runways be kept short. Airport fields may be low quality habitat because the diversity of forbs may be low, but there is potential for habitat improvement by increasing the forb component of the area if this is compatible with airport safety.

Dalquest and Scheffer (1944) noted that Bush Prairie, which included the Olympia Airport and area south and west of it, has very deep soil (>5 ft) that is soft and free of rocks. They stated that ungrazed areas had tall and rich vegetation, indicating that this area has optimal soil conditions for gophers, and may explain why they have persisted there. Open habitat occupied by gophers outside the airport boundary is mostly private land and is being developed. The Port of Olympia is in the process of runway re-alignment at the Olympia Airport, which may result in the loss of some occupied gopher habitat, but removal of unused pavement will result in a net reduction of impervious surface.

Several sites on Fort Lewis support gopher populations, where gopher habitat ranges from research natural areas used only for non-destructive training, such as Weir and Johnson Prairie, to Marion Prairie, a portion of which is subject to excavations. Marion Prairie supported the highest density of pocket gophers reported by Steinberg (1995), but training impacts on it and the South Impact Area increased in 1996. Gopher mounds still seem to be widely distributed there but no population estimates have been made (A. Lombardi, pers. comm.).

Two gravel pits were opened in recent years on prairie habitat south of Roy. Gophers were known to be present at least at one of the sites and several acres were set aside for gophers, although gophers do not appear to be there at present (K. McAllister, pers. comm.).

Sanderson Field, the airport near Shelton on

Table 2.5. Ownership and condition of land at Mazama pocket gopher sites by subspecies in Washington.

Site name	Owner	Land use	Habitat condition
T. m. yelmensis			
Scatter Creek Wildlife Area[a]	WDFW	Conservation/ recreation	Degraded prairie, active broom control
Olympia Airport	Port of Olympia	Airport & light industry	Mowed non-native grassland
S of Olympia Airport	Private	Residential	Fragmented, non-native grassland
Webster tree nursery	WDNR	Conifer seedling production	Mowed non-native grassland
Bush Prairie area, Tumwater	Private	Residential/ commercial	Fragmented, non-native grassland
Meridian seed tree farm	WDNR	conifer seed production	Mowed non-native grass, widely spaced rows of conifers
SW Mushroom Corner, Lacy	Private	Undeveloped (planned sports complex) and church parking,	Non-native grasses, Scotch broom; tall grass.
Rocky Prairie Natural Area Preserve vicinity[ab]	WDNR, private	Conservation; rural residential/pasture?	Native prairie, non-native grassland
Rock Prairie	Private	Rural residential	Pasture, non-native grasses; small patch of mounded prairie
Kelly's Corner area	Private	Residential/commercial	Non-native grasses, much habitat lost to turf farm
Rich Rd & Yelm Hwy, Lacey/Hewitt Lake	Private	Residential/commercial	Non-native grasses; residential development occurring
Hannus Rd.	Private	Rural residential, powerline	Scotch broom invading?
James Rd.	Private	Rural residential, Christmas tree farm	Non-native grasses, forbs?
Weir Prairie Research Natural Area, Fort Lewis[a]	U.S. Army	Non-destructive military training	Grassland; percent native vegetation varies with location from moderate to high
Johnson Prairie, Ft. Lewis	U.S. Army	Military training area	Grassland; percent native vegetation varies with location from moderate to high
91st Division Prairie (AIA), Fort Lewis	U.S. Army	Military training area	Grassland; percent native vegetation varies with location from moderate to high
Marion Prairie and South Impact Area, Fort Lewis	U.S. Army	Military training area	Grassland; percent native vegetation varies with location from low to moderate; disturbed by digging, training
Roy Prairie	Private	Gravel extraction, pasture, residential development	Non-native grassland
T. m. couchi			
Shelton Airport (Scott's Prairie)	Port of Shelton	Airport	Mowed non-native grassland
McKewan Prairie	Private	Commercial timber	Includes seedling stage stand; gophers likely declining or extinct
Johns Prairie	Private	Industrial park	Degraded; Scotch broom, weeds
T. m. melanops			
Olympic National Park, sublapine meadows[a]	National Park Service	Conservation /recreation	Subalpine meadows subject to foot traffic

[a]Sites with some level of protection; Conservation Status 1 or 2 (Cassidy et al. 2001).
[b]Gophers may not be present on NAP, but may be present on adjacent private lands.

Scott Prairie, includes over 700 ac of grassland, pavement and developed areas. It contains about 272 ac of grassland, which is most of what remains of perhaps 2,603 ac of historical grassland in the Shelton area (Chappell et al. 2001b, 2003). Scotch broom is controlled at the airport by mowing and spraying. The Port of Shelton has plans to develop some of this area over the next several years (GeoEngineers, Inc. 2003). Dalquest and Scheffer (1944) characterized the soil here as shallow (9") and stoney, and the vegetation as scant. Soils at the county fairgrounds south of the airport appears to be even more rocky, and may be marginal for pocket gophers (R. Taylor, pers. comm.). Most of John's Prairie has grown into forest, and the main part is an industrial complex with no vegetation, with some surrounding areas of grass overgrown with Scotch broom. McKewen Prairie is mostly forested, with the last known gophers found only on a regenerating clearcut and along a road right-of-way. Lost Lake Prairie has thin rocky soil and sparse vegetation, and was rapidly being overgrown by forest when gophers were trapped there by Dalquest (Dalquest and Scheffer 1944). Steinberg reported possible gopher mounds on the grounds of the state penitentiary, but this needs further investigation.

The habitat of all known populations of *T. m. melanops* is secure in Olympic National Park. The only potential human-related impacts would stem from trampling damage and erosion. Johnson (1977) noted a few apparent extinctions of local subpopulations between the 1920s and 1950s and speculated about their cause. However, small populations may go extinct due to random demographic factors and periodically be recolonized from nearby populations.

Table 2.5 briefly outlines the ownership, land use and habitat condition of sites with known populations of Mazama pocket gophers. Gophers are likely also present on private lands adjacent to some of these sites. Small fragmented populations of gophers may be unlikely to persist, except perhaps in larger pastures, due to predation by dogs, cats, and trapping by homeowners. Only Rocky Prairie NAP and the *T. m. melanops* sites in Olympic National Park and are Conservation Status 1 (i.e., maintained primarily in a natural state; Cassidy et al. 2001). Scatter Creek Wildlife Area and Weir Prairie Research Natural Area would be considered Conservation Status 2, or areas maintained mostly in their natural state but with some conflicting uses. The remaining Fort Lewis sites and portions of the airports would be considered Conservation Status 3: lands with some protection from development but subject to broad, low intensity or locally intense extractive uses (Cassidy et al. 2001). The remaining sites are not protected and are at-risk to development or land use that is incompatible with gopher persistence.

LEGAL STATUS

Federal. The Washington population of the Mazama pocket gopher is a Candidate for listing under the federal Endangered Species Act (USFWS 2001).

State. The Mazama pocket gopher is currently not protected by state law in Washington. The species has been listed as a candidate for state listing as threatened, endangered, or sensitive in Washington since 1997. Prior to that time, certain subspecies (Roy, Tenino, Tacoma, Shelton, and Cathlamet pocket gophers, or subspecies *glacialis, tumuli, tacomensis, couchi*, and *louiei*) had been candidates since 1991.

County. The western (Mazama) pocket gopher is a Species of Local Importance in the critical area ordinances of Thurston and Pierce counties. The Shelton pocket gopher (*T. m. couchi*) is a species of local importance in the critical area ordinance of Mason County.

MANAGEMENT ACTIVITIES

Surveys

U.S. Army-funded surveys improved available information on the distribution and relative abundance of gophers on Fort Lewis (ENSR 1993, 1994). The Nature Conservancy, the US. Fish and Wildlife Service, National Science Foundation, and several other institutions or organizations supported

the surveys and research by E. Steinberg (1999). Steinberg (1995, 1996a) visited nearly all known historical gopher sites in the south Puget Sound area as well as all remnant prairie sites identified as having native vegetation, or restorable to native vegetation. Farrell and Archer (1996) surveyed populations of *T. m. couchi* in Mason County. Although these recent surveys have provided much of the data necessary for this status review, additional surveys are needed throughout the species range in Washington.

Habitat Management and Restoration

Little management has occurred to benefit Mazama pocket gophers specifically, although removal of Douglas-fir and Scotch broom, and other prairie restoration activities likely have benefited gophers. Several agencies and organizations have been involved in conducting and improving methods of prairie maintenance and restoration, including the U.S. Army/DOD Fort Lewis, the Nature Conservancy of Washington, WDFW, the Center for Urban Horticulture at University of Washington, and the Washington Department of Natural Resources. See the introductory chapter for a summary of recent activities. The Prairie Management Plan for Fort Lewis (Altman 2003b) includes the goal of maintaining viable populations of special status prairie flora and fauna, which includes Mazama pocket gophers.

Research

The Mazama pocket gopher has received limited research attention in Washington since the taxonomic work of Dalquest and Scheffer (1944), Gardner (1950), and Johnson and Benson (1960). Some research on the species has focused on control efforts to reduce winter damage to conifer seedlings (Barnes et al. 1970, Hooven 1971, Teipner et al. 1983, Marsh and Steele 1992). Witmer et al. (1996) collected data on biology and habitat use of *T. mazama* in Washington during field trials of population control methods. Wagner and Nolte (2000) used *T. mazama* in Washington while testing the efficacy of a repellant to reduce mammal damage during reforestation.

Steinberg (1999) recently completed studies of the systematics of *T. mazama* in Washington. She also studied the influence of soil rockiness on gopher distribution (Steinberg and Heller 1997) and the influence of soil disturbance by gophers on the abundance and distribution of native and introduced plants on prairie sites (Hartway and Steinberg 1997). Steinberg (1995) identified factors that need further investigation, including: taxonomy; status and distribution of all remaining populations; dispersal; the impact of soil compaction by military vehicles and training; the influence of Scotch broom; the possible influence of moles on the distribution and abundance of gophers; and the influence of gophers on the biodiversity of the native prairie ecosystem. Corey Welch and Dr. J. George Kenagy of University of Washington are currently investigating genetic differentiation within and between populations of *T. mazama*.

Schmidt (2004) developed and tested the use of various devices to capture hair from gophers; she found that hair could be used to indicate the presence of gophers, but that gophers often responded to the device by blocking off the tunnel so that the frequency of obtaining hair was very low. If the technique can be perfected, it could be used to detect gophers at a site without live-trapping which is dangerous for the gophers and time consuming. The technique may also be useful for monitoring populations if DNA from hair follicles can be used to identify individuals.

FACTORS AFFECTING CONTINUED EXISTENCE

Adequacy of Existing Regulatory Mechanisms

Federal protection. The Mazama pocket gopher was recently listed as a candidate for protection under the Endangered Species Act. This status increases the protection from federal actions and on federal lands. The species is not otherwise protected under federal law. It is Army policy to consider candidate species when making decisions that affect them, to avoid taking actions that may cause them to be listed,

and to take affirmative actions that can preclude the need to list them (J. Foster, pers. comm.)

State and county protection. The Mazama pocket gopher is currently not directly protected by state laws, but would become protected wildlife if listed as threatened, endangered or sensitive. As a Priority Species, their habitat may receive some protection subsequent to environmental review of applications for county or municipal development permits through critical area ordinances. Washington's Growth Management Act requires counties to develop critical area ordinances that address development impacts to important wildlife habitats. The specifics and implementation of critical area ordinances vary somewhat by county. The Mazama pocket gopher is recognized as a species of local importance in the critical area ordinances of Pierce, Thurston, and Mason counties. This generally means that when development activities are proposed where gophers are present, the developer must assess the impact to gophers and submit a Habitat Assessment Report (Pierce), or Habitat Management Plan (Mason, Thurston). The county generally consults with WDFW and the permit then may impose conditions on the development to avoid, minimize and mitigate impacts to the gopher population. Known gopher populations in Clallam County are all on national park lands. In at least three instances, portions of a development site have been set aside for Mazama pocket gophers and other wildlife, but the sites are small and the permit conditions may not require maintaining the vegetation in suitable condition. The counties also may not be able to effectively address the issue of connectivity between gopher populations.

Impacts of Habitat Loss, Fragmentation, and Degradation

Mazama pocket gopher habitat has been lost to development and succession to forest, and what remains continues to be degraded by the invasion by Scotch broom and other non-native plants. Residential development has been particularly destructive to prairie habitat. Most of the historic prairie habitat has been lost and over half of the historic gopher populations have gone extinct.

Implications of habitat loss for populations. Pocket gophers are vulnerable to local extinctions because of the small size of local breeding populations (Steinberg 1999). Daly and Patton (1990) noted that the skewed sex ratios and high variance in male reproductive success in *T. bottae* results in low effective size of local populations and relatively large genetic differences between populations. They observed consistent genetic differences between local populations despite documenting gene flow during 7 generations. Daly and Patton (1990) also observed reproductive females at low density in small pockets of grassland removed from larger populations. They speculated that these small, perhaps ephemeral subpopulations may contribute to gene flow. Pocket gophers have probably persisted by continually re-colonizing habitat after local extinctions, and the loss of habitat patches has likely stopped much of the re-colonization that historically occurred.

Where additional habitat exists within a few hundred meters, some dispersal and resulting gene flow occurs between local populations, and vacant habitat is rapidly colonized. However, as habitat patches become smaller, fewer, and further apart, the likelihood of each patch continuing to support pocket gophers declines. The likelihood of local populations suffering from inbreeding depression, diminished genetic diversity, and other consequences of small population size increases as these populations are reduced through the loss of habitat.

Residential development. Loss of habitat, particularly to development, apparently led to the extinction of the Tacoma pocket gopher, *T. m. tacomensis*. Pocket gophers apparently survived on vacant lands within the matrix of suburbs south of Tacoma for some years, but eventually went extinct probably due to the changed habitat condition, trapping by homeowners, and persecution by domestic cats and dogs. The last records of this subspecies were of individuals killed by domestic cats. When gopher populations become small and isolated, these sources of mortality may speed their extinction. Gophers may survive in pastures in rural residential areas, but several populations that existed on pastures and rural residential areas near Tenino, Lit-

tlerock, and Vail have apparently gone extinct (Table 2.3). Studies in California indicate that gopher density tends to decrease in grazed pastures (Eviner and Chapin 2003).

Gravel mining. South Puget Sound prairies are located on glacial outwash gravels. Some of these glacial gravel deposits are very deep and valuable for use in construction and road-building, and prairie sites of significant size may be destroyed by gravel mining. One of the historic sites where Tacoma pocket gophers were collected became a large gravel pit, and two gravel pits have been opened on occupied gopher habitat in Pierce County south of Roy.

Airport Management and Development

Pocket gophers occur in grasslands surrounding airport runways and adjoining lands at Olympia, Shelton, and Gray Field on Fort Lewis. Airport safety considerations requires that the vegetation be mowed to maintain visibility and provide a safety margin should aircraft overshoot or land short of the runway. This management benefits gophers by keeping out woody vegetation and maintaining the grassland. Gopher activity could potentially conflict with airport management if gopher digging softened the soil and created a potential hazard at the end of runways should an aircraft run off the end or the side of the runway, but this is not considered a significant issue at the Olympia Airport (S. Alhadeff, pers. comm.). Airports may also be reluctant to improve habitat for pocket gophers because of the potential for attracting predators that then could pose some hazard for aircraft.

The Olympia Airport is currently realigning its runway. This will add 444,786 feet^2 of new pavement and result in the loss of some habitat occupied by gophers. The old runway will remain as pavement, but the Port agreed to remove 568,497 ft^2 of unneeded pavement for a net reduction in impervious surface (S. Alhadeff, pers. comm.). The footprint of the runway is larger than the pavement, however, because Federal Aviation Administration (FAA) regulations require the runway safety zone extend 250 feet on each side of the runway centerline and 1,000 ft beyond each of the runways (FAA 1994). The soil within the safety zone must be compacted and graded during runway construction, which may exclude gophers from the safety zone. This may not be an issue at the Olympia or Shelton airports, which generally service smaller aircraft and have very well-drained soils. The Olympia Airport is preparing a management plan that will address pocket gophers.

Development of surrounding port lands at the Shelton and Olympia Airports poses a greater threat of habitat loss for pocket gophers. The Port of Shelton had a habitat management plan prepared for the Shelton pocket gopher population on Sanderson Field to comply with Mason County regulations. The habitat plan was prepared in response to revisions in the Comprehensive Plan which identified several portions of the property for development (GeoEngineers Inc. 2003). The plan identifies an area of Port property where Scotch broom and other woody vegetation would be controlled to replace gopher habitat lost to development. However, the type and rock content of the soil on the proposed mitigation area apparently was not investigated, so it is unknown if the habitat will have comparable value for gophers.

Military Training

The presence of Fort Lewis has prevented the loss of habitat to agriculture and residential development for some of the largest remaining *T. mazama* populations. Mazama pocket gophers exist primarily on prairies where vehicular traffic is currently restricted to established roads, but there are no specific restrictions on training to protect gophers (J. Foster, pers. comm.). Fort Lewis has also been involved in prairie restoration work and has supported some of the most important work on the species to date. Nonetheless, military training by mechanized units may negatively affect some gopher populations by compacting the soil (Steinberg 1995). Vegetative cover declined by 36% after intensive, unauthorized tracked vehicle training occurred on Lower Weir Prairie, which is supposed to be off-limits to vehicle use (ENSR 2000). Areas damaged by military training are repaired by the Land Rehabilitation and Maintenance program. Without restoration,

native grasses tend to become replaced by invasive species such as colonial bentgrass and Scotch broom (ENSR 2000:21). Digging activity affects soil and vegetation; digging removes vegetation and creates disturbed sites that are susceptible to colonization by exotic weeds (ENSR 2000), although Parker (2002) demonstrated that disturbance was not necessary, nor does it facilitate, invasion by Scotch broom. Some soil contamination from vehicles, explosives, metals, and other chemicals likely occurs. At least one training area (TA 7S) includes both native prairie vegetation as well as a Superfund site (Altman 2003).

Fires that burn the vegetation, whether as part of restoration activities or as a side-effect of training during the summer, help reduce invasion by Douglas fir and Scotch broom and have maintained some of the highest quality prairie sites on Fort Lewis. However, smaller portions of the AIA seem to burn too frequently, have a low percentage of native species, and a cover of mostly exotic annual grasses (Tveten and Fonda 1999).

One brigade is presently stationed at Fort Lewis, but the stationing of a second heavy brigade there is planned (ENSR 2000:23; D. Clouse, pers. comm.). The increase in training needs is likely to increase impacts on grasslands and pocket gophers. The transition from heavy tank training to wheeled Stryker vehicles may change the impacts of training on vegetation (Altman 2003). The relative impact on vegetation of Strykers compared to M1A1 tanks is unknown. The most damaging training has been concentrated on the same areas, so some less-used prairies have been maintained in good condition.

Trapping and Poisoning

Pocket gophers can damage young trees and, like moles, their diggings can be considered an untidy nuisance to landowners desiring attractive lawns. They may also be a problem at a few Christmas tree farms in the area. Gophers are often trapped or poisoned when they are considered a problem. When larger populations are suppressed by these methods, they often recover if habitat remains suitable, but small and isolated populations can perhaps be exterminated.

CONCLUSIONS AND RECOMMENDATION

The Mazama pocket gopher is declining in Washington and many populations are in danger of extinction. Although the springtime population may number a few thousand individuals, this includes 3 distinct subspecies and about 27, mostly small, populations. Populations of gophers in Tacoma and Wahkiakum County that were previously considered distinct subspecies now appear to be extinct. Many other populations that existed on and around the south Puget Sound prairies have also disappeared since the 1940s. Some of the largest remaining populations are on airports, where they are affected by airport management and development. Only one subspecies, the Olympic pocket gopher, whose entire range lies within Olympic National Park, is relatively secure. However, even some of the populations there have gone extinct for unknown reasons.

Populations of small short-lived animals can fluctuate dramatically year-to-year, making populations less stable and probably more susceptible to extinction. Though populations may triple temporarily after annual dispersal of young, annual mortality is likely high, and a single year of reproductive failure or disease could eliminate small subpopulations.

Expanding human development has resulted in an increasing number of species being restricted to small pieces of isolated habitat that require intensive management for the species to survive. Until several large populations are established where management is consistent with the perpetuation of gophers, and genetic exchange between populations is established or facilitated, the Mazama pocket gopher is at risk in much of its range.

For these reasons, we recommend that the Mazama pocket gopher be listed as threatened in the State of Washington.

CHAPTER 3: STREAKED HORNED LARK

INTRODUCTION

The streaked horned lark (*Eremophila alpestris strigata*) is a rare distinctive subspecies of the horned lark and is an endemic Pacific coastal form found only in western Washington and Oregon. It is not restricted to native prairie habitats, but has adapted to nesting on grassland of airports and on sandy coastal spits and dredge spoil islands. The streaked horned lark was once abundant on Puget Sound prairies, but has become increasingly rare with the decline in habitat and is now restricted to a few large open grassland sites in Washington.

TAXONOMY

The horned lark is a member of the family Alaudidae (larks) in the order Passeriformes. Of the 76 species of lark, it is the only lark native to North America. The species was originally named *Alauda alpestris* by Linnaeus, which means "lark of the mountains." The horned lark is a common and widespread species found in both the New and Old Worlds, and it is known as the shore lark in Europe and Asia (Beason 1995). The horned lark is most closely related to Temminck's Horned Lark (*E. bilopha*) of North Africa with which it might form a "superspecies" (AOU 1998). Horned larks are more distantly related to the skylark (*Alauda arvensis*), a Eurasian species that was introduced to Vancouver Island, British Columbia, in 1903 and temporarily colonized San Juan Island, Washington, from the 1960s to 1990s (Lewis and Sharpe 1987, Wahl et al. 2005). The horned lark has 24 described subspecies in North America based on differences in size and plumage color (AOU 1957, Beason 1995). However, there is much intergradation between many of the subspecies, and further study is needed to determine the validity of many subspecies.

The streaked horned lark (*E. a. strigata*), called the Pacific horned lark by Dawson and Bowles (1909), is perhaps the most distinct subspecies and its breeding range is isolated from other subspecies. *E. a. strigata* was first described by Henshaw (1884) in part from the type specimens collected by George Suckley at Fort Steilacoom, Pierce County, Washington, in 1856. Three other subspecies breed in Washington. *E. a. alpina* breeds only in alpine areas of the Cascades and Olympics (Mt. Rainier, Mt. Adams, Glacier Peak, Hart's Pass, Chopaka Mountain, and Hurricane Ridge) and probably winters in surrounding lowlands (Jewett 1943, Jewett et al. 1953). *E. a. merrilli* breeds in intermountain valleys of northeastern Washington, the east slope of the Cascades, and the Blue Mountains. *E. a. lamprochroma* breeds in the low elevations of the Columbia Basin (Fig 3.1). *E. a. arcticola* breeds in Alaska, Yukon, and mountains of British Columbia and occurs in Washington as a common migrant and winter resident (Jewett et al. 1953, Beason 1995). Most populations of horned lark are contiguous and show clinal variation in characteristics. *E. a. strigata* is one of the few populations that are disjunct and likely truly deserves the subspecies label (R. Beason, pers. comm.). Recent genetic analysis confirms the distinctness of *E. a. strigata* from the other Washington subspecies (Drovetski et al. *in press*). Genetic data suggest that *E. a. strigata* was once part of a larger Pacific coast lineage and is most closely related to a California subspecies, *E. a. actia.* However, it has been evolving independently for some time. This analysis did not find genetic differences between *E. a. merrilli* and *E. a. alpina,* although the sample size was small (Drovetski et al. *in press*). Additional genetic analyses may result in changes to the number of recognized subspecies.

DESCRIPTION

The horned lark is a small ground-dwelling passerine. *E. a. strigata* males are 62-69 mm in length with wings 95-102 mm (n = 32), and females are 55-64 mm (n = 13) in length with wings 89-94 mm (Pyle 1997). The sexes can be distinguished by the female's duller plumage and small size. Adult males from Washington and the lower Columbia averaged 28.6 g (25.5 – 32 g, n = 23) in eight, and adult females averaged 26.9 g (24.5 – 30.0, n = 14)(S. Pearson, unpubl. data). Dwight (1890) noted that horned larks in populations along the west coast decrease in size as one goes north from

Mexico, reaching a minimum in *E. a. strigata* and increasing inland to a maximum in *E. a. leucolaema* of the upper Great Plains; this reverses the usual pattern that northern races of birds in the Northern Hemisphere are usually the larger (Dwight 1890).

Horned larks have black occipital feather tufts, or "horns," that are usually erect in males, but not as prominent and rarely erected in females (Beason 1995). Their plumage is also marked with a black breast band, lores, and cheek patches that contrasts with a yellow to white eyebrow stripe, ear coverts, and chin. The nape, back, rump, and upper surface of the tail are shades of brown streaked with dusky brown to black (Beason 1995).

E. a. strigata may be the most colorful and well defined of all the subspecies (Rogers 1999b, P. Unitt, pers. comm.). Behle (1942:252) states "the combination of small size, dark brown back, and yellow on the underparts serves to distinguish this race from all others." The subspecies name "strigata" comes from the conspicuously striped dorsum (Henshaw 1884). However the amount of back streaking varies, being much more subtle on birds in the southern part of the range (Behle 1942). The wide central black streaks on the two longest uppertail coverts are distinct (Behle 1942, Pyle 1997). *E. a. strigata* have a nape of walnut brown (Behle 1942) or bright chestnut (Rogers 1999b), which is brighter than in other subspecies. *E. a. strigata* are smaller and more brightly colored than *E. a. alpina*, and more closely resemble *sierrae* of northeastern California, which also has yellow underparts. *E. a. strigata* are darker brown dorsally and show more contrast between the nape and back than *sierrae* (Behle 1942). *E. a. strigata* most closely resembles *insularis* of the California Channel Islands in size and general appearance, but are distinguished by having lighter upperparts, a less heavily streaked breast, and more yellow on the underparts.

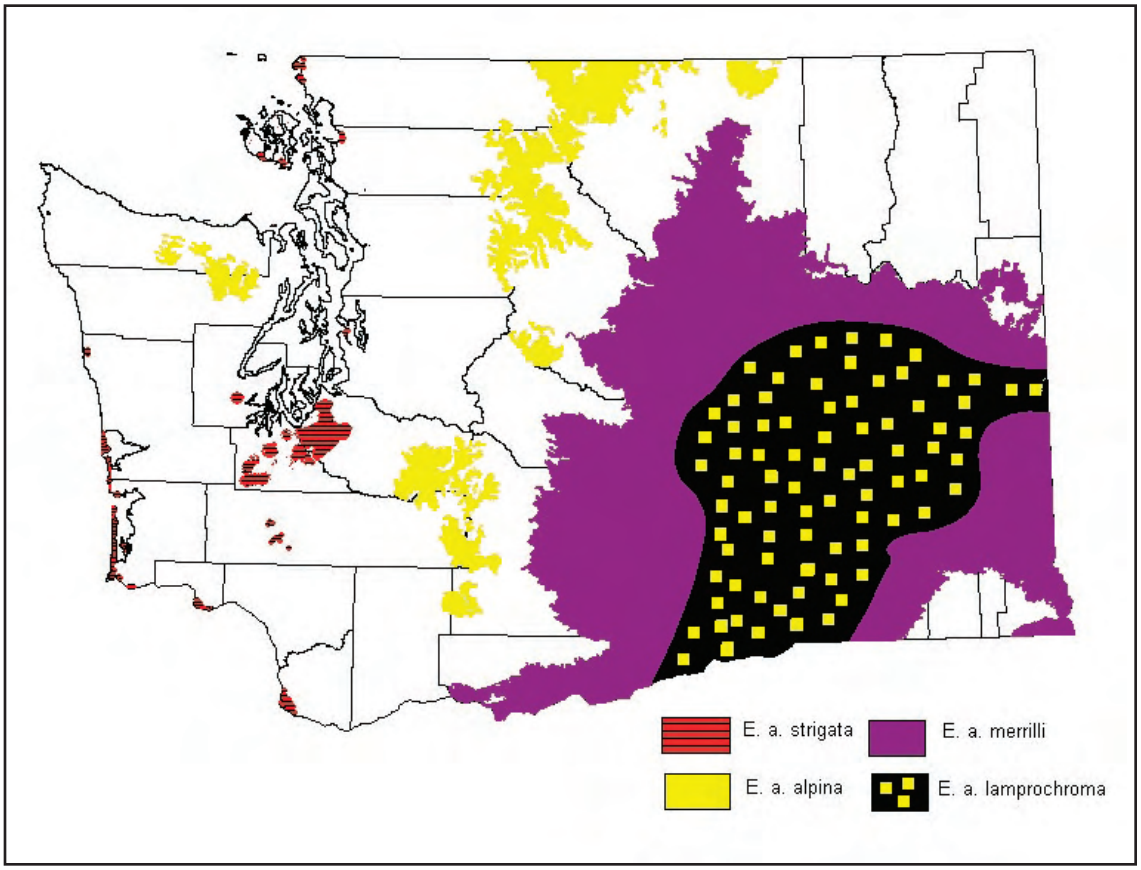


Figure 3.1. Ranges of horned lark subspecies in Washington (modified from Jewett et al. 1953 and Smith et al. 1997); larks are only found in appropriate open habitat within these areas.

DISTRIBUTION

North America

Horned larks breed across a large part of North America from arctic islands to the highlands of Mexico. They are largely absent from heavily forested regions, such as interior Canada and the southeastern United States, except where forests have been replaced by agriculture (Beason 1995). The species is not found south of Mexico with the exception of an isolated population in the eastern Andes of Columbia (AOU 1998). Horned larks can be very locally distributed in suitable habitat within the breeding range, and populations or subspecies are often closely associated with specific habitats, such as coastal grassland, alpine, or desert (Beason 1995).

The wintering range of horned larks encompasses the southern half of their breeding range; they winter from the southern fringes of Canada and further south, but they also move into parts of the southeastern United States beyond the southern limit of their breeding range. Populations seem to generally shift south, because individuals wintering south of the breeding range seem to be from southern breeding populations, rather than northern populations (Beason 1995). Alpine populations in Washington are believed to make an altitudinal migration to winter in surrounding lowlands (Jewett et al. 1953).

E. a. strigata historically bred in prairie and open coastal habitats from the southwestern corner of British Columbia (Fraser et al. 1999) through the Puget Trough, and possibly as far south as Eugene, Oregon in the Willamette Valley, and in the Rogue River Valley from Medford, Oregon, north to Eagle Point (Fig. 3.2). Early literature (Dwight 1890, Gabrielson and Jewett 1940) describes the breeding range of *E. a. strigata* as including the Channel Islands and northern Sierra Nevada of California, but Behle (1942) assigns these populations to *E. a. insularis* and *E. a. sierrae*.

Washington: Past

Horned larks breed in the steppe and agricultural areas of eastern Washington and in dry alpine meadows, but *E. a. strigata* has always been restricted to prairies and open coastal habitats in western Washington, particularly the glacial outwash prairies of the south Puget Sound region (Smith et al. 1997; Jewett et al. 1953, Rogers 2000). Dawson and Bowles (1909) state that the subspecies was "chiefly confined to Pierce, Thurston, and Chehalis" (Grays Harbor) counties; there are numerous specimens from Pierce County (Appendix B). Oberholser (1902) and Jewett et al (1953) describe a range that included a good portion of southwest Washington including Grays Harbor and up the Columbia River as far as Cliffs, 9 miles southeast of Goldendale, Klickitat County. However, Behle (1942) describes the breeding range of *E. a. strigata* as limited to west of the Cascades. He identified the specimens from Klickitat County as *E. a. merrilli,* which would be consistent with the more arid nature of the habitat there. There is an *E. a. strigata* specimen record from Ridgefield, Clark County (Oberholser 1902), and several records from the Oregon side of the Columbia at Sauvie Island, and as far east as Government Island, Multnomah County (Rogers 2000).

There are a few old records for the Olympic Peninsula and outer coast. Kitchin (1949) described *E. a. strigata* as a spring and summer resident of prairie habitats between Shelton and Olympia. Lawrence (1892) listed *E. a. strigata* as a "resident?" of the Grays Harbor region, based on sightings of a pair 12 June on the upper Quinalt River, one reported at Lake Quinalt several times in April, and a pair that lived from April-June at some open beaver marshes 4 miles north of Humptulips, Grays Harbor County. Oberholser (1902:839) examined a specimen in breeding condition from Shoalwater (Willapa) Bay. More recent records from the coast in Pacific County include an observation of 3 at Leadbetter Point 6 May 1967 (Crowell and Nehls 1967), and 4 birds collected 26 July 1974 at Graveyard Spit (Appendix B).

Streaked horned larks have been reported breeding further north in the Puget trough. Rathbun (1902) observed *E. a. strigata* on the tide flats south of Seattle, but does not mention evidence of breeding. There are 5 breeding season (April, May) specimens

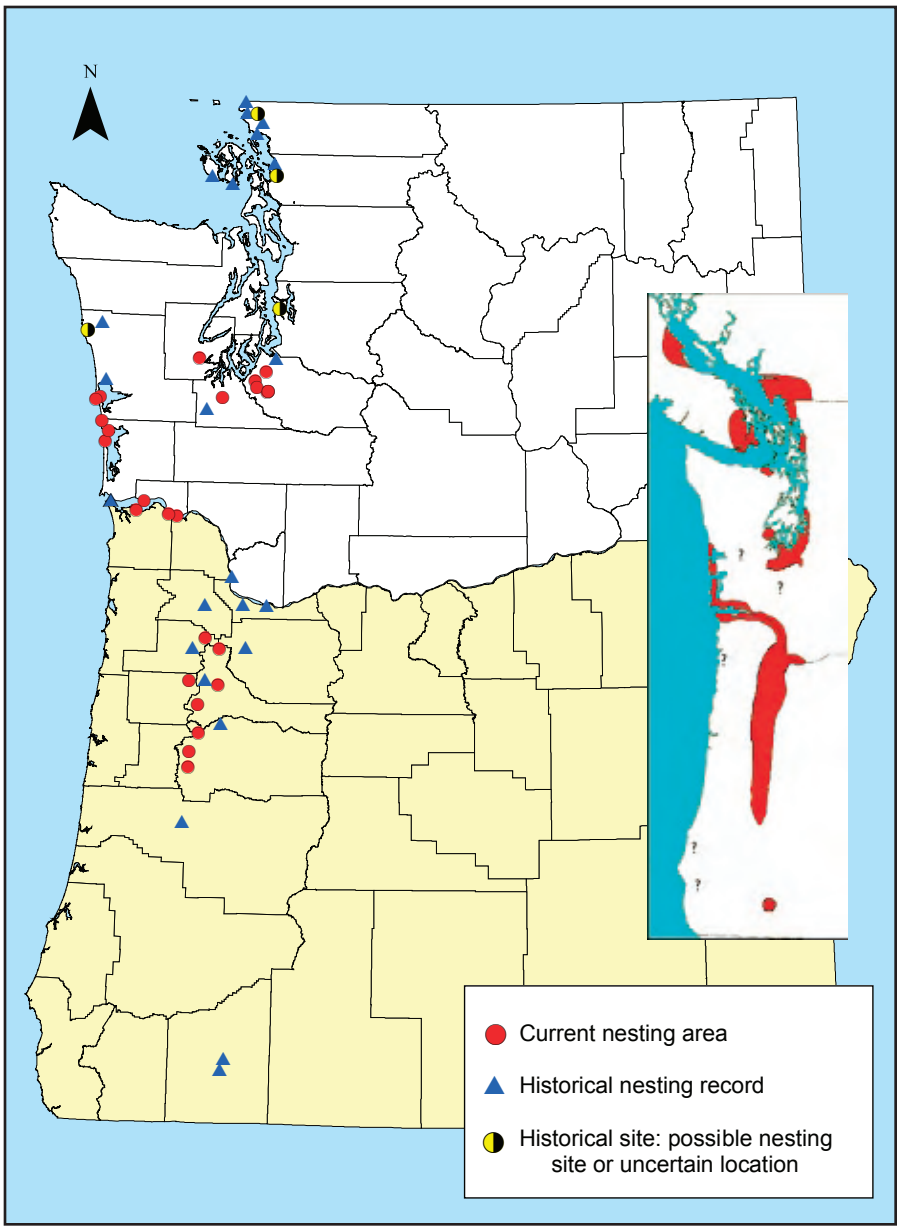


Figure 3.2. Historical and current breeding locations of the streaked horned lark in Washington and Oregon, and (inset) hypothesized breeding distribution (Gabrielson and Jewett 1940, Behle 1942, Jewett et al. 1953, Fraser 1999, Rogers 2000, MacLaren 2000, Altman 2003, and WDFW data).

from Skagit and Whatcom counties in 1929 and 1935. J. M. Edson noted that they probably nested in Laurel in 1933 and near Fort Bellingham in 1937 (Wahl 1995). Adults and young were reported from Blaine in summer 1951, 1952 and 1953 (Flahaut 1952, 1953, Flahaut and Schulz 1954). The most recent Whatcom County breeding record was a territorial male at Bellingham Airport on 26 June 1962 (Wahl 1995). Records for Skagit County include 3 breeding season specimens collected at Anacortes on 18 July 1937 and nesting near Edison in 1929 (Wahl 1995).

Streaked horned larks may have colonized the San Juan Islands in the 1940s. No horned larks were reported in the San Juans by Miller et al. (1935), Miller (1944), or Gove (1946). The first breeding season record is from 1948 (Goodge 1950). They apparently nested at Cattle Point and False Bay on San Juan Island, and Richardson and Davis Bay on Lopez Island from 1948-1962 (McMannama 1950, Retfalvi 1963, Bakus 1965). They have not been reported from the San Juans since 1962 (Lewis and Sharpe 1987).

Washington: Present

Surveys conducted during the breeding seasons in 1999 and 2000 found streaked horned larks present at only 11 locations in Pierce, Thurston, Mason, Pacific, Grays Harbor, and Wahkiakum Counties (Rogers 1999a, MacLaren and Cummins 2000). They were not detected during recent surveys north of Pierce County. There were reports of horned larks on the Samish Flats, Skagit County, in July and August 1999, but R. Rogers (pers. comm.) could not confirm their presence in response to the reports, and none were detected there during surveys in 2000 (MacLaren and Cummins 2000). Streaked horned lark nesting now seems to be restricted to isolated locations at the south end of Puget Sound, on the outer coast, and in the Columbia River estuary. During winter, most

streaked horned larks are found on fields in the Willamette Valley of Oregon, with smaller flocks seen on the Washington coast and lower Columbia River islands (Pearson et al. 2005).

NATURAL HISTORY

Reproduction

Horned larks are believed to breed when 1 year old, as do most small passerines (Beason 1995). They breed annually and are monogamous for at least the season, but there have been no long-term studies of pair bonds (Beason 1995). In Colorado, half of banded horned larks returned to the same mate the following season (Boyd 1976).

Territorial and courtship behavior. Streaked horned lark males begin to sing and establish territories after they arrive in Washington in the latter half of February and early March (Bowles 1900, Rogers 2000, Pearson 2003). Streaked horned larks seem to be semi-colonial nesters. Bowles (1898) reported that some locations had high densities of nests, while large expanses of seemingly perfect habitat were vacant. Males sing both from the ground and in flight. Ground singing functions in territorial defense, and is often done from a post, rock, or dirt mound (Beason 1995). Males do most of the territorial defense and chase intruding males. Females chase away the occasional intruding female (Beason 1995). *E. a. strigata* sing most actively the first few hours after daybreak and again around dusk (Rogers 2000). In May and June, males begin to sing 1.5-2 hours before sunrise (S. Pearson, pers. comm.). I other parts of North America, singing reaches a peak within 15 minutes of starting and almost ceases 15 minutes after sunrise (Beason 1995). Aerial singing is part of an elaborate courtship display. The male ascends at a steep angle, or stepwise if it is windy, in a wide spiral to a height of 262-820 ft (80-250 m), spreads its wings and tail and glides into the wind while singing, remaining almost stationary over the ground (Beason 1995). It then regains altitude and repeats the song. At the end of the flight the male plunges to the ground, sometimes making a loop while braking near the ground. Song flights last 0.5-8 minutes and are performed most frequently before nest-building, for a brief period after broods fledge, and when a nest is destroyed (Beason 1995).

Territory size. Territory sizes vary with habitat quality. Streaked horned lark territories in Oregon averaged 0.77 ha (range 0.6-1 ha; n = 3; Altman 1999). Territories are defended until the last brood leaves the nest. There are no data on seasonal home ranges of broods after territories are abandoned, or on home ranges of winter flocks (Beason 1995).

