

Monarch Butterfly Conservation in the Western United States



Sarina Jepsen, Xerces Society
Samantha Marcum, U.S. Fish &
Wildlife Service

Photo by: Keenan Adams, USFWS

U.S. Fish & Wildlife Service

- 2014 Presidential Memo
- 2014 ESA petition
- 2014 Director memo
- 2015 *Nat'l Strategy to Promote the Health of Honey Bees & Other Pollinators*
- 2015 Monarch Initiative: \$4M/yr until 2020 (\$20M total)
- Currently developing national framework for conservation
- Service & Xerces coordinate on int'l, national, State, local scales



Service's Monarch Conservation Strategy

LEADERSHIP

- Trilateral Committee
- Association of Fish & Wildlife Agencies
- National Fish & Wildlife Foundation

HABITAT

- 200,000 acres of habitat restored or enhanced (FY15)
- Natural Resource Conservation Service (NRCS) and Farm Bill programs

SCIENCE

- U.S. Geological Survey Monarch Science Partnership (Powell Center)
- National Inventory & Monitoring Strategy

PEOPLE

- Communications Campaign
- National Wildlife Federation
- Over 750 schoolyard habitats, pollinator gardens (FY15)

THE XERCES SOCIETY

FOR INVERTEBRATE CONSERVATION

For over forty years, the Xerces Society has been at the forefront of invertebrate protection worldwide, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs

Conservation programs:

- Native Pollinators
- Endangered Species
- Aquatic invertebrates
- Pesticides

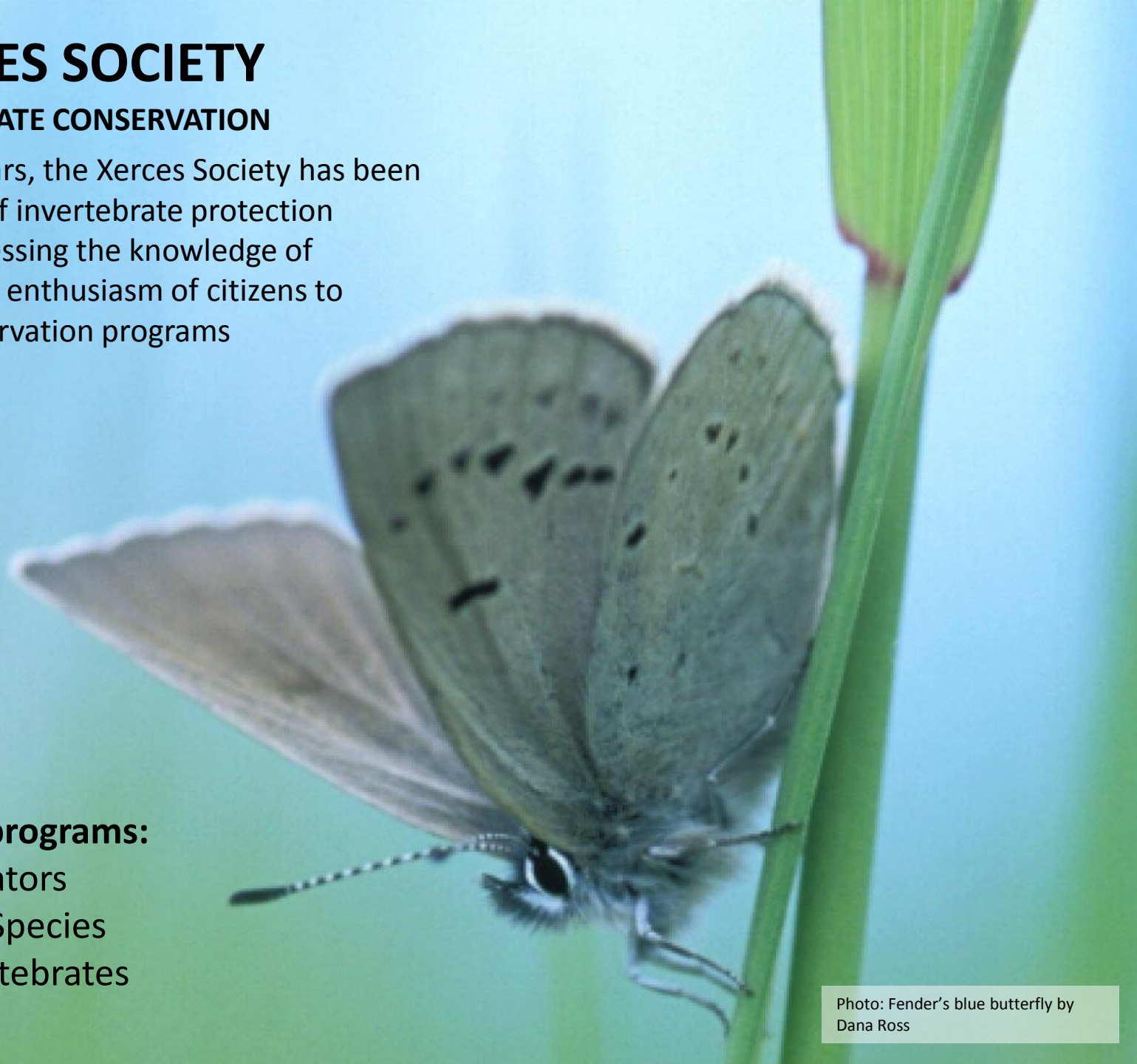


Photo: Fender's blue butterfly by
Dana Ross

Xerces Society Staff



Photo: Matthew Shepherd, the Xerces Society

The Xerces Society for Invertebrate Conservation

HOW WE WORK

- Conservation Planning
- Applied Research
- Citizen Science
- Education
- Restoration
- Policy



Overview

- Life History
- Conservation Status
- Potential Threats
- Priority Research & Conservation efforts
- Opportunities for Conservation
- Resources and Tools
- Questions and Acknowledgements



Photo by: AnnMarie Krmpotich, USFWS

Life History



Photo by: Joanna Gilkeson, USFWS

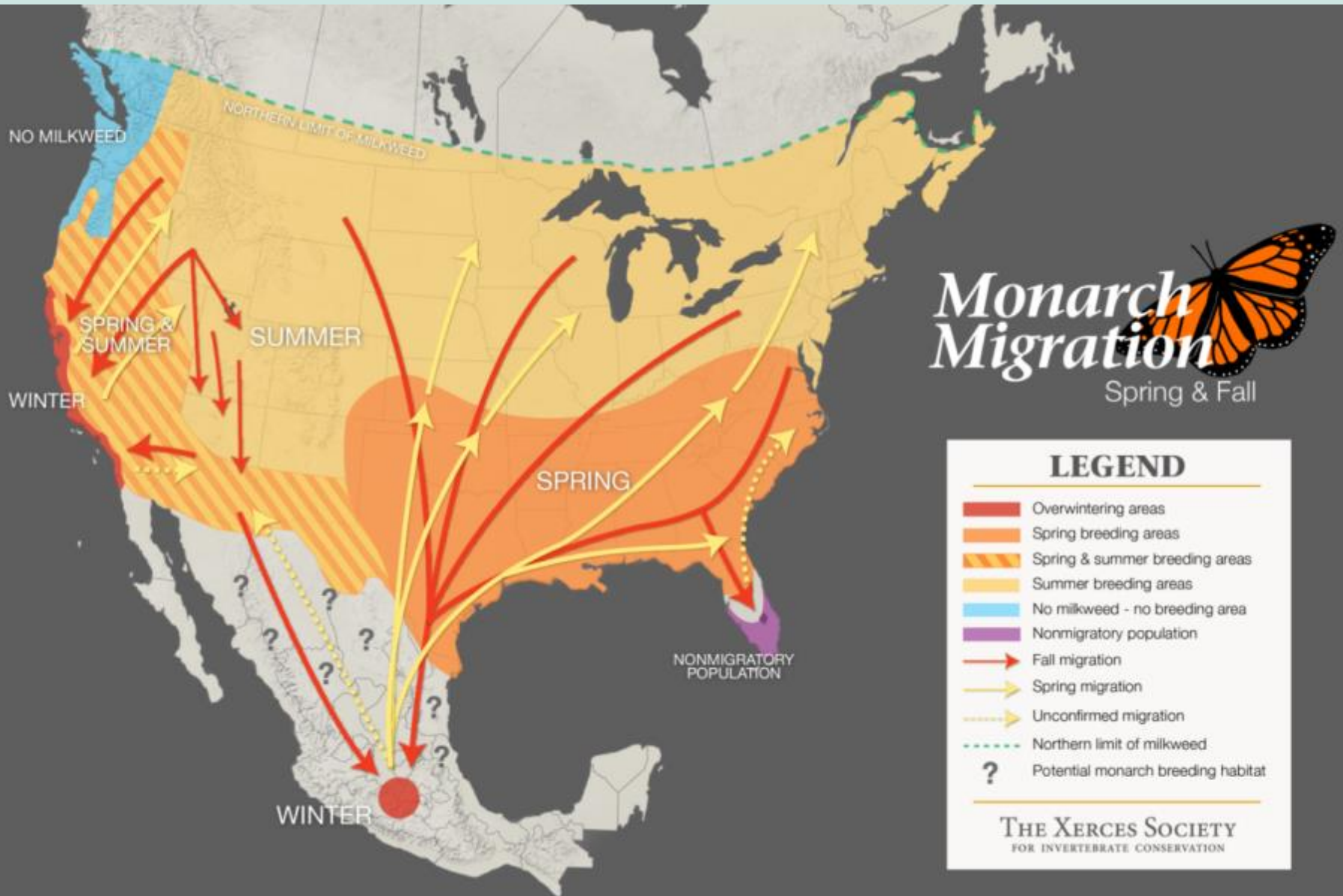
Life History

- World-wide distribution for *Danaus plexippus plexippus*
- We are focusing on N. American distribution
- Eastern & western monarchs = same genetics
- Much more info for eastern population
- Breeding locations unknown for west



Photo by: Joanna Gilkeson, USFWS

Life History



Life Cycle





- Multiple generations for western monarch migration each year
 - Number of generations is unknown (3-4?)
- Adults need nectar sources year-round for migration and overwintering fuel and hydration
- Monarchs lay eggs on milkweed & Caterpillar food source is milkweed
 - More than 35 milkweed species in western U.S.



