Fender's Blue Butterfly

(*Icaricia icarioides fenderi*)

Species Status Assessment Report

Photos courtesy of Cheryl Schultz.

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U.S. Fish and Wildlife Service. 2020. Fender's Blue Butterfly (*Icaricia icarioides fenderi*) Species Status Assessment Report. U.S. Fish and Wildlife Service, Oregon Fish and Wildlife Office, Portland, Oregon.

Terms that appear in **bold** at first use are defined in the Glossary (Appendix A).

Executive Summary

This species status assessment reports the results of the comprehensive status review for the Fender's blue butterfly (*Icaricia icarioides fenderi*) and provides a thorough account of the species' overall viability and extinction risk. The Fender's blue butterfly is a subspecies of Boisduval's blue butterfly (*Icaricia icarioides*) found only in the upland prairie and oak savannah habitats of the Willamette Valley in western Oregon. The U.S. Fish and Wildlife Service (Service or USFWS) listed the Fender's blue butterfly as endangered, without critical habitat, under the Endangered Species Act on January 25, 2000 (65 FR 3875). At the same time, the Service listed one of the butterfly's primary host plants, the Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*), as threatened (65 FR 3875). At the time of listing in 2000, Fender's blue butterfly and Kincaid's lupine were confined almost exclusively on the western side of the Willamette Valley in Oregon. Critical habitat for the Fender's blue butterfly was designated on October 31, 2006, in Benton, Lane, Polk, and Yamhill Counties, Oregon (71 FR 63862) and a recovery plan was published in May 2010, establishing three recovery zones as well as population and habitat targets. In the case of Fender's blue butterfly, we have determined the term metapopulation is most accurate to describe groups of sites occupied by Fender's blue butterflies that are within 2 kilometers (km) (1.2 miles (mi)) of one another and not separated by barriers.

To evaluate the biological status of the Fender's blue butterfly both currently and into the future, we assessed a range of conditions to allow us to consider the species' resiliency, redundancy, and representation (together, the 3Rs). Based on the biology of the species and the information presented in the recovery plan, we determined that to be resilient, Fender's blue butterfly metapopulations need an abundance of lupine host plants and nectar plants within prairie patches at least 6 hectares (ha) (15 acres (ac)) in size, with habitat heterogeneity and minimal amounts of invasive plants and woody vegetation. Resilient metapopulations would also contain a minimum of 200 butterflies each year for at least 10 years distributed across multiple groups (within-metapopulation redundancy) in lupine patches that are within 0.5 to 1.0 km (0.3 to 0.6 mi) of one another. Ideally, at the species level, resilient metapopulations would be distributed across the historical range of the species (redundancy and representation) and have a plethora of stepping stones for connectivity across the landscape (redundancy and representation).

While we do not know the precise historical abundance or distribution of Fender's blue butterfly, there were approximately 3,391 individuals on 32 sites at the time of listing in 2000. Those numbers have grown across all three recovery zones as a result of metapopulation expansion, metapopulation discovery, and metapopulation creation. There are currently 15 known Fender's blue butterfly metapopulations distributed throughout the Willamette Valley in Benton, Lane, Linn, Polk, Washington, and Yamhill Counties. There are 137 total sites containing

approximately 13,700 Fender's blue butterfly that occur over a broad range of land ownerships with varying degrees of land protection and management on an area totaling approximately 344 ha (825 ac)(Table ES-I).

Table ES-I. Comparison in status of Fender's blue butterfly populations and distribution between time of listing in 2000 to survey results from 2018.

	Listed as endangered (2000)	**As of 2018**
Number of metapopulations	12	15
Number of independent groups	0	6
Total abundance (# of individuals)	3,391	13,700
Number of sites	32	137
Area of prairie habitat known to be occupied (hectares/acres)	165/408	344/825
Counties known to be occupied	4 Benton, Lane, Polk Yamhill Counties	6 additionally in Linn and Washington Counties

The presence of Fender's blue butterflies in new counties and the expansion of existing metapopulations increases both the geographic range of the species and connectivity throughout the landscape. An increased number of metapopulations, composed of a greater number of individuals and with expanded distribution and connectivity across the range of Fender's blue butterfly, means the species has a greater chance of withstanding stochastic events (resiliency), surviving potentially catastrophic events (redundancy), and adapting to changing environmental conditions (representation) over time.

Our analysis of the past, current, and future influences on what the Fender's blue butterfly needs for long-term viability revealed that there are four influences that pose the largest risk to future viability of the species. These influences are (1) habitat conversion (agricultural and residential); (2) alteration of natural and human-mediated disturbance processes (e.g., fire and flooding) resulting in habitat succession; (3) invasion by nonnative plants; and (4) insecticides and herbicides. Most of these influences are likely to be exacerbated by climate change due to changes in vegetation composition and management, as well as from changes in disturbance occurrences. These influences are being offset by continuing conservation efforts.

Based on our understanding of the life history of the species and guided by the recovery plan, we developed criteria to evaluate specific habitat and demographic factors contributing to the overall health or resiliency of metapopulations. We then included data from an upland prairie habitat calculator and a Fender's blue butterfly calculator to score the current condition of each metapopulation. These calculators were created as a rapid assessment tool by the Institute for Applied Ecology, in coordination with the Willamette Partnership and with guidance from a Prairie Technical Working Group comprised of local experts. They assess overall prairie habitat quality, evaluate and weight key aspects of site quality specifically for Fender's blue butterfly, and assess site quality for at-risk upland plant species, including Kincaid's lupine.

Five of the 15 Fender's blue butterfly metapopulations were ranked as having a high overall condition, while 3 were ranked moderate, 6 were ranked low, and one metapopulation is at possible risk of extirpation. All three recovery zones contained metapopulations in high condition (Table ES-II).

Table ES-II. Current condition of Fender's blue butterfly metapopulations.

Metapopulation	**Current Condition**
Salem Recovery Zone	
Baskett	High
Gopher Valley	Moderate
Hagg Lake	High
Moores Valley	Possible extirpation
Oak Ridge	Moderate
Turner Creek	Low
Corvallis Recovery Zone	
Butterfly Meadows	Low
Finley	Moderate
Greasy Creek	Low
Lupine Meadows	Low
Wren	High
Eugene Recovery Zone	
Coburg Ridge	Low
Oak Basin	Low
West Eugene	High
Willow Creek	High

Evaluating the predicted future condition of the Fender's blue butterfly under alternative plausible future scenarios enables us to create a "risk profile" for the species, which captures the range of most likely status outcomes for the species within the foreseeable future, while simultaneously acknowledging the degree of uncertainty inherent in such future projections. We forecasted what the Fender's blue butterfly may have in terms of resiliency, redundancy, and representation under three plausible future scenarios. These future scenarios forecast Fender's blue butterfly viability over the next 25 to 35 years. We chose this timeframe because it represents up to 35 generations of Fender's blue butterfly; it was used in the recovery plan to determine downlisting criteria; and it can address the immediate effects of management strategies given that our current interim protections (e.g., Safe Harbor Agreements) have a lifespan ranging from 10 to 50 years.

The Continuing Efforts scenario evaluated the condition of Fender's blue butterfly if risk remains unchanged in the metapopulations from what exists today, while the other scenarios

evaluated the response of the species to changes in those risks. The Considerable Impacts scenario evaluated the response of Fender's blue butterfly to projected climate change effects and limited prairie management. The Conservation Effort scenario evaluated the response of Fender's blue butterfly to an increased level of habitat restoration within existing populations and surrounding areas containing potential habitat.

Table ES-III. Number of metapopulations under each condition rank in current and future scenarios.

	Number of Metapopulations			
Condition Rank	**Current Condition**	**Continuing Efforts Scenario Condition**	**Considerable Impacts Scenario Condition**	**Conservation Effort Scenario Condition**
High	5	6	5	7
Moderate	3	2	1	5
Low	6	3	2	2
Possible Extirpation	1	4	7	1
Likelihood of Scenario at 25-35 years		Highly likely	Somewhat Likely	Moderately Likely

In conclusion, the Fender's blue butterfly has made considerable gains since being listed in 2000. As a whole, the species has a greater chance of withstanding stochastic events (resiliency), surviving potentially catastrophic events (redundancy), and adapting to changing environmental conditions (representation) due to an increased number of metapopulations, composed of a greater number of individuals and with expanded distribution and connectivity across the range since listing. Persistence will require addressing influences on viability including (1) habitat conversion; (2) alteration of natural and human-mediated disturbance processes resulting in habitat succession; (3) invasion by nonnative plants; (4) insecticides and herbicides; (5) climate change; and continued conservation and management efforts.

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List of Acronyms

BLM	Bureau of Land Management
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
CRD	County Roads Department
CWS	Clean Water Services
ESA	Endangered Species Act
GLT	Greenbelt Land Trust
HCP	Habitat Conservation Plan
IAE	Institute for Applied Ecology
IPCC	Intergovernmental Panel on Climate Change
ITIS	Integrated Taxonomic Information System
MWRC	Marys River Watershed Council
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge
ODA	Oregon Department of Agriculture
ODOT	Oregon Department of Transportation
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
PFW	Partners for Fish and Wildlife
PVA	Population viability analysis
ROW	Right-of-way
RMP	Resource Management Plan
Service or USFWS	U.S. Fish and Wildlife Service
SHA	Safe Harbor Agreement
SSA	Species Status Assessment
SWCD	Soil and Water Conservation District
TNC	The Nature Conservancy
USACE	U.S. Army Corps of Engineers
WCPD	Washington County Parks Department
WVNWRC	Willamette Valley National Wildlife Refuge Complex

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Chapter 1. Introduction and Overview of the Species Status Assessment Framework

The Fender's blue butterfly (*Icaricia icarioides fenderi*) is a subspecies of Boisduval's blue butterfly (*Icaricia icarioides*) found only in the upland prairies of the Willamette Valley in western Oregon. The U.S. Fish and Wildlife Service (Service or USFWS) listed the Fender's blue butterfly as endangered, without critical habitat, under the Endangered Species Act, as amended (ESA) on January 25, 2000 (65 FR 3875). At the same time, the Service listed one of the butterfly's primary **host plants**, the Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*), as threatened (65 FR 3875). Habitat loss from a wide variety of causes (*e.g.*, urbanization, agriculture, silvicultural practices, and roadside maintenance), encroachment of shrubs and trees into prairie habitats due to fire suppression, fragmentation, invasion by nonnative plants, and elimination of natural disturbance regimes, were identified as problems faced by both Fender's blue butterfly and Kincaid's lupine (USFWS 2000, pp. 3882, 3886; USFWS 2010, p. III-10). Critical habitat for the Fender's blue butterfly was designated on October 31, 2006, in Benton, Lane, Polk, and Yamhill Counties, Oregon (71 FR 63862). At the time of designation, critical habitat consisted of both known occupied areas and areas with the potential to support Fender's blue butterfly. The Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (Recovery Plan), which includes the Fender's blue butterfly and four prairie plant species, including Kincaid's lupine, was published by the Service in May 2010 (See Appendix B; USFWS 2010, entire).

1.1 Species Status Assessment

The Species Status Assessment (SSA) framework (USFWS 2016, entire) is intended to support an in-depth review of the species' biology, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term **viability** of the species, as synthesized in an SSA Report. The intent is for the SSA Report to be easily updated as new information becomes available and to support all functions of the Endangered Species Program from Candidate Assessment to Listing to Consultations to Recovery. As such, the SSA Report will be a living document upon which other documents, such as recovery plans, and 5-year reviews, would be based.

This SSA Report provides biological information in support of the 5-year review and evaluation of listing status for the Fender's blue butterfly under the ESA. Importantly, the SSA Report does not result in a decision by the Service on whether the status of the species should be changed under the ESA. Instead, this SSA Report provides a review of the available information strictly related to the biological status of the Fender's blue butterfly. Any recommendation for a possible change in status will be made by the Service after reviewing this document and all relevant laws, regulations, and policies, and the results of a proposed change in status, if any, will be announced in the *Federal Register,* with appropriate opportunities for public input.

For the purpose of this assessment, we generally define viability as the ability of the Fender's blue butterfly to persist in prairie ecosystems over time. To assess the viability of Fender's blue butterfly, we apply the conservation biology principles of **resiliency**, **redundancy,** and **representation** (or the "3Rs," for short; Wolf et al. 2015, entire; Smith et al. 2018, entire). In general, there is a positive association between measures of the 3Rs and the relative viability of a species: as resiliency, redundancy, and representation increase, the viability of the species over

time increases (conversely, risk to the persistence of the species decreases). To assess the ability of Fender's blue butterfly to persist in prairie ecosystems over time, here we apply the SSA analytical framework (Figure 1.1) to evaluate the needs of the species, the current condition of the species in terms of the 3Rs, and the relative viability of the species under likely future conditions (Smith et al. 2018, entire). Evaluating the predicted future condition of the Fender's blue butterfly under alternative plausible future scenarios enables us to create a "risk profile" for the species, which captures the range of most likely status outcomes for the species within the foreseeable future, while simultaneously acknowledging the degree of uncertainty inherent in such future projections.

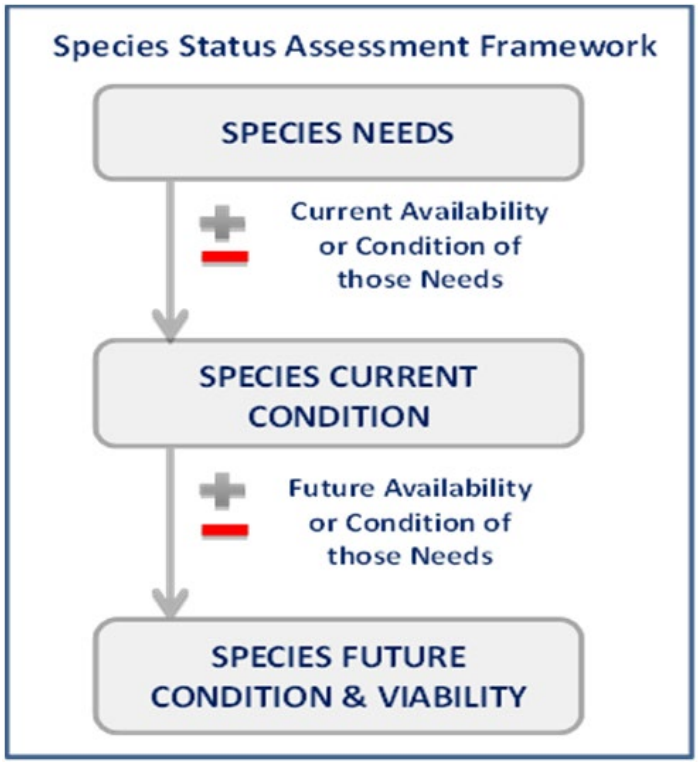

Figure 1.1. Species Status Assessment Framework (USFWS 2016).

Resiliency describes the ability of **populations** to withstand **stochastic** events – these are random disturbances or perturbations that generally fall within the range of normal variation. Examples include year-to-year variation in temperatures, or stochastic events such as fire or flooding. Resiliency can also buffer a population against fluctuations in **demographic** or genetic parameters, such as sex ratios or **heterozygosity**. Resiliency is most simply described as the ability to "bounce back" from stochastic disturbance events; to be resilient, a population must be able to sustain itself through good years and bad years. Resiliency can be measured based on metrics of population health; it is positively related to population size, survivorship, **productivity** (and ultimately population growth rate), and may be influenced by **connectivity** between populations.

Redundancy describes the ability of a species to withstand catastrophic events by spreading the risk across multiple populations and/or across a large area. Measured by the number of populations (or **metapopulations**, in the case of Fender's blue butterfly), their resiliency, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand catastrophic (extreme) events outside the range of normal variability (such as a highly destructive natural event, or a large-scale episode involving many metapopulations). Risk to the species as a whole from impacts due to catastrophic events decreases with greater numbers of metapopulations distributed over a wider geographic area. In metaphorical terms, redundancy can be thought of as the principle of "not putting all of your eggs in one basket".

Representation describes the ability of a species to adapt to changing environmental conditions over time, or its "**adaptive capacity**," as characterized by the breadth of genetic or environmental diversity within and among metapopulations. We use indicators of diversity as a proxy because it is difficult to directly measure the adaptive capacity of a species. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics across the geographical range, or simply by distribution over the historical geographical range of the species. Representation thus refers to the conservation of a species across areas of significant ecological, genetic, or life-history variation, or ecological settings, in which it occurs. The more representation, or diversity, a species has, the more likely it has the capacity to adapt to changes (natural or human caused) in its environment, and therefore to persist over time.

In sum, the SSA framework uses the conservation principles of the 3Rs to construct a risk assessment that takes into account demographic factors, distribution, and diversity. **Resiliency** reflects factors such as abundance and growth rate that contribute to the ability to bounce back from disturbance and persist over time. **Redundancy** spreads the risk through multiple populations distributed across an increased geographic extent, and adds to resiliency by increasing the potential for connectivity between subpopulations or metapopulations. **Representation**, as measured by diversity in genetic, geographic, environmental, or life history variation, contributes to the adaptive capacity of the species. The "3Rs" are not mutually exclusive, but often overlap with one another to contribute to relative species viability (Figure 1.2). In general, the greater the resiliency, redundancy, and representation of a species, the greater its probability of persisting over time in the wild.

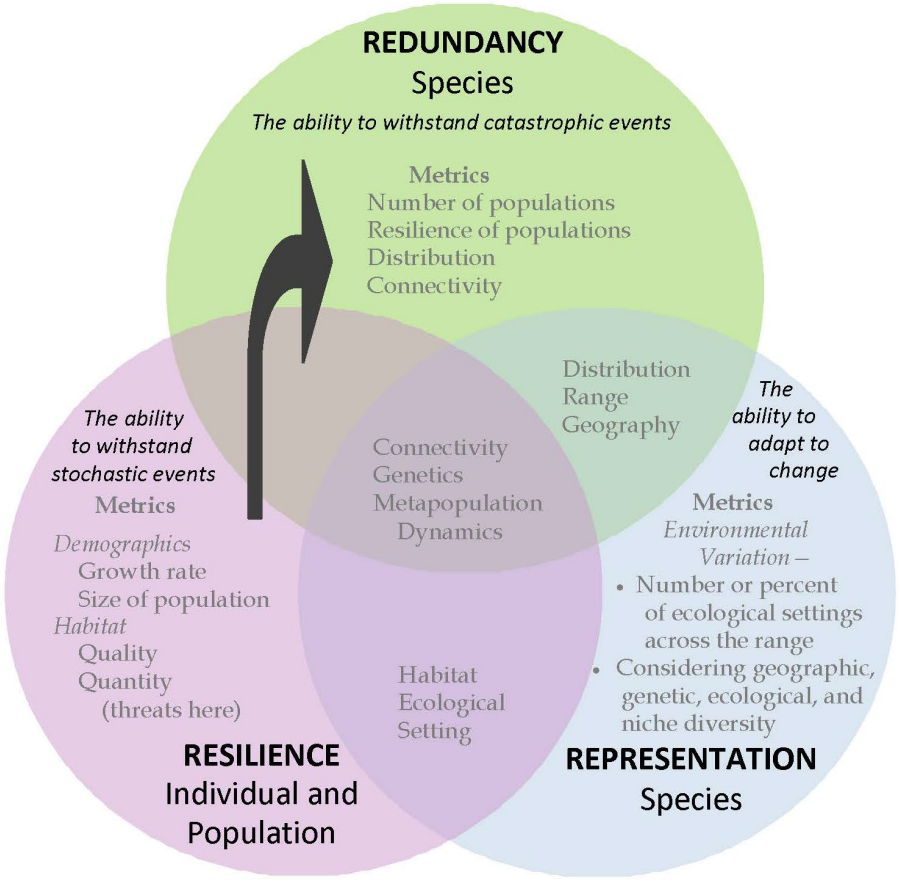

Figure 1.2. The overlapping conservation biology principles of resiliency, redundancy, and representation (the 3Rs), all of which contribute to species viability, or, conversely, reduce risk of species extinction. Resiliency is generally considered to operate at the level of the individual or population, whereas redundancy and representation operate at the species level. However, in the case of **metapopulations**, **subpopulations** contribute to redundancy and representation as well.

The format for this SSA Report is as follows:

Chapter 2 — the biology and life history of Fender's blue butterfly, and resource needs of individuals and metapopulations

Chapter 3 — the historical and current distribution and abundance of Fender's blue butterfly, and a framework for determining the distribution of resilient metapopulations across its range needed for species viability

Chapter 4 — a review of the likely causes of the current and future status of the species and determining which of these factors affect the species' viability

Chapter 5 — recovery criteria for Fender's blue butterfly and population viability analysis (PVA)

Chapter 6 — our assessment of the current condition and future viability of Fender's blue butterfly

Chapter 2. Species Information – Life History and Biology, Individual and Metapopulation Needs

In this chapter we provide basic biological information about the Fender's blue butterfly, including its taxonomic history, **morphological** description, and known life history traits. We then outline the resource needs of individuals and metapopulations in the context of resiliency. Here we report only those aspects of the life history of the Fender's blue butterfly that are important to our analysis.

2.1 Taxonomy

The Fender's blue butterfly was first described in 1931 as *Plebejus maricopa fenderi* based on specimens collected 10 km (6 mi) southeast of McMinnville, Oregon, in Yamhill County (Macy 1931, pp. 1-2; Figure 2.1). The Fender's blue butterfly was classified in the Lycaenidae family within the subfamily Polyommatinae as a subspecies of Boisduval's blue butterfly based on adult characters and geographic distribution (Hammond and Wilson 1993, pp. 3-4). The species *maricopa* was considered a synonym of the species *icarioides* and was later determined to be a member of the genus *Icaricia*, rather than the genus *Plebejus* (Miller and Brown 1981, pp. 124-125). The worldwide taxonomic arrangement of the subtribe Polyommatina (which contains blue butterflies) was fluctuating between *Plebejus* and *Icaricia* until it was revised in 2013 as *Icaricia* (Talavera et al. 2013, p. 166). The current scientific name was validated by the Integrated Taxonomic Information System (ITIS) and experts at the McGuire Center for Lepidoptera and Biodiversity, a division of the Florida Museum of Natural History at the University of Florida (ITIS 2017; J. Pelham, pers. comm. 2017). Genetic studies have not been conducted on the Fender's blue butterfly.

The currently accepted classification is:

Phylum: Arthropoda
Class: Insecta
Order: Lepidoptera
Family: Lycaenidae
Subfamily: Polyommatinae
Genus: *Icaricia*
Species: *icarioides*
Subspecies: *fenderi*

We do not know the precise historical distribution of Fender's blue butterfly due to the limited information collected on this subspecies prior to its description in 1931 (Macy 1931, pp. 1-2). Although Ralph W. Macy collected the **type specimens** for this butterfly in 1929, only a limited number of collections were made between the time of the subspecies' discovery and Macy's last observation on May 23, 1937, in Benton County, Oregon, leading the scientific community to assume the species was extinct (Hammond and Wilson 1993, p. 3). Dr. Paul Hammond rediscovered Fender's blue butterfly in 1989 at the McDonald State Forest, Benton County, Oregon, on the uncommon plant, Kincaid's lupine. Surveys since its rediscovery indicate that the Fender's blue butterfly is confined to the Willamette Valley in Benton, Lane, Linn, Polk,

Yamhill, and Washington counties in Oregon (Figure 2.2). Additional information on the distribution of Fender's blue butterfly will be presented in Chapter 3.

Figure 2.1. Photos of the female type specimen described by Macy in 1931.

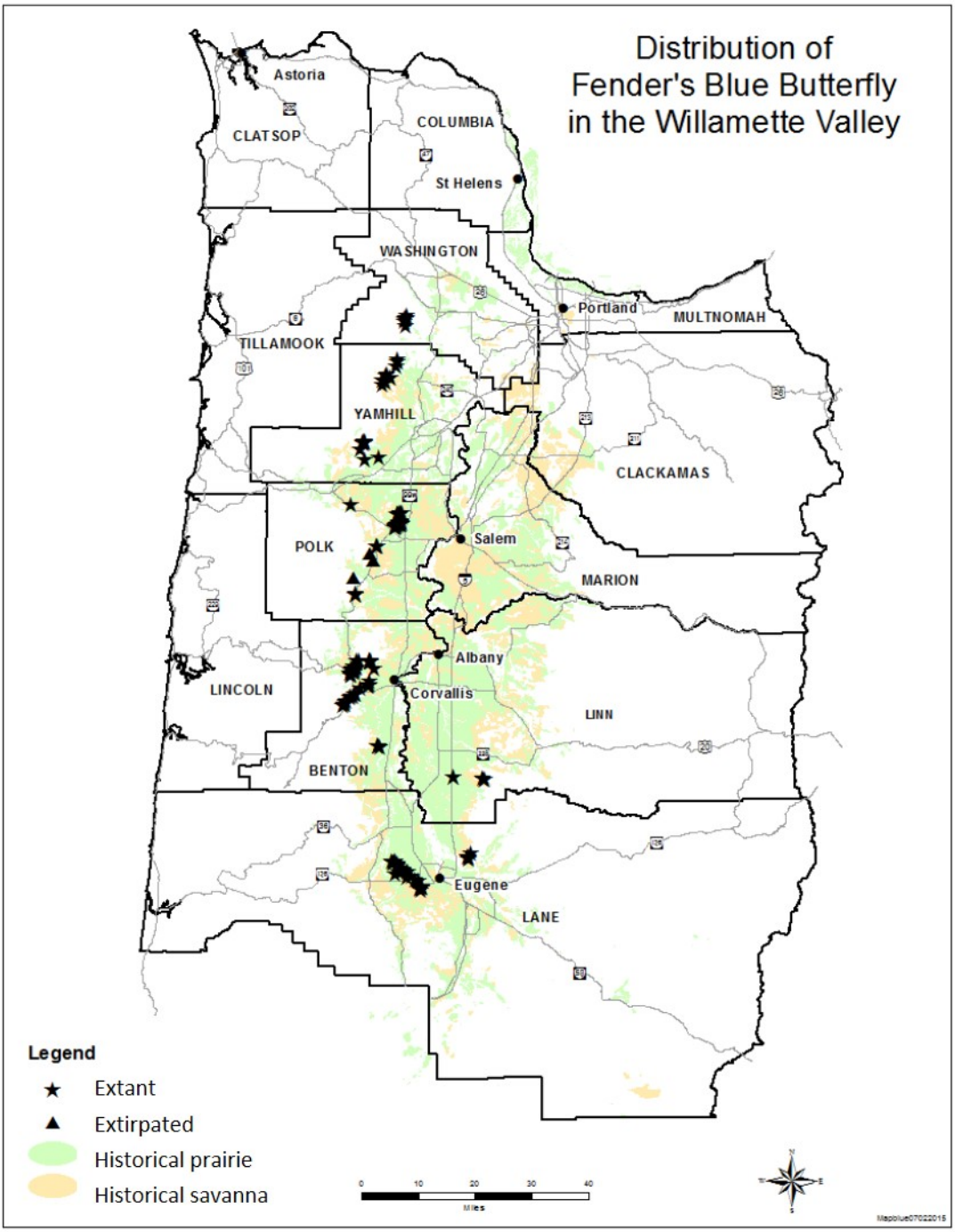

Figure 2.2. Current range of the Fender's blue butterfly showing historical habitat.

2.2 Morphological Description

Adult Fender's blue butterflies are quite small, having a wingspan of approximately 25 millimeters (mm) (1 inch (in)). The upper wings of males are brilliant blue in color with black borders and basal areas, whereas the upper wings of females are completely brown (Figure 2.3). The undersides of the wings of both sexes are cream-tan with small, black spots surrounded by a fine white border or halo. The size of the spots and both the color and size of the halos distinguishes the Fender's blue butterfly from other subspecies of Boisduval's blue butterfly and similar species such as the silvery blue butterfly (*Glaucopsyche lygdamus*), which may co-occur in areas with Fender's blue butterfly (Figure 2.4; Schultz et al. 2003, pp. 62-63). There is great inter- and intra-population variation in **dorsal** (blue vs. brown in females) and **ventral** (size of black spots and presence/absence of white halos around these spots) **phenotypes** throughout the range of the Boisduval's blue butterfly and its subspecies (A. Warren, pers. comm. 2015). Genetic data are unavailable to explain such variation within the Boisduval's blue butterfly or any of its subspecies.

In the **larval** state, this species emerges as a reddish-pink color before changing to solid green and appears humped in profile (Figure 2.5). The eggs are small, 2 mm (0.08 in) in diameter, puck shaped, and white when unhatched (Figure 2.5). Very little is known regarding the Fender's blue butterfly **pupae** (**chrysalis**). Pupae are brownish in color and likely reside near the base of the host lupine plant (C. Shultz, pers. comm. 2017).

Figure 2.3. A male (left) and a female (right) adult Fender's blue butterfly. Photo of male courtesy of Jeff Dillon, USFWS.

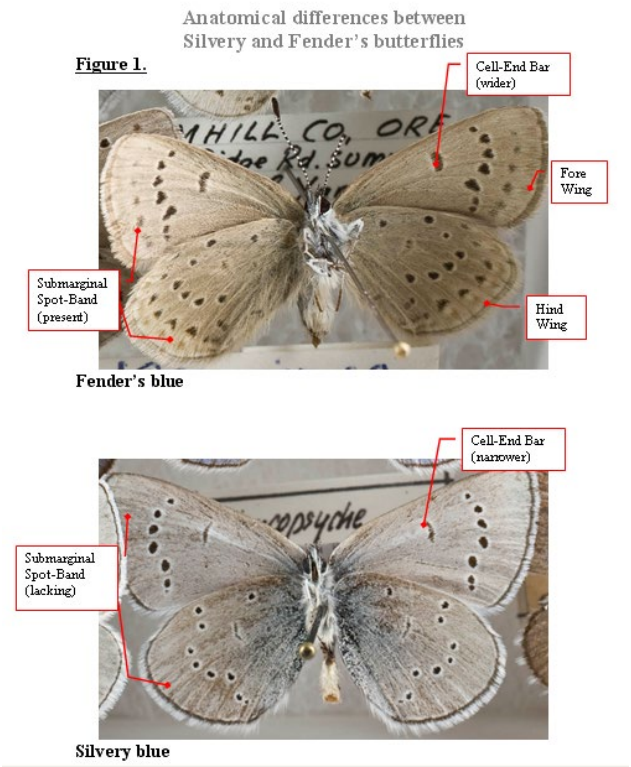

Figure 2.4. Differences between the Fender's blue butterfly and the silvery blue butterfly. Photo courtesy of USFWS.

Figure 2.5. Fender's blue butterfly larvae and eggs on a lupine plant (*Lupinus* sp.).

2.3 Life History

2.3.1 Life cycle

Butterflies have four stages in their life cycle: egg, larva/caterpillar, chrysalis/pupa, and adult butterfly. The life history of the Fender's blue butterfly is similar to other subspecies of *Icaricia icarioides* (Figure 2.6; Table 2.1). Between late-April and the end of June, approximately 350 eggs are individually **oviposited** from each adult female exclusively on the underside of the leaves of the following three plant species: Kincaid's lupine, longspur lupine (*Lupinus arbustus*), or sickle-keeled lupine (*Lupinus albicaulis*) (Schultz et al. 2003, pp. 64-67). Of the three possible host plant species, Fender's blue butterflies are most frequently found on Kincaid's lupine (Hammond and Wilson 1993, p. 2); however, one of the largest current Fender's blue butterfly sites primarily utilizes longspur lupine. When the eggs hatch after 2-3 weeks in mid-May through mid-July, the larvae feed exclusively on the host lupine plant, which allows them to reach their second **instar** in mid-summer. An instar is a developmental stage that allows the larvae to grow in preparation for the chrysalis stage. The second instar larvae move to the base of the plant when the host lupine plant senesces in July to enter **diapause** (a state of developmental arrest) for the fall and winter. Most larvae stay within 1 centimeter (cm) (0.33 in) of the soil surface and within 1 cm (0.33 in) of lupine during diapause (Schultz 1996, p. 1). After approximately 8 months, the larvae exit diapause, generally beginning to emerge in March. Once diapause is broken, the larvae feed exclusively on the host lupine and grow through 3 to 4 additional instars in March and April. Once the larvae reach approximately 18 mm (0.7 in) in size, they will enter the pupation stage to undergo **metamorphosis**. We do not know where the Fender's blue butterfly pupates, though we presume it is in the leaf litter near the host lupine plant. After approximately 2 weeks as a chrysalis, adult butterflies emerge between mid-April and the end of June, living only 7-14 days (Schultz 1995, p. 36; Schultz et al. 2003, pp. 64-65). The earliest known emergence of adult Fender's blue butterflies occurred April 18, 2016, at the Green Oaks site at the Fern Ridge Reservoir, located 19.3 kilometers (km) (12 miles (mi)) west of Eugene, Oregon. For most sites in most years, the peak time of emergence will occur between May 12 and 31 (Hicks 2014, p. 9; Menke, pers. comm. 2019).

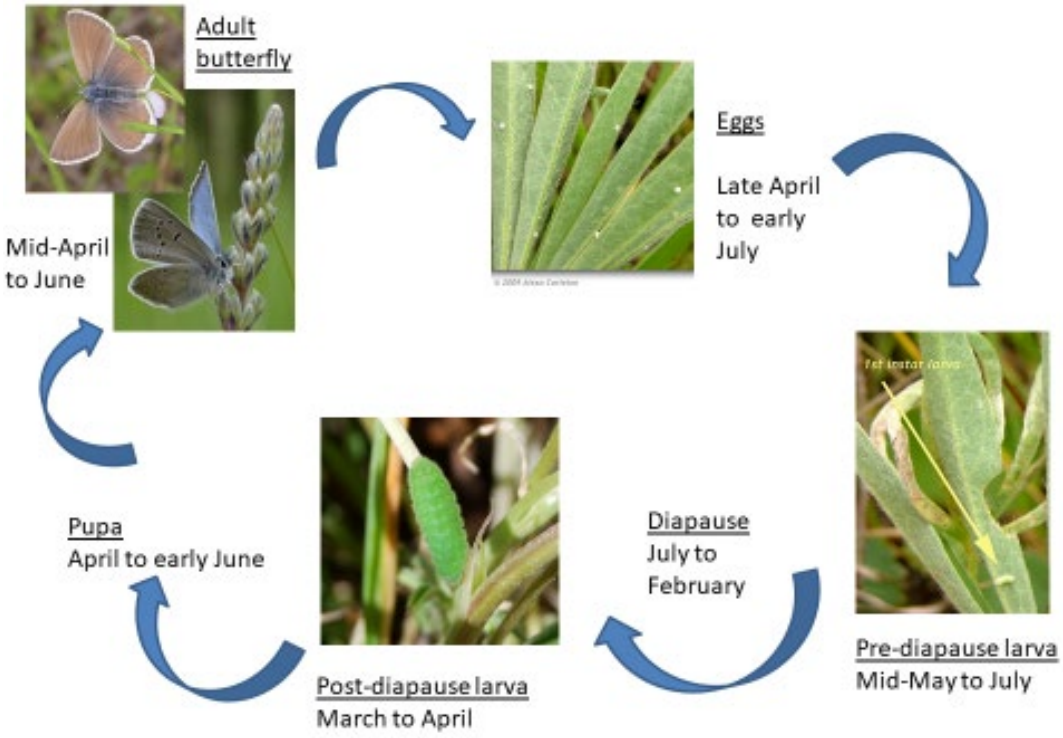

Figure 2.6. Life cycle diagram of the Fender's blue butterfly.

Table 2.1. Timing of life-history stages of Fender's blue butterfly.

Life History Stage	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Eggs *Incubation 2-3 weeks*	Eggs present on underside of lupine leaves												
Larvae (pre-diapausal)			Larvae hatch and feed on lupine										
Diapause *Larvae break diapause when ≥ 6.5 mm*				Larvae enter diapause when lupine senesce; present in leaf litter at base of lupine plants									
Larvae (post-diapausal)												Larvae emerge from diapause and feed on lupine before pupating	
Pupae *Chrysalis stage 2 weeks*	Pupae present, presumed in leaf litter												
Adults *Males emerge first* *Adult lifespan 7-14 days*		Adults present; nectaring, mating, & oviposition											

The time of year when a butterfly is in the adult life stage is called the **flight period**. Since butterflies are **poikilothermic** (cold-blooded) invertebrates, they cannot maintain a constant internal body temperature. As such, flight activity is most prevalent when the day is sunny or warm with the adult butterfly seeking cover at night and in cool weather. When active, adult butterflies feed by sipping on **nectar** of flowering plants using a tube extending from the face called a **proboscis**. The proboscis stays in a curled position and is only extended when the butterfly senses sugar. The Fender's blue butterfly is considered a nectar generalist using a wide range of wildflower species (Table 2.2).

Table 2.2. Partial list of plant species used as nectar sources by Fender's blue butterfly (Crone and Kallioniemi 2009, pp. 7-8; USFWS 2010).

Scientific Name	Common Name	Native Species
Allium acuminatum	Tapertip onion	Yes
Allium amplectens	Narrowleaf onion	Yes
Anthemis arvensis	Corn chamomile	No
Bellis perennis	Lawndaisy	No
Calochortus tolmiei	Tolmie star-tulip	Yes
Camassia quamash	Small camas	Yes
Cryptantha intermedia	Clearwater cryptantha	Yes
Eriophyllum lanatum	Common woolly sunflower or Oregon sunshine	Yes
Geranium oreganum	Oregon geranium	Yes
Hypochaeris radicata	Hairy cat's-ear	No
Iris tenax	Oregon iris	Yes
Lathyrus sphaericus	Grass pea	No
Leucanthemum vulgare (= Chrysanthemum leucanthemum)	Oxeye daisy	No
Linum angustifolium (= L. bienne)	Pale flax	No
Lomatium triternatum	Nineleaf biscuitroot	Yes
Lupinus arbustus	Longspur lupine	Yes
Lupinus sulphureus ssp. *kincaidii*	Kincaid's lupine	Yes
Myosotis discolor	Changing forget-me-not	No
Plectritis congesta	Shortspur seabrush	Yes
Sidalcea malviflora ssp. *virgata*	Rose checker-mallow	Yes
Vicia americana	Purple vetch	Yes
Vicia hirsuta	Tiny vetch	No
Vicia sativa	Common vetch	No
Vicia villosa	Winter vetch	No

Survivorship from egg to late-instar larva and survivorship from late-instar larva to adult was investigated at two sites in Lane County. Survivorship from egg to late-instar larva averaged 0.094 while survivorship from late-instar larva to adults averaged 0.043 (Schultz and Crone 1998, p. 247; Schultz et al. 2003, p. 67). At another study site in Lane County, late-instar larva to adult survivorship ranged from 0.025 to 0.060 (Schultz and Crone 1998, p. 247). Estimates of overwinter (egg to post-diapause) survivorship vary between years and studies suggest a typical range of 0.05 – 0.10 (Schultz 2019, *in litt*). While the variables affecting survivorship are not completely understood, there is a strong correlation between the number of eggs laid and lupine leaf abundance and density (Schultz 1995, p. 30; Gisler and Kaye 2004, p. 11). In other words, the denser the lupine, the more eggs can be laid in one habitat patch by the Fender's blue butterfly. Because a female Fender's blue butterfly spreads her eggs across available habitat,

butterflies in smaller patches likely emigrate before laying enough eggs to replace themselves while butterflies in larger patches will remain in their natal patch.

2.3.2 Dispersal and patch size

Given its short adult lifespan, the Fender's blue butterfly has limited **dispersal** ability. In their 7-14 day lifetime, both male and female Fender's blue butterflies are estimated to disperse approximately 0.75 km (0.5 mi) if they remain in their **natal** lupine **patch** and approximately 2 km (1.2 mi) if they disperse between lupine patches (Schultz 1998, p. 290). Within a lupine patch, Fender's blue butterflies often fly short distances, turning frequently, whereas outside lupine patches, butterflies fly longer distances in straight lines (Crone and Schultz 2003, p. 568).

A study at Willow Creek Preserve in Lane County, Oregon, showed 95 percent of adult Fender's blue butterflies are found within 10 meters (m) (33 feet (ft)) of large lupine patches (Schultz 1998, p. 289), reinforcing that dispersal may be infrequent. The maximum dispersal distance reported for the Fender's blue butterfly is 3.2 km (2 mi) (Severns 2004, p. 4). A study in Benton County demonstrated that Fender's blue butterflies move freely within, and near the boundaries of, open prairies as well as open woodland, and they were commonly seen entering woods at boundaries with dense forests (Schultz et al. 2011, p. 4). In a mark-recapture study at the same site in Benton County, one female Fender's blue butterfly was observed ovipositing in a new location 1.1 km (0.68 mi) from where she was marked, which would have required movement through dense forest (Schultz et al. 2011, p. 4). Anecdotal evidence from marked butterflies showed multiple females moved through Douglas fir (*Pseudotsuga menziesii*) forest. Specifically, one female moved at least 125 m (410 ft) through forest and then returned to her original patch, another female dispersed approximately 140 m (459 ft) through forest, and one female moved nearly 1 km (0.62 mi) through a 75-150 m (246-492 ft) wide forest (T. Hicks, pers. comm. 2016). Additionally, one female moved nearly 2 km (1.2 mi) through riparian hardwood forests (T. Hicks, pers. comm. 2016). Male Fender's blue butterflies have been seen in lupine patches near forest fringe (Hammond 2011, p. 17; Fitzpatrick 2015, p. 25); however, marked butterflies that entered forest were not found within the forest or on the other side (J. Smokey, pers. comm. 2017). Collectively, these observations suggest that riparian hardwood and dense forests are an impediment to butterfly dispersal rather than an absolute barrier to movement. Impediment likely occurs because these habitats contain shady understory, which does not support lupine (Schultz et al. 2011, p. 31; Schultz et al. 2012a, p. 724; T. Hicks, pers. comm. 2016).

The importance of patch size as it relates to Fender's blue butterfly persistence has been investigated using multiple models. Using several isolated habitat remnants, a model estimated that Fender's blue butterfly populations needed a minimum prairie patch size of 2 to 6 hectares (ha) (5 to 15 acres (ac)) in the absence of immigration from other patches to persist (Crone and Schultz 2003, p. 575). This threshold takes into account that habitat quality affects minimum patch size. If habitat is of low quality (likely less lupine density), then the patch size would need to be larger to take into account the likelihood of lower **recruitment** rates. Data acquired since the model was performed show that habitat patches are not isolated and that immigration from other lupine patches occurs. Additionally, some smaller patches have seen population increases over time, suggesting other factors such as habitat management or greater habitat connectivity may contribute to persistence probability. A later study modeling the existing patches of

Fender's blue butterfly populations in the West Eugene Wetlands area concluded that management of existing patches, restoration of degraded patches, and establishing connectivity among patches could support a very large viable population of Fender's blue butterflies, which would be sufficient for long-term persistence of the species in the Eugene area (McIntire et al. 2007, p. 725).

As discussed in Chapter 1, we do not have immigration or **emigration** data from across the range to definitively determine subpopulation boundaries for Fender's blue butterflies. However, given research results demonstrating that Fender's blue butterflies typically disperse up to 2 km (1.2 mi) between lupine patches, we assume that Fender's blue butterflies are likely to interact at least intermittently if groups are within 2 km (1.2 mi) of one another and not separated by barriers. We define a **barrier** as a structural component of the landscape that reduces the likelihood of Fender's blue butterfly movement. Although barriers have not been studied, we expect that barriers would include roads with four or more lanes of traffic, large bodies of water (e.g., lakes), ridgelines, and dense forest with canopy cover greater than 90 percent (Schultz et al. 2012b, p. 81). Specifically, a Fender's blue butterfly metapopulation is defined as several potentially interacting groups of butterflies that are within 2 km (1.2 mi) of one another and not separated by barriers. We do not anticipate that metapopulations will interact with one another given the distance and the structural barriers between them. Locations containing Fender's blue butterfly occur across multiple land ownerships have varying degrees of habitat protection and are managed in different ways. We use the term **site** to identify a management unit or land ownership designation; multiple sites may therefore comprise a metapopulation.

2.3.3 Ant tending

Many butterflies, including the Fender's blue butterfly, have evolved **symbiotic** relationships with ant species (Figure 2.7; see Atsatt 1981a for review; DeVries 1988, p. 387; Fielder 2006, p. 77; Warchola et al. 2015, p. 1064). Ten ant species have been observed tending to Fender's blue butterfly larvae over the entire range of post-diapause larval size from 4 to 18 mm (0.16 to 0.7 in) (Table 2.3; Warchola et al. 2015, p. 1068; Thomas et al., *in review*). Larval survival did not differ when being tended by the two predominant tending species, *Prenolepis imparis* and *Aphaenogaster occidentalis (*Thomas et al., *in review).* Lycaenid larvae have special glands that secrete a sweet, nectar-like substance high in amino acids and sugars that are harvested by ants (Pierce et al. 2002, p. 740). The ants encourage the larvae to secrete these fluids by drumming them with their antennae. In exchange, the ants are thought to protect the larvae and pupae from predators and parasitism, which may increase larvae survival (Stadler et al. 2001, p. 475; Forister et al. 2011, p. 1539). A recent study suggests that the mutually beneficial relationship between **lycaenid butterflies** and ants is maintained through manipulative behavior of the butterfly larvae. Specifically, ants that ingested the nectar-like substance secreted by the larvae showed a reduction of locomotor activity and an increase in aggression as a result of decreased levels of **dopamine** (Hojo et al. 2015, p. 2260). The larvae and pupae of some species of lycaenid butterflies produce sounds to attract ants (DeVries 1988, p. 382), however, it is unknown if Fender's blue butterflies emit these sounds. In addition, some lycaenids oviposit preferentially in habitats with ants (Atsatt 1981b, p. 62; Pierce and Elgar 1985, p. 209). It is unknown if Fender's blue butterfly seek out and oviposit in habitats with both lupine and preferred ant species. We do know that ant communities are not homogeneous across the landscape, which may be the result of soil temperature and the density of vegetation (Thomas et al., *in review*). We

also know that Fender's blue butterfly larvae recruit ants quicker in warmer temperatures, making fire history an important factor in the relationship between ants and butterflies (Warchola et al. 2015, p. 1064). Further research is needed to elucidate the relationship between Fender's blue butterfly and site-specific ant communities as well as how invasive ant species may affect this symbiotic relationship.

Figure 2.7. Fender's blue butterfly larvae being tended by an ant.

Table 2.3 Ant species known to tend to Fender's blue butterfly.

Scientific name	Common name
Aphaenogaster occidentalis	None
Brachymyrmex depilis	None
Camponotus modoc	Carpenter ant
Formica fusca spp.	Unidentified subspecies
Formica lasioides	None
Lasius alienus	Cornfield ant
Liometopum occidentale	Velvety tree ant
Prenolepsis impairs	False honey ant
Tapinoma sessile	Odorous house ant
Tetramorium immigrans	Pavement ant

2.4 Habitat Requirements

Both Fender's blue butterfly and its larval host plant, the Kincaid's lupine, are restricted to the upland prairies and oak savannah habitats in the Willamette Valley in western Oregon. The Willamette Valley is approximately 200 km (130 mi) long and 30 to 50 km (20 to 40 mi) wide, characterized by a broad alluvial floodplain with an overall northward gradient (Franklin and Dryness 1988, p. 15). The valley is narrow and flat at its southern end, widening and becoming hilly near its northern end at the confluence of the Willamette and Columbia Rivers. The prairies of the Willamette Valley occur at low elevation (between 50 and 130 m (165 and 425 ft)), generally on deep **alluvial soils** in the valley bottoms and low foothills (Franklin and Dryness 1988, p. 16). The alluvial soils of the Willamette Valley host a mosaic of grassland, woodland,

and forest communities. Most Willamette Valley grasslands are **early seral** (one stage in a sequential progression) habitats, requiring natural or human-induced disturbance for their maintenance (Franklin and Dryness 1988, p. 122). Prairies in this area were historically created and maintained through burning by the native Kalapuya peoples to maintain high quality hunting and gathering grounds (Johannessen et al. 1971, p. 286; Boyd 1986, p. 65). Frequent burning reduced the abundance of shrubs and trees, favoring open prairies or savannahs with a rich variety of native plants and animals. As settlers arrived in the valley, native habitats were converted to agricultural landscapes, annual burning ceased, and both woody species and nonnative weeds encroached on the remaining prairie habitats. Native upland prairies and wet prairies have substantially declined since the arrival of settlers (Habeck 1961, p. 76; Johannessen et al. 1971, p. 301). Native upland prairies and wet prairies are essential habitat for Fender's blue butterfly because they contain open areas with short-stature plants and varying slopes containing **microtopography**. Most importantly, these prairies contain lupine plants.

The association of Fender's blue butterfly with upland prairie is a direct result of its dependence on specific species of lupine throughout its entire life cycle (Table 2.2). Lupine plays an integral function in Fender's blue butterfly reproduction because the plants provide the sole food source for the developing larvae. Currently, the most frequent larval host plant, Kincaid's lupine, is present at the majority of known Fender's blue butterfly population sites. Kincaid's lupine occurs in dry, open prairies in well-drained soils. It is a long-lived **perennial** species with low seed set, low seed production, and few numbers of flowers producing fruit from year to year (Figure 2.8;). Its leaves are **palmately** divided with 7 to 13 leaflets, the stem is unbranched, the flower whorls are interrupted, and the flowers bloom from April to June with a peak in May. If Kincaid's lupine is minimal or unavailable, Fender's blue butterfly larvae will feed on longspur lupine and sickle-keeled lupine (Figure 2.8; Schultz et al. 2003, p. 65). Longspur lupine is a perennial species found on dry, open slopes in shrub-steppe or east-side forests. Its leaves have a long **petiole** and 7 to 13 leaflets. The flowers of longspur lupine are yellow, white, or lavender, fading to blue or pink, the upper petal can have a white or cream patch, and the **calyx** is distinctly spurred. Sickle-keeled lupine is a perennial species located on dry, open slopes in foothills and west-side forests. Its leaves are palmately divided into 5 to 10 leaflets. The flowers of sickle-keeled lupine can be white, purple, or yellow in color and have a strongly curving upward **keel**.

The three aforementioned lupine species' leaves grow to approximately 61 cm (24 in) tall, with the flowers extending up to 90 cm (35 in) and all require sunny open areas without dense canopy cover to grow. The near absence of the Fender's blue butterfly at sites without Kincaid's lupine led some surveyors to speculate that longspur lupine and sickle-keeled lupine may be secondary food plants (Hammond and Wilson 1993, p. 16). At this time, we have no information to suggest that longspur lupine or sickle-keeled lupine are inferior or superior host plants either physically or biochemically, or that oviposition behavior of the Fender's blue butterfly reflects a preference for Kincaid's lupine. For instance, at the William L. Finley National Wildlife Refuge (Finley NWR), which has both Kincaid's lupine and longspur lupine, introduced post-diapause larvae showed no differences between the species in the number of leaves consumed on the lupine host plants or in plant abandonment (Severns and Fitzpatrick 2014, p. 1). However, when adult female butterflies from sites containing only Kincaid's lupine were introduced at the aforementioned site, they tended to stay either in Kincaid's lupine patches or move from longspur lupine patches to Kincaid's lupine patches, suggesting a possible innate preference for

Kincaid's lupine or, more likely, a preference for the lupine species they occupied as larvae (Severns and Fitzpatrick 2014, p. 2). Occurrences where Fender's blue butterfly apparently do not rely on Kincaid's lupine as its host plant have been noted at Coburg Ridge where longspur lupine is the sole host plant across greater than 95 percent of the site (Schultz et al. 2003, p. 65), at Baskett Slough National Wildlife Refuge (Baskett Slough NWR), two other sites where longspur lupine is the primary food plant (Schultz 1996, p. 13-14; M. Collins, pers. comm. 2017), and an additional two sites where longspur lupine co-occurs with Kincaid's lupine (Hammond and Wilson 1993, p. 2). At the time of listing, Fender's blue butterfly occupied six sites where sickle-keeled lupine was the primary food plant (USFWS 2000, p. 3877); however, several of these sites were small roadside patches and are now **extirpated**. Sickle-keeled lupine is the primary host plant for Puget blue butterfly (*Icaricia icarioides blackmoreii*), another subspecies of Boisduval's blue butterfly (C. Schultz, pers. comm. 2005). While broadleaf lupine (*Lupinus latifolius*) occurs in occupied Fender's blue butterfly habitat, the larvae have not been observed using this plant even though it is commonly used as a food source by other subspecies of Boisduval's blue butterfly (Schultz et al. 2003, p. 65).

Figure 2.8. Lupine plants used by Fender's blue butterfly. Kincaid's lupine is on the left, longspur lupine is in the middle, and sickle-keeled lupine is on the right. Kincaid's photo courtesy of Jeff Dillon, USFWS.

In addition to lupine, upland prairie habitats used by Fender's blue butterfly often contain scattered Oregon white oaks (*Quercus garryana*) and the following grass species: California oatgrass (*Danthonia californica*), colonial bentgrass (*Agrostis capillaris*), sweet vernalgrass (*Anthoxanthum oderatum*), Roemer's fescue (*Festuca idahoensis roemeri*), blue wild rye (*Elymus glaucus*), silver hairgrass (*Aira caryophylla*), little quaking grass (*Briza minor*), rattail fescue (*Vulpia myuros*), tall oatgrass (*Arrhenatherum elatius*), and tall fescue (*Festuca arundinacea*) with the latter five being exotic invasive species. Tall grasses, especially invasive tall oatgrass and tall fescue, inhibit the growth of the lupine host plants and native nectar sources by shading them out or crowding them out (Hammond 1996, p. 3; Schultz et al. 2003, p. 68). When these highly invasive nonnative plants become dominant, they can effectively preclude Fender's blue butterfly from using the native plant species the butterfly needs to survive and

reproduce (Hammond 1996, p. 3). Without lupine, quality prairie habitat supporting nectar species can provide beneficial **stepping stone habitat** for dispersing Fender's blue butterflies to reach other lupine patches. Stepping stone habitat consists of undeveloped open areas with the physical characteristics appropriate for supporting the short-stature prairie or oak savannah plant community. Given Fender's blue butterfly's dependence on lupine for each stage of its life cycle, we assume the Fender's blue butterfly will not reproduce in quality prairie habitat containing the aforementioned prairie plant species if lupine is absent. However, if lupine is also present, then the stepping stone patch may facilitate connectivity over multiple generations since butterflies can remain in the patch to reproduce. Thus, stepping stone habitat can function in two ways depending on the plant composition.

While lupine is an **obligate** larval food source for Fender's blue butterfly, wildflowers are essential for the adult stage. Nectar from wildflowers is the sole food source for adult butterflies, making it a required component of Fender's blue butterfly prairie habitat. Nectar provides sugar, water and amino acids for adult butterflies and evidence from other butterfly species suggests that butterflies live longer and lay more eggs as nectar availability increases (Murphy et al. 1984, p. 269; Boggs and Ross 1993, p. 437; O'Brien et al. 2004, p. 279). Both nectar availability and nectar use by Fender's blue butterfly changes throughout the flight season depending on which plants are present (Thomas and Schultz 2016, p. 174). Native nectar sources used most frequently, in addition to lupine host plants, include wild onion (*Allium amplecten*) also known as narrowleaf onion, Tolmie star-tulip (*Calochortus tolmiei*), dwarf checkermallow (*Sidalcea malviflora* ssp. *virgata*) also known as rose checkermallow, Oregon sunshine (*Eriophyllum lanatum*), Oregon geranium (*Geranium oreganum*), and common camas (*Camassia quamash*) (Wilson et al. 1997, pp. 9-10; Schultz et al. 2003, p. 67; Thomas and Schultz 2016, p. 176). Nonnative species such as oxeye daisy (*Leucanthemum vulgare*), common vetch (*Vicia sativa*), and tiny vetch (*V. hirsuta*) are also frequently used as nectar sources (Wilson et al. 1997, pp. 9-10; Thomas and Schultz 2016, p. 176). Of the nine most frequently used nectar species in one study, the native species had more sugar per **inflorescence** and more densely clustered inflorescences compared to the nonnative species (Thomas and Schultz 2016, p. 176). Differences in sugar content may explain selection of nectar sources. Early studies demonstrated that Fender's blue butterflies selected native nectar sources based on frequency of visitation to flowers (Hammond and Wilson 1993, p. 8; Schultz 1994, p. 37; Wilson et al. 1997, p. 3). A more recent study observed that female Fender's blue butterflies selected native nectar sources more so than nonnative nectar sources, whereas males did not show a clear pattern (Thomas and Schultz 2016, p. 171). It is unknown if selection translates to a preference for specific nectar sources.

Fender's blue butterfly densities have been positively correlated with native sugar densities and lupine leaf densities (Schultz and Dlugosch 1999, p. 234-236). The study estimated total native nectar density from four sites in a single metapopulation located within Lane County to be 29.22 mg/m^2, 8.10 mg/m^2, 5.20 mg/m^2, and 7.47 mg/m^2 (Schultz and Dlugosch 1999, p. 235). Kincaid's lupine leaf densities were estimated to be 15.8 leaves/m^2, 22.8 leaves/m^2, 24.2 leaves/m^2, and 54.7 leaves/m^2 (Schultz and Dlugosch 1999, p. 234). Based on the analysis conducted in Lane County by Schultz and Dlugosch (1999), Schultz (2001, p. 1008) suggested that suitable habitat for Fender's blue butterfly contained 20 mg/m^2 of sugar of nectar from native species and 40 leaves/m^2 of lupine. While the highest population density of Fender's blue

butterfly was associated with close to 30 mg/m^2 of sugar from native nectar flowers and 55 leaves/m^2 of lupine, the positive relationships were driven by data collected at The Nature Conservancy's Willow Creek Natural Area. At the time, Willow Creek Natural Area was one of the few sites in the Willamette Valley that was being actively managed for Fender's blue butterfly. The aforementioned study did not find a relationship between Fender's blue butterfly density and lupine cover (Schultz and Dlugosch 1999, p. 234). Lupine cover has been used as a substitute measure for leaf densities due to the time consuming demands of quantifying number of leaves. Lupine cover and leaf density have been positively correlated; however, sites in full sun have much higher leaf densities than those in the shade (Kaye and Benfield 2005, p. 37). Therefore, the strength of the relationship between lupine cover and leaf density is dependent upon location, which may account for the lack of relationship between these variables in other studies. In conclusion, it appears that Fender's blue butterfly occur in areas with wide variation in lupine and nectar resources and uncertainty exists regarding which prairie characteristics influence Fender's blue butterfly densities. Repeating the aforementioned analyses using current rangewide data and factoring in habitat management actions would be beneficial.