Nesting and brood rearing. Horned larks build a small compact cup of dead grass, plant fibers, rootlets, bark strips, fir needles, and plant down (Bowles 1900, Fraser et al. 1999). The nest is usually placed in a depression scratched out to 2-3 inches deep with the feet and bill, but larks will also use horse or cow hoof prints, or a cavity from an upturned stone (Bowles 1900, Pickwell 1931, Campbell et al. 1997). Horned lark nests sometimes have a collection of debris, such as cow dung, corn cobs, pebbles, etc. called "pavings" (Pickwell 1931, DuBois 1935). The debris may form a sort of entrance ramp for the nest, or be randomly distributed around the nest. Although they provide a clear approach, the larks do not always enter over them (Beason 1995). During construction, the lark drops paving material into the nest, perhaps to keep materials from blowing away (Beason 1995). The function of paving is unknown, but it covers soil excavated from the nest cavity (Beason 1995), so may help reduce detection by predators.

Based on studies of *E. a. praticola* in Illinois (Pickwell 1931, Beason and Franks 1974) and *E. a. leucolaema* in Montana (DuBois 1936), Beason (1995) stated that nest site selection, construction, and incubation are all performed by the female alone. Bowles (1900) indicated that in *E. a. strigata*, both birds work in scratching out the nest hole and birds participate in incubation, but male involvement has not been observed during recent research (S. Pearson, pers. comm.). This suggests that Bowles may have observed a pair exhibiting anomalous behavior patterns.

E. a. strigata has a long nesting season. Nest building in the south Puget Sound area was first observed

18 April, 25 April and 5 May during 2002, 2003, and 2004, respectively (Pearson and Hopey 2005). Clutch initiation dates for *E. a. strigata* vary with location; the first eggs were observed on 30 April in 2002, and on 4 May in 2003 (Pearson 2003, Pearson and Hopey 2004). Clutch initiation dates for British Columbia range from 5 April - 19 July (Campbell et al. 1997), but eggs have been found in Oregon as early as 15 March (Gabrielson and Jewett 1940). Bowles (1898) stated that one could confidently look for eggs at Washington locations between 1 May and the "last of July," and perhaps earlier and later. Except at high altitudes or high latitudes, horned larks typically raise 2 or more broods per season (Beason 1995). South Puget Sound birds seem to exhibit two peaks in clutch initiation, with the first peak from late April/early May and lasting until late May/early June. A peak of second clutches or renests after failures follows in late June to late July (Pearson and Hopey 2005). Data from coastal and Columbia River sites in 2004 suggested more clutches were initiated both earlier and later than on Puget Sound sites, and there may be 3 peaks in clutch initiation dates (Pearson and Hopey 2005). Pearson (2003) noted that there also appeared to be 3 peaks of clutch initiation on Puget Sound sites in 2002 probably reflecting first nests, re-nesting after failures, and second nests after fledging of young from successful first nests. Gabrielson and Jewett (1940) state that *E. a. strigata* raise "two and possibly three broods" each season in Oregon. On south Puget Sound sites, nesting activity ended 8 August, 9 August, and 30 July in 2002, 2003, 2004, respectively (Pearson and Hopey 2004, 2005). The last nest under observation at Midway Beach was abandoned on 12 August in 2004.

The clutch size of *E. a. strigata* is most often 3, sometimes 1 or 2 and rarely 4 or 5 (Bowles 1900, Dawson and Bowles 1909, Fraser 1999, Pearson 2003). Pearson and Hopey (2005) reported clutches of 1-5 with a mean of 3.03 eggs (± 0.07 SE) for 107 clutches in Washington. Clutch size may vary somewhat with conditions, because DuBois (1936) noted a high occurrence of 4-egg clutches in *E. a. leucolaema* in Montana during a particularly wet spring. The eggs are dark greenish slate to a very light slate-white, with light gray to deep greenish red speckles evenly distributed on the surface and sometimes forming a wreath around the large end (Bowles 1900). Incubation lasts about 11 days (Beason 1995).

At hatching horned lark chicks are covered with a cream-buff down, and they have a distinctive gape with a bright yellow-orange tongue and mouth lining, and 5 black spots (Beason 1995). Chicks in Illinois and Northwest Territories weighed 2.4 g at hatching (Beason 1995). The eyes open during days 2-4, and the chicks' bodies are covered with contour feathers by days 8-10 (Dubois 1936, Beason 1995). Both parents feed the young. The chicks attain 60% of the adult body weight in the first 8 days (Beason 1995). In British Columbia, horned lark chicks leave the nest at 8-10 days, and Kennedy (1913a in Jewett et al. 1953) noted chicks in eastern Washington leaving the nest at 6-8 days. The chicks can flutter and hop at departure, fly a few meters in a few days, and can walk and fly well by day 27 (Beason 1995). The parents provide food for a week or more after fledging. Chicks start to become independent by 3 weeks of age and are mostly independent at 4 weeks (Beason 1995).

Nest success. Pearson and Hopey (2005) reported that 63 of 167 (37%) active nests found on south Puget Sound study areas in 2002 - 2004 fledged at least 1 young. The Mayfield method compensates for potential biases associated with the date of discovery (i.e. a nest discovered when young are near fledging, is more likely to fledge young than a nest discovered early in incubation) by calculating a daily nest success rate for the egg-laying, incubation, and nestling stages separately (Mayfield 1975, Johnson 1979, and Hensler and Nichols 1981). Overall nest success at four Puget lowland study sites calculated using the Mayfield method was 28%, 21%, and 28% in 2002, 2003, and 2004 (Pearson and Hopey 2005). In 2004, Mayfield nesting success was highest at Damon Point (66%) and McChord AFB (46%). At 2 coastal and 1 Columbia River nesting areas in 2004, 18 of 31 nests (58%) were successful and the Mayfield estimate was 33%. Mayfield nest success has been lowest on 13th Division Prairie during 2002-2004 (7%, 15% and 7%) (Pearson and Hopey 2005). Altman (1999) reported Mayfield nest success was 14% for 13 nests in Oregon.

Plate 2. Streaked horned lark, clockwise from upper left: nest on Midway beach (photo by Cyndie Sundstrom); week-old chicks on Gray Army Airfield (Morgan Pett); fledgling on Whites Island (Mark Hopey); and young of the year or adult males near Portland, Oregon (Randy Moore).

Predation was the most frequent cause (69%) of nest failure at sites in south Puget Sound in 2002-2004, and caused 46% of failures at 2 coastal and 1 river island sites in 2004 (Pearson and Hopey 2005). Abandonment was the source of failure for 22% of south Puget Sound and 46% (3 or 13) of coastal and river island nests. Some abandonment was human-related (e.g., tents erected next to nests on Gray Army Airfield for Armed Services Day caused nest abandonment). Failures directly caused by humans include 8 (8%) caused by mowing at south Puget Sound sites, and 1 (8%) that was crushed by a horse and rider on Midway Beach (Pearson and Hopey 2005). Recreational activities, including dog walking, beachcombing, vehicles, and horseback riding, may increase predation and nest abandonment at coastal sites (Pearson and Hopey 2005).

Cowbird parasitism. Horned lark nests are sometimes parasitized by brown-headed cowbirds (*Molothrus ater*). Cowbirds have been observed on all *E. a. strigata* study areas, but none of the 198 nests found to date contained cowbird eggs or chicks. However, fledgling cowbirds were observed begging food from adult streaked horned larks at Columbia River island sites in 2004 (Pearson and Hopey 2005). In an eastern Washington study, horned lark nests were not parasitized (n = 12) because they were well underway by the time cowbirds arrived in the study area (Vander Haegen and Walker 1999). In Kansas, none of the first clutches were parasitized, but over 63% of second clutches were parasitized by cowbirds (Hill 1976). In Illinois, horned lark eggs hatch sooner and develop faster than cowbirds, so the cowbird chick was often left behind when the larks fledged (Pickwell 1931). However, in the Kansas study, 25% of cowbird eggs produced fledglings (Hill 1976). Cowbird parasitism lowered horned lark fledging success on the study area from 1.4 young/nest to 0.7 young per parasitized nest (Hill 1976). Parasitism rates of horned lark nests are lower in other study areas (Beason 1995). Five of 26 nests (19.2%) were parasitized in North Dakota (Friedmann and Kiff 1985).

Movements and Dispersal

Migration and wintering. Many streaked horned larks that breed in Oregon remain there for the winter (Gabrielson and Jewett 1940), but the Washington population is largely migratory. Bowles (1898, 1900) reported that Washington birds assembled in flocks in mid to late October and departed the area soon thereafter, although a few single birds stayed through the winter. Rogers (1999b) noted that most streaked horned larks in Washington appear to leave their breeding grounds by mid to late August. In spring, they begin arriving in Washington in the latter half of February (Bowles 1900, Rogers 2000). The peak spring arrival date may vary by location and year. Bowles (1898) reported that they arrive in large numbers suddenly about the fourth week of March. In 2002, males first appeared at nesting areas on 19 or 20 Feb and the first females appeared 8 March, but did not arrive in numbers until 22 March (Pearson 2003).

The winter range of *E. a. strigata* and destination of Washington birds was unclear until very recently. The early literature, including Oberholser (1902), Behle (1942) and Gabrielson and Jewett (1940), stated that *E. a. strigata's* winter range included eastern Washington, north-central Oregon and northern California (Rogers 2000). Dawson and Bowles (1909) scoffed at the idea that larks would migrate from the mild coastal areas eastward to winter in inland areas where winters are more severe. Behle (1942:232, 256) notes "In winter, some … presumably move south into northern California," but indicated that birds collected in California and previously identified as *E. a. strigata* may all be *E. a. merrilli* or *E. a. sierrae*. However, at least 2 *E. a. strigata* specimens from California may exist at the Los Angeles County Museum (*fide* K. Garrett, pers. comm. to R. Rogers); future genetic analysis may determine if they are indeed *E. a. strigata*. The *E. a. strigata* population that formerly nested north of Medford, Oregon, may have been the source of any larks that wintered in northern California.

The hypothesis of a west-to-east fall migration is based on a small number of specimens, but most of these appear to be birds showing some intergradation between *E. a. strigata* and *E. a. merrilli*. P. Unitt (pers. comm.) describes the specimen record:

"Some of these specimens from north-central

Oregon look like *merrilli* but have the underparts variably tinged yellow, one of the main characters of *strigata*. I suspect that these represent intergradation/hybridization between the subspecies back when *strigata* were common enough to generate dispersers up the Columbia River. Even though most birds differ grossly, there are enough of these intermediates to generate the confusion [in the literature]."

Philip Unitt, San Diego Natural History Museum

Many winter specimens that were the basis for Gabrielson and Jewett's (1940: 403) statement that *E. a. strigata* wintered into eastern Washington and Oregon have since been relabeled by P. Unitt (pers. comm.) and perhaps other museum collections managers. Drovetski et al. (*in press*) reports that 1 of 32 eastern Washington individuals sampled contained the *E. a. strigata* haplotype, indicating past gene flow from western to eastern Washington. This is consistent with suggestions by Behle (1942) and Phil Unitt that the intermediate specimens represent intergradation between subspecies. R. Moore (pers. comm.) suggests that some yellow under the black bib may be a normal plumage variant in *E. a. merrilli/lamprochroma*, because there seem to be a lot of eastern Oregon/Washington specimens with various amounts of yellow, that are otherwise typical of those subspecies. However, S. Pearson (pers. comm.) notes that in general, *E. a. merrilli* have very little to no yellow, and he hasn't seen any specimens with yellow as extensive as *E. a. strigata*.

Surveys conducted during the winters of 2003-2004 (Robinson and Moore 2004) and 2004-2005 (Pearson et al. 2005) indicate that, as suggested by Rogers (2000), most streaked horned larks winter along the lower Columbia River and in western Oregon. From November 2004 through February 2005, Pearson et al. (2005) visited 28 sites, including 5 in the south Puget lowlands, 4 on the Washington coast, 7 along the Columbia, and 11 in the Willamette Valley, Oregon, and 1 in the Rogue Valley, Oregon. They observed flocks of up to 125 *E. a. strigata* in the Willamette Valley, and modest-sized flocks on Columbia River islands (1 to 61 birds) and the Washington coast (12-30 birds); only 1 pair and 1 single bird were observed at two Puget Sound sites (Pearson et al. 2005). The maximum counts at all sites totaled 542 birds, perhaps accounting for most of the subspecies. Robinson and Moore (2004) reported similar numbers from 16 locations in 2003-2004. Of a total of 780 horned larks observed, up to 630 were *E. a. strigata*; 421 were positively identified as *E. a. strigata* and an additional 209 larks were 'possible' *E. a. strigata*, but may have included other subspecies. They did not visit islands in the lower Columbia or south Puget Sound sites.

Pearson et al. (2005) noted that most wintering birds (72%) were in the Willamette Valley, with 20% along the lower Columbia, 8% on the Washington coast, and 1% on south Puget Sound sites. Based on re-sightings of color-banded individuals, birds from the Puget lowlands move south to the Willamette Valley or to the Washington coast, whereas many birds on the Washington coast and lower Columbia seem to be resident or move between these two area (Pearson et al. 2005). *E. a. strigata* may also overwinter on the southern Oregon coast in Coos County and occurs as an annual migrant and occasional winter visitor on the northern Oregon coast (Pearson and Altman 2005). No surveys were conducted in California; a few birds may move into northern California, or did historically before the breeding population in southern Oregon went extinct.

Dispersal and Fidelity. In Illinois, horned larks that nested successfully returned the following year to the same or nearby territories (Beason 1995). In Colorado, 65% of banded horned larks returned to the same territories, and half to the same mate (Boyd 1976). There are no data on dispersal distance from natal site to first breeding location for horned larks (Beason 1995). Fidelity to wintering sites in the Willamette Valley between years seems to be low because only a few fields are left fallow each winter with the location of fallow fields changing among years (Pearson et al. 2005).

Diet and Foraging

Diet has not been studied in *E. a. strigata*, but horned larks are largely granivorous, both in winter (80-100% seeds) and in the breeding season (up

to 73% seeds), while the chicks are fed insects exclusively (Beason 1995). Insects eaten include grasshoppers, beetles, and Lepidoptera larvae. Plant foods are primarily grass seeds, but include seeds of forbs, plant sprouts, and some fruits (Beason 1995). Horned larks forage on the ground, usually in short vegetation or bare agricultural fields. In winter, flocks feed on waste grain and weed seeds in stubble fields and occasionally in feedlots and roadsides, especially if fields are covered with snow (Jewett et al. 1953, Beason 1995). Adults will dig up worms and insect larvae, and pry moth larvae from weed clumps to obtain food for chicks. They are also adept at chasing and catching small insects (Beason 1995).

Behavior

Few observations of behavior have been reported for *E. a. strigata*, but they likely exhibit the same behaviors reported for other horned lark subspecies. Territorial males frequently strut before each other at the territory boundary like barnyard roosters (Pickwell 1931). Territorial disputes between males often involve chasing and fighting. Males will use their wings to strike at each other while on the ground, or fly straight up pecking and clawing each other (Beason 1995). Fights may be more ritual than actual, because contestants are rarely hurt, and the winner seems to be whichever bird persists longest in the behavior (DuBois 1936). In the most common form of chase, one male chases an intruder, but the roles reverse when they cross the territorial boundary (Pickwell 1931). Horned larks are reported to chase chickens and vesper sparrows that approach too close to their nests (Beason 1995).

Horned larks keep their earth-colored backs turned toward an observer (or potential predator) which makes it difficult to observe the brighter ventral plumage (Dubois 1936). During incubation, horned larks react differently to predators depending on the distance at which the predator is detected, the weather, and frequency of disturbance. If a predator is detected at some distance (25-100 yards), the lark may flush directly and silently, flying near the ground (Pickwell 1931). It may "slip off quietly and sneak at thirty yards" (Dawson and Bowles 1909). If the predator is very close, the bird may use a distraction display involving fluttering over the ground, or landing near the nest (30 cm) in a crouched position, and wings spread, and utter a soft distress call in an attempt to lead the predator away (Pickwell 1931, Beason 1995).

In late summer, young horned larks gather into small flocks of 10-25 birds. These nomadic foraging flocks are joined by adults in the fall (Beason 1995). In winter, small flocks may aggregate into large flocks of several hundred individuals at foraging areas. When large flocks gather on bare fields in the Willamette Valley, these flocks often include hundreds of pipits (*Anthus* spp.) (R. Moore, pers. comm.). In other regions mixed winter flocks include Lapland longspurs (*Calcarius lapponicus*), snow buntings (*Plectrophenax nivalis*), lark sparrows (*Chondestes grammacus*), tree sparrows (*Spizella arboreas*), dark-eyed juncos (*Junco hyemalis*) and pipits (Beason 1995).

Longevity, Survival and Mortality

There have been no long-term studies of horned larks, so survival rates, life expectancy, and longevity are mostly unknown. The oldest banded horned lark that has been recovered was at least 8 years old (Klimkiewicz and Futcher 1989). In one Illinois study, 5 of 13 marked adults were killed by predators in a single breeding season (Beason 1995). Eggs and chicks are killed by a variety of factors. Of 198 active nests in Washington, 79 were depredated, 29 were abandoned for unknown reasons, and 9 failed due to mowing or other human activities (Pearson and Hopey 2005). Of 13 streaked horned lark nests in Oregon, 3 failed due to predators, 2 were destroyed by farming activities, and 3 were abandoned (Altman 1999).

The major causes of mortality are probably predation, weather, and human activities (particularly agriculture and mowing) (McBee 1931, Bent 1963, Beason 1995, Pearson and Hopey 2005). Horned larks are early nesters, so severe weather can eliminate the first clutches (DuBois 1936). McBee (1931) indicated that untold thousands of nests, eggs, and young birds in stubblefields were destroyed by spring plowing in eastern Washington. Agricultural

activity is perhaps the most important factor, both positive and negative, for local populations. Given their habit of nesting in fallow fields, *E. a. strigata* may often be exposed to agricultural chemicals in the Willamette Valley. Pesticides, including Carbofuran and Fenthion are known to have killed horned larks (Beason 1995). Horned larks are known to feed on lettuce seedlings (*Lactuca sativa*) in fields in California where repellents or scaring methods are used to reduce crop damage (York et al. 2000). Dubois (1936) believed that poison baits intended to kill ground squirrels seemed to kill more birds than squirrels.

Predators. Pearson (2003) and Pearson and Hopey (2004, 2005) reported American crows (*Corvus brachyrhynchos*) and a garter snake (*Thamnophis* sp.) depredating nests of *E. a. strigata*. Crows were more frequently present at Gray Army Airfield than at other sites (Pearson and Hopey 2005). Crows were also observed walking on study areas systematically searching for and depredating killdeer (*Charadrius vociferus*) nests, suggesting that they may be an important predator of streaked horned lark nests (Pearson 2003). Bent (1963: 358) reported that crows were a major predator of streaked horned lark nests in western Washington. A killdeer also apparently pecked a hole in an egg (Pearson and Hopey 2004). Other potential nest predators include domestic cats and dogs, coyotes, raccoons (*Procyon lotor*), striped skunks, red foxes, long tailed weasels, and opossums (*Didelphis virginiana*), meadow voles (*Microtus pennsylvanicus*), deer mice (*Peromyscus maniculatus*), and shrews (*Sorex* spp.) (Creighton and Porter 1974, Bent 1963, Beason 1995, Pearson 2003). Cowbirds have been observed depredating eggs of grassland birds without parasitizing the nest (Pietz and Granfors 2000). Predators reported to prey on adult horned larks include the peregrine falcon (*Falco peregrinus*), loggerhead shrike (*Lanius ludovicianus*), snowy owl (*Nyctea scandiaca*), and burrowing owl (*Athene cunicularia*) (Bent 1963, Beason 1995).

Parasites. There have been no studies of parasite loads in streaked horned larks to date. In 1998, R. Rogers (pers. comm.) observed a fledgling on the 13th Division Prairie with 8-10 wounds characteristic of the subcutaneous avian blowfly *Protocalliphora braueri* (Diptera: Calliphoridae). However, of 22 *E. a. strigata* nests collected at Olympia Airport after the nesting season in 2002, none showed the presence of Calliphorid larvae, pupae, or adults (R. Rogers, pers. comm.).

Collisions, mowing, and disturbance. Disturbance of nests and collisions with vehicles may be a significant source of mortality for streaked horned larks. Altman (2003a) noted that mortality from collisions with vehicles may affect horned lark populations due to their propensity for nesting and foraging on unpaved roads. Pearson and Altman (2005) noted that dead streaked horned larks have been observed along runways at McChord AFB and Gray Army Airfield. According to statistics compiled by the Bird/Wildlife Aircraft Strike Hazard Team of the U.S. Air Force, Aviation Safety Division, the horned lark is the species of bird most frequently reported in birdstrikes with USAF aircraft (BASH 2004) (*see Factors Affecting*). Human disturbance during the nesting season contributes to nest abandonment; it may also increase predation because the eggs and chicks are vulnerable when the adult has been flushed and kept away from the nest by human activity. Mowing at airfields is likely a source of mortality for eggs and chicks where the mowing schedule and blade height has not been adjusted to minimize impacts to larks. Mortalities of eggs and chicks may also occur on Columbia River sites when nests are buried under dredge spoil. Human activities may result in significant mortality of eggs and chicks at Midway Beach, 13th Division Prairie, McChord AFB, and Gray Army Airfield.

HABITAT REQUIREMENTS

Breeding Habitat

Streaked horned larks inhabit open grasslands, sparsely vegetated beaches and islands, and agricultural fields, and generally avoid forest (Beason 1995). They do not seem to be associated with any specific vegetation type and strongly prefer bare ground to vegetation that is more than several inches tall (Beason 1995, Altman 1999, Rogers 2000, Pearson and Hopey 2005). Horned larks may select bare ground or short vegetation because adults normally walk rather than hop (Beason 1995). In

agricultural areas, horned larks often nest on bare ground, stubble fields, and pastures. In grazed areas, horned lark population densities are highest in the most heavily grazed sites (Bock and Webb 1984). Mowed fields adjacent to runways provide the only habitat for nesting larks in some areas (Beason 1995), and provide the most important remaining nesting areas for streaked horned larks in Washington (Rogers 2000).

The streaked horned lark nested in greatest numbers on the prairies that were formerly widespread in the south Puget Sound area and the Willamette Valley in Oregon. Dawson and Bowles (1909) described the prairie soils as glacially deposited gravel so thoroughly washed that many areas were capable of supporting little more than a carpet of moss. Bowles (1898) described the soil as dry and sandy, and the vegetation as mainly short grass mixed with sparse clumps of small "prairie ferns" of 6-7 inches, possibly a reference to stunted bracken (*Pteridium aquilinum*). When selecting territories, males on south Puget Sound sites seemed to avoid areas dominated by shrubs, perennial bunchgrasses, sod-forming perennial grasses, and non-native perennial forbs (Pearson 2003). They appear to select areas that are sparsely vegetated with short annual grasses and have a relatively high percent cover by rocks (≅ 9%) (Pearson and Hopey 2004, 2005). On the coast and Columbia River island sites, larks used areas that were sparsely vegetated, with more driftwood and cover of annual grasses than adjacent areas (Pearson and Hopey 2005).

Nearly all nests were located at the base of a grass plant or forb, and larks preferentially selected perennial forbs while generally avoiding annual and perennial grasses (Pearson and Hopey 2005). Most nests (89%) were placed on the north side of the plant. Nelson and Martin (1999) and Hartman and Oring (2003) reported that horned lark nests are often placed on the north to northeast side of plants, apparently so they are exposed to morning sun but have some shade during the heat of the day. Bowles (1900) noted that though they selected hot dry locations, streaked horned larks seemed to take advantage of stones, tin cans, boards, or tarpaper that provided shade during incubation.

On the outer coast of Washington, streaked horned larks nest on open dune sites where snowy plovers (*Charadrius alexandrinus*) are also found (Rogers 2000). These sites are areas of unstable substrate with little or no vegetation, such as sand spits and dune-backed beaches (Richardson 1995). Streaked horned larks in Oregon have been reported nesting in a wider variety of habitats including dry mudflats, newly planted Christmas tree farms, gravel roadsides, fallow fields, plowed or burned fields, row-crop fields and bare or sparsely vegetated areas of grass seed fields and moderate to heavily grazed pastures (Altman 1999, Altman 2003a).

Foraging sites. Streaked horned larks on Fort Lewis prairies selected foraging sites with a large percentage of bare ground (>40% of 1 m radius plots; included occasional mosses) and low vegetation (<30 cm) (Rogers 2000). Nearly all lark sites were in military tank tracks that had more bare soil than the surrounding area. Foraging sites had lower horizontal density and more bare ground than control plots in prairie or in mowed grassland (Rogers 2000). Rogers (2000) noted that larks seemed to select foraging sites that were atypical of the existing prairie landscape, but suggested that in the historical prairies, "such sites would not have been hard to find." Streaked horned larks in Oregon also used territories and nesting sites with a relatively high percentage of bare ground (Altman 1999). Given their selection for sparse, short vegetation and bare ground, streaked horned larks may have historically been restricted to the driest parts of the south Puget Sound prairies. Dalquest and Scheffer (1944) reported that the prairie areas with the thinnest soils had a sparse cover consisting mainly of mosses and lichens. Larks may have selected areas where the vegetation was sparse because it burned frequently, had a poorly developed A horizon, had a high gravel/cobble content, or a combination of these factors (Pearson and Hopey 2004). In a 2004 experiment, burned plots on 13th Division Prairie received much higher use by post-breeding streaked horned larks than unburned plots (Pearson and Hopey 2005).

Migration and Winter Habitat

Horned larks use the same open habitats during

migration and winter, but there is more frequent use of ocean beaches, dunes, and airports (Beason 1995). All habitats where streaked horned larks were detected in winter were large treeless/ shrubless expanses with a high percentage of bare ground (Robinson and Moore 2004). Most birds were recorded on fallow ryegrass fields in the Willamette Valley and on dredge spoil along the lower Columbia River; smaller numbers were found on sandy Washington coastal sites (Robinson and Moore 2004, Pearson et al. 2005).

POPULATION STATUS

North America: all subspecies

Horned larks have expanded and retracted their range and numbers with changes in regional patterns of agriculture such as the historical clearing of forest and subsequent abandonment of fields in the northeastern states (Beason 1995). Destruction of grassland habitats has resulted in widespread declines in grassland birds throughout North America (Peterjohn and Sauer 1999, Brennan and Kuvlesky 2005). Widespread degradation of native prairie to nonnative pasture and hay fields occurred before the 20th century, but conversion of pasture and hayfields to cropland has been occurring in the last 50 years. Beason (1995) concluded that the continent-wide population has been relatively stable since Breeding Bird Surveys began in 1966, but with regional declines in the northeastern and western states, and increases in the southeastern states. Breeding Bird Survey data for Washington indicate a decline of 2.2%/yr ($p = 0.01$) from 1966-2003 (Sauer et al. 2004). The Columbia Plateau also exhibited an annual decline of 3.3%/yr (1966-2003; $p<0.01$). These declines can probably be attributed to conversions of steppe and desert habitats to irrigated and intensive agriculture.

Streaked Horned Lark: Oregon and British Columbia

The streaked horned lark was said to be "an abundant summer visitor, nesting very commonly" in the northern Willamette Valley, and "not uncommon" at suitable sites around Portland in the late 19th century (Johnson 1880, Anthony 1902, both cited in Altman 2003a). In the 1930s, it was still a "common breeding bird of the open fields in suitable localities throughout western Oregon" and in grassland east of Medford, Jackson County (Gabrielson and Jewett 1940). Most of the native grassland was destroyed in the Willamette Valley in the 20th century. Recent surveys indicate there may be fewer than 250 pairs (Altman 2003a, Pearson and Altman 2005).

In British Columbia, streaked horned larks were a locally distributed resident of southern Vancouver Island and the lower Fraser Valley (Campbell et al. 1997). By the 1960s, nesting was limited to small numbers on the mowed fields at Vancouver International Airport, possibly near Abbotsford, and in sand dune habitat on Sea and Iona Islands (Beauchesne and Cooper 2003). Up to 7 birds were observed on Sea Island from 1963 –1966, but the last confirmed nesting was in 1978, and they may have last nested there in 1981. The streaked horned lark was recently considered extinct on Vancouver Island, and possibly in all of British Columbia (Fraser et al. 1999). However, during 30 days of surveys of grasslands for Oregon vesper sparrows in 2002, a single male streaked horned lark was found displaying at the Nanaimo Airport in 2002 (Beauchesne and Cooper 2003). No mate or nest was found during 16 hours of searching in 2002, and no larks were observed during 30 days of vesper sparrow surveys in 2003. The have been no other recent reports of streaked horned larks in British Columbia.

Washington: Past

There is little information about historical populations of streaked horned larks in Washington. George Suckley noted that streaked horned larks were "a very abundant summer resident on the gravelly prairie near Fort Steilacoom" south west of present-day Tacoma (Suckley and Cooper 1860). Bowles (1906) listed the subspecies as a "common summer resident of the driest prairies." Bowles (1900) guessed that there were around 100 pairs nesting on the links of the Tacoma Golf Club, an area of around 480 ac. Dawson and Bowles (1909) later noted that the golf links had "surrendered to the demands of the growing city."

It is probably impossible to derive a reliable estimate for the historical population on the 170,000 ac of grassland soils in the Puget Sound region (Chappell et al. 2001b). It is not known what portion of the prairies were suitable for streaked horned larks, or if the proportion changed and shifted around the landscape with fire occurrence. Bowles (1898) noted that they had a "peculiar distribution, large areas being almost untenanted, where conditions are to all appearances perfect...half a mile further... a bird may be flushed on average every hundred feet." It is unknown if the patchy distribution of streaked horned larks was a product of a semi-colonial nesting behavior or more specialized habitat needs that escaped the notice of Bowles. The remainder of our knowledge about historical populations and declines can only be surmised from changes in distribution of the birds and known loss of prairie habitat.

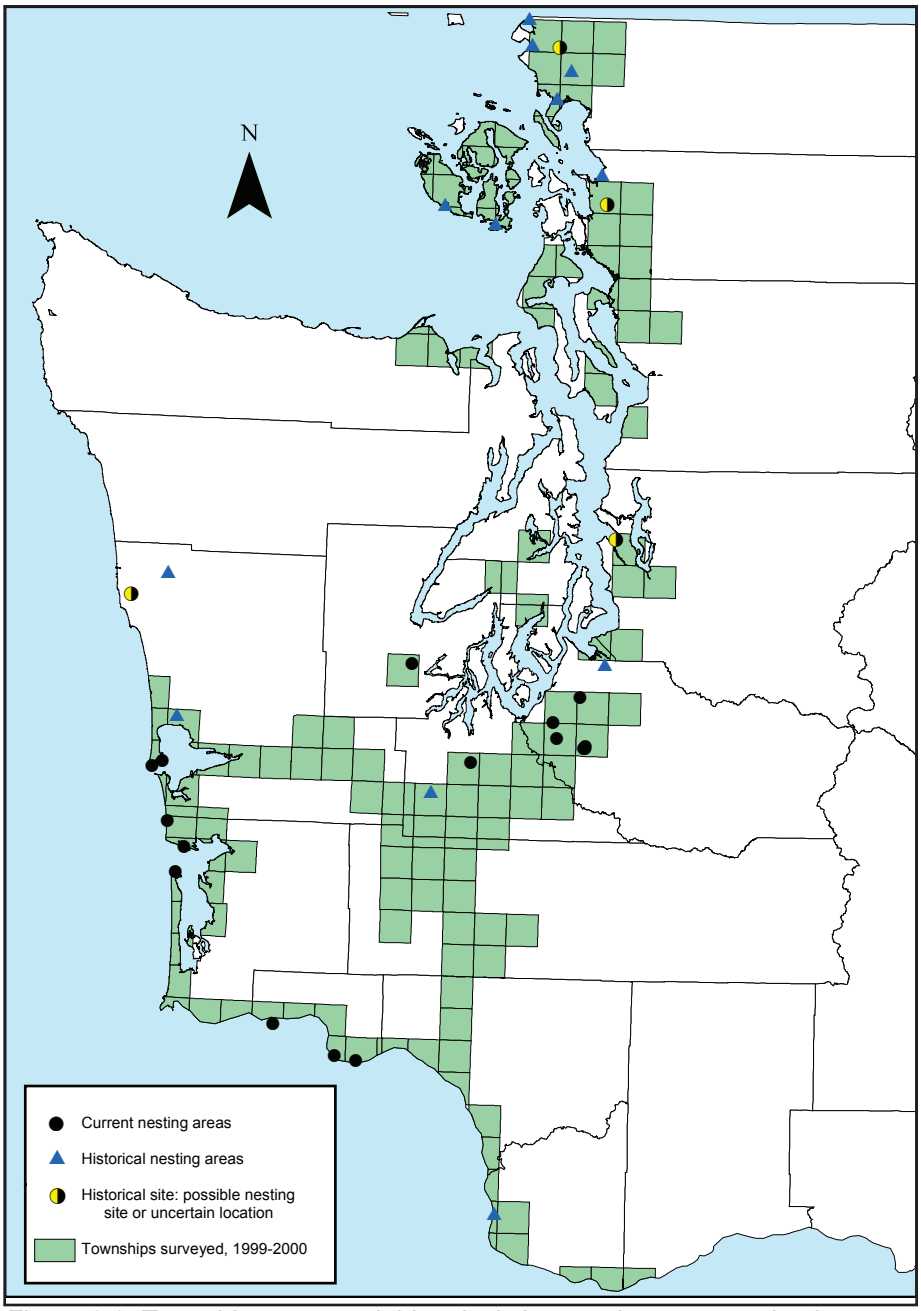


Figure 3.3. Townships surveyed, historical sites, and current nesting locations detected in Washington, 1999-2000 (not all shaded islands were surveyed; Rogers 2000, MacLaren 2000, WDFW data).

Washington: Present

Surveys were conducted in 1999 and 2000 to determine the present status of streaked horned larks. Rogers (1999a) identified 124 townships with known or suspected recent or historical streaked horned lark location records. This included locations on south Puget Sound prairie remnants, the San Juan Islands, northern Puget Sound sites (e.g. Skagit, Stillaguamish, Lummi Flats, Dungeness Spit), sites on the outer coast in Grays Harbor and Pacific counties, and along the lower Columbia River. Rogers visually searched suitable habitat, and used a tape recording of streaked horned lark calls to elicit responses and increase the chances of detections. He surveyed 29 of the 31 townships identified as high priority, the exceptions being those containing Paine Field, Snohomish County, and the Bellingham Airport. Rogers reported that few townships contained

suitable breeding sites and found no new inland sites besides those already known at Fort Lewis, McChord AFB, Olympia Airport, and Shelton Airport. No larks were detected at Mima Mounds NAP, Thurston County, or Boeing Field, both of which had sightings in the recent past, nor were larks detected at northern Puget Sound locations or in the San Juan Islands. Rogers (1999a) detected 49 singing males in 11 of 88 townships surveyed. He discovered two previously unknown breeding sites on small sand islands (Coffee Pot Island and Whites Island off the east end of Puget Island) in the Columbia River in Wahkiakum County.

MacLaren and Cummins (2000) surveyed several sites recommended by Rogers (1999a) (Cattle Point and Lime Kiln Point on San Juan Island, Protection Island, Dungeness and Travis spits), or where other individuals reported lark sightings in 1999 (Welts-Samish restoration site on Samish Flats) (Fig. 3.3). Areas surveys included the 2 remaining high priority sites and 33 additional low priority sites listed by Rogers (1999a). No new breeding locations for streaked horned larks were found (MacLaren and Cummins 2000). Musche et al. (2005) surveyed for streaked horned larks, snowy plovers and other species of concern on potential habitat at Leadbetter Point, Fort Canby, and Loomis Lake State Parks on the Long Beach Peninsula, Pacific County, during April – September 2003. Single birds were detected at Leadbetter Point and Fort Canby State Parks on a few occasions in July and August, but no nesting activity was detected.

In 2002, Scott Pearson began research that included developing census methods and documenting breeding activities by streaked horned larks on Fort Lewis, McChord AFB, and Olympia Airport (Pearson 2003). He mapped a combined total of 45 territories on the most densely populated portions of each location, but he did not conduct total censuses. In 2003, Pearson and Hopey (2004) discovered 10 territorial male larks on a portion of 91st Division Prairie, (Artillery Impact Area) on Fort Lewis, not

Table 3.1. Number of singing male streaked horned larks detected during surveys in 1999 and 2000, and estimated number of territories during research in 2002-04 (Rogers 1999a, MacLaren and Cummins 2000, Pearson 2003, Pearson and Hopey 2004, 2005).

Location	County	1999	2000[a]	2002	2003	2004
Whites Is./Brown Is. (off E tip of Puget Is.); T8N R5W S29	Wahkiakum	4	14	-	-	8
Coffee Pot Island; T8N R6W S25, 26	Wahkiakum	5	6	-	-	2
Rice Island (WA portion); T9N R8W	Wahkiakum	-	-	-	-	1
Leadbetter Point; T13N R11W	Pacific	6	6	-	-	2
Graveyard Spit; T14N R11W S10	Pacific	2	1 (2)	-	-	3
Midway Beach; T15N R11W S18,19	Pacific	2	1 (5)	-	-	21
Damon Point; T17N R12W	Grays Harbor	6	5 (8)	-	-	17
Olympia Airport; T17N R2W S14	Thurston	2	3 (6)	18	-	-
13th Division Prairie, Fort Lewis; T18N R3E S29	Pierce	8	7 (10)	8	10	18
Gray Airfield, Fort Lewis; T19N R2E S32	Pierce	4	2	[6][b]	30	31
91st Division Prairie, Artillery Impact Area, Range 74; T18N R2E S20	Pierce	-	-	-	10	-
McChord Air Force Base; T19N R3E S7	Pierce	7	5	[13][b]	-	31
Shelton Airport; T20N R4W S11	Mason	3	1	-	-	-
Total high counts of males/territories						165

[a]Number in parentheses are the total larks observed, including females and birds of unreported sex.
[b]These nesting areas were not completely surveyed in 2002.

previously known to host larks, and documented a total of 50 territories on 3 Fort Lewis study areas. In 2004, Pearson and Hopey (2005) mapped lark territories on McChord AFB, Gray Army Airfield, 13th Division Prairie, Damon Point, Midway Beach, and Whites Island. They also surveyed all other known and potential breeding locations along the Washington coast and on Columbia River islands. They mapped 110 territories and estimated an additional 24 territories based on surveys (Table 3.1).

There were no years when surveys were completed at all sites, but taking the results of the 2004 surveys (134 territories) and the high counts of males during 1999-2003 for the remaining 3 sites (18 at Olympia Airport; 10 at 91st Division AIA; and 3 at Shelton Airport) provides a total of 165 singing males. Assuming all males were mated, this would give a total estimate of about 330 birds in Washington. This estimate may be somewhat high or low, because: 1) some of the 1999 and 2000 numbers and the 2004 estimates at Coffeepot and Rice Islands were based on one or two visits, so some birds may have been missed; 2) assuming that all the males had mates may not be justified, and may bias the estimate upwards to an unknown extent (Mayfield 1981); and 3) there may be one or more additional nesting sites that remain to be discovered, although this is not expected. Pearson and Altman (2005) estimated that there are about 774 *E. a. strigata*, based on combining the Washington total (330) with a total from Oregon (444). They cautioned that this estimate combines data from separate efforts using different methods, different levels of effort, and from a time period of 8 years. Habitats may have changed during that period, and one or more populations may not have been detected.

In summary, the streaked horned lark is by all indications very rare in Washington. It currently is known to breed at 13 locations: 6 inland sites, 4 coastal sites, and 3 Columbia River sites. The most recent estimates indicate the Washington breeding population in 2004 was about 330 birds.

HABITAT STATUS

South Puget Sound Prairie Breeding Areas

Historically, at least 170,000 acres of prairie soil types existed in the Puget Trough area (Chappell et al. 2001b). Streaked horned larks selected particular portions of prairies for nesting (Bowles 1989), perhaps favoring only the driest and recently burned areas with rather scant vegetation. The proportion of the original prairie that would have been suitable and occupied by horned larks is not known. The currently used nesting sites are those with a disturbance regime that controls invasion by woody or tall and dense vegetation. Larks may have been eliminated from some prairie sites because of changes in vegetation structure. Intact prairie has significant cover of cryptogams between grass bunches, especially mosses and lichens, and this may have provided the open vegetation structure larks seem to prefer. Habitat loss in Oregon has also been dramatic. More than 99% of the presettlement grasslands in the Willamette Valley have been lost (Johannessen et al. 1971). Grasslands were initially converted to agriculture, some of which is compatible with use by larks. However, agricultural lands are increasingly being converted to commercial and residential developments, and incompatible agricultural crops (Pearson and Altman 2005).

13th Division Prairie, Fort Lewis. Parts of the 13th Division Prairie are heavily impacted by military training that affects nesting success. However, disturbance has apparently helped maintain the low plant density the larks seem to prefer (Rogers 2000). In fact, nearly all foraging locations observed by Rogers (2000) were on bare ground in tracks left by tanks.