Photo by: Courtney Celley, USFWS

Life Cycle Timeline



Stage		Time	Total Time
Egg		3-5 days	4 days
Larva		10-14 days	16 days
Pupa		10-14 days	28 days*
Adult		1 month or up to 9 months	

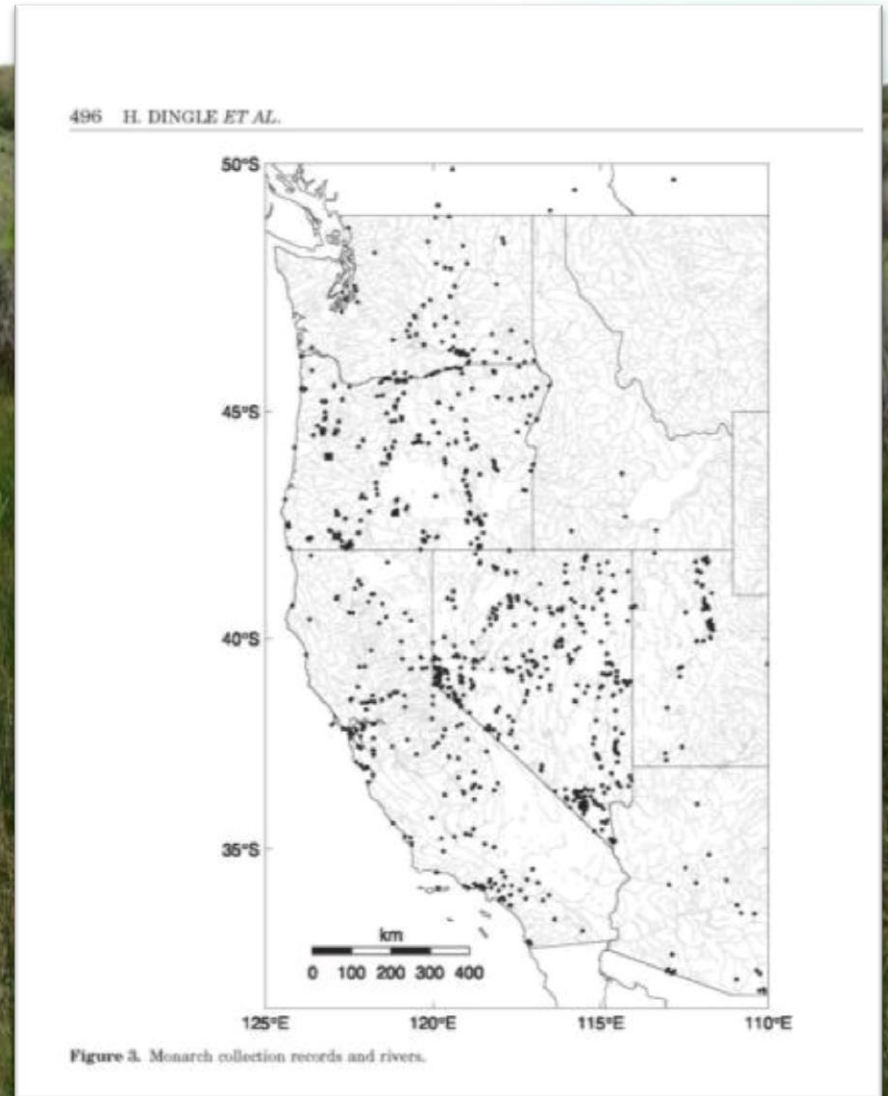


*Time from egg to new adult

Life History of Western Monarchs: Migration

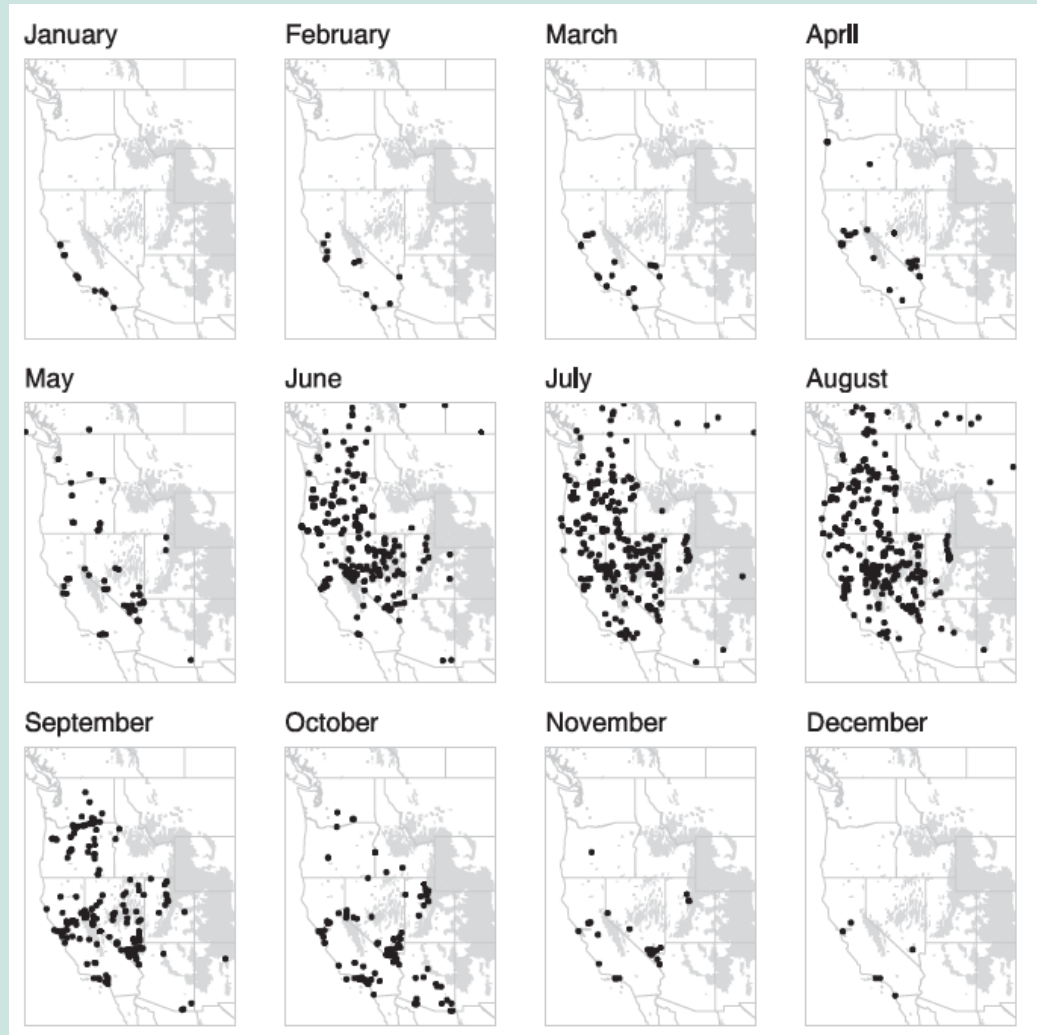
Dingle et al. (2005) found that monarch distribution was associated with rivers, consistent with anecdotal observations that fall migrants use river corridors