2.5 Resource Needs of Individuals

Habitat requirements for the successful development and survival of individuals of Fender's blue butterfly include open prairie or oak savannah, host lupine plants, and nectar sources. In addition, the presence of ants, leaf litter, and mud puddling locations may be beneficial resources warranting further investigation. At this time, the known direct resource needs of Fender's blue butterfly, by life stage, are summarized in Table 2.4.

Table 2.4. Resource needs of the Fender's blue butterfly based on its life stages.

Life Stage	Timeline	Resource Needs
Egg	Mid-April through June	• Kincaid's lupine, longspur lupine, or sickle-keeled lupine
Larva (including diapause)	Mid-May through early April (including diapause)	• Kincaid's lupine, longspur lupine, or sickle-keeled lupine
Pupa	April through May	• Kincaid's lupine, longspur lupine, or sickle-keeled lupine
Adult butterfly	Mid-April through June	• Early seral upland prairie, wet prairie, or oak savannah habitat with a mosaic of low-growing grasses and forbs, an open canopy, and a disturbance regime maintaining the habitat • Kincaid's lupine, longspur lupine, or sickle-keeled lupine • Variety of nectar flowers

2.6 Metapopulation Needs

In the case of Fender's blue butterfly, we have defined **resiliency** as the ability to sustain metapopulations in the face of environmental or demographic variation. As previously mentioned, a metapopulation is defined as several potentially interacting groups of Fender's blue butterflies that are within 2 km (1.2 miles) of one another and not separated by barriers. We developed a basic conceptual diagram to illustrate the relationship between the resources and circumstances that most likely influence the resiliency of Fender's blue butterfly metapopulations (Figure 2.9). In this model, we identified lupine plants, nectar plants, open prairie or oak savannah habitat, ant tending, and leaf litter as important resource needs that influence demographic characteristics. In turn, demographic characteristics then influence the ability of a metapopulation to grow over time. Resiliency is positively related to metapopulation size and may be influenced by connectivity among sites within a metapopulation. Thus, greater abundance and greater connectivity mean greater resiliency of Fender's blue butterfly metapopulations. Resiliency describes the ability of metapopulations to withstand stochastic events; it gauges the probability that the metapopulations comprising Fender's blue butterfly are able to withstand or bounce back from environmental or demographic stochastic events.

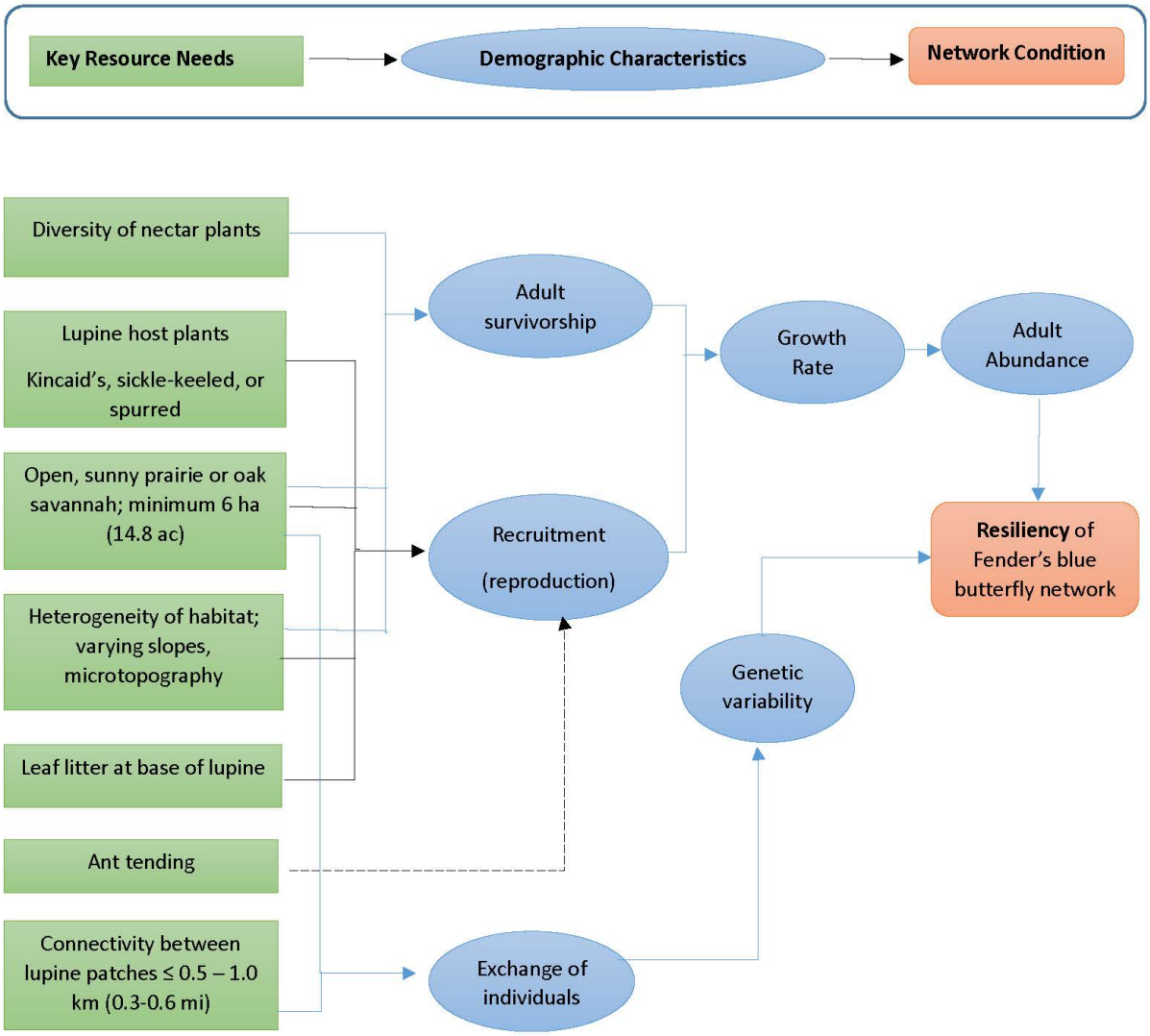

Figure 2.9. Conceptual diagram of key resource needs and demographic characteristics influencing the relative resiliency of Fender's blue butterfly metapopulations. The dashed line indicates greater uncertainty in the strength of the relationship between the factors.

Following the completion of the influence diagram to visualize relationships between variables, we evaluated specific elements of habitat and demographics to develop metapopulation needs, taking into account recovery criteria, and identified uncertainties that influence those elements (Table 2.4). Habitat quality and quantity describe what is needed for successful breeding, feeding, and sheltering. Abundance and demographics consider the structure of the metapopulation. This typically factors in characteristics such as the number of individuals, **fecundity**, age distribution, survival rates, growth rates, and genetics. In the case of Fender's blue butterfly, adults exhibit daily reproductive output over their 7 to 14-day lifetime and typical **age structure** elements found within vertebrate taxa do not apply. We lack information on population genetics to inform existing levels of heterozygosity, private alleles, connectivity, and so forth so that element cannot be evaluated.

Some of the elements of habitat and demographics were evaluated for Fender's blue butterfly in the Recovery Plan referenced in Chapter 1. The recovery goals for all the listed species covered by the Recovery Plan stress maintaining large populations distributed across their entire historical range, with management plans focusing on protecting sites with high habitat heterogeneity and a range of elevations (USFWS 2010, p. IV-6). Specific to Fender's blue butterfly, the Recovery Plan set a minimum population criterion of 200 adult butterflies distributed among groups within a functioning network (analogous to a metapopulation, as used in this document) each year for at least 10 years (USFWS 2010, p. IV-12). The Recovery Plan also set downlisting goals at a 90 percent probability of species persistence for 25 years. The Recovery Plan will be discussed in further detail in Chapter 3.

Based on the biology of the species and the information presented in the Recovery Plan, we determined that to be resilient, the metapopulation needs of the Fender's blue butterfly are an abundance of lupine host plants and nectar plants within prairie patches at least 6 ha (14.8 ac) in size[1], with habitat heterogeneity and minimal amounts of invasive plants and woody vegetation. Healthy metapopulations would also contain a minimum of 200 butterflies (resiliency) each year for 10 years distributed across multiple groups (within-metapopulation redundancy) in lupine patches that are within 0.5 to 1.0 km (0.31 to 0.62 mi) of one another[2]. Ideally, at the species level, resilient metapopulations would be distributed across the historical range of the species (redundancy and representation) and have a plethora of stepping stones for connectivity across the landscape (redundancy and representation).

[1] A patch size of 6 ha was selected based on modeling research by Schultz and Duglosch (1999) that found 2 to 6 ha was the minimum patch size necessary for Fender's blue butterfly.
[2] This estimated distance between patches reflects the observation that 95 percent of butterflies remain within 0.75 km of their natal lupine patch.

Table 2.5. Resources and circumstances needed to support resiliency in Fender's blue butterfly metapopulations and redundancy and representation at the species level based on the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (USFWS 2010).

Metapopulation Needs		
Habitat Quantity/Quality	**Abundance**	**Distribution**
Abundant density of lupine host plants	Minimum of 200 adult butterflies per metapopulation for 10 years	0.5 – 1.0 km (0.3 – 0.6 mi) between lupine patches within a metapopulation
A diversity of nectar plant species throughout the flight season.	Consists of multiple groups of butterflies	Occur across the historical range
Prairie relatively free of invasive plants and woody vegetation, especially those that prevent access to lupine or nectar (*e.g.*, tall grasses)		Stepping stone prairie patches with lupine and/or nectar to facilitate connectivity within a metapopulation
Prairie patch sizes of at least 6 ha (15 ac) per metapopulation		
Heterogeneity of habitat including varying slopes and microtopography		
Assumptions/Uncertainties • assume a 1:1 sex ratio, but surveys only count males • minimum viable metapopulation size unknown • trends difficult to interpret due to high variability and mix of survey methods • 90 percent probability of persistence over 25 years as per the Recovery Plan		

Chapter 3. Abundance and Distribution

In this chapter we consider the Fender's blue butterfly's historical distribution, its distribution at the time of listing under the ESA, and its current distribution. We also discuss the creation and implementation of a recovery plan for Fender's blue butterfly. Finally, we compare the current conditions of the Fender's blue butterfly to conditions at the time of listing.

3.1 Historical Abundance and Distribution

The historical distribution of Fender's blue butterfly is not precisely known due to the limited information collected on this species prior to the first collection made in 1929. As noted earlier, Fender's blue butterfly was not seen again for decades after 1937. A lack of information on the identity of the butterfly's host plant caused researchers to focus their survey efforts on common

lupine species known to occur in the vicinity of where the first type specimens were found southeast of McMinnville, Oregon. As a result, no Fender's blue butterflies were observed during years of widespread investigation from 1937 until 1989, when it was rediscovered at the McDonald State Forest, Benton County, Oregon. The Fender's blue butterfly metapopulation located within the McDonald State Forest, now known as the McDonald Research Forest owned by OSU, is known as Butterfly Meadows. Starker Forests, a private company owns a predominant portion of the site containing the Butterfly Meadows metapopulation.

3.2 Abundance and Distribution at the Time of Listing

At the time of listing in 2000, known populations of Fender's blue butterfly and Kincaid's lupine were confined almost exclusively on the western side of the Willamette Valley, within 33 km (21 mi) of the Willamette River (Figure 3.1). At that time, we knew of an estimated total of 3,391 individuals located in 32 prairie fragments across 165 ha (408 ac) in Yamhill, Polk, Benton, and Lane Counties (Table 3.1; Hammond and Wilson 1993, p. 1; Schultz 1996, p. 5); Kincaid's lupine occupied 54 sites across 158 ha (370 ac). Of the 32 sites found to support Fender's blue butterfly, Kincaid's lupine was documented co-occurring as a larval host plant at 27 of them. Of the five sites where Kincaid's lupine was not the dominant host plant, longspur lupine and sickle-keeled lupine were used as host plants by the Fender's blue butterfly. At least 15 of the 32 sites occupied by Fender's blue butterfly and 49 of 54 sites with Kincaid's lupine were located on private land. The 32 sites known at listing were subsequently grouped into 12 metapopulations in 2017, based on the criteria described in section 1.1, above (Table 3.2). While the listing document reported a total of 165 ha (408 ac) of occupied Fender's blue butterfly habitat, we now know that the occupied habitat at several sites was overestimated. The Coburg metapopulation was overestimated by 17.8 ha (44 ac) in the listing document, Butterfly Meadows was overestimated by 16.3 ha (40.3 ac), and the Baskett metapopulation was overestimated by 10 ha (24.7 ac).

Table 3.1. Summary of information known at the time of listing in 2000 (65 FR 3875, January 25, 2000).

	Fender's blue butterfly	Kincaid's lupine
Number of sites	32	54
Number of estimated individuals	3,391	Unknown
Number of hectares (acres) occupied	165 (408)*	158 (370)

*Overestimated (see Section 3.2 for explanation)

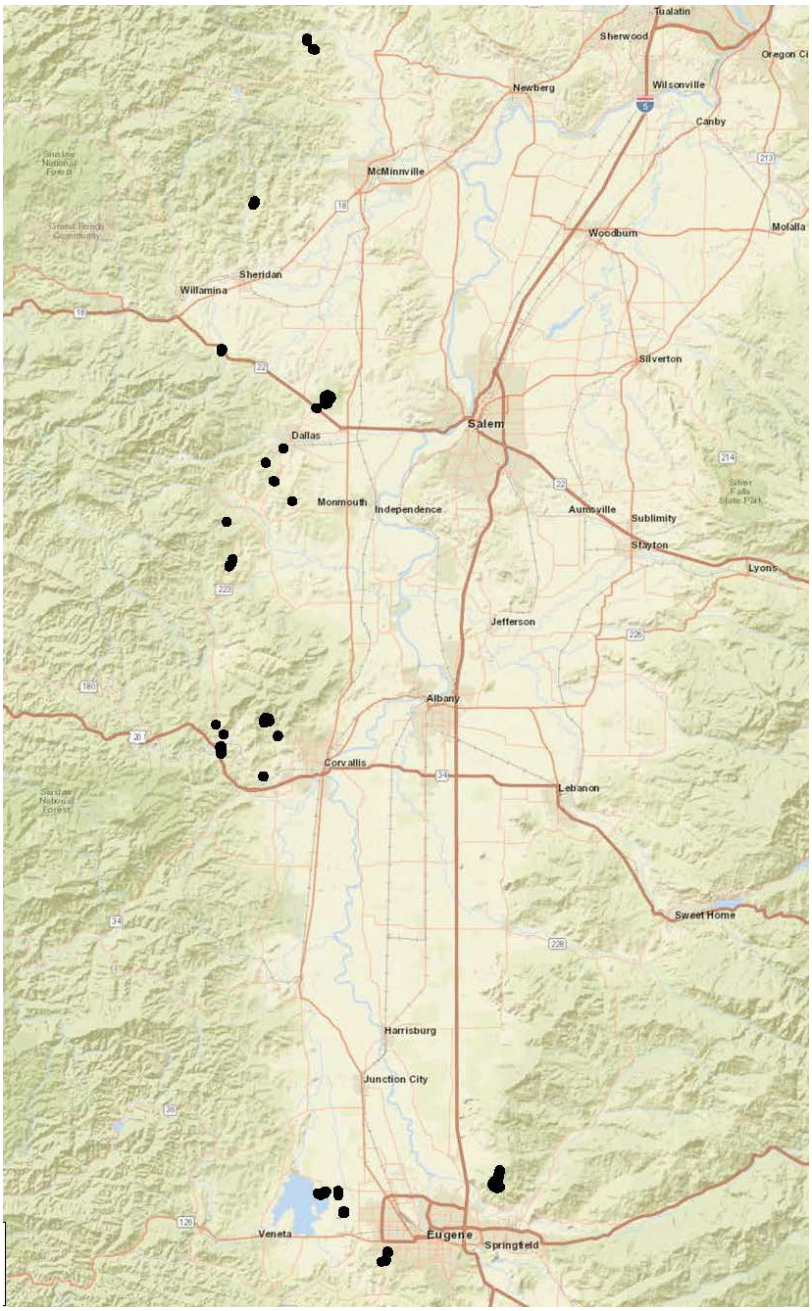

Figure 3.1. Distribution of Fender's blue butterfly at the time of listing the species as endangered in 2000.

Table 3.2. Known locations of Fender's blue butterfly at the time of listing, grouped into 12 metapopulations.

Metapopulation	Site Name	County	Estimated Hectares	Estimated Acres	Land Ownership
Baskett	Baskett Butte	Polk	38.2	94.5	Public
	Baskett Satellite	Polk	0.6	1.6	Public
	McTimmonds Valley Hwy223	Polk	0.1	0.4	Public Right-of-way
Butterfly Meadows	Butterfly Meadows	Benton	2.4	7.4	Private
	Butterfly Meadows NW 1	Benton	0.5	1.1	Public
Coburg	Coburg TNC	Lane	18.8	46.3	Conservation Easement
	Coburg WEYCO	Lane	1.0	2.5	Private
Dallas	Dallas Hill Street E	Polk	0.3	0.7	Private
	Dallas Hill Street Mid	Polk	0.3	0.8	Private
	Dallas Hill Street W	Polk	0.1	0.2	Private
	Fern Creek - Weston Corner	Polk	7.2	17.7	Private
	Grant Creek	Polk	0.5	1.2	Public Right-of-way
Fern Ridge	Fern Ridge Spires	Lane	6.6	16.2	Public
	Fern Ridge Eaton Lane	Lane	5.9	14.4	Public
	Fern Ridge Shore Lane	Lane	3.1	7.4	Public
Gopher Valley	Gopher Valley Dupee Road	Yamhill	0.0	0.1	Public Right-of-way
	Yamhill Oaks Preserve	Yamhill	6.6	16.1	Conservation Easement
Lupine Meadows	Lupine Meadows	Benton	7.2	17.9	Conservation Easement
	West Hills Roadside	Benton	0.3	0.8	Public Right-of-way
Mill Creek	Mill Creek	Polk	1.5	3.7	Public
	Mill Creek	Polk	0.2	0.5	Public
Oak Ridge	Oak Ridge	Yamhill	2.6	6.3	Private
	Oak Ridge Area 3 Road	Yamhill	1.9	4.8	Public Right-of-way
West Eugene	Fir Butte Main	Lane	7.1	17.7	Public
	Fir Butte Road	Lane	0.8	1.9	Public Right-of-way
Willow Creek	Willow Creek Main	Lane	4.3	10.5	Conservation Easement
	Willow Creek Bailey Hill	Lane	1.1	2.8	Conservation Easement
Wren	LaBare Rd Hwy 223	Benton	0.0	0.0	Public Right-of-way
	Wren Area 1 B	Benton	6.2	15.4	Private
	Wren Prairie (Wren 1 M)	Benton	0.5	1.3	Private
	Wren Summers Lane Corner	Benton	0.8	1.9	Public Right-of-way
	Wren TNC (Wren 1 T)	Benton	0.1	0.3	Conservation Easement

The 32 sites containing Fender's blue butterfly occurred across a broad range of land ownerships with varying degrees of land protection and management (Table 3.2). Nine sites were on tracts of public land owned by the Service, the Army Corps of Engineers (USACE), the Bureau of Land Management (BLM), or Oregon State University (OSU). Thus, these sites had permanent protection. Of these, four were being managed for prairie habitat in a limited capacity due to limited funding. Two sites were in public right-of-ways (ROWs) managed by the Oregon Department of Transportation (ODOT) and six sites were in public ROWs managed by various County Public Works; however, none of these sites were being actively managed for prairie even though they were permanently protected. Nine sites were on private land without any form of protection or active management for Fender's blue butterfly or its habitat. Six sites were on private land with a conservation easement held by either The Nature Conservancy (TNC) or by Greenbelt Land Trust (GLT). A conservation easement is a voluntary legal agreement between a landowner and either a conservation organization or a government agency that limits the use of the land in order to protect its conservation values.

3.3 Recovery Plan Creation and Implementation

Shortly after being listed as endangered, a count-based **population viability analysis (PVA)** suggested that the Fender's blue butterfly was at high risk of extinction throughout most of its range, with even the largest populations given a poor chance of survival over the next 100 years (Schultz and Hammond 2003, pp. 1379-1380). In general, a population needs a growth rate of 1.0 to remain stable, while a growth rate above 1.0 means the population is increasing and a growth rate below 1.0 means the population is decreasing. The PVA estimated that Fender's blue butterfly populations experience very high natural variance in population growth rate (0.112 to 1.715), which requires mean population growth rates to be relatively high to remain stable or to grow (in the range of 1.4 or higher) (Schultz and Hammond 2003, p. 1377). However, the variation in population growth rate is, biologically, a combination of **demographic** and **environmental stochasticity**. As populations get larger, the influence of demographic stochasticity declines, so the overall variance in growth rate declines. Thus, at population sizes large enough to have a low extinction risk, a somewhat lower variance in population growth rate can reasonably be assumed. Based on the PVA for the Fender's blue butterfly, Schultz and Hammond (2003, p. 1381) concluded that recovery of the species would require a minimum average growth rate of 1.55 at three independent sites in each of three zones that span the species' presumed historical range. The rate of 1.55 was based on the minimum growth rate needed for a 95 percent probability that at least one site survived 100 years given an initial population size of 300 individuals, a variance in population growth rate of 0.79, and 3 independent sites. Independent sites were defined in the PVA as isolated populations that meet certain minimum size and habitat quality criteria, and which would be likely to persist in the long-term at the **minimum patch size** (defined as 6 ha (15 ac) in the Recovery Plan). A projected 100-year time frame is frequently used for PVA analyses and was used in delisting criteria for the Fender's blue butterfly; however, general agreement on the time frame and probability of survival does not exist. A 100-year time frame may underestimate the risk of extinction in long-lived species (Armbruster et al. 1999, p. 69) and may potentially overestimate the risk of extinction in short-lived species such as Fender's blue butterfly.

Variance in population growth rate is normally high for insect populations; stochastic factors, especially variation in weather from year to year, will periodically reduce population numbers.

Given this, maintaining high quality habitats and connectivity among sites was determined to be critical to allow Fender's blue butterfly populations to rebound after bad weather years. Thus, recovery tasks emphasized establishing connections among populations with stepping stone habitats to allow natural recolonization while reintroduction and augmentation programs were considered a secondary part of recovery effort for the species.

The Recovery Plan aimed to achieve viability of Fender's blue butterfly by establishing a series of metapopulations composed of multiple subpopulations in restored prairie reserves distributed across the presumed historical range of the species (USFWS 2010, p. IV-10). Based on the presumed historical range, the Recovery Plan established three recovery zones for establishing these metapopulations to ensure representation across the range (Figure 3.2). The Salem zone encompasses the northern portion of the range, the Corvallis zone encompasses the middle, and the Eugene zone encompasses the south. In this SSA, we use the distribution of metapopulations across these three recovery zones to evaluate representation for Fender's blue butterfly.

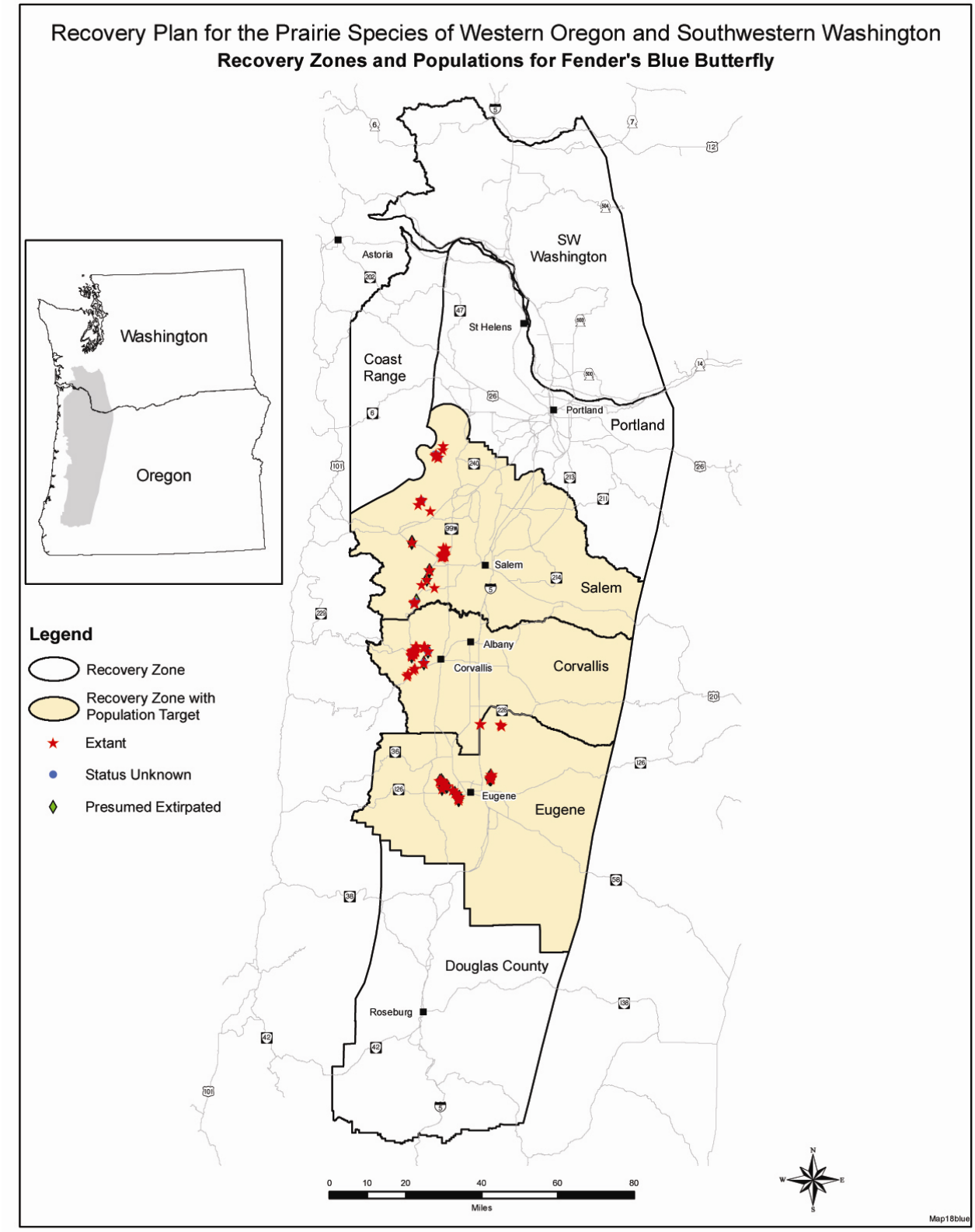

Figure 3.2. The three recovery zones for establishing Fender's blue butterfly metapopulations.

A "functioning network" was defined in the Recovery Plan as a metapopulation that consists of several potentially interacting subpopulations of Fender's blue butterfly distributed across a landscape. In addition, the Recovery Plan stipulated that a functioning network must be composed of three or more subpopulations, each occupying habitat of at least the minimum patch size (6 ha (15 ac)) and separated by no more than the maximum separation distance (2 km (1.2 mi)) or connected by stepping stone patches of lupine and nectar plants less than 1 km (0.6 mi) apart (USFWS 2010, p. IV-10). Minimum patch size was defined as 6 ha (15 ac) based on modeling done by Crone and Schultz (2003, p. 575). **Maximum separation distance** was defined as approximately 2 km (1.2 mi) from the next nearest subpopulation based on flight distance data (Schultz 1998, p. 291). There was no minimum size necessary for a patch to function as a stepping stone, as long as the patch contained both lupine and nectar plants and the intervening habitats were relatively free from barriers to butterfly movement. Reestablishing stepping stones between existing populations was intended to increase the likelihood that individuals would move from one large patch of lupine to the next, facilitating dispersal (Schultz 1998, p. 291). Populations that did not meet functioning network criteria were considered **independent populations**.

Based on the distribution of prairie habitat and distance between known sites occupied by Fender's blue butterfly, there are currently six groups of butterflies that may be functioning independently rather than as part of a metapopulation. Dispersal data are not available for these groups and areas surrounding these groups have not been extensively surveyed, thus it is unclear whether there may actually be additional butterflies present nearby that may be interacting with them. We therefore refer to these independent occurrences as **groups**, rather than subpopulations, since it is unclear if they are functioning as part of a larger metapopulation of Fender's blue butterflies.

In this document we are using the term metapopulation rather than functioning network, as in the Recovery Plan, in part because this term will be more familiar to most readers. In addition, we found that the term "functioning network" as defined in the Recovery Plan does not allow for circumstances such as when populations do not meet the Recovery Plan definition of either an independent population or a functioning network. For example, in some instances two occupied sites are within 2 km (1.2 mi) of one another without barriers, yet the Recovery Plan did not provide a classification for such a scenario, since it required a minimum of three connected sites to be considered a functioning network. Additionally, the Recovery Plan definition of functioning network included a requirement for a minimum patch size of 6 ha (15 ac) for each subpopulation, and since a functioning network was defined as at least 3 subpopulations, a total of 18 ha (44 ac) was required for each network (6 ha multiplied by 3 subpopulations is 18 ha). The models that provided the basis for a 6-ha (15-ac) minimum patch size assumed sites were isolated and based on that, predicted Fender's blue butterfly subpopulations needed a minimum patch size of 2 to 6 ha (5 to 15 ac) in the absence of immigration from other patches to persist (Crone and Schultz 2003, p. 575). We now know that these sites are not isolated and that Fender's blue butterfly networks can thrive in small patch sizes under 6 ha (15 ac). Thus, our definition of metapopulation eliminates this patch size requirement.

The definition of metapopulation that we use here, as introduced in section 2.3.2, above, is several potentially interacting groups of Fender's blue butterflies that are within 2 km (1.2 mi) of

one another and not separated by barriers. The definition of independent group is occupied sites that are more than 2 km (1.2 mi) from another occupied site and/or are separated by barriers from other occupied sites such that butterflies are unable to interact.

3.4 Current Abundance and Distribution

As of 2018, there are a total of 15 known Fender's blue butterfly metapopulations and 6 independent groups distributed across the known historical range of the species in Benton, Lane, Linn, Polk, Washington, and Yamhill Counties (Figure 3.3; Table 3.3). Of those metapopulations, six are located in the Salem Recovery Zone, five are in the Corvallis Recovery Zone, and four are in the Eugene Recovery Zone. The six independent groups are known as Bond Butte, Dallas, McCaleb Road, McTimmonds Valley, Mill Creek, and Tanager. As a result of being small and isolated, independent groups are not monitored regularly.

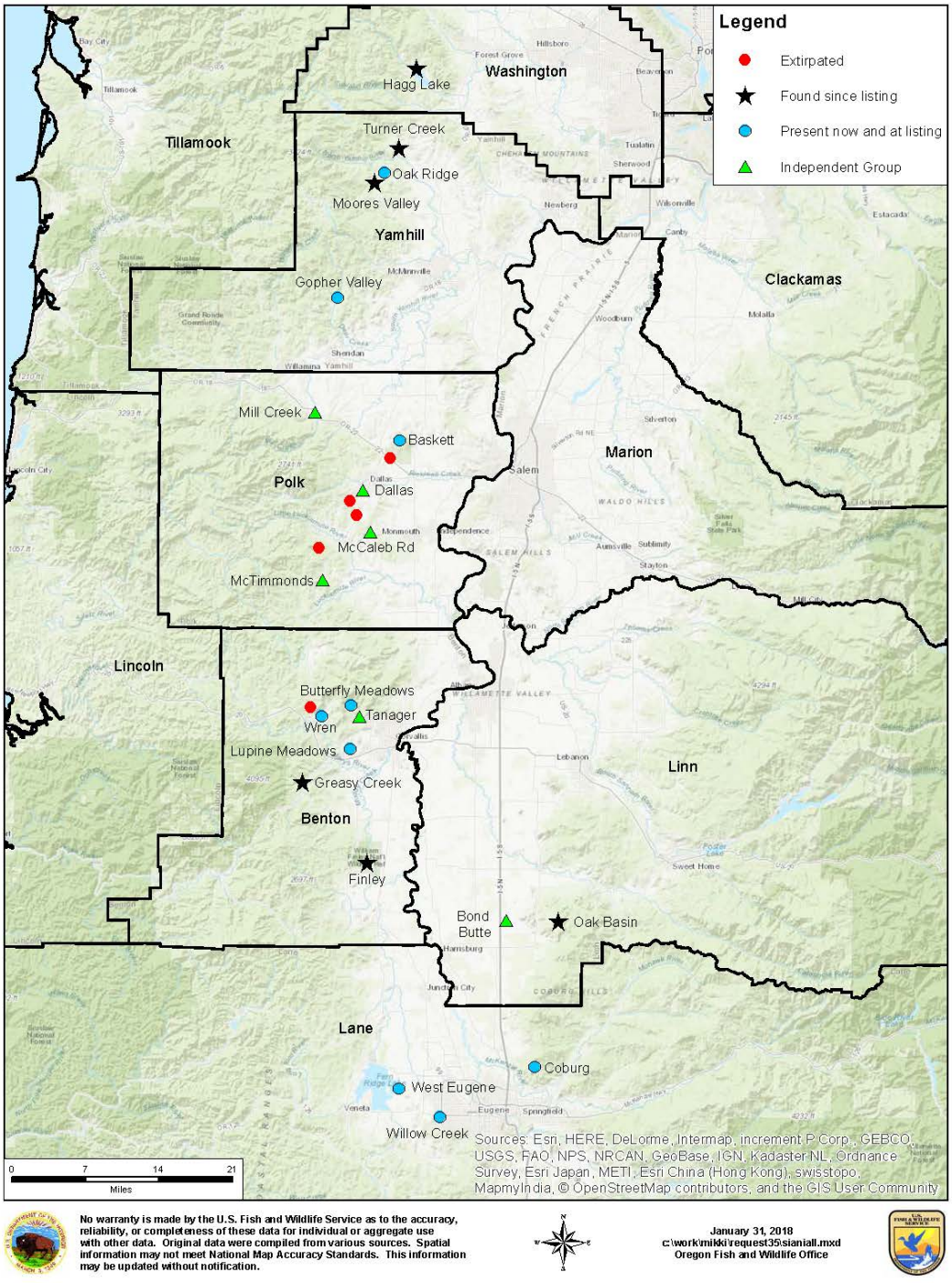

Figure 3.3. Distribution of current Fender's blue butterfly metapopulations in Benton, Lane, Linn, Polk, Washington, and Yamhill Counties along with extirpated sites. Metapopulations are categorized as present at listing or as either found or created since being listed as endangered in 2000. Red circles are extirpated sites, not metapopulations.

Fender's Blue Butterfly Independent Groups

Of the six independent groups of Fender's blue butterflies, five were known at the time of listing and one has been discovered since listing. McCaleb Roadside, McTimmonds Valley, and Mill Creek independent groups are roadside sites known at the time of listing under ODOT management. Due to the lack of regular surveys both on the sites and in the surrounding landscape, it is unclear if Fender's blue butterfly still occupies these locations. The McTimmonds Valley and McCaleb Roadside sites still contain habitat, but the Mill Creek site has become increasingly infested with nonnative plant species which are outcompeting the lupine host plants. The Dallas independent group, which was known at listing, occurs on privately-owned land and is surrounded by urban development in the City of Dallas, Oregon. Although the habitat at the Dallas group is not managed under a formal agreement, this site still supports Fender's blue butterfly, with a population estimate of 14 individuals in 2016 (Fitzpatrick and Menke 2016, p. 23).

The Tanager Drive independent group is comprised of two small roadside sites (Oak Creek Drive and Tanager Drive) under the management of the Benton County Roads Department (Benton CRD). The Oak Creek Drive site was first reported in 1995 (Hammond 2004, p. 23) and was initially grouped with the Butterfly Meadows metapopulation (Hammond 2003, p. 24). However, given the densely forested landscape between Butterfly Meadows SE1 site and the Oak Creek Drive site, it is unclear if Fender's blue butterfly could regularly disperse between these lupine patches. Fender's blue butterfly was last observed at the Oak Creek Drive site in 2002 (Hammond 2003, p. 24), despite presence/absence surveys conducted in the area since that time. During 2012 surveys, Fender's blue butterflies were observed in the Kincaid's lupine along Tanager Drive near Oak Creek Drive, and it was reported that the adjacent privately-owned meadow also contained a significant patch of lupine (Fitzpatrick 2013a, p. 42). Butterfly surveys were conducted again in 2013 on public land near Tanager Drive, but Fender's blue butterflies were not observed. In 2014, Kincaid's lupine was discovered 1.4 km (0.87 mi) southwest of the Tanager Drive site but it is unknown if Fender's blue butterflies occupy this area (Adapt, Inc. 2014, p. 12). Surveys have not been conducted at the public sites since 2013 and we have not been given access to adjacent private land to survey. Given the amount of unsurveyed land in the area surrounding the Fender's blue butterfly sites in this metapopulation, there is a high degree of uncertainty regarding the status of this independent group; however, habitat exists to support a potential metapopulation at these sites.

Lastly, Bond Butte, the independent group discovered in 2008, is divided between private land containing lupine plant habitat and ODOT ownership containing nectar resources. The Service has not had permission to conduct a Fender's blue butterfly abundance estimate on the private lands, so there is significant uncertainty about the status of the Bond Butte independent group. Fender's blue butterflies have been intermittently observed on the ODOT portion of the Bond Butte metapopulation, although no recent estimates are available.

Fender's Blue Butterfly Metapopulations

Within the Salem Recovery Zone, which represents the northernmost extent of the geographic range of Fender's blue butterfly, there are six metapopulations in Polk, Washington, and Yamhill Counties. The metapopulations are known as Baskett, Gopher Valley, Hagg Lake, Moores Valley, Oak Ridge, and Turner Creek (Table 3.3). Of these metapopulations, three have been found since listing and three have expanded since listing. Collectively, the metapopulations have an estimated 5-year average abundance of 5,370 Fender's blue butterflies across 128 ha (316 ac) of prairie containing 8.1 ha (20 ac) of lupine patch area, 10,092 sq m of lupine cover, and 93.2 ha (229 ac) of nectar area. Across the six metapopulations, 78.7 ha (194.5 acres) are permanently protected for the Fender's blue butterfly and 38.4 ha (94.9 acres) have interim protection.

Within the Corvallis Recovery Zone, there are five metapopulations known as Butterfly Meadows, Finley, Greasy Creek, Lupine Meadows, and Wren (Table 3.3, Figure 3.3). Of these metapopulations, one was created after listing, one has been found since listing, one has remained the same, and two have expanded since listing. Collectively, the metapopulations have an estimated 5-year abundance of 3,461 Fender's blue butterflies across 117.4 ha (290 ac) of prairie containing 13.8 ha (34 ac) of lupine patch area, 3,617.5 sq m of lupine cover, and 52 ha (129 ac) of nectar area. Across the five metapopulations, 35.4 ha (87.5 ac) are permanently protected and 14 ha (35 ac) have interim protection.

Within the Eugene Recovery Zone, there are four metapopulations known as Coburg Ridge, Oak Basin, West Eugene, and Willow Creek (Table 3.3, Figure 3.3). Of these metapopulations, one has been found since listing and three have expanded since listing. Collectively, the metapopulations have an estimated 5-year average abundance of 11,175 Fender's blue butterflies across 62.2 ha (153.7 ac) of prairie containing 16.5 ha (40.8 ac) of lupine patch area, 6,018 sq m of lupine cover, and 73.9 ha (182.6 ac) of nectar area. Across the four metapopulations, 100.6 ha (248.6 ac) are permanently protected and 10.2 ha (25.2 ac) have interim protection.

Table 3.3. Current Fender's blue butterfly metapopulations.

Recovery zone	Metapopulation Name	Status since listing	5-year abundance average*	Continuous years with ≥ 200 butterflies since listing	Total prairie habitat (ha)	Total Lupine Patch area (ha)	Percent of Prairie that is Lupine	Total Lupine Cover (sq m)	Primary Nectar Area (ha)	Permanent Protection (%)	Interim Protection (%)
Salem	Baskett	Expanded	2,091	18	81	3.82	4.7	1,220	62.2	71	29
	Gopher Valley	Expanded	465	7	8.2	0.45	5.5	309	6.5	100	.
	Hagg Lake	New	1,649	8	10.1	1.2	11.9	1,306	9.2	100	.
	Moores Valley	New	31	0	11.3	0.13	1.2	168	1.03	12	88
	Oak Ridge	Expanded	1,082	6	12.6	2.2	17.5	6,894	9.7	0	35
	Turner Creek	New	37[a]	0	4.85	0.31	6.4	195.4	4.6	32	13
Corvallis	Butterfly Meadows	Expanded	111	6	4.38	0.77	17.6	108.5	3.51	23.5	0
	Finley^	New	239	3	8.5	1.6	18.8	180	6.26	100	.
	Greasy Creek	New	69	0	7.4	1.4	18.9	229.2	6	3.9	0
	Lupine Meadows	Same	28	6	7.6	0.35	4.6	205.8	5.01	99	1
	Wren	Expanded	3,047	7	34.3	9.7	28.3	2,894	31.2	52.7	40.5
Eugene	Coburg Ridge	Expanded	54	2	28.4	0.76	2.7	104	13.9	77	0
	Oak Basin	New	25	0	17.6	1.1	6.3	180	6.6	42	58
	West Eugene	Expanded	8,448	15	45.9	4.5	9.8	2,750	29.9	100	.
	Willow Creek	Expanded	2,599	25	25.5	10.17	39.9	2,984	23.5	100	.

*Survey year varies per site so this number represents the most recent survey data for each site combined to form a metapopulation total
^ Butterflies were introduced to this area in 2014 and 2015
[a] Likely underestimated due to inability to access private lands

There are 137 total sites containing Fender's blue butterfly that occur over a broad range of land ownerships with varying degrees of land protection and management. Not all sites are surveyed every year, however. Surveys at 93 of the 137 sites in 2018 estimated there were approximately 13,700 individuals of Fender's blue butterfly occurring on an area totaling approximately 344 ha (825 ac) in Benton, Lane, Linn, Polk, Washington, and Yamhill Counties. Forty-four sites are on tracts of public land owned by the USACE; BLM; Bureau of Reclamation (BOR); OSU; or the Service, all of which are being managed for prairie habitat to varying degrees given funding and personnel. Fourteen sites are in public ROWs managed by ODOT or County Public Works and all are being managed for prairie. Thirty sites are on private land without any form of protection or active management for Fender's blue butterfly or its habitat. Another 43 sites are on private land with some level of protection via a conservation easement (20 sites) or under a cooperative agreement (23 sites) and are being managed for prairie habitat. Expansion of existing metapopulations has naturally occurred as a result of habitat management specifically designed for Fender's blue butterflies.

In addition to metapopulation expansion, new metapopulations have been found and one new metapopulation was created via a reintroduction. Fender's blue butterflies were discovered in Linn County, Oregon, in multiple locations in 2009 and at Henry Hagg Lake in Washington

County, Oregon, in 2011 (Hammond 2011, p. 3). A new metapopulation was created when Fender's blue butterflies were introduced to Pigeon Butte in the southern portion of Finley NWR in 2014. For more detailed information on each metapopulation see Appendix C: *Metapopulation Descriptions under Current Conditions*.

3.4.1 Changes in population estimate methodology

Estimates from 1993 to 2018 for all the surveyed Fender's blue butterfly metapopulations in the Willamette Valley indicate the total number of butterflies fluctuated from an estimate of 3,200 in 32 sites in 1993 to a high of 28,700 in 87 sites in 2016 and a current estimate of 13,700 (Figure 3.4; Hammond 1994, pp. 35-37; Fitzpatrick and Menke 2016, p. 10; Menke 2018, p. 4). Numbers of butterflies naturally vary annually at individual sites, often doubling or halving between years (*e.g.*, as seen between 2004 and 2005, Figure 3.4). Interpretation of these data is complicated by changes in sites surveyed, changes in our survey methodology as well as differences in observer ability to detect butterflies at varying distances, and to differentiate between the Fender's blue butterfly and the silvery blue butterfly. As previously mentioned, silvery blue butterflies are a related species that look remarkably similar to Fender's blue butterfly. Additional complicating factors are that both their flight period and their range overlaps with that of Fender's blue butterfly. However, silvery blue butterflies have a larger home range, use a greater variety of larval host plants, and tend to emerge as adults earlier than Fender's blue butterfly. Differentiating between these two species is essential for accurate counts of Fender's blue butterfly.

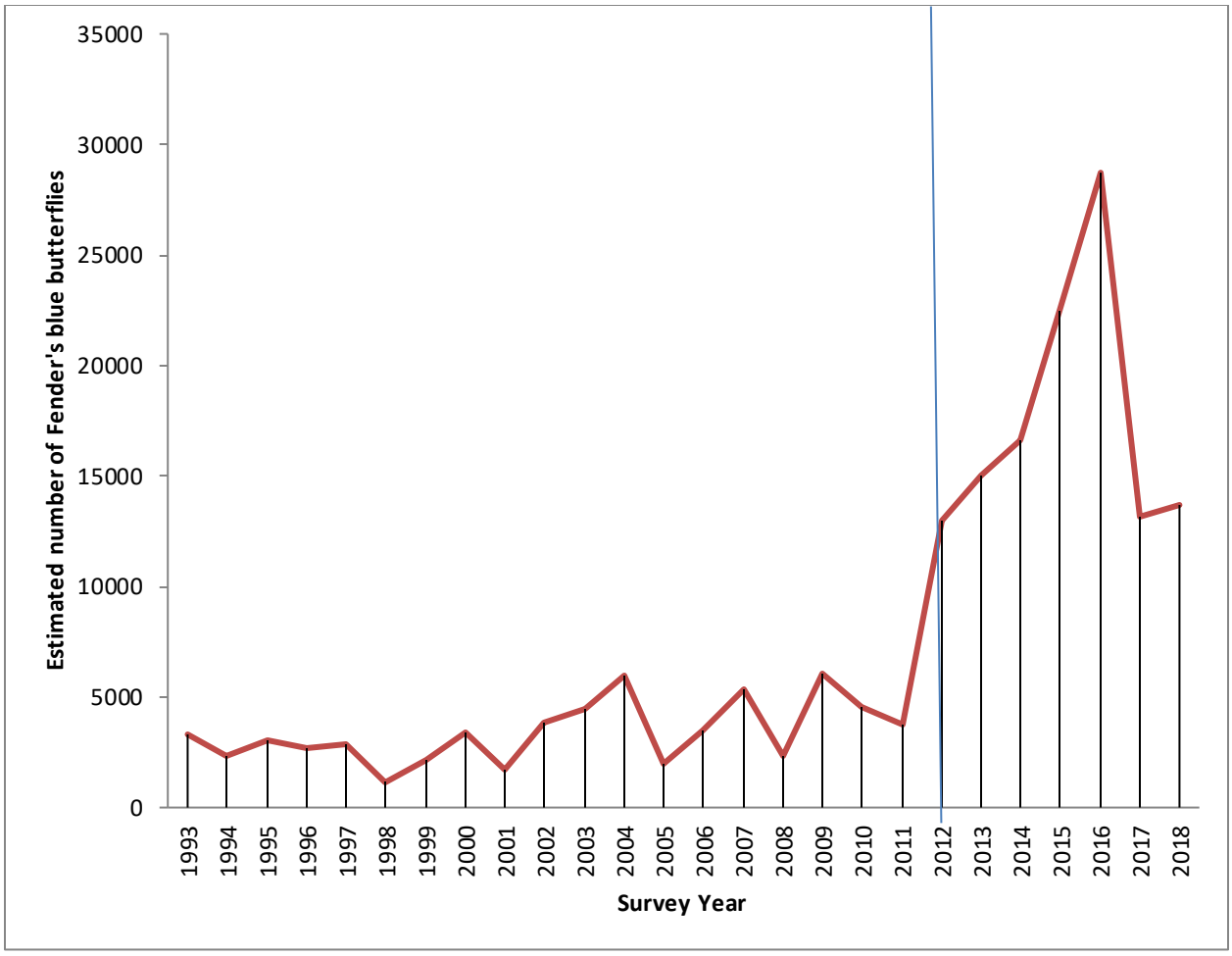

Figure 3.4. Annual rangewide Fender's blue butterfly population estimates. Greater confidence exists in estimates from 2012-2018 due to implementation of new survey methods in 2012 (blue line).

Surveys are now standardized; however, this was not the case in the past. Due to differences in survey methods, comparing Fender's blue butterfly estimates across years and across sites has proven challenging. Six different forms of monitoring have been used to estimate numbers of Fender's blue butterfly over the past 20 years: presence/absence surveys, peak counts, modified peak counts, distance sampling, Severns method, and Protocol 1. For all of these methods, surveys are limited to the time between 10:00 am to 6:00 pm on days with less than 50 percent cloud cover, greater than 60-65 degree Fahrenheit air temperature, and winds less than 12 mph. The surveys count only male butterflies because they are easier to find and identify. Numbers are then extrapolated by doubling that count to determine the total number of butterflies at a given site, assuming a 1:1 sex ratio of males to females.

- **Presence/absence surveys** are conducted to confirm occupancy in the larval or adult stage and to monitor persistence of Fender's blue butterfly sites. These surveys are the least intensive method of monitoring with the broadest temporal window of time for completion and do not provide a numerical estimate.
- **Peak** and **modified peak** counts are conducted to provide an estimate of the number of Fender's blue butterflies with a minimal amount of time invested in surveying. The

accuracy of the estimate is dependent on the ability to survey during the peak flight period of male Fender's blue butterfly. Peak flight period is the time when the majority of adult butterflies has completed pupation and are flying. Multiple site visits are necessary prior to surveying to ensure that the site is surveyed during the peak flight season. A sudden spike in the number of males flying with no wing wear and bright colors is a reliable indicator of peak flight, as are observations that 30-40 percent of individuals flying are females (Hicks 2014, p. 9). Modified peak, but not peak, include a ratio of Fender's blue butterfly to silvery blue butterflies.

- **Distance sampling** is an intensive, transect-based survey technique that can account for undetected butterflies, observer differences, variability in detectability due to abiotic and biotic factors (e.g., weather, vegetation), and generates confidence intervals around estimates. To obtain accurate estimates, sites are surveyed a minimum of five times during the flight season with at least one visit during the peak of flight season. An earlier version of intensive sampling was called Protocol 1 prior to implementation of the standardized distance sampling plan.
- In the **Severns method,** all Fender's blue butterflies are counted on the first site visit, while only individuals that have emerged from chrysalis within the prior 3 to 4 days are counted on subsequent visits. The date of emergence is inferred based on patterns of wing wear. Site visits occur at 7-day intervals and are terminated when the flight period has ended, as indicated by the lack of newly emerged individuals. Because of the detail and skill required by this method, it is only performed on very small populations of butterflies by a limited number of individuals. A ratio of Fender's blue butterflies to silvery blue butterflies is not obtained because butterflies do not need to be netted because species identification is determined by watching individuals in flight.
- **Protocol 1** requires five to seven visits per season at each site. Each site has a rectangular grid with 12-m spacing in which the observer walks the centerline and counts all male butterflies observed, including perching, basking, and flying butterflies. An estimate of the ratio of Fender's blue butterflies to silvery blue butterflies is assessed by netting a subsample of 20 blue butterflies at each visit; this ratio is then used to calibrate the count of Fender's blue butterflies (see Schultz and Dlugosch 1999 for full methods).

Distance sampling data are analyzed in the program Distance to acquire detectability curves and density and population estimates (± 95 percent confidence interval) for each survey date assuming a 1:1 sex ratio, and including a correction for the presence of the similar silvery blue butterfly. To correct for the presence of silvery blue butterfly, population estimates are multiplied by the percentage of male Fender's blue butterflies detected post-survey. This percentage is acquired by netting individual butterflies at sites that use modified peak, protocol 1 or distance sampling methodology. Total population size for the flight season is then estimated for each site following Schultz and Dlugosch (1999, entire) or the program INCA (see Figure 3.5); (INsect Count Analyzer, Longcore et al. 2003, entire).

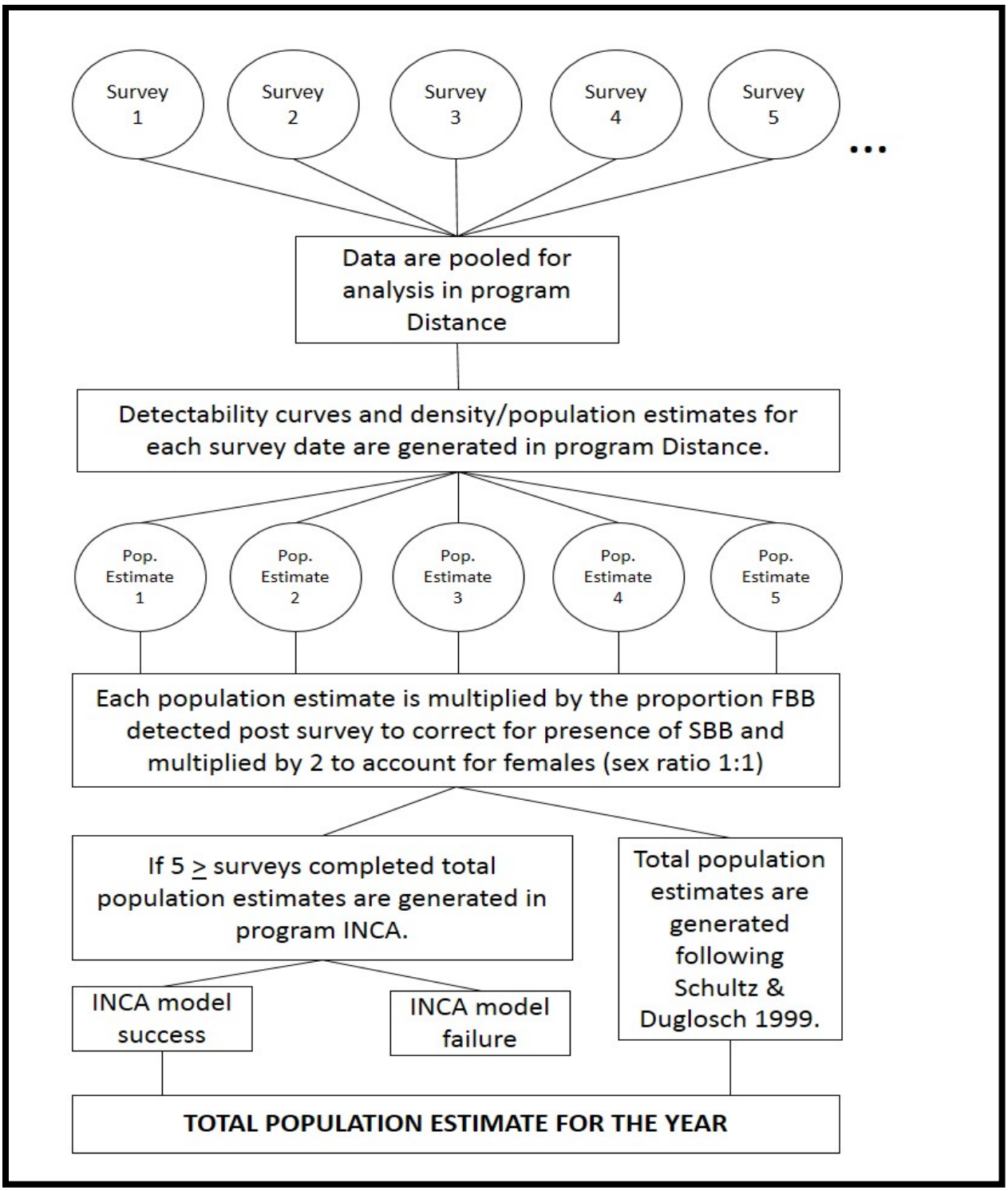

Figure 3.5. Flow chart showing how the total estimated Fender's population is calculated and what parameters are important using the program INCA (Longcore et al. 2003, entire). FBB=Fender's blue butterfly; SBB=silvery blue butterfly.

To reduce the complexity of data interpretation, the Service developed a standardized rangewide monitoring plan to gather Fender's blue butterfly population estimates using a structured

decision making framework (Collins et al. 2011, entire). The new monitoring plan specified the measurable attributes to estimate, the level of precision required from the resulting analysis, what data were needed, and how the data were to be collected. With a standardized monitoring plan in place, the Service could determine if the current probability of persistence was above a given threshold, evaluate effects of habitat management at the site level, minimize program cost and time investment, and minimize the impact of monitoring on the butterflies and habitat.

In 2012, the Service began implementation of the standardized monitoring plan. The plan consisted of using distance sampling at 18 sites based on the size of the site and the number of individuals likely present according to past surveys; using the peak count method across the remainder of the range of the species (less the sites selected for distance sampling) for a total of 67 sites; using presence/absence surveys at 10 sites believed to be extirpated; and using the Severns method at 7 sites. The monitoring plan also includes a method for estimation of the peak of the flight period; counts of adult male butterflies near the peak flight period at all sites; and an estimate of the ratio of silvery to Fender's blue butterflies for each site.

By 2016, distance sampling was being performed at 21 sites, while peak count surveys were being performed at 64 sites, presence/absence surveys were being performed at 3 sites, and the Severns method being performed at 2 sites. While the aforementioned changes have influenced population estimates, which are not comparable to counts made prior to implementation of the new standardized method, our confidence in the new protocols and the resulting estimates will allow us to make better predictions regarding the viability of the Fender's blue butterfly into the future.