91st Division Prairie, Fort Lewis. A large portion of this prairie is an artillery impact zone and has been maintained as grassland by frequent fires ignited by exploding ordnance. Artillery impacts create open ground while fires keep out Scotch broom, Douglas-fir, and exotic sod-forming perennial grasses.

Airports. Four of the six inland nesting areas are associated with actively used airports (Gray Army

Airfield, McChord AFB, Olympia Airport, Shelton Airport). These sites have short mowed grass fields surrounding runways and taxiways. Rogers (2000) compared foraging sites of larks on Fort Lewis with plots in prairie and mowed grass areas in the approach zone at McChord AFB. Although the grass was maintained at <6 in, it was much denser than native prairie and the sites used for foraging by larks. However, S. Pearson (pers. comm.) indicates that vegetation density is quite variable at the airports with some areas appropriate for nesting and foraging, and others having vegetation that is too dense.

Coastal Breeding Areas

Coastal sand accretion. Some coastal beaches where streaked horned larks currently breed may be larger than during the prehistoric period. Sand accretion rates on the beaches of southwest Washington were much higher in the early historic period than in both prehistoric times and recent decades (Peterson et al. 1999). The timing of rapid accretion in the early part of the 20th century suggests that jetty construction was the primary cause (Gelfenbaum et al. 1999). Some beach areas have recently been decreasing in area due to increased erosion. For example, Cape Shoalwater eroded from about 837 ac in 1937 to only 20 ac in 1992 (Richardson 1995). The sediment supply from the Columbia River to the estuary has likely been reduced due to the reduction in transport capacity resulting from flow regulation, and probably by direct trapping of sediments by the dams (Gelfenbaum et al. 1999).

Although some beach areas may have increased in size, the area suitable for streaked horned larks has likely decreased dramatically as a result of the spread of beachgrasses (*Ammophila* spp.) that were introduced for dune reclamation programs. It has increased the density of vegetation on the fore and secondary dunes where larks would have been most likely to nest, making these areas unsuitable for nesting and foraging by larks. (Rogers 2000). Reduced accretion, increased erosion, and the spread of beachgrasses have reduced the area of open dune used for nesting by larks in recent years.

Leadbetter Point. The tip of the Long Beach peninsula became part of the Willapa Bay National Wildlife Refuge in 1968. At that time, Leadbetter Point included about 1,200 ac of dunes, but reduced sand accretion and spreading beachgrass has decreased the amount of potential nesting habitat for larks. The vegetation line moved westward and narrowed the distance from vegetation to the water from 119 m (390 ft) in 1977 to 85 m (280 ft) in 1987 (Phipps 1990, in Richardson 1995).

Midway Beach. Midway Beach is a 1.7 mi long sandy beach encompassing about 86 ac north of Cape Shoalwater to Heather, just north of Willapa Bay, Pacific County. Recreational activities during the lark nesting period, such as beachcombing, dog walking, vehicles, and horseback riding can be a problem on Midway Beach by increasing nest abandonment and increasing nest predation. Pearson and Hopey (2005) recommended keeping a road access gate closed from March – August to reduce recreational impacts on the dune habitat.

Damon Point. Damon Point is a sand spit of about 330 ac at the southeastern end of the Brown Point peninsula at the mouth of Grays Harbor, Grays Harbor County. It is non-trust state land under the jurisdiction of the Department of Natural Resources, and is managed cooperatively by WDFW, Washington State Parks and Recreation, and the City of Ocean Shores under a management agreement (Richardson 1995). It is adjacent to Oyhut Wildlife Area managed by WDFW. In 1985, Anthony (1987) estimated that one half of the spit was unvegetated open sandy beach, but encroaching beachgrass was reducing the open area. Vegetation had spread to cover about two thirds of the spit by 1992 (Persons 1992), and vegetation density has continued to increase in recent years (Richardson 1995). A road wash-out during a recent storm has limited some recreational impacts on Damon Point (Pearson and Hopey 2005).

Graveyard Spit. Graveyard Spit is a 1.8 mi long sand spit east of Cape Shoalwater, across the mouth of Willapa Bay from Leadbetter Point in Pacific County. It is owned by the Shoalwater Indian Tribe and private landowners (Richardson 1995).

Columbia River Island Sites

Plate 3. Coastal and Columbia River nesting areas of streaked horned lark in Washington (top: Coffeepot Island, Damon Point; Middle row: Graveyard Spit and Leadbetter Point; Bottom: Whites Island/east end Puget Island, and Midway Beach). Photos by Washington Dept. of Ecology.

Historically, the Columbia River had dramatic annual fluctuations before the dams were constructed, seasonally rising 50 ft to submerge Celilo Falls (Dietrich 1995). Dietrich (1995:190) describes the Columbia before the dams as swifter and narrower, with "broad bars of flood-washed boulders, [and] gray sand beaches." There may have been more sandbar banks and islands in the lower Columbia that were kept cleared of vegetation by episodic flooding before dams were built. Annual high water in the spring and summer may have covered many bars and banks, however, making them unavailable to streaked horned larks. Sandy areas that were cleared of vegetation during exceptionally high water may have been available for nesting for several years. However the creation of dredge spoil islands since the damming of the Columbia may have compensated for some of the loss of sparsely vegetated areas on sandbars.

Streaked horned larks nest on small islands in the lower Columbia River, including some created by dumping of dredge spoil. Although the dumping of dredge spoil creates habitat, it also attracts Caspian terns (*Sterna caspia*) to vulnerable concentrations of salmon smolts. Rice Island was planted with vegetation and managed to prevent terns from nesting there, consequently reducing lark nesting habitat. Rice Island hosted 8 singing males in June 2000 and 8-12 in 2004; most of Rice Island is in Clatsop County, Oregon, so only 1-2 territories can be considered Washington birds (MacLaren and Cummins 2000, Pearson and Hopey 2005). Larks were detected on Whites Island (also called Brown Island; off the eastern end of Puget Island) in Wahkiakum County in 1999 and 2000, though this site was largely buried under a large pile of dredge spoil in 2000 (MacLaren and Cummins 2000). Eight lark territories were present there in 2004 (Pearson and Hopey 2005). Coffeepot is an island of about 160 ac between Puget Island and Wauna, in Clatsop County, Oregon; 2 singing males were present there in 2004. Small numbers of larks were

Table 3.2. Locations, ownership, and land use at streaked horned lark nesting areas.

Location	County	Owner/Managers	Land use
Coffee Pot Island	Wahkiakum	Private	Low impact recreation, dredge spoil deposition
Rice Island (WA portion)	Wahkiakum	U.S. Fish and Wildlife Service, Lewis and Clark National Wildlife Refuge	Low impact recreation, dredge spoil deposition
Whites Island	Wahkiakum	WDFW Natural Area Preserve	Conservation, low impact recreation, dredge spoil deposition
Leadbetter Point	Pacific	U.S. Fish and Wildlife Service, Willapa National Wildlife Refuge	Conservation, recreation
Graveyard Spit	Pacific	Shoalwater Indian Tribe, private	Recreation
Midway Beach	Pacific	Washington State Parks, Grayland Beach State Park	Recreation
Damon Point	Grays Harbor	WDNR (cooperatively managed by WDFW, State Parks, and City of Ocean Shores)	Recreation
Olympia Airport	Thurston	Port of Olympia	Municipal airport
13th Division Prairie	Pierce	U.S. Army	Training
Gray Field, Fort Lewis	Pierce	U.S. Army	Air strip, training
91st Division Prairie	Pierce	U.S. Army	Military training
McChord Air Force Base	Pierce	U.S. Air Force	Military air base
Shelton Airport	Mason	Port of Shelton	Municipal airport

also nesting in 2004 on Miller Sands, Pillar Rock Island (Jim Crow Is.), and West Wallace Island, all on the Oregon side of the river (Pearson and Hopey 2005).

Land Ownership

Land at most of the sites where streaked horned larks now breed in Washington is in public ownership (Table 3.2). Of the 13 sites where larks are known to nest in Washington: 4 sites are on military bases; 2 are on municipal airports; 3 are on dredge spoil islands (2 publicly owned, 1 private); 1 is on a national wildlife refuge beach; 1 on a state park beach; and 2 are on coastal spits that are a combination of tribal, state, municipal, and private ownership. Airports, McChord AFB, and Fort Lewis currently support most of the nesting population of streaked horned larks in Washington.

LEGAL STATUS

Federal. The streaked horned lark is a Candidate for listing under the federal Endangered Species Act (USFWS 2001). The streaked horned lark will be listed as Threatened or Endangered at some point in the future, unless conservation actions are determined to be adequate to preclude the need for listing.

Washington. All birds not classified as game or predatory are classified as 'protected wildlife' in Washington. The streaked horned lark was listed as "proposed threatened" in 1983 (WDG 1983), but a formal listing process was not established until 1990, and no action was taken. It became a Candidate species in October 1998.

Oregon. The streaked horned lark is listed as a Sensitive Species with "critical status" in Oregon (Altman 2003a).

British Columbia. The streaked horned lark is on the Provincial "Red List" for endangered species (Fraser et al. 1999: Appendix 3) and is a federal endangered species in Canada (Beauchesne and Cooper 2003).

MANAGEMENT ACTIVITIES

Surveys. WDFW recently conducted formal surveys (Rogers 1999a, MacLaren and Cummins 2000), which covered nearly all the current and historical sites in the Washington range of the streaked horned lark. Rogers surveyed the grassland around runways at McChord AFB intensively in 1997 (TNC 1999). Many records of horned larks from birder field trip reports (e.g. WOS News, Audubon Field Notes) are not useful for determining the status of streaked horned larks because most data do not distinguish among the 3 or more horned lark subspecies that could be present in western Washington. Rogers (2000) summarizes past records from field trip reports.

Personnel with Washington Natural Areas Program and Oregon State University have conducted surveys more recently with funding from Fort Lewis, The Nature Conservancy, U.S. Fish and Wildlife Service, and McChord AFB. Pearson (2003) recorded the number of territories at the Olympia Airport, 13th Division Prairie, and on portions of Gray Army Airfield and McChord AFB. Pearson and Hopey (2004, 2005) inventoried territories at Gray Army Airfield, 13th Division Prairie, part of 91st Division Prairie (Range 74 on the Artillery Impact Area), and all the known coastal and Columbia River sites. Robinson and Moore (2004) conducted winter surveys in the Willamette Valley, Oregon and on the Washington coast. Comprehensive winter surveys that included the Oregon sites, Washington coast, and Columbia River Islands were conducted during 2004-2005 (Pearson et al. 2005).

Habitat Management and Restoration

Puget prairie management. Various agencies and organizations have been involved in developing methods of restoring and maintaining native prairie vegetation (see Chapter 1). The apparent selection by larks of bare ground (sparse moss cover was included in "bare ground") for foraging may complicate prairie restoration efforts intended to benefit other prairie species (Rogers 2000). It is not clear if efforts to restore native prairie vegetation may actually harm streaked horned lark sites due to their specialized need for bare and sparsely vegetated

ground, or if healthy native prairie contained sufficient short vegetation, moss, and bare ground to provide optimal nesting areas. Pearson and Hopey (2004) recommended that habitat restoration for horned larks focus on degraded prairie sites with a high gravel/cobble content that is likely to result in a higher percentage of bare ground and less robust plant growth, and preferably areas hundreds of acres in size. Another strategy for managing sites for larks is frequent burning. Habitat restoration focused on the lark may not be compatible with restoration for Mazama pocket gophers or Taylor's checkerspot (Pearson and Hopey 2004).

Fort Lewis management. Fort Lewis maintains grasslands by mowing and prescribed burning of prairies and oak savannahs to control Scotch broom. They have also been experimenting with prescribed burning and herbicides for improving habitat for larks. Fort Lewis has initiated several management activities in response to recommendations developed during recent research activities (Pearson and Hopey 2005). Gray Army Airfield modified their mowing schedule to avoid disturbing or destroying nests of horned larks. In the training areas, mowing is not done on occupied lark habitat during the breeding season. Fort Lewis did not renew the permit for a model airplane club to host events on the 13th Division Prairie that had created major disturbances to nesting larks in previous years. They also erected signs prohibiting recreational activities near nesting larks. Burning of the AIA due to artillery impacts and the creation of bare ground caused by mechanized vehicles on training areas may actually help maintain appropriate habitat conditions for larks and offset the negative impacts of disturbance and any mortality of larks associated with military training, vehicles, and fires.

Snowy plover recovery activities. Since streaked horned larks nest at 4 areas used by snowy plover and both species use sparsely vegetated substrates, activities intended to protect nesting plovers and maintain or restore plover nesting areas may benefit larks. Activities include restricting beach traffic during the nesting season and control of beachgrass at Willapa National Wildlife Refuge. Whether or not horned larks benefit from these activities remains to be documented.

Research

Russell Rogers evaluated microhabitat selection by streaked horned larks and several other prairie associated species on McChord AFB and Fort Lewis with funding from the Department of Defense through the The Nature Conservancy of Washington (Rogers 2000). Scott Pearson (formerly with WDNR, now with WDFW) has led a research project focused on the streaked horned lark supported by Fort Lewis, The Nature Conservancy, U.S. Fish and Wildlife Service, and Washington Dept. of Transportation. Topics investigated included breeding activities, nesting success, habitat selection at both the territory and nest site scale, the impact of human activities on nesting larks, survey methods, and habitat management using herbicides and fire (Pearson 2003, Pearson and Hopey 2004, 2005). He, along with Oregon State University researchers, investigated wintering locations and habitat (Robinson and Moore 2004, Pearson et al. 2005). Pearson and Hopey (2005) also collected tissue samples for a study of the genetic relationships of horned lark subspecies (Drovetski et al. *in press*). In 2005, a pilot project using automated recordings of lark vocalizations to attract nesting larks to an unused prairie was being conducted at Fort Lewis and on Mima Mounds NAP (S. Pearson, pers. comm.).

FACTORS AFFECTING CONTINUED EXISTENCE

Adequacy of Existing Regulatory Mechanism

The streaked horned lark and its habitat are not adequately protected. Breeding and wintering habitat continues to be lost on public and private lands in both Washington and Oregon. There are no nesting areas that are not subject to human-related sources of mortality and disturbance.

Federal protection. The streaked horned lark is legally protected from physical harm by the Migratory Bird Treaty Act. *E. a. strigata* was recently listed as a Candidate for protection under

the Endangered Species Act. This status should increase the protection from federal actions and on federal lands, but the species does recieve formal protection under the Act. The streaked horned lark has not consistently received consideration during planning or implementation of federal actions. For example, it was not considered in the environmental impact documents for the Columbia River dredging project by the Army Corps of Engineers (USACOE 2003), nor in the Biological Opinion concluding consultation under Section 7 of the Endangered Species Act (USFWS 2002).

Grasslands on Fort Lewis and McChord AFB are important lark nesting areas. It is Army policy to consider candidate species when making decisions that affect them, to avoid taking actions that may cause them to be listed, and to take affirmative actions that can preclude the need to list them (D. Clouse, pers. comm.). However, larks are being impacted to an unknown extent by training and operations at Gray Army Airfield, 13th Division Prairie, and McChord AFB (Pearson and Altman 2005).

State protection. The streaked horned lark is protected from direct intentional killing or physical harm as 'protected wildlife'. However, state laws do not protect them from unintentional mortality, such as when nests are abandoned or destroyed as a result of human activity. Lark habitat is not protected directly by state laws.

County and city. As a state candidate species, streaked horned larks may be protected on some sites by county or city ordinances that require review and mitigation for critical wildlife habitat. Most of the streaked horned lark nesting areas are on military bases or publicly owned beaches where development is not a threat and county regulations may not apply. Pacific County has critical area ordinances that would give some protection for streaked horned larks if they were state listed, but Grays Harbor County does not have ordinances that protect wildlife habitat. The municipal code of the City of Tumwater, which protects state Priority Habitat and Species (listed and candidate species), applies to streaked horned larks at the Olympia Airport. Wahkiakum County codes may apply to land uses on the privately owned Coffeepot Island. Washington's Growth Management Act does not apply to Wahkiakum County, but the county reports that it protects habitat of state listed species (Wiles 2001). State shoreline regulations would likely also apply to applications for development on Coffeepot and other islands with nesting larks.

Habitat Loss and Fragmentation

Prairie habitat continues to be lost, particularly to residential development. In the south Puget Sound area, over 90% of the original grassland has been destroyed. As the habitat patches become smaller, fewer, and further apart, the likelihood decreases that additional sites will be found that support larks. However, if the larger patches of grassland on Fort Lewis, McChord AFB, and area airports can be maintained and managed in a way that is consistent with horned lark nesting, then larks may persist in the region. Olympia and Shelton Airports are planning for development of significant portions of their grasslands, which may affect nesting lark populations. As is typical of some grassland birds, horned larks seem to need rather large open areas, and habitat fragmentation is an important factor in their decline (Peterjohn and Sauer 1999, R. Rogers, pers. comm.). If large areas of grass had not been maintained at airports, the streaked horned lark might be extinct in the south Puget Sound area. The lark's selection of large open sites with some bare ground may complicate restoration efforts geared to restoring robust prairie vegetation. Some grassland habitat may be lost with development of port lands around airports.

Loss of wintering habitat is also an issue. Sparsely vegetated dredge spoil along the lower Columbia provides wintering habitat for perhaps 20% of streaked horned larks. There are few specifics known about loss of this habitat type in Washington, but habitat is being lost at a North Portland, Multnomah County site in Oregon. Grading in preparation for development was apparently responsible for a decline from 150-200 wintering birds in 2002 and 2003 to 61 wintering birds in 2004 (Pearson and Altman 2005).

Implications of habitat loss for populations. Given

the historical habitat loss, streaked horned lark populations were once probably much larger. The small size of local nesting populations makes them more vulnerable to extinction due to severe weather, predation, and disturbance. Analysis of mitochondrial DNA indicates that streaked horned larks probably have suffered a loss of genetic diversity (Drovetski et al. *in press*). Diminished genetic diversity increases the likelihood of populations suffering from inbreeding depression, reduced resistance to disease, and reduced adaptability to environmental change (Frankham et al. 2002). Inbreeding depression, in turn, can lead to reduced reproductive success.

Habitat Degradation and Succession

Habitat succession and invasion. Fire suppression allows succession by both native and exotic flora, such that without vegetation management the native prairies will disappear. Invasion by shrubs, tall vegetation, and turf-forming grasses would eliminate the short, open structure that larks seek for nesting and foraging. Nearly all the remaining prairie sites are degraded to some extent by exotic forbs and grasses, creating conditions that are not compatible with lark use.

European beachgrass. European beachgrass is an erect perennial grass up to 1 m tall adapted to drifting sand. It is native to Europe where it has been used for centuries to stabilize dunes (Wiedemann 1987). It was first introduced to this continent in California in 1869, and is now found along the Pacific coast from the Queen Charlotte Islands to southern California. It has been widely planted for dune stabilization. Beachgrass stabilizes the sand just above the high tide line and causes the formation of a foredune which was not part of the natural coastal topography in Washington. It produces high steep dunes, while native species form low rounded dunes with relatively sparse cover. Beachgrass can spread quickly by seed, rhizomes, and dissemination of rhizome fragments, and unless large areas are eradicated, cleaned areas will quickly regenerate (Wiedemann 1987). Beachgrass dramatically changes the ecology of the coastal dune community degrading conditions for many native species. Changes include a reduction or elimination of unvegetated or sparsely vegetated sand used for nesting by streaked horned larks and snowy plovers. Beachgrass control and eradication methods have been studied and tested in recent years. Hand digging is effective for small areas, but is very labor intensive. Burning does not kill beachgrass, but may be useful in removing above-ground biomass (Dorsey 1993). Dorsey (1993) described several potential control methods that need evaluation, including mechanical separation, combinations of tilling, burning and herbicide, and compaction by heavy equipment or off-road vehicles. Control programs are conducted at Willapa National Wildlife Refuge and several ecological preserves in California and Oregon where snowy plovers nest.

Army Training on Fort Lewis

The Fort Lewis sustainability goal of recovering all federal candidate species by the year 2025 indicates a commitment to lark recovery, and Fort Lewis has generally been proactive in the conservation of the prairie species. The nuimber of aircraft at Gray Army Airfield is increasing and this may negatively impact larks (see *Gray Army Airfield* below). Military training activities may negatively impact horned lark nesting areas where disturbance of native vegetation results in increases in exotic vegetation. Larks are also sometimes directly affected by Army training activities when they coincide with lark nesting (Pearson and Hopey 2004). Nest abandonment caused 20% of nest failures and some abandonment was likely caused by human disturbance during training activities. The largest remaining prairie is the 91st Division Prairie, Artillery Impact Area, and larks nest on the part designated as Range 74 (Pearson and Hopey 2004). Portions of the area are subject to bombardment with explosive ordnance, and fires occur on some portion of the area each year. Although these actions may be hazardous to larks, they maintain the open gound the larks require.

Control of Scotch broom, Douglas-fir and weedy forbs on military bases is beneficial to larks by maintaining open prairie (Clampitt 1993). On much of Fort Lewis, as is true elsewhere, *F. roemeri* has been replaced by exotics such as *Anthoxanthum*

odoratum, *Agrostis tenuis*, and *Poa pratensis,* probably because bunchgrasses like *F. roemeri* are less tolerant of disturbance than are sod-forming species (Mack and Thompson 1982, Clampitt 1993). Mosses, lichens, and native forbs, like Aster curtus, that grow in the gaps between grass bunches decline with disturbance, and are eliminated under severe vehicle disturbance (Clampitt 1993). The soil surface is bare or covered with leaf litter (Clampitt 1993). R. Rogers (pers. comm.) included moss cover in "bare ground" in characterizing the foraging sites of streaked horned larks, though he indicates that moss was infrequently encountered. Bare ground may be as acceptable for lark nesting and foraging as moss cover, but disturbance of the moss and lichens may exacerbate the invasion by exotic vegetation and the loss of native plants. The moss carpet may have provided a better substrate for rhizomes of native plants than bare gravelly soil (Clampitt 1993).

Military training may benefit larks by maintaining lower vegetation density and higher bare ground than would exist without training activities or restoration of prairie. However, management that restores and maintains the sparse bunchgrass structure and abundant moss that existed historically may be optimal for lark nesting areas. Fort Lewis has an aggressive program using Roemer's fescue and other native species to restore areas damaged by trainign activies.

Disturbance, Mortality and Development at Airports and Military Airfields

Mowing of airports and military airfields likely benefits larks by keeping the vegetation short, but can cause mortalities to eggs, chicks, or adults during nesting unless it is timed to minimize impacts. Airports can be hazardous environments for nesting due to mowing, potential for collisions with aircraft, and special events hosted at military bases. In 2004, Gray Army Airfield and McChord AFB were the most important nesting areas for streaked horned larks in Washington.

Gray Army Airfield. Careful timing of mowing can help minimize horned lark mortality, and Gray Airfield adjusted its mowing schedule to minimize impacts to larks in 2003, 2004, and 2005 (Pearson and Hopey 2005, Pearson and Altman 2005). Gray Airfield is preparing for the arrival of Apache attack helicopters that will impact portion of the habitat used by larks in recent years. In addition to the increased disturbance and physical footprint of added aircraft, the hot downdraft produced by these aircraft may make some portion of the habitat unusable for lark nesting. Additionally, the amount of paved area covered by the west ramp is being expanded (Pearson and Altman 2005).

McChord Air Force Base. McChord AFB has not adjusted mowing schedules to minimize impacts to larks during the nesting season. Horned larks do not seem to be overly disturbed by the routine comings and goings of the large military cargo aircraft based there (S. Pearson, pers. comm.). However, McChord occasionally hosts military training and civilian events that impact larks. In June 2005, an Air Force training event called the "Rodeo" involved hosting many aircraft and their crews from several countries. Aircraft were parked on pads that are normally vacant and where larks had established territories. Tents were erected on lark nesting areas, vehicles drove across lark territories, and people camped and walked across lark nesting territories (Pearson and Altman 2005). The base also hosts an annual air show, including a performance by the Thunderbirds. In August 2005, the show included simulated bombing and fire bombing of a portion of the area most heavily used by larks and likely affected fledglings of late nests.

To minimize the likelihood of bird and aircraft collisions, McChord has contracted with a falconer to fly falcons at the base to scare off larger birds, such as gulls, crows, and waterfowl. The larks are small enough to be largely ignored by the falcons. However, in 2005, the falconer also had 2 dogs that regularly walked through the grass and disturbed the larks (S. Pearson pers. comm.).

Civilian airports. The Olympia Airport has modified mowing schedules to minimize impacts to larks during nesting. Some existing lark habitat may be lost at the Olympia Airport where the runway is being re-aligned, but the removal of unused pavement may mitigate for lost habitat. The future loss of

grassland to development at airports may be more significant. The Shelton Airport has hosted a very small number of birds in recent years; development of open space around the airport may result in the loss of some habitat.

Collisions with aircraft. Nationwide data indicate that horned larks are particularly susceptible to being struck by aircraft, probably due to their affinity for the open, short-grass habitat surrounding runways. Between 1985 and 2004, horned larks accounted for 1,422 reported bird strikes on U.S. Air Force aircraft, which was the highest number recorded for any species (BASH 2004). In contrast, horned larks were involved in only 153 of >45,000 bird strikes on civilian aircraft reported to the Federal Aviation Administration from 1990-2002; only 5 of these caused any damage to the aircraft (Cleary et al. 2003). The difference in horned lark strikes between military and civilian aircraft is probably artifactual because only 20% of bird strikes recorded at civilian airports are reported to the FAA (Cleary et al. 2003), particularly when little or no damage to the aircraft occurs. Dead larks have been found along the runways at McChord AFB and Gray Army Airfield (Pearson and Hopey 2005). It is not known how significant a source of mortality aircraft collisions are for the *E. a. strigata* population in Washington, but 4 of 12 known nesting populations are at airports, and they include the sites with the highest nesting populations. Collisions may be more likely at airports with closely mowed vegetation concentrated next to runways, but less likely where mowed vegetation attracts larks to areas set back from active runways (S. Pearson, pers. comm.). Assessments are needed to determine whether aircraft collisions are an important source of mortality of streaked horned larks. Given the size of current nesting populations at airports, it seems unlikely that airports are population sinks due to high mortality.

Management of Columbia River Islands

Dredge spoil deposition. The creation of dredge-spoil islands in the lower Columbia River has provided nesting sites for streaked horned larks and has the potential to create new sites or expand existing ones. The deposition of new material at existing sites may help maintain the presence of bare ground and sparsely vegetated areas. However, depending on the timing, horned larks can be disturbed and nests destroyed if material is deposited on sites occupied during the breeding season. For example, in 2000, a mountainous pile of material was deposited on Whites Island on the site where larks nested in 1999, and little or no other sparsely vegetated area remained on the island. Territorial males were observed on Rice Island in June 2000, but dredge spoil was deposited in July at the site where the males had been observed (MacLaren and Cummins 2000). The outcome of breeding and fate of any nests in 2000 was unknown, although larks were again nesting on the island in 2004. Dredge spoil was also deposited on the nesting area of larks during the breeding season on Miller Sands, Oregon, in 2004 and 2005 (S. Pearson, pers. comm.), which resulted in the failure of several nests in 2005 (Pearson and Altman 2005).

Caspian tern management. Streaked horned larks may also have been affected by management of vegetation to discourage Caspian terns from nesting on dredge spoil islands in the lower Columbia. In 1999 and 2000, winter wheat (*Triticum aestivum*) was planted on all open unvegetated areas of Rice Island and silt fences were erected to discourage tern nesting and thereby reduce predation on salmon smolts (Roby et al. 2002). The combination of wheat and drift fences trapped many seeds and resulted in thick weedy vegetation. Larks do not require the bare sand that Caspian terns do, but these activities accelerated vegetative colonization of the sandy dredge spoil by beachgrass and weeds, and may have eliminated potential nesting areas for horned larks. Wheat was also sown on unvegetated areas of Miller Sands Spit and Pillar Rock Sands, where horned larks have been observed (A. Emlen, pers. comm.).

Other Human-related Factors

Recreation. Coastal sites may be subject to trespassing vehicles and ORVs on beaches despite seasonal restrictions (Richardson 1995). Rogers (2000) noted that all the remaining prairies are subject to several types of recreation that may impact nesting larks, including horseback riding, dog-walking and

training, model airplane flying, and bird watching. Fort Lewis has restricted some recreation uses on important prairie sites in recent years, including 13th Division Prairie where larks nest (Pearson 2003).

Predation by cats and crows. Birds on prairie remnants within a matrix of suburbs may be subject to high rates of predation by domestic cats and crows. Pearson (2003) observed crows depredating streaked horned lark nests, and Rogers (2000) observed both cats and crows preying on grassland birds at airport nesting sites. Crow populations are high in urban habitats, perhaps due to a scarcity of predators and human associated food sources. Additional suburban predators that could be a problem for a ground nesting bird include opossums; opossums are not native to Washington, but were introduced prior to 1941 (Johnson and Cassidy 1997).

CONCLUSIONS AND RECOMMENDATION

The streaked horned lark is perhaps the most endangered bird in Washington (Rogers 2000); fewer than 200 breeding pairs remain. There are also about 200 pairs in Oregon, and the subspecies is apparently extinct in British Columbia. The south Puget Sound prairies, the historical center of abundance for the larks in Washington, have been reduced by >90% in area, and much of what remains is unsuitable to horned larks. All of the known south Puget Sound sites where streaked horned larks breed are either airports or military training areas, where larks are able to persist due to management or other activities that maintain short and sparse vegetation. Much of the prairie not consumed by development is dominated by exotic pasture grasses or has succeeded to forest as a result of fire suppression. Nesting habitat continues to be degraded by invasive exotic vegetation including Scotch broom and European beachgrass. Dredge spoil deposition along the lower Columbia creates potential future nesting habitat, but the sparsely vegetated sites currently suitable are buried. The new material becomes suitable in a few years, but without vegetation management it becomes colonized by woody vegetation. Nesting sites on dredge spoil islands are subject to the conflicting goal of eliminating open sites that attract nesting Caspian terns to reduce predation on salmon smolts.

The threats to remaining streaked horned larks populations are considerable. Military airfields support the largest nesting populations in Washington, but due to the demands of training and safety, airfield managers have not been consistently willing or able to protect nesting larks. There are no nesting sites where larks are not subject to disturbance or human-related mortality. Streaked horned larks are unlikely to persist at these low numbers for long; their low genetic diversity suggests that they may become affected by inbreeding depression or otherwise vulnerable to extinction. The streaked horned lark is likely to become extinct in Washington unless nesting areas are protected and additional nesting areas are established. It is uncertain whether prairie restoration projects will succeed in creating additional sites that will be colonized by larks for nesting, but dredge spoil islands and coastal beaches could be managed to maintain suitable nesting areas.

For these reasons, we recommend that the streaked horned lark be listed as endangered in the State of Washington.

CHAPTER 4: TAYLOR'S CHECKERSPOT

INTRODUCTION

The brightly colored Taylor's checkerspot (*Euphydryas editha taylori*) was probably abundant historically on the grasslands and prairies of Puget Sound, southeast Vancouver Island, and the Willamette Valley of Oregon. The subspecies has declined concurrent with the loss of these prairie habitats and now persists on a small number of sites. One population in British Columbia and two populations in Oregon also survive. Taylor's checkerspot is threatened by habitat loss and degradation, as well as the demographic and genetic risks associated with small and isolated populations. Several occupied sites are on public lands, nonetheless, they are affected by recreation, military training, wildfires, and habitat degradation by exotic plants. The survival of the subspecies will require protecting and maintaining grassland habitat at existing sites and restoring additional habitat on degraded historical prairie.

TAXONOMY

Taylor's checkerspot is a subspecies of Edith's checkerspot (*E. editha*). It is one of a small group of rare Pacific coastal subspecies, that includes the bay checkerspot (*E. e. bayensis*) from an area south of San Francisco and the Quino checkerspot *(E. e. quino*) from the San Diego area, both of which are federally listed as endangered. Three other subspecies of *E. editha* also occur in Washington: *beani*, *edithana*, and *colonia* (Table 4.1).

Checkerspots belong to the family Nymphalidae, or brush-footed butterflies, which is a large and diverse group of medium-sized (1½ -3") butterflies with a set of reduced brushy forelegs (Pyle 2002:258). Adults walk on their 4 mid and hind legs; the brushy forelegs are not used for walking, but in many nymphalids have been converted to sensory organs that the female uses to select plants on which to lay eggs (Scott 1986, Murphy et al. 2004). Butterflies with common names of "checkerspot" in Washington include 3 species of *Euphydryas* (*E. editha*, *E. anicia*, *E. chalcedona*), and 2 species of *Chlosyne* or *Charidryas* (*C. palla* and *C. hoffmanni*) (Table 4.1; Hinchliff 1996, Guppy and Shepard 2001). In addition to checkerspots, the Nymphalidae includes admirals, fritillaries, crescents, painted ladies, tortoiseshells, anglewings, wood nymphs, and the monarch.

The name "checkerspot" is derived from the checkerboard pattern on the upperside of the butterfly's wings. The genus name "Euphydryas" is a combination of Greek words that means roughly "goodly shaped wood nymphs" (Guppy and Shepard 2001). The species is presumably named after a woman named Edith, whose identity seems to be lost to history (Guppy and Shepard 2001, Pyle 2002). Taylor's checkerspot was first described by Edwards (1888) as *Melitaea taylori*. The subspecies is named after Reverand George W. Taylor, who first collected it; Taylor, the first serious amateur lepidopterist in British Columbia, collected extensively and contributed to many museums in North America (Guppy and Shepard 2001). The common name "whulge," sometimes used for *E. e. taylori*, was coined by R.M. Pyle and is a Salish word for the greater Puget Sound basin (Pyle 1989).

Table 4.1. Subspecies of Edith's checkerspots and ranges in Washington (Hinchliff 1996, Pyle 2002).

Scientific name	Range in Washington
Euphydryas editha taylori	Western Washington prairies, balds, and headlands
E. e. beani	Northern Cascades
E. e. edithana	Foothills surrounding the Columbia Basin
E. e. colonia	Southern Cascades and northeast Olympic Mountains

Plate 4. Taylor's checkerspot: top left to right, eggs (photo by Mike Walker) and pre-diapause larva (Rod Gilbert); middle row: post-diapause larvae (Rod Gilbert, Dan Grosboll); bottom: adult (Derek Stinson, inset by Kelly McAllister).

DESCRIPTION

The upper wing surfaces of *Euphydryas editha* are generally red-orange with checkered bands of black and cream (Plate 3). On the underside, the forewing is orange with black bars and cream spots and the hindwing has alternating bands of orange and cream spots (Pyle 1981). The head and abdomen are black. Adults have wingspans of < 2" (60 mm) (Pyle 2002). Unlike the other two Washington *Euphydryas* species (*E. chalcedona*, *E. anicia*), Edith's checkerspot is never predominantly black or cream colored, and has shorter, more rounded wings (Pyle 1981). The chalcedon and anicia checkerspots can be distinguished by the absence of the "editha-line," a black line that runs through the orange on the ventral side of the hind wing (Pyle 2002:311). The editha-line does not occur in all *E. editha* populations, but is present in all those in Washington (J. Pelham, pers. comm.). In Oregon, *taylori* is the darkest of the Oregon *E. editha* subspecies and, "its rows of cream and deep red spots are well separated by heavy black lines or bands, and the wings are proportionately broader and rounder than those of the other races" (Dornfeld 1980).

The greenish yellow eggs, which later turn orange-brown (Scott 1986), are laid in clusters on larval food plants. Larvae, or caterpillars, are black with white speckles forming a mid-dorsal and lateral line and are adorned with many black branching bristles that, along the dorsal and lateral line, have an orange base (Dornfeld 1980, Guppy and Shepard 2001). The chrysalis, or pupa, is white or gray with black and orange markings and an orange dorsal cone (Dornfeld 1980, Scott 1986).

DISTRIBUTION

North America

Taylor's checkerspot was historically documented in British Columbia on southeastern Vancouver Island and nearby smaller islands, in Washington around Puget Sound, and in the Willamette Valley in Oregon (Fig. 4.1). The subspecies was thought extinct in British Columbia, but a population was discovered at a previously unknown location in May 2005 (J. Heron, pers. comm.). The historical distribution in British Columbia included Hornby Island and 20 locations on Vancouver Island, including 16 sites in the greater Victoria area (Shepard 2000; J. Miskelly, pers. comm.). In Oregon, *E. e. taylori* was formerly found at 13 sites in Benton,

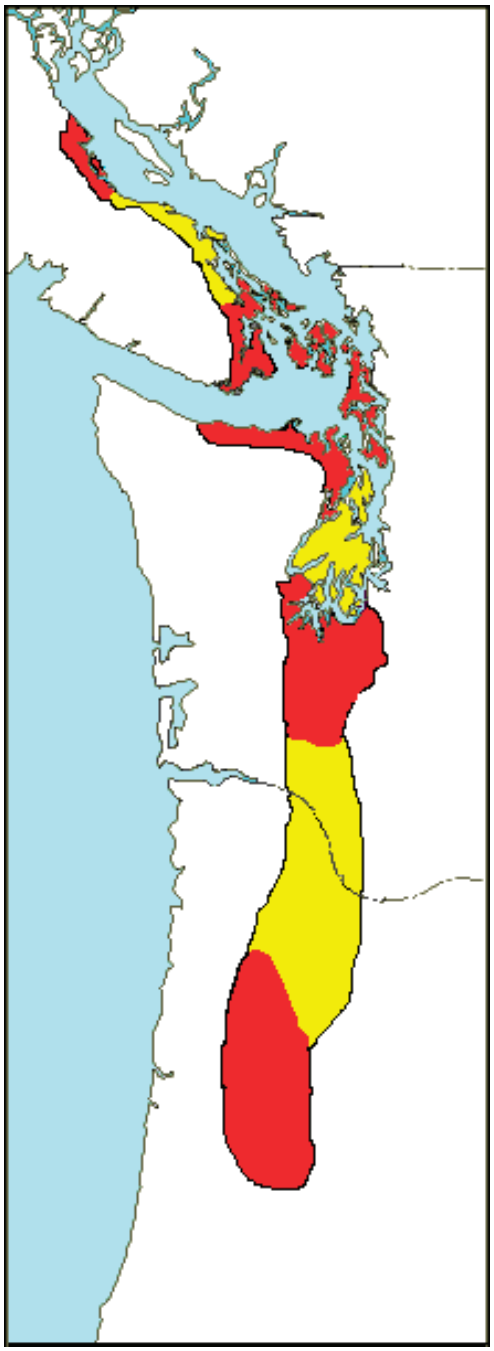


Figure 4.1. Likely historical range of Taylor's checkerspot; lighter shaded areas represent large gaps in the historical records.

Lane, and Polk counties, but is now restricted to two population complexes in Benton County (Hinchliff 1996, S. Hoffman-Black, pers. comm.).

Washington

Taylor's checkerspot has been reported from at least 37 locales in western Washington, from the San Juan Islands south to the Cowlitz River in Lewis County (Hinchliff 1996; WDFW data). Taylor's checkerspot was historically found in San Juan County, Whidbey Island in Island County, on balds, coastal bluffs, and estuarine grasslands along the Straits of Juan de Fuca in Clallam County, and on prairies and balds in Thurston, Mason, Pierce and Lewis counties (Fig. 4.1). Several of these populations now seem to be extinct. Taylor's checkerspot is currently known to occur at only 10 Washington sites. The species may have been more widely distributed on the prairies and savannahs that occurred in the Cowlitz and Willamette vegetation zones described by Cassidy et al. (1997)(see Fig. 1.1), but these areas were among the first localities to be settled by Euro-Americans and converted to agriculture.

NATURAL HISTORY

Life Cycle

The life cycle of Taylor's checkerspot lasts about one year, but only a week or two of this is spent as an adult (Fig. 4.2). Taylor's checkerspot is univoltine (single generation per year) and nonmigratory. In any given population, adults emerge over a one to several week period. The time during which adult butterflies are present is referred to as the flight period. Taylor's checkerspots have one brood, and there is a single annual flight when adults emerge to mate and lay eggs. They are one of the first butterflies to appear in the spring. The flight period in Washington is typically mid-April through May, with a peak in early May. Adults are seen from early April through May in Oregon (Dornfeld 1980, D. Ross, pers. comm.) and mid-April through mid-May in British Columbia (Guppy and Shepard 2001).

Mate finding and mating. Butterflies have adaptations that help in finding mates, including mechanisms that concentrate the emergence of adults in time and draw them to similar locations (Clench 1975). Taylor's checkerspot males emerge a few days before females, a phenomenon called protandry. Protandry is typical in polygynous insects and is an advantage to males in the competition to find and mate with females while they are still receptive (Boggs and Nieminen 2004).