Source: Dingle *et al.* 2005

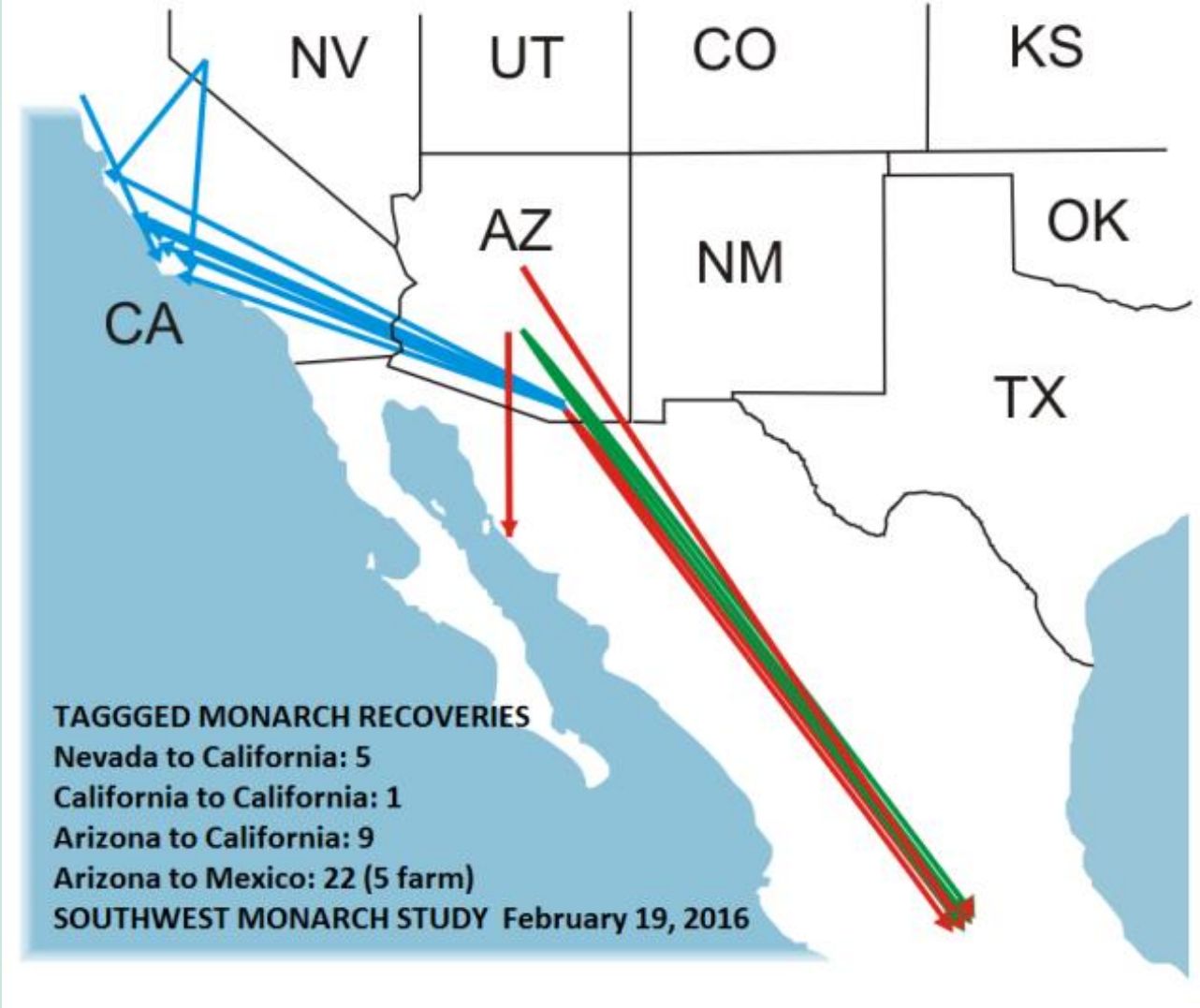


Life History of Western Monarchs: Migration

Monarch collection records mapped throughout the calendar year



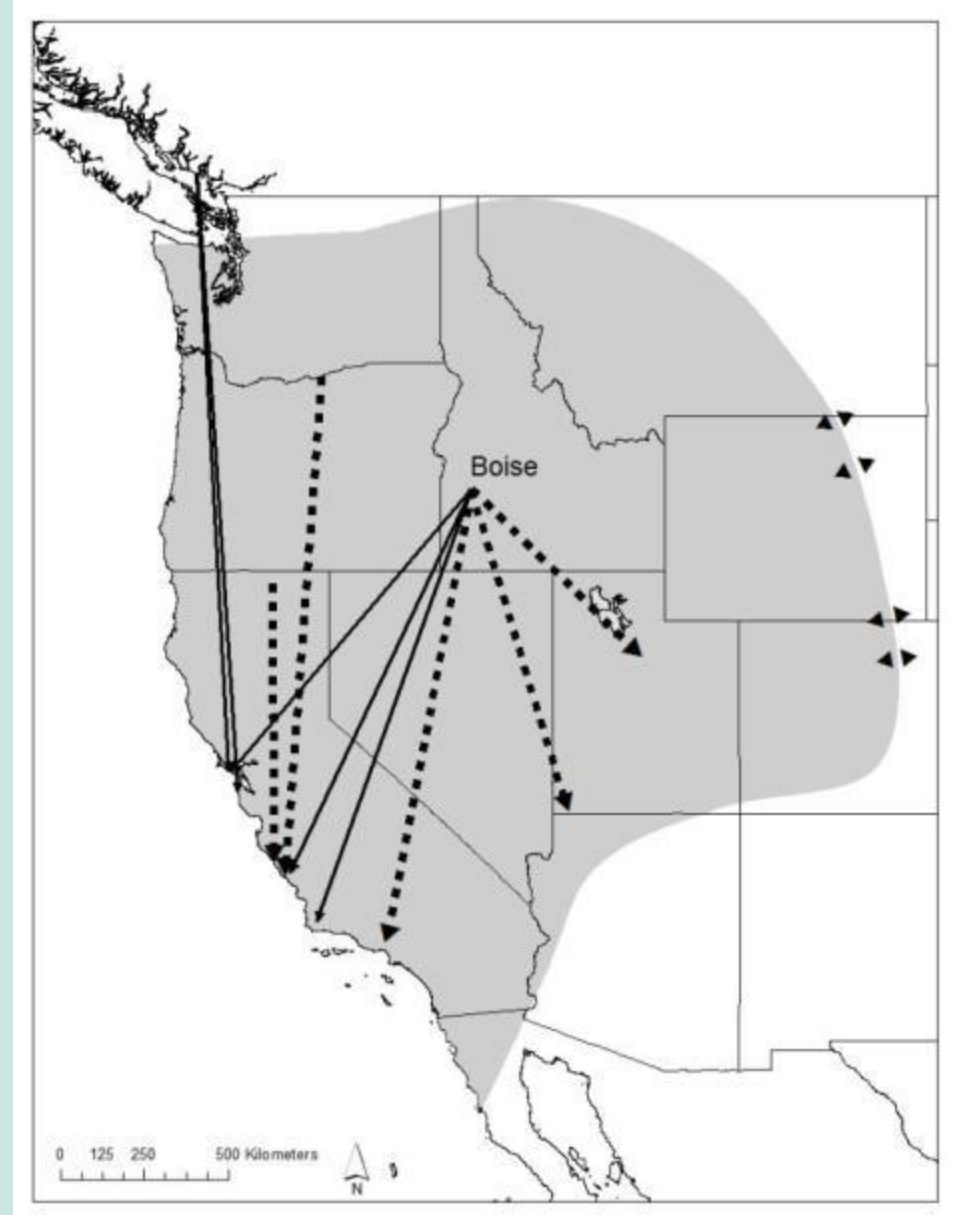
Life History of Western Monarchs: Migration



We have recently learned that western monarchs overwinter both in California and Mexico, although the relative proportions are unknown

Life History of Western Monarchs: Migration

Recoveries of tagged, wild monarchs indicate that monarchs move S, SW, and SSE in the late summer, suggesting that monarchs from more northerly areas of the West may also overwinter in Mexico



Source: Robert Michael Pyle. 2015. *Monarchs in the Mist*. In *Eds. Oberhauser, Nail, and Altizer. Monarch Butterflies in a Changing World*. Cornell University Press.

Life History of Western Monarchs: Overwintering

Monarchs spend each winter at hundreds of forested groves on the California Coast

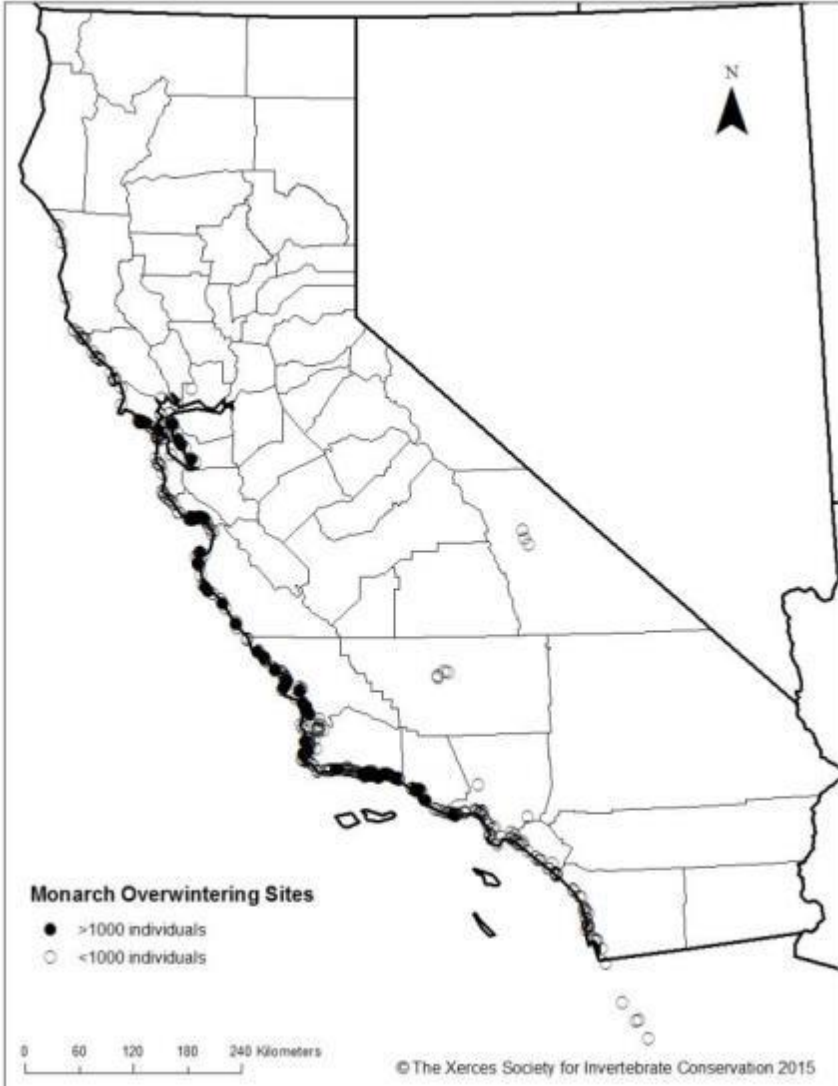


Photo: Carly Voight, the Xerces Society

Life History of Western Monarchs: Overwintering

- Adult monarchs arrive at overwintering sites from Sept-Oct
- From Nov-Feb, monarchs overwinter in protected microhabitats of tree groves
- Monarchs are in reproductive diapause for the winter, with a few exceptions



Life History of Western Monarchs: Overwintering

Tree groves

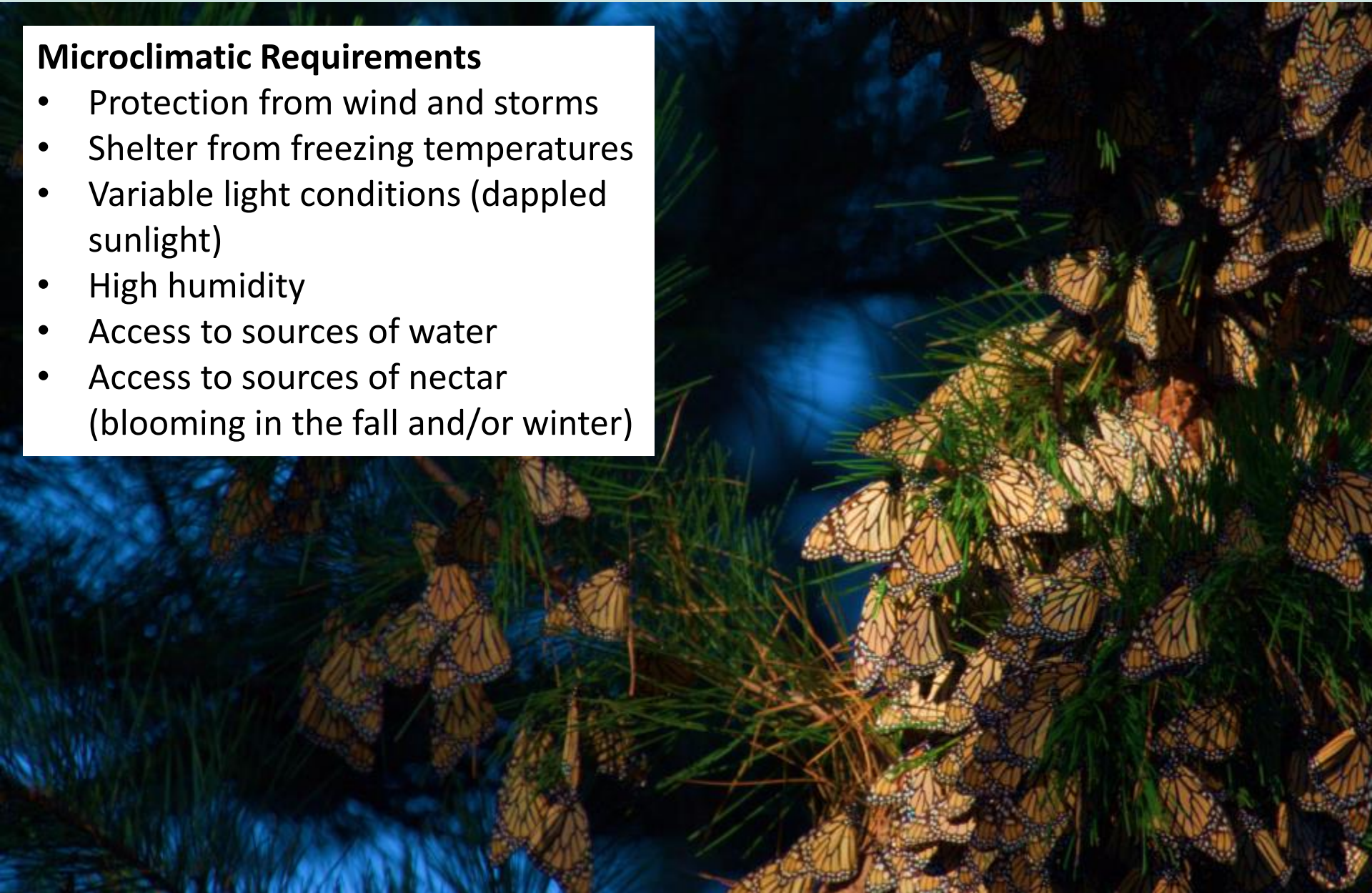
- Most California overwintering sites are dominated by exotic *Eucalyptus*
- Recent research by Griffiths & Villablanca (2015) demonstrated that monarchs do not prefer *Eucalyptus* trees over native tree species



Life History of Western Monarchs: Overwintering

Microclimatic Requirements

- Protection from wind and storms
- Shelter from freezing temperatures
- Variable light conditions (dappled sunlight)
- High humidity
- Access to sources of water
- Access to sources of nectar (blooming in the fall and/or winter)