3.4.2 Descriptions of metapopulations

The 15 Fender's blue butterfly metapopulations (groups of occupied sites within 2 km (1.2 miles) of one another, interacting with one another, and not separated by barriers) are distributed across three Recovery Zones (Figure 3.2). The sites comprising each metapopulation have varying degrees of protection, management, and connectivity, habitat heterogeneity and unique landscape features. When evaluating habitat protection, we consider all public land (Federal, State, County and City) as well as parcels with conservation easements to have "permanent" protections. "Interim" protections include landowner agreements such as Safe Harbor Agreements (SHA) and Partners for Fish and Wildlife agreements (PFW). Under PFW Agreements, the landowner works one-on-one with a local Service biologist to develop a project plan addressing the goals and objectives of the landowner and the Service to benefit fish and wildlife species on his/her land, which can include Fender's blue butterfly. SHAs specifically identify conservation goals to provide a net conservation benefit for Fender's blue butterfly. Typically, these landowner agreements have a minimum duration of 10 years.

Several of the metapopulations have sites with "intermittent" Fender's blue butterfly occupancy. Intermittent occupancy occurs at small lupine patches within 1 km (0.6 mi) of known Fender's blue butterfly sites that are not surveyed, or infrequently surveyed, due to time and funding constraints. Some of these sites have been documented with a few individuals or butterfly eggs every few years. Other sites have never had occupancy documented, but given their proximity to

Fender's blue butterfly populations and the presence of lupine, they are assumed to be utilized at least intermittently.

The distribution of all metapopulations and independent groups of Fender's blue butterfly across the known range of the species is presented in the map shown in Figure 3.2, above. We describe in detail each of the metapopulations and the sites comprising that metapopulation in Appendix C of this document. We also provide site-specific data, including whether the metapopulation is meeting the minimum population criterion of 200 adult butterflies over a consecutive 10-year period as per the Recovery Plan (USFWS 2010, p. IV-12). The 5-year abundance is determined by calculating the **geomean**, a type of average that is used to describe population growth over time.

3.5 Changes in Abundance and Distribution since Listing

Since being listed as endangered in 2000, the abundance and distribution of Fender's blue butterfly has improved as a result of metapopulation expansion, metapopulation discovery, and metapopulation creation. Survey data from the year 2018 demonstrate that the number of metapopulations, number of individuals, number of sites, number of hectares of prairie habitat, and the number of counties supporting Fender's blue butterfly have all shown marked increases since listing; these changes are summarized in Table 3.4, below.

Table 3.4. Comparison in status of Fender's blue butterfly populations and distribution between time of listing in 2000 to survey results from 2018.

	Listed as endangered (2000)	**As of 2018**
Number of metapopulations	12	15
Number of independent groups	0	6
Total abundance (# of individuals)	3,391	13,700
Number of sites	32	137
Area of prairie habitat known to be occupied	165 ha (408 ac)	344 ha (825 ac)
Counties known to be occupied	4 Benton, Lane, Polk Yamhill Counties	6 additionally in Linn and Washington Counties

Changes in the abundance and distribution of Fender's blue butterfly have occurred across all three recovery zones as a result of metapopulation expansion, metapopulation discovery, and metapopulation creation. In the northern part of the range, the Salem Recovery Zone has increased from three metapopulations and one independent group to six metapopulations and four independent groups even though four sites known at listing are now extirpated (Figure 3.6). The four extirpated sites and the independent groups are all small roadside patches lacking both continuous prairie habitat and prairie management since their discovery. In addition to the expansion of sites to metapopulations in this recovery zone, a large Fender's blue butterfly metapopulation was discovered at Henry Hagg Lake in Washington County, Oregon, in 2011 (Hammond 2011, p. 3). Prior to this, Fender's blue butterfly was not known to occur in Washington County. Extensive surveys have not been conducted in Lane or Polk County within

the Salem Recovery Zone because these areas are mostly private lands and we have not been granted access to survey. Given the number of metapopulations currently located on private land, we expect there may be more locations within these counties containing Fender's blue butterfly.

The Corvallis Recovery Zone has increased from four metapopulations and one independent group to five metapopulations while only one site became extirpated (Figure 3.7). The increase in the number of metapopulations occurred as a result of reintroducing Fender's blue butterfly to Pigeon Butte in the southern portion of Finley NWR in 2014. The independent group known at listing has expanded in terms of habitat quantity and number of sites. While we suspect that Fender's blue butterflies are using private land adjacent to the two roadside public sites given the quality and quantity of habitat, we cannot confirm this until we are granted access to these lands to survey.

In the southern part of the range, none of the sites known at listing have become extirpated and the Eugene Recovery Zone has increased from three metapopulations to now having four metapopulations and one independent group (Figure 3.8). The new metapopulation (Oak Basin) and independent group (Bond Butte) were found in Linn County in 2009. Previously, Fender's blue butterfly was not known to occur in Linn County. Thus, across all recovery zones for Fender's blue butterfly, there has been an increase in the number of metapopulations, the size of existing metapopulations, and the distribution of metapopulations despite the extirpation of several small sites since listing in 2000.

The presence of Fender's blue butterflies in new counties and the expansion of existing metapopulations increases both the geographic range of the species and connectivity throughout the landscape. An increased number of metapopulations, composed of a greater number of individuals and with expanded distribution and connectivity across the range of Fender's blue butterfly, means the species has a greater chance of withstanding stochastic events (resiliency), surviving potentially catastrophic events (redundancy), and adapting to changing environmental conditions (representation) over time.

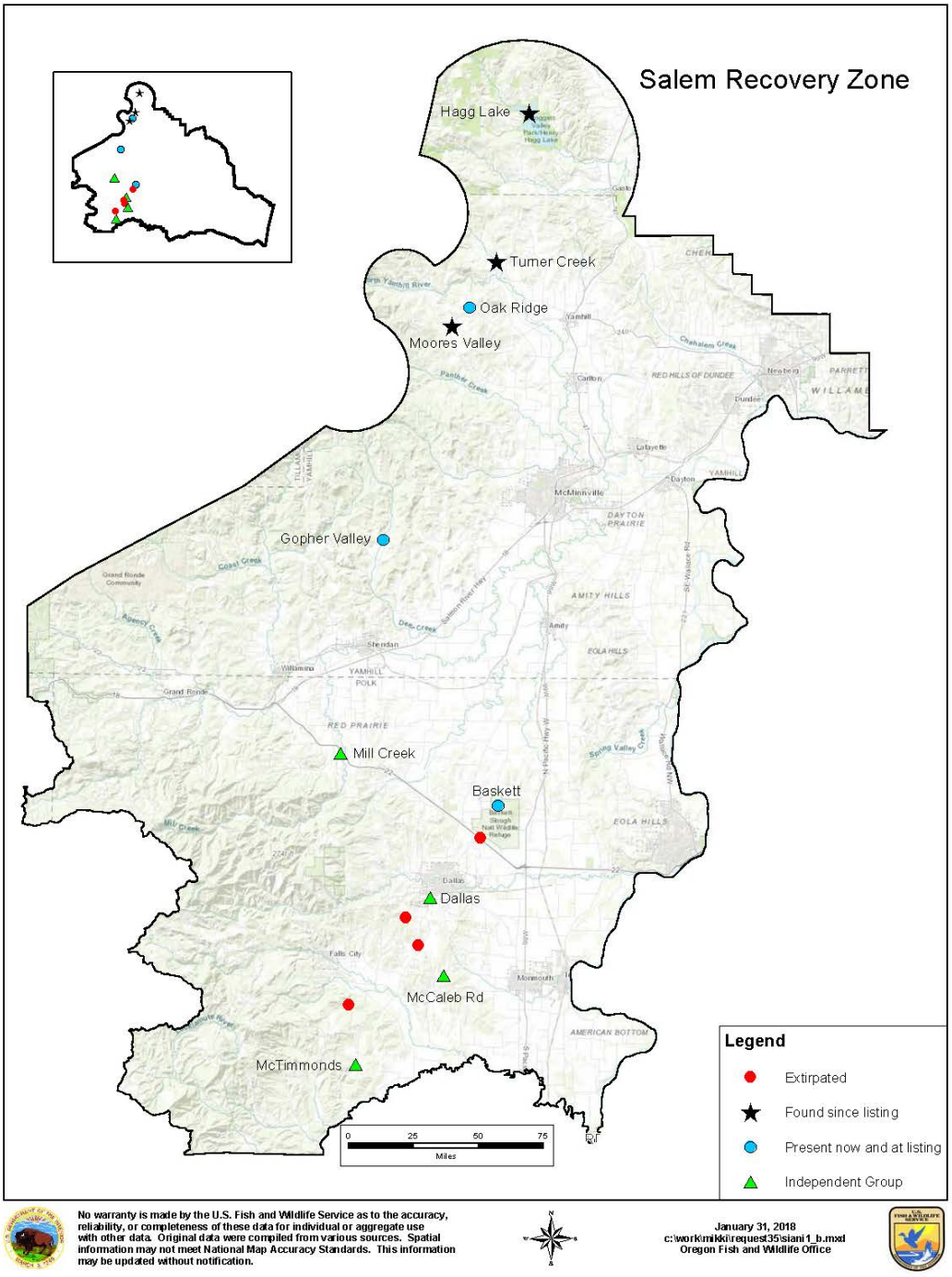

Figure 3.6. Changes in the metapopulation distribution of Fender's blue butterfly within the Salem Recovery Zone since being listed as endangered in 2000. Blue dots are metapopulations known at listing and still present; stars indicate metapopulations discovered after listing. Red dots indicate sites, not metapopulations, that are presumed extirpated. The green triangle represents an independent group present now and at listing.

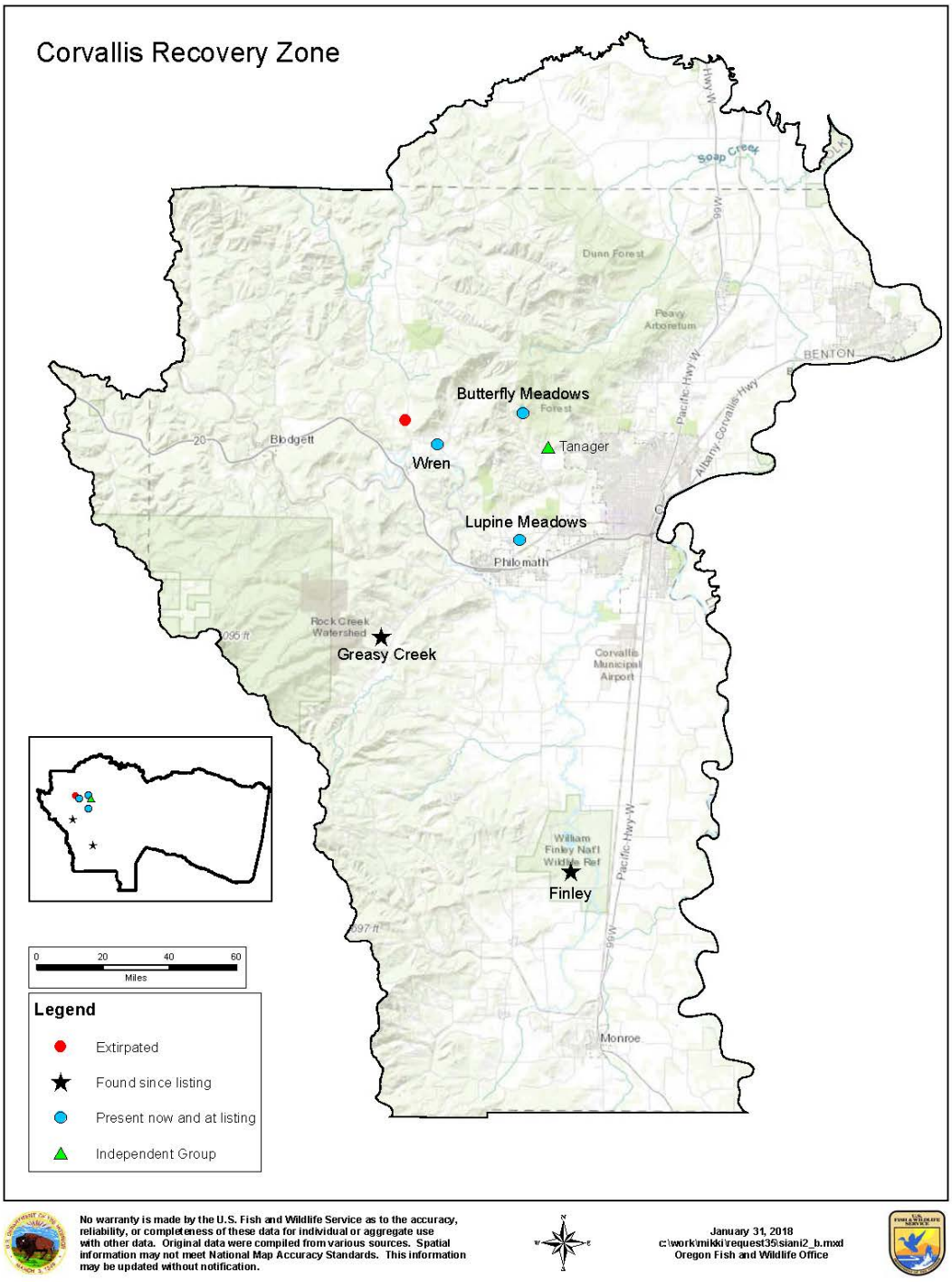

Figure 3.7. Changes in the metapopulation distribution of Fender's blue butterfly within the Corvallis Recovery Zone since being listed as endangered in 2000. Blue dots are metapopulations known at listing and still present; stars indicate metapopulations discovered after listing. Red dots indicate sites, not metapopulations, that are presumed extirpated. The green triangle represents an independent group present now and at listing.

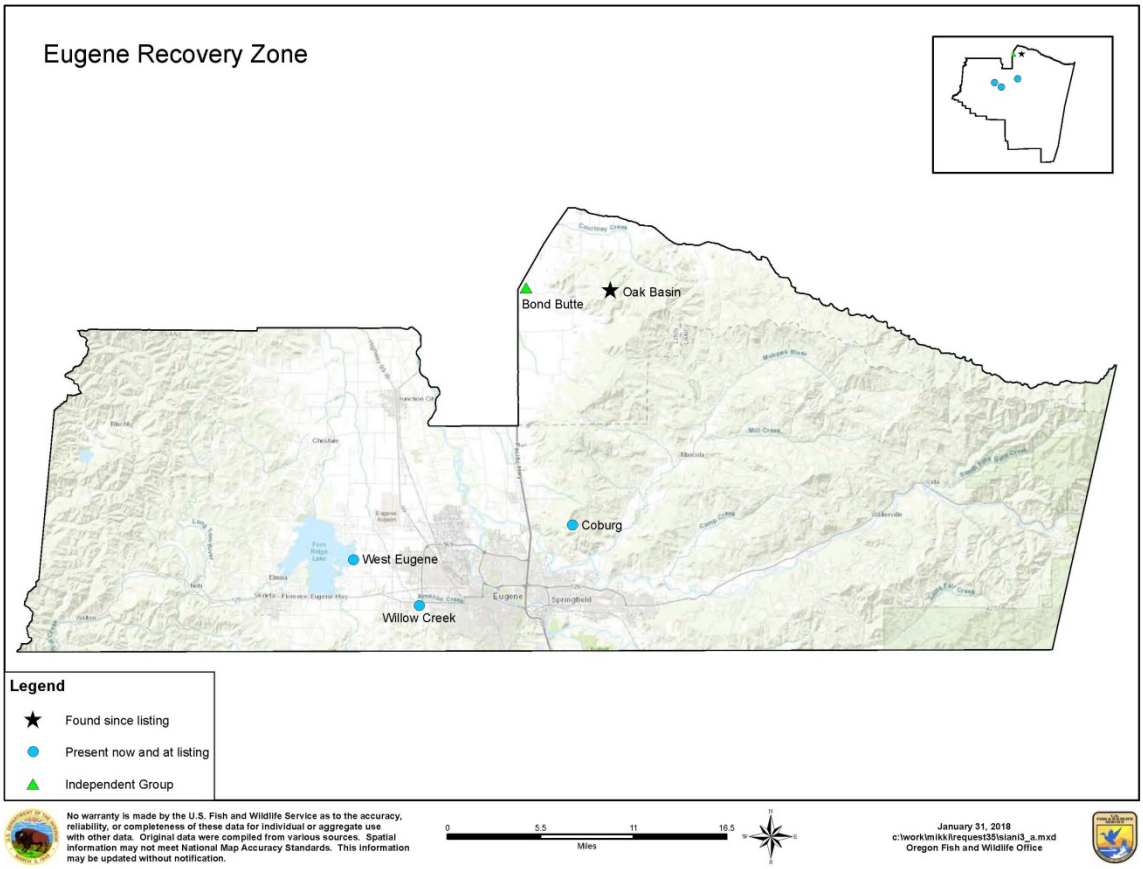

Figure 3.8. Changes in the metapopulation distribution of Fender's blue butterfly within the Eugene Recovery Zone since being listed as endangered in 2000. Blue dots are metapopulations known at listing and still present; stars indicate metapopulations discovered after listing. The green triangle indicates an independent group that was found after listing.

The overall number of sites containing Fender's blue butterfly has increased across all land ownership categories since listing, as has the percentage of sites with habitat management (Table 3.5). While the number of current sites far exceeds the number of sites known at listing, 137 as opposed to 32, the percentage of those sites with protection has remained similar. At listing, 72 percent of sites (23 of 32) were protected and currently, 74 percent of sites (101 of 137) have protection. The difference between conditions at the time of listing and now occurs in the management of sites. At listing, only 31 percent of known sites (10 of 32) and only 44 percent of protected sites (10 of 23) were being managed for prairie habitat to some degree. In contrast, 74 percent of current sites (101 of 137) and 100 percent of protected sites (101 of 101) are being managed for prairie habitat. Specifically, the number of public ROW sites has increased from 8 to 14 sites and all are now protected and managed, whereas none were managed in 2000. The number of public sites has increased from 9 to 44 sites and all are now protected and managed, whereas roughly only half were managed in 2000. The overall number of private land sites has

increased from 15 to 79 sites. Private sites with both habitat management and permanent protection have increased from 6 to 23, while private sites with habitat management and interim protection have increased from zero to 20 sites. Private sites with known occupancy of Fender's blue butterfly lacking both habitat management and protection have increased from 9 to 36; however, the percentage that these sites make up of all sites has decreased somewhat (28 versus 26). The Service and our partners hope to obtain some level of habitat management and protection on these sites in the future. With continued protection and proper habitat management, even greater range expansion is possible, which in turn will increase representation and possibly redundancy of the Fender's blue butterfly.

Table 3.5. Comparison of habitat management and protection at sites known at listing and as of 2018.

			At listing (2000)		Current (2018)	
Land Ownership	**Habitat Management**	**Permanent Habitat Protection**	**Number of sites**	**Percentage of total sites**	**Number of sites**	**Percentage of total sites**
Public	Yes	Yes	4	13	44	32
Public	No	Yes	5	16	0	0
Private	Yes	Yes	6	19	23	17
Private	No	No	9	28	36	26
Private	Yes	No*	0	0	20	15
Public Right-of-way	Yes	Yes	0	0	14	10
Public Right-of-way	No	Yes	8	25	0	0
Total			32		137	

*These sites are not permanently protected but they do have interim protections.

Chapter 4. Influences on Viability

In this chapter, we evaluate the past, current, and future influences that are affecting what the Fender's blue butterfly needs for long-term viability. We analyzed these factors in detail using the tables in Appendix D in terms of causes and effects to the species. These tables analyze the pathways by which each influence affects the species, and each of the causes is examined for its historical, current, and potential future effects on the species' status. Current and potential future effects, along with current expected distribution and abundance, determine present viability and, therefore, vulnerability to extinction. We organized these influences around the **stressors** (*i.e.*, changes in the resources needed by the Fender's blue butterfly) and discuss the sources of those stressors. For more information about each of these influences, see Appendix D. Those risks that are not known to have effects on Fender's blue butterfly populations, such as overutilization for commercial and scientific purposes and disease, are not discussed in this SSA report.

4.1 Habitat Loss, Conversion, and Fragmentation

Prior to 1850, approximately 277,000 ha (685,000 ac) within the Willamette Valley were upland prairie native grasslands (USFWS 2000, p. 3876). In 2000, the remaining native upland prairie in

the Willamette Valley had been reduced to approximately 400 ha (988 ac) (USFWS 2000, p. 3876). Most prairie remnants are degraded areas, with very patchy distribution of lupine resources. The major factors in the decline of western Oregon and southwestern Washington prairie species have been: (1) alteration of natural and human-mediated disturbance processes that historically maintained prairie conditions (e.g., fire and flooding); (2) habitat conversion (livestock grazing and croplands); (3) urbanization, which results in the permanent loss of native prairies; and (4) invasion by nonnative plants (Altman et al. 2001, p. 262; Wilson et al. 2003, p. 79).

For Fender's blue butterfly, loss of prairie habitat due to habitat conversion is considered one of the largest causes for metapopulation declines. Conversion to agriculture has been the largest driver of prairie habitat loss in the Willamette Valley (Johannessen et al. 1971, p. 296; Hulse et al. 2002, pp. 78-81), with approximately 50 percent of the modern Willamette Valley in agricultural production (Morlan et al. 2011, p. 11). In addition to agricultural conversion, prairies in the Willamette Valley are experiencing urban and residential development (USFWS 2000, p. 3880). This is especially a concern where prairie habitat abuts existing urban areas, such as near the town of Dallas in Polk County and the West Eugene Wetlands in Lane County, Oregon. Urbanization is expected to continue in order to accommodate a population that is projected to nearly double from the current count of over 2 million people in the Willamette Valley by the year 2050 (Hulse et al. 2002, p. 107; Oregon Department of Fish and Wildlife 2006, p. 235). Habitat fragmentation has isolated some Fender's blue butterfly metapopulations. The rarity of host lupine patches and fragmentation of habitat are the major ecological factors limiting reproduction, dispersal, and subsequent colonization of new habitat by Fender's blue butterfly (Hammond and Wilson 1993, p. 26; Schultz 1997, p. 88; Schultz and Dlugosch 1999, p. 237). Small, isolated populations are especially vulnerable to extirpation from localized events and probable low **genetic diversity** associated with small populations. In addition, small patch size is a problem for emigration out of sites as well as immigration into sites. All of these factors limit the potential redundancy of Fender's blue butterfly metapopulations and its representation across its range.

Converting habitat, regardless of the type of conversion, fragments existing Fender's blue butterfly habitat. Fragmentation of prairie habitat to small, isolated patches can result in a variety of adverse effects to Fender's blue butterfly at both the individual and metapopulation level. Potential adverse effects include the inability of remaining patches to support viable populations of larval host plants or nectar plants, which in turn limits fecundity and survival of Fender's blue butterfly; an increased risk of inbreeding and loss of genetic diversity; and vulnerability to extinction from stochastic fluctuations in metapopulation size and demographic composition resulting from reduced metapopulation size and lack of immigration.

Activities associated with land use change and development that impact Fender's blue butterfly habitats are vegetation removal, infill, paving, and other land alterations. These activities affect all life stages of the Fender's blue butterfly as they can result in direct mortality of individuals during land clearing or in indirect mortality by limiting dispersal if connectivity between sites is compromised. Habitat conversion can occur rangewide, although it is relatively more prevalent in Lane and Polk counties. Areas containing existing metapopulations tend to be less affected by habitat loss and fragmentation relative to the time of listing due to active habitat management or

protection. Thus, impacts from habitat conversion are decreasing in areas with habitat management and protection, whereas impacts are likely staying the same or increasing in areas without habitat management or protection.

4.2 Woody Succession and Invasive Species

Throughout the Fender's blue butterfly range, alteration of natural and human-mediated disturbance processes (e.g., fire and flooding) that historically maintained the early seral stage of prairie plant communities has allowed shrub and tree species to overtake grasslands, while agricultural practices have hastened the decline of native prairie species through habitat loss and increased grazing (Johannessen et al. 1971, p. 286; Franklin and Dyrness 1988, p. 122). Additionally, the prairies of western Oregon have been overtaken by nonnative plants that dramatically change the structure of prairies, often forming tall, dense patches that shade out the natives, and compete for water and nutrients (Wilson et al. 2003, pp. 79-80). When woody and invasive nonnative plants become dominant, they can preclude Fender's blue butterfly from using the native plant species the butterfly needs to survive and reproduce (Hammond 1996, pp. 28-31; Schultz et al. 2003, p. 68). Common native species that invade and ultimately take over prairie habitats in the absence of periodic disturbance include: black hawthorn (*Crataegus douglasii*), Oregon ash (*Fraxinus latifolia*), Oregon white oak (*Quercus garryana*), Douglas fir (*Pseudotsuga menziesii*), and Western poison oak (*Toxicodendron diversilobum*). Thick, shrubby invasive plants such as Scotch broom and Himalayan blackberry crowd out native species, including host lupines and nectar plants, and impede movement by adult butterflies. Among the most common and difficult to manage invasive plant species are bentgrasses (*Agrostis* spp.), tall oat grass meadow knapweed (*Centaurea* x *pratensis*), Scotch broom, and Himalayan blackberry. Of these aforementioned invasive plants, tall nonnative grasses such as oat grass may be the most significant species limiting the ability of the Fender's blue butterfly to find its host plant (Severns 2008, p. 651). Fence rows and intervening strips of land along agricultural fields and roadsides often serve as the only refugia from these forces of change.

Habitat succession from prairie to woody species and invasion by nonnative plant species alters the light environment and causes a shift in plant community structure and composition. The increased shading and resource competition associated with woody encroachment results in reduced growth, survival, and reproduction of both lupine host plants and nectar plants. This can lead to reduced connectivity for Fender's blue butterfly and affects all life stages due to the loss of host and nectar plants. While all life stages are affected, adult butterflies experience the greatest impact due to their need to move through the landscape.

Active management, such as prescribed fire and mowing, can help to reduce impacts of woody succession by native and nonnative species on the Fender's blue butterfly (Schultz and Crone 1998, entire). In the West Eugene Wetlands, for example, annual mowing reduced shrubby blackberry cover and increased lupine leaves, flowers, and foliar cover when compared to mowing every other year or every third year (Kaye and Benfield 2005, p. 24). While mowing and burning are effective at reducing native and nonnative woody species, reliable and effective methods for managing and controlling herbaceous invasive species are unclear. Habitat management efforts are underway to remove invasive plants; however, invasive plants continue to increase in some areas despite active management. In addition, both woody succession and

invasive nonnative plants are likely increasing in areas without management. Habitat management is discussed further in section 4.5 *Conservation Measures*.

4.3 Insecticides and Herbicides

Insecticides and herbicides (collectively known as pesticides) directly kill eggs, larvae, and adult butterflies during application of the chemicals to vegetation and sublethal effects may indirectly kill all life stages. Both insecticides and herbicides are used in agricultural practices, while herbicides are also used for roadside maintenance and to control invasive species and woody vegetation encroachment.

Insecticides used to control invertebrates that pose a threat to human health or agricultural products may affect the Fender's blue butterfly. For instance, pesticide application is necessary to control mosquitos and the gypsy moth (*Lymantria dispar dispar*) (Oregon Department of Human Service 2003, entire; Oregon Department of Agriculture 2006). The Oregon Department of Agriculture's (ODA) Gypsy Moth Eradication Program sprays Btk (*Bacillus thuringiensis* var. *kurstaki*) whenever an infestation of the nonnative gypsy moth (*Lymantria dispar*) is detected (Oregon Department of Agriculture 2006). Btk, a bacterium that is lethal to all butterfly and moth larvae, has been shown to drift at toxic concentrations over 3 km (2 mi) from the point of application (Barry et al. 1993, p. 1977). There is evidence that Btk application in the Northwest has reduced populations of non-target butterflies (Boulton 2004, pp. 1300-1301), suggesting that Btk could incidentally kill larvae when Btk is sprayed near or on a site occupied by Fender's blue butterfly. The ODA has sprayed for gypsy moths in the Eugene, Oregon area, however they performed surveys prior spraying to ensure Fender's blue butterfly were not present (M. Collins 2019, pers. comm). There is also a known infestation of gypsy moth near Corvallis, Oregon, where Btk will likely be sprayed in 2019.

Additionally, the application of insecticides targeting adult mosquitos to control the spread of West Nile Virus poses a risk of incidental harm to Fender's blue butterflies. The Oregon Department of Human Services' program to control West Nile Virus focuses on reduction of breeding habitat for the mosquito carriers of the disease and the use of insecticides targeted to kill mosquito larvae (Oregon Department of Human Services 2003). The insecticides used to kill adult mosquitoes and their larvae are lethal to other invertebrates, making it likely that they would also kill Fender's blue butterflies.

Herbicide use in the timber industry and at roadsides may affect Fender's blue butterflies by negatively affecting native prairie plants. Herbicide spraying associated with reforestation after logging has altered habitat and caused a decline of a population of Kincaid's lupine on BLM properties (USFWS 2000, p. 3881). This occurred after a jeep trail was renovated and the surrounding areas logged, destroying Kincaid's lupine and any butterfly eggs or larvae. Likewise, at the Coburg Ridge area-2 site in Lane County, native plant species were severely damaged by the application of a grass-specific herbicide that eliminated grasses and damaged other herbaceous species prior to tree planting activities (USFWS 2000, p. 3881).

Since small habitat patches along State and county roadsides may be impacted more so than patches that occur along non-roadside areas, three habitat conservation plans (HCPs) were

developed to protect these patches. The Benton County HCP was developed in 2011, the Yamhill County Road ROWs HCP in 2014, and the ODOT HCP in 2017 (further discussed in Section 4.5.2).

When prairie habitats are converted to agriculture or to golf courses, new herbicides are introduced into the environment. For instance, strains of creeping bentgrass (*Agrostis stolonifera*) that are resistant to glyphosate (a broad-spectrum systemic herbicide) were commercially developed for the golf course industry and have successfully established in prairie habitat. Because glyphosate-based products are the only herbicides that are both labeled for use in wet areas and do not place non-target plant species at risk by moving in the soil, invasion of glyphosate-resistant creeping bentgrass into wet prairie habitat is problematic for managing Fender's blue butterfly habitat.

Insecticides and herbicides affect all life stages of Fender's blue butterfly across its geographic range, and are likely more prevalent in agricultural areas. Effects are more likely to occur in the spring and summer months due to both butterfly activity and timing of chemical application. Exposure is expected to continue in prairie habitat because herbicides are the most effective tool for eradicating some invasive species and woody vegetation.

4.4 Climate Change

Between 1895 and 2011, temperatures in the Pacific Northwest rose an average of 0.72˚C (1.3˚F) and they are expected to continue to warm from 0.11˚C to 0.45˚C (0.2˚ to 1˚F) per decade (Mote and Salathe 2010, p. 29; Mote et al. 2014, p. 489). Precipitation on the other hand has shown natural variability with increases and decreases depending on the specific location making forecasting precipitation changes more challenging (Mote et al. 2014, p. 489). University of Washington researchers have developed finer-resolution regional, predictive climate models that account for local terrain and other factors affecting weather (e.g., snow cover, cloudiness, soil moisture, and circulation patterns) in the Pacific Northwest (Salathe et al. 2010, entire). Collectively, the models project increased average temperatures across all seasons, warmer, drier summers and warmer, wetter autumns and winters for much of the Pacific Northwest, which will likely result in diminished snowpack, earlier snowmelt, and an increase in extreme heat waves and precipitation events such as flooding over the next 50-100 years (Mote et al. 2008, pp. 203-204; Salathe et al. 2010, pp. 72-73; Doppelt et al. 2009, entire; USFWS 2017, p. B-3). Relative to other regions in Western North America, however, the Pacific Northwest and the Willamette Valley may experience less change and therefore, fewer impacts, from climate change (USFWS 2017, p. B-7)

Studies of the potential effects of climate change on the Willamette Valley indicate a trend towards warmer and wetter winters along with hotter and drier summers, which may increase the likelihood of drougt. Under best-case scenarios, vegetation types are projected to remain stable in the Willamette Valley; however, other changes are anticipated such as higher water levels in wet prairies during winter and spring, increased spring flooding events, and prolonged summer droughts (Kaye et al. 2013, p. 3; USFWS 2017, p. B-5). Under best-case scenarios, average annual temperatures are expected to increase 1.1–2.8°C (2–4°F) over the 1961-1990 average by 2050, with greater increases in summer temperatures (2.2–3.3°C [4–6°F] on average) (Doppelt et

al. 2009, p. 5; Kaye et al. 2013, p. 10). Under moderate and worst-case scenarios, average temperatures across the Willamette Valley are projected to increase by 1.2–3.8°C and by 1.4–3.9°C (2.7-7.9°F)(Kaye et al. 2013, p. 10). Such changes could alter prairie plant composition, structure, or timing of plant life cycles. If so, Fender's blue butterflies would be negatively impacted by the loss of nectar species availability and potential increases in nonnative plants, making it difficult to locate host lupine species.

Climate change is likely to affect Fender's blue butterflies at all life stages but we cannot quantify the precise level of effect. Two models have conducted climate change vulnerability assessments for butterfly species within the Willamette Valley using the Special Report on Emissions Scenarios (SRES) created by the Intergovernmental Panel on Climate Change. Under the SRES B1 scenario (comparable to the RCP 4.5 scenario), which represents a best-case climate change scenario, both models ranked Fender's blue butterfly as stable. Under the SRES A1B scenario (RCP 6.0), which represents a moderate level of climate change, both models ranked Fender's blue butterfly as moderately vulnerable (Steel et al. 2011, p. 5; Kaye et al. 2013, p. 23). Under the SRES A2 scenario (RCP 8.5), which represents a worst-case climate change scenario, however, Fender's blue butterfly was ranked as extremely vulnerable under one model (Steel et al. 2011, p. 5) and highly vulnerable under another model due to its limited range and loss of both nectar and host plants (Kaye et al. 2013, p. 23). While the models do not agree on the degree of vulnerability, both models did show an increase in vulnerability as climate change scenarios worsened. Fender's blue butterflies would be negatively impacted by the loss of nectar species (observed only under severe climate change scenarios) resulting from natural and anthropogenic barriers, limited dispersal capacity, minimal historical variation in temperature, and unknown genetic variability (Kaye et al. 2013, p. 24). Fender's blue butterflies would also be impacted by the fact that invasive plant species were not vulnerable to climate change, with the exception of tall oatgrass, which became moderately vulnerable under the worst-case scenario (Kaye et al. 2013, p. 24). A reduction in nectar plants without a change in invasive species may lead to altered prairie vegetation structure or overall habitat loss for the Fender's blue butterfly within the Willamette Valley. Other studies projected butterfly population extinctions due to an increase in habitat loss from both precipitation variability (McLaughlin et al. 2002, p. 6073) and from decreases in soil moisture from increased water evaporation and transpiration (Field et al. 1999, p. 21). Although unconfirmed, temperature increases may alter the developmental rate of Fender's blue butterflies, which would reduce synchronization with lupine cycles. Based on climate change models, it appears likely that the Fender's blue butterfly may be negatively affected by long-term consequences of climate change; however, we are not able to specifically quantify the magnitude of effects to the species. Additionally, existing studies suggest that the Willamette Valley, and prairies specifically, may fare better than other regions (Bachelet et al. 2011, p. 424; USFWS 2017, p. B-10). In our analysis of the future condition of the Fender's blue butterfly, we considered climate change to be an exacerbating factor in the decrease in nectar plants, lupine plants, and open prairie or oak savannah habitat.

4.5 Conservation Measures

Conservation measures are ongoing efforts that offset influences on Fender's blue butterfly viability. These actions are performed by Federal, State and County agencies; non-governmental organizations (NGO) such as TNC; and private landowners. Collectively, the agencies and organizations that manage lands have acquired conservation easements and conducted

management actions to benefit prairie habitat and the Fender's blue butterfly. Various types of agreements are also in place with private landowners to perform voluntary conservation actions on their land. Many agencies are working collaboratively on habitat restoration such as at Baskett East, where sites are enrolled in the PFW program and actively managed under interagency agreements between the Service, TNC and Natural Resources Conservation Service (NRCS). Below we summarize some of the conservation efforts occurring across the range of the Fender's blue butterfly and beneficial results of these efforts.

4.5.1 Habitat Management

Native prairie habitat restoration and management is occurring on public lands or lands that are managed by a conservation organization at the following locations: Baskett Slough NWR and surrounding areas, Finley NWR, Fern Ridge Reservoir, West Eugene Wetlands, Willow Creek Preserve, Yamhill Oaks Preserve, Coburg Ridge, Lupine Meadows, Hagg Lake, a small portion of the McDonald State Forest, and some Benton County public lands. Upland prairie sites that do, or that could, support Fender's blue butterflies and Kincaid's lupine generally require routine treatment to remove woody vegetation and invasive plants in order to maintain and enhance the native plant community and open prairie conditions. Manual and mechanical plant removal methods, prescribed fire, and herbicides have been successful at reducing woody vegetation in some areas. For example, TNC successfully removed Himalayan blackberry and young conifers that were encroaching into lupine patches (Hammond 2008, p. 10). While woody vegetation has been reduced, tall invasive grasses are more challenging to eliminate and there are no known methods to completely eradicate any of the invasive plant species, and control requires continuous maintenance over time.

Fender's blue butterfly responds positively to habitat restoration and management as demonstrated in oviposition rates, adult butterflies numbers, larvae numbers, and egg numbers. For example, even with lower lupine density, oviposition in restored prairie frequently exceeded oviposition in existing prairie habitat within 5 years post-restoration (Carleton and Schultz 2013, p. 517). Numbers of Fender's blue butterflies increased in habitat restoration sites using mowing, burning and mechanical removal of invasive vegetation. At two sites in the West Eugene Wetlands (TNC's Willow Creek Natural Area and the BLM's Fir Butte site), both adult and larval Fender's blue butterflies have increased in number following mowing to lower the stature of herbaceous nonnative vegetation (Fitzpatrick 2005, p. 17; Kaye and Benfield 2005, pp. 24-25). At Fern Ridge Reservoir, Fender's blue butterfly counts have increased since fall mowing of lupine patches has been implemented (U.S. Army Corps of Engineers 2006, p. 4). At Baskett Slough NWR, a study on the effects of fire and mowing found that Fender's blue butterfly eggs were 10 to 14 times more abundant in plots that were previously burned or mowed compared to undisturbed, control plots, and that woody plants were reduced 45 percent with burning and 66 percent with mowing (Wilson and Clark 1997, pp. 23-24). The same trend for egg numbers was observed at Bailey Hill (Fitzpatrick 2005, p. 16; Fitzpatrick 2006, p. 22). Although fire killed all larvae in burned patches, fecundity was higher in burned areas for two years following the burn in one study and overwinter larval survivorship was higher the year after the burn (Warchola et al 2018, pp. 804-805). Another study also showed that all larvae were killed, however, female Fender's blue butterflies from the nearby unburned source patch were able to colonize the entire burned area the following year, including lupine patches that were 107 m (350 ft) from the

unburned source plants (Wilson and Clark 1997, p. 10). A study that modeled the effect of prescribed burning found that the best long-term population growth could be achieved by burning one-third of the habitat of a Fender's blue butterfly population each year (Schultz and Crone 1998, p. 244) and targeted burning, ideally of one-quarter of the habitat each year, led to much higher population growth rates than wildfire (Warchola et al 2018, p. 806).

4.5.2 Habitat Protection

Approximately 96 percent of the Willamette Valley ecoregion is in private ownership (Oregon Department of Fish and Wildlife 2006, p. 235) and the majority (53 percent) of designated critical habitat for Fender's blue butterfly is on private lands (USFWS 2006, p. 63883). Thus, the conservation and recovery of Fender's blue butterfly, Kincaid's lupine, and the suite of native species associated with them will rely in large part on the voluntary actions of many willing non-Federal landowners to conserve, enhance, restore, reconnect and actively manage native prairie habitats that support these species (USFWS 2010, entire).

NGOs have actively pursued conservation easements and acquisition of properties throughout the Willamette Valley. Some specific examples include the 2005 acquisition and establishment of the Lupine Meadows Preserve by GLT and the 2008 acquisition and establishment of the of Yamhill Oaks Preserve by TNC. More information on conservation measures performed by NGOs specific to each metapopulation of Fender's blue butterfly can be found in Appendix C: *Metapopulation Descriptions under Current Conditions.*

The Service provides several voluntary options for working with private landowners and non-Federal property owners. As mentioned in the descriptions of current metapopulations in Chapter 3, many sites across the range have PFW agreements, SHAs, or HCPs. SHAs are voluntary agreements involving private or other non-Federal property owners whose actions contribute to the recovery of species listed as threatened or endangered under the ESA. In exchange for actions that contribute to the recovery of listed species on non-Federal lands, participating property owners receive formal assurances from the Service that if they fulfill the conditions of the SHA, the Service will not require any additional or different management activities by the participants without their consent.

The Service administers and implements a programmatic SHA for the benefit of Fender's blue butterfly, which encourages non-Federal landowners to undertake proactive conservation and restoration actions in Benton, Lane, Linn, Marion, Polk, Washington, and Yamhill Counties of Oregon (USFWS 2008, entire). The programmatic SHA provides eligible landowners with a streamlined process for obtaining assurances that certain actions taken to benefit the Fender's blue butterfly will not result in additional regulatory obligations under the ESA. Under the programmatic SHA, the Service has 19 properties with site-specific plans and Certificates of Inclusion covering approximately 567 ha (1,400 ac) as of February 2019. Another 10 agreements are in the process of being developed, which will cover approximately 405 ha (1,000 ac). Of those lands with completed SHAs, six properties contain Kincaid's lupine and may contain Fender's blue butterflies and eight properties are actively managing habitat to support Kincaid's lupine in the future.

Three HCPs designed to minimize and mitigate effects to the Fender's blue butterfly have been developed: the 2011 Benton County HCP, the 2014 Yamhill County Road ROWs HCP, and the 2017 ODOT HCP. Conservation measures to avoid, minimize, or compensate for adverse effects under the Benton County HCP for the next 50 years include: acquiring properties with existing populations of Fender's blue butterfly and prairie habitat from willing sellers; designating Prairie Conservation Areas on over 500 acres of public lands or lands under conservation easement to be managed specifically for prairie species; implementing best management practices for Fender's blue butterfly in the Prairie Conservation Areas and other covered lands owned by Benton County and the cooperators; augmenting and/or enhancing populations of Fender's blue butterfly; and implementing a Prairie Conservation Strategy to facilitate effective and voluntary conservation actions by public and willing private landowners in Benton County. The Yamhill County Road ROWs HCP addresses county road routine and necessary maintenance activities over the next 30 years. The county, in cooperation with the Service, surveyed the road ROW for Fender's blue butterflies and designated 11 km (7 mi) of road fragments as Special Maintenance Zones that receive special protection and management for butterflies under the HCP. An additional 12 km (7 mi) of Special Maintenance Zones were designated to protect seven Kincaid's lupine sites that are not currently used by Fender's blue butterflies. The ODOT HCP is a statewide plan addressing routine maintenance of State roads over the next 25 years. ODOT may conduct routine maintenance from the edge of pavement to the ROW boundary on all highway ROWs statewide except for those locations outside of the operational roadway (identified as areas of the ROW necessary to maintain safe operation of the highway) where Fender's blue butterflies occur. Mitigation for these impacts to Fender's blue butterflies include protection of butterflies and their habitats in areas where normal required maintenance activities will not impact them.

4.6 Summary

Our analysis of the past, current, and future influences on what the Fender's blue butterfly needs for long-term viability revealed that there are four influences that pose the largest risk to future viability of the species. These influences are (1) habitat conversion (agricultural and residential); (2) alteration of natural and human-mediated disturbance processes (e.g., fire and flooding) resulting in habitat succession; (3) invasion by nonnative plants; and (4) insecticides and herbicides. Most of these influences are likely to be exacerbated by small metapopulation or patch size and climate change due to changes in vegetation composition and management, as well as from changes in disturbance occurrences. We did not assess overutilization for scientific and commercial purposes or disease, because these influences do not appear to be occurring at a level that affects Fender's blue butterfly metapopulations.

Chapter 5. Recovery Criteria and Population Viability Analyses (PVA)

The Recovery Plan set downlisting and delisting criteria in terms of extinction risk thresholds based on the census-based PVA conducted shortly after listing the Fender's blue butterfly (USFWS 2010, pp. IV-29-IV-31 and IV-34). To downlist Fender's blue butterfly to threatened, the Recovery Plan set an extinction risk threshold of 90 percent probability of persistence for 25 years. To achieve this standard, each recovery zone was expected to have at least two

functioning networks[3] or one functioning network and two independent populations. One functioning network in each recovery zone had to meet a minimum population criterion (a count of 200 adult butterflies) each year for at least 10 years; the 200 butterflies would be distributed among the population sites in the network. Two functioning networks or one functioning network and two independent populations in each zone would be protected and managed for high quality prairie habitat. To delist Fender's blue butterfly, the Recovery Plan set an extinction risk threshold of 95 percent probability of persistence for 100 years using a variety of combinations of networks and independent populations in each of the 3 recovery zones. The Recovery Plan also stipulated that populations that do not drop below a minimum threshold would be maintained for at least 10 years at all functioning networks and independent populations to meet the delisting criteria and that the habitat supporting the populations would be managed for high quality prairie habitat, and would be in secure, conservation-oriented ownership, with management and monitoring.

The PVA used to develop these initial recovery criteria made several assumptions and we now have additional information to further evaluate these assumptions. First, the PVA assumed minimal observer error in population counts. A subsequent protocol comparison conducted in 2007 and 2008 indicated significant observer error due to weather conditions, timing of counts, and confusion between silvery and Fender's blue butterflies (Fitzpatrick 2009, p. 1). Second, the model assumed that population estimates came from independent sites. Historically, Fender's blue butterfly sites were thought to be isolated from neighboring sites, and interactions between sites were thought to be rare events (Schultz 1998, p. 286). However, extensive survey efforts have resulted in the discovery of several new sites proximal to extant sites, and conservation efforts have reestablished connectivity between some sites by restoring habitat and creating stepping stone habitat patches (Schultz et al. 2011, p. 377). Thus, the sites used in the original model may actually have been part of a much larger metapopulation. If these sites only represent a subset of a larger, more connected metapopulation, then the estimated growth rates from the model were likely affected by migration between these sites and hence, the assumption of independence was violated. We continue to believe that a minimum number threshold remains valid because population size targets based on minimum population size relate directly to minimum acceptable extinction risk and avoid the "noise" inherent in averaging population counts across years, which can mask potentially large variations due to environmental stochasticity.

The PVA utilized the best available data at that time; however, additional data are now available. The Fender's blue butterfly PVA used monitoring data from 12 sites collected over an 8 to 10 year span, mostly concentrated in the southern end of the species' range, all with average population estimates of fewer than 100 individuals and projected out 100 years (Schultz and

[3] A "functioning network" is a metapopulation that consists of several potentially interacting subpopulations of Fender's blue butterfly distributed across a landscape. A functioning network must be composed of three or more subpopulations, each occupying habitat of at least the minimum patch size (currently defined as 6 hectares [15 acres]) and separated by no more than the maximum separation distance (currently defined as approximately 2 kilometers [1.2 miles]) from the next nearest subpopulation or connected by stepping stone patches of lupine less than 1 kilometer (0.6 mile) apart.

Hammond 2003, p. 1379). Unfortunately, count-based estimates of absolute measures, such as viable population sizes, often require several decades of monitoring data to be reliable (Lotts et al. 2004, p. 1224). Additionally, with such small population sizes at the sites, the variance would be expected to be large with even small year-to-year population changes. Using 8 to 10 years of data with such high variance from small sites questions the reliability of projecting 100 years into the future, as was done with some of the Fender's blue butterfly modeling. A 100-year time frame has been the standard for PVA analyses; however, such a time frame underestimates the risk of extinction in long-lived species (Armbruster et al. 1999, p. 69) and thus, may potentially overestimate the risk of extinction in short-lived species such as Fender's blue butterfly. Since the original PVA was completed, an additional decade of monitoring data has been collected; the number of sites being monitored has increased and is more representative of the range of the species; the monitoring program has been updated to address detectability; and additional research exists regarding butterfly movement and dispersal. Based on these considerations, the Service is in the process of conducting a new PVA using an individual-based population model and plans to revisit the existing recovery criteria based on the results.

In addition to population criteria, the Recovery Plan also set specific habitat targets. The Recovery Plan targeted a minimum of 20 mg/m^2 of sugar, with sugar coming from at least 5 native nectar species in each habitat patch, to have sufficient abundance and diversity of nectar for Fender's blue butterfly (USFWS 2010, Appendix D). It also recommended having nectar plants available within the habitat patch throughout the entire flight season of the plant's pollinator species (March through September) (USFWS 2010, Appendix D). In addition, the Recovery Plan recommended that sites with breeding habitat have a minimum of 30 lupine leaves/m^2 of habitat to have sufficient abundance of lupine for Fender's blue butterfly larvae (USFWS 2010, Appendix D).

Given that nectar and lupine thresholds were developed based solely on four sites with highly variable nectar data in Lane County in the southern part of the Fender's blue butterfly range, and given conflicting data suggesting that these resources are not correlated to Fender's blue butterfly densities, current nectar and lupine recovery criteria may also warrant reconsideration (see *Section 2.3.2 Dispersal and Patch Size* for more thorough discussion).

Because the Service is in the process of re-evaluating the current recovery criteria for Fender's blue butterfly as presented in the Recovery Plan for the species (USFWS 2010, pp. IV-29 -IV-31 and IV-34), for the reasons detailed above, we do not assess the status of Fender's blue butterfly relative to all of the specific existing criteria. However, in this SSA we do consider the status of the species relative to the overarching goals of protecting existing populations, securing the habitat, and managing for high-quality prairie habitats; all of these were downlisting considerations described in the recovery plan (USFWS 2010, p. IV-9). In addition, our evaluation under the SSA framework (USFWS 2016) reflects the fundamental concepts captured in the recovery plan criteria of achieving multiple populations with connectivity between them distributed across the historical range of the species. We also explicitly consider not only the quality of the prairie habitat, using the recommended guidelines for prairie quality and nectar availability in the recovery plan, but also the management and protection status of butterfly occurrences (see, e.g., USFWS 2010, p. IV-13, pp. IV-29–IV-31).

Chapter 6. Current Condition and Future Viability of Fender's Blue Butterfly

As discussed in Chapter 1, for the purpose of this assessment, we define viability as the ability of the Fender's blue butterfly to sustain metapopulations in its native prairie habitat over time. Using the SSA framework, we describe the viability of Fender's blue butterfly by evaluating the status of the species in terms of its resiliency, redundancy, and representation (3Rs) now and within the foreseeable future. Using the estimated levels of the 3Rs in response to the current and predicted influences on the viability of the species, we describe the projected viability of the species over time under various reasonable future scenarios to describe the risk profile of the species.

In Chapter 4, we discussed the key influences on the viability of Fender's blue butterfly. Those key influences on species viability, which act by affecting the key resources needs of the species, are incorporated here into the conceptual diagram presented in Figure 6.1.

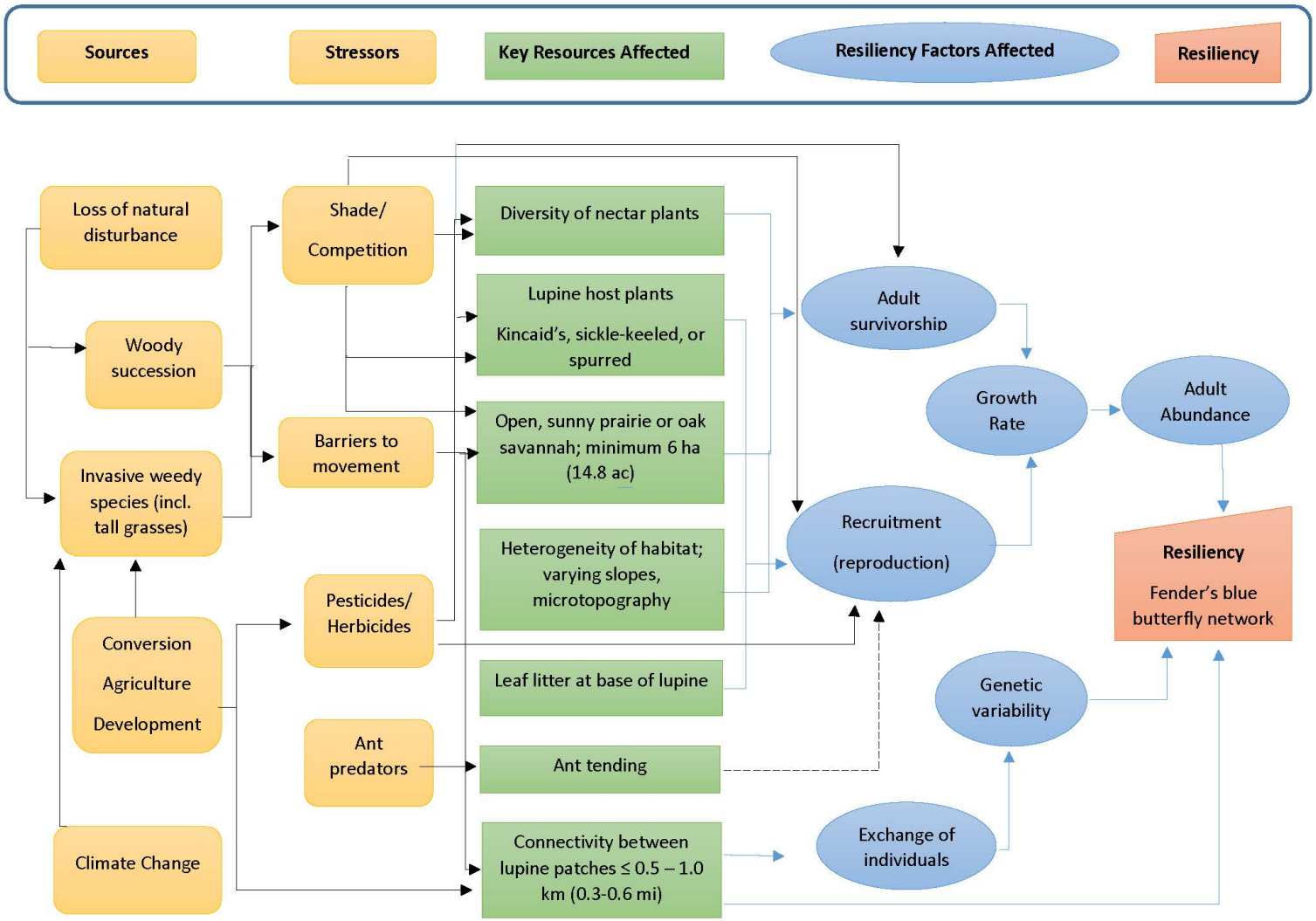

Figure 6.1. Stressors and sources of stressors influencing the viability of Fender's blue butterfly by affecting metapopulation resiliency.

6.1 Needs of Fender's Blue Butterfly

6.1.1 Metapopulation Resiliency

For Fender's blue butterfly, resiliency is the ability to sustain metapopulations in the face of stochastic events. Examples of stochastic events that have the potential to affect Fender's blue butterfly include fire, drought, or unseasonably cold or wet weather, especially during the adult flight period. To evaluate resiliency, we created a core conceptual model of resource needs in Chapter 2. There, we identified lupine plants; nectar plants; and open prairie or oak savannah habitat as the most important habitat requirements to sustain individuals and metapopulations of Fender's blue butterfly. We also identified abundance and connectivity as important demographic factors influencing the ability of a metapopulation to grow and persist over time. Thus, greater abundance and greater connectivity within a metapopulation mean greater resiliency of Fender's blue butterfly metapopulations.

As summarized earlier in Table 2.4, we determined that for a metapopulation of Fender's blue butterfly to be resilient, the requisite resource needs are an abundance of lupine host plants and nectar plants within prairie patches at least 6 ha (15 ac) in size, with habitat heterogeneity and minimal amounts of invasive plants and woody vegetation. In terms of abundance, a resilient metapopulation would support a minimum of 200 butterflies each year for at least 10 consecutive years. Connectivity would be achieved by ensuring that butterflies are distributed in multiple groups or subpopulations across lupine patches that are within easy dispersal distance of one another and free from barriers to movement, ideally within 0.5 to 1.0 km (0.3 to 0.6 mi) of one another.

6.1.2 Species Redundancy

Fender's blue butterfly needs to have multiple resilient metapopulations distributed throughout its range to provide for redundancy. The more metapopulations, and the broader their distribution across the historical range of the species, the greater the redundancy (and representation) for the species, with concomitant gains in relative viability. Redundancy increases the likelihood of a species surviving rare but catastrophic events, such as a widespread climatic event or the introduction of a serious pathogen. Having multiple resilient metapopulations spread out across a broad geographic area reduces the risk that all or a large portion of the species' range will be negatively affected by a catastrophic natural or anthropogenic event at a given point in time. Ideally, to maintain both redundancy and representation, resilient metapopulations of Fender's blue butterfly would be distributed across the historical range of the species, as indicated by the occurrence of multiple metapopulations distributed across each of the three recovery zones established for the species.

6.1.3 Species Representation

Representation is the maintenance of genetic or ecological diversity within a species in order to retain its adaptive capacity, or the ability to adapt to change over time. In the case of Fender's blue butterfly, we do not have any information available specific to the genetic composition or diversity of the species. In addition, there is little indication of significant differences between

groups or metapopulations in terms of ecological settings occupied across the range of the species. Most of the ecological settings occupied by Fender's blue butterfly are relatively similar in terms of the habitat type, although there are some elevational differences as shown in areas like West Eugene and Coburg Hills, as well as some variety in terms of metapopulations occupying drier, upland prairie sites as opposed to some metapopulations that are found in wetter prairie types. Lacking any specific information about genetic or ecological diversity within the species, we can only attempt to maintain the capacity of Fender's blue butterfly to adapt to future environmental change by preserving the full suite of geographic and habitat representation available through retaining metapopulations throughout its full range.