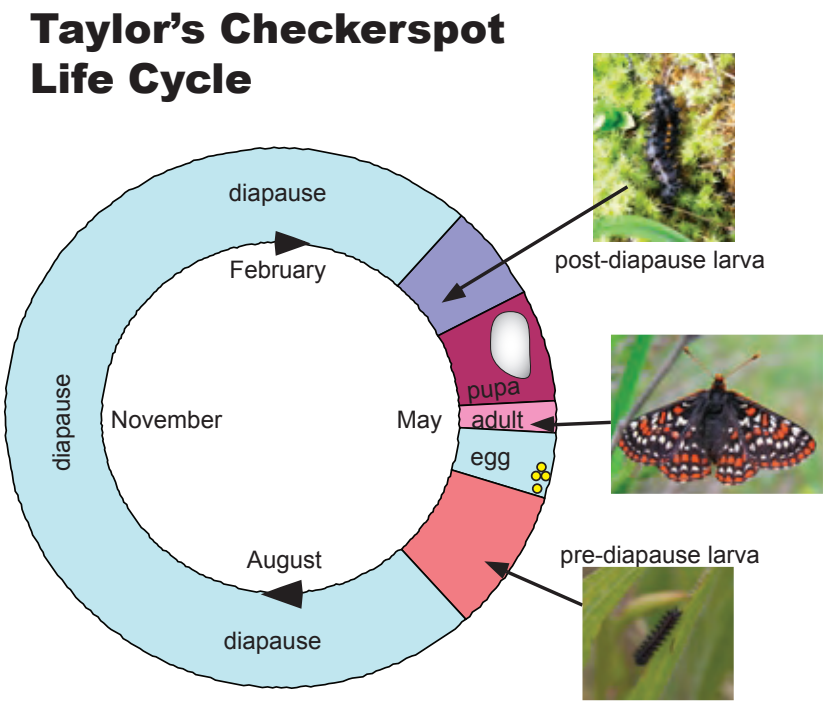
Some species mate at specific types of sites such as hilltops or valley bottoms (Scott 1986). Butterflies have two basic strategies for mate-finding: perching and patrolling. Some species, such as *E. editha*, use both (Scott 1986). In species that use perching, males perch at selected sites at certain times of the day, and dart out at passing butterflies to determine if it is a female of its species. The type of perching place for a species is genetically determined and both sexes are attracted to them (Scott 1986). In patrolling species, males search for females by almost constant flying, often along a regular route or territory.

Male butterflies use movement, wing color, and sometimes odor in finding females. Patrolling males are often attracted to motionless objects of the correct color. Perching males are first attracted to moving or fluttering objects, and may approach other butterflies, insects, small animals, or blowing leaves and may appear pugnacious or territorial (Scott 1986). Though active territorial defense against rival males, in which males actually fight, does occur in a few species (Guppy and Shepard 2001), most males simply approach to better see or smell the object to determine if it is a potential mate (Scott 1986). Pheromones and ritualized courtship behaviors are important in determining if it is the correct species and the opposite sex.

E. editha mate-finding behavior varies among populations; males seek females all day by perching on ridge tops or patrolling throughout the habitat, depending on the distribution of host plants and flowers (Scott 1986). *E. e. bayensis* males generally patrol small areas (Boggs and Nieminen 2004). Roughly half the males in many butterfly species never mate. Ehrlich et al. (1984) calculated

that nearly 12% of *bayensis* males did not live long enough to see a female.

In patrolling checkerspot populations, when a flying male spots a resting female, he lands and nudges or pushes under her hindwings. If the female is receptive, courtship usually lasts less than a minute and copulation generally lasts 1 –3 hours (Guppy and Shepard 2001). If checkerspots are disturbed while mating, the females will take flight, with the male dangling behind. *E. editha* are polygynous: females typically mate once or occasionally twice, whereas males may mate multiple times. Unreceptive females reject males by flicking their wings or flying away. After mating, the neck of the spermatophore (the phragis) plugs the female's genital track (Boggs and Nieminen 2004). Once the plug hardens, mating is difficult to impossible. Occasional second matings occur before the plug hardens or after it has eroded.



Eggs, larvae, and pupation. Once a female checkerspot has mated, she is capable of laying eggs (ovipositing) immediately (Scott 1986:59). Females in *E. e. bayensis* populations emerge from pupae with 17-18% of their total egg complement mature and ready to be fertilized and oviposited (Boggs and Nieminen 2004). Most butterflies lay one egg at a time and move quickly to another site to lay another (Scott 1986). Edith's checkerspots lay clusters of eggs, and *E. e. bayensis* females have been observed laying clusters that totaled up to 1,200 eggs. *E. e. bayensis* average cluster size is 45 eggs (range 21-75), but cluster size declines with female age and varies with the larval host plant used

TAYLOR'S CHECKERSPOT LIFE CYCLE CALENDAR for WASHINGTON

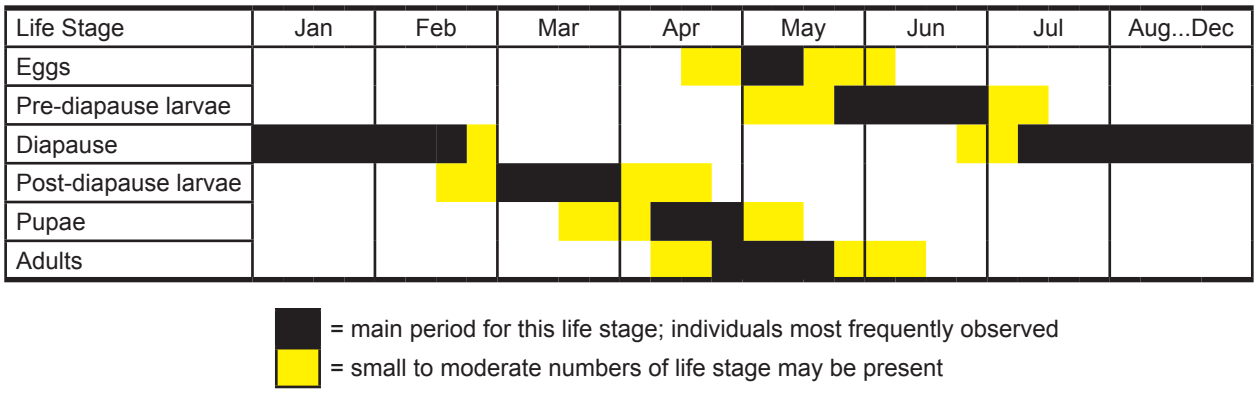


Figure 4.2. Annual life cycle and calendar for Taylor's checkerspot in Washington (pre-diapause photo by R. Gilbert; post-diapause by D. Grosboll; adult by D. Stinson).

(Boggs and Nieminen 2004, Kuusaari et al. 2004). Cluster size averaged 50-90 eggs on *Pedicularis semibarbata*, 20-30 on *Collinsia tinctoria*, and 5-7 on *C. torreii* (Kuusaari et al. 2004). The egg cluster size is also affected by the nutritional state of the female and is correlated with female mass at eclosion. Total egg production in *E. e. bayensis* is also affected by the availability of nectar sources and can double when nectar is plentiful (Murphy 1983).

Female butterflies recognize appropriate host plant species by the size, color, and shape of the leaf. They confirm that it is the correct species by detecting chemicals in the plant with their forelegs, antennae, proboscis, and ovipositor (Guppy and Shepard 2001). *E. editha* may spend an average of 30 minutes searching and examining many plants before ovipositing, often examining each of several plants for several minutes (Singer 2004). Nearly all caterpillars that hatch from eggs laid on a non-host plant die. Eggs in a cluster hatch simultaneously after about 2 weeks. Newly hatched larvae may starve if there is no food within 10 cm (Singer and Ehrlich 1979). Hellmann (2002a) detected movements by *E. e. bayensis* larvae from natal host to a second host plant within 3 days of hatching.

The larval, or caterpillar stage, is devoted to eating and growth, resulting in an increase in weight of 10,000 fold or more (Dornfeld 1980). The larval skin, unable to accommodate the rapid growth, is shed or molted and reformed. Molting is preceded by a day or so during which the larvae do not feed (Dornfeld 1980). The larval stages between molts, called instars, express change in color or markings. Butterfly species go through 4 to 9 instars, but most species go through 5. In *E. editha*, newly hatched caterpillars join in making a loose silk web which the larvae inhabit for various lengths of time. The web is thought to deter generalist predators and parasitoids (Kuusaari et al. 2004). In some populations of *E. editha*, the larvae remain in the web for the entire pre-diapause period, while in other populations the larvae disperse after only several days (Moore 1989, Kuusaari et al. 2004). *E. editha* larvae feed on leaves and flowers, sometimes eating the whole plant, and may starve while searching for another host plant (Scott 1986). In the summer, larvae race to mature before host plants dry out and become unpalatable.

Diapause is a quiescent state of hibernation (refers to winter) or aestivation (refers to summer), when no feeding, growth or development occurs (Scott 1986). The metabolism and breathing rate are low, blood thickens with glycerol, water content is reduced, free water becomes gelatin-like to prevent damage from freezing. Butterflies diapause at the life stage specific to that species, either as eggs, a specific larval stage, as pupae, or in a few as adults (Scott 1986). *E. e. bayensis* larvae feed for 3 to 5 weeks depending on weather conditions and host plant quality, and enter diapause solitarily in the 3rd or 4th instar (Kuusaari et al. 2004). However, *E. e. taylori* larvae may not diapause solitarily because they were observed in groups on Hornby Island, BC by J. Shepard (pers. comm.). In *E. editha*, the diapausing instars develop a thick exoskeleton that helps prevent summer drying of the larvae (Scott 1986). The larvae hibernate in a sheltered spot under rocks, logs, or debris (Guppy and Shepard 2001). If *E. e. taylori* reach the 4th or 5th instar stage (Guppy and Shepard 2001), they will enter diapause as a half-grown caterpillar and remain in this state until the following late winter or early spring. When temperatures begin to rise in the late winter, perhaps in February or March for *E. e. taylori*, the caterpillars resume feeding for several weeks (A. Potter, pers. comm.). When the caterpillar is fully grown, it usually moves to a sheltered site for pupation (Dornfeld 1980). The 4 stages of development (egg, larvae, pupae, and adult), appear to be distinct, but continual changes occur inside the larvae (Scott 1986). After a pupation site is found, the mature larva becomes a sedentary prepupa, and the antennae, proboscis, wings, and legs appear on the surface of its exoskeleton. By the time the larva pupates, many of the major changes to adult form have already happened (Scott 1986). The pupae of *E. a. taylori* seem to be well-concealed, as only a few have been found; all were attached to vegetation within a few inches of the ground (D. Ross, pers. comm.). Pupation lasts about two weeks (Pyle 1981). The adult butterfly then ecloses (emerges) and lives only from a few days to 2 weeks (Cushman et al. 1994).

Miscellaneous Behavior

Basking. Butterflies are exothermic and warm their bodies to operating temperature primarily by basking in the sun (Scott 1986). They typically require a body temperature of 60-108° F (16-42° C) before being capable of flight, and optimal temperature range is generally 82-100° F (28-38° C) (Scott 1986). Checkerspot butterflies are dorsal baskers, that is, they bask as well as rest and feed with their wings spread and their abdomen exposed to the sun (Guppy and Shepard 2001). Butterflies also warm themselves by resting on warm rocks or soil (Scott 1986). When the ambient temperature is too hot, butterflies cool themselves by closing their wings and holding them parallel to the suns rays, or by flying to a shaded or moist location. Small butterflies seem to lose heat while flying on cool days and will stop to bask and warm up (Singer and Hanski 2004). Checkerspot larvae also bask; post-diapause larvae bask and/or move across slopes of different exposure and among microclimates to raise their body temperature. The growth rate is enhanced in large larval groups of a European species of checkerspot, the Glanville fritillary (*Melitaea cinxia;* the word "fritillary" is broadly applied in Europe; *M. cinxia* is actually a checkerspot; R. Pyle, pers. comm.), by basking (Kuusaari et al. 2004). The temperature of large groups of black larvae *M. cinxia* tended to be 20º C above ambient temperature in Finland during early spring.

Puddling. Some butterflies sip water from puddles or moist soil to avoid dehydration. However, aggregations of butterflies at puddles are largely males and often occur where the water contains salts from the soil, animal urine, or feces (Guppy and Shepard 2001). Males puddle to replace sodium ions lost in the transfer of spermatophores to females during mating. Males need to replenish sodium in order to produce additional spermatophores for subsequent matings. Despite decades of intensive study, bay checkerspots were not observed puddling until 1990, the third year of a drought (Launer et al. 1993), and have not been observed puddling since then (Boggs and Nieminen 2004). That year large numbers of male and female bay checkerspots acquired moisture from the banks of a seasonal creek. Launer et al. (1993) suggested that nutrients that are acquired from puddles are not limiting during most years for bay checkerspots, but during exteme drought, nutrient reserves derived from larval feeding may need to be replenished. Taylor's checkerspots have not been observed puddling; however, during extreme spring droughts, puddles or other water features may provide an important component of good habitat.

Movements, Dispersal and Colonization

Movements by larvae. Checkerspot larvae move to find new host plants or pupation sites, and to thermoregulate. Pre-diapause larvae move to new host plants when a host becomes completely eaten, and may shift to an alternate host with changes in palatability as the season advances (Hellmann et al. 2004). Adult females that emerge early improve the chances of survival for offspring, so post-diapause larvae increase their reproductive success if they grow, pupate, and eclose to adults as quickly as possible. Larval growth rate is affected by microclimate, which is determined in part by the slope, aspect, and the degree of sun exposure. Weiss et al. (1987, 1988) found that many post-diapause larvae move to gain the advantage of a warmer location. Last instar *E. e. bayensis* can disperse over 10 m/day (Weiss et al. 1987). Movements of larvae are not strongly directional, but the net effect is that late instar larvae accumulate on warm sites. Larvae which move from a northern exposure to a warm southern exposure can speed their growth considerably and decrease the time to eclosion by > 3 weeks (Weiss et al. 1987).

Movements and colonization by adults. Some butterfly species, such as the Monarch (*Danaus plexippus*) and painted lady (*Vanessa cardui*), are long-distance migrants or emigrants, but most species are fairly sedentary, flying only a few hundred meters from where they pupate (Scott 1986). However, even in sedentary species, at least a few individuals will disperse from their site of emergence to another patch of habitat a few hundred meters or a few km away. Dispersal rates can vary widely from 1% in sedentary species to >20% in highly mobile species like the common branded skipper (*Hesperia comma*) (Thomas and

Hanski 1997). Harrison (1989) identified several factors that affect the likelihood and extent of dispersal in each species, including: 1) its innate propensity to leave a patch; 2) its ability to move long distances across an unsuitable matrix; 3) its ability to locate new habitat; and 4) its capacity to establish a population from a small number of founders. The key to some species' survival may be the existence of a few large source populations that supply colonists to the vacant patches after severe conditions lead to local extinctions (Murphy and Weiss 1988).

Adults of different ecotypes of Edith's checkerspot vary in their mobility and willingness to move into different habitat. When not chased, bay checkerspots in one population were reluctant to fly over vegetation >10 cm tall, and would turn sharply when reaching taller grass (20-30 cm) or shrubs off the edge of the serpentine soil (Singer and Hanski 2004). A chaparral ecotype of *E. e. bayensis* was undeterred by vegetation 3 m tall, and routinely moved longer distances than other populations studied, commuting between areas with abundant nectar and larval hosts (Singer and Hanski 2004). Where *E. e. taylori* are found on small grassland patches surrounded by woodland in Washington, one individual was observed about 40 feet up on a Douglas-fir, and two other individuals were observed to fly up over trees at the edge of the patch toward the next habitat patch (K. McAllister and M. Walker, pers. comm.).

Edith's checkerspots, however, do not usually disperse very far. Of marked *E. e. bayensis*, 15% were recaptured 100 m away, 2-4% moved 500 m, and only 0.5% moved 1 km (Weiss 1996, in USFWS 1998). One marked *E. e. bayensis* is known to have moved 7.6 km (USFWS 1998). Adults may move greater distances where nectar sources and host plants are separate than where both plants are found together. Harrison (1989) released 100 *E. e. bayensis* at each of 9 distances up to 5.6 km from a suitable patch. She reported that 1 individual moved 5.6 km in <24 hrs, 1 moved 3 km, and 18 individuals moved 0.5-1 km; released checkerspots moved randomly until they were within 50 m of a suitable patch (Harrison 1989). Dispersal studies of *Melitaea cinxia* have shown similar results. Movement distances of marked and recaptured individuals were generally <500 m, and studies of lifetime movement indicate that 95% of colonizations have been within 2.3 km of the nearest source, and no colonizations >6.8 km have been observed (Nieminen et al. 2004).

Colonization of unoccupied habitat patches in checkerspots may be somewhat episodic, occurring primarily in boom years when there is a high rate of emigration from sources with very high density. There are reports of *E. editha* emigration being unidirectional during these episodes, but Singer and Hanski (2004) suggested that the directionality may have been an artifact of limited observations. Butterflies tend to leave habitat patches with few nectar sources or that do not have the preferred host plants (Wahlberg et al. 2004). Murphy and White (1984) reported that a Quino checkerspot population exhibited marked increase in dispersal during drought when nectar sources and oviposition sites were scarce due to drought or massive defoliation by larvae. They stated that dry winters result in adults that show increased tendency to disperse because: 1) nectar plant quality and quantity is reduced; 2) fewer oviposition plants are available and senesce earlier, so females must fly further to oviposit; and 3) post-diapause larvae defoliate many host plants before adults emerge. Near total defoliation of *Plantago* (*P. insularis* and *P. hookeriana*) by larvae also led to mass dispersal after consecutive years of average or above rainfall led to a population build-up (Murphy and White 1984). Murphy and White (1984) noted that it is not known if larval food stress predisposes adults to migrate, but an abundance of nectar did not seem to deter adults from migrating. Several *E. e. taylori* were observed dispersing from Oregon sites in 2004 when their numbers were high and weather conditions were good (M. Vaughan, pers. comm.); drought was not a factor, but no data were collected on the condition of larval host or nectar resources.

In general, emigration of male checkerspots decreases with increasing population density. This is also true of *M. cinxia* females, but females in other species vary in their response. Female Anicia checkerspots (*Euphydryas anicia*) and bog fritillaries (*Proclossiana eunomia)* increase emigration

with increasing density, apparently in response to frequent encounters with males (Singer and Hanski 2004). One study of a montane population of *E. editha* found emigration rate did not correlate with densities (Boughton 1998). Female *M. cinxia* from newly colonized populations are more dispersive than are females from older established populations (Ehrlich and Hanski 2004). The prairie specialist, regal fritillary (*Speyeria idalia*), in Iowa was also less likely to exit a plot with a high density of individuals (Ries and Debinsky 2001). Higher emigration from low density populations is known to affect mating success and lead to inbreeding depression and reduced fitness in *M. cinxia* (Nieminen et al. 2004).

Mortality and Survival

Adult lifespan in E. editha. Cushman et al. (1994) reported that the maximum lifespan of adult female *E. e. bayensis* captured in the field in their study was 14 days, with just over 50% surviving to 4 days. Females kept in a greenhouse lived longer, with just over 50% surviving 11 days, and the maximum was 19 days. At least one female lived 26 days in captivity (Boggs and Nieminen 2004)

Sources of mortality in butterflies. Of the many eggs that a female butterfly lays, on average, only two survive to reach adulthood (Scott 1986). Weather can cause high mortality at any stage of the butterfly life cycle. Wind, rain, and hail can knock small caterpillars or egg clusters off host plants. Unseasonable weather can kill larvae and adults (Guppy and Shepard 2001), or kill host plants and result in starvation of local populations. Other causes of mortality include abnormal development, bacterial, fungal, and viral diseases, parasitism, and predation (Dornfeld 1980).

Most butterfly predators are other arthropods. Predators of butterfly eggs include stink bugs, stilt bugs, predaceous mites, and small birds (Guppy and Shepard 2001, van Nouhuys and Hanski 2004). Larvae are eaten by mantids, lacewings, stink bugs, assassin bugs, carabid beetles, spiders, ants, and wasps. Early instar larvae may be taken more often by spiders, ants and bugs, and later instars are more often taken by birds and wasps (Guppy and Shepard 2001:59). Pupae are probably more often taken by small mammals than by birds (Guppy and Shepard 2001). Based on published life table data for 8 species, pupal mortality rates can vary from 0-100%, but may average around 60% (White 1986). Adults are attacked by robber flies, ambush bugs, spiders, dragonflies, ants, wasps, and tiger beetles (Scott 1986). Vertebrate predators of larvae, pupae, and adults, include lizards, frogs, toads, mice, chipmunks, squirrels, shrews, and birds. Sometimes adults caught by the wings escape, and one researcher observed 5-7% of the butterflies in his study had beak marks (Scott 1986:71). Though bird predation rates on adults can be very high, butterflies are at best only moderately palatable to birds. Palatability varies between species, populations, and even between individuals, and is affected by age, sex, and species of plant eaten as larvae (Guppy and Shepard 2001).

Mortality in checkerspots. Mortality rates for the bay checkerspot were estimated at about 50% during diapause, 20% during the post-diapause stage, and 50% during the pupal stage (Cushman et al. 1994). Thus for an adult generation of bay checkerspots to replace itself, each adult female must produce 10 offspring that reach diapause (Cushman et al. 1994). Moore (1989) reported that mortality varied dramatically between generations in an *E. editha* population and between different host plants within generations. In other populations, weather was often the most important factor affecting *E. editha* mortality. If *E. e. taylori* is like *E. e. bayensis*, populations fluctuate widely in size from year to year, often due to variation in pre-diapause mortality rates that can be 90-95% (Murphy and Weiss 1988). *E. editha* larvae are in a race with the senescence of their food plants; most fail to reach the 4th instar before the plants dry up, are unable to enter diapause for the dry summer, and do not survive (Murphy and Weiss 1988, Ehrlich 1992). Droughts that cause early plant senescence can cause the extinction of many local populations. This situation has apparently been exacerbated for the bay checkerspot because nearly all remaining populations are restricted to serpentine soils that dry up earlier than surrounding areas (Cushman et al. 1994). In one study area, *E. editha* larvae occasionally starved when they broke diapause

before growth began in their host plant (Moore 1989). However, many individuals diapaused in the soil at the base of a host plant and did not break diapause until growth of the host pushed them to the surface of the soil. Starvation mortality of larvae can also be high due to competition when all the host plants at a site are defoliated. White (1974) found that host plant defoliation was "quite common and often extensive," and combined with plant senescence, cause starvation rates of pre-diapause larvae that varied from 0 to 99% among years and populations. Host plant defoliation has also been evident some years among Washington populations of *E. a. taylori* feeding on *Plantago lanceolata* (A. Potter, pers. comm.). However, Moore (1989) reported only 2-5% mortality of *E. editha* pre-diapause larvae in her study population, and variation in yearly mortality was caused by levels of parasitism.

The larvae, pupae and adults of *E. editha* are somewhat toxic to vertebrates (Scott 1986), so may be less subject to vertebrate predation than other species. The degree that they are unpalatable may vary, however, depending on the host plant eaten as larvae. Moore (1989) did not observe predation on adults by birds or wings with beak marks in a dense study population. She noted that newly emerged adults occasionally fell prey to ants before their wings were dry. D. Ross (pers. comm.) observed 2 adult *E. e. taylori* in spider webs and 1 adult being eaten by a crab spider (possibly *Misumenoides formosipes*) on a mariposa lily.

Mortality of the egg stage has been little studied (Kuusaari et al. 2004). Predation accounted for 0% and 2% morality of the egg stage in 2 populations of *E. editha,* and predation of the egg and pre-diapause stage combined was 79.6 – 85.1% in a third population (White 1973). Moore (1989) reported egg mortality in a population of *E. editha* ranged from 31 – 65% during a 3-year study. A rainstorm apparently knocked some eggs and small larvae off of host plants (Moore 1989). Being inadvertently eaten by herbivores, including pocket gophers, accounted for 0-8% of mortality of eggs and pre-diapause larvae of *E. editha* (Moore 1989). White (1986) estimated that about 35% of a population of *E. e. bayensis* could be lost to crushing each generation on sites that are heavily grazed. Stilt bugs (Berytidae) are another known minor predator of *E. editha* eggs (Moore 1989); spiders, including jumping spiders (Salticidae) and an American pipit (*Anthus rubescens*) have been observed eating adults (Hendricks 1986, Moore 1989).

Mortality rates of pupae likely vary widely among species and populations. Mortality of bay checkerspot pupae placed in the field ranged from 53-89% (White 1986). Predators that left remains took 23-32% of the pupae. Predation and cold weather were the major factors in mortality; cold weather probably increases the incidence of fungus and viruses. Other mortality factors included being stepped on by cattle, which killed 10% at one site. Parasitism was a minor factor, taking 1-10% of pupae (White 1986). Moore (1989) reared an unidentified wasp (Chalcidae) from *E. editha* pupae. Moore (1989) found pupal mortality to be quite low in her study population. She noted that pupae appear to be vulnerable to ants before the case is hardened.

Parasitism. Parasitic wasps and flies lay eggs on the eggs, larvae, and pupae of butterflies. These parasitoids are specialized predators that eat their prey while keeping it alive as long as possible (Guppy and Shepard 2001). The eggs hatch and the larvae grow and develop inside the victim, eating body fluids at first, but later eating internal organs and killing the butterfly (Scott 1986). Tothill (1913) reported a tachinid fly, *Siphosturmia confusa*, was a parasite of *E. e. taylori*. D. Ross (pers. comm.) observed parasitism by wasps on late instar *E. e. taylori* in Oregon. Caterpillars of *Euphydryas* species are commonly attacked by 1 to 3 species of parasitoid, including braconid (*Apanteles* spp., *Cotesia koebelei*) and ichneumonid wasps (*Benjaminia* spp.), and a tachinid fly (Stamp 1984, Moore 1989). The level of parasitism varies widely from year to year. Parasitism by the braconid wasp, *Cotesia koebelei*, varied from 5-57% in one *E. editha* population (Moore 1989). Parasitism rates in *E. editha* larvae varied from 0-67%, with later instars more often infected perhaps because first instars are well protected in their silk tent (Stamp 1984). Parasitoids may in turn be parasitized by hyperparasitoids that deposit their eggs inside the

eggs or larvae of the parasitoids (these hatch into larvae that feed inside and kill the parasitoid). In one study, hyperparasitoids, killed about half the parasitoids in larvae of the Baltimore checkerspot (*Euphydryas phaeton*) (Stamp 1984).

Pesticides. Pesticides can also be a locally important source of mortality. Widespread use of DDT and other pesticides had devastating effects on populations of butterflies in the fruit-growing regions of Washington (Hopfinger 1947). Orchard spraying is blamed for the extirpation of the viceroy (*Limenitis archippus*) from British Columbia and northern and central Washington (Guppy and Shepard 2001:36). The spraying of 'BT' (*Btk* or *Bacillus thuringiensis* var. *kurstaki)*, a widely used bacterial based insecticide that affects Lepidopteran larvae, can impact local populations of rare butterflies and moths. Herbicides also affect butterfly populations by reducing the number and variety of host and nectar plants available.

Population Dynamics

Butterfly conservation is usually best accomplished through habitat preservation, in part, because their numbers can not be readily managed (New et al. 1995). Butterfly populations may total anywhere from a few to millions of individuals, and densities can be >1,000/ha to as low as <3/ha (Scott 1986). Factors that affect populations include starvation and other agents of mortality, and anything that affects mate finding and the number of eggs deposited (Scott 1986). Weather extremes can delay mating, shorten life spans and reduce the total number of eggs deposited by a generation. The number of individuals in most butterfly populations or colonies are difficult to count or estimate, but appear to be roughly the same from year to year, but with occasional booms and busts (Scott 1986). Populations may fluctuate regularly or unpredictably (Douglas 1986). The short generation time of butterflies means that populations are not buffered from extremes in weather or habitat condition by long-lived individuals (Ehrlich and Hanski 2004). However, the short generation time and the ability for females to lay many eggs means that they can rebound quickly from a temporary decline (Scott 1986). Population reductions by a factor of 40 in a single year have been observed in the bay checkerspot, and marked increases have been observed following a favorable year (Weiss 1996).

Washington *E. a. taylori* populations have exhibited boom years with several thousand individuals and then declined dramatically for unknown reasons with only 100 or so the following year. Population dynamics in *E. a. taylori* have not been studied, but probably have similarities to that of the bay checkerspot. Singer and Ehrlich (1979) were reluctant to generalize about the population dynamics of *E. editha* because of the variation between populations and the complex interactions of climate, host plants, predators and parasites. Phenomena that threaten one population do not necessarily threaten another (Ehrlich 1992). Some populations of *E. editha* seem to be controlled by density dependent factors and decline as a result of starvation from intra-specific competition, while other populations fluctuate due largely to density independent factors, particularly the interactions of host plants and annual weather (Singer and Ehrlich 1979). Some bay checkerspot populations fluctuate dramatically year-to-year due primarily to variation in mortality rates of pre-diapause larvae (Murphy and Weiss 1988), while other populations are more affected by mortality of post-diapause due to parasites (Moore 1989).

Metapopulation structure in butterflies. Metapopulations are common in checkerspots, and apparently in butterflies in general (Wahlberg et al. 2004). A butterfly metapopulation can be thought of as a collection of distinct breeding colonies that may blink on and off with the extinction and re-colonization of individual colonies over time (Douglas 1986). Butterfly populations fluctuate, sometimes dramatically (New et al. 1995), and as a result they can be more vulnerable to local extinction. Most butterfly species are relatively sedentary and only a small percentage of individuals migrate to another habitat patch. Where there are other occupied patches within dispersal distance, a vacant patch may soon be re-occupied. Thus the population in a region is actually multiple populations forming a metapopulation. Typically, larger populations act as sources of migrants that recolonize habitat where smaller populations have disappeared. Small local popula-

tions are prone to extinction and isolated patches are less likely to be re-colonized; the higher rate of extinction may be due to a lower number of immigrants (Thomas and Hanski 1997). The likelihood of re-colonization is probably determined in part by the size of the source population, and the size and distance to the target habitat patch (Thomas and Hanski 1997). Metapopulation structure is increasingly evident as development imposes a fragmented pattern of habitat on landscapes (Wahlberg et al. 2004). Habitat patches that are temporarily vacant may be important in maintaining connectivity and the metapopulation as a whole. The preservation of butterfly species likely requires the protection of minimum viable metapopulations that include key source populations as well as smaller populations that allow the re-colonization of vacant patches to continue (Murphy and Weiss 1988, Harrison 1989).

Taylor's checkerspot populations likely exist, or historically existed, as metapopulations, as observed in the bay checkerspot. The Victoria area populations of *E. e. taylori* appear to have formed a metapopulation with a main source population at Beacon Hill (J. Shepard, pers. comm.). The bay checkerspot exists as metapopulations comprised of a small number of reservoir or source subpopulations and many smaller ones. There are always some demographic units that are extinct, i.e. temporarily vacant (Ehrlich and Murphy 1987). Re-colonization of empty patches may not occur in most years, but primarily in rare years of extraordinary abundance and explosive dispersal (Murphy and White 1984). Checkerspot populations can build up in good years to the point of widespread defoliation of host plants; most post-diapause larvae then starve and emerging adults disperse. Weather and its effect on host plant quantity, quality and phenology is the major proximate cause of local extinctions. Movements to distant habitat patches (>10 km) appear to be very limited, and re-colonization of distant patches may depend on the location, size, and quality of intervening patches (Murphy and Weiss 1988). Extremes in annual weather may cause subtle differences between habitat patches that result in populations switching their role as sinks or sources. Boughton (1999) observed a population of *E. e. bayensis* that in most years served as a source population, but went extinct after an unseasonable frost, and another population that had previously acted as a "sink" then acted as a source in re-colonizing the original area.

HABITAT REQUIREMENTS

Taylor's checkerspot requires grassland dominated by fescue or other short-stature grass species, with a diversity of larval host plants and spring nectar sources. Within native grassland habitat, the topography and resulting microclimate may strongly affect the distribution of larvae and adult butterflies. Habitat heterogeneity is likely an important feature; during drought in California, some populations of bay checkerspot in large homogenous habitats went extinct, while populations in smaller patches with more diverse topographies and microclimates persisted (Weiss et al. 1987, 1988). Based on the importance of a diversity of micro relief and microclimates for bay checkerspots (Weiss et al. 1988), sites with some topographic variety, or a fringe of sparse trees such as Garry oak may be optimal for *E. a. taylori*. Some degree of shading may be needed in dry years, but completely open sunny sites needed in cooler years. The habitat heterogeneity of large habitat patches may be more important for the persistence of the local population than the area's size. What appears to be relatively poor habitat in most years because it never hosts high numbers of butterflies may be essential during severe weather years because of its heterogeneity (Thomas and Hanski 1997). Habitat patches that consistently host moderate populations and allow recovery after low years may be a better measure of habitat quality for the long-term than patches that host high numbers during optimal years (Hanski et al. 2004).

Habitat quality is in part also determined by the availability of resources. For butterflies, habitat degradation often means a reduction in larval hosts and adult nectar sources. Schultz and Dlugosch (1999) showed that local population size of Fender's blue (*Icaricia icarioides fenderi*) was correlated with the density of larval host plant leaves as well as the quantity of native nectar available. The total abundance of flowers and nectar from all sources

did not predict butterfly numbers, but numbers were significantly associated with the abundance of nectar from native species (Schultz and Dlugosch 1999).

Larval Requirements

Larvae (caterpillars) are the main feeding and growth stage of butterflies. The plants eaten by larvae must contain sufficient carbohydrates and the amino acids required for growth, and much of the needed resources for producing eggs (Boggs and Nieminen 2004). The butterfly life history strategy of "reproduce fast—die young" reduces the susceptibility to fluctuations in nectar resources, but increases the importance of larval food resources. Eggs laid in the first 2 days or so are produced from larval-derived nutrients, and female *E. editha* larvae are known to be particularly affected by food shortages during the late instar stages (Boggs and Nieminen 2004).

For most butterfly species, larvae feed on plants within a single family (Scott 1986). Some butterfly species are highly specialized and feed on only a single plant species or a few closely related species. Host plant selection can be even more specialized where different butterfly subspecies or populations select different host plant species. This results from the development of chemical substances in plants as defenses against insect attack. Butterflies typically have adapted by evolving tolerance or detoxification mechanisms for certain substances through genetic mutations. Thus they can eat some plants, while many others are toxic. Butterflies and plants seem to have evolved through a sort of bio-chemical war in which plants develop a chemical defense, and butterflies slowly adapt by developing a tolerance or mechanism to deal with it. This specialization in larval food plants is one factor responsible for the restrictive habitat requirements of some species, and necessitates conservation of the specialized habitat to maintain the butterfly. New et al. (1995) states that butterflies are often much more restricted in distribution than are their host plants. Some species are associated with the host plant only in sunny or shady sites. It is not clear if these specialized associations result from adaptations to competition from similar species, or specialization to the environment and differences in the host plants between sites.

Singer et al. (1988) found that larval food preference in *E. editha* populations is inherited, and larvae exhibit higher rates of survival and growth on their primary host plant, apparently due to differences in digestive physiology (Rausher 1982, Singer et al. 1988). Edith's checkerspots generally select members of the figwort family (Scrophulariaceae), including species of *Castilleja*, *Orthocarpus*, *Pedicularis*, *Collinsia*, and *Penstemon*, as well as members of the closely related Plantain family (Plantaginaceae), including *Plantago* spp. (Pyle 1981, Opler et al. 1995). Regional or local *E. editha* populations usually specialize on a few species within this group. *Plantago* spp. and figworts contain iridoid glycosides, an unusual group of bitter tasting chemicals that deter many generalist herbivores and are thought to be a defense against herbivory (Kuusaari et al. 2004). Iridoid glycosides have been found to stimulate oviposition in *E. chalcedona* and feeding by larvae in some *Euphydryas* (Ehrlich and Murphy 1981, Kuusaari et al. 2004). Individual plants within species often vary in the amounts of iridoids and other compounds, and adult females select an oviposition plant based on chemical composition, not just on species identification (Wahlberg et al. 2004). The iridoid glycosides are sequestered in the larvae and make the adults distasteful, if not emetic, to birds and other predators. Common Buckeye (*Junonia coenia*) larvae fed a diet high in iridoids were rejected by some species of spider, ants, wasps and stink bugs (Kuusaari et al. 2004). Unpalatibility varies among checkerspot species and with the host plant eaten (Kuusaari et al. 2004). The only known specialist enemies of checkerspots are internal larval parasitoids that presumably have evolved strategies to avoid, tolerate or otherwise deal with the iridoid compounds.

In Washington, ribwort/English plantain (*Plantago lanceolata)*, harsh paintbrush *(Castilleja hispida*), blue-eyed Marys (*Collinsia parviflora, C. grandiflora),* and sea blush (*Plectritis congesta*) have been identified as larva food plants (Table 4.2; Char and Boersma 1995, D. Grosboll, pers. comm., A. Potter, pers. comm.). Hays et al.

Table 4.2. Larval host plant associations for populations[a] of Taylor's checkerspot.

Plant species	Oviposition	Pre-diapause	Post-diapause
Castilleja hispida	WA4, WA5, WA31, WA32, WA16	WA4, WA5, WA16, WA32	WA16 WA35
Castilleja attenuata/ Orthocarpus attenuatus	WA37		
Orthocarpus pusillus/ Triphysaria pusillus		WA37	
Collinsia grandiflora	WA32, WA37	WA37, WA32	WA31, WA32?
Collinsia parviflora		WA32	WA31, WA32?
Plantago lanceolata	WA12, WA19	WA2	WA1, WA2, WA12, WA19, Oregon, British Columbia
Plantago elongata			British Columbia
Plectritis congesta	WA37	WA32, WA37	WA31, WA37, British Columbia

[a]WA numbers refer to populations listed in Table 4.4; sources include: Danby 1890, Llewellyn-Jones 1934, 1935, Dornfeld 1980, Char and Boersma 1995, Hays et al. (2000), Guppy et al. 2003, and observations by Dan Grosboll, Mary Linders, Ann Potter, Jon Shepard.

(2000) observed *E. a. taylori* ovipositing on and immediately adjacent to *P. lanceolata*, a common introduced weed, and late instar larvae were also observed near this plant. *E. e. taylori* populations are also known to feed on this plant in Oregon and British Columbia (Danby 1890, Shepard 2000), but since *P. lanceolata* is of European origin, it is not a plant that supported *E. e. taylori* prior to the late 19th century. *E. e. taylori* was found feeding on *P. lanceolata* and the native plantain (*P. elongata*) on Hornby Island, British Columbia (Guppy et al. 2003). *P. elongata* and *P. macrocarpa* are native species found in Washington, but are not found on the inland prairies (Pojar et al. 1994), so inland *E. a. taylori* populations could not have used them historically. Populations of *Melitaea cinxia* in Finland feed on *P. lanceolata;* recent management shifts away from traditional haying or light grazing decreases the abundance of *P. lanceolata* and is a common cause of extinction for populations of *M. cinxia* (Hanski et al. 2004).

Char and Boersma (1995) and Hays et al. (2000) reported larval *E. a. taylori* feeding on *Castilleja hispida* at 2 different locations. *C. hispida* is uncommon in the south Puget Sound area, but may have been much more common historically (Hays et al. 2000). Golden paintbrush (*Castilleja levisecta*) is a rare regional endemic associated with *Festuca* grasslands that is federally listed as a threatened species (USFWS 1997). *C. levisecta* persists at only 9 sites in Washington and 2 sites in British Columbia; it has gone extinct at 14 known historical sites in Washington, 6 in Oregon and 9 in British Columbia. *C. levisecta* may have historically been an important larval host, but use by larvae has not as yet been documented. *C. levisecta* showed a large increase in reproductive activity following a controlled burn (Dunwiddie and Pearson 2004), and regular burning by Native Americans may have maintained it, as well as *C. hispida* and *C. attenuata*, in much greater abundance. *E. a. taylori* may be more flexible in use of host plants than is reported for *E. e. bayensis* populations; population WA32 has been observed ovipositing or feeding on up to 4 plant species (Table 4.2). Post-diapause larvae were not found feeding on *C. hispida* at that location, possibly because all the *C. hispida* were in cool shaded sites (A. Potter, pers. comm.). Several additional figworts that are possible food species on that site include chickweed monkey-flower (*Mimulus alsinoides*), yellow monkey-flower (*M. guttatus*), and broad-leaved penstemon (*Penstemon ovatus*) (D. Grosboll, pers. comm.). *Plantago major* is another widespread introduced weed, but it is uncertain if larvae will feed on it in the wild.

Plate 5. Host plants of Taylor's checkerspot larvae, clockwise from upper left: *Castilleja hispida*, *Collinsia parviflora*, *Plectritis congesta*, and *Plantago lanceolata* (photos by D. Stinson).