Conservation Status of Monarchs

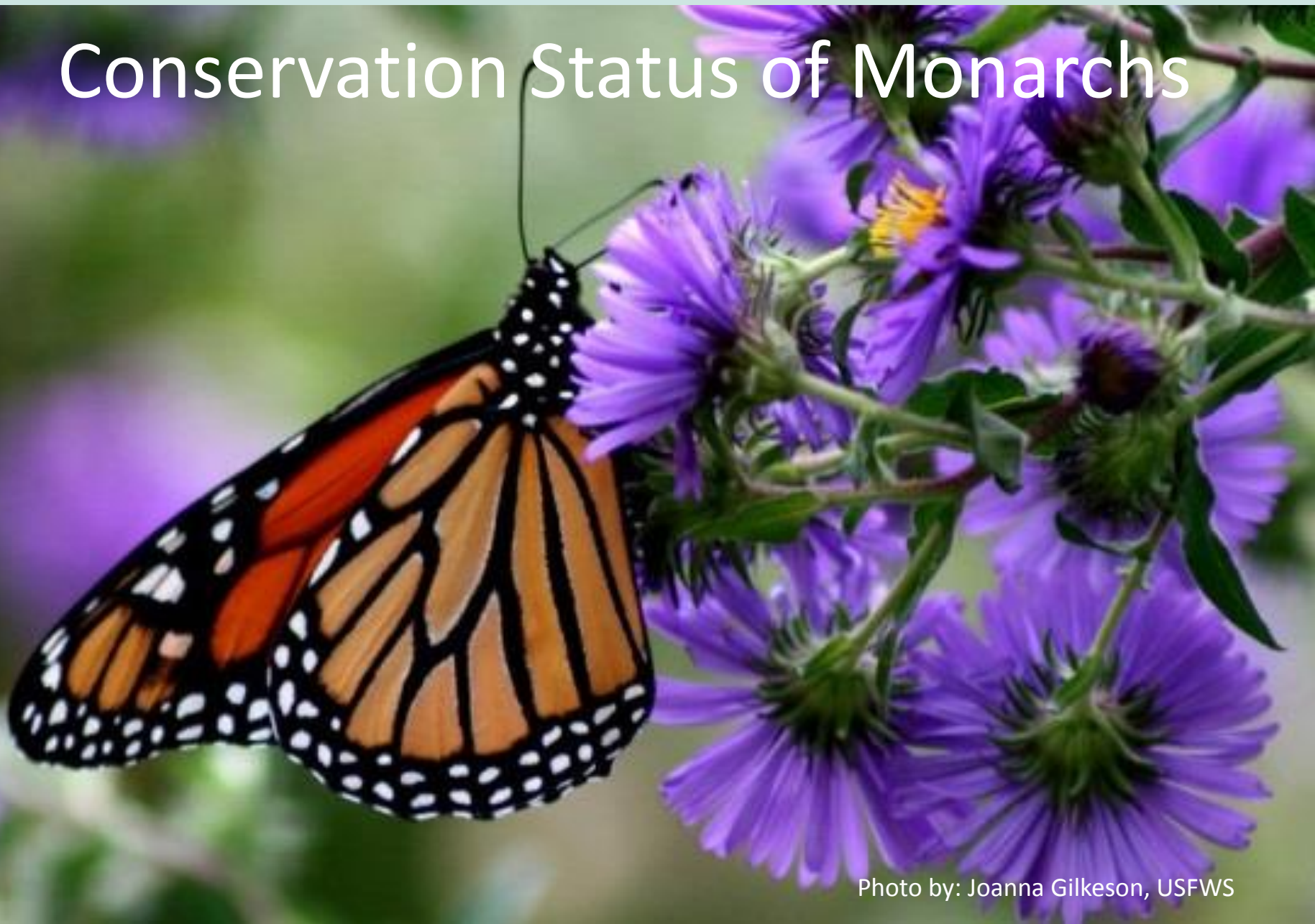


Photo by: Joanna Gilkeson, USFWS

Endangered Species Act Process

- August 2014: Service was petitioned to list monarch as threatened with critical habitat & 4d special rule
- Dec 2014: Service 90-day finding that listing may be warranted
- Jan 2016: Notice of intent to sue for failure to meet 12-month finding deadline
- 2016: Species Status Assessment (SSA) initiated
- 12-month finding will be made based on SSA
- If warranted, final listing review made within 1 year of proposed listing

Conservation Status

Monarch populations are estimated at overwintering sites in Mexico and California

Mexico

1990s: populations reached **675 million** monarchs

2015: only ~150 million; recent low of 25 million in 2013

California

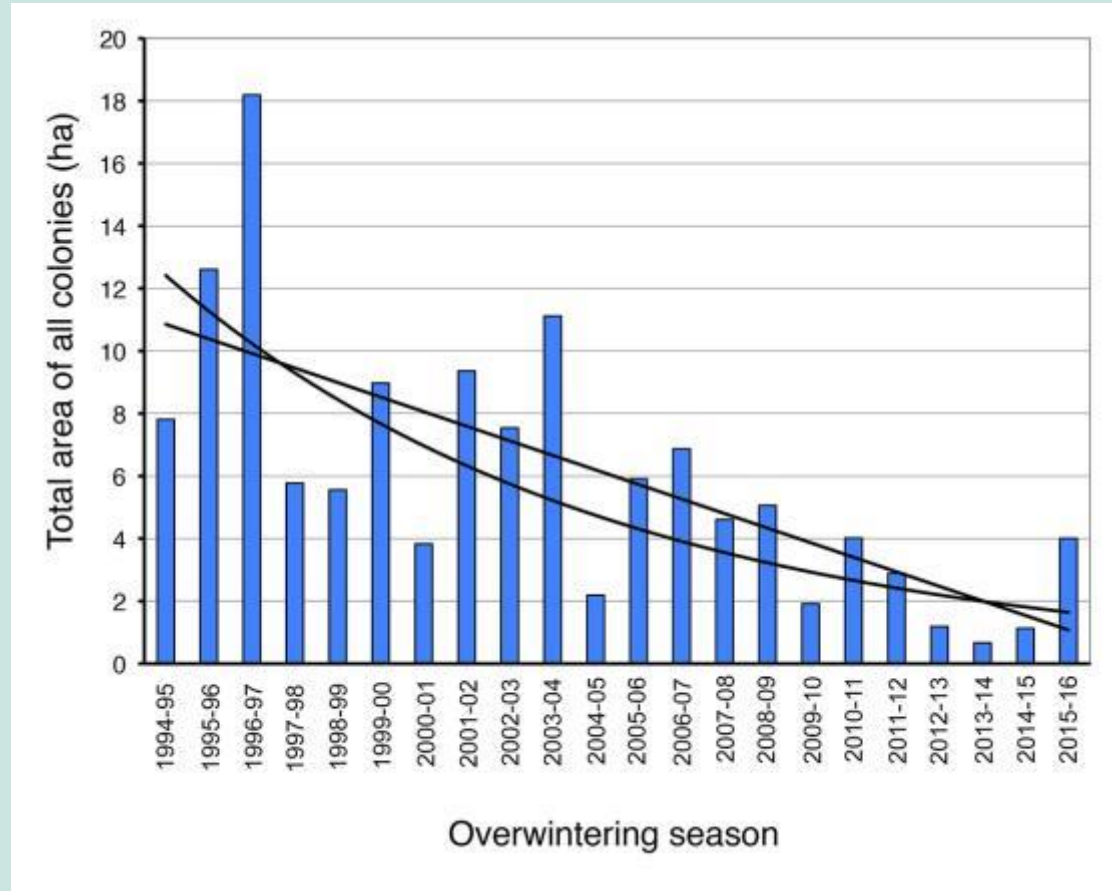
1990s: populations reached ~**one million** monarchs

2015: only ~270,000



Conservation Status: Monarchs Overwintering in Mexico

- Analyses of long term population trends of monarchs at Mexican overwintering sites show an annual decline of $\sim 9\%$ per year for the past 22 years
- Historic high of 675 million monarchs; recent low of 25 million monarchs
- Substantial probability of quasi-extinction (11-57%) over 20 years (Semmens et al. 2016); vulnerable to extreme weather events

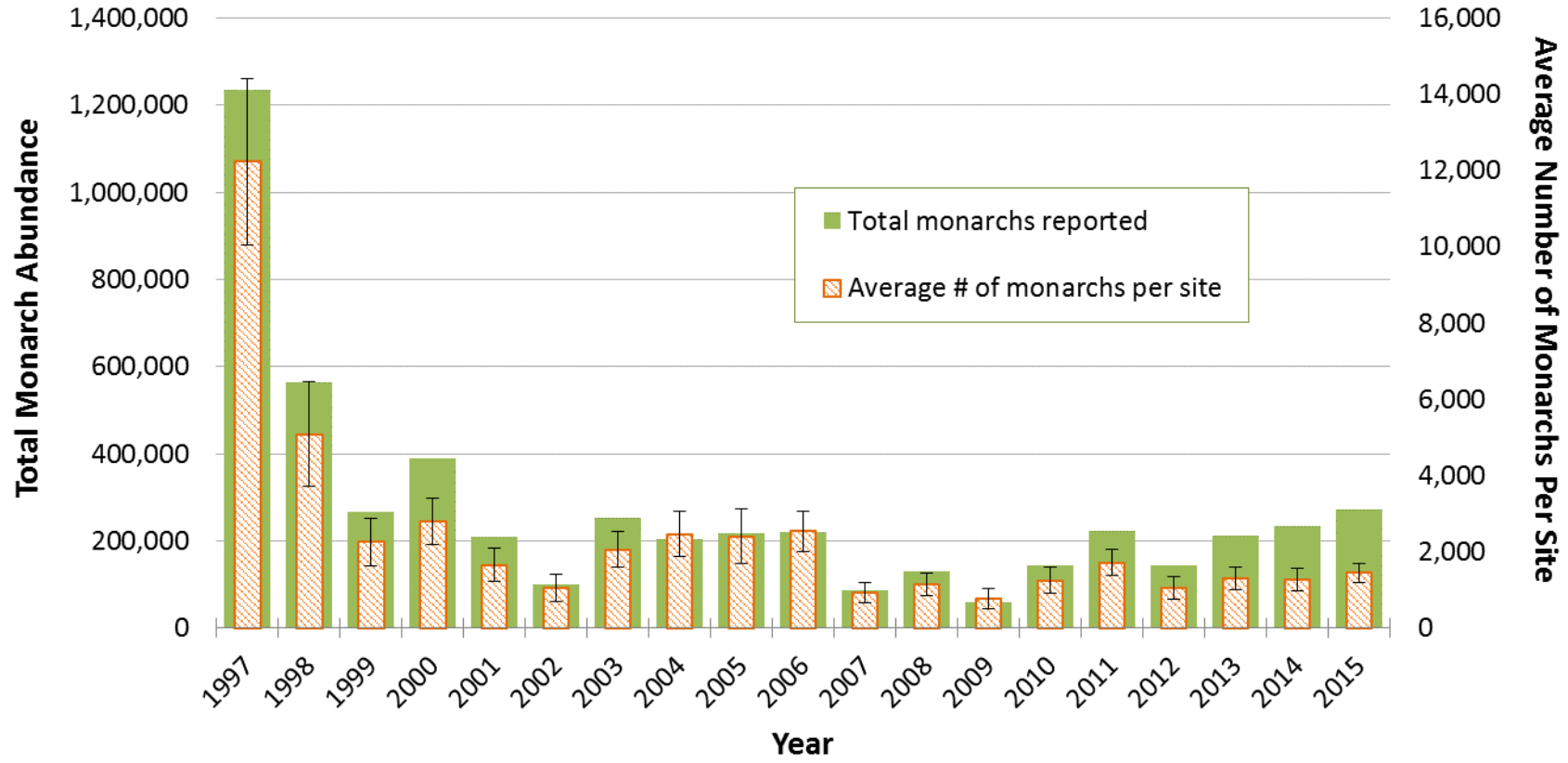


Conservation Status: Monarchs Overwintering in California

Western Monarch Thanksgiving Count

Total and Average Abundance Estimates w/ Standard Error of the Means
at 76-187 Overwintering Sites from 1997-2015
(Monroe *et al.* 2016)