Historically, metapopulations of Fender's blue butterfly were likely distributed in a more continuous distribution across the prairies and oak savannahs of the Willamette Valley. Anthropogenic changes to the valley since European settlement, however, have resulted in extensive losses of prairie habitats and permanent alterations of the environment to the extent that it is not feasible to contemplate the re-establishment of metapopulations that are connected across the range of the species. Realistically, and as acknowledged by the Recovery Plan, the best possible outcome for Fender's blue butterfly in today's Willamette Valley is the attainment of resilient metapopulations distributed across the historical range of the species, as evidenced by multiple metapopulations occurring within each of the three recovery zones, but without the expectation that all of these metapopulations will be capable of interacting with one another. The establishment of numerous "stepping stone" habitats between existing metapopulations may possibly help to address this connectivity issue in the future, at least between those metapopulations where distances make movements between them potentially feasible. In addition, representation across the range could be increased by establishing metapopulations on the eastern side of the Willamette Valley (east of I-5) and conducting habitat restoration in the northern and the higher elevation edges of the range for heterogeneity. For example, habitat along Wild Iris Ridge just southeast of Willow Creek has potential to connect from low elevation to high elevation to provide an altitudinal gradient. As mentioned in Chapter 5, the Service is in the process of developing an individual-based spatial model that will integrate such considerations into a population viability assessment for Fender's blue butterfly with the intent of further refining the current recovery criteria for the species.

6.2 Current Species Condition

The available information indicates that the status of Fender's blue butterfly has improved since it was listed as an endangered species under the ESA in the year 2000 (January 25, 2000; 65 FR 3875). As detailed in Chapter 3, the species was rediscovered in 1989 after an absence of more than 50 years, during which time it had been thought extinct. At the time of listing, there were an estimated total 3,391 individuals of Fender's blue butterfly found at 32 sites scattered across a total of 165 ha (408 ac) in four counties in the Willamette Valley (although we now know that the estimated geographic extent in terms of acres occupied was overestimated in the listing document). The term metapopulation was not in use at the time of listing. Therefore, to compare the status at listing to today, we retroactively applied the criteria for defining metapopulations of butterflies as used in this Report, resulting in what would be 12 metapopulations of Fender's blue butterfly known at the time of listing.

As of 2018, there were 13,700 individuals of Fender's blue butterfly estimated at the 93 sites surveyed that year, distributed across an area of 344 ha (825 ac) in six counties. Fender's blue butterfly occupies 137 sites, but it is not possible to survey all sites every year, so we do not have an overall total abundance estimate for the species as a whole (thus we know the estimate of 13,700 individuals to be less than the total number of Fender's blue butterflies rangewide). Since standardized monitoring was implemented, the butterfly has experienced fluctuations in population estimates ranging from a low of 13,011 in 2012 to a high of almost 29,000 butterflies in 2016. The number of individuals estimated in 2016, counted at only a subset of known occupied sites, represents a more than 8-fold increase in abundance of the species relative to the estimated number at the time of listing. Following the high numbers recorded in 2016, Fender's blue butterfly declined rangewide in 2017, with some sites increasing in numbers and others decreasing. The rangewide estimates increased in 2018 and we anticipate that they will likely continue to do so, as it is common for populations to double or halve between years based on rangewide estimates from 1993 to 2018 (USFWS 2010, p. IV-5; Menke 2018, p. 1). The amount of occupied habitat has also doubled since the time of listing. Distribution of Fender's blue butterfly has additionally increased, as subsequent to listing it was found in two additional counties where it was not previously known to occur.

Although a few small groups of butterflies known at the time of listing are believed to have become extirpated, these losses have been offset by the discovery of new, larger groups or even entire metapopulations of Fender's blue butterflies elsewhere in the range. In addition, one new metapopulation was established through reintroduction, and several existing metapopulations have expanded through active management aimed at habitat restoration for the benefit of the species. Not all changes have been entirely positive, however; for reasons unknown, at least one metapopulation (Lupine Meadows) continues to decline in abundance, despite seemingly quality habitat available and active management in place for the butterfly.

Methods

Viability is the ability of the Fender's blue butterfly to sustain metapopulations in its native prairie habitat over time. We describe the viability and the probability of Fender's blue butterfly persistence by evaluating the current condition of the species. For our purposes, we chose to evaluate the probability of Fender's blue butterfly metapopulations of persistence over a period of 25 years because this timeframe was used in the Recovery Plan to determine downlisting criteria as it was viewed to be consistent with the standard of classifying a species as threatened. It is important to note that the probability of persistence presented here is not the result of a quantitative calculation, but rather represents the best professional judgment of experts familiar with the species and its habitat. If a metapopulation is ranked in the high condition category, then the metapopulation has a higher degree of resiliency and a lower risk of extirpation, thus, it is more likely to persist over time (Table 6.1). In contrast, if a metapopulation is ranked in the low condition category, then the metapopulation has a lower degree of resiliency and is less likely to persist over time.

Table 6.1. Presumed probability of persistence of current condition categories.

Overall condition category based on resiliency	Risk	Persistence over 25 years	Probability of persistence
High	Low	Very likely	90-100%
Moderate	Moderate	Likely	60-89%
Low	High	More unlikely than likely	0-59%

We utilized the best available scientific data to rank the current condition of each Fender's blue butterfly metapopulation in terms of resiliency based upon the how well the needs of the metapopulation are being met. Using the core conceptual diagram developed in Chapter 2 and the Recovery Plan for Fender's blue butterfly, we developed criteria to evaluate specific habitat and demographic factors contributing to the overall health or resiliency of metapopulations and then assigned each metapopulation a qualitative rank of High, Moderate, or Low condition (Table 6.2). We included data from an upland prairie habitat calculator and a Fender's blue butterfly calculator to assess each metapopulation. These calculators were created by the Institute for Applied Ecology (IAE), in coordination with the Willamette Partnership and with guidance from a Prairie Technical Working Group comprised of local experts. The calculators were designed as a rapid assessment tool to include metrics that were responsive to recovery criteria, evaluated key aspects of site quality for Fender's blue butterfly, included species-specific habitat needs, and tracked habitat conditions for listed prairie species. For instance, the 2010 Recovery Plan developed specific criteria for identifying overall habitat quality and identified three key features for habitat: the presence of a larval host plant, native forbs for adult nectar sources, and a mixture of native grasses and forbs that maintain the historical short-grass structure of the upland prairies. The calculators are consistent with these criteria and key features to allow for some standardized assessment of habitat quality between sites. The Fender's blue butterfly module of the calculator specifically addresses lupine and nectar flower abundance and accounts for the impact of structure and patch size on overall quality of Fender's habitat. The calculator prioritizes habitat that is more conducive to recovery and incorporates measures of habitat management and protection. Thus, the calculators assess overall prairie habitat quality, evaluate and weight key aspects of site quality for Fender's blue butterfly, and assess site quality for at-risk upland plant species, including Kincaid's lupine (see Appendix E for additional information). For the 5-year population estimates, we used data from 2012 through 2016 for the evaluation of current condition. We acknowledge that the population estimates declined across the majority of metapopulations in 2017 with a slight increase in 2018; however, this trend occurred across all three recovery zones. Therefore, we believe the 2016 data more accurately reflect the variation among metapopulations. Once current condition rankings were established for each category identified in Table 6.2, we used best professional judgement to interpret the overall current condition. This included consideration of site history and recovery criteria such as whether the metapopulation was over 200 butterflies.

Table 6.2. Analysis criteria for evaluating metapopulation health and resiliency.

Habitat and Demographic Resources Analysis Criteria for Metapopulations									
Condition	**Number of sites**	**Abundance over time**	**Average 5-year Abundance**	**Connectivity**	**Prairie patch Size (ha)**	**Lupine** (leaves/m^2) and (sq m)	**Nectar**	**Prairie**	**Habitat Heterogeneity**
High	≥8	≥200 adults for 10 consecutive years	≥1400 adults	≤0.5 km between groups within a meta-population	≥18	≥30 ≥1500	A plentiful diversity of nectar species present throughout the entire flight season	Short stature plant community with regular habitat management that mimics natural disturbance and ≤15% woody vegetation and <5% invasive species	Many varying slopes and aspects with micro-topography
Moderate	4-7	≥200 adults for some of the past 10 consecutive years	200-1400 adults	0.5-1.0 km between groups within a meta-population	6-18	20-30 500-1499	A mix of native and nonnative nectar species present throughout part of the flight season	Short stature plant community with intermittent habitat management that mimics natural disturbance and ≤25% woody vegetation and between 5 and 10% invasive species; tall grasses present but do not dominate the landscape	Some varying slopes and aspects with micro-topography
Low	≤3	<200 adults for most or all of the past 10 consecutive years	<200 adults	≥1.0 km between groups within a meta-population	<6	<20 <500	Few nectar species present	Limited short stature plant community lacking habitat management that mimics natural disturbance and >25% woody vegetation and >10% invasive species; tall grasses dominate the landscape	Lacking variation in micro-topography

6.2.1 Current Metapopulation Resiliency

Five of the 15 Fender's blue butterfly metapopulations are ranked in high condition, while 6 are ranked moderate and 4 are ranked low (Table 6.3). All three recovery zones contain metapopulations ranked as having either high or moderate condition.

- Within the Salem Recovery Zone, two metapopulations were ranked as high, two were moderate, and two were low.
- Within the Corvallis Recovery Zone, one metapopulation was ranked as high while two metapopulations were moderate and two metapopulations were low.
- Within the Eugene Recovery Zone, two metapopulations were ranked as high and two were moderate, while no metapopulations were ranked as low.

Thus, each recovery zone contains both highly resilient and moderately resilient metapopulations that are likely to withstand stochastic events. Overall, the strong majority of metapopulations – 11 out of 15 – are ranked in either high or moderate condition, indicating an appreciable degree of resiliency in metapopulations across the range of the species. A high degree of variability in metapopulation condition remains, however, with some large metapopulations responding positively to active management, growing in abundance and expanding in extent over time (e.g., Fern Ridge), while others continue to decline despite management efforts and the availability of what appears to be suitable habitat for the species (e.g., Lupine Meadows). The latter situation indicates there is some stressor acting on the species that we do not yet recognize or have not sufficiently addressed at these particular locations.

6.2.2 Current Species Redundancy

Fender's blue butterfly exhibits metapopulation redundancy within and across each of the three recovery zones spanning the geographic range of the species. The presence of multiple highly and moderately resilient metapopulations distributed across the geographic range of the Fender's blue butterfly increases the likelihood that the species will be able to adapt to environmental changes as well as to withstand catastrophic events.

Individual metapopulation condition categories are broadly distributed across the recovery zones. All three recovery zones contained metapopulations with a range of numbers of sites comprising multiple metapopulations ranked as high, moderate, or low condition. The greater the number of sites within a metapopulation, the more likely a given metapopulation will be able to handle random events and persist into the future. Abundance data from the last 10 years indicates that all recovery zones have at least 1 metapopulation ranked as high, however, all recovery zones also had metapopulations ranked low. The low rankings were most prevalent in the Corvallis Recovery Zone. Across the range of the species, lupine abundance was low. Given that Kincaid's lupine is a threatened species under the ESA, this result is not surprising and restoration efforts continue to focus on increasing lupine abundance. Based on the prairie calculator scores, the highest quality prairie was found within the Eugene Recovery Zone, though all recovery zones had at least one metapopulation with a ranking of high. The Salem Recovery Zone generally scored higher on the Fender's blue butterfly calculator than the other recovery zones. Having a wide distribution of metapopulations with condition categories ranking predominantly as high or moderate across all recovery zones, and hence the geographic range, increases the likelihood that the species will be able to adapt to environmental changes and withstand catastrophic events.

6.2.3 Current Species Representation

We consider the Fender's blue butterfly to have representation across the known range of the species. Although no direct measures of genetic or ecological diversity are available, there are multiple metapopulations and groups of Fender's blue butterfly distributed relatively evenly across the geographic range of the species (six in the Salem Recovery Zone, five in the Corvallis Recovery Zone, and four in the Eugene Recovery Zone), and with representation of all known habitat types (upland prairie, wet prairie, and oak savannah) and elevations, ranging from 98 m (320 ft) to 604 m (1980 ft). Representation has increased relative to the time of listing, with new metapopulations now known in Linn County and Washington County (representing the northernmost extent of the species' range). No known ecological settings for the species have been lost; known local extirpations of the species have been from relatively small, isolated roadside occurrences. Having multiple populations distributed across the range of the species, in a variety of habitat types and elevations, increases the adaptive capacity of Fender's blue butterfly and the ability of species to respond to environmental change.

Table 6.3. Current condition rankings of Fender's blue butterfly metapopulations.

Meta-population	Overall Current Condition	Number of sites	Site Rank	# consecutive years ≥ 200 butterflies since	Time and Number Rank	5-year average abundance score (2016)	5-year average abundance rank	Lupine Abundance (sq m)	Lupine Rank	Prairie Calculator Score	Prairie Calculator Rank	Fender's blue butterfly calculator score	Fender's blue butterfly calculator Rank
Salem Recovery Zone													
Baskett	**High**	28	High	18	High	2091	High	1220	Moderate	66.9%	Moderate	45.3%	Moderate
Gopher Valley	**Moderate**	7	Moderate	7	Moderate	465	Moderate	309	Low	72.9%	High	47.0%	Moderate
Hagg Lake	**High**	9	High	8	Moderate	1664	High	1306	Moderate	64.3%	Moderate	66.9%	High
Moores Valley	**Possible Extirpation**	3	Low	0	Low	31	Low	168	Low	64.0%	Moderate	34.1%	Low
Oak Ridge	**Moderate**	5	Moderate	6	Moderate	1082	Moderate	6984	High	64.0%	Moderate	59.4%	High
Turner Creek	**Low**	7	Moderate	0	Low	37	Low	195.4	Low	68.9%	Moderate	30.3%	Low
Corvallis Recovery Zone													
Butterfly Meadows	**Low**	11	High	6	Moderate	111	Low	108.5	Low	56.5%	Low	31.8%	Low
Finley	**Moderate**	3	Low	3	Low	239	Moderate	180	Low	73.4%	High	49.4%	Moderate
Greasy Creek	**Low**	3	Low	0	Low	69	Low	228.2	Low	43.8%	Low	No data	No data
Lupine Meadows	**Low**	3	Low	6	Low	28	Low	205.8	Low	79.2%	High	30.7%	Low
Wren	**High**	17	High	12	High	3047	High	2894	High	66.1%	Moderate	59.7%	High
Eugene Recovery Zone													
Coburg Ridge	**Low**	3	Low	2	Moderate	54	Low	104	Low	77.5%	High	45.5%	Moderate
Oak Basin	**Low**	7	Moderate	0	Low	28	Low	180	Low	73.3%	High	44.0%	Moderate
West Eugene	**High**	13	High	15	High	8511	High	2750	High	71.8%	High	56.6%	High
Willow Creek	**High**	8	High	25	High	2582	High	2984	High	79.4%	High	57.4%	High

6.3 Future Condition

In this section, we have forecasted what the Fender's blue butterfly may have in terms of resiliency, redundancy, and representation under three plausible future scenarios. These future scenarios forecast Fender's blue butterfly viability over the next 25 to 35 years. We chose this timeframe because it represents up to 35 generations of Fender's blue butterfly; it was used in the Recovery Plan to determine downlisting criteria; and it can address the immediate effects of management strategies given that our current interim protections (HCPs, SHAs) have a lifespan ranging from 10–50 years.

The **Continuing Efforts** scenario evaluates the condition of Fender's blue butterfly if risk remains unchanged in the metapopulations from what exists today, while the other scenarios evaluate the response of the species to changes in those risks. The **Considerable Impacts** scenario evaluates the response of Fender's blue butterfly to projected climate change effects and limited prairie management. The **Conservation Effort** scenario evaluates the response of Fender's blue butterfly to an increased level of habitat restoration within existing populations and surrounding areas containing potential habitat. We used two different methodologies for assessing future conditions. Under scenario 1 and 2, we analyze the metapopulation's ranking for each variable under current conditions and project that out into the future. In scenario 3, we mapped and identified potential areas for conservation and worked with partners on the feasibility of conservation actions there. We then used these responses to come up with changes in habitat quality in these areas and what impact that may have on the population trends of the species. While these two methods do differ, they both apply our knowledge of the species and current and planned management actions in order to project what its condition will be in the future. Specifically, we evaluated the response of Fender's blue butterfly to each scenario in terms of long-term viability. We forecasted the likelihood of continuing current habitat management and protection, of limited habitat management combined with climate change, and of increased habitat restoration and metapopulation expansion during the chosen timeframe based on best professional judgment.

6.3.1 Scenario 1 – Continuing Efforts

Under this scenario, the Service considers the likelihood that over the next 25–35 years, Fender's blue butterfly abundance and distribution will continue on its current trajectory. It assumes that current influences on viability will continue at the same level as will current habitat management and conservation measures. Therefore, we believe it is highly likely that this scenario will occur. To gauge the likelihood that metapopulation condition would increase or decrease, we created a general rule based on rankings under current condition as these variables include habitat quality, protection, habitat management, and population survey information. Under current conditions, high ranks received 3 points, moderate ranks received 2 points, and low ranks received 1 point. Since there are 6 categories, the minimum score is 6 and the maximum score is 18. Therefore, we forecasted that current condition would go down a rank under this scenario if a metapopulation

had a score of 6-8; current condition would stay the same if a metapopulation had a score of 9-13; and current condition would go up a rank if a metapopulation had a score of 14-18.

Most of the metapopulations would be likely to retain their overall condition under the Continuing Efforts scenario (Table 6.4). Six populations were forecasted to be in good (high) condition and therefore have high resiliency, while two metapopulations would be in moderate condition and therefore have moderate resiliency. Four metapopulations would be in poor (low) condition and therefore have minimal resiliency, while three metapopulations face the possibility of extirpation. At least one metapopulation would be in good condition in each recovery zone. We anticipate that metapopulations may experience short-term reductions in numbers and density over time as we have seen throughout the past years, but given ongoing management actions, they would likely rebound in most cases. If a stochastic event were to occur that reduces or eliminates individual sites, we anticipate that responses to these events would happen quickly on managed and protected sites as opposed to sites without management.

We anticipate that Oak Ridge would increase from moderate condition to high condition based upon current conservation and management actions. Sickle-keeled lupine in this metapopulation was treated with herbicide in spring 2016, which resulted in decreased host plant availability for Fender's blue butterfly. While the population initially declined, population estimates are increasing at most sites and observations in 2018 suggest the lupine is recovering (Menke 2018, p. 5). We also anticipate that two metapopulations would be at risk of possible extirpation that are in low condition currently and one would continue to be at risk of extirpation. One metapopulation, Turner Creek, would have been considered at risk of extirpation based on our general rule, however, extensive habitat restoration has occurred within this metapopulation and we have seen numbers increasing as a result (Fitzpatrick and Menke 2016, pp. 56-57). Therefore, we opted to retain its condition at this time given the optimistic butterfly response. On the other hand, the Moores Valley metapopulation abundance estimates dropped from 31 butterflies in 2016 to just 2 in 2018. While sites have some management occurring, two of the three sites that comprise this metapopulation are narrow roadside strips of remnant prairie though the third is considered fairly high-quality prairie. Likewise, the Greasy Creek metapopulation has consistently low estimates of Fender's blue butterfly with most of the metapopulation present on private lands without active management for Fender's blue butterfly. While there is good-quality protected habitat at Lupine Meadows, numbers have been under 50 butterflies since 2011 with no signs of rebounding even with habitat management. The most recent estimate in 2018 found 14 butterflies. With low numbers and minimal current management, these three metapopulations are unlikely to withstand stochastic or catastrophic events.

Table 6.4. Forecasted condition of Fender's blue butterfly metapopulations under the Continuing Efforts scenario.

Metapopulation	Current Condition (as of 2018)	Continuing Efforts Scenario Condition
Salem Recovery Zone		
Baskett	High	High
Gopher Valley	Moderate	Moderate
Hagg Lake	High	High
Moores Valley	Possible Extirpation	Possible Extirpation
Oak Ridge	Moderate	High
Turner Creek	Low	Low
Corvallis Recovery Zone		
Butterfly Meadows	Low	Low
Finley	Moderate	Moderate
Greasy Creek	Low	Possible Extirpation
Lupine Meadows	Low	Possible Extirpation
Wren	High	High
Eugene Recovery Zone		
Coburg Ridge	Low	Low
Oak Basin	Low	Low
West Eugene	High	High
Willow Creek	High	High

6.3.2 Scenario 2 – Considerable Impacts

Under this scenario, the Service considers the likelihood that over the next 25–35 years, Fender's blue butterfly abundance and distribution will decline as a result of increased risk from the influences on viability (previously discussed in Chapter 4). We anticipate higher risk of drought and an increased susceptibility to wildfire due to possible changes in precipitation and air temperatures and heavier winter stream flows along with lighter summer flows. Such a scenario would likely have negative effects on habitat quality. These aforementioned changes increase the likelihood of vegetational shifts such that invasive nonnative plants and woody succession may become more prolific and/or more difficult to manage. There is a high degree of uncertainty regarding whether this scenario will occur. To gauge the likelihood that metapopulation condition would increase or decrease, we created a general rule based on rankings under current condition as these variables include habitat quality, protection, habitat management, and population survey information using a point system similar to the one used in the Continuing

Efforts scenario. The minimum and maximum score remained the same; however, the forecasting differed because we do not anticipate any metapopulations would be able to improve their status. Under this scenario, we forecasted that current condition would go down a rank if a metapopulation had a score of 6-12 while current condition would stay the same if a metapopulation had a score of 13-18.

Under the Considerable Impacts scenario, many metapopulations would decrease in condition although at least one metapopulation would still be ranked in good condition in each recovery zone (Table 6.5). Five populations would be ranked in good (high) condition and therefore have high resiliency, while one metapopulation would be in moderate condition and therefore have moderate resiliency. Two of the metapopulations would be in poor (low) condition, while seven metapopulations would likely be at risk of extirpation under this scenario. We anticipate that habitat management and protection would continue, however, we also anticipate that it would be more difficult to manage sites given changing environmental conditions. As with the Continuing Efforts scenario, we anticipate that metapopulations may experience short-term reductions in numbers and density and that responses to these events would happen quickly on managed and protected sites as opposed to sites without management. It is possible that metapopulations in moderate or good condition will be able to bounce back from these changes, though it may depend on the severity of the individual losses. If a stochastic event were to occur that reduces or eliminates sites within a metapopulation, it may take longer for the remaining individuals to recolonize these sites.

The seven metapopulations that would be at risk of extirpation are not currently meeting the minimum criteria of 200 Fender's blue butterflies per metapopulation over 10 consecutive years. Under current conditions, six of these metapopulations had a ranking of low while one metapopulation, Moores Valley, was already at risk of extirpation. Several metapopulations had moved from low condition to possible extirpation under the Continuing Efforts scenario and these metapopulations would be at even greater risk of extirpation under the Considerable Impacts scenario. The metapopulations with a low current condition may persist at a low ranking under the Continuing Efforts scenario; however, it is unlikely that they will be able to do so if conditions worsen given already decreasing population estimates and relatively poor habitat quality. Oak Basin and Coburg Ridge have higher quality habitat and more extensive habitat management taking place than some of the other metapopulations. Should habitat quality decrease, these metapopulations would have difficulty sustaining themselves due to low current population estimates and very few sites (three each), making them susceptible to extirpation under the Considerable Impacts scenario.

Table 6.5. Forecasted condition of Fender's blue butterfly metapopulations under the Considerable Impacts scenario.

Metapopulation	Current Condition (as of 2018)	Considerable Impacts Scenario Condition
Salem Recovery Zone		
Baskett	High	High
Gopher Valley	Moderate	Low
Hagg Lake	High	High
Moores Valley	Possible Extirpation	Possible Extirpation
Oak Ridge	Moderate	Moderate
Turner Creek	Low	Possible Extirpation
Corvallis Recovery Zone		
Butterfly Meadows	Low	Possible Extirpation
Finley	Moderate	Low
Greasy Creek	Low	Possible Extirpation
Lupine Meadows	Low	Possible Extirpation
Wren	High	High
Eugene Recovery Zone		
Coburg Ridge	Low	Possible Extirpation
Oak Basin	Low	Possible Extirpation
West Eugene	High	High
Willow Creek	High	High

6.3.3 Scenario 3 – Conservation Effort

Under this scenario, the Service considers the likelihood that over the next 25–35 years, Fender's blue butterfly abundance and distribution will improve beyond the Continuing efforts scenario. There are three possible sources for improved Fender's blue butterfly abundance and distribution: 1) improved habitat conditions at currently occupied sites, 2) metapopulation expansion by restoring currently unoccupied prairie sites, and 3) butterfly augmentation, translocation, and/or introduction. Improving habitat quality and lupine abundance at currently occupied sites will increase butterfly abundance, which will also increase the likelihood of natural colonization of the potential expansion areas. We forecasted the likelihood of metapopulation expansion during the chosen timeframe based on confidence terminology.

Over the next 25–35 years, with increased conservation effort there is significant potential to increase habitat quality, and consequently butterfly abundance, at some of the currently protected

and managed sites. In this scenario, we evaluated the potential for expansion at currently protected sites within the dispersal range of Fender's blue butterfly, and protected areas that have been identified as possible introduction sites. To our knowledge, there is potential for expansion in eight existing metapopulations and one currently unoccupied area ("Muddy Valley").

If the current risk levels of invasive nonnative plants, especially tall grasses, are reduced, butterfly abundance and dispersal will likely increase. This scenario is contingent on adequate funding for habitat management at currently protected sites occupied by Fender's blue butterfly. The Service anticipates that most of the currently protected sites will continue to be maintained and enhanced for Fender's blue butterfly resulting in stable or increasing population trends at most of the current metapopulations. Increased butterfly abundance at currently occupied sites will also increase the likelihood of natural colonization in the surrounding landscape of the eight potential expansion sites (described below).

The Recovery Plan identified tasks for reintroducing populations, as necessary, to meet recovery goals (USFWS 2010, p. IV-50). An introduction protocol was developed for the 2011 experimental introduction of Fender's blue butterfly to Finley NWR. If necessary to meet recovery goals, the Service could implement this protocol for population augmentations, by species translocations and/or introductions. Augmentation involves collecting individuals from donor site(s) and releasing them at currently occupied sites. Translocation involves moving individuals between sites that are within 2 km (1.2 mi) of one another. Introduction involves moving individuals to an unoccupied site greater than 2 km (1.2 mi) from an occupied site.

Over the last two decades, numerous landowners and managers have successfully restored and expanded Fender's blue butterfly distribution and abundance (Schultz and Crone 2015, p. 1114). There are several unoccupied parcels with permanent and interim protections in areas surrounding existing butterfly populations. Many landowners and managers have outlined specific plans to restore additional Fender's blue butterfly habitat in order to improve species distribution and abundance. Metapopulation expansion could result from natural colonization, or butterfly introductions and translocations from nearby sites. After evaluating currently protected and unoccupied sites with the potential to support Fender's blue butterfly, the Service concluded there are nine potential metapopulation expansions along with one possible new metapopulation, each with estimated probabilities based on the probability descriptions in Table 6.4 (described below.)

Fender's blue butterfly has been documented using lupine patches immediately following restoration (Carleton and Schultz 2013, p. 517), however, introduced lupine patches most often take several years before butterfly occupancy is documented. Studies show it takes at least 5 years of lupine growth before restored sites support comparable butterfly egg loads as those reported in remnant lupine patches (Carleton and Schultz 2013, p. 517). For the purposes of predicting future expansions, we assume butterfly occupancy is likely to occur within 5 years of lupine introductions to sites within 1 km (0.6 mi) of existing butterfly populations without dispersal barriers. It is important to note that the probability of expansion (Fender's blue butterfly occupancy in areas not occupied in 2016) presented below is not the result of a

quantitative calculation, but rather represents the best professional judgment of experts familiar with the species, its habitat, and opportunities for habitat expansion at protected/managed sites. When coordinating with land managers about potential expansion sites, we learned that some of the potential expansion sites were already planted with lupine and had recently become occupied by Fender's blue butterfly. Therefore, the potential metapopulation expansion descriptions below include additional lupine and butterfly occupancy information through 2018, even though the metapopulation descriptions for current conditions (Appendix C) evaluates the Fender's blue butterfly status through 2016.

The nine potential metapopulation expansions evaluated include the following metapopulations: Baskett (Figure 6.2), Hagg Lake (Figure 6.3), Turner Creek (Figure 6.4), Lupine Meadows (Figure 6.5), Greasy Creek (Figure 6.6), Finley (Figure 6.7), Oak Basin (Figure 6.8), West Eugene (Figure 6.9) and Willow Creek (Figure 6.10). It is somewhat likely that a new metapopulation, Muddy Valley, will be established by introducing Fender's blue butterfly to unoccupied, protected site(s). Three of the nine potential metapopulation expansions may require butterfly augmentations and/or translocations from nearby sites. It is highly likely expansion will occur in six metapopulations, moderately likely expansion will occur in two metapopulations, and somewhat likely expansion will occur in one metapopulation.

6.3.3.1 Baskett Potential Metapopulation Expansion

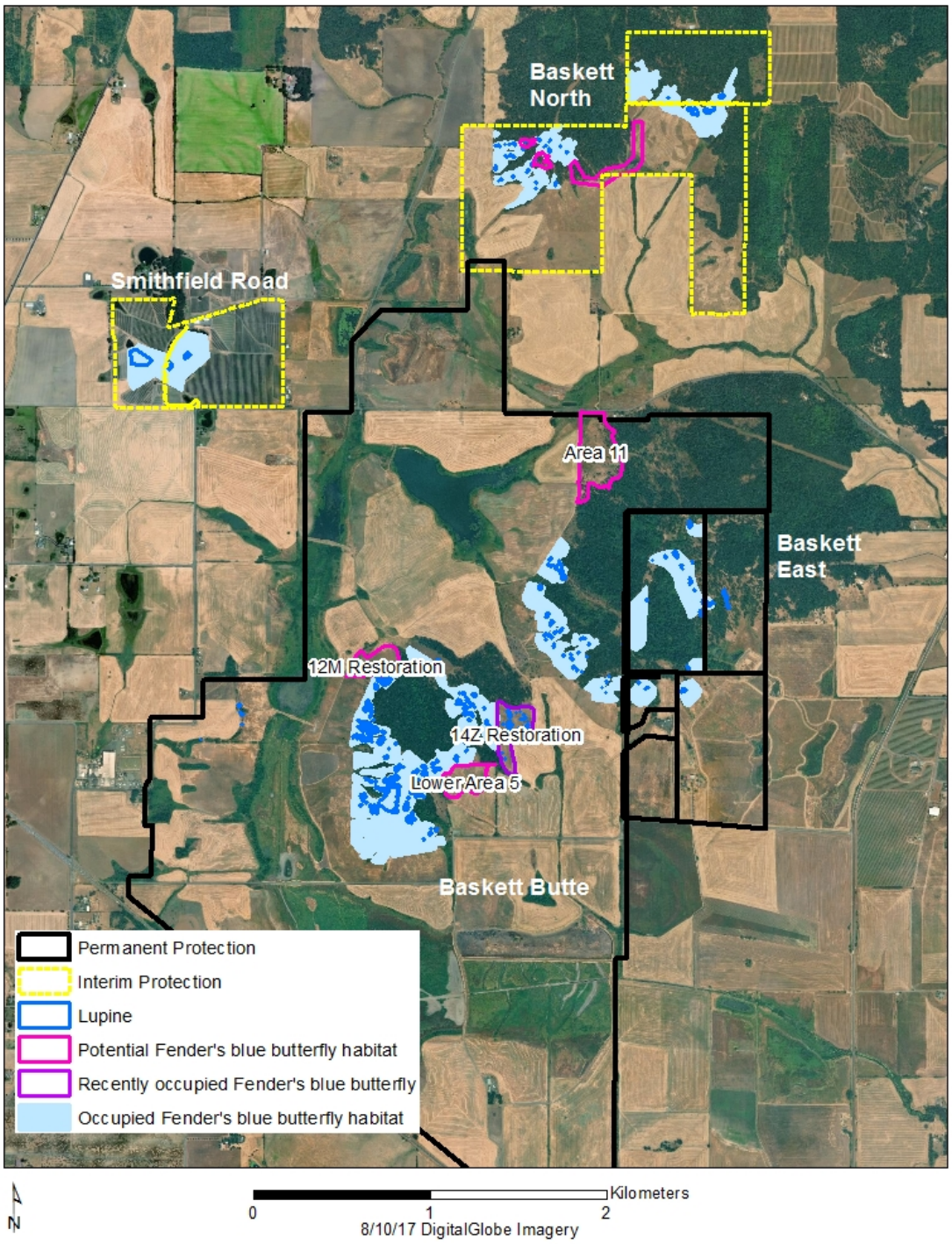

Figure 6.2 Baskett Potential Metapopulation Expansion.

The following four potential expansion sites are located on Service land within the Baskett Refuge boundary: Areas 14Z Restoration, Lower Area 5, Area 11 and 12M Restoration (Figure 6.1). The Smithfield Oaks potential expansion site is privately owned and managed under a PFW agreement and SHA with the Service. As described in the current conditions section, the Polk County Soil and Water Conservation District (SWCD) has been restoring the site using Oregon Watershed Enhancement Board (OWEB) grant funding, and have been awarded a grant to acquire the site from the owners (voluntary sale). The Willamette Valley National Wildlife Refuge Complex (WVNWRC) staff developed a Fender's blue butterfly management plan for their land in the Baskett metapopulation, including their four restoration sites (WVNWRC 2016, p. 13). Prairie restoration has been on-going at all four sites for several years. Kincaid's lupine plugs were planted in Area 14Z in the spring of 2015 and in Lower Area 5 in the spring of 2018. All four sites were seeded with Kincaid's lupine in the fall of 2018. Fender's blue butterfly eggs were discovered in Area 14Z in the spring of 2018, just 3 years after the lupine was planted at the site. The potential expansion areas at the Smithfield Oaks site have been managed to restore prairie conditions for several years. The Service anticipates lupine will be planted in these restored areas over the next 5 years.

Since all of the currently occupied sites in this metapopulation are being actively managed, the Service anticipates habitat conditions to improve and butterfly abundance to remain stable over the next several years and potentially increase. The Baskett Metapopulation supports a high butterfly abundance, which increases the likelihood that dispersing individuals will move into the surrounding landscape. Since all of the potential expansion sites are within easy dispersal distance of existing butterfly populations and free from barriers to movement, the restoration sites will improve metapopulation connectivity, and increase species distribution and abundance. Fender's blue butterfly is highly likely to occupy all of the restored sites in the Baskett Metapopulation over the next 25–35 years.

6.3.3.2 Hagg Lake Potential Metapopulation Expansion

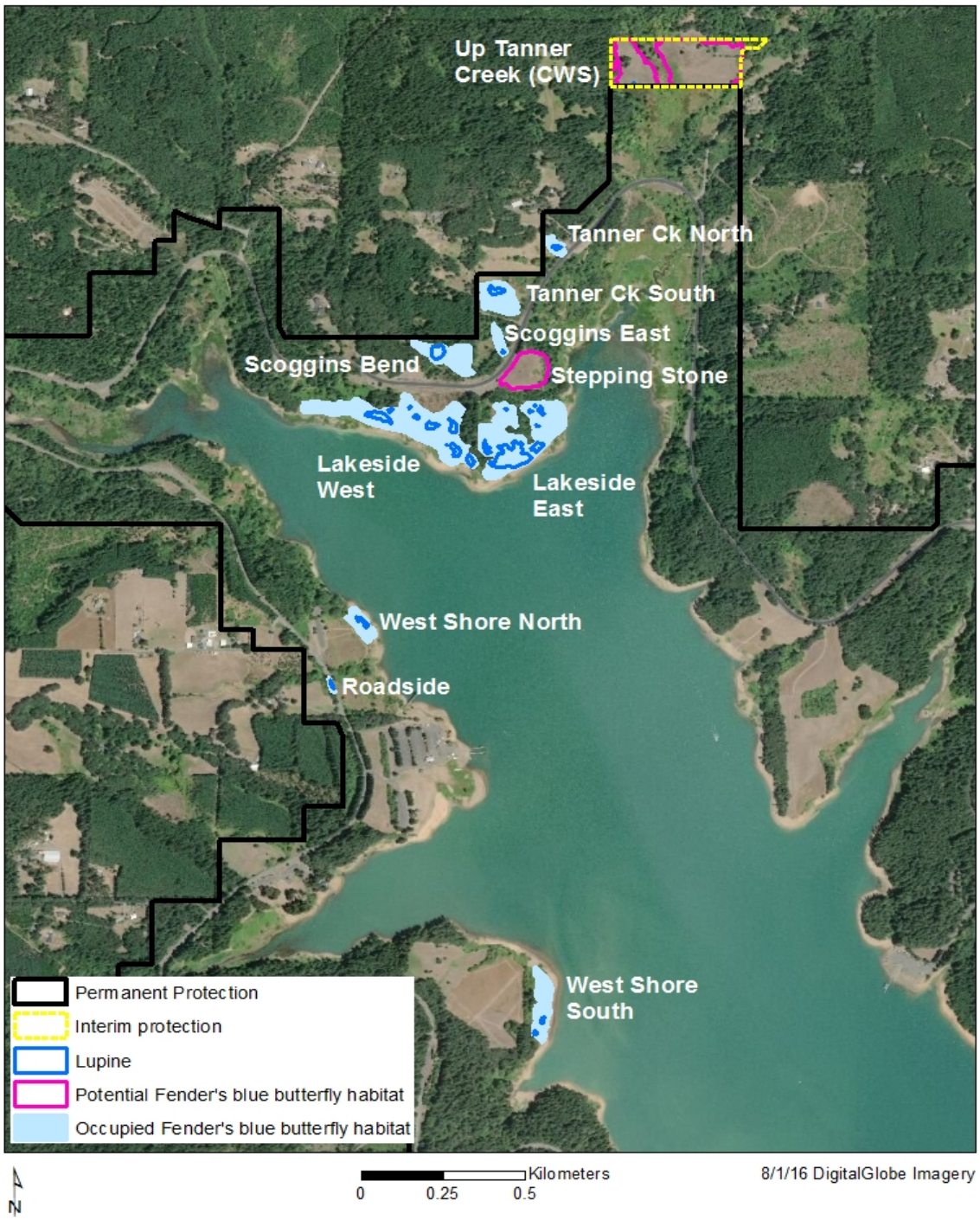

Figure 6.3. Hagg Lake Potential Metapopulation Expansion.

The following two potential expansion sites occur in the Hagg Lake Metapopulation and are being managed for Fender's blue butterfly: Stepping Stone and Up Tanner Creek. The Stepping Stone site is owned by BOR and Up Tanner Creek is owned by Clean Water Services (CWS). In 2017, BOR and the Service amended their 2016 Habitat Restoration Interagency Agreement (described in current conditions section) to include habitat expansion at the Stepping Stone site. The Service has been working collaboratively with BOR, Washington County Parks Department (WCPD), and IAE to prepare the Stepping Stone site to seed native bunch grasses and forbs in 2020. The Service anticipates seeding Kincaid's lupine at the Stepping Stone site by 2022. For several years, CWS has been actively restoring habitat at the Up Tanner Creek site in order to improve habitat conditions for the remnant lupine patches on the property. CWS and the Service are in the process of developing an SHA for the Up Tanner Creek site which is currently unoccupied by Fender's blue butterfly.

As of 2016, the Hagg Lake Metapopulation supported a high butterfly abundance and in recent years, butterfly abundance has increased to a record high of 4,035 individuals in 2018 (Menke 2018, pp. 5, 13), more than doubling the 5-year average abundance reported in the current conditions section. The Service expects butterfly abundance at Hagg Lake to continue to increase with ongoing management. Given the high population abundance at the Hagg Lake Metapopulation, and the Stepping Stone site's proximity to Lakeside East and Scoggins East sites, it is highly likely that dispersing adult(s) will colonize the site and improve metapopulation connectivity in the next 25–35 years.

The woody vegetation between the Tanner Creek North and Up Tanner Creek is an impediment to butterfly dispersal, and the sites are greater than 1 km (0.6 mi) apart. Currently, there is not a plan to restore the area between these sites to promote Fender's blue butterfly dispersal. Therefore, it is unlikely that Fender's blue butterfly will occupy the Up Tanner Creek site in the next 25–35 years. An additional consideration at this metapopulation is the possibility of a dam raise at Hagg Lake. At this time, we do not have information to determine the likelihood of this occurring.

6.3.3.3 Turner Creek Potential Metapopulation Expansion

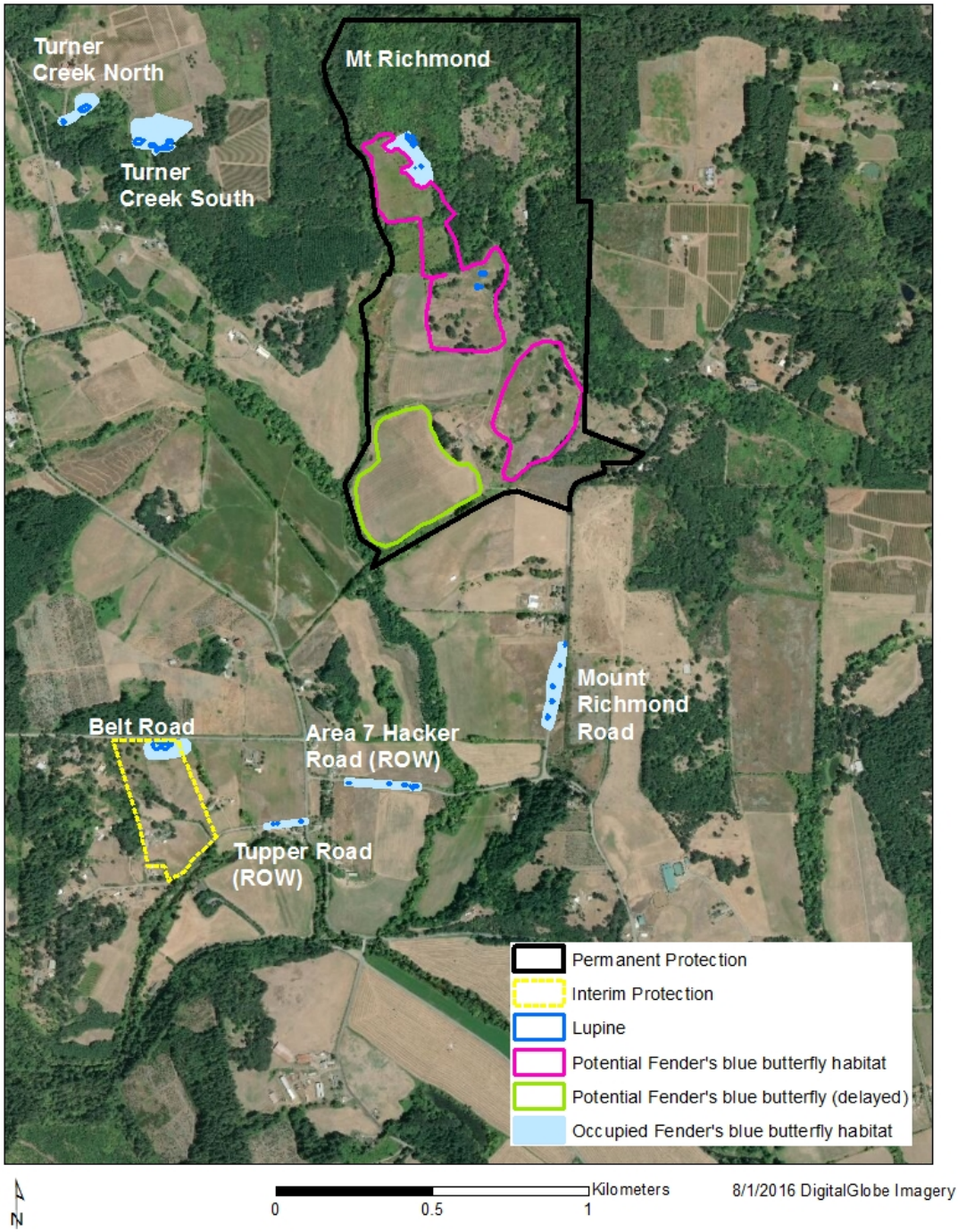

Figure 6.4. Turner Creek Potential Metapopulation Expansion.

The Yamhill SWCD has held a conservation easement since 2018 for the Mt. Richmond site in the Turner Creek Metapopulation, which has three restoration areas that could support Kincaid's lupine. For several years, the Yamhill SWCD has been treating weeds annually in the occupied meadow, and in the meadows outlined in pink on Figure 6.4. The Yamhill SWCD has documented lupine expansion in the occupied Fender's blue butterfly habitat. The meadow northeast of the occupied habitat was treated for 3 years in preparation for seeding native grasses and forbs, which occurred in the fall of 2018. Kincaid's lupine plugs were planted in the meadow southwest of the occupied patch (lupine patch shown on Figure 6.4) in the spring of 2017 and 2018. The Yamhill SWCD intends to thin the forest areas between units in the next few years. Kincaid's lupine will be seeded in the thinned areas and the meadow recently seeded with prairie grasses once the habitat conditions are stable. Restoration activities will not occur in the southeastern hayfield (outlined in green on Figure 6.4) until funding becomes available which is unlikely to occur until after 2035.

In recent years, the Yamhill SWCD has already successfully expanded lupine distribution and abundance at the Mt. Richmond site and maintained adequate lupine seed production for restoring other areas on the property. Given the expansion area's proximity to occupied habitat within the Mt. Richmond site and surrounding private lands, it is moderately likely Fender's blue butterfly will occupy the expansion areas within 25–35 years with the exception of the SW corner hayfield area. In recent years, Fender's blue butterfly abundance has been low in the Turner Creek Metapopulation so the Service may decide to augment the population in the future, after the habitat expansion areas have adequate lupine cover to support a larger butterfly population.

6.3.3.4 Lupine Meadows Potential Metapopulation Expansion

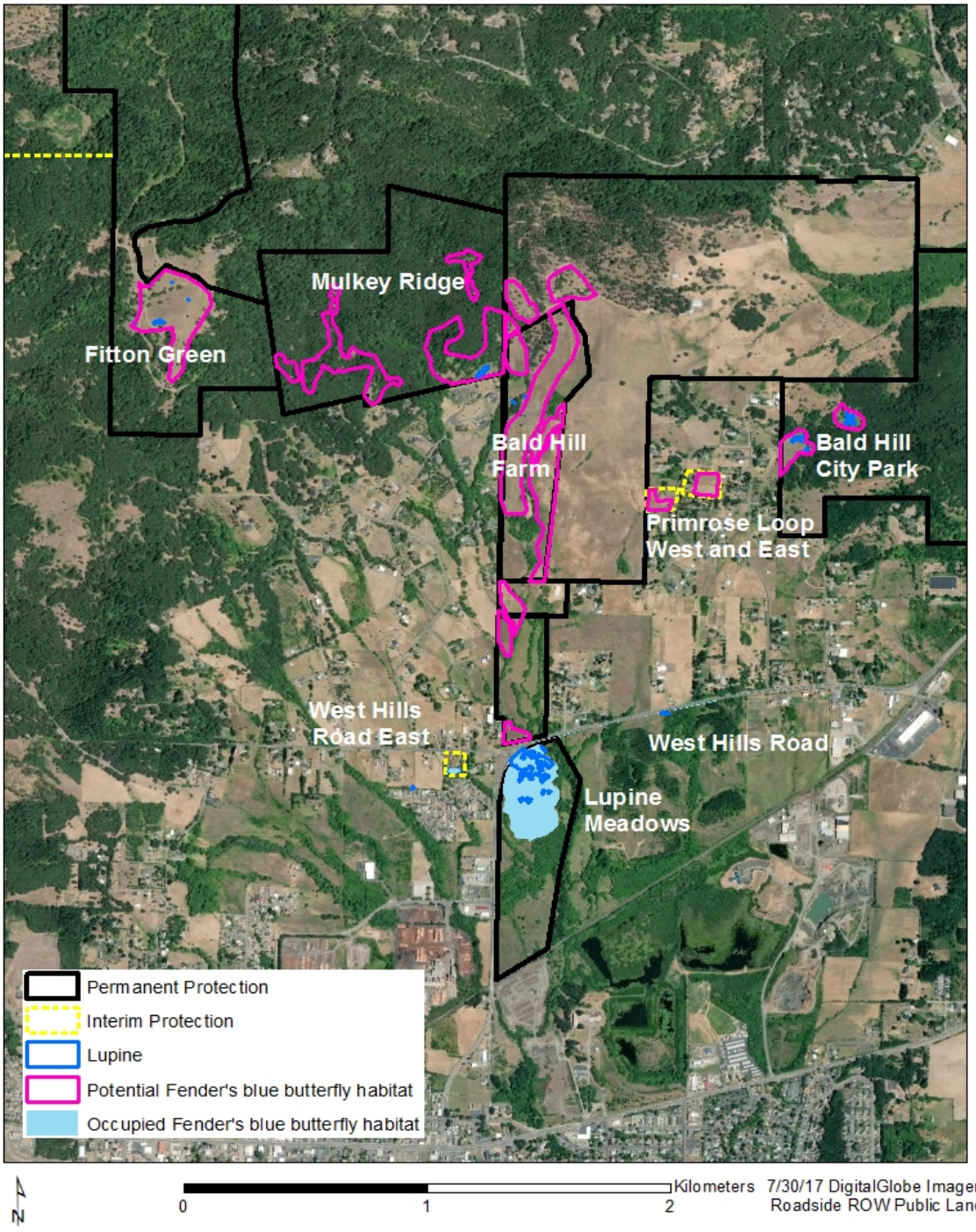

Figure 6.5 Lupine Meadows Potential Metapopulation Expansion.

The following six potential expansion sites occur in the Lupine Meadows Metapopulation area: Bald Hill Farm, Mulkey Ridge, Fitton Green, Bald Hill City Park, Primrose Loop East and West sites. The Primose East and West sites are private lands with interim protections under PFW and SHA programs, and both landowners have expressed interest in planting lupine on their properties. The other four potential expansion sites are considered permanently protected. The GLT owns and manages the Bald Hill Farm and Mulkey Ridge sites and intend to plant lupine on approximately 35 acres of Bald Hill Farm in the next 5 years and on portions of the Mulkey Ridge site in the next 10 years. In 2017, a remnant lupine patch of approximately 100 plants was discovered in a clearing on the Mulkey Ridge property (shown on Figure 6.5) which indicates the site may be suitable for lupine expansion. The Fitton Green site is owned by Benton County and is identified as a prairie conservation area in their HCP (Benton County 2010, p. 39). The County has been managing the habitat to improve prairie conditions and has successfully established a few small lupine patches totaling approximately 0.5 m^2. The Bald Hill City Park site is owned by the City of Corvallis, but to our knowledge, they currently have no plans to expand the lupine habitat on the property.

GLT and Benton County have consistently demonstrated success with improving prairie habitat conditions for Fender's blue butterfly, however restoration efforts in this zone are somewhat limited by lupine seed availability. Currently, the butterfly population at Lupine Meadows is very small and there is not enough lupine seed available to support this scale of Fender's blue butterfly habitat expansion. However, the Service is working with conservation partners, including GLT, to increase lupine seed availability for the Corvallis Recovery Zone. If an adequate supply of lupine seed were to become available for the planned Fender's blue butterfly restoration, the Service could consider augmenting the existing butterfly population to improve persistence probability in the Lupine Meadows Metapopulation. The Service anticipates Fender's blue butterfly distribution is moderately likely to expand from Lupine Meadows across Bald Hill Farm and Mulkey Ridge to Fitton Green over the next 25–35 years, but unlikely to expand across the Primrose sites to Bald Hill City Park.

6.3.3.5 Greasy Creek Potential Metapopulation Expansion

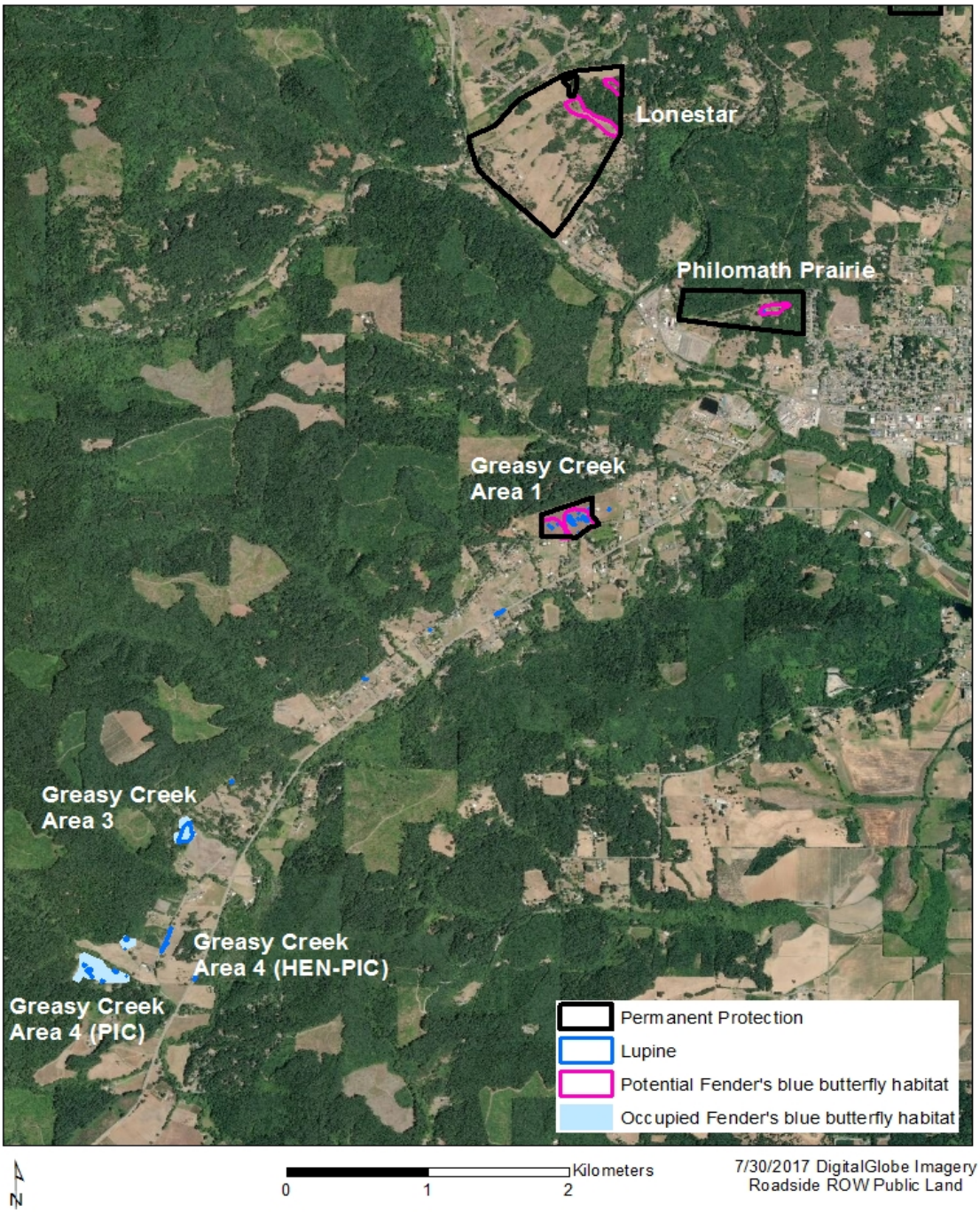

Figure 6.6 Greasy Creek Potential Metapopulation Expansion.

The following three potential expansion sites have permanent protection in the Greasy Creek Metapopulation area: Greasy Creek Area 1, Philomath Prairie, and Lonestar (Figure 6.6). The Greasy Creek Area 1 site was purchased by ODOT to serve as a mitigation site for Fender's blue butterfly impacts associated with routine road maintenance and bridge replacement activities. Although currently unoccupied by Fender's blue butterfly, the site has several remnant lupine patches and is approximately 3 km (1.9 mi) from the Greasy Creek Area 3 Fender's blue butterfly population. IAE is developing an updated Planting Plan for the site with the goal of increasing lupine, which has been planted annually since 2015, and nectar abundance for Fender's blue butterfly. While the Philomath Prairie site is protected, there are no to implement habitat restoration treatments on the property. Over a decade ago, Kincaid's lupine and nectar species were seeded at this remnant prairie site, but it is unclear if any of the plants survived. GLT holds a conservation easement on the Lonestar site and intends to establish Kincaid's lupine patches across a 4-ha (10-ac) area. GLT has been actively improving habitat conditions at Lonestar for several years and plans to seed Kincaid's lupine on a 1.2-ha (3-ac) area in the next couple of years.

None of the currently occupied sites in this metapopulation are managed for butterfly recovery, so butterfly abundance in the metapopulation is not expected to increase. Although Lonestar and Philomath Prairie are protected sites, with the potential to support Fender's blue butterfly over the next 50 years, the Service believes it is unlikely Fender's blue butterfly will disperse to these sites from currently occupied sites.

The Greasy Creek Area 1 site is 3 km (1.9 mi) from the Greasy Creek Area 3 butterfly population, and remnant lupine patches between the two sites could provide stepping stone habitat for dispersal to the site. The Service could also relocate butterflies from the currently unprotected and managed sites (Areas 3 and 4) if adequate lupine and nectar habitat is restored to the Greasy Creek Area 1 site. Establishing a butterfly population on protected and managed land in this metapopulation would likely improve metapopulation stability and increase the likelihood of persistence over the next 50 years. The Service believes butterfly expansion is somewhat likely to occur at the Greasy Creek Area 1 site over the next 25–35 years.