Potential role of pocket gophers. In one California population of bay checkerspot, many of the larvae that survive to diapause are from eggs laid on *Plantago* in soil recently tilled by Botta's pocket gophers (*Thomomys bottae*) (Singer and Ehrlich 1979, Murphy et al. 2004). These plants appear to be larger and to exhibit delayed senescence, lasting 2-3 weeks longer into the dry season (Ehrlich and Murphy 1987). The distribution of *E. e. taylori* overlaps with that of the Mazama pocket gopher, but gophers are not currently found at all *E. e. taylori* sites. There may not be an important relationship between the species, although the presence of gophers may improve habitat quality. Plant diversity on Puget prairies is higher on soil disturbed by pocket gophers, but the soil disturbance benefits both native and introduced plant species (Hartway and Steinberg 1997). The potential relationships between butterflies and pocket gophers are not always beneficial, however, as occasionally larvae or eggs are killed when a gopher eats a host plant (Moore 1989).

Adult Habitat Requirements

Feeding. Adult butterflies do not grow, but feeding is required to maintain activity and develop eggs or sperm. Adult butterflies have mouthparts formed into a coiled straw-like proboscis which is used to obtain nectar from flowers, and occasionally sap from trees or juice from rotting fruit. In general, adult butterflies are less specialized in their use of food plants than larvae, and can meet their needs in the vicinity of the larval food plants. Butterflies feed on mud, dung, and carrion to obtain salts, minerals, amino acids, and proteins, which are largely unavailable in the plant diet of larvae. To feed on dry substances, butterflies eject a drop of saliva from their proboscis onto the substrate to be dissolved and then suck it back up (Scott 1986). Many species are exclusively nectar feeders, but most species are not choosy and visit dozens of kinds of flowers (Scott 1986). Some species are more selective, however, and certain flowers are known to be favorites (Clench 1975). The nectar of frequently visited flowers contains sugars, plus some amino acids and other trace chemicals (Boggs and Nieminen 2004). The concentration of amino acids in the nectar may be affected by soil fertility (Gardener and Gilman 2001). Nectaring behavior makes butterflies important pollinators of many flowers because they tend to visit the same species several times in succession (Guppy and Shepard 2001).

Suitable habitat for checkerspots needs to include not only adequate numbers of larval host plants, but an abundance and variety of nectar sources. The distribution of nectar plants is known to affect the movements of adult checkerspots and the distribution of egg clusters (Boggs and Nieminen 2004). O'Brien et al. (2004) studied the relative contribution of carbon derived from feeding during the adult life stage to the formation of eggs in 4 species, including *E. chalcedona*. Carbon obtained by adults (vs. carbon obtained while a larvae) contributed an increasing proportion of carbon in manufacture of successive egg clusters to a maximum of 44% in *E. chalcedona*. The availability of nectar is known to affect egg production in Edith's checkerspots, and high egg production is important due to the high mortality of early instars. *E. e. bayensis* reared in a lab and fed nectar produced nearly double the number of eggs and lived longer than those not fed (Murphy 1981), though the increase was primarily in late-season egg clusters (Hellmann et al. 2004).

Taylor's checkerspots may be somewhat specialized on certain nectar sources, and the number of nectar sources is limited during their spring flight period (Table 4.3). Shepard (2000) indicates that *E. e. taylori* in British Columbia nectared almost exclusively on spring gold (*Lomatium utricularium*) and the elimination of this species by weedy exotic vegetation may have contributed to some *E. e. taylori* extinctions there. Jackson (1982) observed nectaring by *E. e. taylori* on camas (*Camassia quamash*) at a Puget prairie site and she considered it a specialist pollinator. Hays et al. (2000) noted nectaring by *E. e. taylori* on camas (73-77% of 74 visits) and nineleaf biscuitroot (*Lomatium triternatum; 10-15%* of 74 visits), and rare visits to field chickweed (*Cerastium arvense*), western buttercup (*Ranunuculus occidentalis*), and Scotch broom. Hays et al. (2000) observed that during a warm spell in the spring of 1999, nectar plants senesced on open grassland, and checkerspots shifted their foraging to the grassland/conifer edge

Table 4.3. Nectar sources used by adult Taylor's checkerspot.

Plant species	Common name	Washington	Oregon	British Columbia
Armeria maritima	Thrift	√		
Balsamorhiza deltoidea	Puget balsamroot	√		
Berberis spp.	Oregon grape	√		
Calochortus tolmiei	Tolmie's mariposa lily		√	
Camassia quamash	Common camas	√		
Cerastium arvense	Field chickweed	√	√	
Eriophyllum lanatum	Woolly sunflower	√		
Fragaria spp.	Strawberry	√	√	√
Linanthus bicolor	Bicolored flaxflower		√	
Lomatium triternatum	Nineleaf biscuitroot	√		
Lomatium utriculatum	Spring gold			√
Malus sp.	Apple	√	√	
Mimulus spp.	Monkey-flower	√		
Potentilla anserina	Silverweed	√		
Plectritis congesta	Sea blush	√	√	
Saxifrage integrifolia	Alaska saxifrage	√		
Sedum sp.	Stonecrop	√		
Zygadenus venenosus	Meadow death-camas	√		

Sources: Jackson (1982); Hays et al. (2000), Shepard (2000), and pers. comm. with R. Gilbert, D. Grosboll, M. Linders, A. Potter, D. Ross, and M. Walker.

with flower patches in partial shade where camas and lomatium flowers had recently emerged. Shepard (2000) noted *E. e. taylori* nectaring on wild strawberries (*Fragaria* spp.), but considered it an abnormal food source. *E. e. taylori* have also been observed nectaring on wild strawberries in Washington (M. Linders, pers. comm.). D. Ross (pers. comm.) reported wild strawberries as the main nectar source in April at one of the last two populations in Oregon, with checkerspots shifting primarily to Tolme's mariposa lily (*Calochortus tolmei*) as *Fragaria* senesced. Bicolored flaxflower (*Linanthus bicolor*) and *Plectritis congesta* were also used later in the season (D. Ross, pers. com.). The use of nectar sources varies with availability. For example, use of *Sedum* spp. has only been observed at sites on balds, and use of *Potentilla anserina* only at coastal sites (A. Potter, unpubl. data).

POPULATION STATUS

British Columbia. Taylor's checkerspot had not been observed for several years in British Columbia and was believed to be extinct there until its rediscovery on an island in 2005 (J. Heron, pers. comm.). A population on Hornby Island in Helliwell Provincial Park, the last known population until the 2005 rediscovery, persisted until 1996. None were detected there during surveys in 2001. Although local residents claimed to have seen it in 2002, none were detected during surveys in 2003 and 2004 (Miskelly 2003, J. Heron, pers. comm.). This population was conservatively estimated at about 1,100 individuals as recently as 1995 (Shepard 2000). A second population along a powerline (Shawnigan Lake to Mill Bay Rd) was roughly estimated at 1,000 individuals in 1989, but checkerspots were not detected there in 1996 and that population also appears to be extinct (Shepard 2000, J. Miskelly, pers. comm.).

Oregon. Taylor's checkerspot was formerly known from at least 13 locations in Benton, Lane, and Polk counties. Dornfeld (1980) stated that *E. e. taylori* "fairly swarms" on certain meadows north of Corvallis. In recent years, *E. e. taylori* was considered extinct in Oregon, until a population was discovered in Benton County in 1999. An additional metapopulation was discovered in 2004. Recent surveys of the metapopulation found in 1999 produced estimates of 550-770 adults in 2003, and 1,104 adults in 2004 (D. Ross, pers. comm.). It is one of the largest remaining populations and may be an important source for reintroduction efforts elsewhere. At the checkerspot site complex discovered in 2004, 130+ adults were observed and it was estimated that it harbored perhaps 500 individuals (S. Hoffman-Black, pers. comm.).

Washington: Past

According to data collected by The Evergreen Aurelians, a group of Pacific Northwest lepidopterists, Taylor's checkerspot records in Washington date back to 1893, when an unknown collector obtained a single specimen. That specimen, housed in the Cornell University collection, is labeled with the general locale "Olympia." *E. e. taylori* has been recorded recently or historically at 38 identifiable sites in Washington. There are records for several Pierce and Thurston County *E. e. taylori* sites from the 1920s, 1940s and 1950s. Most of the historical population decline of *E. e. taylori* is undocumented and can only be surmised from historical records of the progress of settlement and the invasion of prairies by Douglas-fir and Scotch broom, and changes in distribution noted in recent decades. Excluding locations in Clallam, Island, and San Juan counties, south Puget prairie habitat has declined >92% and *E. e. taylori* are not present on most of the remaining prairies. Based on their recent presence at sites scattered across the south Puget Sound region, *E. e. taylori* were likely widespread and abundant on those prairies. Local populations probably waxed and waned temporarily with extremes in weather and fires set by Native Americans.

Washington: Present

Personnel from WDFW, The Nature Conservancy, Fort Lewis, and DNR Natural Heritage Program

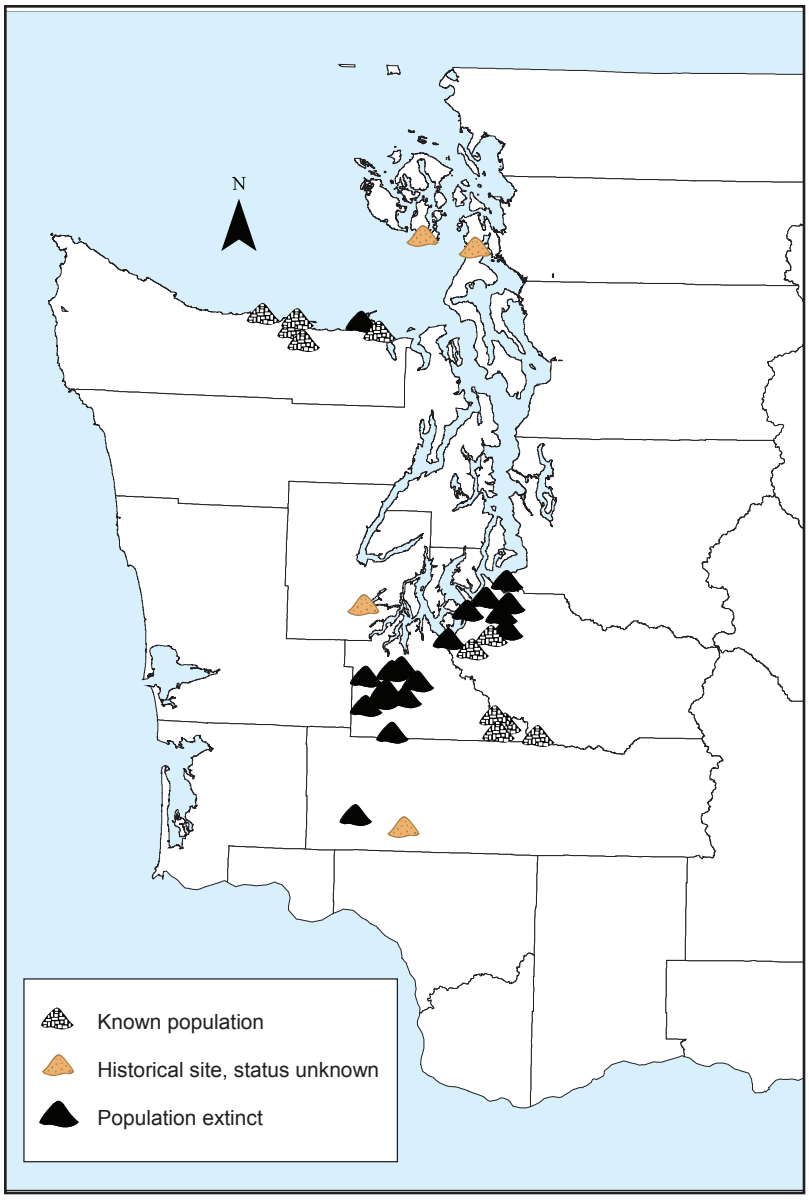


Figure 4.3. Existing and extinct populations of Taylor's checkerspot in Washington.

have recently attempted to survey known and potential *E. e. taylori* sites. This effort included locating and surveying all historical sites, finding and surveying potential habitat within the historical range of the species, and monitoring occupied sites. Surveys for adult checkerspots were done during the brief April – May flight period. Table 4.4 is a compilation of records from recent systematic surveys and many earlier lepidopterists' records. Recent surveys typically involved systematically searching sites under conditions when butterflies are active (low wind, little or no cloud cover, temp ≥ 55° F). The information in Table 4.4 was assembled by Ann Potter from three primary data sources: John Hinchliff's unpublished notebooks which were the source documents for *An Atlas of Washington Butterflies* (1996); interviews with area lepidopterists, including Barry Bidwell, Art Frost, Paul Hammond, Bob Hardwick, Dave McCorkle, James Miskelly, Jonathan Pelham, Bob Pyle, and Jon Shepard; and recent survey data and new site locations, primarily from WDFW and Fort Lewis biologists.

As of 2004, *E. e. taylori* was believed to survive at 10 sites, and may still persist at up to 3 other sites where their status is unknown. The exact location of 4 sites mentioned in old records cannot be determined, but habitat in those areas has been searched. Surveys re-confirmed the presence of

Table 4.4. The status and survey history for populations of Taylor's checkerspot in Washington[a].

Site Code[b]	County	Current Status	Year	Survey results and notes
WA1	Clallam		1970-72	Checkerspots present
		Extinct	1999-2004	None observed.
WA2	Clallam		1993	> 1 observed
			1998	Possible sighting during 1 site visit
			2000	None observed during 1 site visit
			2002	None observed during 1 site visit
			2003	2 observed during 2 site visits; habitat is degraded.
		Present	2004	Larvae observed; No adults observed, 2 surveys
WA3	Clallam		1985	Several observed, 6 collected
			1986	Several observed, 2 collected
			1988	Several observed, 4 collected
			2003	4 or 5 observed, 1 collected during 2 site visits; little habitat remains and is degraded by roads and utilities
		Unknown	2004	None; 4 surveys; habitat affected by road widening
WA4	Clallam		2003	Estimate 100+, two collected during 3 site visits
		Present	2004	92 , 2 surveys
WA5	Clallam		2003	Many observed, 3 collected during 3 site visits.
		Present	2004	19 (high count); steep, complete survey not possible
WA6	Clallam		2003	> 2 observed
		Present	2004	None; 1 survey
WA7	Island		Old	> 1 observed
		Unknown	2004	None; 1 survey

Site Code[b]	County	Current Status	Year	Survey results and notes
WA8	Lewis		1983	> 1 observed
		Unknown	2004	None; 2 partial surveys
WA9	Lewis		1993	> 1 observed
		Extinct	1998,'00, '04	None observed
WA10	Mason		1971	> 1 observed
		Unknown	1997	None observed during 1 site visit
WA11	Pierce		1947	> 1 observed
		Extinct	2002	Habitat in area has been destroyed
WA12	Pierce		1991	3 males
			1994-96	47-679 individuals: Limited time/area count
			1997	Estimate for area with highest density: 7,000
			1998	Estimate 100+ individuals
			1999	Estimate 30+ individuals
			2000	Estimate 10+ individuals
		Extinct	2001, '03, '04	None observed during multiple surveys each year
WA13	Pierce		1980	Common, 8 counted
		Extinct	2001-03	None observed; multiple surveys during 2003; core of site destroyed in 1990's
WA14	Pierce		1980	1 observed
		Extinct	2002	None observed for years. Edge of 1992 USDA Btk (Asian gypsy moth control) spraying
WA15	Pierce		1986	1 observed
		Extinct	2002	None observed for years
WA16	Pierce		1999	1 observed during 1 site visit.
			2000	1: Estimate pop. 10-20 individuals. Multiple surveys
			2001	4: Estimate pop. 10-20 individuals. Multiple surveys.
			2002	19: Estimate pop. 30-40 individuals. Multiple surveys
			2003	32: Estimate pop. 50+. Multiple surveys.
		Present	2004	1, multiple surveys
WA17	Pierce		1955	Large numbers observed
		Extinct	1995 1996	None – edge of 1992 USDA Btk spraying for Asian gypsy moth control. Almost no butterflies observed
WA18	Pierce		1952-54	Several observed over 3 year period
		Extinct	1980s?	Habitat replaced by shopping mall complex
WA19	Pierce	Present	2004	68 (high count); estimate 100s present

Site Code[b]	County	Current Status	Year	Survey results and notes
WA20	Thurston		1978	Abundant
			1999	None: 1 survey during poor weather,
		Unknown	2002	Denied access
WA21	Thurston	Unknown	? & 1929	> 1 observed; exact location unknown
WA22	Thurston		1967	> 1 observed
			1970	"Strong" population
			1980	> 1 observed
			1993	3 observed; Large portion of site burned 1992
		Extinct	1994, 97-03	None observed during multiple surveys each year
WA23	Thurston		1947 - 1976	> 1 observed during each of 10 visits in 9 years
			1982	16 counted
			1983	Many observed.
		Extinct	1998 - 2002	None observed during 3 site visits
WA24	Thurston		1929 to 1985	> 1 observed during each of 9 visits in 8 years; exact location unknown.
		Extinct	1997 -01	None; searched local suitable habitat in last 5 years
WA25	Thurston		1972	[Plumb Rd.]1; exact location unknown, near or same as WA27
		Unknown	1973	7 checkerspots
WA26	Thurston	Unknown	?	Several. Exact location unknown (possibly WA-27)
WA27	Thurston		1983	4 observed
			1988	16 observed
			1997	1observed: multiple visits
		Extinct	1998-04	None: multiple surveys each year
WA28	Thurston		1983	Estimated > 100
			1985	46 counted
			1986	> 1 observed
		Extinct	1997	Site destroyed
WA29	Thurston		1893	Exact location unknown, may refer to another Thurston Co site
		Extinct?	1995 -02	None found, most of possible habitat has been checked
WA30	Thurston		1988	Common; none observed after 1988
		Extinct	2004	None; 3 surveys
WA31	Thurston		1996	Estimate 20-50 present
			1997	4 observed

Site Code[b]	County	Current Status	Year	Survey results and notes
			2000	4 observed
			2002	30 to 40 counted, multiple surveys
			2003	30: high count of 6 surveys
		Present	2004	21: high count of 5 surveys
WA32	Thurston		1999	6-20 observed during 1 survey
			2002	7 observed during 1 survey
			2003	10: high count of 5 surveys
		Present	2004	123: high count of 3 surveys
WA33	Thurston		2002	2: 2 surveys
			2003	None: 2 survey
		Unknown	2004	None; 2 surveys
WA34	Thurston		1995	21 counted during transect count.
			1996	115 counted during transect count
			1997	131counted during transect count
			1998	9 counted during transect count
		Extinct	1999-04	None; annual surveys
WA35	Thurston		1993,'94	3 observed both years
			1997	20; high count of multiple surveys
			2000	1 observed during multiple surveys
		Extinct	2001-04	None observed during multiple surveys
WA36	Thurston		1997	6 observed
			1998	1 observed
		Extinct	1999 -04	None observed during multiple surveys
WA37	Thurston		2002	1 during 1 survey; observations grouped with WA-32 in 2002
			2003	14-20 observed during 1 survey
		Present	2004	65, peak count; 5 surveys
WA38	Thurston		2002	3 observed during 1 survey. Obs. grouped with WA-32 in 2002
			2003	25-35 counted during 1 survey
		Present	2004	15; 3 surveys

[a]Information compiled by A. Potter, with data primarily from Evergreen Aurelians, compiled by John Hinchliff; additional data from B. Bidwell, Char and Boersma (1995), A. Frost, P.Dunn, D. Grosboll, R. Hardwick, A. Lombardi, K. McAllister, A. McMillan, J. Pelham, A. Potter, R. Pyle, M. Walker.

[b]Locations of populations have been obscured to protect them from collecting.

Taylor's checkerspots at 2 historical sites, and located 7 new sites (Fig. 4.3). None were detected in recent surveys at 18 historical sites, including 5 or 6 sites that seem to have gone extinct since 1995. No *E. e. taylori* were detected at 60 additional potential sites. The 10 extant populations include 6 small populations where <25 adults were detected during surveys in 2003 or 2004, and only 4 populations where >50 adults were detected. No population estimate has been attempted because butterfly populations vary so much year-to-year, and are very difficult to estimate accurately without intrusive techniques, such as marking of individuals. Given the volatility of populations, these numbers indicate the subspecies status is precarious.

HABITAT STATUS

Past

Historically, there were over 180,000 ac of prairies and grassy balds in the Puget Sound lowlands and Willamette Valley ecoregion in Washington (Chappell et al. 2001b). Only about 9% remains in grassland, and only about 3% is still dominated by native vegetation. *E. e. taylori* was probably widespread and abundant in these prairies, and only limited by the distribution of *Castilleja* and other larval food plants and occasionally eliminated locally by fires. Additional smaller prairies or grasslands and oak woodland existed in Cowlitz, Clark, and Lewis counties, though there are no *E. e. taylori* records in Washington south of Lewis County. Many of these grassland areas were farmed very early after European settlement began and little native grassland remains. Washington *E. e. taylori* populations may have once been connected with populations in Oregon and BC, perhaps during a drier climatic period about 7,000-10,000 years ago when grassland was more extensive (Brubaker 1991). In addition to the dry glacial outwash prairie sites that are familiar from the sites that remain today, the Puget trough had many smaller mesic or seasonally wet prairies that provided a wide variety of nectar sources even if larval food plants were not present. Some of these sites were likely favored for crops and pasture early in the settlement period, and others have succeeded to forest with the cessation of regular burning. Some sites have also been degraded by the introduction of pasture grasses and reed canary grass (*Phalaris arundinacea*).

Several Washington populations of *E. e. taylori* have gone extinct in recent decades after destruction or degradation of their habitat. A site in Lakewood, Pierce County, was destroyed by the construction of a shopping mall, and the habitat at the Dupont site was lost to residential and commercial development. One site has been steadily degraded starting in the 1990s by the spreading of dairy waste; the added nitrogen benefits the alien turf grasses to the detriment of native species and *E. e. taylori* appears to be extinct there. At another site, *E. e. taylori* has not been seen since the core of it was developed as a gravel pit. Certain Clallam County sites have been degraded by the construction of roads, communication facilities, and past use for log landings. Known loss of prairie habitat on Fort Lewis since Euro-American settlement includes the loss of 6,500 ac to development and 10,500 ac that succeeded to Douglas-fir forest (ENSR 2000).

Development or loss of habitat by the invasion of Douglas-fir, Scotch broom, and exotic turfgrasses and weeds has also been a common fate of many of the historic sites in British Columbia and Oregon. Development has eliminated most of the suitable habitat on Vancouver Island, and weed invasion and trampling in park sites has degraded what little remains (Guppy et al. 2003, Miskelly 2003). The cause of extinction for the Hornby Island population is unclear; Miskelly (2003) suggested that forest encroachment had reduced the extent and quality of habitat, but J. Shepard (pers. comm.) notes that the *E. e. taylori* population occurred in a strip of several acres, and the Douglas-firs appeared to be old.

The decline of *E. e. taylori* somewhat parallels the decline of golden paintbrush. Golden paintbrush is a possible larval host plant that was formerly widespread on glacial prairies and steep coastal headlands from the Willamette Valley of Oregon to southeastern Vancouver Island (USFWS 2000). Many golden paintbrush populations went extinct because the habitat was converted to agriculture, residential, or commercial development. Golden paintbrush is now found on only 9 sites in Washington

and 2 sites in British Columbia (Douglas and Ryan 1999); it is extinct in Oregon (USFWS 2000).

Present

There is little high quality *E. e. taylori* habitat remaining, and most remaining sites are small or seriously degraded by past or ongoing factors. *E. e. taylori* are not present on most of the remnant native prairie sites, possibly due to disturbances that caused excessive mortality, degradation of habitat and loss of larval food plants, or perhaps related to the lack of immigration and inbreeding resulting from increased isolation of habitat patches. Of the sites where *E. e. taylori* still occur, approximately two thirds are owned and managed by public agencies, but only 2 are dedicated primarily to conservation. Most of the publicly owned sites are subject to conflicting uses that can produce moderate to high levels of disturbance to butterflies or the vegetation. Potential threats on publicly-owned sites include wildfire, disturbance of vegetation, crushing of eggs, larvae, or adults, and mortality of host plants from herbicide for weed control. Private sites are at risk to development or habitat destruction of various sorts. Even where conservation is a priority, prairie vegetation will become degraded without control of invasive plants, particularly Scotch broom, with mowing, hand removal, burning, and herbicides.

Five sites where *E. e. taylori* went extinct in the last 10 years are public lands of Conservation Status 1 or 2 (Cassidy et al. 2001); these five sites are among sites considered potential reintroduction sites.

LEGAL STATUS

Federal. Taylor's checkerspot became a candidate for listing under the Endangered Species Act in 2001 (USFWS 2001).

State. Taylor's (Whulge) checkerspot became a candidate for listing as sensitive, threatened, or endangered in Washington State in 1991.

Oregon. Taylor's checkerspot is considered critically imperiled by the Oregon Natural Heritage Program (Pyle 2002).

British Columbia. Taylor's checkerspot is provincially red-listed in British Columbia. The species is also nationally listed as Endangered by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) and protected under the federal Species at Risk Act (http://www.speciesatrisk.gc.ca/).

MANAGEMENT ACTIVITIES

Surveys

In British Columbia, all the Gulf Islands and Saanich Inlet have been searched for extant populations of *E. e. taylori* (Guppy et al. 2003), and a search at Helliwell Provincial Park on Hornby Island was conducted in 2003 (J. Heron, pers. comm.). In Oregon, the Xerces Society sponsored surveys of the existing populations and searches for additional populations in 2003 and 2004, and plans to continue in 2005. Most known populations of *E. e. taylori* in Washington are surveyed annually by WDFW, TNC or Fort Lewis personnel. There are 3-4 historical sites that still need to be surveyed to determine if the species is still present. Many additional potential sites were surveyed for *E. e. taylori* in spring 2004.

Research

Washington. Several research projects have been or are being conducted with cooperation between WDFW, TNC, and Fort Lewis. These include investigating methods of controlling Scotch broom and introduced turf-grasses, and the propagation of native prairie plants (see Research in Chapter 1). Char and Boersma (1995) conducted research on the impact of habitat fragmentation on south Puget Sound prairie butterflies. Hays et al. (2000) investigated habitat components of several prairie butterflies and made key observations of the use of larval host and nectar plants. In addition, preliminary research has been conducted on captive rearing of *E. e. taylori*, the propagation of *Castilleja hispida,* and experimental plantings of host plants to increase their abundance at sites (D. Grosboll, pers. comm.). In 2004 and 2005, *E. e. taylori* larvae were brought to the Oregon Zoo for captive rearing. The

goal of the project is to develop practical husbandry protocols for the butterfly and its host plants.

British Columbia. James Miskelly recently completed a M.S. thesis at the University of Victoria that focused on identifying critical components of suitable habitat and potential sites for habitat restoration in BC (Guppy et al. 2003, J. Miskelly, pers. comm.).

Miscellaneous Activities

British Columbia recovery activities. A National Recovery Strategy is in preparation for the British Columbia Ministry of Water, Land and Air Protection that incorporates the recovery of Taylor's checkerspot with the island marble (*Euchloe ausonides insulanus*) and 7 plants. This strategy, entitled *Maritime Meadows Strategy*, will emphasize the habitat as well as the species (J. Heron, pers. comm.). The Strategy will presumably include reintroductions possibly using individuals from Oregon or Washington. There is also a draft Recovery Strategy for Garry Oak and Associated Ecosystems and their Associated Species at Risk in Canada, 2001-2006 (Garry Oak Ecosystems Recovery Team 2002) which includes Taylor's checkerspot among >90 associated species. The Strategy outlines planning and tasks needed for species recovery planning, conservation, and habitat protection and restoration that will improve grassland habitat where adjacent or intermixed with oak.

Habitat acquisition. There are no immediate plans to acquire private lands that host extant *E. e. taylori* populations. Some prairie sites being acquired for the conservation of other species formerly supported *E. e. taylori* populations and have potential for habitat improvement and reintroductions. Several acquisitions underway or being discussed may eventually benefit *E. e. taylori* by providing reintroduction sites, including West Rocky Prairie, South Weir, the expansion of Mima Mounds NAP, and the easement on the Cavness ranch. The core of the largest remaining population in Oregon is on private land. This population may be an essential source for future captive breeding and reintroductions. Discussions have been initiated with the landowners and a local land trust in hopes of acquiring a conservation easement or title to this site (S. Hoffman-Black, pers. comm.).

FACTORS AFFECTING CONTINUED EXISTENCE

Adequacy of Existing Regulatory Mechanism

In general, invertebrates are not well protected by current law. About 20% of European butterflies and perhaps 15% in the U.S and Canada are imperiled in all or part of their range (Hanski et al. 2004). Distinct population segments of vertebrates can be listed under the Endangered Species Act, but invertebrates cannot be listed unless an entire subspecies or species is imperiled. Similarly under state law, subspecies of wildlife can be state listed, but populations cannot. Taylor's checkerspot is a recognized subspecies, although as research on *E. editha* in California has found, populations or ecotypes may be more biologically relevant than the named subspecies.

Taylor's checkerspot is not currently listed as protected wildlife in Washington or as a federal Endangered species, so it is not protected from direct harm. More importantly for a butterfly, its habitat is not well protected. Both state and federal regulations are inadequate for protecting habitat, particularly habitat patches in which the species is temporarily extinct. Patch occupancy in a metapopulation varies, but for a variety of taxa, ≥20% of the patches are unoccupied at any particular time (Wahlberg et al. 2004). *Melitaea cinxia* in Finland is found among 4,000 habitat patches, but only 300-500 (≈10%) are simultaneously occupied (Murphy et al. 2004). Of 1,452 habitat patches monitored since 1993, only 33 (3.9%) were continuously occupied from 1993-2001 (Nieminen et al. 2004). Federal critical habitat designation after listing may help protect unoccupied habitat on federal lands, but it does not necessarily protect sites on private land and does not require proactive recovery actions. The loss of these patches to development prevents movement and re-colonizations between the remaining extant populations and dooms them to extinction. As

40 years of research on Edith's checkerspot in California has shown, even small patches of habitat can be essential for maintaining demographic and genetic connections between populations. Loss of habitat patches that are temporarily vacant results in further isolation of extant populations which can lead to their extinction.

State and county. Taylor's checkerspot is not currently protected by state law, but direct take would be forbidden if the species is listed. However, take resulting from habitat alteration may be difficult to prove. As a state candidate and Species of Concern, some counties offer some protection by requiring review and mitigation for impacts due to proposed development projects. Habitat that supports populations of *E. e. taylori* is protected by critical area ordinances in Pierce and Thurston counties, and would be protected in Clallam and Island counties if the species is listed. Lewis County code currently requires that WDFW show that the species would be expected to persist on the site after full urbanization (20-year buildout) for the county to impose conditions.

Impacts of Habitat Loss and Fragmentation

> "…a species will go regionally extinct when the amount of suitable habitat in the fragmented landscape falls below a threshold value. Below the threshold, fragments of suitable habitat are so few or small that the rate of extinction will exceed the rate of reestablishment even when most habitat fragments are unoccupied and there seems to be potential for metapopulation growth." (Hanski et al. 2004)

Direct habitat loss is the most frequent threat to butterfly populations (New et al. 1995). Butterfly populations are also affected by the increasingly fragmented nature and degraded condition of remaining habitat patches. The size and shape of habitat patches can be the most important determinant of emigration rates, so emigration rates may be high in highly fragmented landscapes (Ries and Debinski 2001). High emigration rates in severely fragmented landscapes may have a negative effect on populations because the likelihood of encountering another suitable patch may be very small (Ries and Debinski 2001). If *E. e. taylori* are more likely to emigrate from low density patches, re-establishing populations after extirpation may be difficult because initial density would probably be low.

Implications of metapopulation structure and small population sizes. Loss of habitat patches and fragmentation can upset the stability of metapopulations and cause a long series of extinctions that characterize a decline. Apparently as a result of this phenomenon, butterfly extinction rates in British nature reserves have been almost as high as in the surrounding landscape (Thomas and Hanski 1997). Some currently existing metapopulations may be doomed to extinction even without further loss of habitat because the size and distribution of remnant patches do not support adequate numbers of migrants to populations in the smaller more isolated and lower quality patches. Small stepping stone patches of habitat may be required to maintain populations in what have become isolated reserves. However, as patches become more isolated and habitat is fragmented, many of the remaining populations are, at least in some years, very small. In small populations, a substantial fraction of females may remain unmated (Nieminen et al. 2004).

Extant populations of *E. e. taylori* in Washington likely are the remnants of one or more metapopulations that historically had many more large populations. Though several local extinctions are known to have been the result of habitat destruction, or chronic degradation or disturbance, several others have no obvious cause. These extinctions may have resulted from severe weather, host plant defoliation, or other processes, and we assume that historically these sites would have been re-colonized. However, with habitat loss the remaining sites are increasingly isolated and natural re-colonization may no longer be possible. Hellmann et al. (2004) suggested that for a metapopulation of extinction-prone, but well connected local populations to be viable, it should be represented by at least 15-20 habitat patches. There may be no remaining metapopulations of *E. e. taylori* with that many suitable habitat patches remaining. Small populations are at high risk of extinction due to habitat factors, weather extremes, increased mortality due to human impacts, and inbreeding. Without management inter-

vention many of these sites will not be re-occupied. As Hanski and Ovaskainen (2002) stated:

> "In the case of landscapes that have recently experienced substantial habitat loss and fragmentation, it would be a fatal mistake to assume that all extant species would have viable populations if any additional loss and fragmentation of the habitat were to be prevented. The only way to save such "living dead" species is to improve the quality of the landscapes for these species"

Maintaining the status quo for Taylor's checkerspot may not be a viable option; the choices may be recovery of a larger more widespread metapopulation through habitat protection, improvement and restoration, or a rather quick spiral to extinction.

Consequences of inbreeding. Small populations can experience a loss of genetic diversity. Genetic factors such as inbreeding can play an important role in the decline and extinction of local populations, though demography and environmental factors may often be the primary causes. Ehrlich (1992) did not believe that inbreeding depression was likely to be a major concern in endangered butterfly populations because tiny populations probably rarely persist for many generations. However, recent studies indicate that the likelihood of extinction for small populations can be increased as a result of inbreeding. Studies of a metapopulation of *Melitaea cinxia* in Finland showed that an increased risk of extinction was associated with small population size, lower density of occupied patches in the area, lower flower abundance, and lower heterozygosity (Saccheri et al. 1998). Inbreeding caused a low hatching rate of eggs, reduced survival of larvae, and reduced adult longevity in *M. cinxia* (Saccheri et al. 1998, Nieminen et al. 2001). The lower longevity of adults was expected to impact reproduction because females lay up to 7 batches of eggs, but females can only lay 1 batch per day of favorable weather. *M. cinxia* larvae are gregarious and cooperatively spin a web nest in which the larvae overwinter. Inbreeding was associated with more weakly constructed nests and reduced winter survival (Nieminen et al. 2001). Saccheri et al. (1996) also reported that inbreeding reduced the egg hatching rate in another butterfly, *Bicyclus anynana*. Inbreeding depression has not been reported in *E. editha*, but some populations of *E. e. taylori* are small enough that reduced genetic diversity and inbreeding depression may be a problem. Saccheri et al. (1998) reported that heterozygosity was low in populations that had been reduced to <5 larval groups of *M. cinxia* the previous year; each larval group was 50-250 offspring from a female. Saccheri et al. (2000) recommended that captive breeding of butterflies should include at least 10 unrelated pairs to avoid marked inbreeding depression, based on experiments using *Bicyclus anynana*.

Habitat Degradation

The introduced weed, Plantago lancolata*: beneficial resource or ecological trap?* Larvae of the bay checkerspot in California feed on both a *Castilleja* spp. and *Plantago erecta*, a native annual. In drought years, *P. erecta* senesces early, resulting in very high mortality in populations that rely on it. In contrast, *Plantago lanceolata* in Washington is an introduced, weedy perennial that often senesces later than the native hosts, and during some years remains green throughout the summer. Some populations of *E. e. taylori* have adapted to feed on *P. lanceolata*. Adapting to feed on a widespread weed that remains edible much longer than other hosts would seem like a significant advantage. However, the abnormally low mortality of pre-diapause larvae that probably results may produce population explosions of *E. e. taylori* that outstrip the food supply, and result in local starvation and extinction. This phenomenon may be aggravated by the sedentary nature of *E. e. taylori* and differences in the distribution pattern of native hosts vs. the weedy *P. lancolata* (D. Grosboll, pers. comm.). If native plants were clumped and relatively rare, then dispersal may have normally been a poor strategy, but being sedentary might be a poor strategy for a species that feeds on a widely distributed, long lasting weed species, such as *P. lanceolata* (D. Grosboll, pers. comm.). This hypothesis was formed after the observation that at least 2 of the populations in Washington that were thought to be feeding only on *Plantago* have gone extinct in the last several years after 1 or more years of extraordinary abundance (A. Potter, unpubl. data). In one case (site WA-12), adults were extraordinarily abundant in 1997, with an estimate of 7,000 seen in a single day.

In early May 1998, observers saw few adults and had difficulty locating any *P. lanceolata*, except a few tiny individuals. *P. lanceolata* presumably had been severely reduced by the extraordinary number of larvae produced in 1997, most of which likely starved (A. Potter, pers. comm.). Another factor that may be important is that 1997-98 included an extreme El Niño event that resulted in severe drought conditions in summer 1998. However, the severe drought conditions were not evident until after the 1998 flight period when a population crash was already evident. If adaptation to *P. lanceolata* allows extraordinary survival that results in local population booms and busts, the dynamics of *E. e. taylori* metapopulations may be more unstable, reducing the prospect for survival. These questions need to be investigated to help direct conservation and habitat restoration efforts.

Succession to Douglas-fir forest. Vegetation dynamics and other habitat changes are likely the most common cause of local extinction for medium-sized and larger populations of butterflies (Thomas and Hanski 1997). The cessation of burning by Native Americans and successional processes have allowed Douglas-fir and native shrubs to become established on large portions of historic prairies, including over 10,000 ac on Fort Lewis. Forest encroachment in British Columbia may have caused *E. e. taylori* to be restricted to only dry meadows that resisted invasion by trees (J. Miskelly, pers. comm.), although J. Shepard (pers. comm.) states that the next to the last population was on a mesic site.

Scotch broom and other invasive non-native plants. Scotch broom and other invaders displace and compete directly with native plants, obscure nectar plants from foraging adults, and result in hotter fires than those that occurred historically. Scotch broom also is a nitrogen fixer, and the added nitrogen may facilitate invasion by other exotic plants even after the broom has been removed. Nitrogen fallout from air pollution has degraded *E. e. bayensis* habitat patches in California (Weiss 1999). The invasion of Scotch broom is believed to have caused the extinction of 2 or more populations of *E. e. taylori* in BC (Shepard 2000). Tall oat grass has recently become a serious problem on some prairie sites that requires control to prevent the loss of native vegetation.

Military Training

Military training on Fort Lewis may negatively impact *E. e. taylori* and its habitat. Vehicle traffic likely results in direct mortality by crushing of eggs, larvae, pupae, and adults, and may damage host plants and have a significant impact on the local population. In addition to direct mortality, mechanized training can do substantial damage to the native vegetation and can facilitate invasion by exotic turf-grasses and noxious weeds. The Land Rehabilitation and Maintenance program on Fort Lewis monitors the condition of training areas and damage to vegetation, rehabilitates affected areas, and conducts weed control. Scotch broom control that is done on Fort Lewis to maintain open fields for training can benefit butterflies if it is conducted in ways that minimize damage to the native vegetation and mortality of butterflies. Fires caused by vehicles or explosive ordnance can cause direct mortality to eggs, larvae, and pupae, and a large fire could eliminate a local population. Infrequent low intensity fire benefits the native vegetation. Restrictions on training and access to some prairie sites on Fort Lewis are beneficial to butterflies and other prairie species.

Recreation and Other Human-related Factors

The greatest challenge for restoration of *E. e. taylori* habitat may be to integrate the needed activities with the numerous other public uses, especially recreational (Guppy et al. 2003). Off-road driving and horse-back riding on prairies has become another potential source of mortality for eggs, larvae and pupae. Fort Lewis prairies that have had Scotch broom removed inadvertently become more attractive for these activities, although some prairies are off-limits to vehicular traffic. All butterfly life stages and host plants are vulnerable to being crushed. Dog-trials involving horses have been a problem on certain WDFW lands; though riders are supposed to remain on marked trails, compliance has occasionally been poor with some riders straying off trails into areas where prairie restoration is underway. At one site horses trampled much of the area containing *Castilleja hispida* and

may have speeded the extirpation of the *E. e. taylori* population.