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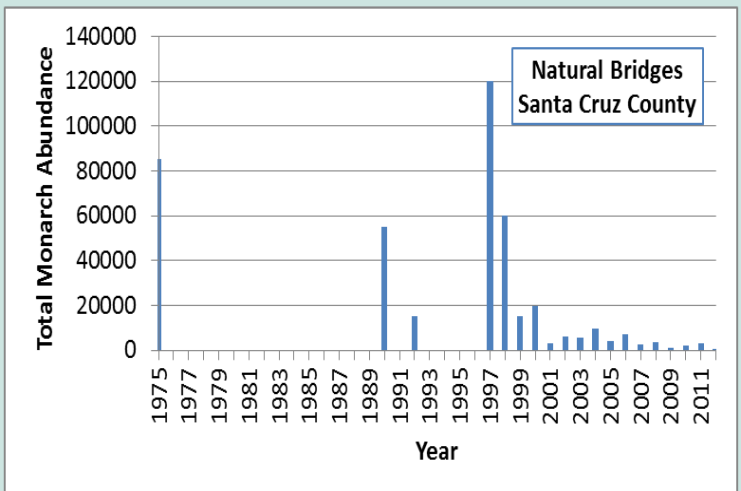
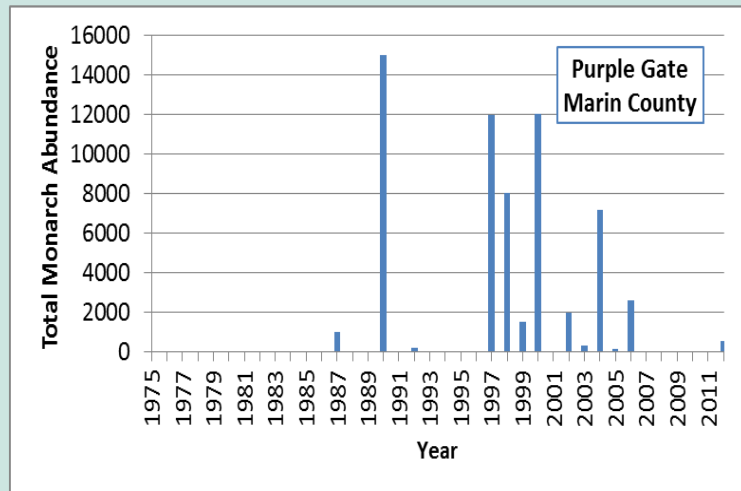
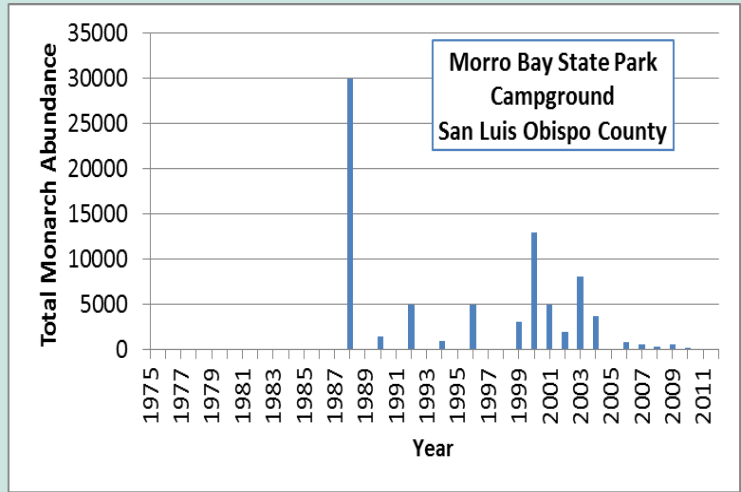
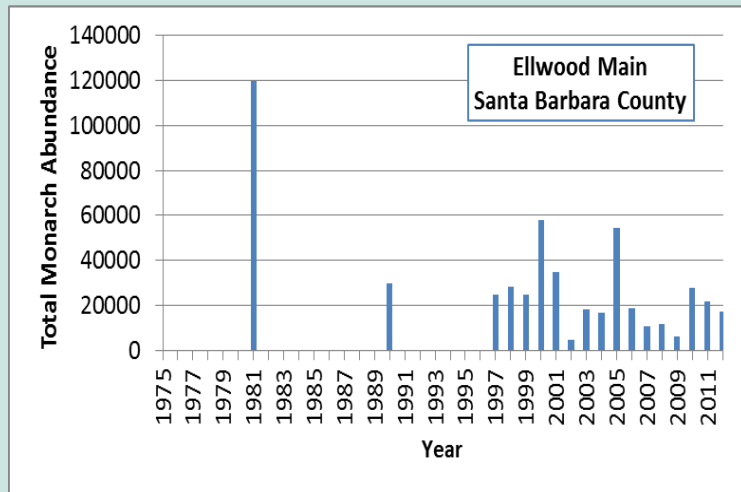


Source: The Xerces Society's Western Monarch Thanksgiving Count

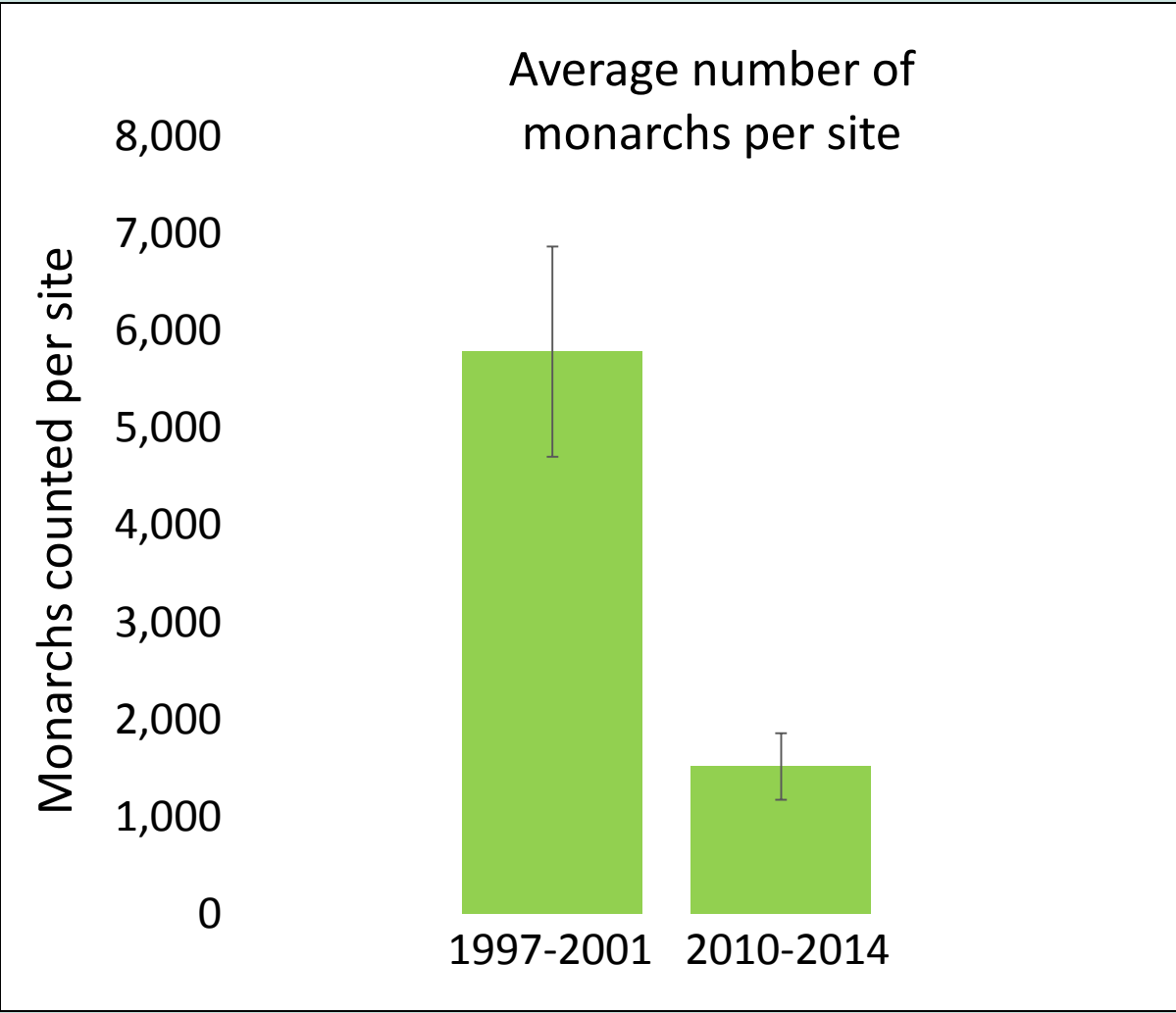
Conservation Status: Monarchs Overwintering in California

Was 1997 an anomaly?

Monarch population estimates illustrate higher pre-1997 population estimates at 3/4 sites for which we have pre-1997 monitoring data



Conservation Status: Monarchs Overwintering in California



A before-and-after site comparison analysis shows a **74% decline** in California overwintering monarchs between recent (2010-2014) and historic (1997-2001) time periods.