6.3.3.6 Finley Potential Metapopulation Expansion

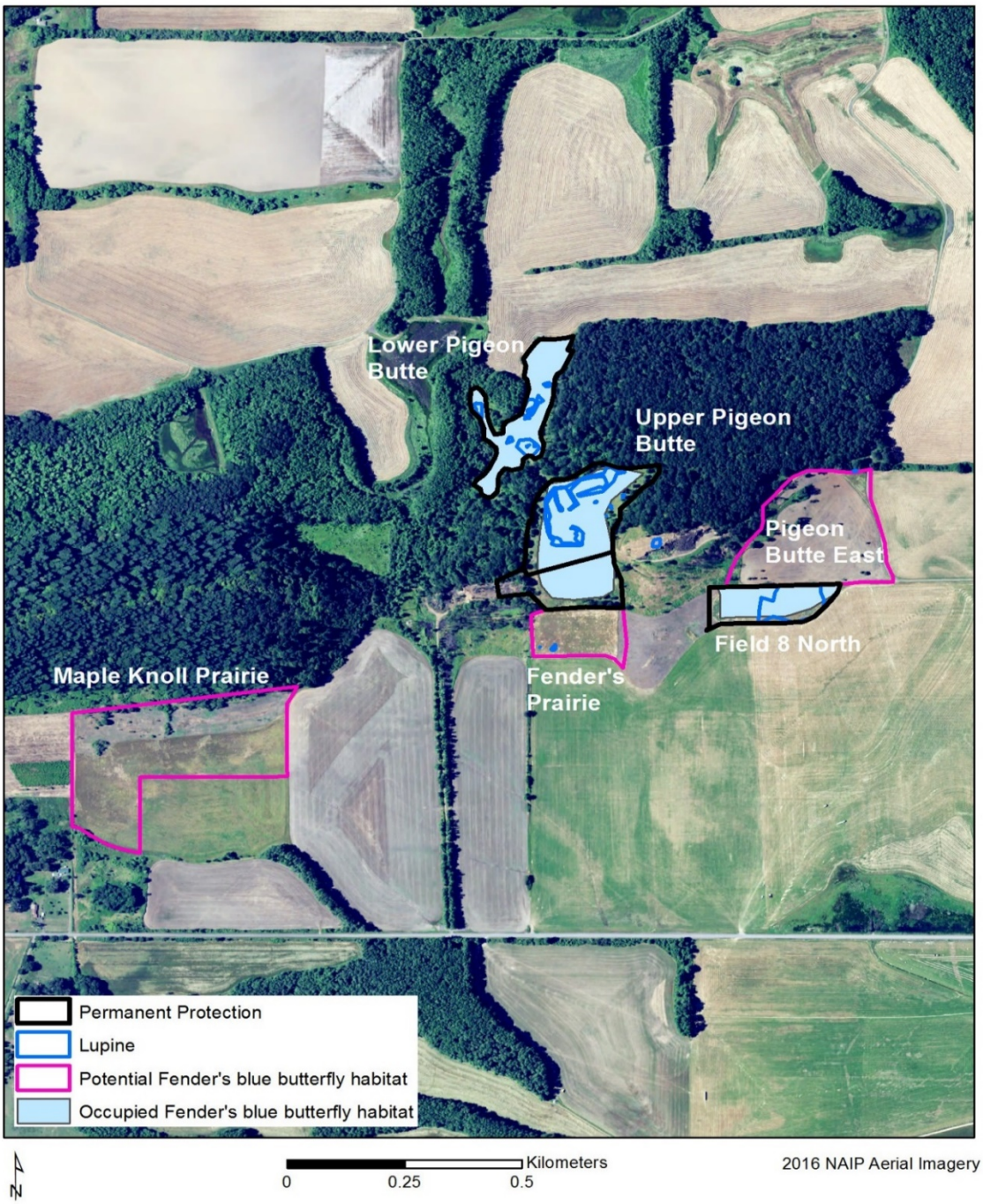

Figure 6.7 Finley Potential Metapopulation Expansion.

The following three potential expansion sites are located on Service land within the Finley Refuge boundary: Maple Knoll, Pigeon Butte East and Fender's Prairie (Figure 6.7). In 2016, the WVNWRC staff developed a Fender's blue butterfly management plan for their land in the Finley metapopulation, including the potential expansion sites (WVNWRC 2016, p. 14). Fender's Prairie was seeded with native bunchgrasses and forbs in the fall of 2014, and Kincaid's lupine plugs were planted in the spring of 2015, 2017 and 2018. Kincaid's lupine was also seeded at Fender's Prairie in the fall of 2017 and 2018. For several years, refuge staff have been preparing Maple Knoll and Pigeon Butte East for seeding. Refuge plans include planting native bunchgrasses and forbs in the fall of 2019 and Kincaid's lupine by 2022. Additionally, Refuge biologists intend to create a lupine patch between Fender's Prairie and Maple Knoll to improve connectivity.

All of the currently occupied sites in this metapopulation are actively managed to control weeds, and the Service anticipates habitat conditions will improve and butterfly abundance will increase over the next decade. The shortage of Kincaid's lupine seed for the Corvallis Recovery Zone may delay lupine plantings, but the Service is committed to establishing adequate habitat for a viable Fender's blue butterfly population. As described in Appendix C, *Metapopulation Descriptions for Current Conditions*, the Finley butterfly population was introduced in 2015, and the population appears to be stable with natural expansion occurring into the surrounding landscape (8 North Site). Refuge biologists have plans to continue to improve connectivity and increase species abundance in the occupied areas. Given all three potential expansion sites are free from barriers to movement and within easy dispersal distance of existing butterfly populations, they are highly likely to become occupied by Fender's blue butterfly in the next 25–35 years, thus improving metapopulation viability.

6.3.3.7 Oak Basin Potential Metapopulation Expansion

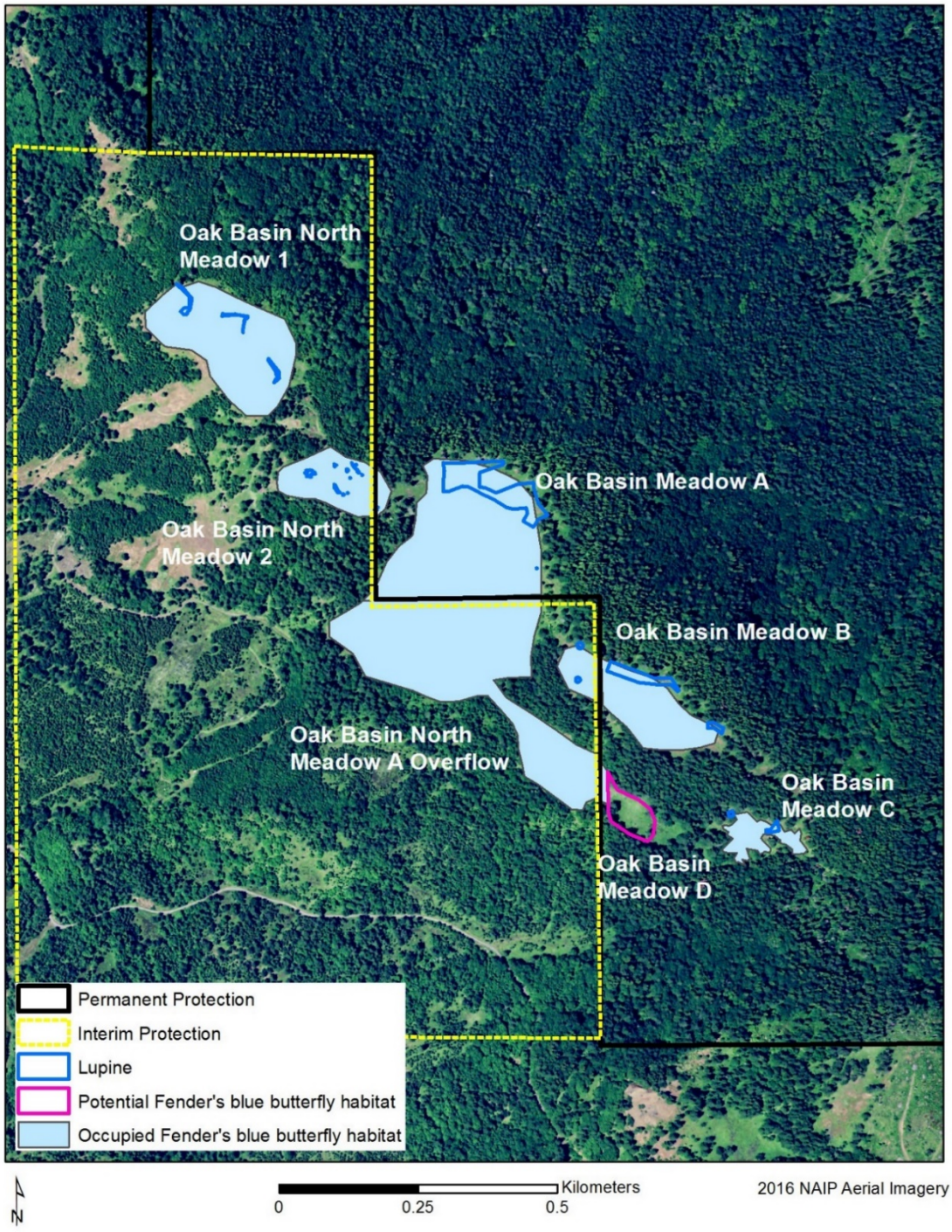

Figure 6.7 Oak Basin Potential Metapopulation Expansion.

The following two potential expansion sites occur in the Oak Basin Metapopulation: Oak Basin Meadow D and North Meadow A Overflow (Figure 6.7). Oak Basin Meadow D is owned by BLM who have contracted IAE to implement site preparation treatments at the meadow for future lupine plantings. BLM has initiated a lupine seed collection project in order to have seed to plant in Meadow D in the future. The North Meadow A Overflow site is privately owned and is being managed under a PFW agreement with the Service. Fender's blue butterfly was documented dispersing through the private land (Severns 2008, p. 9), so planting lupine in this meadow could improve butterfly connectivity. The private landowners have expressed interest in increasing lupine density and distribution on their property.

Lupine and butterfly abundance are expected to improve at existing and potential sites over the next 10 years since they will likely continue to be managed to improve habitat conditions. Both expansion sites are within dispersal distance of existing populations and free from barriers to movement so they are highly likely to become occupied in the next 25–35 years, and these sites are expected to improve butterfly connectivity and metapopulation stability.

6.3.3.8 West Eugene Potential Metapopulation Expansion

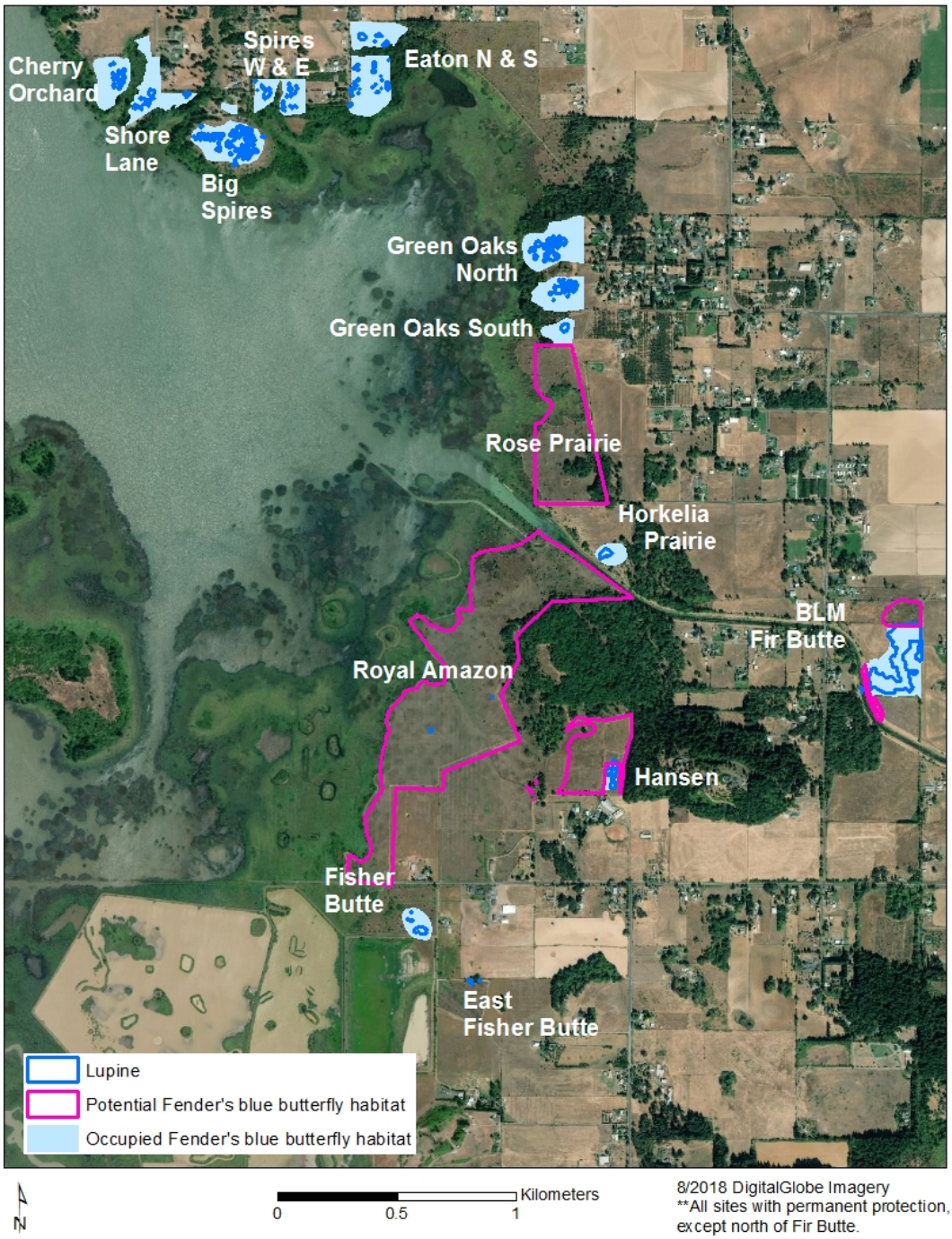

Figure 6.8 West Eugene Potential Metapopulation Expansion.

Cherry Orchard, Royal Amazon, Hansen, and Fir Butte sites are four potential expansion sites in the West Eugene metapopulation. The Cherry Orchard and Royal Amazon sites are owned by the USACE and have potential to support Kincaid's lupine habitat. In 2015, the USACE planted lupine at the Cherry Orchard site, and Fender's blue butterfly was documented occupying the site in 2018. Most of the Royal Amazon site is too wet to support Kincaid's lupine, but the USACE was able to establish a small patch of lupine on upland mounds within the wet prairie. The area highlighted in pink on Figure 6.8 includes small areas of upland potential at the Royal Amazon site and the USACE is considering planting lupine in this area to establish additional butterfly stepping stone patches. The Hansen site is owned by the BLM and in 1999, Kincaid's lupine was introduced to a small area in the southeastern corner of the property. Fender's blue butterfly was first observed occupying that small habitat patch in 2010 (Fitzpatrick 2013a, pp. 144-147). The BLM's West Eugene Wetlands Resource Management plan identifies the Hansen site as an area for expansion to support Fender's blue butterfly recovery goals. The area site to the north of Fir Butte is privately owned and the landowner has expressed interest in working with BLM to improve habitat conditions to promote lupine expansion on the property.

The USACE and BLM biologists have successfully expanded Fender's blue butterfly distribution and improved connectivity with stepping-stones across the area for many years, with demonstrated success at Horkelia Prairie, Big Spires and Cherry Orchard. BLM has increased lupine and Fender's blue butterfly distribution within their Fir Butte site. We anticipate the expansion will continue in this area over the next 50 years as outlined in the agencies' respective planning documents and it is highly likely Fender's blue butterfly expansion will continue across the West Eugene metapopulation.

6.3.3.9 Willow Creek Potential Metapopulation Expansion

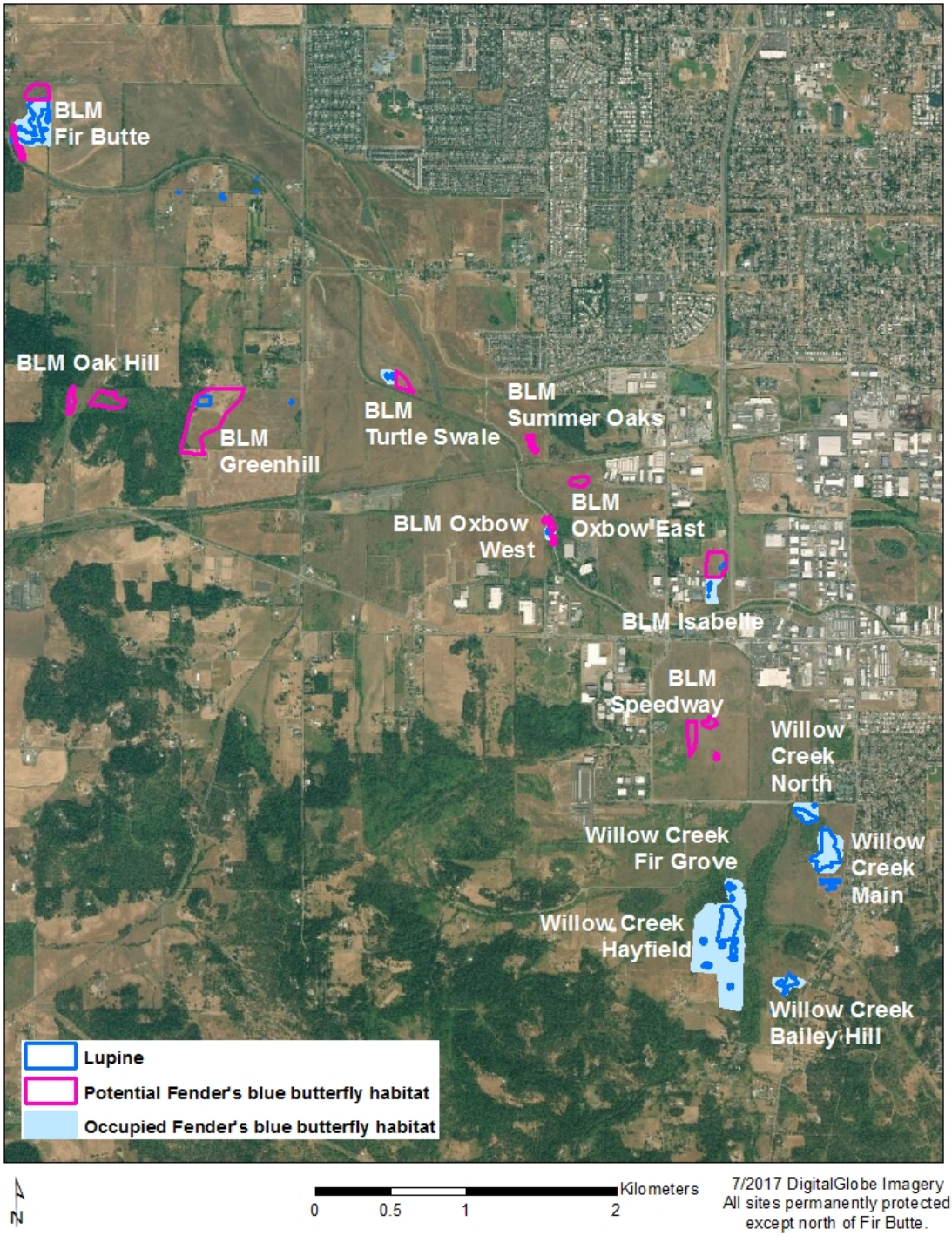

Figure 6.9 Willow Creek Potential Metapopulation Expansion.

The 11 potential expansion sites identified in the Willow Creek Metapopulation are owned and managed by the BLM (Figure 6.9). All of these sites are identified in the BLM/s West Eugene Wetlands Resource Management plan (BLM 2015) as areas they intend to restore to meet Fender's blue butterfly recovery goals. To our knowledge, the BLM does not have a specific timeline for planting lupine at these sites, but they have contracted the IAE to establish lupine seed production fields in order to have the necessary seed to implement planned restoration in the metapopulation. The expansion sites are within dispersal distance of existing populations and free from barriers to movement so at least a portion of these sites are highly likely to become occupied in the next 25–35 years, which we anticipate will improve butterfly connectivity and metapopulation stability.

6.3.3.10 Muddy Valley Potential Metapopulation

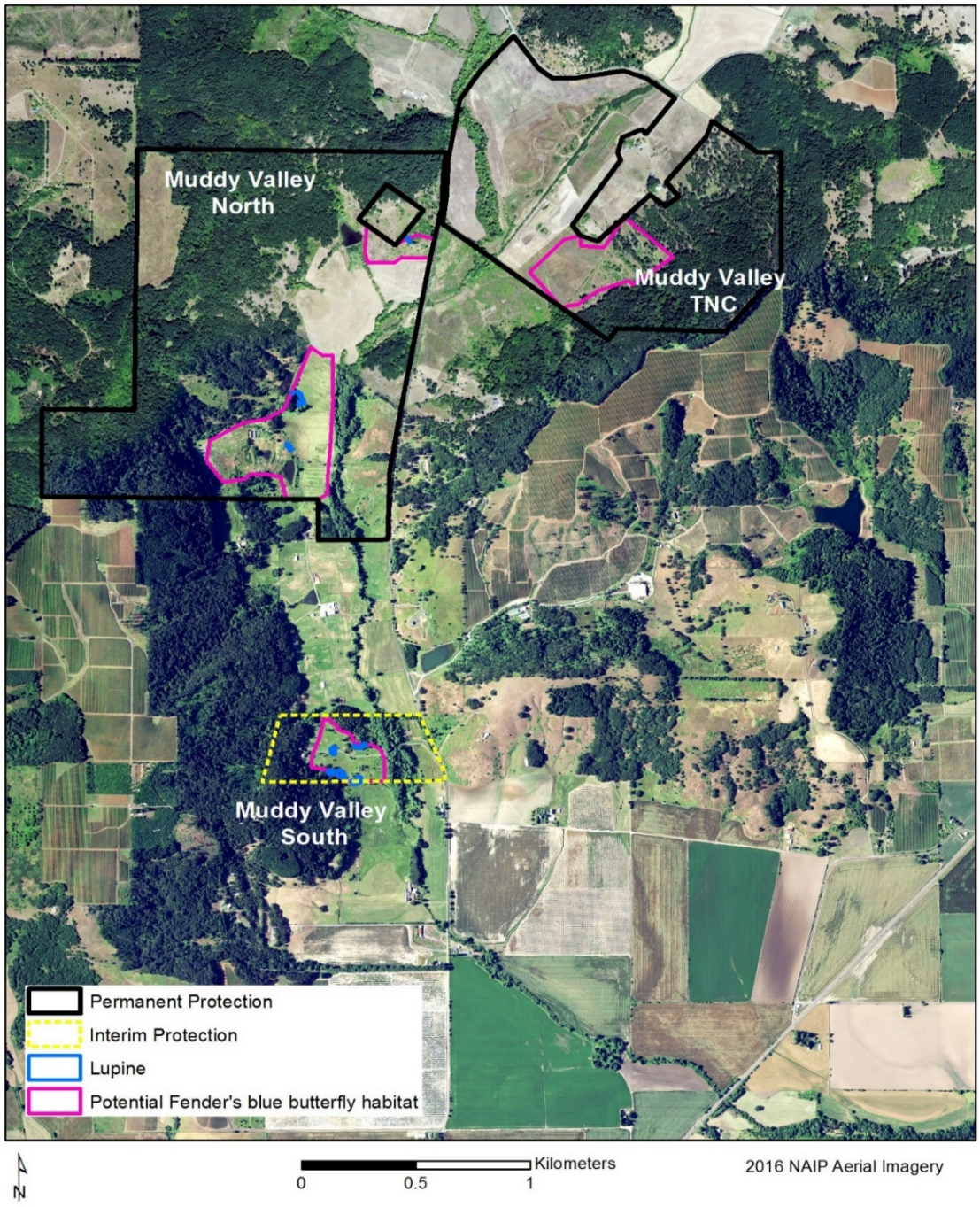

Figure 6.10. Muddy Valley Potential Metapopulation.

Muddy Valley does not currently support Fender's blue butterfly. However, this area has three potential sites with permanent (Muddy Valley North and Muddy Valley TNC) and interim (Muddy Valley South) protection that are being managed for Fender's blue butterfly habitat to create a metapopulation. The Yamhill SWCD holds a conservation easement for the Muddy Valley North site and acquired the Muddy Valley TNC site in 2019. The Muddy Valley South site has a PFW agreement and SHA, and the Yamhill SWCD is working collaboratively with the landowner and the Service to improve habitat conditions on the property. The Muddy Valley North and South sites have remnant Kincaid's lupine patches that will likely spread over the next several years, as a result of ongoing habitat management. The Muddy Valley TNC site does not currently support lupine, but is suitable for introduction and Yamhill SWCD is likely to plant lupine at the site in the next 25 years.

Although it will be many years before these sites would be ready for Fender's blue butterfly introduction, the Yamhill SWCD's draft HCP identifies a goal of introducing Fender's blue butterfly to Muddy Valley (Yamhill SWCD 2018, Appendix B, p. 20). During the HCP planning process, the Service agreed to a "good neighbor" policy (Yamhill SWCD 2018, Appendix B, p. 21) which should simplify the regulatory process associated with introducing Fender's blue butterfly to an unoccupied metapopulation area. Therefore, if all three sites were successfully restored with adequate lupine abundance and distribution, we could consider introducing Fender's blue butterfly to the area. Therefore, we believe that Fender's blue butterfly is somewhat likely to occupy Muddy Valley in the next 25–35 years.

To summarize, under the Conservation Efforts scenario it is likely that some degree of expansion will occur in 9 of the 15 existing metapopulations and there is potential for creation of a brand new metapopulation (Table 6.6). These changes will occur because of habitat improvement, abundance augmentation, and reintroduction. We anticipate these changes will improve conditions in 6 of the 15 metapopulations.

Table 6.6. Forecasted condition of Fender's blue butterfly metapopulations under the Conservation Effort scenario.

Metapopulation	**Current Condition (as of 2016)**	**Conservation Effort Scenario Condition**
Salem Recovery Zone		
Baskett	High	High
Gopher Valley	Moderate	High
Hagg Lake	High	High
Moores Valley	Possible Extirpation	Possible Extirpation
Oak Ridge	Moderate	Moderate
Turner Creek	Low	Moderate

Corvallis Recovery Zone		
Butterfly Meadows	Low	Low
Finley	Moderate	High
Greasy Creek	Low	Moderate
Lupine Meadows	Low	Moderate
Wren	High	High
Eugene Recovery Zone		
Coburg Ridge	Low	Low
Oak Basin	Low	Moderate
West Eugene	High	High
Willow Creek	High	High

6.3.4 Summary of Viability

For the purposes of creating a risk profile to evaluate the potential future condition of Fender's blue butterfly over the next 25 to 35 years, we considered the possible condition of the species under three plausible future scenarios. Our goal was to describe the viability of the species in a manner that will address the needs of the species in terms of future resiliency, redundancy, and representation. We considered a range of potential scenarios that we think incorporate important influences on the status of the species, and that are reasonably likely to occur. We additionally forecast the relative likelihood of each scenario occurring, based on our experience with the species and best professional judgment. Our results describe a range of possible conditions in terms of future viability of the Fender's blue butterfly (Tables 6.7 and 6.8).

Table 6.7. Comparison of the number of metapopulations under each condition rank currently and across all three future scenarios.

	Number of Metapopulations			
Condition Rank	**Current Condition**	**Continuing Efforts Scenario Condition**	**Considerable Impacts Scenario Condition**	**Conservation Effort Scenario Condition**
High	5	6	5	7
Moderate	3	2	1	5
Low	6	4	2	2
Possible Extirpation	1	3	7	1
Likelihood of Scenario at 25-35 years		Highly likely	Somewhat Likely	Moderately Likely

As a species that depends upon disturbance to maintain its early seral prairie habitat, Fender's blue butterfly is reliant upon ongoing management to set back succession and control invasive tall grasses and woody plant species since the natural historical processes that once maintained this ecosystem are now largely absent from the Willamette Valley. Whether management to restore and maintain prairie systems in the Willamette Valley continues, and similarly to maintain populations of its lupine host plant and nectar resources, is therefore an important consideration in our evaluation of the future viability of the species.

Table 6.8. Summary condition rankings for each metapopulation under current conditions and across all three future scenarios

Metapopulation	Current Condition (as of 2018)	Continuing Efforts Scenario Condition	Considerable Impacts Condition	Conservation Effort Scenario Condition
Salem Recovery Zone				
Baskett	High	High	High	High
Gopher Valley	Moderate	Moderate	Low	High
Hagg Lake	High	High	High	High
Moores Valley	Possible Extirpation	Possible Extirpation	Possible Extirpation	Possible Extirpation
Oak Ridge	Moderate	High	Moderate	Moderate
Turner Creek	Low	Low	Possible Extirpation	Moderate
Corvallis Recovery Zone				
Butterfly Meadows	Low	Low	Possible Extirpation	Low
Finley	Moderate	Moderate	Low	High
Greasy Creek	Low	Possible Extirpation	Possible Extirpation	Moderate
Lupine Meadows	Low	Possible Extirpation	Possible Extirpation	Moderate
Wren	High	High	High	High
Eugene Recovery Zone				
Coburg Ridge	Low	Low	Possible Extirpation	Low
Oak Basin	Low	Low	Possible Extirpation	Moderate
West Eugene	High	High	High	High
Willow Creek	High	High	High	High

Under Scenario 1 – Continuing Efforts, we assume that current influences on viability will continue at the same level as will current habitat management and conservation measures. This scenario leads several metapopulations currently ranked as moderate to improve in condition over time, as conservation efforts continue. On the other hand, metapopulations that are currently in low condition or already at risk of extirpation would likely either remain in that state or might degrade in condition from low to possible extirpation. Overall, we expect that the viability of Fender's blue butterfly under this scenario would improve relative to its current condition, characterized by increases in resiliency of existing metapopulations. There would be six metapopulations in high condition, two in moderate condition, four in low, and three at risk of possible extirpation. There would be at least one metapopulation in high condition in each of the three recovery zones; the Salem recovery zone would be in the best condition, with three metapopulations in high condition, whereas resiliency of metapopulations would be lowest in the Corvallis recovery zone, with three of five metapopulations ranked either low or at risk of extirpation. Thus, there is a possibility for some loss of redundancy, with the Corvallis recovery zone at greatest risk. We anticipate that most, but not all, of the current metapopulations would persist under this scenario.

Under Scenario 2 – Considerable Impacts, we assume an increase in the influence of negative factors affecting the resources required by Fender's blue butterfly as a result of climate change. Specifically, we considered the potential for an increase in invasive nonnative plants and assumed that woody succession may become more prolific under the future environmental changes forecast. We did not presume that management actions for the species would cease, but we did assume that the effectiveness of such management efforts would be more limited under this future scenario. Under this scenario, we would expect losses in resiliency and redundancy with seven metapopulations subject to possible extirpation. However, all recovery zones would still maintain at least one metapopulation in high condition; the Salem recovery zone would be at the least risk, as it would retain one metapopulation in moderate condition and two in high. We therefore anticipate that under these conditions, Fender's blue butterfly would persist, but its long-term viability in terms of resiliency, redundancy, and representation would be diminished.

Under Scenario 3 – Conservation Effort, we assume that in addition to efforts currently underway as in the Continuing Efforts scenario, conservation actions to improve habitat conditions increase over current levels. Additionally we assume that some augmentation or translocation of butterflies may occur at sites with high potential to expand existing metapopulations or introduce Fender's blue butterfly to sites that are currently unoccupied. We assumed it was most reasonable to limit our consideration of these increased conservation efforts to sites that are already protected and managed. Under this scenario, we expect that viability of Fender's blue butterfly would be characterized by increased resiliency as several metapopulations remain at or move into high condition, with others transitioning from low to moderate condition. Under this scenario there would be seven metapopulations in high condition, five in moderate condition, two in low condition and one at risk of extirpation, and all recovery zones would have a minimum of two metapopulations in high condition. Redundancy and representation would be maintained in all recovery zones. We anticipate that all of the current

metapopulations would persist under this scenario, with the exception of Moores Valley, which is small and at risk of extirpation under all scenarios considered.

6.4 Status Assessment Summary

The Fender's blue butterfly had made considerable gains since being listed in 2000. As a whole, the species has a greater chance of withstanding stochastic events (resiliency), surviving potentially catastrophic events (redundancy), and adapting to changing environmental conditions (representation) due to an increased number of metapopulations, composed of a greater number of individuals and with expanded distribution and connectivity across the range since listing. Persistence will require addressing influences on viability including (1) habitat conversion; (2) alteration of natural and human-mediated disturbance processes resulting in habitat succession; (3) invasion by nonnative plants; (4) insecticides and herbicides; and continued conservation and management efforts.

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Appendices

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APPENDIX A: Glossary[1]

Adaptive Capacity. The capacity for an organism to adapt in response to changes in its environment, governed by genetic diversity. Such changes can be expressed through characteristics or behavior. When information regarding the underlying degree of genetic diversity is absent, representation through behavioral or ecological diversity is used as a proxy for adaptive capacity.

Age structure refers to the distribution of individuals amongst various age classes in a population**.**

Alluvial soils. Fine**-grained fertile soil deposited by water** flowing over flood plains or in river beds.

Barrier. As used in this SSA report, specific to Fender's blue butterfly we define a barrier as a structural component of the landscape that reduces the likelihood of Fender's blue butterfly movement. Based on our understanding of the butterfly's behavior, we expect that barriers would include roads with four or more lanes of traffic, large bodies of water (*e.g.*, lakes), ridgelines, and dense forest with canopy cover greater than 90 percent.

Calyx. The sepals of a flower, typically forming a whorl that encloses the petals and forms a protective layer around a flower in bud

Chrysalis. The pupal stage that moths and butterflies enter after the larval stage. It is an immobile stage, but one in which considerable internal activity is occurring as adult structures are formed.

Connectivity refers to the degree to which the landscape facilitates or impedes movement between patches of habitat or resources utilized by an organism, and is highly species specific (i.e., the degree of connectivity will in large part depend upon the behavior, movement capability, and resource requirements of the organism, and will therefore vary between species).

Demographics are the numerical characteristics of a population. Typically used to understand how a species changes over time, demographics can be expressed as numbers, rates, and trends. In the SSA we are interested in how the demographic characteristics are influenced by natural or human caused events, and how characteristics such as population size (abundance), mortality

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[1] In this glossary we occasionally differentiate between terms as used in this document and as used in the Recovery Plan. In the latter instance, we are referring to the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (USFWS 2010).

rates and recruitment (the number of juveniles moving to adulthood) rates are influencing population growth over time; from which you can develop a trend in population growth.

Demographic stochasticity refers to the variability in population growth rates arising from random differences among individuals in survival and reproduction within a season. This variability will occur even if all individuals have the same expected ability to survive and reproduce and if the expected rates of survival and reproduction don't change from one generation to the next. Even though it will occur in all populations, it is generally important only in populations that are already fairly small.

Diapause. A period of suspended growth or development, characterized by greatly reduced metabolic rate.

Dispersal refers to the movement of individuals; movement may be away from their place of birth to a breeding site (natal dispersal), or away from one existing population or breeding site to another (breeding dispersal). Dispersal usually, but not always, refers to movement that is likely to result in gene flow.

Dopamine. A neurotransmitter in the brain produced when an animal expects or receives a reward or experiences pleasure, and which can therefore trigger reinforcing reward/response or addictive behaviors.

Dorsal. Of or relating to the side of an organism that is normally directed upward in a normal stance; the top or back side of an organism.

Early seral. A seral community is the name given to each group of plants in the various stages of ecological succession as a system advances from an unvegetated state towards its climax (final stage) community. For prairie systems in the Willamette Valley, **early seral** refers to a community of grasses and herbaceous plants (forbs). If allowed to proceed through ecological succession without disturbance (e.g., fire), woody plants (shrubs) and trees will start to appear and over time the grassland community will be lost. Disturbance "sets back" succession and maintains the early seral condition.

Ecological settings are areas representative of geographic, genetic, or life history variation throughout a species' range.

Environmental stochasticity refers to unpredictable fluctuations in environmental conditions, often resulting from weather, disease, and predation or other factors external to the population. Environmental stochasticity influences the variability of birth and death rates and thus how population abundance fluctuates and affects species viability

Extirpation refers to the "localized" extinction of an organism from a particular geographic area. In such a case, representatives of the species are still found elsewhere. Extirpation differs

from extinction, which describes the situation where no single individual of the species remains anywhere on the earth.

Fecundity. The capacity to produce offspring; reproductive capability.

Flight Period. The adult stage of a butterfly's life cycle.

Genetic diversity. The variation in the amount of genetic information within and among individuals of a population, a species, an assemblage, or a community. Genetic diversity provides the adaptive capacity for organisms to adapt to changing environments. With more variation, it is more likely that some individuals in a population will possess variations of genes that may be suited for their new environment.

Genetic stochasticity refers to changes in the genetic composition of a population unrelated to systematic forces (selection, inbreeding, or migration), i.e., genetic drift. It can have a large impact on the genetic structure of populations, both by reducing the amount of diversity retained within populations and by increasing the chance that deleterious recessive alleles may be expressed.

Geomean is a type of average used for growth rates that is computed by multiplying *n* variables and then taking the *n* square root. This is different from the arithmetic average mean because it multiples numbers rather than adding numbers and can only be used with positive numbers.

Heterozygosity. Genes come in pairs, called alleles, and each pair is located in a specific position (or locus) on a chromosome. If the two alleles at a locus are identical to each other, they are homozygous; if they are different from one another, they are heterozygous. At the population level, heterozygosity is commonly used as a measure of genetic variability; it is the average proportion of organisms within the population that are heterozygous for a specified set of gene loci (they possess different alleles for the same gene). Higher levels of heterozygosity are generally correlated with increased adaptive capacity.

Host plant. A particular plant species that provides food resources or substrate for certain insects or other organisms. Some animals can use a variety of potential host plant species, and some are highly specialized and will require a few or only one very specific host plant.

Independent groups. As used in this SSA report, independent groups refer to occurrences of Fender's blue butterflies that are more than 2 km (1.2 mi) from any other known occupied site and/or are separated by barriers from other occupied sites such that butterflies are unable to interact.

Independent populations is a term used in the Recovery Plan, referring to any populations of Fender's blue butterfly that did not meet **metapopulation criteria** as defined in that Recovery Plan.

Inflorescence. A group or cluster of flowers**;** the complete flower head of a plant including stems, stalks, bracts, and flowers.

Instar. Any intermoult stage in the development of an arthropod.

Interim protection. We use this term to refer to conservation protections that have a relatively limited lifespan, as in conservation agreements with a term of decades, as opposed, for example, to protections in perpetuity that are part of the deed to the property. Examples include Safe Harbor Agreements or Habitat Conservation Plans, which may have terms from 10 to 50 years or more.

Keel. The two lower fused petals of a pea flower (including lupines), which form a boat-like structure around the stamens and styles.

Larva (s.); Larvae (pl.). The immature, wingless, feeding stage of an insect that hatches from an egg and undergoes complete metamorphosis to become an adult. In butterflies, the larval form is a caterpillar.

Life history. All stages of growth and reproduction within a species and the influences on each stage.

Lycaenid butterflies. Butterflies in the family Lycaenidae (which includes the blue butterflies).

Maximum separation distance. A term from the Recovery Plan pertaining to Fender's blue butterfly, defined as approximately 2 km (1.2 mi) from the next nearest subpopulation based on flight distance data (USFWS 2010, p. IV-10).

Metamorphosis. The process of transformation from an immature form to an adult form in two or more distinct stages.

Metapopulation. A group of spatially separated populations of a species in the same general geographic area, and which interact through the occasional exchange of individuals. If immigration and emigration of individuals between the groups were relatively frequent, such a situation would more accurately be described as simply a population.

Microtopography. The surface features or contours of the earth which create a great variety of environmental conditions that favor the unique requirements of many different species of plants, resulting in a more heterogenous community.

Minimum patch size. For Fender's blue butterfly, defined as 6 ha (15 ac) in the Recovery Plan, based on modeling done by Crone and Schultz (2003, p. 575).

Natal refers to the place or time of birth.

Nectar (n.); Nectar (v.). Nectar refers to a liquid rich in sugars produced by flowering plants to attract pollinators by providing a rich source of nutrients. Adult butterflies feed exclusively on flower nectar, and the act of feeding by butterflies is referred to as "nectaring." Different flower species produce nectars that can vary widely in their sugar content, and thus likewise vary in quality as a nutrient source.

Metapopulation (as used in this SSA). Several potentially interacting groups of Fender's blue butterflies that are within 2 km (1.2 mi) of one another and not separated by ***barriers***.

Network. The Recovery Plan defined a "functioning network" as a metapopulation of potentially interacting subpopulations (3 or more), each occupying habitat of at least the minimum patch size (6 ha (15 ac)) and separated by no more than the maximum separation distance (2 km (1.2 mi)) or connected by stepping-stone patches of lupine and nectar plants less than 1 km (0.6 mi) apart (USFWS 2010, p. IV-10).

Obligate. Essential or required; non-discretionary; restricted to a particular resource or function.

Oviposit. The act of egg laying by a female insect.

Palmate. A leaf type that is shaped like an open palm or like a hand with the fingers extended, having four or more lobes or leaflets radiating from a single point.

Patch. As used in this SSA report, "patch" refers to a discrete grouping of habitat elements required by Fender's blue butterfly, and may be used to refer to either distinct groups of lupine plants or areas of prairie habitat that contain both lupine and nectar plants.

Perennial. A plant that lives more than 2 years, as opposed to annuals (that live only a single season) or biennials (that live for only two seasons).

Persistence refers to the ability of a population to sustain itself over time.

Petiole. The stalk that joins a leaf to a stem.

Phenotype. The observable features of an individual organism, resulting from the interaction between the genotype and the environment in which development occurs.

Poikilothermic. Referring to body temperature regulation in animals**,** a poikilotherm is an organism whose internal temperature varies considerably, usually as a consequence of variation in the ambient environmental temperature (traditionally thought of as a "cold blooded" animal). It is the opposite of a homeotherm, an organism capable of internally regulating and maintaining a relatively constant body temperature ("warm blooded" animals).

Population is typically defined as a group of interbreeding individuals or organism that are more apt to breed among that group than outside the group. There are however, many approaches to

defining species populations. Consistently problematic is defining population boundaries so that the number of populations can be clearly determined. Geneticists use measures of gene flow and genetic differentiation to distinguish one population from another. In a demographic sense, this can be achieved by careful measures of individual movement, which enables the delineation of populations that are sufficiently isolated from each other to have independent dynamics. Populations can also be distinguished with the use of some arbitrarily defined spatial and/or temporal context (e.g. linear distance between groups, or the presence of geographical barriers or other spatial disjunctions) or differences in phenology, morphology or physiology.

Population viability analysis (PVA) describes the process by which data and models are evaluated to determine the risk of population extinction for a particular species over some given time frame and under specified conditions.

Proboscis. An elongated sucking mouthpart that is typically tubular and flexible, used for feeding.

Productivity as used here refers to numbers of offspring produced.

Pupa (s.); Pupae (pl.). An inactive phase between larval and adult stages in some insects. While locomotion and feeding are absent, extensive developments take place in the formation of adult structures within the pupa, which in butterflies and moths is also called a chrysalis.

Recruitment. The increase in a natural population as a result of successful reproduction and survival as well as immigration.

Redundancy describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand or can bounce back from catastrophic events; combined with resiliency and representation to form the three-pronged biodiversity principles.

Representation describes the ability of a species to adapt to changing environmental conditions. Measured by the breadth of genetic or environmental diversity within and among populations, representation gauges the probability that a species is capable of adapting to environmental changes; combined with resiliency and redundancy to form the three-pronged biodiversity principles.

Resilience/Resiliency describes the ability of the populations to withstand stochastic events. Measured by the size and growth rate of each population, resiliency gauges the probability that the populations comprising a species are able to withstand or bounce back from environmental or demographic stochastic events; combined with representation and redundancy to form the three-pronged biodiversity principles.

Site. As used in this SSA report, a site refers to a specific management unit or land ownership designation. We identify sites separately because various land ownerships may have different degrees of habitat protection and/or are managed in different ways, and therefore merit consideration on an individual basis. Multiple sites may comprise a metapopulation or even an independent grouping of Fender's blue butterfly.

Stepping-stone habitat. Undeveloped open areas with the physical characteristics appropriate for supporting the short-stature prairie or oak savanna plant community.

Stochastic events refer to random or non-deterministic events. In the context of an SSA, the events of concern are those that disturb the species or its habitat that results in decreased population size or growth rate.

Stressor. Any factor or influence that has a negative effect on the resource needs, and thus the viability, of an organism.

Subpopulation. A subset or subdivision of a larger, more broadly distributed population.

Survivorship. The proportion of individuals from a particular cohort surviving at any given time.

Symbiotic refers to a relationship between organisms (usually of different species) which may or may not benefit one or both. Mutualism is the form of symbiotic relationship that is beneficial to both parties.

Type Specimen. The original specimen on which the description and name of a new species is based.

Ventral. Of or relating to the underside of an organism, or the side normally directed downward in a normal stance.

Viability is the ability of a species to sustain populations in the wild over time and avoid extinction. "Over time" means beyond specified time periods that are as long as possible given our ability to predict future conditions and that are biologically meaningful considering the life history of the species.

APPENDIX B: Excerpts from the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington[2]

Downlisting Criteria for Fender's Blue Butterfly

Reclassification from Endangered to Threatened will be considered for the Fender's blue butterfly when all of the following conditions have been met:

1. Distribution and abundance. Each recovery zone has one functioning network with a minimum count of 200 butterflies, distributed among three subpopulations, for at least 10 years; in addition to this network, there must be a second functioning network or two independent populations with butterflies present each year in each recovery zone (Table IV-2).

2. Habitat quality and management. Sites supporting populations of Fender's blue butterflies considered in Criterion 1(a)1 above must meet these criteria:

a. **Prairie quality.** Sites supporting populations of Fender's blue butterflies must be managed for high quality prairie habitat. High quality prairie habitat consists of a diversity of native, non-woody plant species, various nectar plants that bloom throughout the flight season of Fender's blue butterfly, low frequency of non-native plant species and encroaching woody species, and essential habitat elements (*e.g.*, nest sites and food plants) for native pollinators. At least one of the larval host plant species, *Lupinus sulphureus* ssp. *kincaidii, L. arbustus* or *L. albicaulis*, must be present. See Appendix D for suggested criteria for evaluating prairie quality and diversity.

b. **Security of habitat.** A substantial portion of the habitat for each population should either be owned or managed by a government agency or private conservation organization that identifies maintenance of the Fender's blue butterfly and the prairie ecosystem upon which it depends as the primary management objective for the site, or the site must be protected by a permanent or long-term conservation easement or covenant that commits present and future landowners to the conservation of the species.

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[2] Tables and Figures, including their headings and numbering scheme, appear as they do within the Recovery Plan.

Table IV-2. Distribution and Abundance Goals for Fender's Blue Butterfly.

DOWNLISTING GOALS

Downlisting goals are set at a 90% probability of persistence for 25 years. Attainment of these population targets in all three recovery zones, together with the criteria for distribution, habitat quality and management described in the text, would indicate that the species' status has improved and could be considered for reclassification to threatened. Note that the minimum population size in the table represents the minimum population count in a network in each of 10 consecutive years. The average population size in a network corresponding to these minima would be substantially larger.

Recovery Zone*	Number of functioning networks (FN) and independent populations (IP) in a recovery zone	Minimum population size in one network/zone over 10 years
Salem (Salem East + Salem West)	2 FN or 1 FN + 2 IP	200
Corvallis (Corvallis East + Corvallis West)	2 FN or 1 FN + 2 IP	200
Eugene (Eugene East + Eugene West).	2 FN or 1 FN + 2 IP	200

DELISTING GOALS

Delisting goals are set at a 95% probability of persistence for 100 years. Each row below represents a combination of functioning networks and independent populations within a recovery zone. If each of the three recovery zones meets the criteria in one row below, the species would be projected to have a 95 percent probability of persistence for 100 years. Attainment of these population targets, together with the criteria for distribution, habitat quality and management described in the text, would indicate that the species has recovered and could be considered for delisting. Note that the minimum population size in the table represents the minimum population count in a network or independent population in each of 10 consecutive years. The average population size in a network or independent population corresponding to these minima would be substantially larger.

Number of functioning networks (FN) and independent populations (IP) in a recovery zone	Minimum population size per network over 10 years	Minimum population size per independent population over 10 years
2 FN + 0 IP	4500	n/a
2 FN + 2 IP	800	3000
2 FN + 2 IP	1000	1000
2 FN + 2 IP	1500	500
2 FN + 3 IP	1000	700
2 FN + 3 IP	1500	300
3 FN + 0 IP	1000	n/a
3 FN + 1 IP	800	200
3 FN + 2 IP	500	250
4 FN + 0 IP	400	n/a

*We have set population targets for Fender's blue butterfly in the following recovery zones: Salem (Salem East + Salem West), Corvallis (Corvallis East + Corvallis West) and Eugene (Eugene East + Eugene West); see Figure IV-2. The other recovery zones shown in Figure IV-1 are not within the historical range of the species.

c. Management, monitoring, and control of threats. Each population site and stepping stone patch must be managed to ensure the maintenance or restoration of high quality prairie habitat to support the Fender's blue butterfly and to control threats. Use of herbicides, mowing, burning or livestock grazing in management should be implemented with appropriate methods and timing to avoid impacts to Fender's blue butterfly or its nectar or host plants. Management should be coordinated with adjacent landowners to minimize effects of pesticide drift, changes in hydrology, timber harvest, or road/utility maintenance. Other potential threats relating to scientific research, overcollection, vandalism, recreational impacts, or natural herbivory/predation/parasitism should be successfully managed so as not to significantly impair recovery of the species.

Each population shall have in place a management and monitoring plan approved by the U.S. Fish and Wildlife Service that includes identification of appropriate management response to any potential declines that may be detected in habitat quality or the Fender's blue butterfly population during the course of monitoring. Management plans should include a focus on protecting habitat heterogeneity within protected sites and across a range of elevations and aspects to buffer the potential effects of climate change.

Delisting Criteria for Fender's Blue Butterfly

Delisting will be considered for the Fender's blue butterfly when all of the following conditions have been met:

1. Distribution and abundance. Each of the three recovery zones has a combination of functioning networks and independent populations such that the probability of persistence is 95 percent over the next 100 years; see Table IV-2 for options that would achieve this standard. Annual population surveys in each functioning network and independent population must count at least the minimum number of adult butterflies specified in Table IV-2 for 10 consecutive years.

2. Habitat quality and management. Sites supporting populations of Fender's blue butterflies considered in Criterion 2(a)1 above must meet these criteria:

a. Prairie quality. Same as Downlisting Criterion 1(a)(2)(a)

b. Security of habitat. Same as Downlisting Criterion 1(a)(2)(b)

c. Management, monitoring, and control of threats. Same as Downlisting Criterion 1(a)(2)(c)

3. Post-delisting monitoring plan and agreements to continue post-delisting monitoring are in place and ready for implementation at the time of delisting. Monitoring of populations following delisting will verify the ongoing recovery of the species, provide a basis for determining whether the species should be again placed under the protection of the Endangered Species Act, and provide a means of assessing the continuing effectiveness of management action the ability to persist into the future
Guidelines for Assessment of Prairie Quality and Diversity

Prairie Quality and Diversity

Habitat quality is an important factor in the long-term viability of populations of the prairie species addressed in this recovery plan. Absent active management, prairie habitats may be overwhelmed by non-native vegetation and encroaching woody species. Management is therefore necessary to maintain high quality prairie habitats for the target species in this recovery plan. The criteria below may be used to evaluate prairie quality at sites managed for recovery of the listed species in the region. Attainment of these criteria would indicate that the subject site supports a diversity of native plants necessary to attract and maintain pollinator populations, and has a low level of invasion by non-native species. These criteria were developed with the prairies of the Willamette Valley in mind, and may not apply to the more wooded prairie and savanna habitats in Douglas County.

The standards set in this appendix apply to managed degraded native prairies, but would not necessarily be applicable to restoration sites, which would likely have higher standards. Criteria in this appendix would not supersede other criteria established elsewhere for restoration or mitigation sites (often associated with mitigation banks or the ecosystem services market). The standards presented here not absolute criteria – they are suggested targets, but can be modified based on expert opinion and local conditions.

- **Cover of native vegetation**: Sites with populations of target species should have relative cover of natives of 50 percent or more. Relative cover is calculated by adding up the cover values for each of the individual native prairie species present and dividing by the total cover value for all of the species present added together at the site.

- **Cover of woody vegetation**: For each site, woody vegetation should make up no more than 15 percent of the absolute vegetative cover, and woody species of management concern will make up no more than five percent (unless the site is savanna habitat, in which case the upper limit would be about 25 percent woody vegetation). Woody species of management concern are identified below in Table D-1.

- **Prairie diversity**: For each population site, native prairie species richness must exceed 10 species (measured in 25-m^2 plots), of which seven or more must be forbs and one must be a bunch grass. Native prairie species are defined as vascular plants that occur as a normal component of healthy prairie habitats. Managers should consult with a knowledgeable botanist or plant ecologist for appropriate species lists for the local area.

- **Non-native vegetation**: At each reserve, no single non-native plant will have more than 50 percent cover. Non-natives of particular concern, as identified in Table D-2, will have no greater than 5 percent cover. Non-native plants should never be planted or seeded in areas being managed for recovery of listed prairie species.

Table D-1. Woody species of management concern.

Scientific name	**Common name**
Crataegus monogyna	Oneseed hawthorn
Crataegus suksdorfii	Suksdorf's hawthorn
Cytisus spp.	Non-native brooms (*e.g.*, Scotch broom, Spanish broom, and others)
Pyrus communis	Feral common pear
Rosa eglanteria	Sweetbriar rose
Rosa multiflora	Multiflora rose
Rubus armeniacus	Armenian blackberry
Rubus laciniatus	Cutleaf blackberry
Toxicodendron diversilobum	Poison oak

Table D-2. Partial list of invasive non-native plant species. The presence of these or other invasive species would disqualify a site from contributing to recovery goals unless they are managed aggressively to maintain less than 5 percent cover.

Scientific name	**Common name**
Arrhenatherum elatius	Tall oatgrass
Brachypodium sylvaticum	False-brome
Centaurea X *pratensis*	Neadow knapweed
Cytisus scoparius	Scotch broom
Phalaris arundinacea	Reed canary grass
Pyrus communis	Feral common pear
Rubus armeniacus	Armenian blackberry
Rubus vestitus	European blackberry

Additional Habitat Quality and Diversity Criteria

Additional quality and diversity criteria are needed for habitats that support populations of Fender's blue butterfly. These criteria focus on resources needed for adult and larval stages of the butterfly. High quality butterfly habitat requires not only overall quality and diversity of native species, but also abundance criteria for larval and adult resources, and resources for pollinators which are essential components of viable prairie habitats. Recent studies have shown that the density of Fender's blue butterflies at a habitat patch is strongly correlated with host plant abundance (measured as the number of lupine leaves/m^2 of habitat) and total nectar from native nectar flowers (measured as mg nectar sugar/m^2 of habitat) (Schultz and Dlugosch 1999, Schultz 2001). Based on these studies, we recommend the following preliminary criteria for measuring habitat quality and diversity for Fender's blue butterfly population sites.

a. Nectar flower abundance and diversity:

- There should be sufficient abundance of flowers that provide nectar for Fender's blue butterfly (Table D-3); the target abundance is a minimum of 20 mg nectar sugar/m^2 of habitat, which may be achieved by planting species identified as abundant nectar producers in Table D-3;
- Each population site should have a minimum of five native nectar species.

b. Lupine host plant abundance: Sites that provide breeding habitat for Fender's blue butterfly should have a minimum of 30 lupine leaves/m^2 of habitat.

c. Nectar plant availability: Nectar plants should be available at the habitat patch throughout the entire flight season of the pollinator species (March through September of each year) to ensure the continued viability of the pollinators and the species they pollinate.

APPENDIX C: Metapopulation Descriptions under Current Conditions

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Here we describe the 15 metapopulations of Fender's blue butterfly in detail broken down by recovery zone. For each metapopulation, we have created the following: a map identifying sites, a figure containing the total number of butterflies over time at each site in relation to the minimum criteria of 200 butterflies per year for 10 consecutive years as per the Recovery Plan, and a table identifying the status and proportion of butterflies at each site.

C.1 Salem Recovery Zone

There are six metapopulations within the Salem Recovery Zone in Polk, Washington, and Yamhill Counties known as Baskett, Gopher Valley, Hagg Lake, Moores Valley, Oak Ridge, and Turner Creek. Of these metapopulations, three have been found since listing and three have expanded since listing. Collectively, the metapopulations have an estimated 5-year average abundance of 5,370 Fender's blue butterflies across 128 hectares (ha) (316 acres (ac)) of prairie containing 8.1 ha (20 ac) of lupine patch area, 10,092 sq m of lupine cover, and 93.2 ha (229 ac) of nectar area (Table 3.2). Across the six metapopulations, 78.7 ha (194.5 acres) are permanently protected for the Fender's blue butterfly and 38.4 ha (94.9 acres) have interim protection.