Weather and Climate Change

Weather has a direct effect on butterfly populations. For example, the amount of sunshine or windy days limits the time available for flying and affects the size of the following generation through the number of eggs deposited (Hellmann 2002b). Extreme weather events can eliminate local populations. Drought resulted in the extinction of some *E. editha* populations in California (Singer and Ehrlich 1979). A severe summer frost killed the host plants of a subpopulation of *E. editha* resulting in the extinction of the subpopulation (Thomas et al. 1996). Ehrlich et al. (1972) reported that a rare June snowstorm in a Colorado study area eliminated one species and severely reduced populations of several other species for at least several years.

Changes in regional climate, whether caused by human or natural factors, can benefit some butterfly species while increasing the likelihood of extinction for others. Climate change may impact butterfly populations in several ways, including affecting the nutrient content and palatability of host plants, the timing of host plant availability, and the vulnerability of butterflies to predators and parasites (Hellmann 2002b). The generalist sachem skipper (*Atalopedes campestris*) has expanded its range >700 km northward from California into central Washington in the last 35 years (Crozier 2002). Crozier's (2002) study suggested that the range expansion has been due to a warming trend, and each step in the range expansion coincided with unusually warm summers. Specialist species, like *E. e. taylori,* are less likely to benefit from increased temperature, and more likely to be negatively affected by changing climate. This is particularly true for species that are found only in reserves or small remnants of habitat (Hellmann 2002b). In Great Britain, half of mobile generalist butterfly species have expanded their ranges northward in the last 30 years, but 89% of habitat specialists have declined due to habitat loss and fragmentation (Warren et al. 2001).

Several experiments have shown that increased CO_2 results in a greater proportion of carbon to water and nutrients, including nitrogen, and slows the growth of herbivores (Hellmann 2002b). Greenhouse experiments by Hellmann (2002a) suggested that increased temperature (3.3º C) alone would not hurt *E. e. bayensis* populations if larvae still had access to *Castilleja*, but might lead to extinctions of populations dependent on *Plantago,* unless they were able to compensate by earlier emergence.

McLaughlin et al. (2002) reported an increase in the variability of growing-season rainfall after 1971, which likely caused the extinction of 2 populations of bay checkerspot. They suggested that extremes in annual precipitation reduced the development overlap of larvae and host plants leading to wide population fluctuations. The butterfly populations were unable to survive the climate change because habitat loss had reduced them to small insular populations (McLaughlin et al. 2002). Parmesan (1996) presented data showing a correlation of extinction in *E. editha* populations in western North America with lower latitude and altitude, presumably related to increased global temperatures. However, the correlation was dependent on low rates of extinction in Canada and at high elevations, where habitat disturbance may have affected fewer habitat patches. Shepard (2000) indicated that for *E. e. taylori*, none of the known extinctions seem to be related to climate change, but were all caused by habitat loss or degradation.

Insecticides and Herbicides

Pest eradication and weed control projects pose a risk to Taylor's checkerspot populations. Herbicides can be detrimental to butterfly populations in farming and industrial forest areas if they affect host and nectar plants, and some may be toxic to larvae or adults. Drift from roadside spraying of weeds adjacent to preserves could affect *E. e. taylori* habitat and populations. Roadside herbicide spraying has been observed at one prairie site (WA9) where *E. e. taylori* now appears to be extinct (R. M. Pyle, pers. comm.).

Gypsy moth eradication with Btk. The European gypsy moth (*Lymantria dispar*) is an alien pest that causes widespread defoliation of trees in

the northeastern U.S. and was first detected in Washington in 1974. The Asian gypsy moth was first detected in Washington in 1991(WSDA 2004). The Asian variety poses a greater danger to Pacific Northwest forests because it is able to spread more quickly and is more inclined to eat conifer foliage than the European variety (WSDA 1992, 2004). *Btk* has become the most commonly used method of eradicating gypsy moths. Although spraying *Btk* is detrimental to many Lepidoptera, the defoliation that would result if gypsy moths became established would also suppress Lepidoptera and likely have a much greater negative ecological impact (Sample et al. 1996). A viral insecticide, Gypchek®, which affects only gypsy moths has been developed, but it is much more expensive to use than *Btk* and is only available in limited quantities (Michigan Dept. of Agriculture and the U.S.D.A. Forest Service 2000).

The use of *Btk* at south Puget Sound sites where Taylor's checkerspot is found could result in extinction of local populations. *Btk* is a pesticide spray containing a suspension of bacteria (*Bacillus thuringiensis* var. *kurstaki*) that is widely used against forest and garden pests. It is effective against Lepidoptera larvae that ingest foliage to which it has been applied. It is often aerially applied over large areas during outbreaks of defoliating pests, including spruce budworm (*Choristoneura occidentalis*), Douglas-fir tussock moth (*Orgyia pseudotsugata*) and gypsy moths. Lepidoptera species vary in their sensitivity to *Btk* and early instar larvae are generally more sensitive that late instar larvae. The exposure of *Btk* to rain and sunlight reduces the duration of its effectiveness. Most studies report much reduced effectiveness a week after application, but some studies reported significant mortality at 16 days (Reardon and Haissig 1984), 30 days (Johnson et al. 1995), and 60 days (Miller 1990). Several studies report reductions in the abundance and species richness of non-target Lepidoptera in treated areas (Miller 1990, 2000, Crawford et al. 1993, Sample et al. 1996, Johnson et al. 1995, Wagner et al. 1996, Peacock et al. 1998, Boulton et al 1999). Reductions in non-target Lepidoptera populations can last for 1-2 years or longer (Sample et al 1996, Whaley et al. 1998, Miller 1990, 2000). In Utah, the density of Ridings' satyr (*Neominois ridingsii*) had not recovered to pre-treatment levels 6 years after treatment (Whaley et al. 1998).

Gypsy moth eradication projects are the most likely *Btk* applications to affect *E. e. taylori* because outbreaks typically occur in the lower elevation areas of western Washington where spruce budworm and tussock moth outbreaks have generally not been a problem. Guppy and Shepard (2001:37) predicted that the spraying of *Btk* to control gypsy moths will, "inevitably have a severe impact on, and likely extirpate, many of the Lepidoptera of conservation concern on southern Vancouver Island." Gypsy moth spray projects in the Pacific Northwest have eradication as the objective, so higher doses of *Btk* are sprayed up to 3 times in a season. Spray projects for native pests, like spruce budworm, often involve single applications of *Btk* because they are designed to suppress populations to minimize defoliation, rather than completely eradicate populations. Spray projects typically buffer sites such as meadows with sensitive species, but the spray can drift long distances away from the target area, especially in rugged terrain. Whaley et al. (1998) reported that spray drift affected survival of some Lepidoptera 3,000 m from the target area, and a 10 ha exclusion plot failed to protect Ridings' satyr from drift. The WSDA conducted the first Washington Asian gypsy moth spray program in 1992. The large 1992 aerial application treatment area (116,457 ac), included portions of King and Pierce counties and was <1/2 mi from Taylor's checkerspot sites WA14 and WA17 and within 3 mi of sites WA13 and WA15 (WSDA 1992). It is not known if these sites were occupied by checkerspots in 1992, or immediately after the *Btk* treatments, but checkerspots are now extinct at these sites. WSDA subsequently detected and treated introductions of the Asian gypsy moth near shipping port facilities in 1994-95, 1995-96, 1996-97, 1997-98, and 1999-2000 (WSDA 2004). Localized incipient western Washington populations of European gypsy moths have been found and treated over the last 25 years.

Populations of common non-target Lepidoptera usually recover or re-colonize a treated area, but rare species are at risk of extinction. Crawford et al. (1993), who surveyed for moths before and after the 1992 gypsy moth spray project in Pierce and King

counties, reported that 3 moth species seemed to be eradicated from the spray area (along with gypsy moths). Two of these were common, widespread species that would be expected to recolonize the area, but one rare Noctuid (*Protorhodes rufula*) may have been extirpated from the Puget Sound area entirely.

Boulton (2003) reported that nontarget Lepidoptera species in Oregon white oak remained reduced in treatment plots by 52.9% 4 years after 1999 *Btk* application on Vancouver Island. Species richness was reduced by 77% the first year (Boulton et al. 1999). The total number of caterpillars was reduced by 84% compared to controls one year after treatment. There were also numerous species (16 in 1999, 17 in 2000, and 7 in 2003) that were collected in control plots, but were absent from treatment plots. Boulton et al. (1999) suggested that some species may have been eliminated from the sprayed area. Whaley et al. (1998) recommended the use of Gypchek® instead of *Btk* around sites where sensitive species are found.

Collecting and Research

Collecting and research have the potential to impact populations of Taylor's checkerspot and other rare butterflies. Collecting of voucher specimens to document previously unknown populations is important and necessary, and should continue by permit if the subspecies is state listed. Butterfly collecting is normally not harmful to populations because females produce an abundance of eggs and most adults collected will have mated and contributed some genetic material to the next generation. The variation in timing of eclosion also means that a single collecting visit to a site would normally only eliminate a small fraction of the adult cohort of the season. Habitat destruction or degradation is a much more significant and common factor in the decline and extinction of butterfly populations. However, when populations become very small and isolated, killing of even a single female could hasten the extinction of a population. Rare butterflies may also be subjected to impacts from unscrupulous collectors and commercial exploitation (New 1997). A small fraction of collectors believe that their own activity will not harm small populations, but they fail to consider the cumulative impacts of all like-minded individuals. This phenomenon has necessitated restricting the publication of location data for some federally listed plants and insects (T. Thomas, pers. comm.). This is also the reason that the site locations of extant populations are obscured in this report.

Research projects that do not carefully consider the impacts of trampling, capture, handling, marking, and releasing butterflies can impact small populations. A University of Washington project on Fort Lewis may have negatively impacted a population of *E. e. taylori* that declined precipitously coincident to the research and it is now extinct (Remsburg 1998, 2000). The research involved capturing hundreds of checkerspots, marking them with ink markers, and releasing them from a central point to determine how far they would disperse. The project was discontinued in 1998 at the request of the Army (Remsburg 2000). New (1997:98) stated, "it is particularly important not to release a number of individuals captured over a considerable area at only one point." This could concentrate egg-laying and result in defoliation of host plants and starvation of larvae. Studies of several species suggest that marking did not seem to affect them, but handling affected survival (Morton 1982). A massive mark and recapture study on the Jasper Ridge population of bay checkerspots may have hastened the population's extinction (McGarrahan 1997). Handling of small delicate species can result in >10% mortality and disrupted behavior (Murphy 1988). Research involving limited capture and handling of *E. e. taylori* will be needed in the future, and recovery will necessitate capturing individuals for captive rearing and translocations, but impacts should be considered carefully. Research methods which do not require handling should be used whenever possible.

CONCLUSIONS AND RECOMMENDATION

Taylor's checkerspot, a regional endemic subspecies of Edith's checkerspot, was once probably widespread and abundant on the prairies of western

Washington. It is the rarest butterfly associated with western Washington prairies, which are among the most endangered ecosystems in North America.

Taylor's checkerspot is known historically from 38 sites in Washington, but now persists at only about 10 sites on various native grassland types around the Puget Sound area. The subspecies is restricted to 2 sites in Oregon and 1 site in British Columbia. The center of abundance for the species in Washington was the glacial outwash prairies of the south Puget Sound area; only about 8% of that habitat remains as grassland, and perhaps 2% is still dominated by native species. Most of the prairie habitat has been lost to residential and commercial development, planted with exotic sod-forming grasses, or succeeded to Douglas-fir forest. Many of the prairie sites that remain are rapidly being degraded by Scotch broom, exotic grasses, and forbs. Checkerspots have recently gone extinct at several sites for unknown reasons, but human disturbance, habitat degradation, and perhaps the lack of immigration between increasingly isolated sites may all have had a role in the extinction of these populations.

Although two-thirds of the known sites are on public lands, most of these are subject to conflicting uses. Military training activities disturb vegetation and in some areas result in frequent fires; although periodic fires help maintain prairie vegetation, they may threaten checkerspot populations and frequent fires can suppress native vegetation. Several of the sites are subject to recreational impacts that can damage vegetation and result in mortality to checkerspots. The existing sites require management to maintain the prairie vegetation using methods that do not eliminate the butterflies. The small isolated checkerspot populations are not likely to persist long without restoration of additional sites to facilitate immigration between populations, to allow recolonization of vacant sites, and to avoid the effects of inbreeding.

For these reasons, we recommend that Taylor's checkerspot be listed as endangered in the State of Washington.

LITERATURE CITED

ACOE (Army Corps of Engineers). 2003. Columbia River Channel Improvements Project: Final Supplemental Integrated Feasibility Report and Environmental Impact Statement. U.S. Army Corps of Engineers, Portland, Oregon.

Agee, J. K. 1993. Fire Ecology of Pacific Northwest Forests. Island Press, Washington, D.C. 493 pp.

Altman, B. 1999. Status and conservation of state sensitive grassland bird species in the Willamette Valley. Unpublished Report for the Oregon Department of Fish and Wildlife, Corvallis, Oregon. 60 pp.

Altman, B. 2003a. Horned lark. Pp. 425-428 *in* D. B. Marshall, M. G. Hunter and A. L. Contreras (eds.). Birds of Oregon: a General Reference. Oregon State University Press, Corvallis, Oregon. 768 pp.

Altman, B. 2003b. Prairie Management Plan for the Fort Lewis Military Installation. Report Prepared for U.S. Army, Fort Lewis Military Installation, Environmental and Natural Resources Division, Wildlife Branch, and The Nature Conservancy, Washington State Office.

Altman, B., M. Hayes, S. Janes, and R. Forbes. 2001. Wildlife of westside grassland and chaparral habitats. Pp 261-291 *in* D. H. Johnson and T. A. O'Neil (dirs.). Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, Oregon. 768 pp.

Andersen, D. C. 1978. Observations on reproduction, growth, and behavior of the northern pocket gopher (*Thomomys talpoides*). Journal of Mammalogy 59:418-422.

Andersen, D. C. and J. A. MacMahon. 1981. Population dynamics and bioenergetics of a fossorial herbivore, *Thomomys talpoides* (Rodentia: Geomyidae), in a spruce-fir sere. Ecological Monographs 51:179-202.

Andersen, D. C. and J. A. MacMahon. 1985. Plant succession following the Mount St. Helens volcanic eruption: facilitation by a burrowing rodent, *Thomomys talpoides*. American Midland Naturalist 114:62-69.

Andersen, D. C., J. A. MacMahon, and M. L. Wolfe. 1980. Herbivorous mammals along a montane sere: community structure and energetics. Journal of Mammalogy 61: 500-519.

Anonymous. 2001. South Puget Sound Prairies Site Conservation Plan DRAFT June 2001. The Nature Conservancy, WDNR, WDFW, USFWS.

Anthony, J. L. 1987. The Snowy Plover and Biopolitics at Damon Point, Washington. MES Thesis, The Evergreen State College, Olympia, Washington. 106 pp.

A.O.U. (American Ornithologists' Union). 1957. Check-List of North American Birds. 5th edition. American Ornithologists' Union, Washington, D.C.

A.O.U. (American Ornithologists' Union). 1998. Check-List of North American Birds. 7th edition. American Ornithologists' Union, Washington, D.C.

Austen, G. T. and D. D. Murphy. 1998. Patterns of phenotypic variation in the *Euphydryas chalcedona* complex (Lepidoptera: Nymphalidae) of the southern intermountain region. Pp. 419 - 432 *in* T. C. Emmel (ed.). Systematics of Western North American Butterflies. Mariposa Press, Gainesville, Florida. 878 pp.

Bailey, V. 1915. Revision of the pocket gophers of the genus *Thomomys*. North American Fauna 39:1-136. (Not seen, cited in Verts and Carraway (2000).

Bailey, F. M. 1917. Handbook of the Birds of Western North America. Houghton Mifflin Company, Boston. 573 pp.

Baker, R. J., R. D. Bradley, and L. R. McAliley, Jr. 2003. Pocket gophers. Pp. 276-287 *in* G. A. Feldhamer, B. C. Thompson, and J. A. Chapman (eds.). Wild Mammals of North America: Biology, Management, and Conservation. (2nd ed.) Johns Hopkins University Press, Baltimore, Maryland. 1,232 pp.

Bakus, G. J. 1965. Avifauna of San Juan Island and Archipeligo, Washington. Allan Hancock Foundation, University of California, Los Angeles. 36 pp.

Bandoli, J. H. 1981. Factors influencing seasonal burrowing activity in the pocket gopher, *Thomomys bottae*. Journal of Mammalogy 62:293-303.

BASH (Bird/Wildlife Aircraft Strike Hazard Team). 2004. Top 50 USAF Wildlife Strikes by Count. Aviation Safety Division, U. S. Air Force. (http://afsafety.af.mil/ AFSC/ Bash/stats/web_spec_count_stat.html).

Barnes, Jr., V. C., P. Martin, and H. P. Teitjen. 1970. Pocket gopher control on Oregon ponderosa pine plantations. Journal of Forestry 68:433-435.

Beason, R. C. 1995. Horned Lark (*Eremophila alpestris*). Birds of North America No. 195. A. Poole and F. Gill (eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C. 24 pp.

Beason, R. C. and E. C. Franks. 1974. Breeding behavior of the horned lark. Auk 91:65-74.

Beauchesne, S. M. and J. M. Cooper. 2003. COSEWIC assessment and update staus report on the Horned Lark *strigata* subspecies *Eremophila alpestris strigata* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 23 pp.

Behle, W. H. 1942. Distribution and variation of the horned larks (*Otocoris alpestris*) of western North America. University of California Publications in Zoology 46:205-316.

Bent, A. C. 1963. Life Histories of North American Flycatchers, Larks, Swallows, and their Allies. (Dover Edition of Bulletin 179 of the U. S. National Museum, Smithsonian Institution, Washington, D.C., 1942) Dover Publications, New York.

Berg, A. W. 1990. Formation of Mima mounds—a seismic hypothesis. Geology 18:281-284.

Bevis, K. R., J. E. Richards, G. M.King, and E. E. Hanson. 1997. Food habits of the northern spotted owl (*Strix occidentalis caurina*) at six nest sites in Washington's east Cascades. Pp. 68-73 *in* J. R.Duncan, D. H. Johnson, and T. H. Nichols (eds.). Biology and Conservation of Owls of the Northern Hemisphere: 2nd International Symposium, 5-9 February 1997, Winnipeg, Manitoba. General Technical Report NC-190, USDA Forest Service, North Central Research Station. 635 pp.

Bock, C. E. and B. Webb. 1984. Birds as grazing indicator

species in southeastern Arizona. Journal of Wildlife Management 48:1045-1049.

Boggs, C. L. and M. Nieminen. 2004. Checkerspot reproductive biology. Pp. 92-111 *in* Erhlich and Hanski (2004a).

Booth, E. S. 1947. Systematic review of the land mammals of Washington. Ph.D. Dissertation, State College of Washington, Pullman, Washington.

Boughton, D. A. 1998. Ecological and behavioral mechanisms of colonization in a metapopulation of the butterfly *Euphydryas editha*. Ph.D. Dissertation, University of Texas, Austin, Texas. (Not seen, cited in Singer and Hanski 2004).

Boughton, D. A. 1999. Empirical evidence for complex source-sink dynamics with alternative states in a butterfly metapopulation. Ecology 80:2727-2739.

Boulton, T. J. 2003. Non-target Lepidoptera on southern Vancouver Island: field assessment at four years after the 1999 gypsy moth eradication program. Final Report. 44 pp.

Boulton, T. J., D. A. Rohlfs, and K. L. Halwas. 1999. Non-target Lepidoptera on southern Vancouver Island: field assessments during a gypsy moth eradication program involving three aerial applications of *Btk*. 117 pp.

Bowles, J. H. 1898. Notes on the streaked horned lark. Osprey 3:53-54.

Bowles, J. H. 1900. Nesting of the streaked horned lark. Condor 2:30-31.

Bowles, J. H. 1906. A list of the birds of Tacoma, Washington, and vicinity. Auk 23:138-148.

Boyd, R. 1986. Strategies of Indian burning in the Willamette Valley. Canadian Journal of Anthropology 5:65-86.

Boyd, R. L. 1976. Behavioral biology and energy expenditure in a Horned Lark population. Ph.D. Dissertation, Colorado State University, Fort Collins, Colorado. (Not seen, cited in Beason 1995).

Brennan, L. A., and W. P. Kuvlesky, Jr. 2005. North American grassland birds: an unfolding conservation crisis? Journal of Wildlife Management 69:1-13.

Brubaker, L. B. 1991. Climate change and the origin of old-growth Douglas-fir forest in the Puget Sound Lowland. Pp. 17-24 *in* L. F. Ruggiero, K. B. Aubry, A. B. Carey, and M. H. Huff (tech. coords.). Wildlife and Vegetation of Unmanaged Douglas-Fir Forests. General Technical Report PNW-GTR-285. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. 533 pp.

Burton, D. H., and H. C. Black. 1978. Feeding habits of Mazama pocket gophers in south-central Oregon. Journal of Wildlife Management 42:383-390.

Buschmann, G. 1997. Weeds of south Puget Sound prairies. Pp. 163-178 *in* P. Dunn and K. Ewing (eds.) Ecology and Conservation of the South Puget Sound Prairie Landscape. The Nature Conservancy of Washington, Seattle, Washington. 289 pp.

Campbell, R. W., N. K. Dawe, I. McTaggart-Cowan, J. M. Cooper, G. K. Kaiser, M. C. E. McNall, and G. E. J. Smith. 1997. The Birds of British Columbia. Vol. 3. Passerines: Flycatchers through Vireos. University of British Columbia Press, Vancouver, British Columbia.

Canals, R. M., D. J. Herman, and M. K. Firestone. 2003. How disturbance by fossorial mammals alters N cycling in a California annual grassland. Ecology 84:875-881.

Caplow, F. 2004. Reintroduction Plan for Golden Paintbrush (*Castilleja levisecta*). Washington Natural Heritage Program. Report 2004-01. Washington Department of Natural Resources, Olympia, Washington. 44 pp.

Caplow, F. and J. Miller. 2004. Southwestern Washington prairies: using GIS to find rare plant habitat in historic prairies. Washington Natural Heritage Program, Report 2004-02. Department of Natural Resources, Olympia, Washington. 18 pp.

Carpenter, C. S. 1986. Fort Nisqually: A documented history of Indian and British interaction. Tahoma Research Service, Tacoma, Washington. (Not seen, cited in Lombardi 1997).

Cassidy, K. M., C. E. Grue, M. R. Smith, R. E. Johnson, K. M. Dvornich, K. R. McAllister, P. W. Mattocks Jr., J. E. Cassady, and K. B. Aubry. 2001. Using current protection status to assess conservation priorities. Biological Conservation 97:1-20.

Cassidy, K. M., M. R. Smith, C. E. Grue, K. M. Dvornich, J. E. Cassady, K. R. McAllister, and R. E. Johnson. 1997. Gap Analysis of Washington State: an Evaluation of the Protection of Biodiversity. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle. 192 pp.

Chappell, C. B. and R. C. Crawford. 1997. Native vegetation of the south Puget Sound prairie landscape. Pp. 107-122 *in* Dunn and Ewing (1997).

Chappell, C. B. and J. Kagan. 2001. Westside grasslands. Pp. 41-43 *in* D. H. Johnson and T. A. O'Neil (dirs.). Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, Oregon. 768 pp.

Chappell, C. B., R. C. Crawford, C. Barrett, J. Kagan, D. H. Johnson, M. O'Mealy, G. A. Green, H. L Ferguson, W. D. Edge, E. L Greda, and T. A. O'Neil. 2001a. Wildlife habitats: descriptions, status, trends, and system dynamics. Pp. 22-114 *in* D. H. Johnson and T. A. O'Neil (eds.). Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, Oregon. 736 pp.

Chappell, C. B., M. S. Mohn Gee, B. Stephens, R. Crawford, and S. Farone. 2001b. Distribution and decline of native grassland and oak woodlands in the Puget lowland and Willamette Valley ecoregions, Washington. Pp. 124-139 *in* S. H. Reichard, P. W. Dunwiddie, J. G. Gamon, A. R. Kruckeberg, and D. L. Salstrom (eds.). Conservation of Washington's Rare Plants and Ecosystems. Washington Native Plant Society, Seattle. 223 pp.

Chappell, C. B., M. S. Mohn Gee, and B. Stephens. 2003. A geographic information system map of existing grasslands and oak woodlands in the Puget lowland and Willamette Valley ecoregions, Washington. Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia, Washington. Map and documentation.

Char, P. and P. D. Boersma. 1995. The effects of prairie fragmentation on butterfly species in western Washington. Report to The Nature Conservancy, Washington Field Office and the U.S. Army, Fort Lewis. University of Washington, Seattle.

Chase, J. D., W. E. Howard, and J. T. Roseberry. 1982. Pocket gophers. Pp. 239-255 *in* J. A. Chapman and G. A. Feldhamer (eds.). Wild Mammals of North America. Johns Hopkins University Press, Baltimore, Maryland. 1147 pp.

Clampitt, C. A. 1993. Effects of human disturbances on prairies and the regional endemic *Aster curtus* in western Washington. Northwest Science 67:163-169.

Cleary, E. C., R. A. Dolbeer, and S. E. Wright. 2003. Wildlife Strikes to Civil Aircraft in the United States 1990-2002. Federal Aviation Administration, National Wildlife Strike Database, Serial Report No. 9. Report of the Associate Administrator of Airports, Office of Airport Safety and Standards, Airport Safety and Certification, Washington, DC. 51 pp.

Clench, H. K. 1975. Introduction. Pp. 1-72 *in* W. H. Howe (ed.). The Butterflies of North America. Doubleday & Co, Garden City, New York. 633 pp.

Cox, G. W. and D. W. Allen. 1987. Soil translocation by pocket gophers in a Mima moundfield. Oecologia 72:207-210.

Cox, G. W. and J. Hunt. 1990. Form of Mima mounds in relation to occupancy by pocket gophers. Journal of Mammalogy 71:90-94.

Cox, G. W. and J. Hunt. 1992. Relation of seasonal activity patterns of valley pocket gophers to temperature, rainfall, and food availability. Journal of Mammalogy 73:123-134.

Crawford, R. C. and H. Hall. 1997. Changes in the south Puget Sound prairie landscape. Pp. 11-15 *in* Dunn and Ewing (1997).

Crawford, R. C., C. Chappell, B. Stephens, C. Soper, and D. Rolph. 1995. Inventory and mapping of endangered native ecosystems on Fort Lewis. Report Prepared for the Environmental and Natural Resources Division, Fort Lewis, Washington, Washington Department of Natural Resources, Natural Heritage Program, and The Nature Conservancy, Olympia, Washington. (Not seen, cited in Altmann 2003.).

Crawford, R. L., L. G. Crabo, J. H. Shepard, and J. Austin. 1993. One-year monitoring of non-target Lepidoptera: Asian gypsy moth aerial spray area, King and Pierce Counties, Washington. 40 pp.

Crowell, J. B. and H. B. Nehls. 1967. North Pacific coast region, spring report. Audubon Field Notes 21:534.

Crozier, L. 2002. Climate change and its effects on species range boundaries: a case study of the Sachem skipper butterfly, *Atalopedes campestris*. Pp. 57-91 *in* S. H. Schneider and T. L. Root (eds.). Wildlife Responses to Climate Change: North American Case Studies. Island Press, Washington, D.C.

Cullinan, T. 2001. Important Bird Areas of Washington. Audubon Washington, Olympia, Washington. 170 pp.

Cushman, J. H., C. L. Boggs, S. B. Weiss, D. D. Murphy, A. W. Harvey, and P. R. Ehrlich. 1994. Estimating female reproductive success of a threatened butterfly: influence of emergence time and hostplant phenology. Oecologia 99:194-200.

Dalquest, W. W. 1948. Mammals of Washington. University of Kansas Publications, Museum of Natural History 2:1-444.

Dalquest, W. W. and V. B. Scheffer. 1942. The origin of the Mima mounds of western Washington. Journal of Geology 50:68-84.

Dalquest, W. W. and V. B. Scheffer. 1944. Distribution and variation in pocket gophers, *Thomomys talpoides*, in the state of Washington. American Naturalist 78:308-333, 423-450.

Daly, J. C. and J. L. Patton. 1986. Growth, reproduction, and sexual dimorphism in *Thomomys bottae* pocket gophers. Journal of Mammalogy 67:256-265.

Daly, J. C. and J. L. Patton. 1990. Dispersal, gene flow, and allelic diversity between local populations of *Thomomys bottae* pocket gophers in the coastal rnages of California. Evolution 44:1283-1294.

Danby, W. H. 1890. Food plant of *Melitaea taylori*, Edw. Canadian Entomologist 22:121-122.

Davenport, R. 1997. Rocky prairie restoration and native plant propagation project. Pp. 189-197 *in* Dunn and Ewing (1997).

Dawson, W. L. and J. H. Bowles. 1909. The Birds of Washington. Vol. 1. Occidental Publishing, Seattle, Washington.

del Moral, R. and D. C. Deardorff. 1976. Vegetation of the Mima Mounds, Washington State. Ecology 57:520-530.

Department of the Army. 2003. Fort Lewis Sustainability Implementation Plan For FY03-07 (August 2003). 62 pp.

Dietrich, W. 1995. Northwest Passage: the Great Columbia River. Simon and Schuster, New York. 448 pp.

Dornfeld, E. J. 1980. Butterflies of Oregon. Timber Press, Forest Grove, Oregon. 276 pp.

Dorsey, G. L. 1993. European beachgrass control measures for western snowy plover nesting habitat maintenance and restoration. Unpublished Report, U.S. Army Corps of Engineers. 15 pp.

Douglas, C. L. 1969. Ecology of pocket gophers of Mesa Verde, Colorado. University of Kansas Museum of Natural History 51:147-175 (Not seen, cited in Baker et al. 2003).

Douglas, G. M. and M. Ryan. 1999. Status of the golden paintbrush, *Castilleja levisecta* (Scrophulariaceae) in Canada. Canadian Field Naturalist 113:299-301.

Douglas, M. M. 1986. The Lives of Butterflies. University of Michigan Press, Ann Arbor, Michigan. 241 pp.

Drake, D. and K. Ewing. 1997. Germination requirements for 32 native Washington prairie species. Pp. 181-187 *in* Dunn and Ewing (1997).

Drovetski, S. V., S. F. Pearson, and S. Rohwer. *In press*. Implications of mitochondrial DNA diversity on the conservation status of the streaked horned lark *Eremophila alpestris strigata*. Conservation Genetics.

DuBois, A. D. 1935. Nests of horned larks and longspurs on a Montana prairie. Condor 37:56-72.

DuBois, A. D. 1936. Habits and nest life of the desert horned lark. Condor 38:49-56.

Dunn, P. 1998. Prairie habitat restoration and maintenance on Fort Lewis and within the south Puget Sound prairie landscape: final report and summary of findings. Report Prepared for the U.S. Army, Fort Lewis and The Nature Conservancy of Washington. 59 pp.

Dunn, P. 2003. Integrated control of Scotch broom: techniques

and strategies. Appendix C *in* Altman (2003b).

Dunn, P. and K. Ewing (eds.). 1997. Ecology and Conservation of the South Puget Sound Prairie Landscape. The Nature Conservancy of Washington, Seattle. 289 pp.

Dunn, P. and J. Fleckenstein. 1997. Butterflies of the south Puget Sound prairie landscape. Pp. 75-84 *in* Dunn and Ewing (1997).

Dunwiddie, P. W. and S. F. Pearson. 2004. Effects of prescribed burning on golden paintbrush (*Castilleja levisecta*). [Abstract] 89th Annual Meeting of the Ecological Society of America, August 1-6, Portland, Oregon.

Dwight, J., Jr. 1890. The horned larks of North America. Auk 7:138-158.

Edson, J. M. 1908. Birds of the Bellingham Bay region. Auk 25:425-439.

Edwards, W. H. 1888. Descriptions of two new species of *Melitaeas* belonging to North America. Canadian Entomologist 20(5):81-84.

Ehrlich, P. R. 1992. Population biology of checkerspot butterflies and the preservation of global diversity. Oikos 63:6-12.

Ehrlich, P. R. and I. Hanski (eds.). 2004a. On the Wings of Checkerspots: a Model System for Population Biology. Oxford University Press, New York. 371 pp.

Ehrlich, P. R. and I. Hanski. 2004b. Checkerspot research: background and origins. Pp. 3-16 *in* Ehrlich and Hanski (2004a).

Ehrlich, P. R., D. E. Breedlove, P. F. Brussard, and M. A. Sharp. 1972. Weather and the "regulation" of subalpine populations. Ecology 53:243-247.

Ehrlich, P. R., A. E. Launer, and D. D. Murphy. 1984. Can sex ratio be defined or determined? The case of population of checkerspot butterflies. American Naturalist 124:527-539. (Not seen, cited in Boggs and Nieminen 2004).

Ehrlich, P. R. and D. D. Murphy. 1987. Conservation lessons from long-term studies of checkerspot butterflies. Conservation Biology 1:122-131.

Ehrlich, P. R., D. D. Murphy, M. C. Singer, C. B. Sherwood, R. R. White, and I. L. Brown. 1980. Extinction, reduction, stability and increase: the responses of checkerspot butterfly (*Euphydryas*) populations to the California drought. Oecologia 46:101-105.

Engeman, R. M. and D. L. Campbell. 1999. Pocket gopher reoccupation of burrow systems following population reduction. Crop Protection 18:523-525.

Engeman, R. M. and G. W. Witmer. 2000. Integrated management tactics for predicting and alleviating pocket gopher (*Thomomys* spp.) damage to conifer reforestation plantings. Integrated Pest Management Reviews 5:41-55.

Engeman, R. M., D. L. Campbell, and J. Evans. 1993. A comparison of 2 activity measures for northern pocket gophers. Wildlife Society Bulletin 21:70-73.

Engeman, R. M., D. L. Nolte, and S. P. Bulkin. 1999. Optimization of the one-hole method for assessing pocket gopher, *Thomomys* spp., activity. Canadian Field-Naturalist 113:241-244.

ENSR. 1993. Roy prairie pocket gopher assessment. Doc. No. 6583-022-160. Prepared for the U.S. Army, Fort Lewis, Washington. ENSR Consulting and Engineering, Seattle.

ENSR. 1994. Pocket gopher assessment. Doc. No. 6583-022-170. Prepared for the U.S. Army, Fort Lewis, Washington. ENSR Consulting and Engineering, Seattle.

ENSR. 2000. Final Integrated Natural Resources Management Plan. Contract No. DACA67-97-D-1004. Delivery Order No.17. Prepared for the Department of the Army, Fort Lewis, Washington.

Eviner, V. T. and F. S. Chapin III. 2003. Gopher-plant-fungus interactions affect establishment of an invasive grass. Ecology 84:120-128.

FAA (Federal Aviation Administration). 1994. Runway Design. Chapter 3 *in* Airport Design. Advisory Circular 150/5300-13. Federal Aviation Administration, U. S. Department of Transportation.

Farrell, K. and W. Archer. 1996. The status and distribution of *Thomomys mazama couchi*. Unpublished report to the Washington Department of Fish and Wildlife, Olympia, Washington.

Flahaut, M. R. 1952. North Pacific coast region, summer report. Audubon Field Notes 6:295.

Flahaut, M. R. 1953. North Pacific coast region, summer report. Audubon Field Notes 7:323-324.

Flahaut, M. R. and Z. M. Schultz. 1954. North Pacific coast region, summer report. Audubon Field Notes 8:357-358.

Forsman, E. D., I. A. Otto, S. G. Sovern, M. Taylor, D. W. Hays, H. Allen, S. L. Roberts, and D. E. Seaman. 2001. Spatial and temporal variation in diets of spotted owls in Washington. Journal of Raptor Research 35:141-150.

Foster, J. R. and S. E. Shaff. 2003. Forest colonization of Puget lowland grasslands at Fort Lewis, Washington. Northwest Science 77:283-296.

Frankham, R., J. D. Ballou, and D. A. Briscoe. 2002. Introduction to Conservation Genetics. Cambridge University Press, Cambridge, United Kingdom. 617 pp.

Fraser, D. F., W. L. Harper, S. G. Cannings, and J. M. Cooper. 1999. Rare Birds of British Columbia. Ministry of Environment, Lands and Parks, Wildlife Branch and Resources Inventory Branch, Victoria, British Columbia.

Friedmann, H. and L. F. Kiff. 1985. The Parasitic Cowbirds and Their Hosts. Proceedings of the Western Foundation of Vertebrate Zoology. Vol. 2, No. 4.

Gabrielson, I. N. and S. A. Jewett. 1940. The Birds of Oregon. Oregon State College Press, Corvallis, Oregon.

Gardener, M. C. and M. P. Gillman. 2001. The effects of soil fertilizer on amino acids in the floral nectar of corncockle *Agrostemma githago* (Caryophyllaceae). Oikos 92:101-106.

Gardner, M. C. 1950. An undescribed Washington pocket gopher. Journal of Mammalogy 31:92-93.

Garry Oak Ecosystems Recovery Team. 2002. Recovery Strategy for Garry Oak and Assoicated Ecosystems and their Associated Species ar Risk in Canada, 2001-2006. 201 pp.

Gelfenbaum, G., C. R. Sherwood, C. D. Peterson, G. M. Kaminsky, M. Buijsman, D. C. Twichell, P. Ruggiero, A. E. Gibbs, and C. Reed. 1999. The Columbia River littoral cell: a sediment budget overview. Coastal Sediments

99; Proceedings of the 4th International Conference on Coastal Engineering and Coastal Sediment Processes. American Society of Civil Engineers, June 1999, Long Island, New York.

GeoEngineers, Inc. 2003. Revised Comprehensive Habitat Management Plan for the Shelton Pocket Gopher (*Thomomys mazama counchi*) at Sanderson Field, Shelton, Washington (Revision 2). Unpublished Report Prepared for the Port of Shelton, Shelton, Washington. 21 pp.

Gilligan, J., D. Rogers, M. Smith, and A. Contreras (eds.). 1994. Birds of Oregon: Status and Distribution. Cinclus Publications, McMinnville, Oregon.

Goldman, E. A. 1939. Remarks on pocket gophers, with special reference to *Thomomys talpoides*. Journal of Mammalogy 20:231-244.

Goodge, W. 1950. Some notes on the birds of the San Juan Islands. Murrelet 31:27-28.

Gove, J. G. Mr. & Mrs. 1946. Birds seen and heard on Lopez Island, Washington. Murrelet 27:33-34.

Grant, W. E., N. R. French, and L. J. Folse, Jr. 1980. Effects of pocket gopher mounds on plant production in a shortgrass prairie ecosystem. Southwestern Naturalist 2:215-224. (Not seen, cited in Huntly and Inouye 1988).

Grosboll, D. N. and P. L. Kelley. 1999. Preliminary report on the effectiveness of Poast (Sethoxydim) in the control of introduced grasses in the gravelly outwash plains of south Puget Sound, Washington. Unpublished Report for The Nature Conservancy of Washington, Seattle. 5 pp.

Guppy, C. S. and J. H. Shepard 2001. Butterflies of British Columbia. The Royal British Columbia Museum, Victoria, and UBC Press, Vancouver, British Columbia. 414 pp.

Guppy, C. S., N. G. Kondla, and L. Schaeffer. 2003. [Draft] National Recovery Strategy for Taylor's Checkerspot, *Euphydryas editha taylori* (W. H. Edwards). Novus Consulting, for the British Columbia Ministry of Water, Land and Air Protection, Victoria, British Columbia.

Hall, E. R. 1981. The Mammals of North America. Vol. 1, second ed. John Wiley & Sons, New York.

Hansen, H. P. 1947. Climate versus fire and soil as factors in postglacial forest succession in the Puget lowland of Washington. American Journal of Science 245:265-286.

Hansen, R. M. 1962. Movements and survival of *Thomomys talpoides* in a Mima-mound habitat. Ecology 43:151-154.

Hanski, I. and O. Ovaskainen. 2002. Extinction debt at extinction threshold. Conservation Biology 16:666-673.

Hanski, I., P. R. Ehrlich, M. Nieminen, D. D. Murphy, J. J. Hellmann, C. L. Boggs, and J. McLaughlin. 2004. Checkerspots and conservation biology. Pp. 264-287 *in* Ehrlich and Hanski (2004a).

Harrison, S. 1989. Long-distance dispersal and colonization in the bay checkerspot butterfly *Euphydryas editha bayensis*. Ecology 70:1236-1243.

Harrison, S. and E. Bruno. 1999. Habitat fragmentation and large scale conservation: what do we know for sure? Ecography 22: 225-232.

Harrison, S., D. D. Murphy, and P. R. Ehrlich. 1988. Distribution of the bay checkerspot butterfly *Euphydryas editha bayensis*: evidence for a metapopulation model. American Naturalist 132:360-382.

Hartman, C. A. and L. W. Oring. 2003. Orientation and microclimate of horned lark nests: the importance of shade. Condor 105:158-163.

Hartway, C. and E. K. Steinberg. 1997. The influence of pocket gopher disturbance on the distribution and diversity of plants in western Washington prairies. Pp. 131-139 *in* Dunn and Ewing (1997).