Source: The Xerces Society's State of the California Monarch Overwintering Sites Report, In Prep

Conservation Status: Monarchs Overwintering in California

Long term monitoring within CA monarch breeding range show severe decline



- Analyses by Espeset et al. (2016) of 40 years of summer flight records in northern CA show negative trends
- Declines concentrated early in the breeding season
- Shifting climatic conditions and milkweed loss may not be the most important factors driving monarch declines; overwintering habitat loss and insecticide use should also be investigated

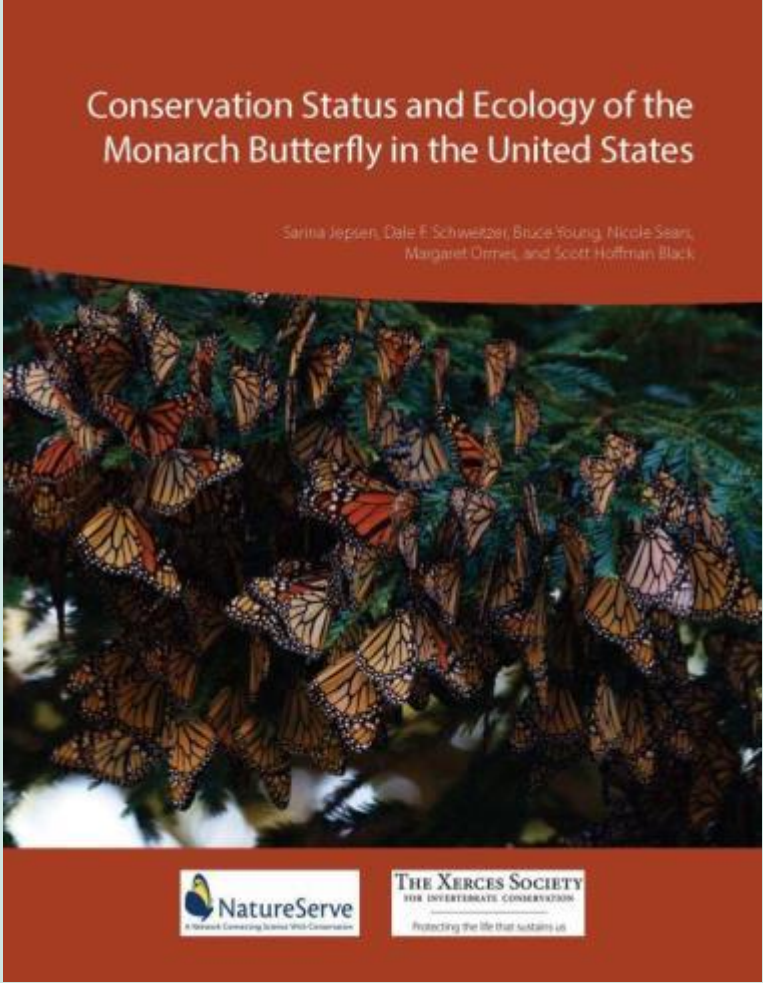
Figure adapted from Espeset et al. 2016.

Conservation Status

NatureServe Conservation Status Assessment

A standardized method to evaluate extinction risk using range extent, population trends, threats, vulnerability, and other factors

<i>Danaus plexippus plexippus</i> (Monarch)	G4T3 – Vulnerable
<i>D. p. plexippus</i> pop. 1 (California Overwintering Population)	G4T2T3 – Imperiled / Vulnerable
<i>D. p. plexippus</i> pop. 2 (Mexican Overwintering Population)	G4T1 – Critically Imperiled



Conservation Status and Ecology of the Monarch Butterfly in the United States

Sarina Jepsen, Dale F. Schweitzer, Bruce Young, Nicole Sears, Margaret Orres, and Scott Hoffman Black



Potential Threats



Photo by: Tom Koemer, USFWS

Potential Threats

- Development
- Agricultural conversion
- Loss and alteration of overwintering habitat
- Breeding & migratory habitat may be declining
- Herbicides & Insecticides
 - Glyphosate common in CA
 - Neonicotinoids
- Drought & climate change
- Disease

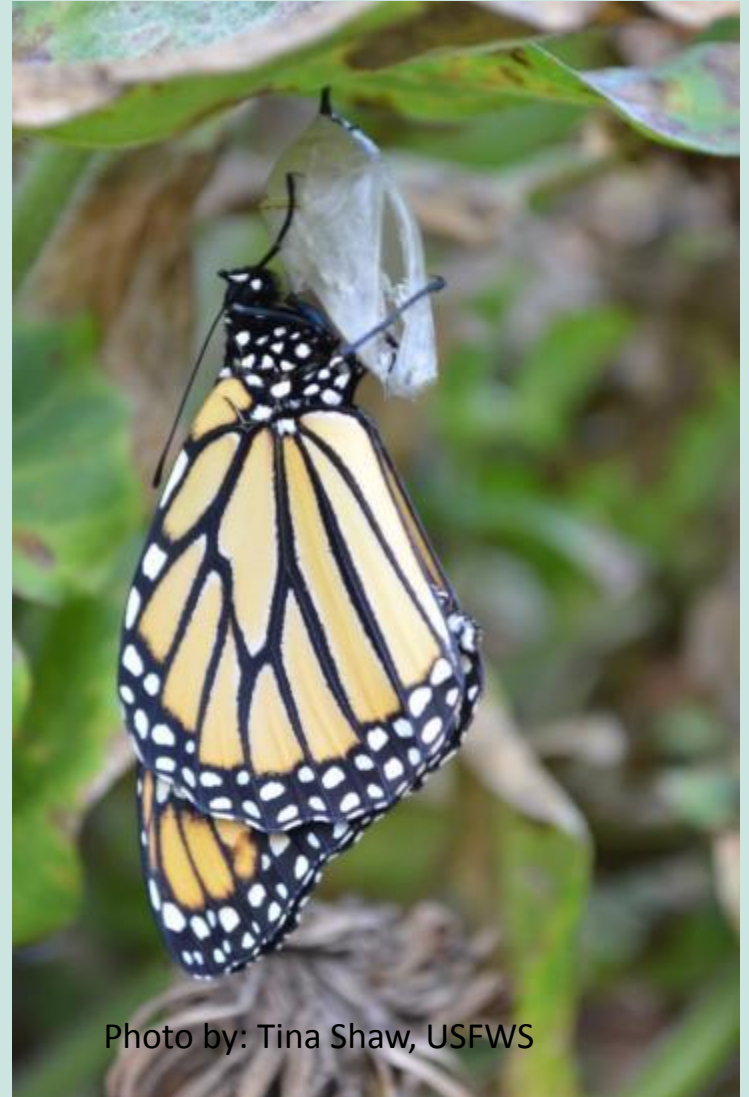


Photo by: Tina Shaw, USFWS

Why are Western Monarchs Declining?

Overwintering Habitat Loss

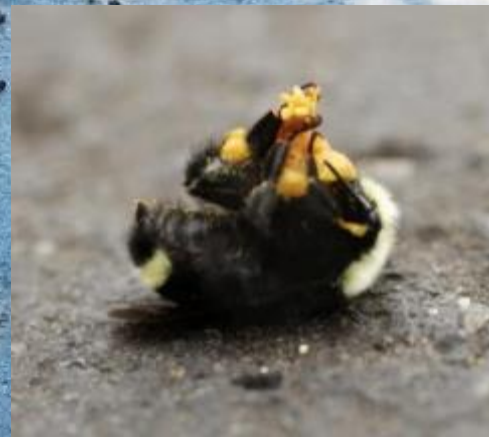
- At least 30 overwintering sites have been logged for housing developments and no longer support monarchs
- 32 additional sites have become unsuitable for monarchs due to diseased trees or habitat alterations (such as tree trimming or fires)



Why are Western Monarchs Declining?

Systemic Insecticides (neonicotinoids):

- Systemic mode of action: in all plant parts including leaf tissue and nectar
- Persistent for long periods in plants, soil, and water bodies
- Highly toxic to bees; new USDA research linked neonicotinoids to monarch declines



Source: Pecenka & Lundgren 2015

Photo: Rich Hatfield, the Xerces Society

Why are Western Monarchs Declining?

Natural Enemies

- Impact of most natural enemies on monarchs is poorly understood
- OE (*Ophryocystis elektroscirrha*) is the most well studied of monarch natural enemies
- Severe infestations of OE can slow development, cripple adults and reduce reproductive fitness



Why are Western Monarchs Declining?

Tropical milkweed and OE

- Due to its evergreen nature, tropical milkweed is associated with winter breeding monarchs
- Winter breeding monarch populations on the Gulf Coast were 5x more likely to be infected with OE than migratory monarchs
- The impact of winter breeding and tropical milkweed in the Western US is currently being investigated by Monarch Health and collaborators



Source: Satterfield, Maerz & Altizer. 2015

Photo: JM Garb, Wikimedia Commons

Priority Research & Conservation Efforts



Priority Research & Conservation Efforts in the West

Natal & Migratory Habitat

- Applied Research and Citizen Science to inform Habitat Management
- Developing Technical Guidance to inform Habitat Management
- Habitat Enhancement

Overwintering Habitat

- Citizen Science
- Developing Technical Guidance to inform Habitat Management



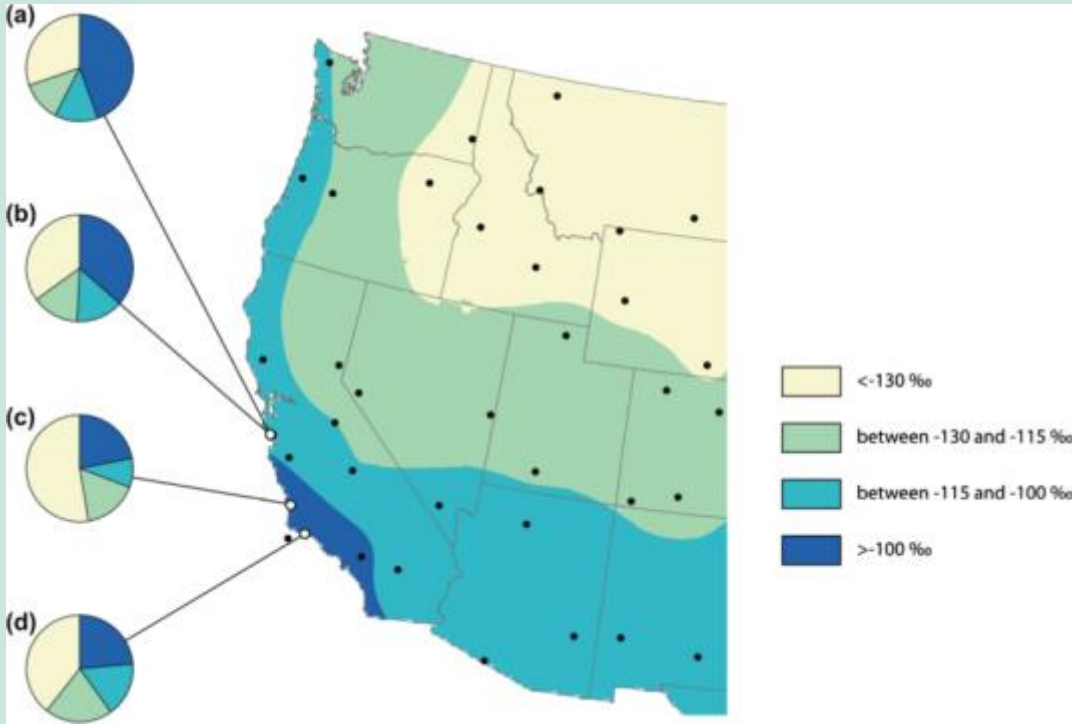
Conservation: Natal & Migratory Habitat

The most important monarch natal sites and migratory pathways in the West are poorly understood



Conservation: Natal & Migratory Habitat

Previous studies have revealed some general regional patterns of monarch natal origins