C.1.1 Baskett Metapopulation

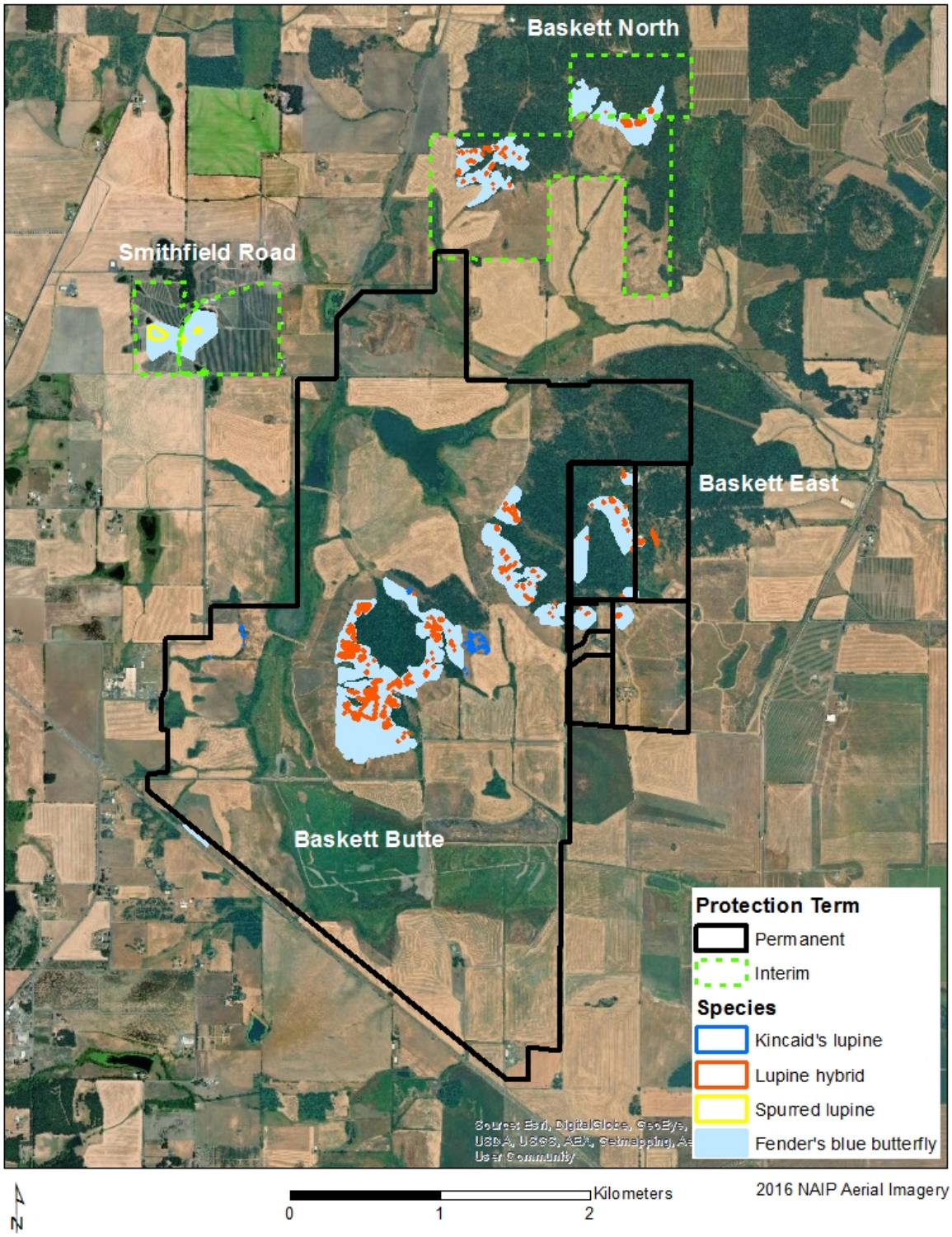

Figure C.1. Baskett Fender's blue butterfly metapopulation in Polk County, Oregon.

The Baskett metapopulation is comprised of 28 sites in Polk County, Oregon, which are divided by ownership and management into 4 general groupings (described below) as shown in Figure C.1. Hammond and Wilson (1992, p. 2) first documented Fender's blue butterfly occupancy in this metapopulation at the Service's Baskett Slough National Wildlife Refuge (NWR). Spurred lupine is the host plant predominantly supporting Fender's blue butterfly at all of the metapopulation sites, but it is reported to have hybridized with Kincaid's lupine (Liston et al. 1995, pp. 318-320). Abundance estimates have been conducted annually at the Baskett metapopulation sites, which collectively support a 5-year average of 2,091 individuals (Service Database, version dated January 2018).

The Baskett Butte group includes the 10 "historic" Baskett Slough NWR sites, which support 87 percent of the metapopulation's 5-year average butterfly abundance. Baskett Slough NWR lands are dominated by agricultural fields and seasonal, managed wetlands with approximately 69 ha (170 ac) of upland prairie and oak-savannah habitats occurring from the valley floor to the North and South Baskett Buttes. Baskett Slough NWR has a management plan describing the treatments necessary to enhance the 10 sites for greater lupine and nectar abundance, while also expanding available habitat to improve connectivity with the neighboring Baskett East and North sites. Although most of the butterflies in this metapopulation occur on refuge lands, butterflies have been documented in the surrounding landscape over the last 14 years.

The Baskett North group includes 10 privately-owned sites, first discovered in June 2003 (Jebousek, *in litt*., 2003, pp. 1-2) and collectively support 10 percent of the 5-year butterfly abundance for this metapopulation. The Service entered into a Partners for Fish and Wildlife (PFW) agreement in 2009 and subsequently signed a Safe Harbor Agreement (SHA) in 2011 with the 2 landowners that own the 10 sites. Habitat restoration for these sites was funded through a Natural Resources Conservation Service's (NRCS) Wildlife Habitat Incentive Program grant for actions occurring between 2009 and 2014. In 2014, the Polk County Soil and Water Conservation District (Polk County SWCD) was awarded an Oregon Watershed Enhancement Board (OWEB) grant to further enhance the oak and prairie habitat for Fender's blue butterfly. The private landowners expressed interest in selling the 10 Fender's blue butterfly sites for conservation, and in 2016, Polk County SWCD was awarded funds from the Bonneville Power Administration (BPA) to acquire them for permanent protection and management. The Service anticipates acquisition will be finalized in 2019.

The Baskett Butte East group is comprised of seven privately-owned sites and Fender's blue butterfly was first discovered in the area in 2006 (Hammond 2006, pp. 21-22). The Baskett East sites collectively support 3 percent of the 5-year average butterfly abundance and all of these sites have conservation easements held by The Nature Conservancy (TNC) and NRCS (2009 and 2010, respectively). All of the Baskett East sites are enrolled in the PFW program and actively managed under interagency agreements between the Service, TNC and NRCS. TNC (2011, pp. 1-51) has a management plan outlining the conservation strategy being implemented at their five Baskett East sites, and NRCS has a Wetland Reserve Plan of Operations (USDA 2010, entire) outlining conservation actions that will be implemented on their sites.

The Smithfield Road site represents one privately-owned site that historically was not occupied by Fender's blue butterfly (presence/absence surveys conducted by Service biologists 2009-

2013; Seal, *in litt.* 2013, p. 1) despite its proximity to Baskett Butte and Baskett North sites, and the presence of suitable prairie and lupine host plants. In 2009, the Service entered into a PFW agreement with the landowner and initiated habitat management on the property. After several years of habitat restoration, Fender's blue butterfly was first observed at the Smithfield Road site in 2014 (Richardson, *in litt.* 2016, p. 1) and is now being monitored annually.

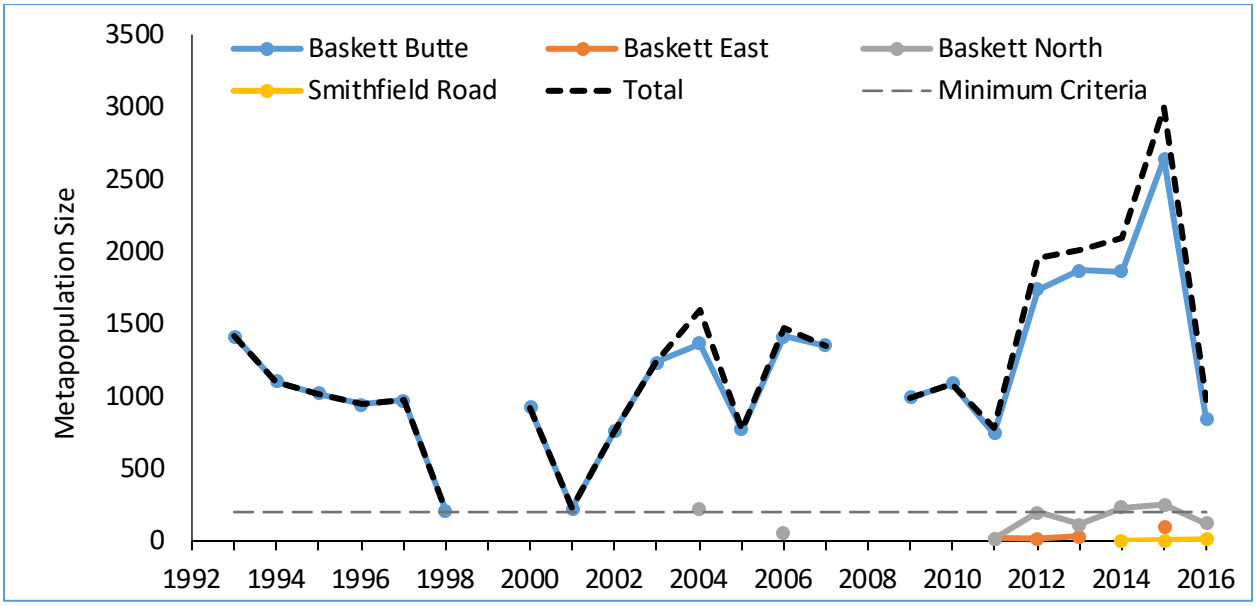

Figure C.2. Estimates of the number of Fender's blue butterflies in the Baskett metapopulation since surveys began at the metapopulation.

Table C.1. Status and abundance of Fender's blue butterflies in the Baskett metapopulation.

Baskett Group	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Baskett Butte	Permanent - Public (FWS)	1822	87
Baskett North	Interim – SHA/PFW w/ Permanent in progress	202	10
Baskett East	Permanent – Easement (TNC and *NRCS)	67	3
Smithfield Road	Interim – SHA/PFW	6	<1

C.1.2 Gopher Valley Metapopulation

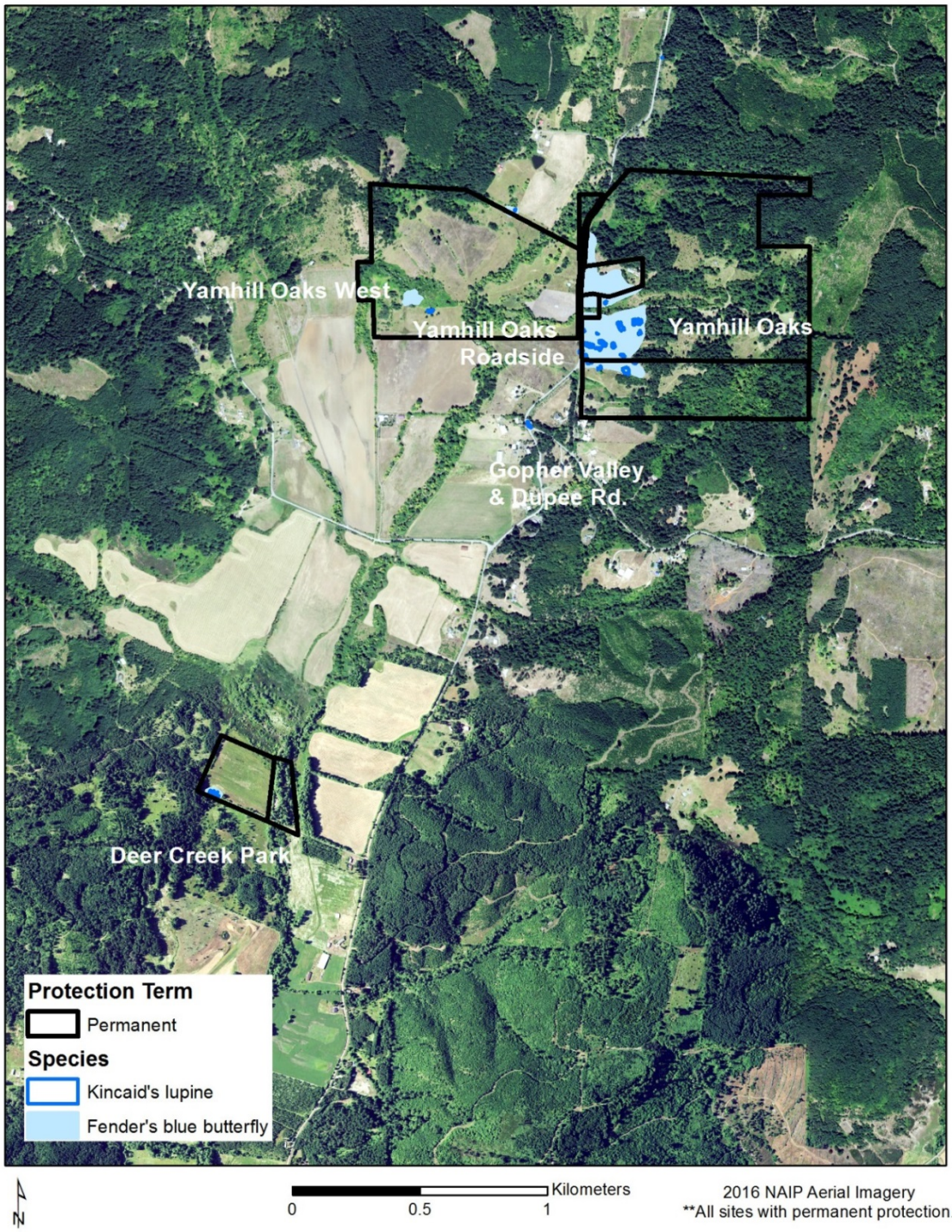

Figure C.3. Gopher Valley Fender's blue butterfly metapopulation in Yamhill County, Oregon.

While part of the Gopher Valley metapopulation was known at listing, additional sites have since been discovered, expanding the known distribution of Fender's blue butterfly in the area. The first Fender's blue butterfly population estimate for the Gopher Valley metapopulation was conducted in 1995 along Dupee Road and the Yamhill Oaks Roadside site and an estimated 30 individuals were reported (Hammond 1996, p. 7). The Dupee Road and Yamhill Oaks Roadside sites are both narrow strips of remnant prairie currently managed by the Yamhill County Public Works to improve conditions for Fender's blue butterfly as outlined in their Habitat Conservation Plan (HCP) (Cardno ENTRIX 2013, Chapter 6). The Gopher Valley metapopulation expanded when Fender's blue butterflies were discovered at the Deer Creek Park site in 2004 (Hammond 2005, pp. 8-9) and the four Yamhill Oaks sites in 2007 (Hammond 2007, p. 10). Thus, the known distribution has expanded since listing from two sites to seven sites within southern Yamhill County, Oregon. Kincaid's lupine is the Fender's blue butterfly host plant at all seven sites in the Gopher Valley metapopulation.

Of those seven sites, 99 percent of the 5-year metapopulation butterfly abundance is supported by the Yamhill Oaks South site. In 2007, private land adjacent to the historic Yamhill Oaks Roadside site was surveyed and butterfly occupancy was documented in several lupine patches in pristine habitat on the western portion of the property (Hammond 2007, p. 10). At that time, Hammond (2007, p. 10) estimated an abundance of 70 individuals, which he estimated to be 75 percent of the metapopulation population. In 2008, TNC acquired the private property and established the Yamhill Oaks Preserve (Hammond 2008, p. 10). TNC's protection and management efforts at the Yamhill Oaks Preserve have substantially increased the health of the Gopher Valley metapopulation. What was historically believed to be a small, roadside population in 1995 (Hammond 1996, p. 7) is now known to be more broadly distributed on surrounding lands that are permanently protected and managed to improve habitat conditions. TNC effectively removed Himalayan blackberry and young conifers that were encroaching into the lupine patches (Hammond 2008, p. 10) and they continue to manage the habitat annually to treat the tall oatgrass that established in the preserve in 2008. Abundance estimates have been conducted annually in the Gopher Valley metapopulation and the sites collectively support a 5-year average abundance of 465 individuals (Service Database, version dated January 2018).

Butterflies have not been observed at the Deer Creek Park site since 2010 (Service Database, version dated January 2018), however, its proximity to other extant sites suggests it may be utilized intermittently. The site is owned and managed by Yamhill County as a mitigation site for unavoidable impacts authorized under their HCP. The Yamhill Oaks Northwest site is private land with a small patch of Kincaid's lupine that Fender's blue butterfly has never been observed using (Fitzpatrick 2013a, p. 24). Given the lupine patch's proximity to the Yamhill Oaks Preserve, it is possible that Fender's blue butterfly uses this site intermittently as well.

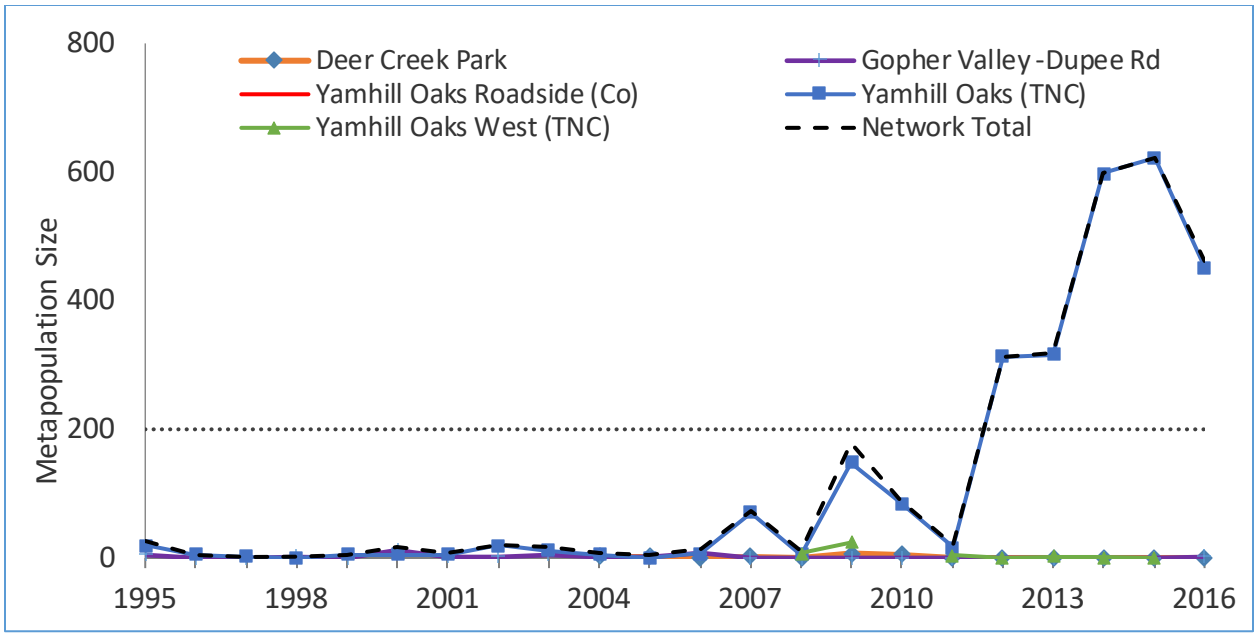

Figure C.4. Estimates of the number of Fender's blue butterflies in the Gopher Valley metapopulation since surveys began at the metapopulation.

Table C.2. Status and abundance of Fender's blue butterflies in the Gopher Valley metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Yamhill Oaks North	Permanent – Easement (TNC)	0	Intermittent
Yamhill Oaks NW	Unprotected – Private	0	Intermittent
Yamhill Oaks West	Permanent – Easement (TNC)	1	<1
Yamhill Oaks South	Permanent – Easement (TNC)	460	99
Gopher Valley/Dupee Road	Permanent – Public (ROW with HCP)	0	Intermittent
Yamhill Oaks Roadside	Permanent – Public (ROW with HCP)	4	<1
Deer Creek Park	Permanent – Public (ROW with HCP)	0	Intermittent

C.1.3 Hagg Lake Metapopulation

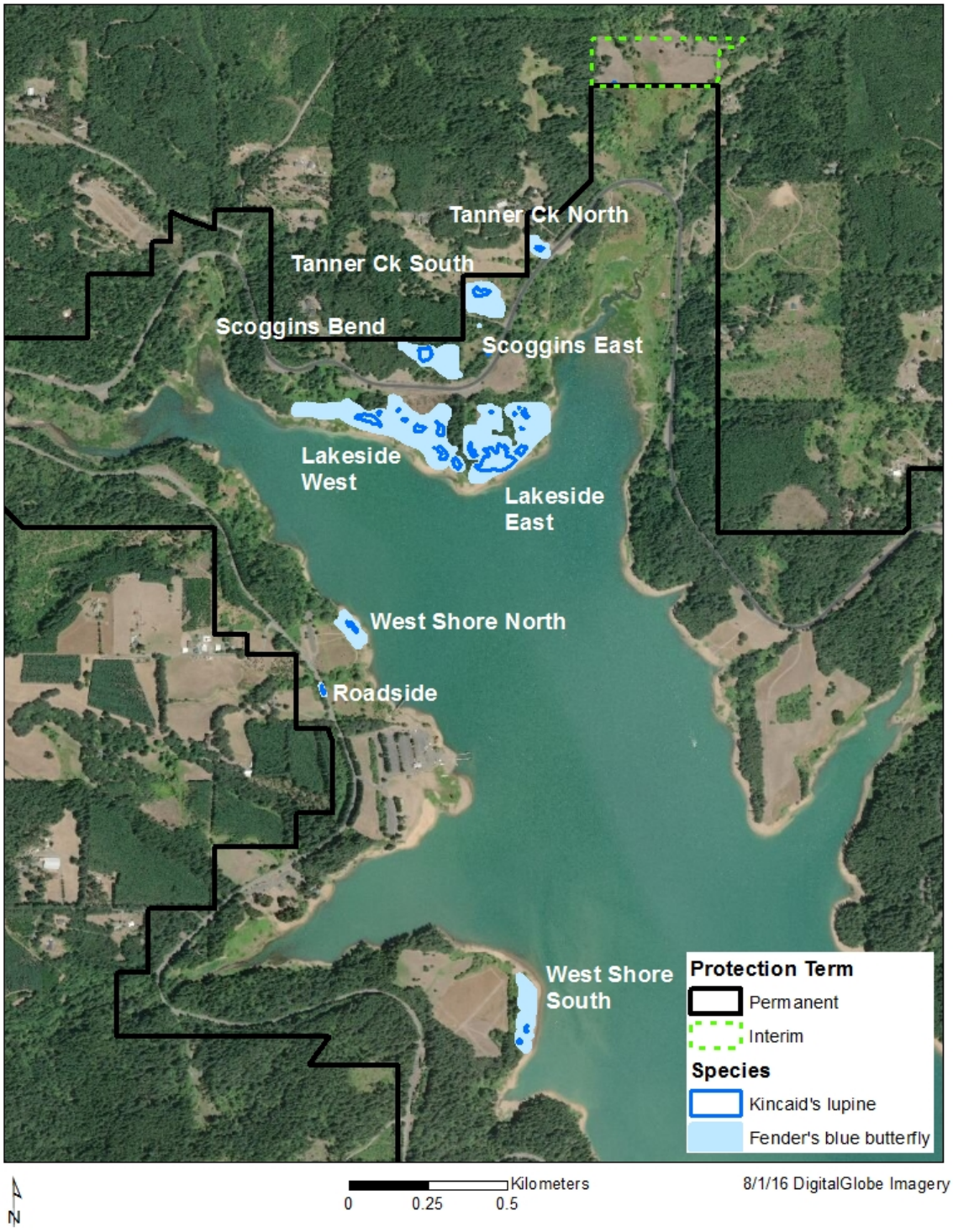

Figure C.5. Hagg Lake Fender's blue butterfly metapopulation in Washington County, Oregon.

The Hagg Lake metapopulation at Henry Hagg Lake was discovered on June 3, 2011, at the Lakeside East site (Hammond 2011, p. 3). This metapopulation is the northernmost metapopulation in the Fender's blue butterfly's range located in Washington County, Oregon. It is comprised of nine sites owned by the Bureau of Reclamation (BOR), however, BOR has a contract with Washington County Parks Department (WCPD) to manage, operate, and maintain the recreation features and natural resources on these lands. Abundance estimates have been conducted annually since 2012, and the sites collectively support a 5-year average abundance of 1,663 individuals (Service Database, version dated January 2018). The highest density of butterflies occurs near the edge of Henry Hagg Lake in the Lakeside East site. An estimated 87 percent of the butterflies occur in the Lakeside East and Lakeside West sites, which are located on steep south-facing hills that extend to the edge of Henry Hagg Lake's north shore. Kincaid's lupine is the Fender's blue butterfly host plant at all nine sites in the Hagg Lake Metapopulation

In September 2014, the Service and BOR completed formal Section 7 consultation [USFWS reference # 01EOFW00-2014-F-0258, and 8330.02374(04)] on the effects of BOR's land management activities on Fender's blue butterfly and Kincaid's lupine. As part of that consultation, BOR agreed to fund annual Fender's blue butterfly abundance estimate surveys and treatments to control nonnative vegetation in order to maintain upland prairie habitat for both listed species. On July 30, 2016, the Service and BOR entered into a 5-year Interagency Agreement so BOR could fund the Service to conduct annual habitat restoration actions at the Lakeside East, Lakeside West and Scoggins Bend sites. Habitat restoration activities were initiated in 2016, and have resulted in a substantial reduction of nonnative woody vegetation at all three sites.

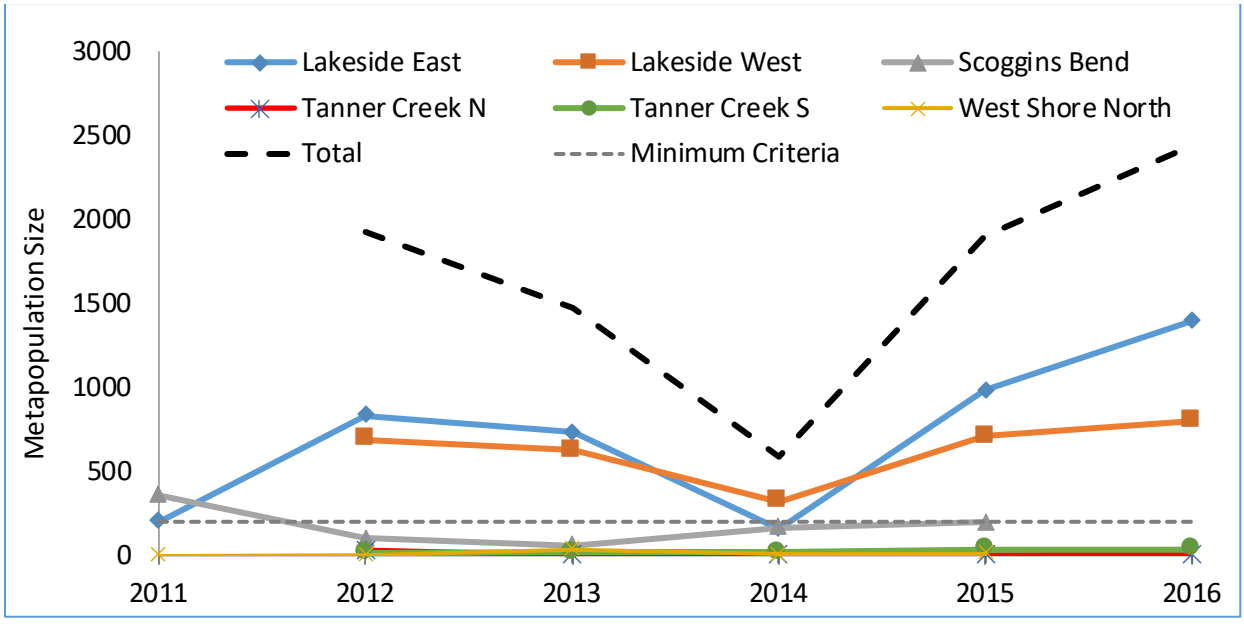

Figure C.6. Estimates of the number of Fender's blue butterflies in the Hagg Lake metapopulation since surveys began at the metapopulation.

Table C.2. Status and abundance of Fender's blue butterflies in the Hagg Lake metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Lakeside East	Permanent – Public (BOR)	818	49
Lakeside West	Permanent – Public (BOR)	627	38
Scoggins Bend	Permanent – Public (BOR)	176	11
Scoggins East	Permanent – Public (BOR)	0	Intermittent
Tanner Creek North	Permanent – Public (BOR)	8	<1
Tanner Creek South	Permanent – Public (BOR)	23	1
West Shore North	Permanent – Public (BOR)	11	<1
West Shore South	Permanent – Public (BOR)	0	Intermittent
Hagg Roadside	Permanent – Public (ROW)	0	Intermittent

C.1.4 Moores Valley Metapopulation

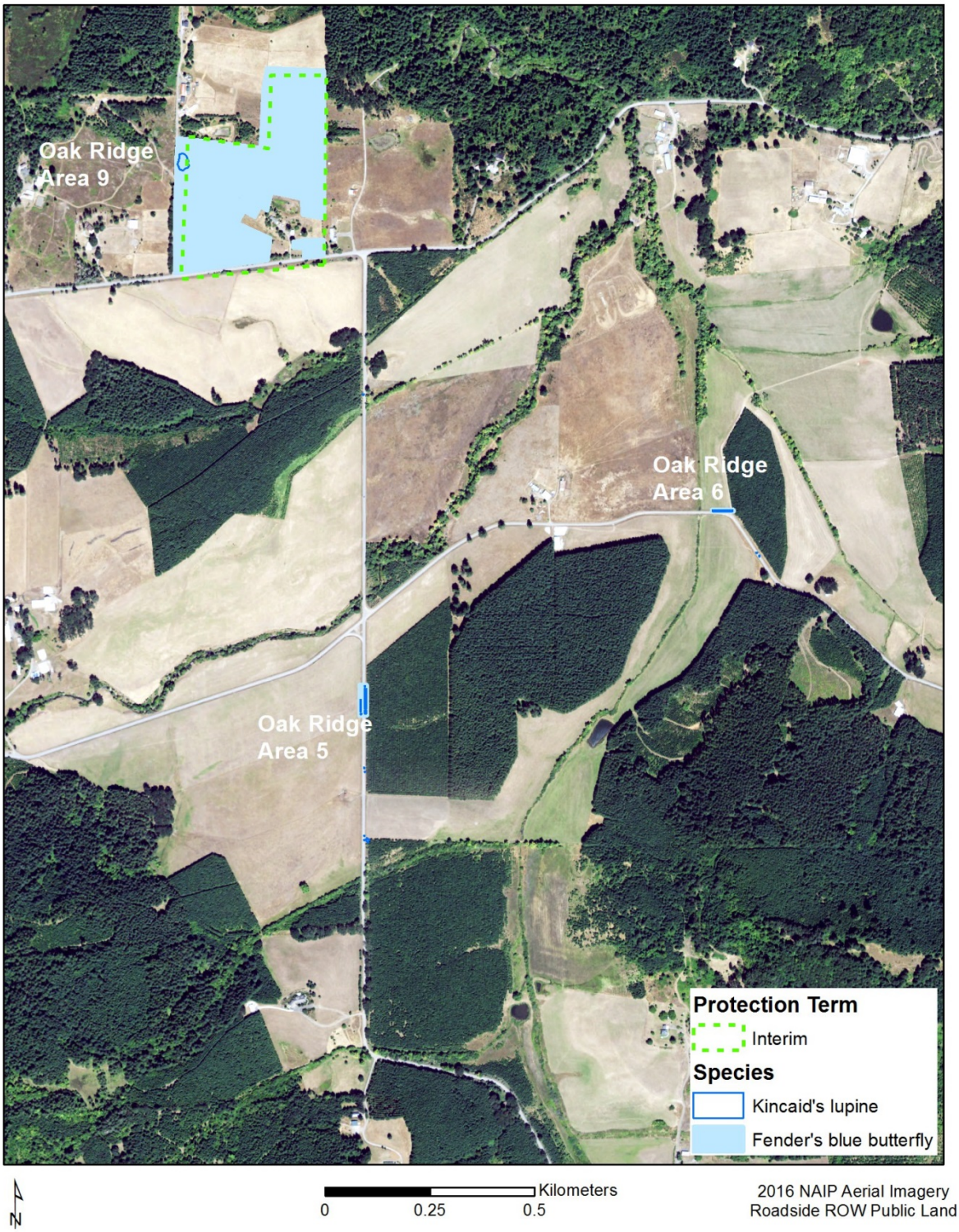

Figure C.7. Moores Valley Fender's blue butterfly metapopulation in Yamhill County, Oregon.

The Moores Valley metapopulation was discovered in 2007 at the Oak Ridge Area 5 site along Old Moores Valley Road (Hammond 2007, p. 7). It is currently comprised of three sites in Yamhill County, Oregon. Fender's blue butterflies were first observed at the Oak Ridge Area 6 site along Moores Valley Road in 2009 (Hammond 2009, pp. 7- 8) and at the Oak Ridge Area 9 site in 2010 (Hammond 2010, p. 7). Abundance estimates have been conducted annually in the Moores Valley Metapopulation and the sites collectively have a 5-year average of 31 individuals (Service Database, version dated January 2018).

Oak Ridge Area 5 and 6 sites are narrow roadside strips of remnant prairie. The Yamhill County Road Department (Yamhill CRD) is managing these sites to improve conditions for Fender's blue butterfly as outlined in their HCP (Cardno ENTRIX 2013, Chapter 6). The Oak Ridge Area 9 site is privately owned and has flat topography with fairly high quality remnant prairie in and along the edge of a cattle pasture (Hammond 2010, p. 7). In March 2012, the Service entered into an SHA with the private landowners and the Yamhill County Soil and Water Conservation District (Yamhill County SWCD) has been facilitating annual surveys at the site.

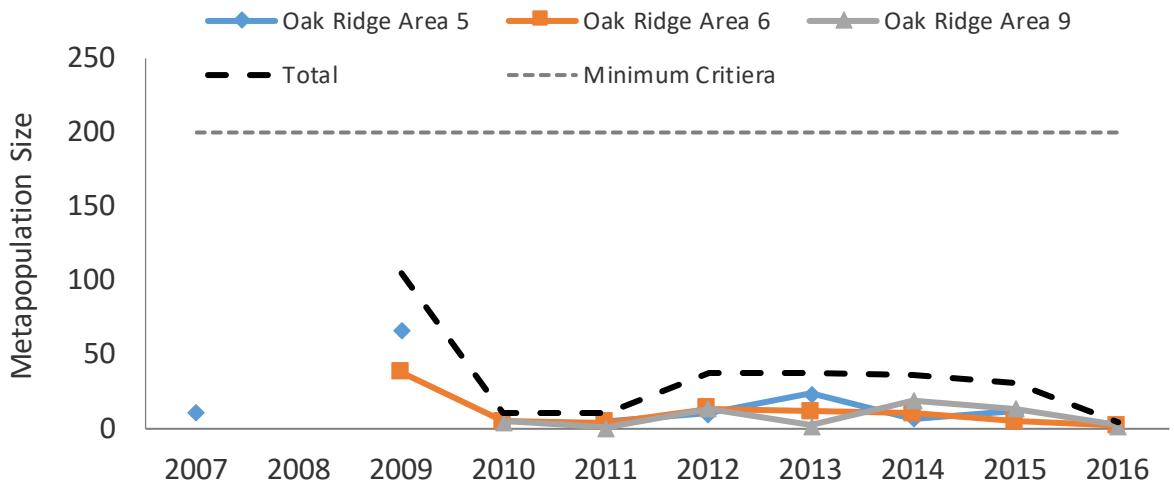

Figure C.8. Estimates of the number of Fender's blue butterflies in the Moores Valley metapopulation since surveys began at the metapopulation.

Table C.4. Status and abundance of Fender's blue butterflies in the Moores Valley metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Oak Ridge Area 5 (THOR and RD-YAMCO)	Permanent – Public (ROW)	11	34
Oak Ridge Area 6 (MOOR-RD-YAMCO)	Permanent – Public (ROW)	10	33
Oak Ridge Area 9 (BLA)	Interim – SHA/PFW	10	33

C.1.5 Oak Ridge Metapopulation

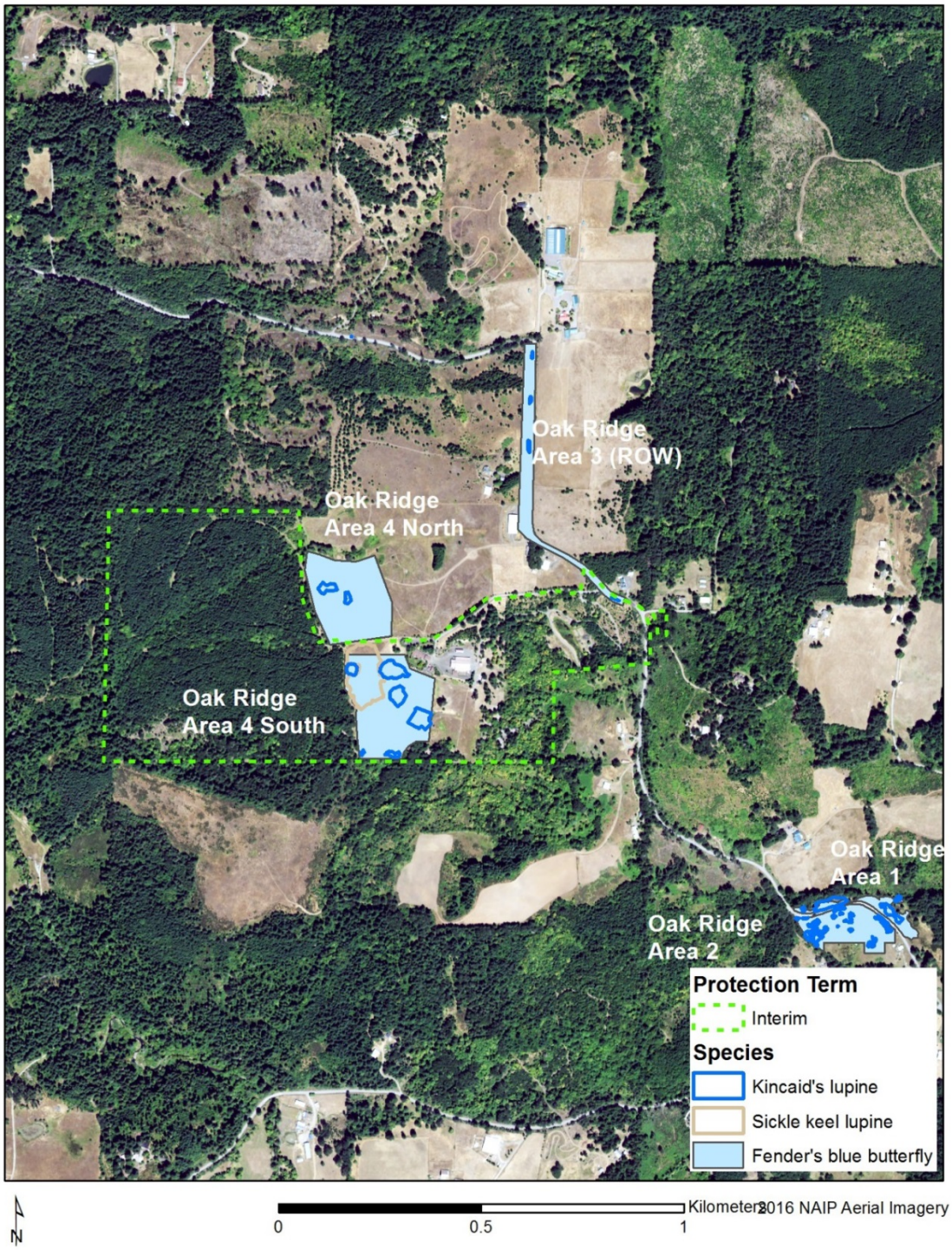

Figure C.9 Oak Ridge Fender's blue butterfly metapopulation in Yamhill County, Oregon.

The Oak Ridge metapopulation is comprised of five privately-owned sites in northern Yamhill County, Oregon. While the Oak Ridge Area 1, 2, and 3 sites have been known since 1992 (Hammond and Wilson 1993, p. 20), the Area 4 South site was discovered in 2006 (Hammond 2006, p. 4) and the Area 4 North site was discovered in 2013 (Fitzpatrick 2013b, p. 33). Abundance estimates have been conducted annually in the Oak Ridge metapopulation and the sites collectively support a 5-year average abundance of 1,083 individuals (Service Database, version dated January 2018).

As of 2016, 79 percent of the metapopulation's butterflies occurred in the gently sloping, lower elevation parts of Area 4 North and South sites (Fitzpatrick and Menke 2016, pp. 51-52). The lupine patches at the Area 4 South site are distributed across low hills, and when discovered in 2006, the habitat was dominated by exotic grassland (Hammond 2007, p. 6). In 2006, the Service entered into a PFW agreement with the Area 4 South site landowners, who subsequently signed an SHA as well in 2010. The Yamhill County SWCD has been restoring and managing habitat for Fender's blue butterfly at this site since 2007 (Hammond 2008, pp. 5-6). Yamhill County SWCD's restoration efforts resulted in successful control of tall oatgrass (Hammond 2011, p. 9) and the establishment of substantial native bunchgrasses and nectar plants (Ottombrino-Haworth et. al 2017, pp. 384-391). Additionally, in 2008, the Service inadvertently seeded sickle-keeled lupine as part of a prairie seed mix, and between 2013 and 2016 the introduced lupine spread extensively across the Area 4 South site. The extensive spread of sickle-keeled lupine across the site appears to have resulted in a significant increase in Fender's blue butterfly abundance between 2013 and 2016 (Fitzpatrick and Menke 2016, p. 51).

Oak Ridge Area 3 and a small portion of the Oak Ridge Area 1 and 2 sites occur along Oak Ridge Road and the Yamhill CRD is managing habitat to improve conditions for Fender's blue butterfly as outlined in their HCP (Cardno ENTRIX 2013, Chapter 6). The topography at Oak Ridge Area 1 and 2 sites is flat or gently sloping and both areas were previously heavily grazed (Hammond and Wilson 1992, p. 20; Hammond 1996, p. 6). The majority of the Oak Ridge Area 1 and 2 sites are privately owned and are not currently being managed through conservation programs. Without habitat management, Area 1 has become overgrown with tall oatgrass, bracken fern and Scotch broom in the last few years. Consequently, the lupine habitat in Area 1 is substantially repressed and butterfly abundance declined in 2016 (Fitzpatrick and Menke 2016, p. 49).

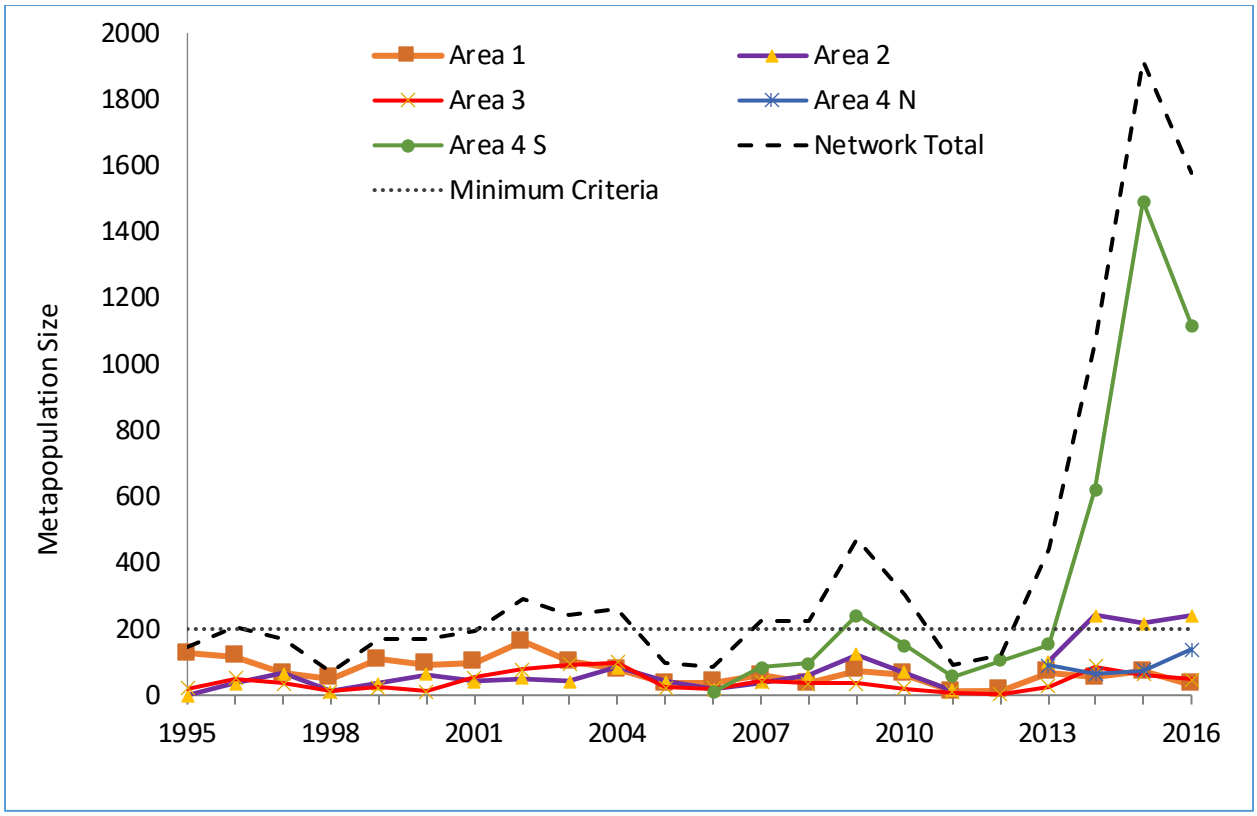

Figure C.10 Estimates of the number of Fender's blue butterflies in the Oak Ridge metapopulation since surveys began at the metapopulation.

Table C.5. Status and abundance of Fender's blue butterflies in the Oak Ridge metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Oak Ridge Area 1	Unprotected – Private	48	4
Oak Ridge Area 2	Unprotected – Private	200	18
Oak Ridge Area 3	Permanent – Public (ROW with HCP)	45	4
Oak Ridge Area 4 North	Unprotected – Private	92	9
Oak Ridge Area 4 South	Interim – SHA/PFW	698	65
Oak Ridge 1 & 2 ROW	Permanent – Public (ROW with HCP)	Included with Areas 1 & 2 above	

C.1.6 Turner Creek Metapopulation

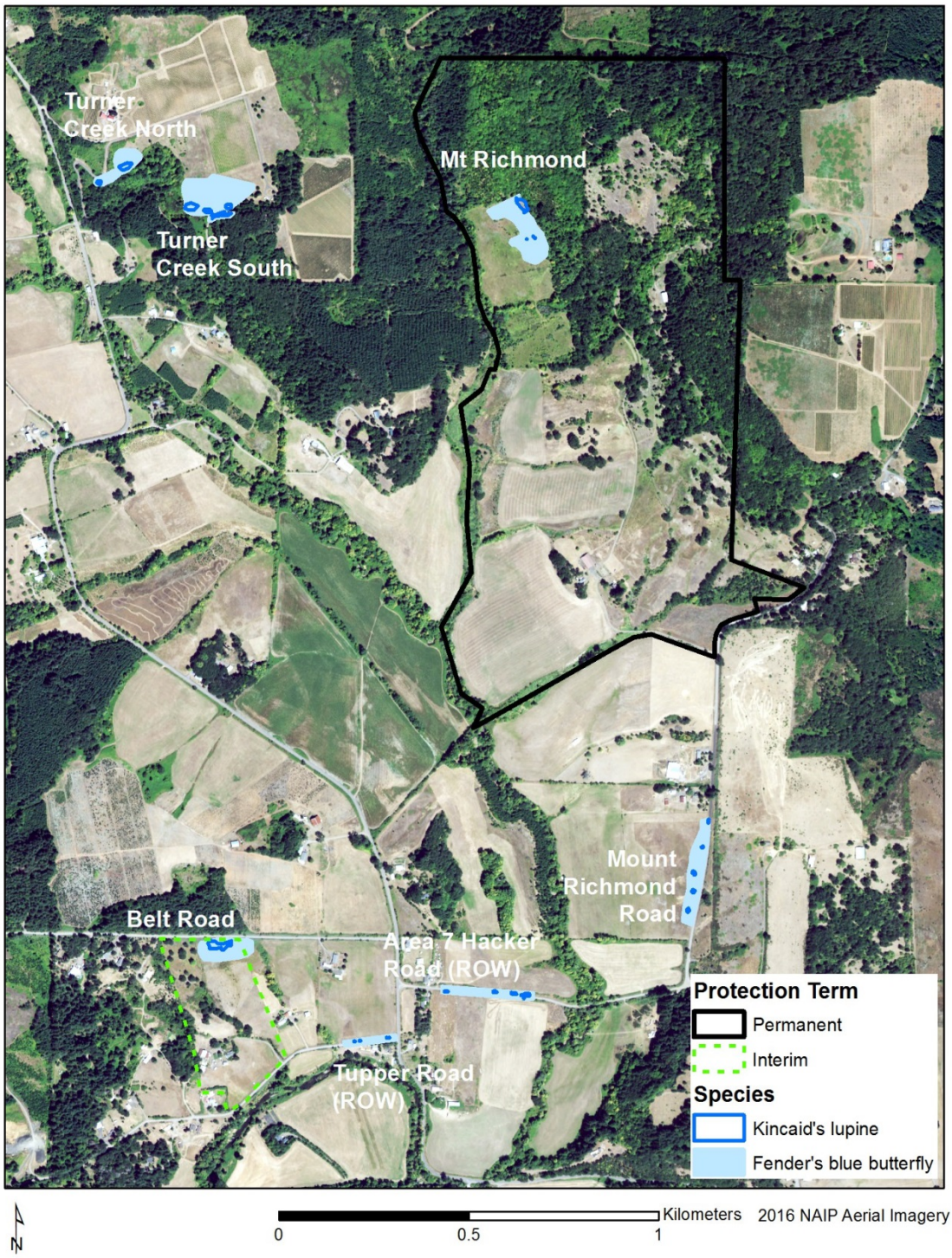

Figure C.11. Turner Creek Fender's blue butterfly metapopulation in Yamhill County, Oregon.

The Turner Creek metapopulation was discovered in 2007 at the Hacker Road site (Hammond 2007, p. 6) (see Figure 3.13). This metapopulation is comprised of seven sites in northern Yamhill County, Oregon. Fender's blue butterfly abundance cannot be accurately assessed for this metapopulation because the Turner Creek North and South sites are privately owned and the landowners have not allowed access for surveys since 2013 when occupancy was first documented (Fitzpatrick 2013b, p. 31). There is speculation that the metapopulation's main concentration of butterflies occurs on the Turner Creek South site (Fitzpatrick and Menke 2016, p. 56). Fender's blue butterfly has never been observed at the Tupper Road or Mt. Richmond Road sites; however, we assume Fender's blue butterfly occupies them intermittently given their proximity to extant locations and the presence of Kincaid's lupine and suitable habitat. The Mt. Richmond, Hacker Road, and Belt Road sites are surveyed annually and collectively support a 5-year average abundance of 37 individuals (Service Database, version dated January 2018).

At the Mt. Richmond site, Kincaid's lupine was discovered in 2006 in a small meadow opening within a conifer plantation (Hammond 2006, p. 6), but Fender's blue butterfly was not observed until 2009 (Hammond 2009, p. 9). In 2007, the Yamhill County SWCD acquired a conservation easement on the Mt. Richmond site and have been actively restoring habitat for Fender's blue butterfly by removing conifer trees and restoring the remnant meadow (Hammond 2008, p. 6). Reports suggest that butterfly abundance increased in 2012 as a result of habitat restoration activities, and given the substantial expansion of Kincaid's lupine at the site in recent years (Fitzpatrick and Menke 2016, pp. 56-57), we anticipate an increase in Fender's blue butterfly abundance in the future. The Service entered into a PFW agreement in 2013 and an SHA in 2015 with the landowners at the Belt Road site, and Yamhill County SWCD began restoring habitat for Fender's blue butterfly at this site in 2014 (Fitzpatrick 2014, p. 38). The Yamhill CRD is managing and restoring habitat for Fender's blue butterfly at the Hacker Road and Tupper Road sites as outlined in their HCP (Cardno ENTRIX 2013, Chapter 6).

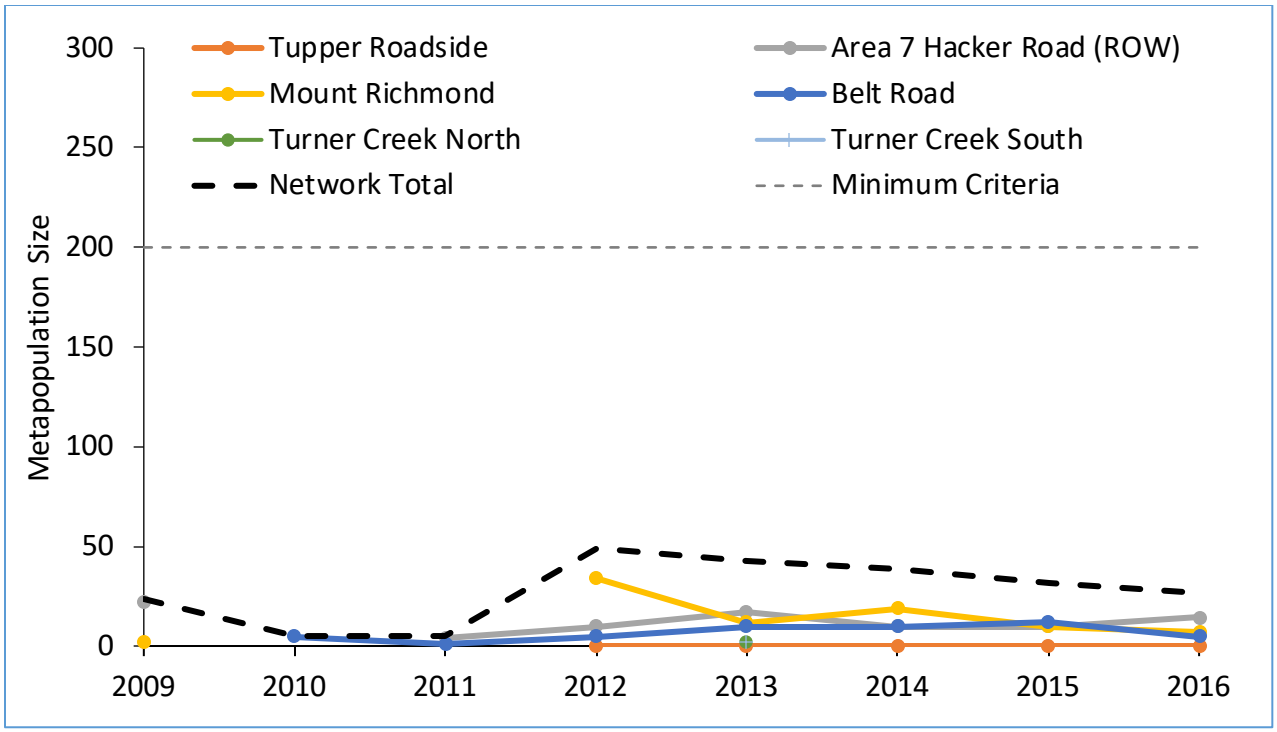

Figure C.12. Estimates of the number of Fender's blue butterflies in the Turner Creek metapopulation since surveys began at the metapopulation.

Table C.6. Status and abundance of Fender's blue butterflies in the Gopher Valley metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Belt Road	Interim – SHA/PFW	8	20
Mount Richmond	Permanent – Easement (YSWCD)	16	40
Turner Creek North	Unprotected – Private	2	5
Turner Creek South	Unprotected – Private	2	5
Tupper Road (ROW)	Permanent – Public (ROW with HCP)	0	Intermittent
Mount Richmond Road (ROW)	Permanent – Public (ROW with HCP)	0	Intermittent
Area 7 Hacker Road (ROW)	Permanent – Public (ROW with HCP)	12	30

C.2 Corvallis Recovery Zone

There are five metapopulations within the Corvallis Recovery Zone known as Butterfly Meadows, Finley, Greasy Creek, Lupine Meadows, and Wren. Of these metapopulations, one was created after listing, one has been found since listing, one has remained the same, and two have expanded since listing. Collectively, the metapopulations have an estimated 5-year abundance of 3,461 Fender's blue butterflies across 117.4 ha (290 ac) of prairie containing 13.8 ha (34 ac) of lupine patch area, 3,617.5 sq m of lupine cover, and 52 ha (129 ac) of nectar area. Across the five metapopulations, 35.4 ha (87.5 ac) are permanently protected and 14 ha (35 ac) have interim protection.