Hays, D. W., A. E. Potter, C. W. Thompson, and P. V. Dunn. 2000. Critical habitat components for four rare south Puget Sound grassland butterflies. Final Report. Washington Department of Fish and Wildlife, Olympia, and The Nature Conservancy, Seattle. 62 pp.

Hellenthal, R. A., and R. D. Price. 1989. *Geomydoecus thomomyus* complex (Mallaphaga: Trichodectidae) from the pocket gophers of the *Thomomys talpoides* complex (Rodentia: Geomyidae) of the United States and Canada. Annals of the Entomological Society of America 82: 286-297.

Hellmann, J. J. 2002a. The effect of an environmental change on mobile butterfly larvae and the nutritional quality of their hosts. Journal of Animal Ecology 71:925-936.

Hellmann, J. J. 2002b. Butterflies as model systems for understanding and predicting climate change. Pp. 93-126 *in* S. H. Schneider and T. L. Root (eds.). Wildlife Responses to Climate Change: North American Case Studies. Island Press, Washington, D.C.

Hellmann, J. J., S. B. Weiss, J. F. McLaughlin, P. R. Ehrlich, D. D. Murphy, and A. E. Launer. 2004. Structure and dynamics of *Euphydryas editha* populations. Pp. 34-62 *in* Ehrlich and Hanski (2004a).

Hendricks, P. 1986. Avian predation on alpine butterflies. Journal of the Lepidopterists Society 40:129.

Henshaw, H. W. 1884. The shore larks of the United States and adjacent territory. Auk 1:254-268.

Hensler, G. L. and J. D. Nichols. 1981. The Mayfield method of estimating nest success: a model, estimators and simulating nesting success. Wilson Bulletin 93:42-53.

Hill, R. A. 1976. Host-parasite relationships of the brown-headed cowbird in a prairie habitat of west-central Kansas. Wilson Bulletin 88:555-565.

Hinchliff, J. 1996. An Atlas of Washington Butterflies. Oregon State University Bookstore, Corvallis, Oregon.

Hobbs, R. J. and H. A. Mooney. 1991. Effects of rainfall variability and gopher disturbance on serpentine annual grassland dynamics. Ecology 72:59-68.

Hoffman, R. 1927. Birds of the Pacific States. Houghton Mifflin Company, Boston. 353 pp.

Hoge, G. and W. Hoge. 1991. Birds of Ocean Shores. Black Hills Audubon Society, Olympia, Washington.

Hooven, E. F. 1971. Pocket gopher damage on ponderosa pine plantations in southwestern Oregon. Journal of Wildlife Management 35:346-353.

Hopfinger, J. C. 1947. Field summary of Lepidoptera – 1947 season. 2. Northwest - Oregon, Washington, Idaho, and British Columbia. Lepidoptera News 1(8):90 (Not seen, cited in Guppy and Shepard 2001).

Howard, W. E. and H. E. Childs, Jr. 1959. Ecology of pocket gophers with emphasis on *Thomomys bottae mewa*.

Hilgardia 29(7):277-358. (Not seen, cited in Chase et al. 1982).

Huntly, N. and R. Inouye. 1988. Pocket gophers in ecosystems: patterns and mechanisms. BioScience 38:786-793.

Ingles, L. G. 1965. Mammals of the Pacific States: California, Oregon, Washington. Stanford University Press, Stanford, California. 506 pp.

Jackson, L. E. 1982. Comparison of phenological patterns in prairie and subalpine meadow communities. Northwest Science 56:316-328.

Jewett, S. G. 1943. A new horned lark from the state of Washington. Auk 60:262-263.

Jewett, S. G., W. P. Taylor, W. T. Shaw, and J. W. Aldrich. 1953. Birds of Washington State. University of Washington Press, Seattle.

Johnson, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96:651-661.

Johnson, K. S., J. M. Scriber, J. K. Nitao, and D. R. Smitley. 1995. Toxicity of *Bacillus thuringiensi*s var. *kurstaki* to three nontarget Lepidoptera in field studies. Environmental Entomology 24:288-297.

Johnson, M. L. 1977. Natural extinction of populations of the pocket gopher of Olympic National Park. Unpublished manuscript and notes for presentation at the 1977 meeting of the American Society of Mammalogists.

Johnson, M. L. and S. B. Benson. 1960. Relationships of the pocket gophers of the *Thomomys mazama-talpoides* complex in the Pacific Northwest. Murrelet 41:17-22.

Johnson, R. E. 1982. Key to the Mammals of Washington. Department of Zoology, Washington State University, Pullman, Washington. 25 pp.

Johnson, R. E. and K. M Cassidy. 1997. Terrestrial mammals of Washington State: Location data and predicted distributions. Vol. 3 *in* K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich (eds.). Washington State Gap Analysis - Final Report. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle. 304 pp.

Kaye, T. N. 2001. Restoration research for golden paintbrush (*Castilleja levisecta*), a threatened species. Institute for Applied Ecology.

Keith, J. O., R. M. Hansen, and A. L. Ward. 1959. Effect of 2,4-D on abundance and foods of pocket gophers. Journal of Wildlife Management 23:137-145.

Kitchin, E. A. 1934. Distributional check-list of the birds of the State of Washington. Northwest Fauna Series 1:1-28. Pacific Northwest Bird and Mammal Society, Seattle.

Kitchin, E. A. 1949. Birds of the Olympic Peninsula. Olympic Stationers, Port Angeles, Washington. 262 pp.

Klaas, B. A., B. J. Danielson, and K. A. Maloney. 1998. Influence of pocket gophers on meadow voles in a tallgrass prairie. Journal of Mammalogy 79:942-952.

Klimkiewicz, M. K. and A. G. Futcher. 1989. Longevity records of North American birds, supplement 1. Journal of Field Ornithology 60:469-494.

Kruckeberg, A. R. 1991. The Natural History of Puget Sound Country. University of Washington Press, Seattle. 468 pp.

Kuusaari, M., S. van Nouhuys, J. J. Hellmann, and M. C. Singer. 2004. Larval biology of checkerspots. Pp. 138-160 *in* Ehrlich and Hanski (2004a).

Lang, F. L. 1961. A study of vegetation change on the gravelly prairies of Pierce and Thurston Counties, western Washington. M.S. Thesis, University of Washington, Seattle. 109 pp.

Launer, A. E., D. D. Murphy, C. L. Boggs, J. F. Baughman, S. B. Weiss, and P. R. Ehrlich. 1993. Puddling behavior by bay checkerspot butterflies (*Euphydryas editha bayensis*). Journal of Research on the Lepidoptera 32:45-52.

Lawrence, R. H. 1892. A preliminary list of the birds of the Grays Harbor region, Washington. Auk 9:39-47.

Laycock, W. A., and B. Z. Richardson. 1975. Long-term effects of pocket gopher control on vegetation and soils of a subalpine grassland. Journal of Range Management 28:458-462.

Leonard, W. P. and L. Hallock. 1997. Herpetofauna of south Puget Sound prairie landscape. Pp. 65-74 *in* Dunn and Ewing (1997).

Leopold, E. B. and R. Boyd. 1999. An ecological history of old prairie areas in southwestern Washington. Pp. 139-163 *in* R. Boyd (ed.) Indians, Fire, and the Land. Oregon State University Press, Corvallis, Oregon. 313 pp.

Lewis, M. G. and F. A. Sharpe. 1987. Birding in the San Juan Islands. The Mountaineers, Seattle.

Link, R. 2004. Living with Wildlife in the Pacific Northwest. Washington Department of Fish and Wildlife and University of Washington Press, Seattle

Livezey, B. C. and B. J. Verts. 1979. Estimates of age and age structure in Mazama pocket gophers, *Thomomys mazama*. Murrelet 60:38-41.

Llewellyn-Jones, J. R. J. 1934. Some food plants of Lepidopterous larvae, list 2. Proceedings of the British Columbia Entomological Society 31:28-31.

Llewellyn-Jones, J. R. J. 1935. Some food plants of Lepidopterous larvae, list 3. Proceedings of the British Columbia Entomological Society 32:29-31.

Lombardi, A. 1997. Food and medicine form the prairie: an ethnobotanical look at the historical use of south Puget Sound prairies. Pp. 29-32 *in* Dunn and Ewing (1997).

Lord, W. R. 1913. A First Book Upon the Birds of Oregon & Washington. Revised edition. J. K. Gill Co., Portland, Oregon. 308 pp.

Mack, R. N. and J. N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. American Naturalist 119:757-773.

MacLaren, P. A. and E. B. Cummins. 2000. Streaked horned lark surveys in western Washington, year 2000. Unpublished report, Washington Department of Fish and Wildlife, Olympia, Washington. 13 pp.

MacMahon, J. A., 1999. Northern pocket gopher/*Thomomys talpoides*. Pp. 474-476 *in* D. E. Wilson and S. Ruff (eds.). The Smithsonian Book of North American Mammals. Smithsonian Institution Press, Washington, DC. 750 pp.

Marsh, R. E. and R. W. Steele. 1992. Pocket gophers. Pp. 205-230 *in* H. C. Black (ed.). Silvicultural approaches to animal damage management in Pacific Northwest forests. Gen. Tech. Rep. PNW-GTR-287. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon. 422 pp.

Marshall, W. H. 1941. *Thomomys* as burrowers in the snow.

Journal of Mammalogy 22:196-197. (Not seen, cited in Chase et al. 1982).

Martinsen, G. D., J. H. Cushman, and T. G. Whitman. 1990. Impact of pocket gopher disturbance on plant species diversity in a shortgrass prairie community. Oecologia 83:132-138.

Maser, C., E. W. Hammer, and S. H. Anderson. 1970. Comparative food habits of three owl species in central Oregon. Murrelet 51:29-33.

Maser, C., B. R. Mate, J. F. Franklin, and C. T. Dyrness. 1981. Natural History of Oregon Coast Mammals. Gen. Tech. Report PNW-133. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 496 pp.

Mayfield, H. 1975. Suggestions for calculating nest success. Wilson Bulletin 87:456-466.

Mayfield, H. F. 1981. Problems in estimating population size through counts of singing males. Studies of Avian Biology 6:220-224.

McBee, C. E. 1931. The dusky horned lark in eastern Washington. Murrelet 7:43-45.

McGarrahan, E. 1997. Much-studied butterfly winks out on Stanford Preserve. Science 275:479-480.

McLaughlin, J. F., J. J. Hellmann, C. L. Boggs, and P. R. Ehrlich. 2002. Climate change hastens population extinctions. Proceedings of the National Academy of Sciences 99:6070-6074.

McMannama, Z. 1950. Additional notes on the birds of the San Juan Islands. Murrelet 31: 29-30.

Michigan Department of Agriculture and USDA Forest Service. 2000. Environmental Assessment: Cooperative Gypsy Moth Suppression, Michigan.

Mielke, H. W. 1977. Mound building by pocket gophers (Geomyidae): their impact on soils and vegetation in North America. Journal of Biogeography 4:171-180.

Miller, J. C. 1990. Field assessment of the effects of a microbial pest control agent on nontarget Lepidoptera. American Entomologist 36(2):135-139.

Miller, J. C. 2000. Monitoring the effects of *Bacillus thuringiensis kurstaki* on nontarget Lepidoptera in woodlands and forests of western Oregon. Pp. 277-286 *in* P. A. Follett and J. J.Duan (eds.) Nontarget Effects of Biological Control. Kluwer Academic Publishers, Boston. 316 pp.

Miller, M. A. 1948. Seasonal trends in burrowing of pocket gophers (*Thomomys*). Journal of Mammalogy 29:38-44 (Not seen, cited in Cox and Hunt 1992).

Miller, M. A. 1957. Burrows of the Sacramento Valley pocket gopher in flood irrigated alfalfa fields. Hilgardia 26:431-452. (Not seen, cited in Cox and Hunt 1992).

Miller, M. R. 1944. A two-year bird census on San Juan Islands, Washington. Auk 61:395-400.

Miller, R. C., E. D. Lumley, and F. S. Hall. 1935. Birds of the San Juan Islands, Washington. Murrelet 16:51-65.

Miskelly, J. 2003. Hornby Island: rare and endangered butterfly inventory 2003. Report to Ministry of Water, Land and Air Protection, Terrestrial Ecosystem Science Section. 11 pp.

Moore, S. D. 1989. Patterns of juvenile mortality within an oligophagous insect population. Ecology 70:1726-1737.

Morgenweck, M. and P. Dunn. 2003. Fort Lewis butterfly survey. The Nature Conservancy, Olympia, Washington. 24 pp.

Morton, A. C. 1982. The effects of marking and capture on recapture frequencies of butterflies. Oecologia 53:105-110.

Murphy, D. D. 1981. The role of adult resources in the population biology of checkerspot butterflies of the genus *Euphydryas*. Ph.D. Dissertation, Stanford University, Stanford, California.

Murphy, D. D. 1988. Are we studying our endangered butterflies to death? Journal of Research on the Lepidoptera 26:236-239.

Murphy, D. D. and S. B. Weiss. 1988. Ecological studies and the conservation of the bay checkerspot butterfly, *Euphydryas editha bayensis*. Biological Conservation 46:183-200.

Murphy, D. D. and R. R. White. 1984. Rainfall, resources, and dispersal of *Euphydryas editha* (Lepidoptera: Nymphalidae). Pan-Pacific Entomologist 60:350-354.

Murphy, D. D., N. Wahlberg, I. Hanski, and P. R. Ehrlich. 2004. Introducing checkerspots: taxonomy and ecology. Pp. 17-33 *in* Ehrlich and Hanski (2004a).

Musche, A. D., A. T. Richards, and E. B. Cummins. 2005. Surveys of Species of Concern on Washington State Parks Lands in Southwestern Washington: April to September 2003. Washington Department of Fish and Wildlife, Olympia, Washington. 18 pp.

New, T. R., R. M. Pyle, J. A. Thomas, C. D. Thomas, and P. C. Hammond. 1995. Butterfly conservation management. Annual Review of Entomology 40:57-83.

Nieminen, M., M. Siljander, and I. Hanski. 2004. Structure and dynamics of *Melitea cinxia* metapopulations. Pp. 63-91 *in* Ehrlich and Hanski (2004a).

Nieminen, M., M. C. Singer, W. Fortelius, K. Schops, and I. Hanski. 2001. Experimental confirmation that inbreeding depression increases extinction risk in butterfly populations. American Naturalist 157:237-244

Noss, R. F., E. T. LaRoe III, and J. M.Scott. 1995. Endangered Ecosystems of the U.S.: a Preliminary Assessment of Loss and Degradation. Biological Report 28. U.S. Department of the Interior, National Biological Service, Washington, D.C.

Nussbaum, R. A. and C. Maser. 1975. Food habits of the bobcat, *Lynx rufus*, in the Coast and Cascade range of western Oregon in relation to present management policies. Northwest Science 49:261-266.

Oberholser, H. C. 1902. A review of the larks of the genus *Otocoris*. Proceedings of the United States National Museum 24:801-883.

O'Brien, D. M., C. Boggs, and M. Fogel. 2004. Making eggs from nectar: the role of life history and dietary carbon turnover in butterfly reproductive resource allocation. Oikos 105:279-291.

Opler, P. A., H. Pavulaan, and R. F. Stanford. 1995. Butterflies of North America. Northern Prairie Wildlife Center Home Page, Jamestown, ND. (www.npwrc.org/resource / distr/lepid/ bflyusa/bflyusa.htm (version 16 Oct 1997).

Ostrow, G. G., N. Huntly, and R. S. Inouye. 2002. Plant-mediated interactions between the northern pocket gopher,

Thomomys talpoides, and aboveground herbivorous insects. Journal of Mammalogy 83:991-998.

Palmer, R. H. 1927. Birds of the Olympic Peninsula, Washington. Part II. Murrelet 8:59-70.

Parker, I. M. 2002. Safe site and seed limitation in *Cytisus scoparius* (Scotch broom): invasibility, disturbance, and the role of cryptogams in a glacial outwash prairie. Biological Invasions 3:323-332.

Parker, I., W. Harpole, and D. Dionne. 1997. Plant community diversity and invasion of the exotic shrub *Cystisus scoparius*: testing hypotheses of invasibility and impact. Pp. 149 -161 *in* Dunn and Ewing (1997).

Parmesan, C. 1996. Climate and species' range. Nature 382:765-766.

Patton, J. L. and P. V. Brylski. 1987. Pocket gophers in alfalfa fields: causes and consequences of habitat-related body size variation. American Naturalist 130:493-506.

Patton, J. L. and J. H. Feder. 1981. Microspatial genetic heterogeneity in pocket gophers: non-random breeding and drift. Evolution 35:912-920.

Peacock, J. W., D. F. Schwitzer, J. L. Carter, and N. R. Dubois. 1998. Laboratory assessment of the effects of *Bacillus thuringiensis* on native Lepidoptera. Environmental Entomology 27:450-457.

Pearson, S. F. 2003. Breeding phenology, nesting success, habitat selection, and census methods for the streaked horned lark in the Puget lowlands of Washington. Natural Areas Program Report 2003-2, Washington Department of Natural Resources, Olympia, Washington. 38 pp.

Pearson, S. F. and B. Altman. 2005. Rangewide streaked horned lark (*Eremophila alpestris strigata*) assessment and preliminary conservation strategy. Washington Department of Fish and Wildlife, Wildlife Program, Science Division, Olympia, Washington. xx pp.

Pearson, S. F. and M. Hopey. 2004. Streaked horned lark inventory, nesting success and habitat selection in the Puget lowlands of Washington. Natural Areas Program Report 2004-1, Washington Department of Natural Resources, Olympia, Washington. 36 pp.

Pearson, S. F., M. Hopey, W. D. Robinson, and R. Moore. 2005. Range, abundance and movement patterns of wintering streaked horned larks (*Eremophila alpestris strigata*) in Oregon and Washington. Natural Areas Program Report 2005-2, Washington Department of Natural Resources, Olympia, Washington. 12 pp

Perdue, V. 1997. Land-use and the Ft. Lewis prairies. Pp. 17-28 *in* Dunn and Ewing (1997).

Persons, P. E. 1992. Snowy plover nesting at Damon Point, Washington. Unpublished Report to Washington Department of Wildlife, Aberdeen, Washington. 10 pp.

Peter, D. 2001. The Skokomish Prairie: history and composition (Draft). Olympia Forestry Sciences Lab, U.S. Forest Service, Olympia, Washington. (unpublished manuscript).

Peterjohn, B. G. and J. R. Sauer. 1999. Population status of North American grassland birds from the North American Breeding Bird Survey, 1966-1996. Studies in Avian Biology 19:27-44.

Peterson, C. D., G. R. Gelfenbaum, H. M. Jol, J. B. Phipps, F. Reckendorf, D. C. Twichell, S. Vandenburg, and L. Woxell. 1999. Great earthquakes, abundant sand, and high wave energy in the Columbia cell, USA. Coastal Sediments 99; Proceedings of the 4th International Conference on Coastal Engineering and Coastal Sediment Processes. American Society of Civil Engineers, June 1999, Long Island, New York.

Peterson, K. L. and L. B. Best. 1987. Effects of prescribed burning on nongame birds in a sagebrush community. Wildlife Society Bulletin 15:317-329.

Phillips, A. R., J. Marshall, and G. Monson (eds.). 1964. The Birds of Arizona. University of Arizona Press, Tucson, Arizona.

Pickwell, G. 1931. Prairie horned lark. Pp. 342-356 *in* Bent (1963).

Pietz, P. J. and D. A. Granfors. 2000. Identifying predators and fates of grassland passerine nests using miniature video cameras. Journal of Wildlife Management 64:71-87.

Pojar, J. and A. MacKinnon (eds.). 1994. Plants of the Pacific Northwest Coast. British Columbia Ministry of Forests and Lone Pine Press. 527 pp.

Proulx, G., M. J. Badry, P. J. Cole, R. K. Drescher, A. J. Kolenosky, and I. M. Pawlina. 1995. Summer activity of northern pocket gophers, *Thomomys talpoides*, in a simulated natural environment. Canadian Field-Naturalist 109:210-215.

Pyle, P. 1997. Identification Guide to North American Birds. Part 1: Columbidae to Ploceidae. Slate Creek Press, Bolinas, California.

Pyle, R. M. 1974. Watching Washington Butterflies. Seattle Audubon Society, Trailside Series, Seattle. 109 pp.

Pyle, R. M. 1981. The Audubon Society Field Guide to North American Butterflies. Alfred A. Knopf, New York. 924 pp.

Pyle, R. M. 1989. Washington Butterfly Conservation Status Report and Plan. Report Submitted to the Nongame Program, Washington Department of Wildlife, Olympia, Washington. 217 pp.

Pyle, R. M. 2002. Butterflies of Cascadia. Seattle Audubon Society, Seattle. 419 pp.

Rathbun, S. F. 1902. A list of the land birds of Seattle, Washington, and vicinity. Auk 19:131-141.

Rausher, M. D. 1982. Population differentiation in *Euphydryas editha* butterflies: larval adaptation to different hosts. Evolution 36:581-590.

Reardon, R. C. and K. Haissig. 1984. Efficacy and field persistence of *Bacillus thuringiensis* after ground application to balsam fir and white spruce in Wisconsin. Canadian Entomologist 116:153-158.

Reichman, O. J. and E. W. Seabloom. The role of pocket gophers as subterranean ecosystem engineers. Trends in Ecology and Evolution 17: 44-49.

Reichman, O. J. and S. C. Smith. 1985. Impact of pocket gopher burrows on overlying vegetation. Journal of Mammalogy 66:720-725.

Reichman, O. J., T. G. Whitham, and G. A. Ruffner. 1982. Adaptive geometry of burrow spacing in two pocket gopher populations. Ecology 63:687-695.

Remsburg, M. 1998. Summary report of LCTA butterfly surveys conducted on Fort Lewis, WA, April – August, 1998. Unpublished Report to the Land Condition Trend

Analysis Program, Fort Lewis.
Remsburg, M. 2000. Summary report of LCTA butterfly surveys conducted on Fort Lewis, WA, 2000. Unpublished Report to the Land Condition Trend Analysis Program, Fort Lewis.
Retfalvi, L. 1963. Notes on the birds of the San Juan Islands. Murrelet 44:12-13.
Rezsutek, M. J. and G. N. Cameron. 1998. Influence of resource removal on demography of Attwater's pocket gopher. Journal of Mammalogy 79:538-550.
Richardson, S. A. 1995. Washington State Recovery Plan for the Snowy Plover. Washington Department of Fish and Wildlife, Olympia, Washington. 87 pp.
Richardson, S. A., A. E. Potter, K. L. Lehmkuhl, R. Mazaika, M. E. McFadzen, and R. Estes. 2001. Prey of ferruginous hawks breeding in Washington. Northwestern Naturalist 82:58-64.
Richens, V. B. 1966. Notes on the digging activity of the northern pocket gopher. Journal of Mammalogy 47:531-533.
Ries, L. and D. M. Debinski. 2001. Butterfly response to habitat edges in the highly fragmented prairies of central Iowa. Journal of Animal Ecology 70:840-852.
Robbins, W. G. and D. W. Wolf. 1994. Landscape and the Intermontane Northwest: an Environmental History. USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-319. 32 pp.
Robinson, W. D. and R. P. Moore. 2004. Range, abundance, and habitat associations of streaked horned lark (*Eremophila alpestris strigata*) during winter. Department of Fisheries and Wildlife and Oak Creek Lab of Biology, Oregon State University, Corvallis, Oregon. 5 pp.
Robohm, R. 1997. Survival and growth of planted *Festuca idahoensis* in prairie restoration sites at Ft. Lewis, Washington. Pp. 199-205 *in* Dunn and Ewing (1997).
Roby, D. D., K. Collis, D. P. Craig, J. Y. Adkins, A. M. Myers, and R. M. Suryan. Effects of colony relocation on diet productivity of Caspian terns. Journal of Wildlife Management 66:662-673.
Rogers, R. 1999a. The streaked horned lark in western Washington. Unpublished Report to the U.S. Fish and Wildlife Service, Western Washington Office. Washington Department of Fish and Wildlife, Olympia, Washington. 14 pp.
Rogers, R. 1999b. Natural history: streaked horned lark and land management. Environmental Practice 1(2):77-78.
Rogers, R. E., Jr. 2000. The Status and Habitat Selection of Streaked Horned Larks, Western Bluebird, Oregon Vesper Sparrow, and Western Meadowlark in Western Washington. M.S. Thesis, Evergreen State College, Olympia, Washington. 185 pp.
Saccheri, I. J., P. M. Brakefield, and R. A. Nichols. 1996. Severe inbreeding depression and rapid fitness rebound in the butterfly *Bicyclus anynana* (Satyridae). Evolution 50:2000-2013.
Saccheri, I., M. Kuusaari, M. Kankare, P. Vikman, W. Fortelius, and I. Hanski. 1998. Inbreeding and extinction in a butterfly metapopulation. Nature 392:491-494.
Sample, B. E., L. Butler, C. Zivkovich, R. C. Whitmore, and R. Reardon. 1996. Effects of *Bacillus thuringiensis* Berliner var. *kurstaki* and defoliation by the gypsy moth [*Lymnatria dispar* (L.) (Lepidoptera:Lymnatriidae)] on native arthropods in West Virginia. Canadian Entomologist 128:573-592.
Sauer, J. R., J. E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey: Results and Analysis, 1966-2003. Version 2004.0 USGS Patuxent Wildlife Research Center, Laurel, Maryland.
Scheffer, T. H. 1931. Habits and economic status of the pocket gophers. USDA Technical Bulletin 224. 26 pp.
Scheffer, T. H. 1932. Weasels and snakes in gopher burrows. Murrelet 13:54-55.
Scheffer, T. H. 1938. Breeding records of Pacific coast pocket gophers. Journal of Mammalogy 19:220-224.
Scheffer, V. B. 1995. Mammals of Olympic National Park and Vicinity (1949). Northwest Fauna 2:5-133.
Schuller, R. 1997. Vegetation response to fall prescribed burning within *Festuca idahoensis*-dominated prairie, Mima Mounds Natural Area Preserve, Washington 1985-1992. Pp. 207-216 *in* Dunn and Ewing (1997).
Schultz, C. B. and K. M. Dlugosch. 1999. Nectar and host plant scarcity limit populations of an endangered Oregon butterfly. Oecologia 119:231-238.
Scott, J. A. 1986. The Butterflies of North America. Stanford University Press, Stanford, California. 583 pp.
Shepard, J. H. 2000. Status of five butterflies and skippers in British Columbia. British Columbia Ministry of Environment, Lands and Parks, Wildlife Branch and Resources Inventory Branch. Wildlife Working Report No. WR-101. 27 pp.
Singer, M. C. 2004. Measurement, correlates, and importance of oviposition preference in the life of checkerspots. Pp. 112-137 *in* Ehrlich and Hanski (2004a).
Singer, M. C. and P. R. Ehrlich 1979. Population dynamics of the checkerspot buttefly *Euphydryas editha*. Fortschritte der Zoologie 25:53-60.
Singer, M. C. and I. Hanski. 2004. Dispersal behavior and evolutionary metapopulation dynamics. Pp. 181-198 *in* Ehrlich and Hanski (2004a).
Singer, M. C., D. Ng, and C. D. Thomas. 1988. Heritability of oviposition preference and its relationship to performance within a single insect population. Evolution 42:977-985.
Smallwood, K. S., and M. L. Morrison. 1999. Spatial scaling of pocket gopher (Geomyidae) density. Southwestern Naturalist 44:73-82
Smith, M. F. and J. L. Patton. 1988. Subspecies of pocket gophers: causal bases for geographic differentiation in *Thomomys bottae*. Systematic Zoology 37:163-178.
Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding Birds of Washington State: Location Data and Predicted Distribution. Vol. 4 *in* K. M. Cassidy, C. E. Grue, M. R. Smith, and K. M. Dvornich (eds.). Washington State Gap Analysis - Final Report. Seattle Audubon Society Publications in Zoology No. 1, Seattle. 538 pp.
Stamp, N. E. 1984. Interactions of parasitoids and checkerspot caterpillars *Euphyrdyas* spp. (Nymphalidae). Journal of Research on the Lepidoptera 23:2-18.

Steinberg, E. K. 1995. A study of genetic differentiation and variation in the Mazama pocket gopher (*Thomomys mazama*) with emphasis on Fort Lewis populations. Final Report Submitted to Fort Lewis and The Nature Conservancy. Department of Zoology, University of Washington, Seattle. 51 pp.

Steinberg, E. K. 1996a. Population studies and management of the threatened Mazma pocket gopher: a regional perspective. Final Report, Contract #WAFO-092795, The Nature Conservancy. 50 pp.

Steinberg, E. K. 1996b. Ecology, phylogeography, and conservation of the Mazama pocket gopher: summary of 1996 research results. Investigators Annual Report to the National Park Service, Olympic National Park, Port Angeles, Washington. 2 pp.

Steinberg, E. K. 1999. Diversification of genes, populations, and species: evolutionary genetics of real and virtual pocket gophers (*Thomomys*). Ph.D. Dissertation, University of Washington, Seattle. 157 pp.

Steinberg, E. and D. Heller. 1997. Using DNA and rocks to interpret the taxonomy and patchy distribution of pocket gophers in western Washington prairies. Pp. 43-51 *in* Dunn and Ewing (1997).

Stromberg, M. R. and J. R. Griffin. 1996. Long-term patterns in coastal California grasslands in relation to cultivation, gophers, and grazing. Ecological Applications 6:1189-1211.

Suckley, G. and J. G. Cooper. 1860. The Natural History of Washington Territory and Oregon. Bailliere Bros., New York. 399 pp.

Svihla, A. and R. D. Svihla. 1933. Mammals of Clallam County, Washington. Murrelet 14:37-41.

Swift, B. 1996. Controlling Scot's broom (*Cystisus scoparius*) in Seattle's Discovery Park. Hortus West 7(2):3-5, 40-42.

Taylor, W. P. 1919. *Thomomys talpoides tacomensis* Taylor. Proceeedings of the Biological Society of Washington 32:169. (Not seen, cited in Hall 1981).

Teipner, C. L., E. O. Garton, and L. Nelson, Jr. 1983. Pocket gophers in forest ecosystems. General Tech Report INT-154, USDA Forest Service Intermountain Forest and Range Experiment Station, Ogden, Utah. 53 pp.

The Nature Conservancy of Washington. 1999. Impact of Declining Oak Woodlands on Missions: Oak Woodland Restoration on McChord Air Force Base. DoD Project No. 9510082 Semi-annual Report #7. The Nature Conservancy of Washington, Seattle.

Thomas, C. D. and I. Hanski. 1997. Butterfly metapopulations. Pp. 359-386 *in* I. Hanski and M. E. Gilpin (eds.). Metapopulation Biology: Ecology, Genetics, and Evolution. Academic Press, San Diego, California.

Thomas, C. D., M. C. Singer, and D. A. Boughton. 1996. Catastrophic extinction of population sources in a butterfly metapopulation. American Naturalist 148:957-975 (Not seen, cited in Hellmann 2002b).

Tothill, J. D. 1913. Tachinidae and some Canadian hosts. Canadian Entomologist 45:69-75. (Not seen, cited in Shepard 2000).

Toweill, D. E. and R. G. Anthony. 1988a. Annual diet of bobcats in Oregon's Cascade Range. Northwest Science 62:99-103.

Toweill, D. E. and R. G. Anthony. 1988b. Coyote foods in the coniferous forest in Oregon. Journal of Wildlife Management 52:507-512.

Tveten, R. 1997. Fire effects on prairie vegetation Fort Lewis, Washington. Pp. 123-130 *in* Dunn and Ewing (1997).

Tveten, R. K. and R. W. Fonda. 1999. Fire effects on prairies and oak woodlands on Fort Lewis, Washington. Northwest Science 73:145-158.

USFWS (U.S. Fish and Wildlife Service). 1997. Determination of threatened status for *Castilleja levisecta* (Golden Paintbrush): Final Rule. Federal Register 62(112:June 11):31740-31748.

USFWS (U.S. Fish and Wildlife Service). 1998. Recovery Plan for the Serpentine Soil Species of the San Francisco Bay Area. U.S. Fish and Wildlife Service, Portland, Oregon. 330 pp.

USFWS (U.S. Fish and Wildlife Service). 2000. Recovery Plan for the Golden Paintbrush (*Castilleja levisecta*). U.S. Fish and Wildlife Service, Portland, Oregon. 51 pp.

USFWS (U.S. Fish and Wildlife Service). 2001. Endangered and Threatened Wildlife and Plants; Review of Plant and Animal Species That Are Candidates or Proposed for Listing as Endanagered or Threatened, Annual Notice of Findings on Recycles Petitions, and Annual Description of Progress on Listing Actions. Federal Register 66(210: October 30):54808-54832.

USFWS (U. S. Fish and Wildlife Service). 2002. Biological and Conference Opinions for the Columbia River Channel Improvements Project. U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2003. Recovery Plan for the Quino Checkerspot Butterfly (*Euphydryas editha quino*). U.S. Fish and Wildlife Service, Portland, Oregon. 179 pp.

Vander Haegen, W. M. and B. Walker. 1999. Parasitism by brown-headed cowbirds in the shrub-steppe of eastern Washington. Studies in Avian Biology 18:34-40.

van Nouhuys, M. and I. Hanski. 2004. Natural enemies of checkerspots. Pp. 161-180 *in* Ehrlich and Hanski (2004a).

Vaughan, T. A. 1961. Vertebrates inhabiting pocket gopher burrows in Colorado. Journal of Mammalogy 42:171-174.

Vaughan, T. A. 1963. Movements made by two species of pocket gophers. American Midland Naturalist 69:367-372.

Vaughan, T. A. 1974. Resource allocation in some sympatric subalpine rodents. Journal of Mammalogy 55:764-795.

Verts, B. J. and L. N. Carraway. 1998. Land Mammals of Oregon. University of California Press, Berkeley, California. 668 pp.

Verts, B. J. and L. N. Carraway. 2000. *Thomomys mazama*. Mammalian Species 641:1-7.

Wagner, D. L., J. W. Peacock, J. L. Carter, and S. E. Talley. 1996. Field assessment of *Bacillus thuringiensis* on nontarget Lepidoptera. Environmental Entomology 25:1444-1454.

Wagner, K. K. and D. L. Nolte. 2000. Evaluation of hot sauce as a repellent for forest mammals. Wildlife Society

Bulletin 28:76-83.
Wahl, T. R. 1995. Birds of Whatcom County: status and distribution. T. R. Wahl, Bellingham, Washington.
Wahlberg, N., P. R. Ehrlich, C. L. Boggs, and I. Hanski. 2004. Bay checkerspot and Glanville fritillary compared with other species. Pp. 219-244 *in* Ehrlich and Hanski (2004a).
Walker, K. M. 1949. Distribution and life history of the black pocket gopher, *Thomomys niger* Merriam. M.S. Thesis, Oregon State University, Corvallis, Oregon. 94 pp.
Walker, K. M. 1955. Distribution and taxonomy of the small pocket gophers of northwestern Oregon. Ph.D. Dissertation, Oregon State University, Corvallis, Oregon. 200 pp. (Not seen, cited in Verts and Carraway 1998).
Warren, D. and P. Dunn. 2005. Recovery of candidate species in the South Puget Sound region: summary of 2004 completed actions and 2005 projected actions. The Nature Conservancy, Olympia, Washington. 22 pp.
Warren, M. S., J. K.Hill, J. A.Thomas, J. Asher R. Fox, B. Huntley, D. B. Roy, M. G. Telfer, S. Jeffcoate, S. G. Willis, J. N. Greatorex-Davies, D. Moss, and C. D. Thomas. 2001. Rapid response of British butterflies to opposing forces of climate change and habitat change. Nature 414:65-69.
Washburn, A. L. 1988. Mima mounds: an evaluation of proposed origins with special reference to the Puget lowland. Report of Investigations 29, Washington Division of Geology and Earth Resources, Washington Department of Natural Resources, Olympia, Washington. 53 pp.
WDG (Washington Department of Game). 1983. Washington State special animal species: preliminary data needs statewide. Nongame Wildlife Program, Washington Department of Game, Olympia, Washington. 23 pp.
WDNR (Washington Department of Natural Resources). 1998. Our Changing Nature: Natural Resource Trends in Washington State. 75 pp.
Weiss, S. B. 1996. Weather, landscape structure, and the population ecology of the threatened butterfly, *Euphydryas editha bayensis*. Ph.D. Dissertation, Stanford University, Stanford, California. 119 pp. (Not seen, cited in USFWS 1998).
Weiss, S. B. 1999. Cars, cows, and checkerspot butterflies: nitrogen deposition and management of nutrient-poor grasslands for a threatened species. Conservation Biology 13:1476-1486.
Weiss, S. B., D. D. Murphy, and R. R. White. 1988. Sun, slope, and butterflies: topographic determinants of habitat quality for *Euphydryas editha*. Ecology 69:1486-1496.
Weiss, S. B., R. R. White, D. D. Murphy, and P. R. Ehrlich. 1987. Growth and dispersal of larvae of the checkerspot butterfly *Euphydryas editha*. Oikos 50:161-166.
Whaley, W. H., J. Anhold, and G. B.Schaalje. 1998. Canyon drift and dispersion of *Bacillus thruingiensis* and its effects on select on target Lepidopterans in Utah. Environmental Entomology 27:539-548.
Whitaker, J. O. Jr., C. Maser, and R. E. Lewis. 1985. Ectoparasitic mites (exluding chiggers), fleas, and lice from pocket gophers, *Thomomys*, in Oregon. Northwest Science 59: 33-39.
White, R. R. 1973. Community relationships of the butterfly, *Euphydryas editha*. Ph.D. Dissertation, Stanford University, Stanford, California. 90 pp.
White, R. R. 1974. Food plant defoliation and larval starvation of *Euphydryas editha*. Oecologia 14:307-315.
White, R. R. 1986. Pupal mortality in the bay checkerspot butterfly (Lepidoptera: Nymphalidae). Journal of Research on the Lepidoptera 25:52-62.
Wiedemann, A. M. 1987. The ecology of European beachgrass (*Ammophila arenaria* (L.) Link): a review of the literature. Technical Report #87-1-01, Oregon Department of Fish and Wildlife, Nongame Wildlife Program, Salem, Oregon. 18 pp.
Wiens, J. A. and J. T. Rotenberry. 1980. Patterns of morphology and ecology in grassland and shrubsteppe bird populations. Ecological Monographs 50:287-308.
Wiens, J. A. and J. T. Rotenberry. 1985. Response of breeding passerine birds to rangeland alteration in a North American shrubsteppe locality. Journal of Applied Ecology 22:655-668.
Wiens, J. A., J. T. Rotenberry, and B. van Horne. 1986. A lesson on the limitations of field experiments: shrubsteppe birds and habitat alteration. Ecology 67:365-376.
Wight, H. M. 1918. The life history and control of the pocket gopher in the Willamette Valley. Oregon Agricultural College Experitmental Sattion Bulletin 153:1-55 (Not seen, cited in Cox and Hunt 1992).
Wiles, G. J. 2001. Summary of county ordinances pertaining to critical wildlife areas and the rrotection of bald eagles in Washington. Unpublished Internal Report, Washington Department of Fish and Wildlife, Olympia, Washington.
Wilkes, C. N., 1844. Narrative of the United States Exploratory Expedition during the years 1838-1842. (*Not seen, in* Lang 1961:16).
Witmer, G. W. and M. J. Pipas. 1999. Field evaluation of radiotransmitters for northern pocket gophers. Prairie Naturalist 31:9-20.
Witmer, G. W., R. D. Sayler, and M. J. Pipas. 1996. Biology and habitat use of the Mazama pocket gopher (*Thomomys mazama*) in the Puget Sound area, Washington. Northwest Science 70:93-98.
WNHP (Washington Natural Heritage Program). 1997. Endangered, Threatened & Sensitive Vascular Plants of Washington—with Working Lists of Rare Non-Vascular Species. Washington Department of Natural Resources, Olympia, Washington. 62 pp.
WSDA (Washington State Department of Agriculture). 1992. Asian gypsy moth in Washington, 1992: a report on a program to exclude, eradicate and detect a dangerous, new insect threat. Washington State Department of Agriculture, Olympia, Washington. 15 pp.
WSDA (Washington State Department of Agriculture). 2004. Final environmental assessment: cooperative gypsy moth eradication project King, Jefferson, and Lewis Counties, Washington. Washington State Department of Agriculture, Plant Protection Division, Olympia, Washington. 20 pp.
Yensen, E. 1998. *Thomomys mazama* Merriam 1897: Mazama pocket gopher; western pocket gopher. Pp. 63-66 *in* D. J.Hafner, E. Yensen, and G. L. Kirkland, Jr. (eds.). North American Rodents: Status Survey and Conservation

Action Plan. IUCN/SSC Rodent Specialist Group, International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland.