Source: Yang et al. 2015



Source: Stephens and Frey 2010

Conservation: Natal & Migratory Habitat Research



To better understand where monarchs reproduce in the West, in 2013 the Xerces Society initiated a milkweed and monarch breeding survey to ask land managers, monarch and native plant enthusiasts, and others to record their observations of milkweeds, monarch eggs, caterpillars, and chrysalises:

www.xerces.org/milkweedsurvey

Conservation: Natal & Migratory Habitat Research

Western Monarch & Milkweed Habitat Suitability Assessment

A collaboration between USFWS and Xerces Society

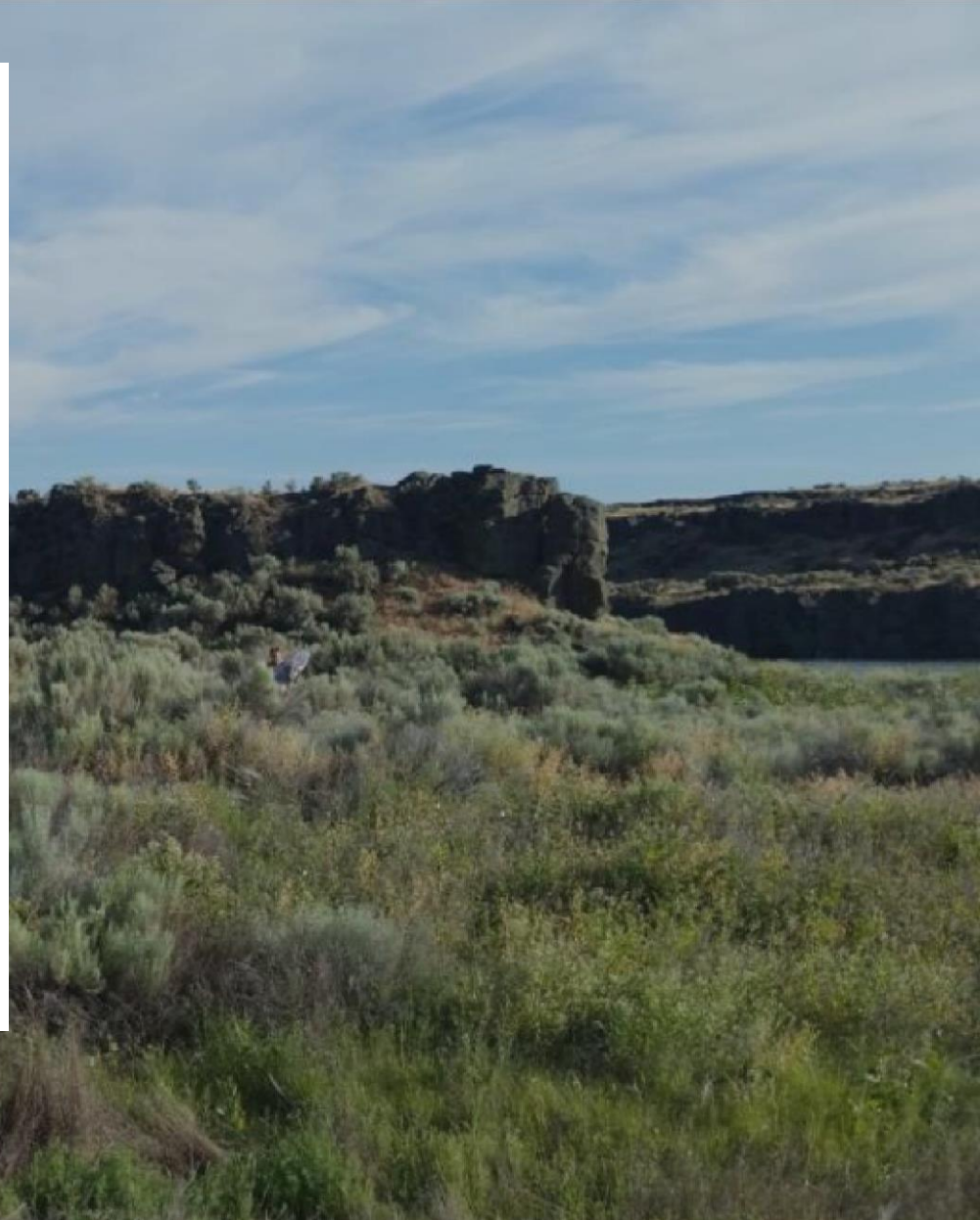
- Geographic features, climate variability, and milkweed availability influence monarch habitat distribution
- Milkweed and monarch data in the West is limited
- Need to identify high priority monarch breeding areas to inform restoration and management efforts
- Species distribution models can quantify these relationships and help to prioritize landscapes



Conservation: Natal & Migratory Habitat Research

USFWS / Xerces Western Monarch & Milkweed Habitat Suitability Assessment Objectives

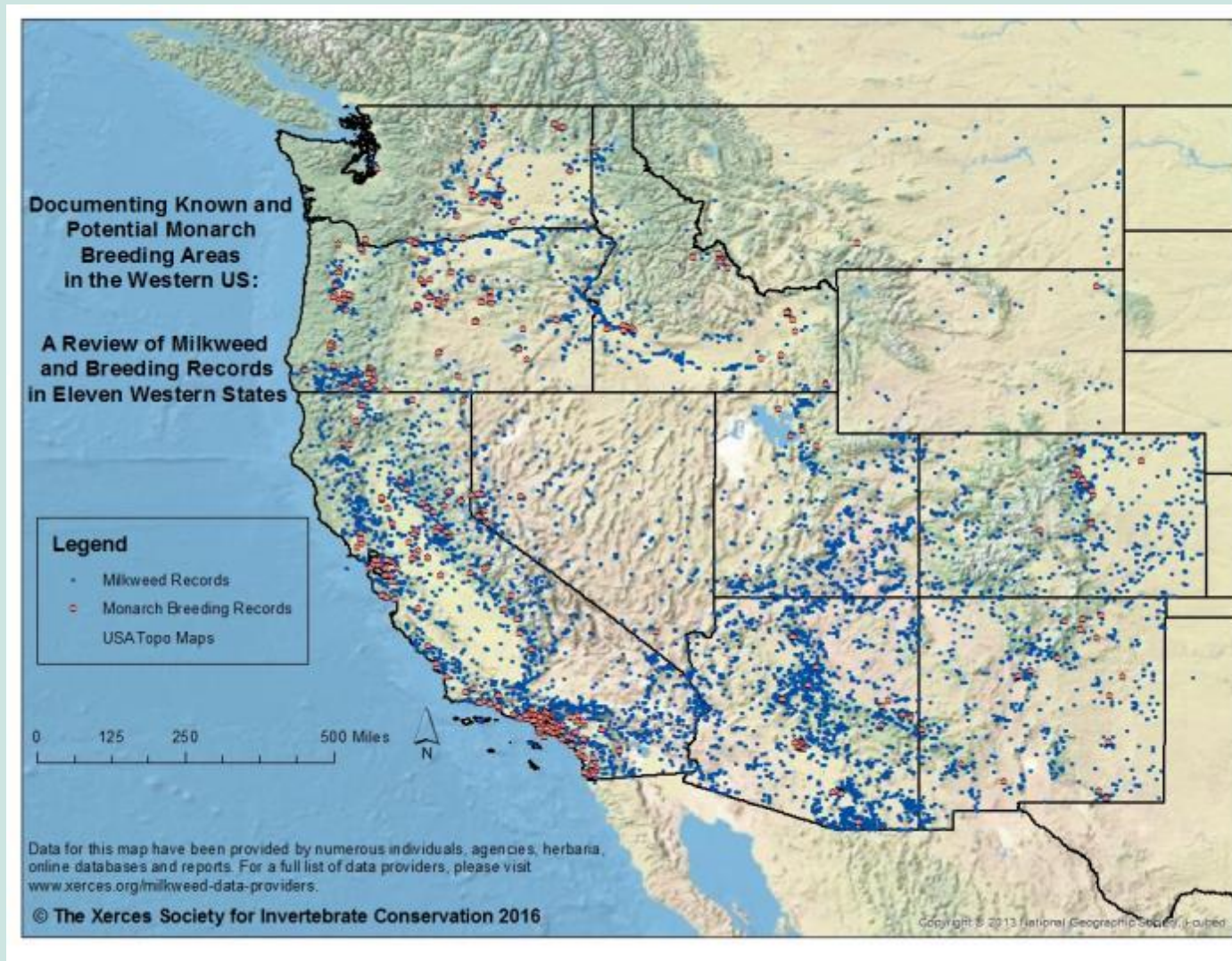
- Consolidate existing western milkweed and monarch records from Xerces database and other sources
- Collect new data for milkweed and monarchs
- Compile geospatial data layers that may influence milkweed & monarch distribution



Conservation: Natal & Migratory Habitat Research

USFWS / Xerces Western Monarch & Milkweed Habitat Suitability Assessment

High and Medium accuracy records used to create habitat suitability models (using Max Ent) for multiple milkweed species and monarchs in the West



USFWS / Xerces Western Monarch & Milkweed Habitat Suitability Assessment

Showy milkweed (*Asclepias speciosa*)

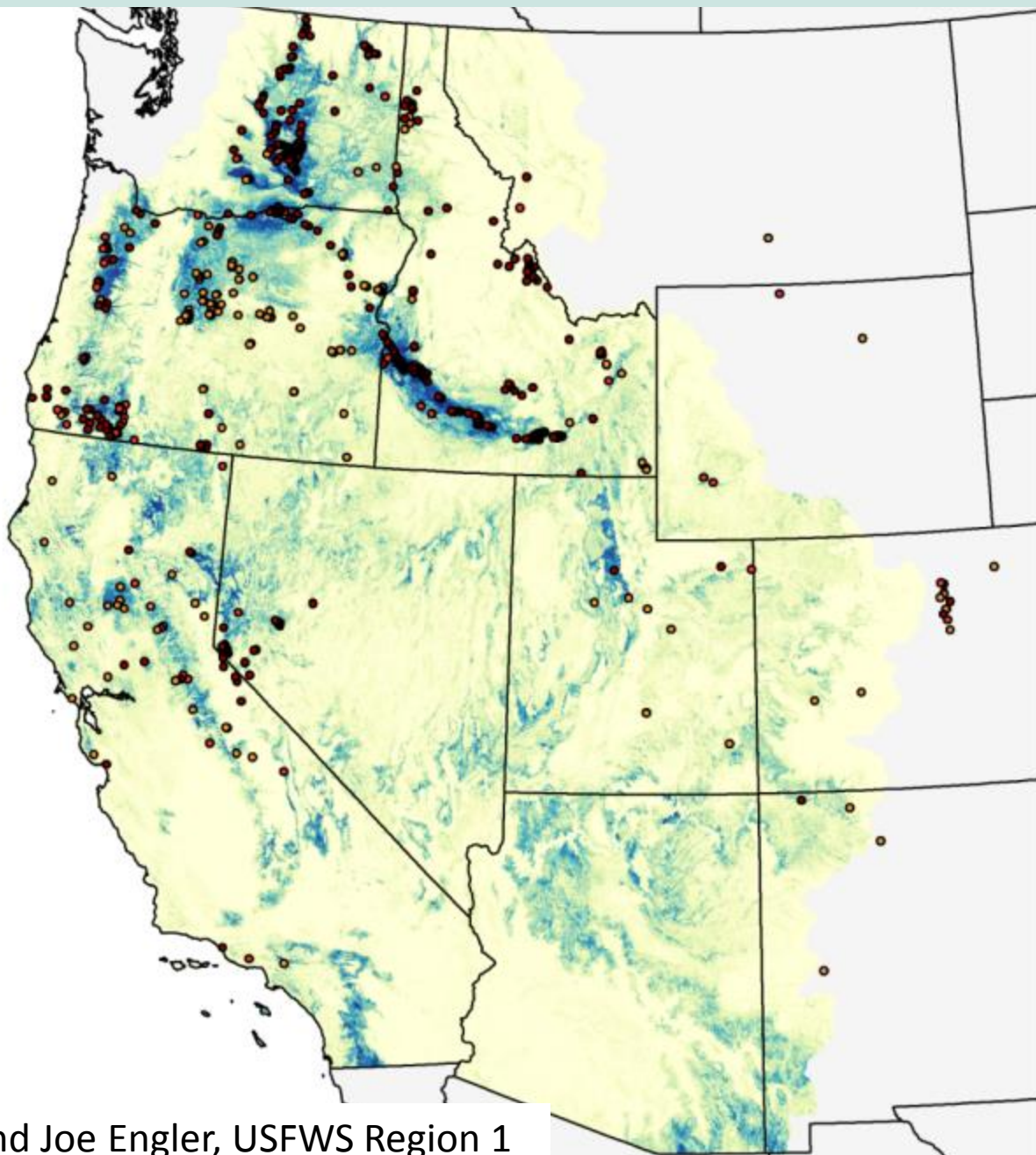
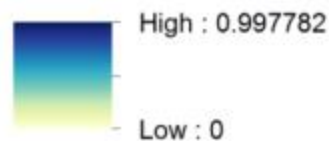
AUC = 0.7 AUC.diff=0.03, RM=2.25