C.2.1 Butterfly Meadows Metapopulation

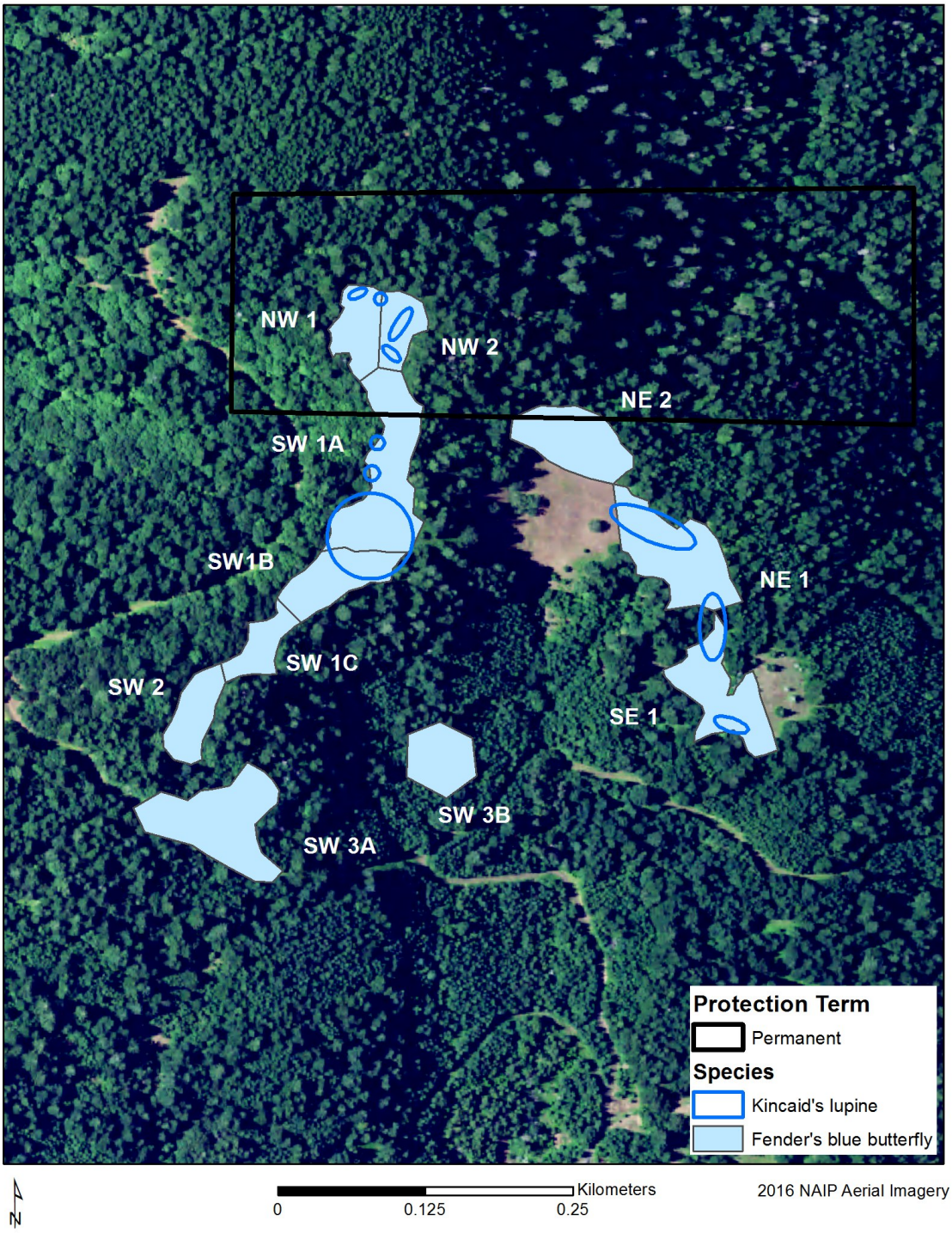

Figure C.13. Butterfly Meadows Fender's blue butterfly metapopulation in Benton County, Oregon.

The Butterfly Meadows metapopulation is located within the McDonald State Forest, which is where the Fender's blue butterfly was rediscovered in 1989 (Hammond and Wilson 1993, p.2). The metapopulation is comprised of two sites owned by OSU and nine sites owned by a private lumber company (Hammond and Wilson 1993, p. 17) in Benton County, Oregon. This metapopulation generally has a south facing aspect with moderate to steep sloping hills located in the foothills along the valley margin (Hammond and Wilson 1993, p. 17) and has a relatively high elevation (Hammond 2005, p. 34) of 549 m (1,800 ft), making it the second-highest site where Fender's blue butterfly is found. Abundance estimates have been conducted periodically at the Butterfly Meadows metapopulation and the sites collectively support a 5-year average of abundance of 111 individuals (Service Database, version dated January 2018). Fender's blue butterfly has not been observed at the SW 3A and SW 3B sites since 1995 and 2009, respectively (Service Database, version dated January 2018), but surveys and habitat assessments have not been conducted at these sites for several years. Given their proximity to extant sites, these areas may be utilized intermittently if suitable habitat remains.

The Butterfly Meadows metapopulation is threatened by succession to forest and infestation of false brome grass and bracken fern (Hammond 2008, p. 35). Fender's blue butterfly populations have been monitored in this metapopulation since 1993 and studies show that without management, habitat health and butterfly abundance decline (Hammond 2007, p. 35, Fitzpatrick and Menke 2016, p. 58). Although Oregon State University (OSU) facilitated restoration and research at this metapopulation between 2006 and 2011 (Hammond 2009, p. 38; Hammond 2011, p. 33), habitat management has not occurred in several years and OSU does not have a management plan for the NW1 and NW2 sites. Periodically, the timber company owning nine sites has implemented invasive grass treatments and removed encroaching woody vegetation (Hammond 2009, p. 38 and Hammond 2011, pp. 32- 33); however, these areas have not been treated in several years and butterfly abundance is currently in decline. In 2016, the timber company began developing a 10-year habitat restoration plan for their lands. Based on communication between the landowner and Service biologists, we anticipate habitat restoration to resume in 2019.

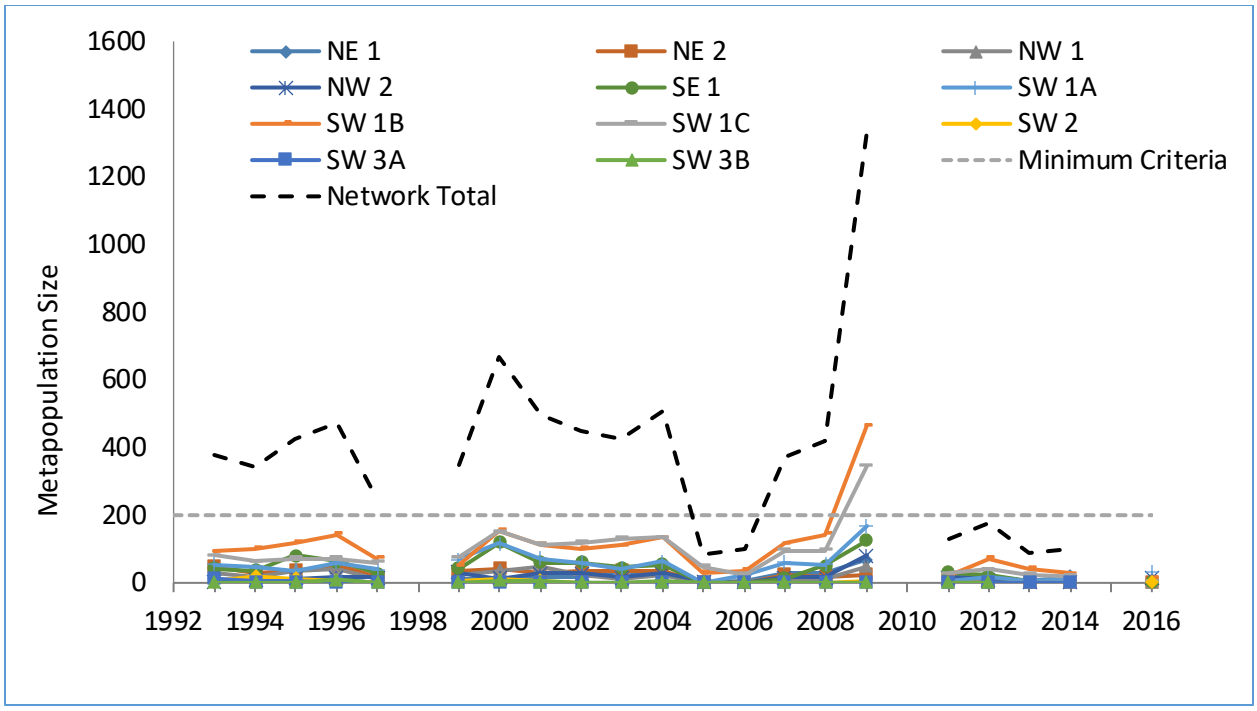

Figure C.14. Estimates of the number of Fender's blue butterflies in the Butterfly Meadows metapopulation since surveys began.

Table C.7. Status and abundance of Fender's blue butterflies in the Butterfly Meadows metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Butterfly Meadows NE 1 (STAR)	Unprotected – Private	11	10
Butterfly Meadows NE 2 (STAR)	Unprotected – Private	2	2
Butterfly Meadows NW 1 (OSU)	Unprotected – Private	5	4
Butterfly Meadows NW 2 (OSU)	Unprotected – Private	8	8
Butterfly Meadows SE 1 (STAR)	Unprotected – Private	7	6
Butterfly Meadows SW 1A (STAR-OSU)	Unprotected – Private	16	15
Butterfly Meadows SW 1B (STAR)	Unprotected – Private	40	36
Butterfly Meadows SW 1C (STAR)	Unprotected – Private	21	19
Butterfly Meadows SW 2 (STAR)	Unprotected – Private	0	Intermittent
Butterfly Meadows SW 3A (STAR)	Unprotected – Private	0	Intermittent
Butterfly Meadows SW 3B (STAR)	Unprotected – Private	0	Intermittent

C.2.2 Finley Metapopulation

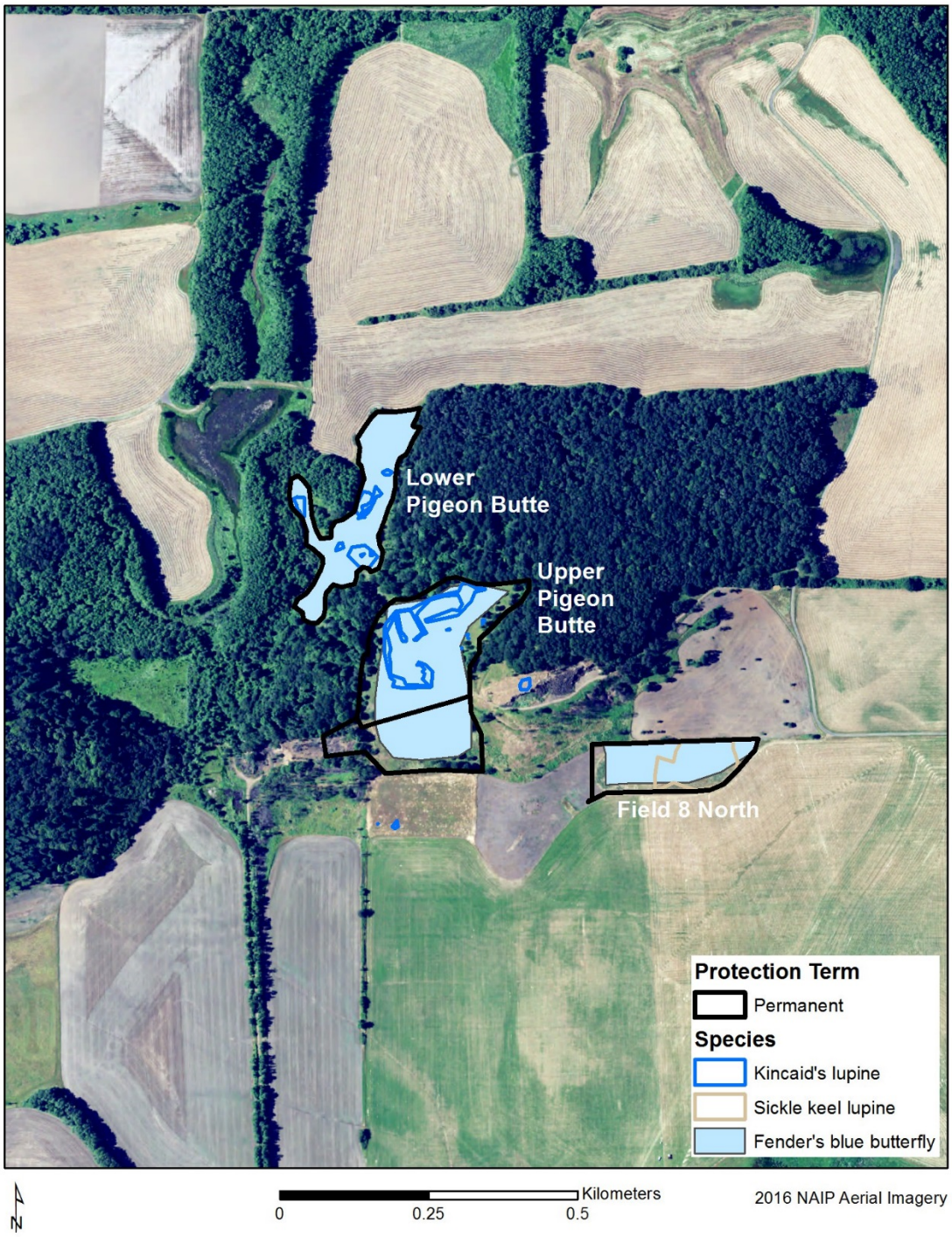

Figure C.15. Finley Fender's blue butterfly metapopulation in Benton County, Oregon.

The sites that comprise the Finley metapopulation provide a variety of habitat conditions. Upper Pigeon Butte has an elevation of approximately 165 m (540 ft) and is dry with shallow soils and moderately steep south/west facing slopes. The Field 8 North site is a flat, previously farmed field with an elevation of 98 m (320 ft) that has been restored to prairie habitat. The Finley metapopulation is unique because all three Fender's blue butterfly host plants occur within the metapopulation. These unique conditions provide an opportunity to better understand how larvae and adult butterflies use and associate with the various host plants (Severns and Fitzpatrick 2014, p. 1; Severns and Fitzpatrick 2016, p. 5). The spurred lupine patches on Pigeon Butte are naturally occurring, while the Kincaid's lupine was planted in 2010, 2014 and 2015. In 2009, sickle-keeled lupine was included in a prairie seed mix that was planted in Field 8 North, but the lupine patches have not been mapped and therefore, are not shown in Figure C.15.

The Finley metapopulation was created by introducing Fender's blue butterflies to Finley NWR in 2014. The Recovery Plan identified tasks for reintroducing populations, as necessary, to meet recovery goals (USFWS 2010, p. IV-50). Fender's blue butterfly was not historically documented at Finley NWR, but the refuge had suitable habitat with ongoing management in a recovery zone with few protected sites, making it a priority area for introduction. To establish the new Fender's blue butterfly metapopulation, 110 presumed pregnant adult females and several males from the Fern Ridge, Willow Creek, and Wren metapopulations were released into 5 lupine patches (Severns and Fitzpatrick 2014, pp. 1, 4). In addition, 40 post-diapause larvae from Fern Ridge were transferred to the base of 10 spurred lupine plants and 10 Kincaid's lupine plants at Upper and Lower Pigeon Butte (Severns and Fitzpatrick 2014, p. 1). In 2014, several individuals were observed to disperse approximately 400 m (1,312 ft) to a large, dense patch of sickle-keeled lupine in the Field 8 North site. In May 2015, the Field 8 North site was augmented with 21 pregnant adult female Fender's blue butterflies from the Wren metapopulation (Severns and Fitzpatrick 2015, p. 1). Unfortunately, wildfire burned this entire site in August 2015, and it is assumed that all Fender's blue butterfly larvae were killed. In response to relatively low numbers of Fender's blue butterfly larvae counted in March 2016, 60 pregnant adult female butterflies were released at all three sites in May 2016 (20 released in each unit) (Severns and Fitzpatrick 2016, p. 5). The Fender's blue butterfly introduction at Finley NWR was seemingly successful with an estimated abundance of 172 and 239 individuals in 2015 and 2016, respectively (Severns and Fitzpatrick 2015, p. 1; Severns and Fitzpatrick 2016, p.1). These abundance estimates do not include the released individuals.

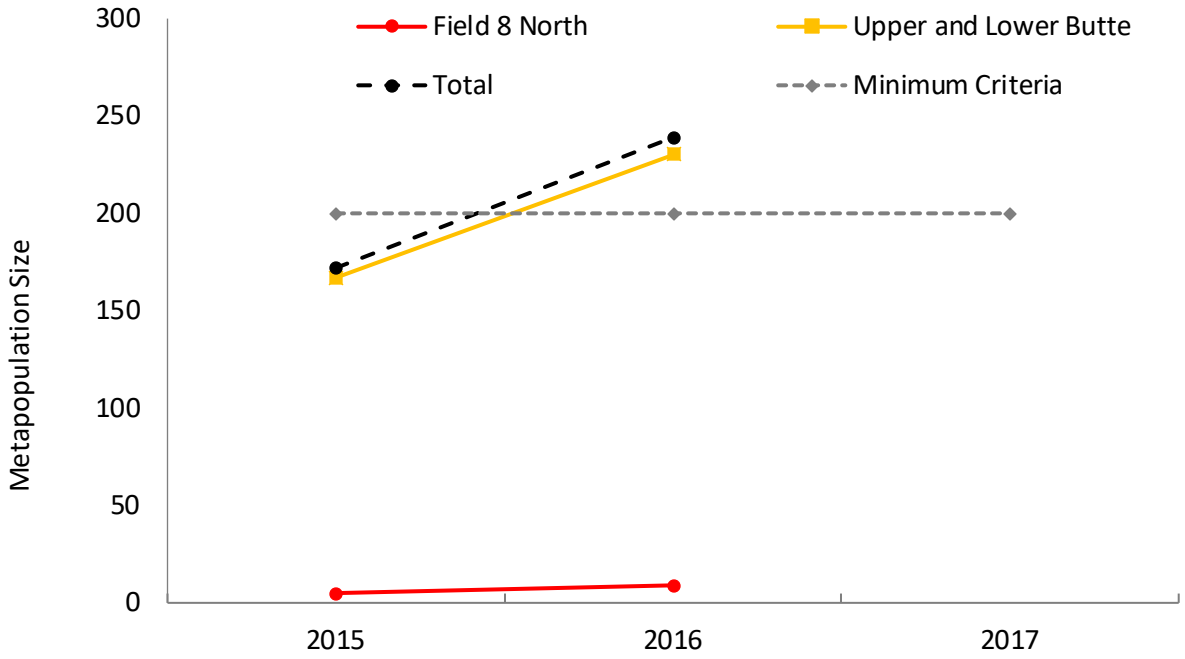

Figure C.16. Estimates of the number of Fender's blue butterflies in the Finley metapopulation since surveys began at the metapopulation.

Table C.8. Status and abundance of Fender's blue butterflies in the Finley metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Finley NWR Field 8 North	Permanent - Public (FWS)	9	4
Finley NWR Pigeon Butte	Permanent - Public (FWS)	230	96

C.2.3 Greasy Creek Metapopulation

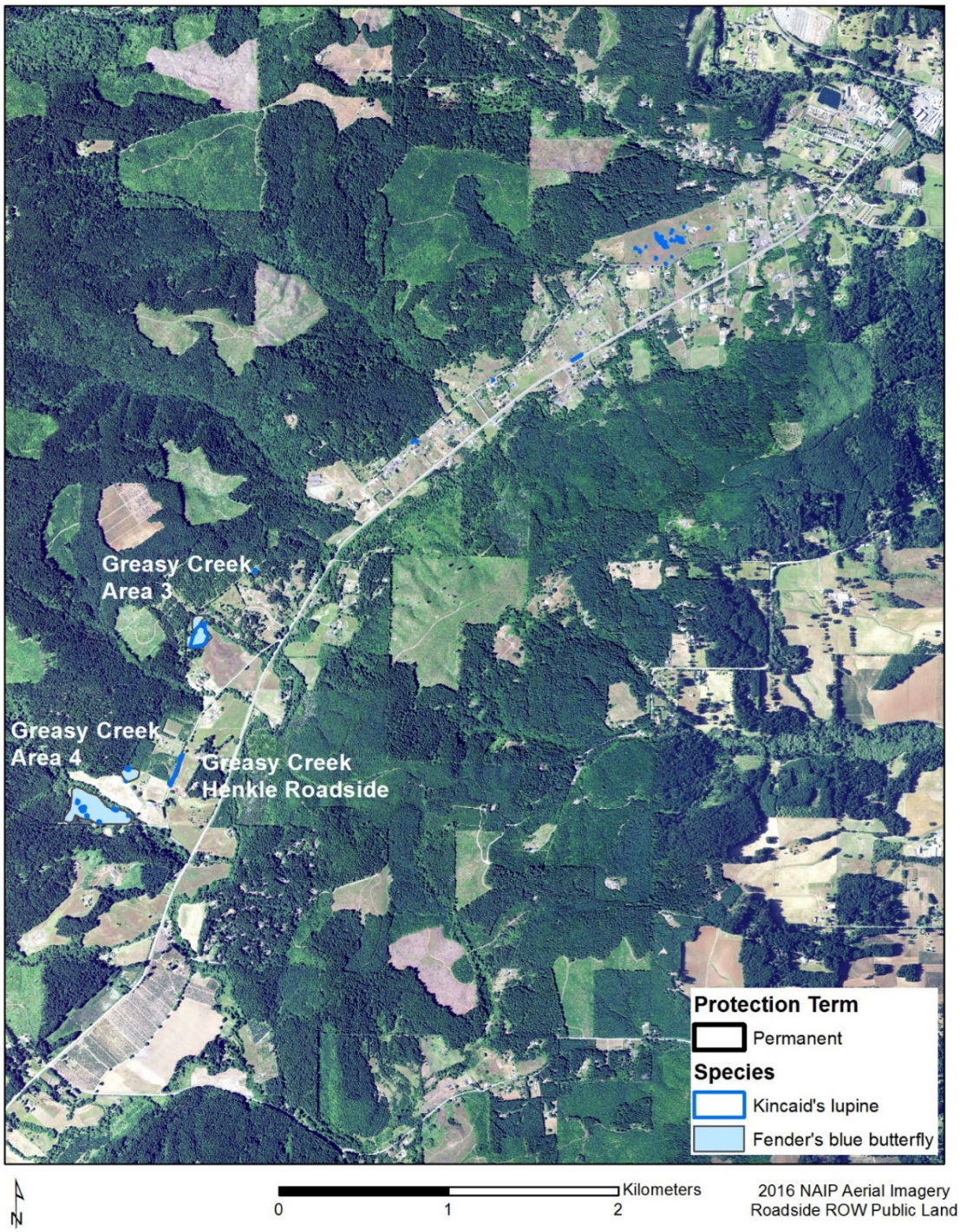

Figure C.17. Greasy Creek Fender's blue butterfly metapopulation in Benton County, Oregon.

The Greasy Creek metapopulation was discovered in 2004 at the Henkle Roadside site (Hammond 2005, p. 28) and is currently comprised of three sites in Benton County, Oregon. Hammond (2007, p. 32) suggests that lupine spread from the Henkle Roadside site into nearby private land. In 2008, during HCP surveys, the Institute for Applied Ecology (IAE) mapped lupine and nectar habitat in the area currently identified as the Greasy Creek Area 4 site (Service Database, version dated January 2018). Although abundance estimates have not been conducted at the Area 4 site, it is assumed to be occupied based on its proximity to extant locations. In 2010, butterflies were discovered at the privately-owned Area 3 site (Hammond 2010, p. 9). Abundance estimates have been conducted annually at the Henkle Roadside and Area 3 sites, and collectively the sites support a 5-year abundance of 69 individuals (Service Database, version dated January 2018).

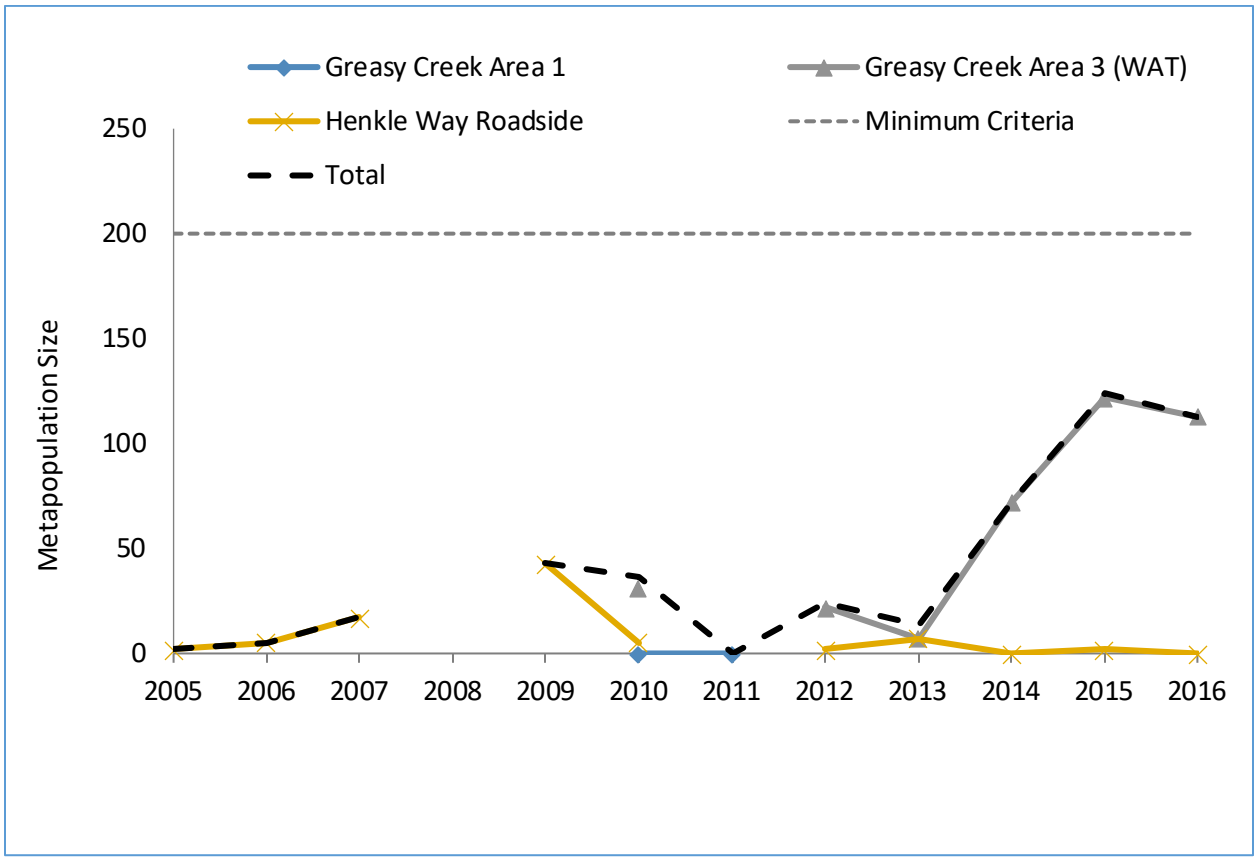

Figure C.18. Estimates of the number of Fender's blue butterflies in the Greasy Creek metapopulation since surveys began at the metapopulation.

Table C.9. Status and abundance of Fender's blue butterflies in the Greasy Creek metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Greasy Creek Area 3	Unprotected – Private	67	97
Greasy Creek Area 4	Unprotected – Private	2	3
Greasy Creek Henkle Roadside	Permanent – Public (ROW)	Unknown	unknown

C.2.4 Lupine Meadows Metapopulation

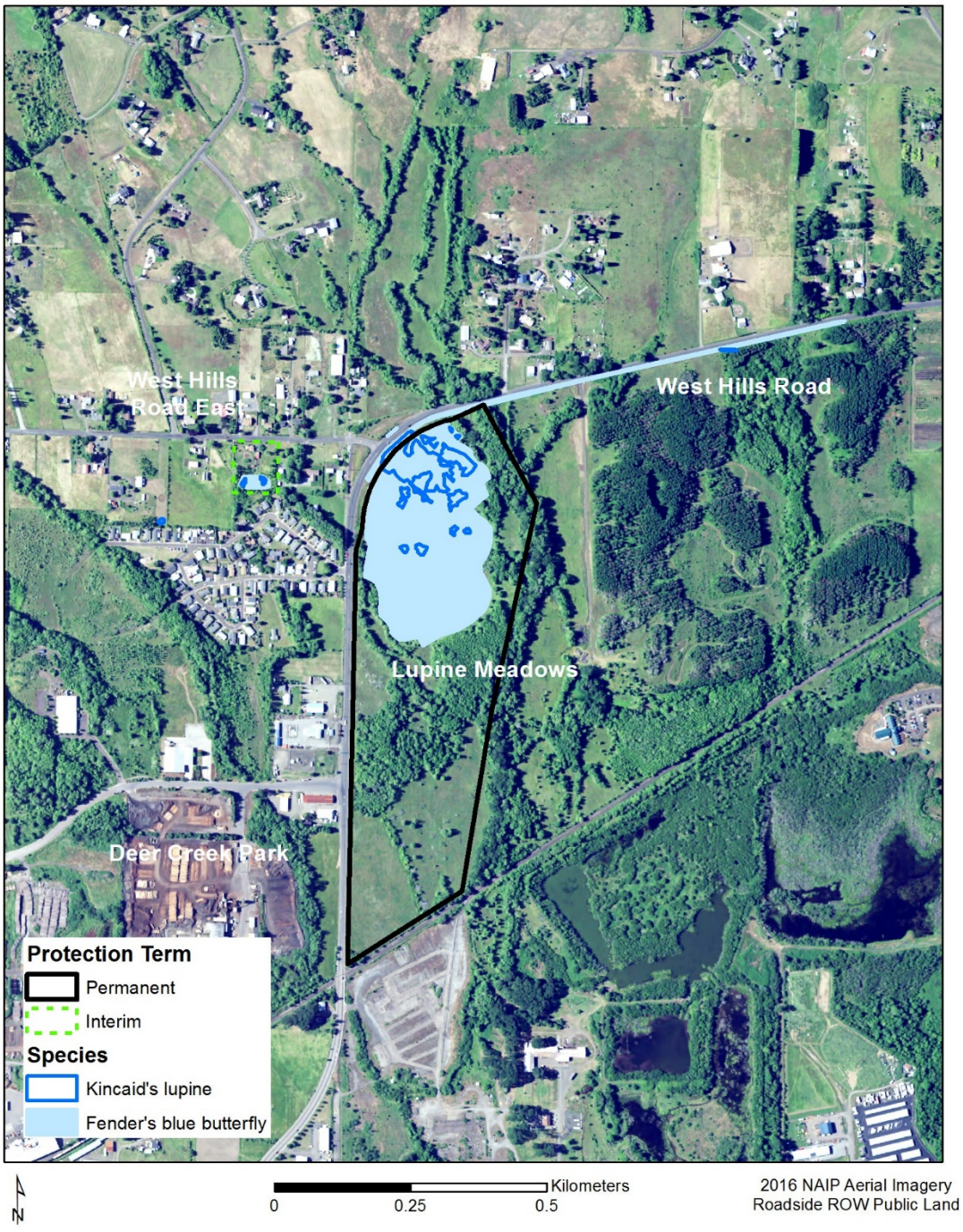

Figure C.19. Lupine Meadows Fender's blue butterfly metapopulation in Benton County, Oregon.

The Lupine Meadows metapopulation is comprised of three sites in Benton County, Oregon. Fender's blue butterfly was first reported as the "West Hills Road" site in 1992 (now referred to as "Lupine Meadows"), and was described as a heavily pastured area dominated by nonnative plants (Hammond and Wilson 1993, p. 21). Most of the metapopulation sites were known when Fender's blue butterfly was listed as endangered, although the small West Hills Road East was later discovered in 2013, and protection and management has occurred since the time of listing. Abundance estimates have been conducted annually at the Lupine Meadows metapopulation and the sites collectively support a 5-year abundance average of 28 individuals (Service Database, version dated January 2018). The Lupine Meadows site supports the primary concentration of butterflies in the metapopulation, but a small number of butterflies have been documented at the privately-owned West Hills Road East site (Fitzpatrick 2014, *in litt*., p. 1). Although Fender's blue butterfly has never been observed at the West Hills Road site, its proximity to the Lupine Meadows site suggests Fender's blue butterfly may utilize the site intermittently.

The Lupine Meadows site is located on a small knoll near the valley margin (Hammond and Wilson 1993, p. 21) at a relatively low elevation of 110 m (360 ft). Hammond (2004, p. 30) reports that due to the low elevation and dry habitat of the Lupine Meadows site, Fender's blue butterfly appear to fly earlier here than other sites in the Willamette Valley. In 2005, the Greenbelt Land Trust (GLT) acquired a conservation easement for the site, followed by a purchase of the site in 2007, establishing the Lupine Meadow Preserve (Fitzpatrick and Menke 2016, p. 13). GLT's habitat restoration at Lupine Meadows has resulted in one of the highest quality prairie remnants occupied by Fender's blue butterfly (Ottombrino-Haworth et. al 2017, p. 29, 31, 37, 41, 45). Despite this high quality habitat, for reasons not understood butterfly abundance declined steeply between 2009 and 2011 (Fitzpatrick 2013a, p. 13), and it has not rebounded (Fitzpatrick and Menke 2016, p.11). In 2010, Benton County completed an HCP, which included designating the West Hills Road site a "Type 1" area, meaning they will avoid impacting the area during routine maintenance activities (Benton County 2010, p. 73). The Service entered into a PFW agreement in 2015 and an SHA in 2017 with the landowners at the West Hills Road East site to expand lupine and nectar resources at the site.

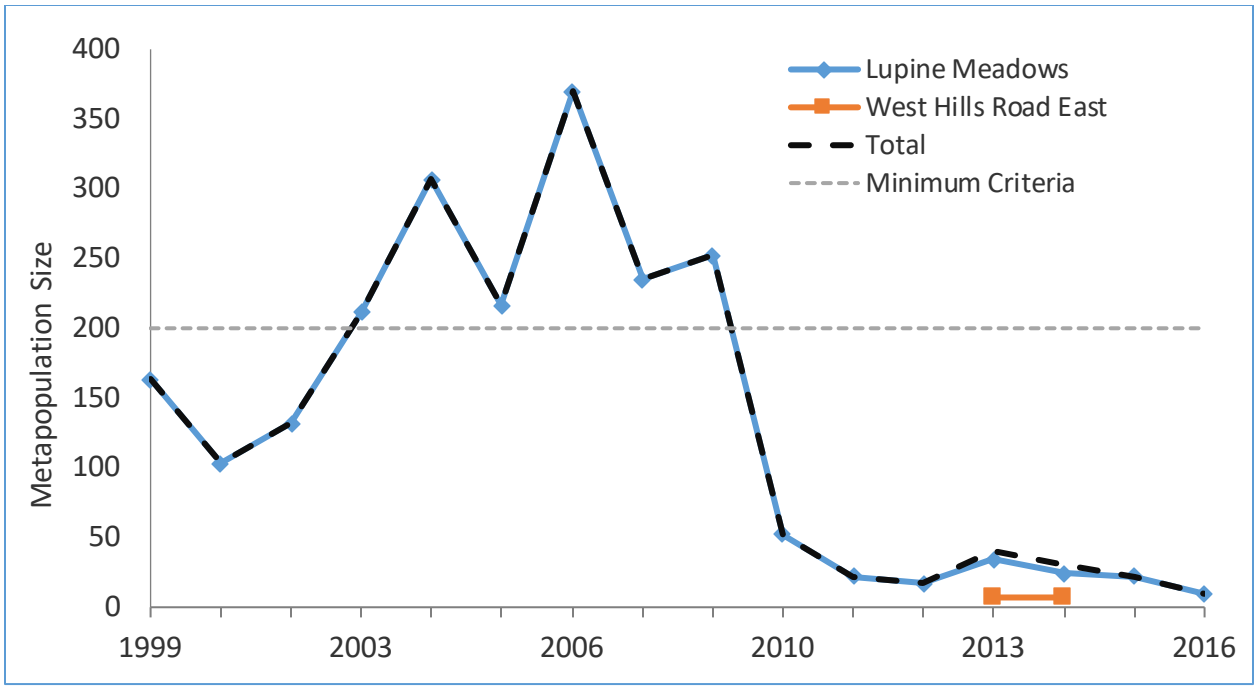

Figure C.20. Estimates of the number of Fender's blue butterflies in the Lupine Meadows metapopulation since surveys began at the metapopulation.

Table C.10. Status and abundance of Fender's blue butterflies in the Lupine Meadows metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Lupine Meadows	Permanent – Easement (GLT)	21	100
West Hills Road East	Interim – SHA/PFW	7	33
West Hills Roadside	Permanent – Public (ROW with HCP)	0	Intermittent

C.2.5 Wren Metapopulation

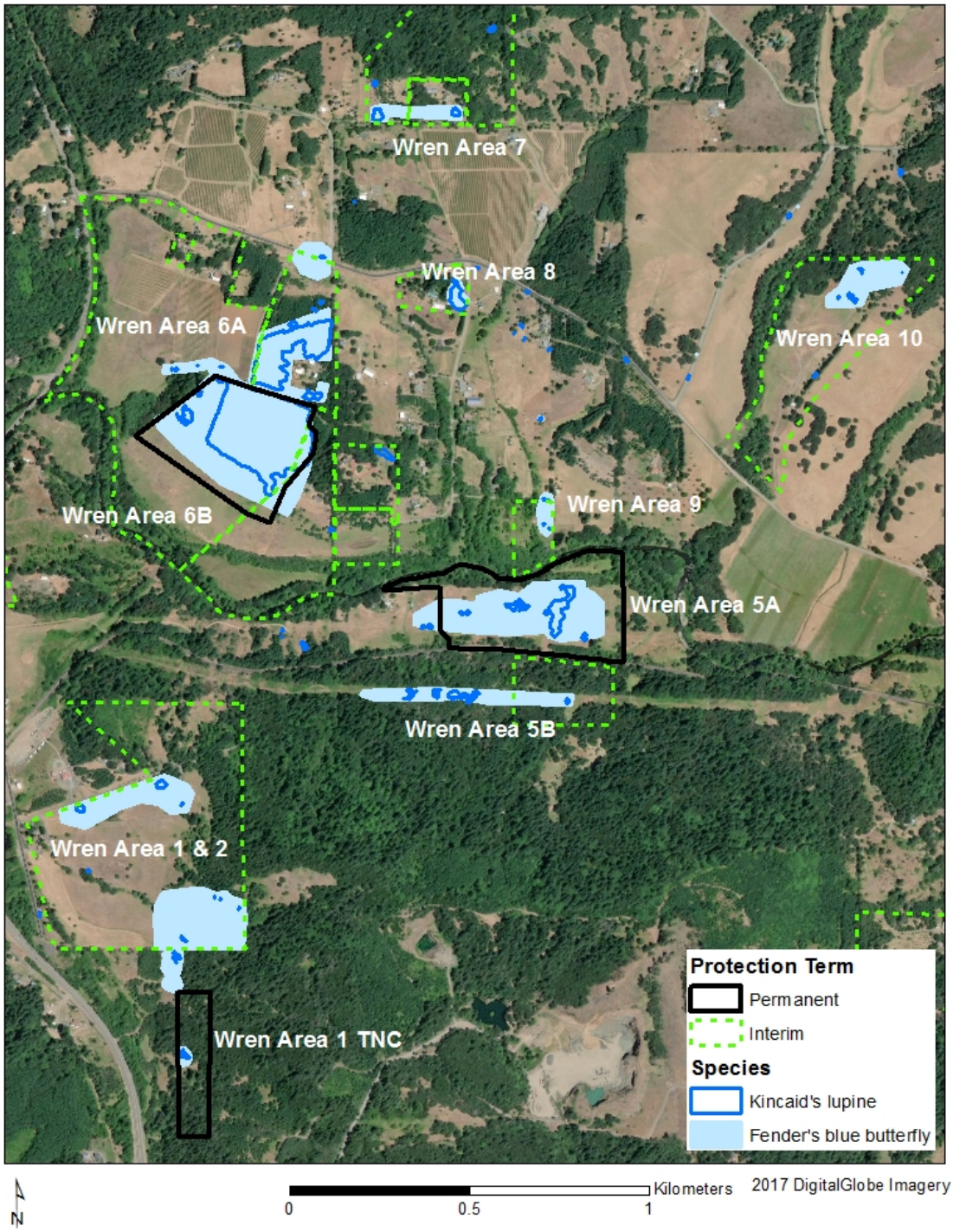

Figure C.21. Wren Fender's blue butterfly metapopulation in Benton County, Oregon.

The Wren metapopulation is comprised of 17 sites in Benton County, Oregon. From 1937 to 2004, Fender's blue butterfly was known to occur in very small patches at sites 1 and 2 (Hammond 2004, p. 23). Larger sites were discovered in 2004 (Hammond 2004, p. 23) at Wren Area 5, and in 2006, at the Wren area 6A and Wren area 6B (Hammond 2006, p.25). These three larger sites, including Wren Area 5B which is a BPA powerline corridor, are monitored regularly and support 99 percent of the current butterfly abundance (Service Database, version dated January 2018). Other sites in this metapopulation are less frequently monitored or not monitored at all because they consist of very small patches of lupine, but these small patches are assumed to be intermittently utilized by Fender's blue butterfly given their proximity to the populations at sites 5A, 5B, 6A and 6B. Five sites are managed through interagency agreements with the Service and Marys River Watershed Council (MWRC). The Wren metapopulation sites collectively support a 5-year average abundance of 3,048 individuals (Service Database, version dated January 2018).

As part of their HCP, Benton County permanently protected and began habitat management at sites 5A and 6A (Benton County 2010, p.38) as a conservation and mitigation area. These permanently protected sites are being managed annually to improve butterfly habitat conditions and support 78 percent of the butterfly's 5-year metapopulation abundance. BPA manages habitat at site 5B, which supports 17 percent of the 5-year average metapopulation abundance. The MWRC has been coordinating with landowners for annual monitoring and actively restoring habitat on Areas 1 and 6 through 9 (5 sites), which surround Areas 5 and 6A. The five sites managed by the MWRC are enrolled in the Service's PFW and SHA programs. This metapopulation is now known to be much larger than the "historic" records documented, and most of the butterfly habitat is now managed under permanent or interim protections.

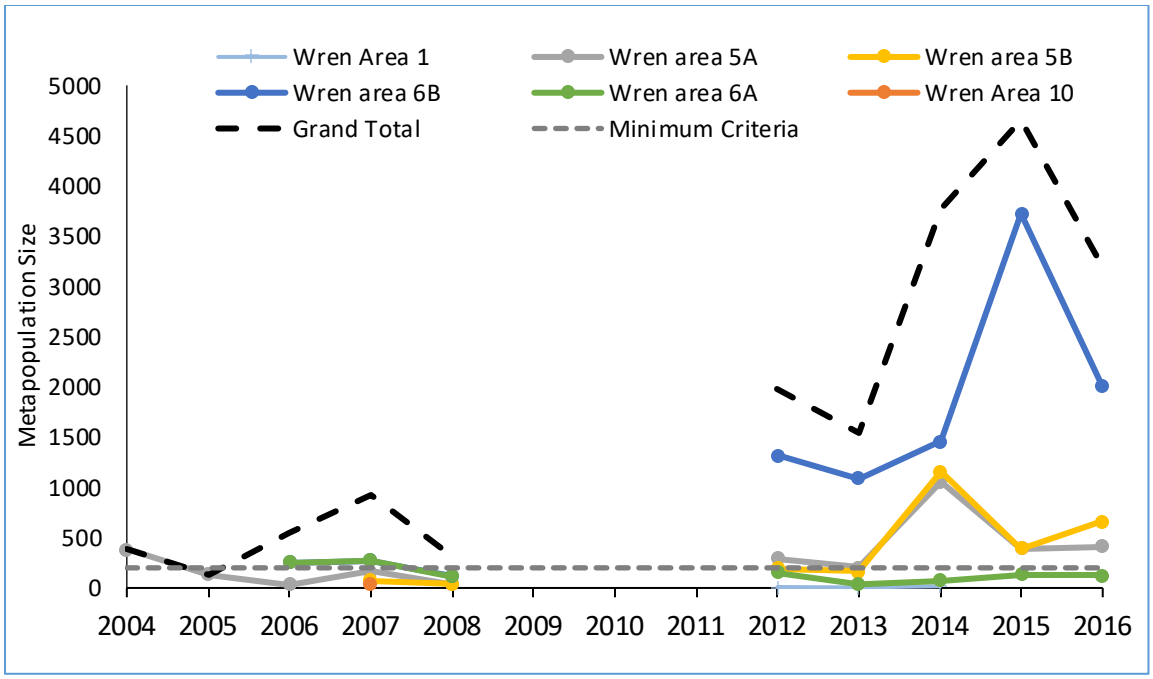

Figure C.22. Estimates of the number of Fender's blue butterflies in the Wren metapopulation since surveys began at the metapopulation.

Table C.11. Status and abundance of Fender's blue butterflies in the Wren metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Wren Area 1 & 2	Interim – SHA/PFW	10	<1%
Wren area 5A	Permanent – Easement (Benton County)	472	16
Wren area 5B (BPA)	Permanent – Public (BPA)	515	17
Wren area 6A (CRI-BENTCO)	Permanent – Easement (Benton County)	1917	63
Wren area 6B (CLA)	Interim – SHA/PFW	105	4
Wren Area 7 (OBR)	Interim – PFW	4	<1%
Wren Area 8 (ISS)	Interim – PFW	13	<1%
Wren Area 9 (HOW)	Interim – PFW	12	<1%

C.3 Eugene Recovery Zone

There are four metapopulations within the Eugene Recovery Zone known as Coburg Ridge, Oak Basin, West Eugene, and Willow Creek. Of these metapopulations, one has been found since listing and three have expanded since listing. Collectively, the metapopulations have an estimated 5-year average abundance of 11,175 Fender's blue butterflies across 62.2 ha (153.7 ac) of prairie containing 16.5 ha (40.8 ac) of lupine patch area, 6,018 sq m of lupine cover, and 73.9 ha (182.6 ac) of nectar area. Across the four metapopulations, 100.6 ha (248.6 ac) are permanently protected and 10.2 ha (25.2 ac) have interim protection.

C.3.1 Coburg Ridge Metapopulation

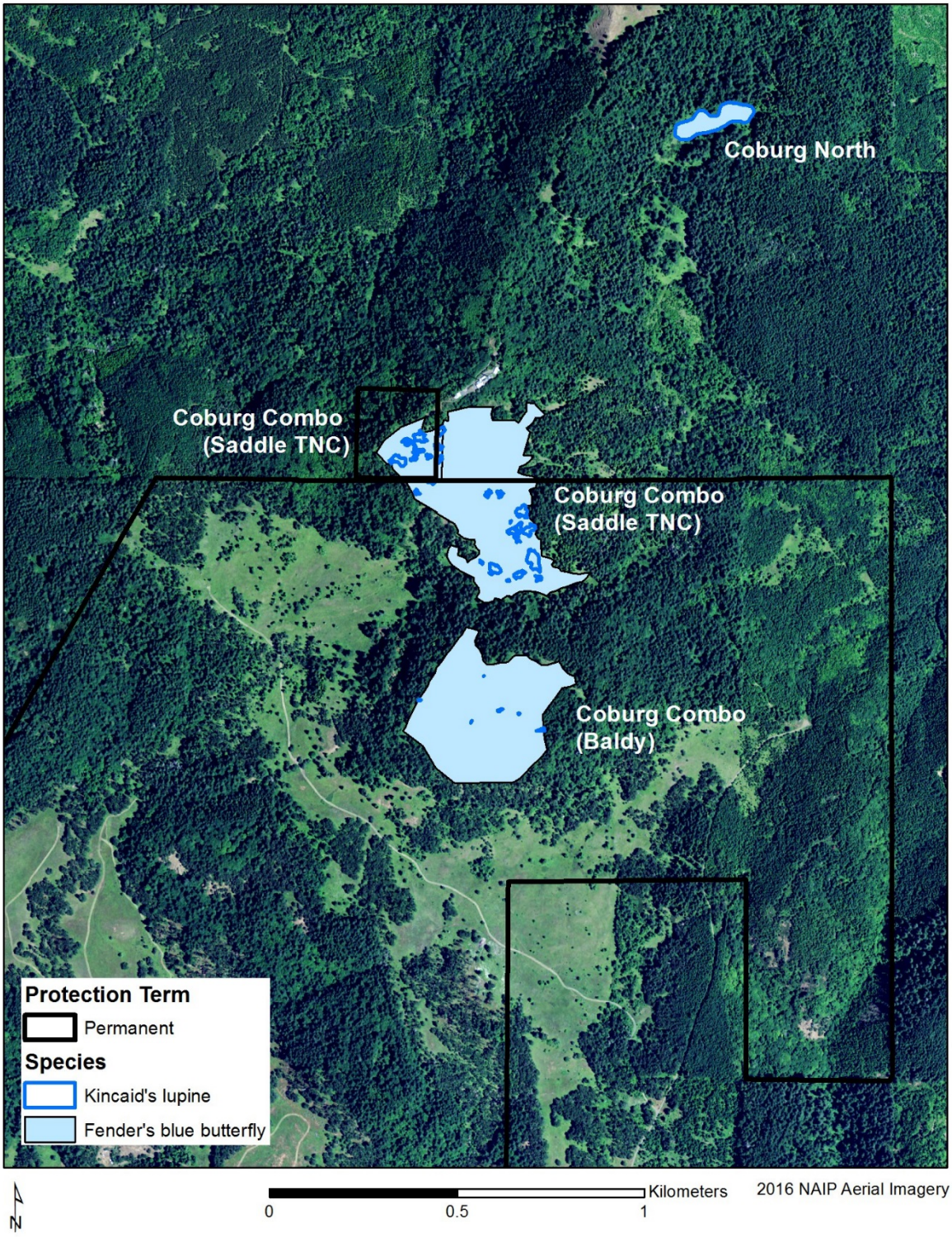

Figure C.23. Coburg Ridge Fender's blue butterfly metapopulation in Lane County, Oregon.

The Coburg Ridge metapopulation is comprised of three sites at the top of Coburg Ridge in Lane County, Oregon. Fender's blue butterfly occupancy was first documented at one site in 1988 (Severns 2006, p. 1) and at two additional sites in the early 1990s (Hammond and Wilson 1993, p. 15; Hammond 1994, p. 48). The Coburg Ridge metapopulation includes steep, south-facing hillsides at the Baldy site, as well as relatively flat areas at the top of the ridge in the northern portion of the Saddle site (Hammond and Wilson 1993, p. 15). It also has extremely dry habitat conditions (Hammond 1994, p. 44). This metapopulation has the highest elevation known to support Fender's blue butterfly at 604 m (1,980 ft). Historically, it was believed to have few habitat threats because of its isolated locality containing rich plant species diversity (Hammond 1994, p. 44); however, that is no longer the case. Spurred lupine is the host plant supporting Fender's blue butterfly at the Coburg Ridge metapopulation.

TNC acquired a conservation easement on the northwestern portion of the Saddle Site in 2001 and on the southern portion of the Saddle site and the Baldy site in 2007, establishing the Coburg Ridge Preserve (Gibbons 2011, p. 2). TNC has had a habitat management plan for the Coburg Ridge Preserve in place since 2007 (TNC 2007, pp. 1-69) and a maintenance plan in place since 2011 (Gibbons 2011, pp. 1-11). The Coburg North site is privately owned and the landowners have not allowed access for surveys since Hammond's initial habitat assessments in the early 1990s. It is unclear in the Fender's blue butterfly reports if this site was ever actually assessed for abundance. The Saddle and Baldy sites have been surveyed annually and collectively support a 5-year average abundance of 54 individuals (Service Database, version dated January 2018). Between 1993 and 2007, Fender's blue butterfly estimates were reported to fluctuate between 23 and 500 individuals, but abundance has declined and seemingly not rebounded since 2007 (Service Database, version dated January 2018). It is unclear if abundance will increase to historic levels.

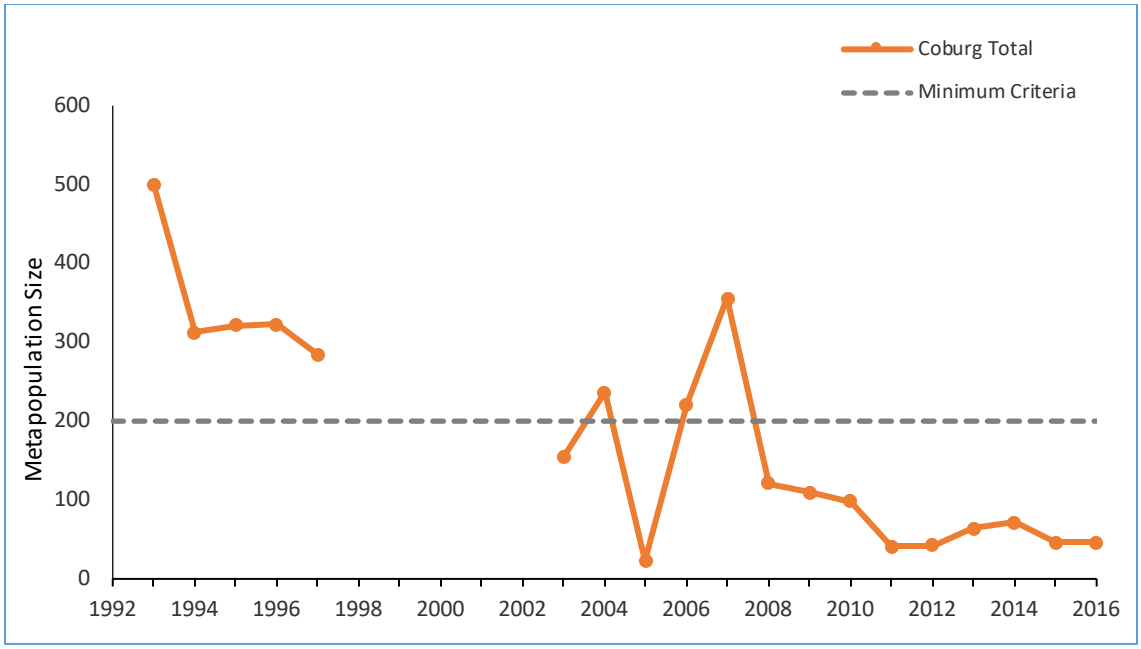

Figure C.24. Estimates of the number of Fender's blue butterflies in the Coburg Ridge metapopulation since surveys began at the metapopulation.

Table C.12. Status and abundance of Fender's blue butterflies in the Coburg Ridge metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Coburg All	Permanent – Easement (TNC)	54	100

C.3.2 Oak Basin Metapopulation

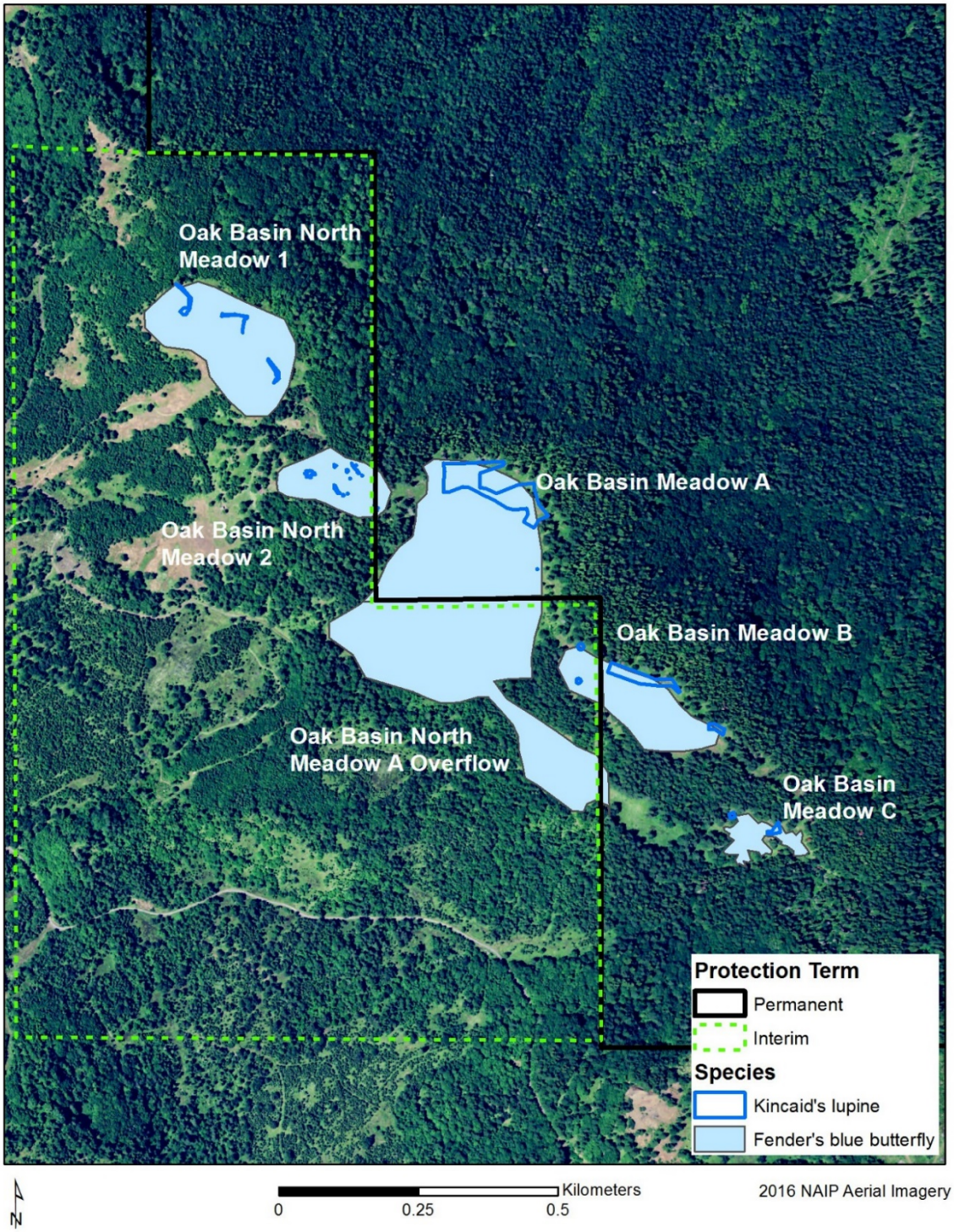

Figure C.25. Oak Basin Fender's blue butterfly metapopulation in Linn County, Oregon.