York, D. L., J. L. Cummings, R. M. Engeman, and J. E.Davis, Jr. 2000. Evaluation of Flight Control™ and Mesurol® as repellents to reduce horned lark (*Eremophila alpestris*) damage to lettuce seedlings. Crop Protection 19:201-203.

PERSONAL COMMUNICATIONS

Sally Alhadeff
Port of Olympia

Robert C. Beason
USDA APHIS National Wildlife Research Center
Sandusky, Ohio

Barry Bidwell
Graham, Washington

Dave Clouse
Fish and Wildlife Program
Fort Lewis

Jeff DeBell
Washington Dept. Natural Resources
Lacey, WA

Andrew Emlen
Skomokawa, Washington

Jeff Foster
Forestry, Public Works
Fort Lewis, Washington

Dan Grosboll (formerly with WDFW)
The Nature Conservancy
Olympia, Washington

Jennifer Heron
Ministry of Water, Land and Air Protection
Vancouver, BC, Canada

Scott Hoffman-Black
The Xerces Society
Portland, Oregon

Mary Linders
WDFW, Olympia, and Fort Lewis

Angel Lombardi
LCTA Program
Fort Lewis

Jim Lynch
Fish and Wildlife Program
Fort Lewis

Kelly McAllister, WDFW
Olympia, Washington

James Miskelly
University of Victoria, British Columbia

Randy Moore
Dept. Fisheries and Wildlife
Oregon State University, Corvallis

Scott Pearson, WDFW
Olympia, Washington

Jonathan Pelham
Mountlake Terrace, Washington

Robert M. Pyle
Gray's River, Washington

Russell Rogers, WDFW
Brinnon, Washington

Dana Ross
Corvallis, Oregon

Greg Schirato, WDFW
Shelton, Washington

Anna Schmidt
WDFW and The Evergreen State College
Olympia, Washington

Jim Sedore
Washington Dept. Natural Resources
Olympia, Washington

Jon Shepard
Pullman, Washington

Ellie Steinberg
University of Montana
Missoula, Montana

Richard Taylor, WDFW (retired)
Tacoma, Washington

Ted Thomas
U. S. Fish and Wildlife Service
Lacey, Washington

Philip Unitt
San Diego Natural History Museum
San Diego, California

Mace Vaughan
The Xerces Society
Portland, Oregon

Mike Walker, WDFW
Olympia, Washington

Corey Welch
Dept of Biology
University of Washington

Appendix A . Historical locations for Tacoma pocket gopher (*T. mazama tacomensis*).

Location	Township/Range/Sec	Specimens collected[a]
Point Defiance Park[b] / 1 mi S of Point Defiance Park	T21N R02E S15	4 collected by MJ/PC[c] in 1947; PC collected 2 in 1940, 1941
N. Pearl St., S of Ruston	T21N R02E S26	M.J/PC collected 1 in 1940, 1 in 1941, 2 in 1947
N End Reservoir, Pearl St.[b]	T21N R02E S25	4 collected by M. J/P.C in 1947.
Tacoma Narrows Bridge approach[b]	T21N R02E S34	5 collected by Dalquest& Scheffer (1944) 6 collected by MJ/PC in 1946-'47
Geiger School, 0.3 mi S 6th on Alexander Jackson Rd.	T20N R02ES3	2 collected by MJ/PC in 1947
E of Titlow lagoon, S 13th and Jackson Rd.	T20N R02 S3	1 collected by MJ/PC in 1947
Hillside above Days Island[b]	T20N R02E S9	1 collected PC in 1941, 1 by MJ in 1947
University Place	T20N R02E	3 in NMNH (Dalquest and Scheffer 1944)
Fircrest, across highway from Tacoma airport (?)	T20N R02E ?	2 collected by MJ/PC in 1947
W of Fircrest Golf Club[b]	T20N R02E S11	1 collected by MJ/PC in 1947
1 mi S of Days Island Bridge	T20N R02E S16	3 collected (Dalquest & Scheffer 1944)
40th St W; 37th St.W (Harder Rd and Dixie Rd.in Dalquest's notes)	T20N R02E S15	2 collected by Dalquest, 1940-1942; E. Booth collected 1 in1940
Narrows View School, A.Jackson Rd, 1 mi N Chambers Crk Rd.	T20N R02E S15	2 collected by MJ/PC in 1947
E of Peach Acres, A Jackson & Chambers Crk Rd.	T20N R02E 22	3 collected by MJ/PC in 1947
Bluff W of New Tacoma Cemetary/ S of Pioneer, (Gravel pits)[b d]	T20N R02E S20	1 collected by MJ/PC in 1947
S of New Tacoma Cemetary[b d]	T20N R02E S21	18 collected by MJ/PC in 1947; 2 by MJ in 1950
above Chambers Creek, opposite New Tacoma Cemetary	T20N R02E S28	MJ/PC collected 11 in 1941, 12 in 1947.
Chambers Crk[d]	T20N R02E S27	2 collected by MJ 1961-'62
Chambers Crk, lower end, Tacoma side[d]	S34	2 collected by PC in 1946
Brookdale Rd[b]	T19N R03E S17	T.H. Scheffer caught gophers circa 1920 (V.B. Scheffer, field notes, 1940)
S. Meridian, Puyallup	T19N R04E	J. Finley reportedly caught gophers here (V. B. Scheffer, field notes 1940)
Wapato Hill, Tacoma[b]	T20N R03E S19 SEofSE	Cats killed several gophers at Wapato Hills in 1974 (WDFW data); none detected in 1998 (R.Taylor)

[a]Information on collections based in part on records at Slater Museum, University of Puget Sound, Burke Mueum, University of Washington, and the Museum of Vertebrate Zoology, University of California, Berkeley.
[b] Steinberg checked these locations and saw no gopher activity (Steinberg 1996a)
[c] MJ = Murray L. Johnson, PC = P.W. Cheney
[d] Dalquest and Scheffer (1944) collected or examined 41 T.m. tacomensis specimens, including 21 from "5 mi SW Tacoma" and probably came from these locations.

Appendix B. Streaked Horned Lark Specimens Collected in Washington.

No.	Location	County	Date	Year	Museum No.	Collector	Notes
1	Ft. Steilacoom	Pierce	20 Mar	1856	USNM#A08733	G. Suckley	Female, cotype
2	Ft. Steilacoom	Pierce	15 Apr	1865	USNM A08734	G. Suckley	Male, cotype
3	Ridgefield	Clark	14 Jul	1892	AMNH #57704	R. H. Lawrence	male
4	S. Tacoma	Pierce	25 Jul	1897	USNM #156613	W. K. Fisher	Male
6	S. Tacoma	Pierce	25 Jul	1897	USNM #156614	W. K. Fisher	Male
7	S. Tacoma	Pierce	25 Jul	1897	USNM #156615	W. K. Fisher	Male
8		Pierce	26 July	1897	USNM#B40500	J. H. Bowles	2 eggs
9	Hillhurst	Pierce	19 Aug	1897	USNM #156569	V. Bailey	female
10	S. Tacoma	Pierce	21 May	1899	USNM#B29868	J. H. Bowles	Nest & 3 eggs
11	S. Tacoma	Pierce	21 May	1899	USNM#B29869	J. H. Bowles	Nest & 2 eggs
12	S. Tacoma	Pierce	19 May	1905	USNM#B44308	J. H. Bowles	2 eggs
13	Spanaway	Pierce	22 Feb	1907	Burke #16697	J. H. Bowles	female
14	S. Tacoma	Pierce	22 Feb	1907	Burke #16698	J. H. Bowles	male
15	Spanaway	Pierce	22 Feb	1908	Burke #16696	J. H. Bowles	male
16	Spanaway	Pierce	27 Feb	1908	Burke #16700	J. H. Bowles	male
17	Tacoma	Pierce	10 Sep	1908	MVZ #33528	J. H. Bowles	male
18	Spanaway	Pierce	22 Feb	1909	Burke #16699	J. H. Bowles	female
19	Tacoma	Pierce	30 May	1911	USNM#B44305	D. E. Brown	3 eggs
20	Tacoma	Pierce	20 Apr	1913	LACM #22341	D. E. Brown	female
21	Tacoma	Pierce	20 Apr	1913	FMNH# 70498	E. E. Armstrong	male
22	Tacoma	Pierce	12 Jul	1913	AMNH#370835	D. E. Brown	male
23	Tacoma	Pierce	12 Jul	1913	MVZ #102673	D. E. Brown	male.
24	Tacoma	Pierce	29 Apr	1914	FMNH# 141422	L. B.Bishop	male
25	Tacoma	Pierce	1 May	1914	FMNH# 141423	L. B. Bishop	female
26	Tacoma	Pierce	31 May	1914	FMNH# 173849	L. B.Bishop	male
27	S. Tacoma	Pierce	27 Jul	1916	AMNH#755644	J. H. Bowles	female
28	Tacoma	Pierce	27 Jul	1916	FMNH# 161561	L. B.Bishop	male?
29	Tacoma	Pierce	6 Mar	1917	AMNH#755645	J. H. Bowles	male
30	Tacoma	Pierce	16 Apr	1917	LACM #22340	J. H. Bowles	male
31	Tacoma	Pierce	10 Feb	1918	Slater #06464	E.A. Kitchen	male
32	Spanaway	Pierce	22 Feb	1919	AMNH#755646	J. H. Bowles	female
33	Spanaway	Pierce	22 Feb	1919	AMNH#755647	J. H. Bowles	male
34	Tacoma	Pierce	24 Apr	1921	MVZ #82381	A.C. Brooks	? on spp.
35	Tacoma	Pierce	14 Jan	1924	Slater #06465	E. A. Kitchen	male
36		Pierce	5 Aug	1926	Slater #15365	E. A. Kitchen	Nest & 5 eggs
37	Tacoma	Pierce	27 Feb	1927	Burke #8131	D. E. Brown	male
38	Tacoma	Pierce	27 Feb	1927	Burke #8132	D. E. Brown	female
39	Tacoma	Pierce	27 Feb	1927	Burke #8133	D. E. Brown	female
40	Tacoma	Pierce	27 Feb	1927	Burke #8134	D. E. Brown	male
41	Tacoma	Pierce	27 Feb	1927	Burke #8135	D. E. Brown	male
42	Tacoma	Pierce	27 Feb	1927	Burke #8136	D. E. Brown	male
43	Tacoma	Pierce	27 Feb	1927	Burke #8137	D. E. Brown	male
44	Tacoma	Pierce	27 Feb	1927	Burke #8138	D. E. Brown	male
45	Tacoma	Pierce	27 Feb	1927	Burke #8139	D. E. Brown	female
46	Tacoma	Pierce	27 Feb	1927	Burke #8140	D. E. Brown	male
47	Tacoma	Pierce	27 Feb	1927	Burke #8141	D. E. Brown	female
48	Tacoma	Pierce	27 Feb	1927	Burke #8142	D. E. Brown	male
49	Spanaway	Pierce	27 Feb	1927	Burke #8143	D. E. Brown	male
50	Tacoma	Pierce	27 Feb	1927	Burke #8144	D. E. Brown	male
51	Tacoma	Pierce	27 Feb	1927	Burke #8145	D. E. Brown	female
52	Tacoma	Pierce	27 Feb	1927	Burke #8146	D. E. Brown	male
53	Tacoma	Pierce	27 Feb	1927	Burke #8147	D. E. Brown	male
54	Tacoma	Pierce	27 Feb	1927	Burke #8148	D. E. Brown	male
55	Tacoma	Pierce	27 Feb	1927	Burke #8149	D. E. Brown	male
56	Samish Flats	Skagit	12 Aug	1928	Slater #19319	J. M. Edson	female,
57	Edison	Skagit	26 May	1929	Slater #19317	E. J. Booth	male

No.	Location	County	Date	Year	Museum No.	Collector	Notes
58	Edison	Skagit	26 May	1929	Slater #19318	E. J. Booth	male
59	Spanaway	Pierce	21 Jun	1931	USNM#B47055	E. A. Kitchin	4 eggs
60		Pierce	7 Jun	1931	Slater #15363	E. A. Kitchen	Nest & 3 eggs
61		Pierce	10 Jun	1931	Slater #15364	E. A. Kitchen	Nest & 4 eggs
62		Pierce	17 May	1931	Slater #15367	G. D. Alcorn	Nest & 4 eggs
63		Pierce	20 Jun	1931	Slater #15368	E. A. Kitchen	Nest & 4 eggs
64	Spanaway	Pierce	20 Apr	1932	Slater #08278	G. D. Alcorn	male
65	Spanaway	Pierce	30 Apr	1932	Slater #08279	G. D. Alcorn	female,
66		Pierce	20 May	1933	Slater #15366	G. D. Alcorn	Nest & 2 eggs
67	Shelton	Mason	6 Mar	1934	Slater #09684	S. Warburton	female
68		Pierce	8 May	1934	Slater #15361	E. A. Kitchen	Nest & 2 eggs
69		Whatcom	26 Apr	1935	Burke #18038	D. E. Brown	male
70		Skagit	12 May	1935	Burke #18039	D. E. Brown	male
71		Whatcom	26 Apr	1935	Burke #18040	D. E. Brown	female
72	Anacortes	Skagit	18 Jul	1937	Burke #10989	W. Dalquest	female
73	Anacortes	Skagit	18 Jul	1937	Burke #10990	W. Dalquest	male
74	Anacortes	Skagit	18 Jul	1937	Burke #10991	W. Dalquest	female
75	Westport	Grays Harbor	19 Nov	1953	USNM #466580	T. D. Burleigh	male
76	Westport	Grays Harbor	5 Nov	1955	USNM #563482	T. D. Burleigh	male
77	Bremerton	Kitsap	28 Aug	1957	USNM #465309	T. D. Burleigh	im male
78	Ocean Shores	Grays Harbor	26 Jul	1974	Burke #28447	S. A. Rohwer	female
79	Ocean Shores	Grays Harbor	26 Jul	1974	Burke #28448	S. A. Rohwer	male
80	Ocean Shores	Grays Harbor	26 Jul	1974	Burke #28449	S. A. Rohwer	male
81	Ocean Shores	Grays Harbor	26 Jul	1974	Burke #28450	S. A. Rohwer	male
82	Ocean Shores	Grays Harbor	11 Oct	1990	Slater #12077	D. R. Paulson	female,
83	Graveyard Spit	Grays Harbor	26 Aug	1994	Slater #20801	B. K. Schmidt	female
84	Graveyard Spit	Grays Harbor	26 Aug	1994	Slater #20802	B. K. Schmitdt	male

[a] Museums: AMNH = American Museum of Natural History, New York; Burke = Burke Museum, University of Washington; FMNH = Field Museum of Natural History, Chicago; LACM = Los Angeles County Museum; MVZ = Museum of Vertebrate Zoology, University of California, Berkeley; Slater = Slater Museum, University of Puget Sound; USNM= Division of Birds, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Table B2. Specimens originally labeled as *E. a. strigata*, but may be *E. a. merrilli*, intergrades between *merrilli* and *strigata* (based on Behle 1942), or *E. a. alpina* (Jewett et al. 1943).

No.	Location	County	Date	Year	Museum No.	Collector	Notes
1	Colton	Whitman	24 Aug	1895	USNM #139899	A. H. Howell	male
2	Rockland [Dallesport]	Klickitat	7 Jul	1897	USNM #156455	V. Bailey	male
3	North Dalles [Dallesport]	Klickitat	14 Jul	1897	USNM #156452	W. K. Fisher	male
4	Kiona	Benton	1 Jan	1917	AMNH#755658	F. R. Decker	male
5	Grande Dalles [Dallesport]	Klickitat	12 Jul	1917	USNM #262596	M. E. Peck	male
6	Grande Dalles [Dallesport]	Klickitat	12 Jul	1917	USNM #262597	M. E. Peck	female
7	Cliffs [5 mi E of Maryhill]	Klickitat	14 Jul	1917	USNM #262604	W. P. Taylor	male
8	Grande Dalles [Dallesport]	Klickitat	17 Jul	1917	USNM #262601	W. P. Taylor	female
9	Grande Dalles [Dallesport]	Klickitat	18 Jul	1917	USNM #262602	W. P. Taylor	male
10	1 mi NE Maryhill	Klickitat	14 Jul	1939	MVZ #77756	W. M. Long-hurst	male
11	1 mi NE Maryhill	Klickitat	14 Jul	1939	MVZ #77757	W. M. Longhurst	male
12	St. Helens Mt (timberline)[a]	Skamania	2 Jul	1948	USNM #590718	I. Gabrielson	im male
13	St. Helens Mt (timberline)[a]	Skamania	2 Jul	1948	USNM #590719	I. Gabrielson	im female
14	St. Helens Mt (timberline)[a]	Skamania	2 Jul	1948	USNM #590722	I. Gabrielson	im fem

[a]Likely subspecies E. a. alpina based on location.

Appendix C. Historical populations of Taylor's checkerspot in Oregon and British Columbia now believed extinct.

Location/ Code	Year	Notes
Oregon[a]		
Benton-1	1957-1980	One to 58 collected during 23 visits in 15 separate years (Hinchliff record: Dornfeld, Baker, Woodley, Mays, Crowe, Hinchliff, Ferris, Pelham, Jewett, Lindberg)
	1990's	None seen during regular visits, also 2000-02 (McCorkle)
	2004	None; site very degraded
Benton-2	1940,'58,'59, '60,'64	Collected during 5 separate years (Hinchliff record: Jewett, Hopfinger, Wooodley, Baker, Dornfeld) exact location unknown (possibly same as B-1)
Benton-3	1939	Exact location unknown (Hinchliff record: Bollinger)
Benton-4	1970's	Regularly observed pop. (McCorkle)
	1990's	None: Regular surveys (McCorkle)
Benton-5	1946	At least one (Hinchliff record: Nerdham)
	2002	None: regularly surveyed in recent years (Hammond)
Lane-1	1940	Exact location unknown, possibly L-2 or L-3 (Hinchliff record: Ellsworth, Jewett, Baker)
Lane-2	1950's	Regularly observed (Rice)
	2003	None: One survey (Severns)
	2004	None; site degraded
Lane-3	1950's	Regularly observed (Rice)
	1980's	None: Trees have grown in and now dominate site (Rice)
Polk-1	1966, '67, '71, '73	Regularly observed (Hinchliff record: McCorkle)
	2002	Possibly some habitat remaining. Site partly developed, access discouraged (McCorkle)
	2004	None; area degraded
Polk-2	1980's	At least one (Hammond)
	2002	None: Visited during intervening years (Hammond)
Polk-3	1969	At least one (Hinchliff record: McCorkle)
	2002	None: Habitat lost to succession (McCorkle)
Polk-4	1979	Small colony (McCorkle)
	2002	None: Visited during intervening years (McCorkle)
British Columbia[b]		
Beacon Hill Park	1901	Last observed
Braefoot	1952	Last observed
Brentwood	1954	Last observed
Cattle Point	1932	Last observed
Central Saanich	1964	Last observed

Location/ Code	Year	Notes
Chain Island	1953	Last observed
Hudson Bay Woods	1954	Last observed
Lost Lake	1953	Last observed
Mt Douglas	1954	Last observed
Mt Findlayson	1958	Last observed
Oak Bay	1951	Last observed
Observatory Hill	1957	Last observed
Royal Oak	1957	Last observed
Thetis Lake	1950's	Last observed
Tod Inlet	1928	Last observed
Trial Island	1953	Last observed
Courtney	1931	Last observed
Duncan	1978	Last observed
Mill Bay	1989	Last observed
Shawnigan	1952	Last observed
Helliwell Park, Hornby Is.	1996	Last observed
Norman Point, Hornby Is.	1996	Last observed
Tribune Bay Park, Hornby Is.	1996	Last observed

[a]Source: compiled by A. Potter from Evergreen Aurelians (as compiled by Hinchliff), P. Hammond, D. McCorkle, H. Rice, D. Ross.
[b]From Shepard (2000) and J. Shepard, pers. com

Appendix D. Washington Administrative Code 232-12-011, 232-12-014, and 232-12-297.

WAC 232-12-011 Wildlife classified as protected shall not be hunted or fished.

Protected wildlife are designated into three subcategories: threatened, sensitive, and other.
(1) Threatened species are any wildlife species native to the state of Washington that are likely to become endangered within the foreseeable future throughout a significant portion of their range within the state without cooperative management or removal of threats. Protected wildlife designated as threatened include:

Common Name	Scientific Name
western gray squirrel	*Sciurus griseus*
Steller (northern) sea lion	*Eumetopias jubatus*
North American lynx	*Lynx canadensis*
Aleutian Canada goose	*Branta canadensis leucopareia*
bald eagle	*Haliaeetus leucocephalus*
ferruginous hawk	*Buteo regalis*
marbled murrelet	*Brachyramphus marmoratus*
green sea turtle	*Chelonia mydas*
loggerhead sea turtle	*Caretta caretta*
sage grouse	*Centrocercus urophasianus*
sharp-tailed grouse	*Phasianus columbianus*

(2) Sensitive species are any wildlife species native to the state of Washington that are vulnerable or declining and are likely to become endangered or threatened in a significant portion of their range within the state without cooperative management or removal of threats. Protected wildlife designated as sensitive include:

Common Name	Scientific Name
gray whale	*Eschrichtius gibbosus*
common Loon	*Gavia immer*
peregrine falcon	*Falco peregrinus*
Larch Mountain salamander	*Plethodon larselli*
pygmy whitefish	*Prosopium coulteri*
margined sculpin	*Cottus marginatus*
Olympic mudminnow	*Novumbra hubbsi*

(3) Other protected wildlife include:

Common Name	Scientific Name
cony or pika	*Ochotona princeps*
least chipmunk	*Tamius minimus*
yellow-pine chipmunk	*Tamius amoenus*
Townsend's chipmunk	*Tamius townsendii*
red-tailed chipmunk	*Tamius ruficaudus*
hoary marmot	*Marmota caligata*
Olympic marmot	*Marmota olympus*
Cascade golden-mantled ground squirrel	*Spermophilus saturatus*
golden-mantled ground squirrel	*Spermophilus lateralis*
Washington ground squirrel	*Spermophilus washingtoni*
red squirrel	*Tamiasciurus hudsonicus*
Douglas squirrel	*Tamiasciurus douglasii*
northern flying squirrel	*Glaucomys sabrinus*
wolverine	*Gulo gulo*
painted turtle	*Chrysemys picta*
California mountain kingsnake	*Lampropeltis zonata*

All birds not classified as game birds, predatory birds or endangered species, or designated as threatened species or sensitive species; all bats, except when found in or immediately adjacent to a dwelling or other occupied building; mammals of the order Cetacea, including whales, porpoises, and mammals of the order Pinnipedia not otherwise classified as endangered species, or designated as threatened species or sensitive species. This section shall not apply to hair seals and sea lions which are threatening to damage or are damaging commercial fishing gear being utilized in a lawful manner or when said mammals are damaging or threatening to damage commercial fish being lawfully taken with commercial gear.

[Statutory Authority: RCW 77.12.047, 77.12.655, 77.12.020. 02-11-069 (Order 02-98), § 232-12-011, filed 5/10/02, effective 6/10/02. Statutory Authority: RCW 77.12.047. 02-08-048 (Order 02-53), § 232-12-011, filed 3/29/02, effective 5/1/02; 00-17-106 (Order 00-149), § 232-12-011,

filed 8/16/00, effective 9/16/00. Statutory Authority: RCW 77.12.040, 77.12.010, 77.12.020, 77.12.770. 00-10-001 (Order 00-47), § 232-12-011, filed 4/19/00, effective 5/20/00. Statutory Authority: RCW 77.12.040, 77.12.010, 77.12.020, 77.12.770, 77.12.780. 00-04-017 (Order 00-05), § 232-12-011, filed 1/24/00, effective 2/24/00. Statutory Authority: RCW 77.12.020. 98-23-013 (Order 98-232), § 232-12-011, filed 11/6/98, effective 12/7/98. Statutory Authority: RCW 77.12.040. 98-10-021 (Order 98-71), § 232-12-011, filed 4/22/98, effective 5/23/98. Statutory Authority: RCW 77.12.040 and 75.08.080. 98-06-031, § 232-12-011, filed 2/26/98, effective 5/1/98. Statutory Authority: RCW 77.12.020. 97-18-019 (Order 97-167), § 232-12-011, filed 8/25/97, effective 9/25/97. Statutory Authority: RCW 77.12.040, 77.12.020, 77.12.030 and 77.32.220. 97-12-048, § 232-12-011, filed 6/2/97, effective 7/3/97. Statutory Authority: RCW 77.12.020. 93-21-027 (Order 615), § 232-12-011, filed 10/14/93, effective 11/14/93; 90-11-065 (Order 441), § 232-12-011, filed 5/15/90, effective 6/15/90. Statutory Authority: RCW 77.12.040. 89-11-061 (Order 392), § 232-12-011, filed 5/18/89; 82-19-026 (Order 192), § 232-12-011, filed 9/9/82; 81-22-002 (Order 174), § 232-12-011, filed 10/22/81; 81-12-029 (Order 165), § 232-12-011, filed 6/1/81.]

WAC 232-12-014 Wildlife classified as endangered species. Endangered species include:

Common Name	Scientific Name
pygmy rabbit	*Brachylagus idahoensis*
fisher	*Martes pennanti*
gray wolf	*Canis lupus*
grizzly bear	*Ursus arctos*
sea otter	*Enhydra lutris*
sei whale	*Balaenoptera borealis*
fin whale	*Balaenoptera physalus*
blue whale	*Balaenoptera musculus*
humpback whale	*Megaptera novaeangliae*
black right whale	*Balaena glacialis*
sperm whale	*Physeter macrocephalus*
killer whale	*Orcinus orca*
Columbian white-tailed deer	*Odocoileus virginianus leucurus*
woodland caribou	*Rangifer tarandus caribou*
American white pelican	*Pelecanus erythrorhynchos*
brown pelican	*Pelecanus occidentalis*
sandhill crane	*Grus canadensis*
snowy plover	*Charadrius alexandrinus*
upland sandpiper	*Bartramia longicauda*
spotted owl	*Strix occidentalis*
western pond turtle	*Clemmys marmorata*
leatherback sea turtle	*Dermochelys coriacea*
mardon skipper	*Polites mardon*
Oregon silverspot butterfly	*Speyeria zerene hippolyta*
Oregon spotted frog	*Rana pretiosa*
northern leopard frog	*Rana pipiens*

[Statutory Authority: RCW 77.12.047, 77.12.655, 77.12.020. 02-11-069 (Order 02-98), § 232-12-014, filed 5/10/02, effective 6/10/02. Statutory Authority: RCW 77.12.040, 77.12.010, 77.12.020, 77.12.770, 77.12.780. 00-04-017 (Order 00-05), § 232-12-014, filed 1/24/00, effective 2/24/00. Statutory Authority: RCW 77.12.020. 98-23-013 (Order 98-232), § 232-12-014, filed 11/6/98, effective 12/7/98; 97-18-019 (Order 97-167), § 232-12-014, filed 8/25/97, effective 9/25/97; 93-21-026 (Order 616), § 232-12-014, filed 10/14/93, effective 11/14/93. Statutory Authority: RCW 77.12.020(6). 88-05-032 (Order 305), § 232-12-014, filed 2/12/88. Statutory Authority: RCW 77.12.040. 82-19-026 (Order 192), § 232-12-014, filed 9/9/82; 81-22-002 (Order 174), § 232-12-014, filed 10/22/81; 81-12-029 (Order 165), § 232-12-014, filed 6/1/81.]

WAC 232-12-297 Endangered, threatened, and sensitive wildlife species classification.

PURPOSE

1.1 The purpose of this rule is to identify and classify native wildlife species that have need of protection and/or management to ensure their survival as free-ranging populations in Washington and to define the process by which listing, management, recovery, and delisting of a species can be achieved. These rules are established to ensure that consistent procedures and criteria are followed when classifying wildlife as endangered, or the protected wildlife subcategories threatened or sensitive.

DEFINITIONS

For purposes of this rule, the following definitions apply:

2.1 "Classify" and all derivatives means to list or delist wildlife species to or from endangered, or to or from the protected wildlife subcategories threatened or sensitive.

2.2 "List" and all derivatives means to change the classification status of a wildlife species to endangered, threatened, or sensitive.

2.3 "Delist" and its derivatives means to change the classification of endangered, threatened, or sensitive species to a classification other than endangered, threatened, or sensitive.

2.4 "Endangered" means any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state.

2.5 "Threatened" means any wildlife species native to the state of Washington that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state without cooperative management or removal of threats.

2.6 "Sensitive" means any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened in a significant portion of its range within the state without cooperative management or removal of threats.

2.7 "Species" means any group of animals classified as a species or subspecies as commonly accepted by the scientific community.

2.8 "Native" means any wildlife species naturally occurring in Washington for purposes of breeding, resting, or foraging, excluding introduced species not found historically in this state.

2.9 "Significant portion of its range" means that portion of a species' range likely to be essential to the long-term survival of the population in Washington.

LISTING CRITERIA

3.1 The commission shall list a wildlife species as endangered, threatened, or sensitive solely on the basis of the biological status of the species being considered, based on the preponderance of scientific data available, except as noted in section 3.4.

3.2 If a species is listed as endangered or threatened under the federal Endangered Species Act, the agency will recommend to the commission that it be listed as endangered or threatened as specified in section 9.1. If listed, the agency will proceed with development of a recovery plan pursuant to section 11.1.

3.3 Species may be listed as endangered, threatened, or sensitive only when populations are in danger of failing, declining, or are vulnerable, due to factors including but not restricted to limited numbers, disease, predation, exploitation, or habitat loss or change, pursuant to section 7.1.

3.4 Where a species of the class Insecta, based on substantial evidence, is determined to present an unreasonable risk to public health, the commission may make the determination that the species need not be listed as endangered, threatened, or sensitive.

DELISTING CRITERIA

4.1 The commission shall delist a wildlife species from endangered, threatened, or sensitive solely on the basis of the biological status of the species being considered, based on the preponderance of scientific data available.

4.2 A species may be delisted from endangered, threatened, or sensitive only when populations are no longer in danger of failing, declining, are no longer vulnerable, pursuant to section 3.3, or meet recovery plan goals, and when it no longer meets the definitions in sections 2.4, 2.5, or 2.6.

INITIATION OF LISTING PROCESS

5.1 Any one of the following events may initiate the listing process.

1.1.1 The agency determines that a species population may be in danger of failing, declining, or vulnerable, pursuant to section 3.3.

1.1.2 A petition is received at the agency from an interested person. The petition should be addressed to the director. It should set forth specific evidence and scientific data which shows that the species may be failing, declining, or vulnerable, pursuant to section 3.3. Within 60 days, the agency shall either deny the petition, stating the reasons, or initiate the classification process.

1.1.3 An emergency, as defined by the Administrative Procedure Act, chapter 34.05 RCW. The listing of any species previously classified under emergency rule shall be governed by the provisions of this section.

1.1.4 The commission requests the agency review a species of concern.

5.2 Upon initiation of the listing process the agency shall publish a public notice in the Washington Register, and notify those parties who have expressed their interest to the department, announcing the initiation of the classification process and calling for scientific information relevant to the species status report under consideration pursuant to section 7.1.

INITIATION OF DELISTING PROCESS

6.1 Any one of the following events may initiate the delisting process:

1.1.1 The agency determines that a species population may no longer be in danger of failing, declining, or vulnerable, pursuant to section 3.3.

1.1.2 The agency receives a petition from an interested person. The petition should be addressed to the director. It should set forth specific evidence and scientific data which shows that the species may no longer be failing, declining, or vulnerable, pursuant to section 3.3. Within 60 days, the agency shall either deny the petition, stating the reasons, or initiate the delisting process.

1.1.3 The commission requests the agency review a species of concern.

6.2 Upon initiation of the delisting process the agency shall publish a public notice in the Washington Register, and notify those parties who have expressed their interest to the department, announcing the initiation of the delisting process and calling for scientific information relevant to the species status report under consideration pursuant to section 7.1.

SPECIES STATUS REVIEW AND AGENCY RECOMMENDATIONS

7.1 Except in an emergency under 5.1.3 above, prior to making a classification recommendation to the commission, the agency shall prepare a preliminary species status report. The report will include a review of information relevant to the species' status in Washington and address factors affecting its status, including those given under section 3.3. The status report shall be reviewed by the public and scientific community. The status report will include, but not be limited to an analysis of:

1.1.1 Historic, current, and future species population trends.

1.1.2 Natural history, including ecological relationships (e.g. food habits, home range, habitat selection patterns).

1.1.3 Historic and current habitat trends.

1.1.4 Population demographics (e.g. survival and mortality rates, reproductive success) and their relationship to long term sustainability.

1.1.5 Historic and current species management activities.

7.2 Except in an emergency under 5.1.3 above, the agency shall prepare recommendations for species classification, based upon scientific data contained in the status report. Documents shall be prepared to determine the environmental consequences of adopting the recommendations pursuant to requirements of the State Environmental Policy Act (SEPA).

7.3 For the purpose of delisting, the status report will include a review of recovery plan goals.

PUBLIC REVIEW

8.1 Except in an emergency under 5.1.3 above, prior to making a recommendation to the commission, the agency shall provide an opportunity for interested parties to submit new scientific data relevant to the status report, classification recommendation, and any SEPA findings.

8.1.1 The agency shall allow at least 90 days for public comment.

FINAL RECOMMENDATIONS AND COMMISSION ACTION

9.1 After the close of the public comment period, the agency shall complete a final status report and classification recommendation. SEPA documents will be prepared, as necessary, for the final agency recommendation for classification. The classification recommendation will be presented to the commission for action. The final species status report, agency classification recommendation, and SEPA documents will be made available to the public at least 30 days prior to the commission meeting.

9.2 Notice of the proposed commission action will be published at least 30 days prior to the commission meeting.

PERIODIC SPECIES STATUS REVIEW

10.1 The agency shall conduct a review of each endangered, threatened, or sensitive wildlife species at least every five years after the date of its listing. This review shall include an update of the species status report to determine whether the status of the species warrants its current listing status or deserves reclassification.

1.1.1 The agency shall notify any parties who have expressed their interest to the department of the periodic status review. This notice shall occur at least one year prior to end of the five year period required by section 10.1.

10.2 The status of all delisted species shall be reviewed at least once, five years following the date of delisting.

10.3 The department shall evaluate the necessity of changing the classification of the species being reviewed. The agency shall report its findings to the commission at a commission meeting. The agency shall notify the public of its findings at least 30 days prior to presenting the findings to the commission.

1.1.1 If the agency determines that new information suggests that classification of a species should be changed from its present state, the agency shall initiate classification procedures provided for in these rules starting with section 5.1.

1.1.2 If the agency determines that conditions have not changed significantly and that the classification of the species should remain unchanged, the agency shall recommend to the commission that the species being reviewed shall retain its present classification status.

10.4 Nothing in these rules shall be construed to automatically delist a species without formal commission action.

RECOVERY AND MANAGEMENT OF LISTED SPECIES

11.1 The agency shall write a recovery plan for species listed as endangered or threatened. The agency will write a management plan for species listed as sensitive. Recovery and management plans shall address the listing criteria described in sections 3.1 and 3.3, and shall include, but are not limited to:

1.1.1 Target population objectives.

1.1.2 Criteria for reclassification.

1.1.3 An implementation plan for reaching population objectives which will promote cooperative management and be sensitive to landowner needs and property rights. The plan will specify resources needed from and impacts to the department, other agencies (including

federal, state, and local), tribes, landowners, and other interest groups. The plan shall consider various approaches to meeting recovery objectives including, but not limited to regulation, mitigation, acquisition, incentive, and compensation mechanisms.

1.1.4 Public education needs.

1.1.5 A species monitoring plan, which requires periodic review to allow the incorporation of new information into the status report.

11.2 Preparation of recovery and management plans will be initiated by the agency within one year after the date of listing.

1.1.1 Recovery and management plans for species listed prior to 1990 or during the five years following the adoption of these rules shall be completed within 5 years after the date of listing or adoption of these rules, whichever comes later. Development of recovery plans for endangered species will receive higher priority than threatened or sensitive species.

1.1.2 Recovery and management plans for species listed after five years following the adoption of these rules shall be completed within three years after the date of listing.

1.1.3 The agency will publish a notice in the Washington Register and notify any parties who have expressed interest to the department interested parties of the initiation of recovery plan development.

1.1.4 If the deadlines defined in sections 11.2.1 and 11.2.2 are not met the department shall notify the public and report the reasons for missing the deadline and the strategy for completing the plan at a commission meeting. The intent of this section is to recognize current department personnel resources are limiting and that development of recovery plans for some of the species may require significant involvement by interests outside of the department, and therefore take longer to complete.

11.3 The agency shall provide an opportunity for interested public to comment on the recovery plan and any SEPA documents.

CLASSIFICATION PROCEDURES REVIEW

12.1 The agency and an ad hoc public group with members representing a broad spectrum of interests, shall meet as needed to accomplish the following:

1.1.1 Monitor the progress of the development of recovery and management plans and status reviews, highlight problems, and make recommendations to the department and other interested parties to improve the effectiveness of these processes.

1.1.2 Review these classification procedures six years after the adoption of these rules and report its findings to the commission.

AUTHORITY

13.1 The commission has the authority to classify wildlife as endangered under RCW 77.12.020. Species classified as endangered are listed under WAC 232-12-014, as amended.

13.2 Threatened and sensitive species shall be classified as subcategories of protected wildlife. The commission has the authority to classify wildlife as protected under RCW 77.12.020. Species classified as protected are listed under WAC 232-12-011, as amended.

[Statutory Authority: RCW 77.12.047, 77.12.655, 77.12.020. 02-02-062 (Order 01-283), § 232-12-297, filed 12/28/01, effective 1/28/02. Statutory Authority: RCW 77.12.040. 98-05-041 (Order 98-17), § 232-12-297, filed 2/11/98, effective 3/14/98. Statutory Authority: RCW 77.12.020. 90-11-066 (Order 442), § 232-12-297, filed 5/15/90, effective 6/15/90.]

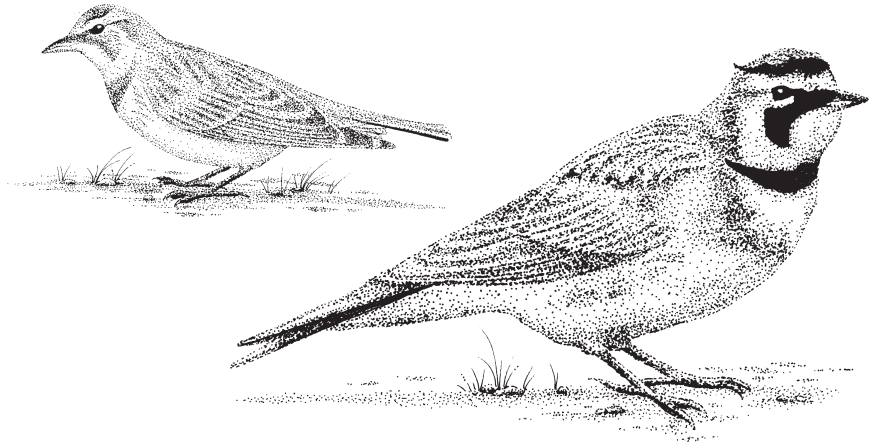
WASHINGTON STATE STATUS REPORTS AND RECOVERY PLANS

Status Reports

2005	Mazama Pocket Gopher, Streaked Horned Lark, Taylor's Checkerspot	√
2005	Aleutian Canada Goose	√
2004	Killer Whale	√
2002	Peregrine Falcon	√
2001	Bald Eagle	√
2000	Common Loon	√
1999	Northern Leopard Frog	√
1999	Olympic Mudminnow	√
1999	Mardon Skipper	√
1999	Lynx Update	
1998	Fisher	√
1998	Margined Sculpin	√
1998	Pygmy Whitefish	√
1998	Sharp-tailed Grouse	√
1998	Sage-grouse	√
1997	Aleutian Canada Goose	√
1997	Gray Whale	√
1997	Olive Ridley Sea Turtle	√
1997	Oregon Spotted Frog	√
1993	Larch Mountain Salamander	
1993	Lynx	
1993	Marbled Murrelet	
1993	Oregon Silverspot Butterfly	
1993	Pygmy Rabbit	
1993	Steller Sea Lion	
1993	Western Gray Squirrel	
1993	Western Pond Turtle	

Recovery Plans

2004	Greater Sage-Grouse	√
2003	Pygmy Rabbit: Addendum	√
2002	Sandhill Crane	√
2004	Sea Otter	√
2001	Pygmy Rabbit: Addendum	√
2001	Lynx	√
1999	Western Pond Turtle	√
1996	Ferruginous Hawk	√
1995	Pygmy Rabbit	√
1995	Upland Sandpiper	
1995	Snowy Plover	

√: These reports are available in pdf format on the Department of Fish and Wildlife's web site: http://wdfw.wa.gov/wlm/diversty/soc/concern.htm.

To request a printed copy of reports, send an e-mail to wildthing@dfw.wa.gov or call 360-902-2515