The Oak Basin metapopulation was discovered in 2006 in two sites known as Meadows A and B. It is now comprised of seven sites in Linn County, Oregon. The majority of butterflies are found in two upper meadows (Meadows A and B) (Ross 2010, p. 1), with additional butterflies observed in 2014 and 2015 in Meadow C (Ross 2015, p. 1). As a result of recent habitat restoration efforts, the lupine plants in Meadow C appear healthier and more robust (Ross 2015, p. 1), improving the habitat quality for the Fender's blue butterfly. Although survey results indicate that butterfly abundance is relatively low, the butterfly population has been relatively stable over the last 5 years (Ross 2015, p. 1). Fender's blue butterfly abundance estimates have never been conducted on the privately owned Meadows North 1 and 2, but occupancy has been documented on the sites (Severns 2008, p. 9). Meadows A, B, and C are owned and managed by the Bureau of Land Management (BLM) and are monitored annually. These meadows are threatened with heavy infestation of invasive plant species, including encroaching woody vegetation, but are being actively managed to improve habitat quality for the Fender's blue butterfly.

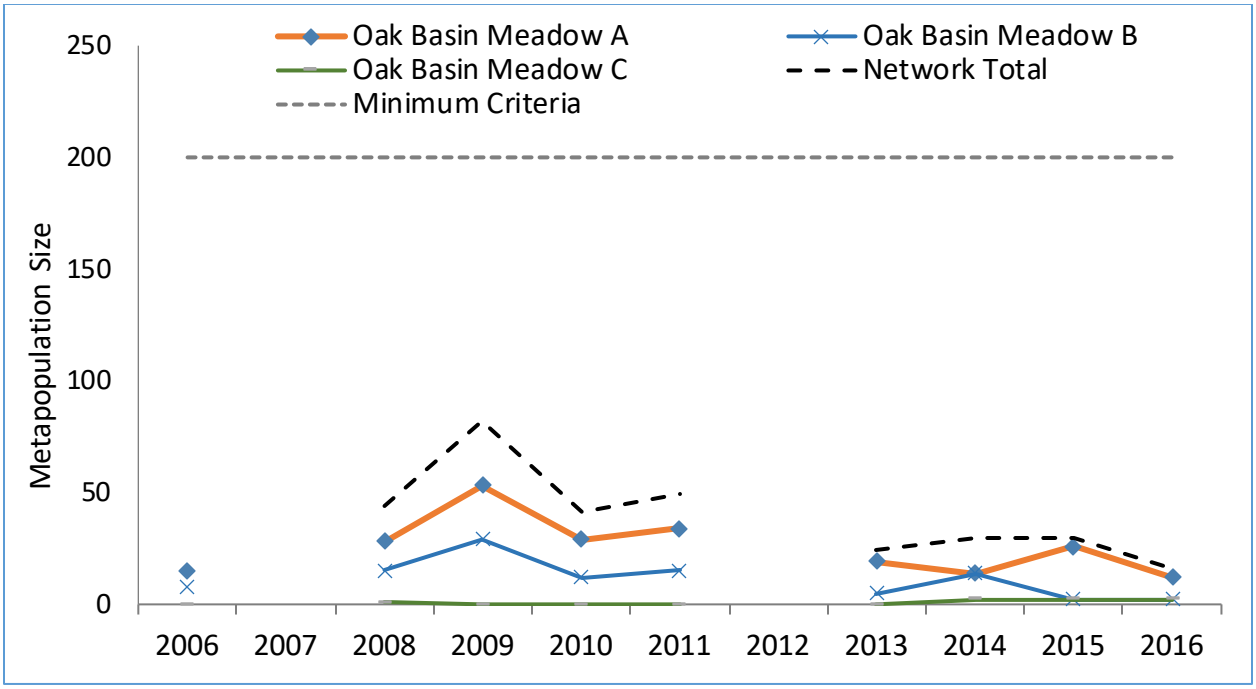

Figure C.26. Estimates of the number of Fender's blue butterflies in the Oak Basin metapopulation since surveys began at the metapopulation.

Table C.13. Status and abundance of Fender's blue butterflies in the Oak Basin metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Oak Basin North Meadow 1	Interim – PFW	unknown	unknown
Oak Basin North Meadow 2	Interim – PFW	unknown	unknown
Oak Basin Meadow A, B, C	Permanent – Public (BLM)	100	100

C.3.3 West Eugene Metapopulation

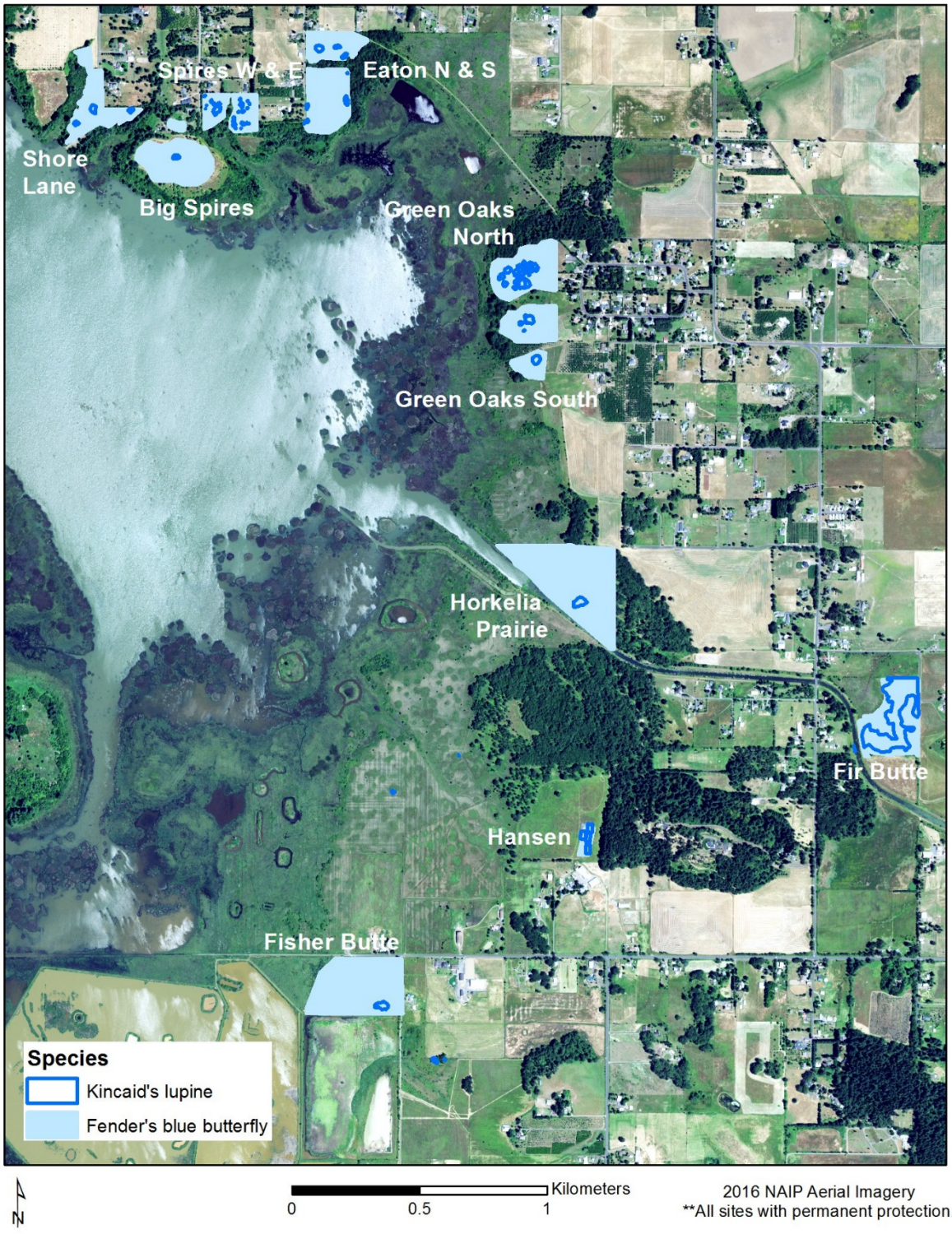

Figure C.27. West Eugene Fender's blue butterfly metapopulation in Lane County, Oregon.

The West Eugene metapopulation is comprised of 12 sites owned and managed by the Army Corps of Engineers (ACOE) and the BLM in Lane County, Oregon, making 100 percent of the sites in this metapopulation protected and managed for the Fender's blue butterfly. Abundance estimates have been conducted annually in the West Eugene metapopulation and the sites collectively support a 5-year average abundance of 8,449 individuals (Service Database, version dated January 2018), which is the largest reported metapopulation abundance in the species' range. Although five sites in this metapopulation were reported supporting Fender's blue butterfly between 1993 and 1995 (Hammond and Wilson 1993, p. 16-17; Schultz 1995, p. 3), the ACOE has improved habitat quality at their sites and restored habitat in several additional units to expand habitat for the butterfly. The BLM has similarly improved habitat conditions at the Fir Butte site and restored habitat at the Hansen site where a small butterfly population was first reported in 2011 (Fitzpatrick and Menke 2016, p. 21). The sites in this metapopulation are relatively flat habitat on the Willamette Valley floor at an elevation of 114 m (375 feet), with large areas of wet prairie habitat in the surrounding landscape.

The 10 ACOE sites are located around the most eastern portion of Fern Ridge Reservoir, which is roughly 12 miles west of Eugene, Oregon. Fender's blue butterfly abundance at the ACOE sites has been steadily increasing since 2005 (Fitzpatrick and Menke 2016, p. 21), and they collectively support 63 percent of the metapopulation's 5-year butterfly abundance. The highest density reported is at the Green Oaks North-North Meadow site. The ACOE developed a Biological Assessment in 2006 and 2011, outlining their management plan for their sites, and the Service completed section 7 consultation on their proposed activities. ACOE submits annual reports to the Service summarizing their treatments and documenting treatment efficacy. In general, the ACOE restoration has created significant habitat expansion around the reservoir that has resulted in increased butterfly abundance and connectivity between the ACOE sites and the BLM's Fir Butte site. One successful habitat restoration project established a small patch of Kincaid's lupine at the Horkelia prairie site in 2001. Fender's blue butterfly eggs have been observed at Horkelia prairie since 2004, and adult butterflies have been observed using the site since 2010 (Fitzpatrick 2014, p. 79). When the lupine patch at Horkelia prairie was established, it was estimated to be 930 m (3,051 feet) from the nearest occupied lupine patch at South Green Oaks site and 1,200 m (3,937 feet) from the nearest occupied lupine patch at Fir Butte. As of 2016, this site was estimated to be supporting 90 individuals (Fitzpatrick and Menke 2016, p. 21).

The two BLM sites are managed annually to improve habitat conditions for the Fender's blue butterfly. Fir Butte is composed of 2.6 ha (6.5 acres) of wet prairie/vernal pool and 4.7 ha (11.7 acres) of upland habitat (Fitzpatrick 2011, p. 15). It supports 37 percent of the metapopulation's 5-year annual butterfly abundance. Habitat restoration at Fir Butte was initiated in 1999 and habitat quality has vastly improved (Fitzpatrick 2006, pp. 12-13) with substantial increases in butterfly abundance recently reported (Fitzpatrick and Menke 2016, p. 21). The Hansen site is composed of a mixture of wet prairie/vernal pool, oak woodland, and upland prairie habitats with lupine found in the upland patches (Fitzpatrick 2011, p. 5). The lupine patches at this site were augmented in 2014, 2016, and 2016 (Schultz 2017, p. 11). A couple of butterflies have been reported intermittently since 2011 (Fitzpatrick and Menke 2016, p. 21). BLM completed a Biological Assessment in 2014 on their proposed Resource Management Plan (RMP) for the

sites they manage in the West Eugene Wetlands, Oregon. The Service completed a section 7 consultation on the management treatments and BLM has been implementing the RMP.

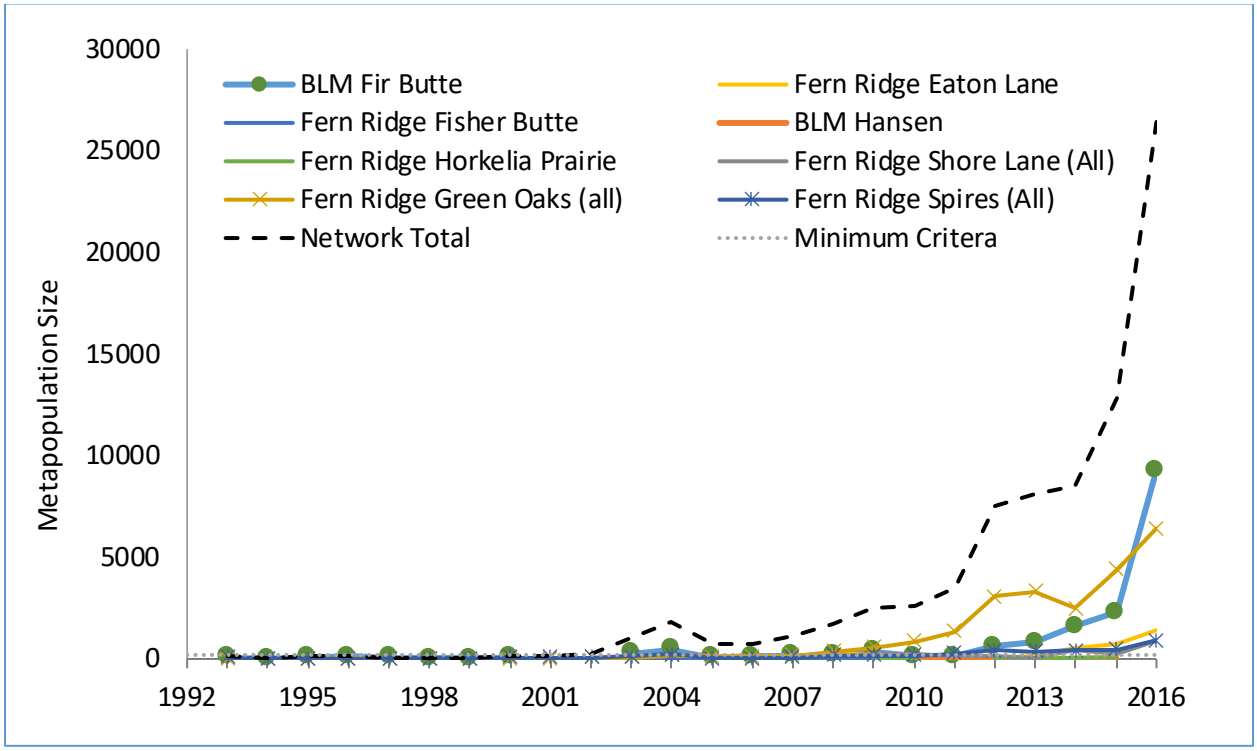

Figure C.28. Estimates of the number of Fender's blue butterflies in the West Eugene metapopulation since surveys began at the metapopulation.

Table C.14. Status and abundance of Fender's blue butterflies in the West Eugene metapopulation.

Site Name	Conservation Status	5-Year Average Abundance	% of Metapopulation Abundance
Fir Butte	Permanent – Public (BLM)	3115	37
Hansen	Permanent – Public (BLM)	2	<1
Big Spires	Permanent – Public (ACOE)	12	<1
Eaton N & S	Permanent – Public (ACOE)	431	5
Fisher Butte	Permanent – Public (ACOE)	5	<1
Green Oaks North	Permanent – Public (ACOE)	3275	39
Green Oaks North – South Meadow	Permanent – Public (ACOE)	620	7
Green Oaks South	Permanent – Public (ACOE)	32	<1
Horkelia Prairie	Permanent – Public (ACOE)	74	<1
Shore Lane East	Permanent – Public (ACOE)	1	<1
Shore Lane West	Permanent – Public (ACOE)	366	4
Spires W & E	Permanent – Public (ACOE)	516	6

C.3.4 Willow Creek Metapopulation

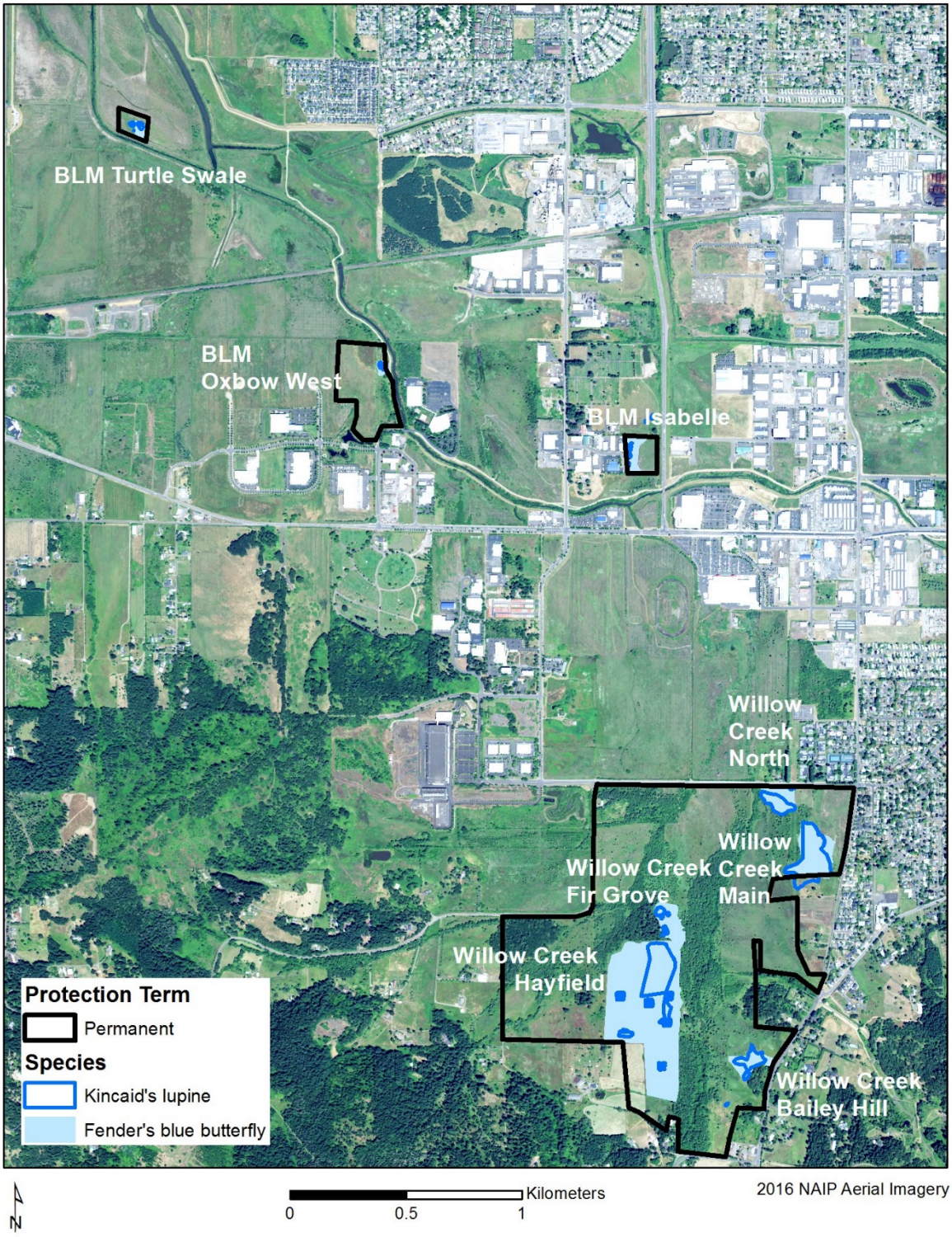

Figure C.29. Willow Creek Fender's blue butterfly metapopulation in Lane County, Oregon.

The Willow Creek metapopulation is comprised of eight sites in Lane County, Oregon. Since they are owned and managed by TNC and the BLM, it means that 100 percent of the sites in this metapopulation are protected and managed for the Fender's blue butterfly. Portions of TNC's Willow Creek Preserve (Bailey Hill, North and Main areas) were documented supporting Fender's blue butterfly before the species was listed (Schultz 1995, p. 4), but since then, TNC has restored additional areas and created more habitat on their lands (Fitzpatrick 2004, pp. 6-8). The BLM's Oxbow West, Isabelle, and Turtle Swale sites were first documented supporting Fender's blue butterfly in 2003, 2004, and 2014, respectively (Fitzpatrick 2004, p. 9; 2006, p. 14; and 2014, p. 20) after the species was listed. Abundance estimates have been conducted annually in the Willow Creek metapopulation since 1993 and the sites collectively support a 5-year average abundance of 2,598 individuals (Service Database, version dated January 2018). Willow Creek Preserve contains 99 percent of individual butterflies.

For over 20 years, TNC has been improving habitat quality at the Willow Creek Preserve and restoring lands to create additional habitat areas (Schultz 2001, p. 1009; Fitzpatrick 2004, p. 7; Fitzpatrick 2006, p. 8). TNC created experimental restoration plots in the northeast corner of the Hayfield site in 1999, expanded the North Area site by restoring upland prairie in 2000 (Fitzpatrick 2004, p. 6), and seeded 17 ha (42 ac) with upland native prairie species including Kincaid's lupine and nectar plants in 2008 and 2009. Fender's blue butterfly was first documented utilizing the Hayfield site in 2011, and now this site supports an estimated 19 percent of the metapopulation's butterfly abundance. The Willow Creek Preserve is currently managed under the Willow Creek Site Maintenance Plan, which was prepared in March of 2014. The BLM sites in this metapopulation are relatively small upland prairie areas generally surrounded by more extensive wet prairie habitat areas, but are considered stepping stone sites for the Fender's blue butterfly. Oxbow West is approximately 0.1 ha (0.25 ac) that was restored from pasture land in 1999 (Fitzpatrick 2014, p. 4). Fender's blue butterfly has been monitored there annually since 2003 when it had the largest reported abundance of 122 individuals. Abundance was reported as low as zero in 2012 and 2013, though it was back up to an estimated 29 individuals in 2016 (Fitzpatrick and Menke 2016, p. 21). The Isabelle site is largely a wet prairie site, but in 1999, Kincaid's lupine seeds were planted in 10 plots along the top of an upland bank. In 2000, 128 plants of Kincaid's lupine were transplanted to the site to serve as a potential Fender's blue butterfly stepping stone (Kaye and Brandt 2005, pp. 14, 23). Kincaid's lupine successfully established and Fender's blue butterfly eggs were subsequently found on these plants (Kaye and Brandt 2005, p. 73). Adult Fender's blue butterfly estimates are not regularly conducted at the Isabelle site. While adults have not been observed, 120 eggs were documented in 2004 and one egg was found in both 2005 and 2006 (Kaye and Thorpe 2006, p. 22). Fender's blue butterfly has been observed at the Turtle Swale site in 2014, 2015, and 2016 (Fitzpatrick and Menke 2016, p. 21). To improve habitat quality, 0.2 ha (0.5 acres) of the upland area at this site was burned and seeded with an upland mix focused on butterfly nectar species, while the rest of the upland habitat was mowed in 2016 (Fitzpatrick and Menke 2016, p. 12). BLM completed a Biological Assessment in 2014 on their proposed RMP for the sites they manage in the West Eugene Wetlands, Oregon. The Service completed a section 7 consultation on the management treatments identified in the proposed RMP, and BLM has been implementing the RMP since 2016.

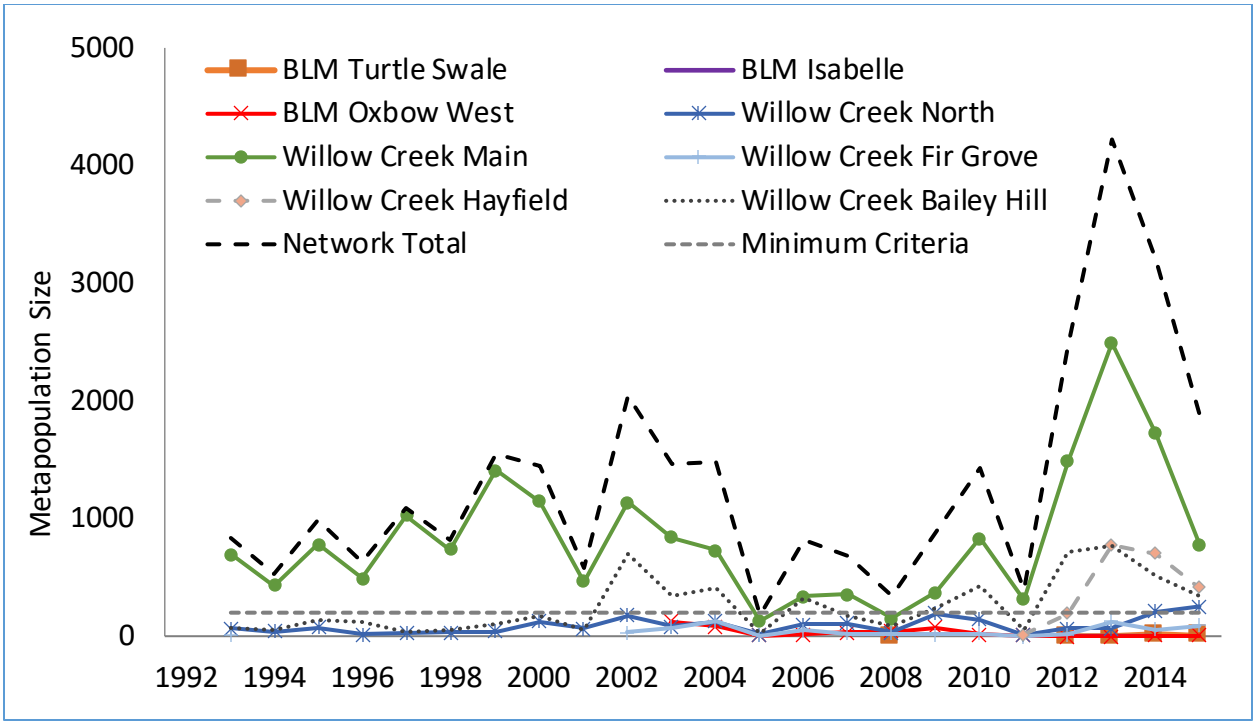

Figure C.30. Estimates of the number of Fender's blue butterflies in the Willow Creek metapopulation since surveys began at the metapopulation.

Table C.14. Status and abundance of Fender's blue butterflies in the Willow Creek metapopulation.

Site Name	Conservation Status	5 Year Average Abundance	% of Metapopulation Abundance
Turtle Swale	Permanent – Public (BLM)	8	<1
Oxbow West	Permanent – Public (BLM)	8	<1
Isabelle	Permanent – Public (BLM)	0	Intermittent
Willow Creek North	Permanent – Easement (TNC)	156	6
Willow Creek Main	Permanent – Easement (TNC)	1384	53
Fir Grove	Permanent – Easement (TNC)	61	2
Hayfield	Permanent – Easement (TNC)	486	19
Bailey Hill	Permanent – Easement (TNC)	495	19

APPENDIX D: Evaluation of Cause and Effect

Table D.1. Confidence terminologies explaining how we characterized our confidence levels in the cause and effects tables on the following pages.

Confidence Terminology	Explanation
Highly Confident	We are more than **90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by documented accounts or research and/or strongly consistent with accepted conservation biology principles.
Moderately Confident	We are **70 to 90% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by some available information and/or consistent with accepted conservation biology principles.
Somewhat Confident	We are **50 to 70% sure** that this relationship or assumption accurately reflects the reality in the wild as supported by some available information and/or consistent with accepted conservation biology principles.
Low Confidence	We are less than **50% sure** that this relationship or assumption accurately reflects the reality in the wild, as there is little or no supporting available information and/or uncertainty consistency with accepted conservation biology principles. Indicates areas of high uncertainty.

Table D.2. Cause and effect analysis of habitat loss, conversion, and fragmentation on Fender's blue butterflies.

THEME: Habitat loss, conversion, and fragmentation		
ESA Factor	**Analysis**	**Confidence or Uncertainty**
Stressor	Loss and fragmentation of prairie and oak savannah habitats	Highly confident
Source(s)	Conversion of habitat for agriculture and development	Highly confident
Affected Resource(s)	Host lupine plants; nectar plants; adult butterflies	Highly confident
Exposure to Stressor	All life stages are affected due to permanent and irreversible loss of habitat.	Highly confident
Immediacy of Stressor	Past, present, and future effects likely. Relative to time of listing, now have several plans in place that help to reduce impacts (e.g., Benton County HCP, safe harbor agreements, management plans).	Moderately confident
Effects of Stressor on individuals	Loss of reproductive capacity due to loss of host and nectar plants; reduced survivorship of adults due to loss of nectar plants; direct mortality when habitat is cleared.	Highly confident
Effects of Stressor on metapopulations	Lower reproductive rates and survivorship within metapopulations reduces the population growth rate. Reduced connectivity between metapopulations could lead to loss of genetic diversity by restricting interchange as well as reduced ability to recolonize when metapopulations are lost or reduced in size. Overall effect suppresses metapopulation growth and disrupts ability to function as a metapopulation, which reduces viability.	Moderately confident
Scope of Stressor	Rangewide geographic scope. Areas with metapopulations are less affected by habitat loss and fragmentation relative to time of listing due to active habitat management or protection. Potential metapopulations in areas not surveyed are most susceptible because they are not subject to management or protection efforts. Habitat loss is still relatively more prevalent in Lane and Polk counties.	Moderately confident

Trajectory of Stressor	Stressor is decreasing in areas with habitat management and protection. Stressor is staying the same or increasing in areas without habitat management or protection.	Highly confident

Table D.3. Cause and effect analysis of woody succession on Fender's blue butterflies.

THEME: Succession		
ESA Factor	**Analysis**	**Confidence or Uncertainty**
Stressor	Habitat succession from prairie to thickly wooded areas with heavy shrub and woody plant species.	Highly confident
Source(s)	Loss of natural and human-mediated disturbance (e.g., fire).	Highly confident
Affected Resource(s)	Host lupine plants; nectar plant species; individual butterflies.	Highly confident
Exposure to Stressor	All life stages are affected from loss of lupine, while adults are affected by loss of nectar. Woody succession shades out lupine and nectar plants, preventing adults from ovipositing on host plants and from accessing nectar plants.	Highly confident
Immediacy of Stressor	Past, present, and future effects likely.	Highly confident
Effects of Stressor on individuals	Loss of reproductive capacity due to inability to find host plants; reduced survivorship of adults due to loss of nectar plants, reduced adult dispersal due to thick stands of plants impeding movement.	Moderately confident
Effects of Stressor on metapopulations	Reduced connectivity due to restricted movement in denser vegetation. This could lead to loss of genetic diversity by restricting interchange as well as reduced ability to recolonize when metapopulations are lost or reduced in size. Overall effect suppresses metapopulation growth and disrupts ability to function as a metapopulation, which reduces viability.	Somewhat confident
Scope of Stressor	Rangewide.	Highly confident
Trajectory of Stressor	Increasing in areas without management. Declining in areas being managed for prairie habitat.	Highly confident

Table D.4. Cause and effect analysis of invasive species on Fender's blue butterflies.

	THEME: Invasive species	
ESA Factor	**Analysis**	**Confidence or Uncertainty**
Stressor	Encroachment of invasive plants.	Highly confident
Source(s)	Expansion of extant introduced species; loss of natural and human-mediated disturbance (e.g., fire) exacerbates the ability of invasive plants to replace native plants.	Highly confident
Affected Resource(s)	Host lupine plants; nectar plant species	Highly confident
Exposure to Stressor	All life are stages affected from loss of lupine. Invasive plant species, especially tall grasses, prevent adult butterflies from finding host plants for oviposition and nectar plants for feeding.	Moderately confident
Immediacy of Stressor	Past, present, and future effects likely.	Highly confident
Effects of Stressor on individuals	Loss of reproductive capacity due to loss of host plants; reduced survivorship of adults due to loss of nectar plants, reduced adult dispersal due to thick stands of invasive shrubs impeding movement (e.g., Himalayan blackberry, Scotch broom).	Moderately confident
Effects of Stressor on metapopulation	Lower reproductive rates and survivorship within metapopulations reduces the population growth rate. Some invasive plants restrict movement and could affect dispersal, connectivity, or expansion of the metapopulations. This could lead to loss of genetic diversity by restricting interchange as well as reduced ability to recolonize when metapopulations are lost or reduced in size. Overall effect suppresses metapopulation growth and disrupts ability to function as a metapopulation, which reduces viability.	Moderately confident
Scope of Stressor	Rangewide	Highly confident

Trajectory of Stressor	Increasing in areas without management and in some areas despite active management. Declining in some areas being managed for prairie habitat.	Highly confident

Table D.5. Cause and effect analysis of insecticides and herbicides on Fender's blue butterflies.

THEME: Insecticides and Herbicides		
ESA Factor	**Analysis**	**Confidence or Uncertainty**
Stressor	Application of pesticides and herbicides	Highly confident
Source(s)	Both pesticides and herbicides are used in agricultural practices. Herbicides are also used for roadside maintenance and to control invasive species and woody vegetation encroachment.	Highly confident
Affected Resource(s)	Lupine host plants; nectar plants; ant species tending larvae; individual butterflies.	Highly confident
Exposure to Stressor	All life stages are exposed. Eggs, larvae, and adult butterflies can be directly killed by application of chemicals to vegetation or incur sublethal effects.	Highly confident
Immediacy of Stressor	Past, present, and future effects likely. Effects more likely in the spring and summer months.	Highly confident
Effects of Stressor on individuals	Loss of reproductive capacity or reduced survivorship due to sublethal effects of chemical exposure; direct mortality.	Moderately confident
Effects of Stressor on metapopulations	Lower reproductive rates and survivorship within metapopulations reduces the population growth rate. If chemicals reduce metapopulation growth and disrupt ability to function as a metapopulation, viability declines.	Somewhat confident
Scope of Stressor	Rangewide, but likely more prevalent in agricultural areas.	Moderately confident
Trajectory of Stressor	Stable. Some pesticides are prohibited at occupied sites and effects from roadside maintenance have been reduced by implementing best management practices in areas covered under an HCP and associated permit. Exposure continues in some areas because the chemicals are the most effective tools for eradicating some invasive species and woody vegetation.	Moderately confident

Table D.6. Cause and effect analysis of climate change on Fender's blue butterflies.

THEME: Climate change		
ESA Factor	**Analysis**	**Confidence or Uncertainty**
Stressor	global climate change	highly confident
Source(s)	increase in carbon emissions from numerous activities	highly confident
Affected Resource(s)	Lupine host plants; nectar plants; ant species tending larvae; individual butterflies; prairie.	moderately confident
Exposure to Stressor	All life stages are affected.	highly confident
Immediacy of Stressor	Climate change is occurring currently and is expected to continue into the future. Some changes may take place gradually while others may be more sudden and severe.	highly confident
Effects of Stressor on individuals	Reduced reproduction, survival, and foraging ability due to loss of nectar and lupine plants. Butterflies may need to disperse further to find adequate resources.	highly confident
Effects of Stressor on metapopulations	Altered prairie vegetation structure from higher water levels, flooding, drought, and precipitation changes may decrease habitat patch size, reducing connectivity within metapopulations.	moderately confident
Scope of Stressor	Range-wide exposure to effects of climate change with regional variability in magnitude over space and time.	highly confident
Trajectory of Stressor	Increasing. Severity or extent of habitat changes could result in demonstrable metapopulation effects over the next 50 years and beyond, particularly where connectivity is already low.	somewhat confident

APPENDIX E: Prairie Calculators

FENDER'S BLUE BUTTERFLY MODULE: PRAIRIE HABITAT QUALITY CALCULATOR - VERSION 2.0							
SITE NAME:			Date:	Investgators:			
Q #	**Category**	**Index Categories**	**Data entry**	**Weights**	**Weighted Data**	**Sub score**	**Indicator Name**
Answer questions 1-4 about HABITAT HETEROGENEITY and CONNECTIVITY with GIS or aerial photos. Contact USFWS for information about nearby Fendersblue butterfly sites (allow 2-3 weeks to obtain information).							
1	**How heterogeneous is the habitat in terms of its topography?**						
	Select only one choice. Enter a "1" next to the most accurate description.						
	Habitat Hetero-geneity	Flat field, no topography.		0	0	%	Topo
		Some slope to habitat, but really only one aspect.		1	0		
		Habitat includes one hill feature and at least two aspects.		2	0		
		Habitat is very topographically diverse, with multiple hill features, gullies and aspects.		3	0		
2	**How heterogeneous is the site in terms of habitat structure?**						
	Select only one choice. Enter a "1" next to the most accurate description for the majority of prairie at the site.						
	Habitat Hetero-geneity	Includes no oak habitat elements.		0	0	%	Oak
		Includes occasional oaks, but far fewer than 2 /ha.		2	0		
		Includes 3-5 oaks on average per ha throughout.		3	0		
		Includes variable sized patches of oak savanna throughout the site that do not create barriers.		2	0		
		Includes patches of dense oaks that are not habitat, but provide heterogeneity.		1	0		
3	**Is the site connected to other sites with Fender's blue butterfly?**						
	Enter a "1" next to ALL the statements below that apply with no barriers (hills, forested swaths greater than 100 m deep, urban areas) to butterfly travel.						
	Connectivity	Within 2 km of two or more FBB-occupied 6 ha sites.		6	0	%	Links
		Within 2 km of another FBB-occupied 6 ha site.		3	0		
		Within 1 km of stepping stone (occupied site of < 6 ha).		2	0		
		Within 2 km of another FBB-occupied site of < 6 ha.		1	0		
		Site isolated by barriers or distance.		0	0		
4	**Are any connected sites (free of barriers) currently occupied by Fender's blue under protection of public ownership, deed restriction or conservation easement?**						
	Enter a "1" next to ALL the statements below that apply to your site.						
	Connectivity	No connected sites protected.		0	0	%	AdjProt
		Connected (w/in 1 km) to protected stepping stone of < 6 ha.		2	0		
		Connected (w/in 2 km) protected site of < 6 ha.		1	0		
		Connected (w/in 2 km) of protected site of ≥ 6 ha.		2	0		

Questions 5-7. Butterfly HOST ABUNDANCE, FENDER'S BLUE POPULATION SIZE and HABITAT AREA. Contact the USFWS Oregon Fish & Wildlife Office to obtain numerical and spatial data (plan on a 2-3 week turnaround) or request survey.							
5	**What is the abundance of Kincaid's lupine, spurred lupine or sickle keel lupine at the site?**						
	Select only one choice. Enter a "1" next to the approximate foliar cover (area of the ground covered by lupine leaves) of lupine at the site.						
	Host	Not present		0	0	%	Host
		Trace to 10 m^2		1	0		
		11-99 m^2		2	0		
		100-249 m^2		3	0		
		250-499 m^2		4	0		
		500-999 m^2		5	0		
		1000 m^2 or more		6	0		
6	**How many Fender's blue butterflies are known to occupy the site?**						
	Select only one choice. Enter a "1" next to the 5 yr average (or average of existing data if < 5 yrs).						
	Population	Never seen at site		0	0	%	Pop
		1-10 individuals		1	0		
		11-25 individuals		2	0		
		26-50 individuals		3	0		
		51-100 individuals		4	0		
		101-300 individuals		5	0		
		More than 300 individuals		6	0		
7	**Use GIS or other means to estimate the area of CURRENTLY occupied habitat at the site, as defined by a 50 meter buffer around the host species.**						
	Select only one choice. Enter a "1" next to the appropriate area. Surveys for host species may be required if current data are not available.						
	Occupancy	Less than 1 hectare (ha)		1	0	%	Occ
		1 hectare or more but less than 3 hectares		2	0		
		3 hectares or more but less than 6 hectares		3	0		
		6 hectares or more		4	0		
8-10. NECTAR SPECIES. Complete a walk through of the site during peak Fender's flight season or just post peak to assess nectar species flower abundance. Enter data gathered in the field in the Nectar Worksheet. Then use the Nectar worksheet to calculate the information to answer the following questions.							
8	**How diverse are native nectar resources during the flight season?**						
	Place a "1" next to the choices describing the diversity of nectar species available during early, peak and late flight season.						
	Nectar	No species.		0	0	%	NecDiv
		One species peak flight season.		1	0		
		Two or more species peak.		2	0		
		One species early		1	0		
		Two or more species early.		2	0		
		One species late.		1	0		
		Two or more species late.		2	0		
9	**For how many periods (Early, Peak, Late) are nectar sugar needs satisfied by native nectar?**						
	Select only one choice. Use Nectar worksheet to calculate totals per flight period.						
	Nectar	None.		0	0	%	NecPer
		One period.		1	0		
		Two periods.		2	0		
		All three periods.		3	0		
10	**What is the total native nectar sugar available over the entire flight season?**						
	Select only one choice. Enter a "1" next to the approximate quantity of nectar that is available per m^2 of habitat over the entire season.						
	Nectar	No nectar		0	0	%	NecTot
		Trace-5 mg		1	0		
		More than 5 mg but less than 10 mg		2	0		
		10 mg or more, but less than 15 mg		3	0		
		15 mg or more, but less than 20 mg		4	0		
		20 mg or more		5	0		

Complete a walk through of the site to answer question 11 about PROBLEM VEGETATION.							
11	**How much of the habitat area is covered by tall non-native grasses or shrubs > 0.75 meters high?**						
	Select only one choice. Based on field surveys in late May or June, enter a "1" next to the approximate vegetative cover of tall grasses (e.g., tall oatgrass) or shrubs in the habitat area that would disrupt butterfly flight.						
	Minimal Problem Vegetation	<5%		4	0	%	Veg
		5-15%		3	0		
		16-25%		2	0		
		26-50%		1	0		
		>50%		0	0		

COMPOSITE INDICATORS TABLE			
Category	**Composite Indicator Description**	**Weight in Final Score**	**Sub Score**
Do not enter data below. Data will automatically transfer from the Main Indicators Table.			
Heterogeneity	Heterogeneity = AVERAGE (Topo, Oak)	1.0	#DIV/0!
Connectivity	Connectivity = (Average (Links, AdjProt))	1.0	#DIV/0!
Host	Host	2.0	%
Population	Population	2.0	%
Occupancy	Occupancy	2.0	%
Nectar	Nectar = AVERAGE(NectDiv,NectPer,NecTot))	1.0	#DIV/0!
Minimal Problem Vegetation	Minimal problem vegetation	1.0	%

FINAL SCORE TABLE		
Do not enter data below. Data will automatically transfer from the Composite Indicators Table.		
Final Score Name	**Final Score Description**	**Final Score**
FENDER'S HABITAT QUALITY	The project site's percentage of optimal Fender's blue habitat quality. (2*Host + 2*Occupancy + 2*Population + Connectivity + Heterogeneity + MinimalProblemVegetation + Nectar)/10)	**#DIV/0!**

NATIVE NECTAR WORKSHEET: PRAIRIE HABITAT QUALITY CALCULATOR - VERSION 2.0

Use the Abundance Index below to describe the quantity of flowering units (FUs) of nectar species available throughout the habitat at the site. The habitat area is defined as the area within 50 meters of the host plants (Lupine) at the site. In the shaded cells, enter the abundance index value that describes the quantity of FUs for each species in the habitat area, the remaining values will calculate automatically.

Abundance Index: **1 = <25 2 = 25- <100 3 = 100- <500 4 = 500- <1,000 5 = 1000- <2,000 6 = 2,000- <5,000 7 = 5,000- <10,000 8 = 10,000- <15,000 9 = 15,000- <20,000 10 = 20,000+**

Nectar Species	Flowering Unit (FU)	Data Entry: FU Abundance	Phenology	mg sugar/FU/ day	Diversity/Abundance				SUGAR: mg sugar/day		
					Early	Peak	Late		Early	Peak	Late
Allium amplectens	Head		Late	22.9							0
Camassia quamash/leichtli	Flower		Early	4.96					0		
Calochortus tolmiei	Flower		Early, Peak	1.52					0	0	
Cryptantha intermedia	Branch		Early	0.74					0		
Eriophyllum lanatum	Head		Peak, Late	3.7						0	0
Geranium oreganum	Flower		Early, Peak	1					0	0	
Iris tenax	Flower		Early, Peak	14.6					0	0	
Lupine host	Branch		Early, Peak, Late	2.54					0	0	0
Sicalcea virgata	Branch		Early, Peak, Late	25.12					0	0	0
Vicia sativa	Branch		Early, Peak	0.77					0	0	
Vicia cracca	Branch		Early, Peak, Late	2.3					0	0	0
Vicia villosa	Branch		Early, Peak, Late	17.01					0	0	0
Habitat area (m2) (Enter your estimated habitat area IN square meters in the red cell below. This may be defined by a 50 meter buffer around FBB host species, or may be the entire evaluation			**Total # Native Species:**		**Early**	**Peak**	**Late**	**Sugar mg/m²:**	**Early**	**Peak**	**Late**
					0	**0**	**0**		***#DIV/0!***	***#DIV/0!***	***#DIV/0!***
								Sugar target mg/m²	**4**	**12**	**4**
								Native Sugar target met?	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**
								Total NATIVE mg sugar per m² habitat	**Missing habitat area.**		
								Total EXOTIC mg sugar per m² habitat	**Missing habitat area.**		

CREDIT CALCULATOR FOR UPLAND PRAIRIE HABITAT QUALITY - VERSION 2.0

Site Name:	
Date:	
Investigator:	

Background Information:

Briefly describe the purpose of using the Prairie Calculator at this site:

Attach a map with an aerial photo background showing polygon of the site where prairie calculator assessment is applied.

What version of the calculator is being used?

Please describe general weather conditions on the day(s) the calculator was applied:

CREDIT CALCULATOR FOR UPLAND PRAIRIE HABITAT QUALITY - VERSION 2.0

	Before entering new data, **clear** any numbers in the **shaded** cells Column D of this worksheet.		**Site Name:**	
			Date:	
			Investigator:	

	Does any part of this site qualify as "upland prairie"? The following questions together determine that. After each question enter "1" for yes or "0" for no.	**Data entry**	**Explanation/ Data Source/ Protocol**
A	Does the same area qualify as a "wetland" based on water regime, hydric soils, or wetland-characteristic plants? If Yes, enter "1" and do not continue.		Eliminates areas that are assessed better with ORWAP
B	Has the occurrence of a **rare** (state-listed)* plant or animal species characteristic of upland prairie been documented? If Yes, enter "1" and skip to #1.		Contact ORNHIC/USFWS for records (allow 2-3 weeks processing), or use observations of qualified biologist.
C	In vegetated parts of the parcel, is the areal cover of **native** herbaceous (non-woody) plants greater than 50% any time during the period May 15 to July 1? If Yes, enter "1" and continue. If site is to be restored, enter "1" if native herbaceous cover is over 15%.		If site is to be restored, enter "1" if native herbaceous cover is over 15%.
D	During the period May 15 to July 1, is there a significant presence of at least 2 native graminoid species and 6 native forb species that are characteristic of Willamette upland prairies ? If Yes, enter "1" and continue.		See Upland Prairie Species Worksheet for list of plant species characteristic of upland prairies. Use location data collected by qualified botanists. significant presence = collectively occupying more than 100 sq. ft.
E	Is any part of the parcel being **managed** specifically to support species that are characteristic of upland prairie? If Yes, enter "1" and continue.		Management may include control of weedy species, intentional burning, planting of prairie species, etc.
F	Was the presettlement (1851) land cover at this location classified as Roemer fescue, tufted hairgrass, wet meadow, or oak savannah, or does a Habitat Conservation Plan designate this parcel as actual or potential habitat for a prairie species? If Yes, enter "1" and continue.		Enter the site's coordinates at **www.oregonexplorer.info/wetlands/orwap** The resulting report will indicate in the upper right table how it was classified. Contact the USFWS for any available Habitat Conservation Plans.
	Does the parcel qualify? (spreadsheet will compute this automatically)	**NO**	If B = 1 then YES. If #C + #D = 2 then YES. If C + E + F = 3 then YES. Else NO.

#	Category	Index Categories	Data entry	Weights	Weighted Data	Sub score	Indicator Name
TO BE ANSWERED IN THE OFFICE							
Answer questions 1-5 regarding SITE CAPACITY AND CONNECTIVITY using GIS or aerial imagery.							
1	**What is the size of the prairie area at the site (either upland or wet)?**						
	Select only one choice. Place a "1" next to the most accurate answer. Estimate via aerial photo and site visit observations.						
	Capacity	>40 ha		4	0	%	Size
		6-40 ha		3	0		
		0.5-5.9 ha		2	0		
		0.1 to 0.5 ha		1	0		
		<0.1 ha		0	0		
2	**What is the percent cover of woody vegetation at the site (all native shrub or tree species except oak and Douglas-fir)?**						
	Select only one choice. Place a "1' next to the most accurate answer. Consult aerial imagery.						
	Structure	<1%		3	0	%	Struct
		1-5%		4	0		
		5-15%		2	0		
		15-25%		1	0		
		>25%		0	0		
3	**What is the distance to closest other prairie patch (either upland or wet)?**						
	Select only one choice. Place a "1" next to the most accurate answer. Consult aerial imagery.						
	Connectivity	<0.75 km		10	0	%	Dist
		0.75-3 km		5	0		
		3.1-8 km		3	0		
		>8 km		0	0		
4	**What is the size of the closest other prairie patch (either upland or wet) within 8 km?**						
	Select only one choice. Place a "1' next to the most accurate answer. Consult aerial imagery.						
	Connectivity	>40 ha		7	0	%	NghSiz
		7-40 ha		6	0		
		0.5-6 ha		4	0		
		0.1 to 0.5 ha		1	0		
		<0.1 ha, or none within 8 km		0	0		
5	**What is the composition of most of the land cover along a beeline between this site and the closest other prairie patch?**						
	Select only one choice. Place a "1" next to the most accurate answer. Consult aerial imagery.						
	Connectivity	Pasture, wet prairie, emergent wetland, oak savanna, and/or undeveloped open land not in crops.		2	0	%	Beeline
		Low-density residential (1 house/2 ha), crops, orchards.		1	0		
		Low-density industrial.		1	0		
		High density industrial.		0	0		
		Forest, impervious surface, open water.		0	0		

Answer questions 6 & 7 about SENSITIVE SPECIES at the site using information from surveys or queries to appropriate state/federal agencies or conservation organizations (allow 2-3 weeks to obtain data).							
6	**Is a special status ANIMAL species known to be present and reproducing on the site or at a site within 0.75 km?** Contact appropriate state agencies and conservation organizations (allow 2-3 weeks to obtain data)						
	Select only one choice. Place a "1' next to the most accurate answer.						
	Rare Spp	No.		0	0	%	TEanim
		Yes, one such species. List here_____		3	0		
		Yes two or more such species. List them here_____		4	0		
7	**Is a special status PLANT species known to be present and reproducing on the site or at a site within 0.75 km?** Contact appropriate state agencies and conservation organizations (allow 2-3 weeks to obtain data)						
	Select only one choice. Place a "1' next to the most accurate answer.						
	Rare Spp	No.		0	0	%	TEplant
		Yes, one such species. List here_____		3	0		
		Yes two or more such species. List them here_____		4	0		
Answer questions 8-11 about SITE SECURITY and LAND USE at the site based on conversations with the land manager and direct observations.							
8	**What is the level of protection from future development or land use change at the site?**						
	Select only one choice. Place a "1' next to the most accurate answer.						
	Security	Publicly owned.		3	0	%	Sec
		Permanent conservation easement.		3	0		
		30 year conservation easement.		2	0		
		10 year conservation easement, USFWS Safe Harbor or Partners for Fish and Wildlife Agreement.		1	0		
		No protections.		0	0		
9	**To what degree are appropriate regimes of mowing, fire, grazing, weed control, and/or planting used to manage the upland prairie part of this parcel for biodiversity?**						
	Select only one choice. Place a "1' next to the most accurate answer.						
	Management	Frequently (multiple practices annually or more frequently, using data/ observations to modify practices)		3	0	%	Mgmt
		Regularly (at least basic mowing)		2	0		
		Sporadically(as resources allow)		1	0		
		Seldom or never		0	0		
10	**To what degree has the soil experienced compaction, plowing, leveling, or excavation unrelated to any restoration activity?**						
	Select only one choice. Place a "1' next to the most accurate answer.						
	LandUse	No major disturbance within past 50 years and no extensive signs of recent compaction (tire/ATV ruts, etc.)		3	0	%	Soil
		No major disturbance within past 50 years but some signs of recent compaction (tire/ATV ruts, etc.)		2	0		
		Major disturbance within past 50 years; no extensive signs of recent compaction (tire/ATV ruts, etc.)		1	0		
		Major disturbance within past 50 years; extensive signs of recent compaction (tire/ATV ruts, etc.)		0	0		
11	**What is the apparent threat to the site's invertebrates from drift of aerially-applied insecticides?**						
	Select only one choice. Place a "1' next to the most accurate answer. Score this based on conversations with land manager and observations of nearby land uses. Assume that only the following have been sprayed for insects: orchards, vineyards, horticultural nurseries, blueberries, hops, mint, and most row crops. Also forest lands with gypsy moth infestations.						
	LandUse	Upland prairie edge is >300 m from lands that typically would be sprayed		2	0	%	Drift
		Upland prairie edge is within 30-300 m of lands that typically would be sprayed		1	0		
		Upland prairie edge is <30 m from lands that typically would be sprayed		0	0		

TO BE ANSWERED IN THE FIELD.							
Complete a walk through at the site to answer questions 12-14 regarding WOODY, NON-NATIVE OR INVASIVE VEGETATION at the site.							
12	**What is the total percent cover of shrubs or vines (woody species) of management concern at the site? (see Woody species of concern table).**						
	Select only one choice. Place a "1' next to the most accurate answer. Estimate during site visit.						
	Invasives	None or less than 5 individual plants.		7	0	%	WdyInv
		More than 5 plants but no more than 5%		6	0		
		6-15%		5	0		
		16-30%		2	0		
		31-50%		1	0		
		> 50%		0	0		
13	**What is the percent cover of NON-native herbaceous vegetation during the period May 15 to July 1?**						
	Select only one choice. Place a "1' next to the most accurate answer. Estimate during site visit.						
	Invasives	No more than 5%		4	0	%	Exotic
		6-25%		3	0		
		26-50%		2	0		
		51-75%		1	0		
		>75%		0	0		
14	**In the prairie, what is the overall cover of invasive non-native HERBACEOUS plants of concern** (e.g., Tall oatgrass, false brome, meadow knapweed, reed canarygrass).						
	Select only one choice. Place a "1' next to the most accurate answer. Estimate during site visit.						
	Invasives	None or less than 5 individual plants.		7	0	%	Invas
		More than 5 plants but no more than 5%		6	0		
		Trace to 15%		5	0		
		16-30%		2	0		
		31-50%		1	0		
		>50%		0	0		
Complete a walk through at the site to answer questions 15-19 regarding NATIVE PLANT COMMUNITY at the site.							
15	**In the entire upland prairie area, what is the diversity of native prairie forb species?**						
	Select only one choice. Place a "1' next to the most accurate answer. Estimate during site visit.						
	Pollinator resources	>20 species of native prairie forbs present.		5	0	%	ForbRich
		16-20 species of native prairie forbs present.		4	0		
		11-15 species of native prairie forbs present.		3	0		
		7-10 species of native prairie forbs present		2	0		
		1-6 species of native prairie forbs present		1	0		
		No native prairie forbs present		0	0		
16	**In the entire upland prairie area, what is the approximate cover of native prairie forb species?**						
	Select only one choice. Place a "1' next to the most accurate answer. Estimate during site visit.						
	Pollinator resources	> 50%		4	0	%	ForbCvr
		31-50%		3	0		
		11-30%		2	0		
		A trace to 10%		1	0		
		No native forbs present or only a few individuals.		0	0		
17	**In the entire upland prairie area, what is the diversity of native perennial grass species?**						
	Select only one choice. Place a "1' next to the most accurate answer. Estimate during site visit.						
	Plant community	5 or more species present		5	0	%	GrassRich
		4 species present.		4	0		
		3 species present.		3	0		
		2 species present.		2	0		
		1 species present.		1	0		
		None present.		0	0		
18	**In the entire upland prairie area, what is the approximate cover of native perennial grass species?**						
	Select only one choice. Place a "1' next to the most accurate answer. Estimate during site visit.						
	Plant community	> 50%		4	0	%	GrassCvr
		31-50%		3	0		
		11-30%		2	0		
		A trace to 10%		1	0		
		No native grasses or only a few individuals.		0	0		
19	**In the entire upland prairie area, what is the approximate cover of native herbaceous species (graminoids and forbs combined)?**						
	Select only one choice. Place a "1' next to the most accurate answer. Estimate during site visit.						
	Plant community	at least 50%		4	0	%	NatCvr
		31-49%		3	0		
		11-30%		2	0		
		A trace to 10%		1	0		
		None or only a few individuals.		0	0		

COMPOSITE INDICATORS TABLE			
Category	**Composite Indicator Description**	**Weight in Final Score**	**Subscore**
Do not enter data below. Data will automatically transfer from the Main Indicators Table.			
Capacity	Capacity	1.0	%
Structure	Structure	1.0	%
Connectivity	Connectivity = AVERAGE (Dist, NghSiz,Beeline)	1.0	#DIV/0!
RareSpp	RareSpp = AVERAGE (RarePl, RareAni)	2.0	#DIV/0!
Security	Security	1.0	%
Land Use	Land Use =AVERAGE (Soil, Drift)	1.0	#DIV/0!
Management	Management	1.0	%
Invasives	Invasives = AVERAGE(Wdy,Exotic,Invas)	1.0	#DIV/0!
Pollinator Resources	Pollinators = AVERAGE(ForbRich, ForbCvr)	1.0	#DIV/0!
Natives	Natives = AVERAGE(NatCvr, ForbRich, GrassRich)	1.0	#DIV/0!

FINAL SCORE TABLE		
Do not enter data below. Data will automatically transfer from the Composite Indicators Table.		
Final Score Name	**Final Score Description**	**Final Score**
UPLAND PRAIRIE HABITAT QUALITY	The project site's percentage of optimal upland prairie habitat. Calculated as: (Capacity + Structure + Connectivity+ 2*RareSpp + Security + LandUse + Management + Invasives + Pollinators + Natives /11)	**#VALUE!**