tmin coldest month: 23.9%
tmax warmest month: 16.1%
ppt warmest quarter: 14.2%
temp seasonality: 12.6%
slope: 11.5%
distance to water: 9.2%
ppt coldest quarter: 8.3%
Topsoil Silt Fraction: 4.2%

Points by accuracy class

- High
- Medium-High
- Medium

Relative Habitat Suitability



Slide courtesy of Madeline Steele and Joe Engler, USFWS Region 1

USFWS / Xerces Western Monarch & Milkweed Habitat Suitability Assessment

Spider milkweed (*Asclepias asperula*)

AUC = 0.71; AUC.diff=0.05, RM=1.5

ppt seasonality: 32.1%

ppt coldest quarter: 21.7%

AET annual mean: 16.3%

ppt warmest quarter: 9.2%


tmean warmest quarter: 6.6%

distance to water: 6.3%

LANDFIRE reclass: 3.7%


slope: 3.6%

Topsoil Silt Fraction: 0.6%

 Modeling extent

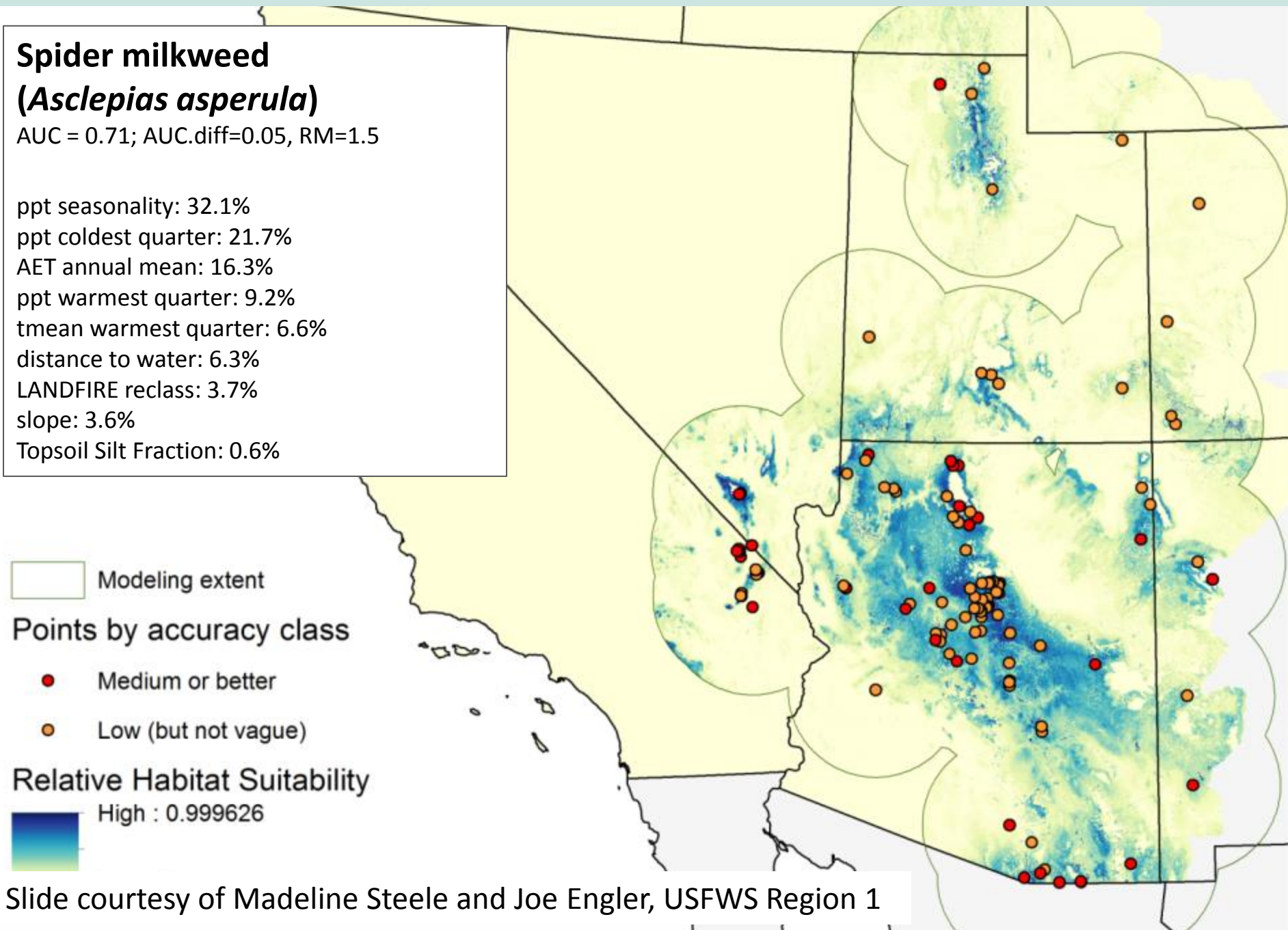
Points by accuracy class

 Medium or better

 Low (but not vague)

Relative Habitat Suitability

 High : 0.999626



USFWS / Xerces Western Monarch & Milkweed Habitat Suitability Assessment

Monarch breeding

AUC = 0.7; AUC.diff=0.06, RM=1.25

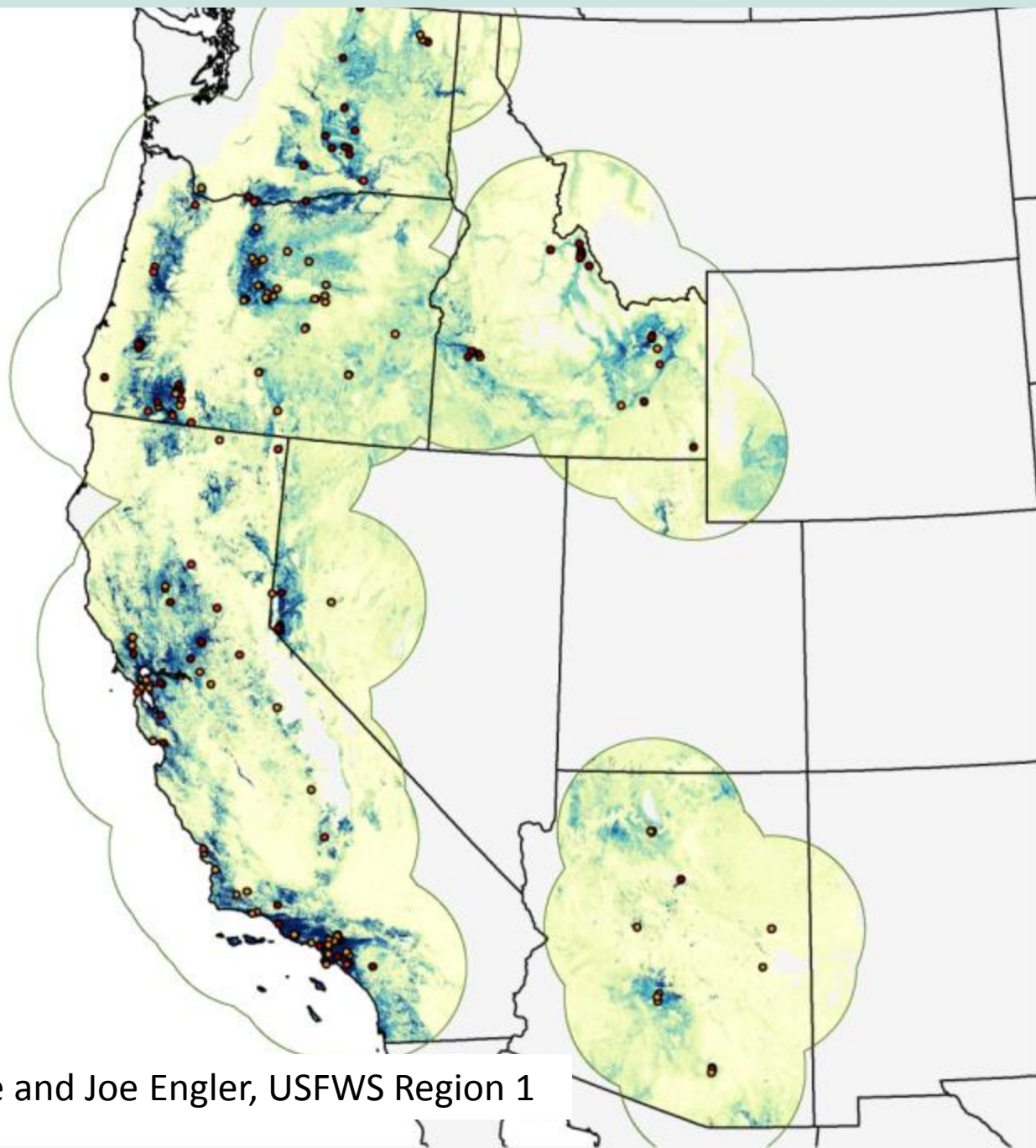
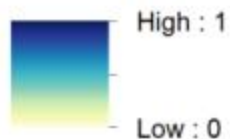
fascicularis model: 41.6%
speciosa model: 22.7%
tmean warmest quarter: 9.7%
AET annual mean: 5.5%
ppt warmest quarter: 4.1%
eriocarpa model: 3.4%
ppt seasonality: 2.9%
asperula model: 2.8%
slope: 2.5%
Topsoil Sand Fraction: 1.5%
cordifolia model: 1.3%
Topsoil Clay Fraction: 1.1%
distance to water: 0.9%

 Modeling extent

Points by accuracy class

- High
- Medium-High
- Medium

Relative Habitat Suitability



Slide courtesy of Madeline Steele and Joe Engler, USFWS Region 1

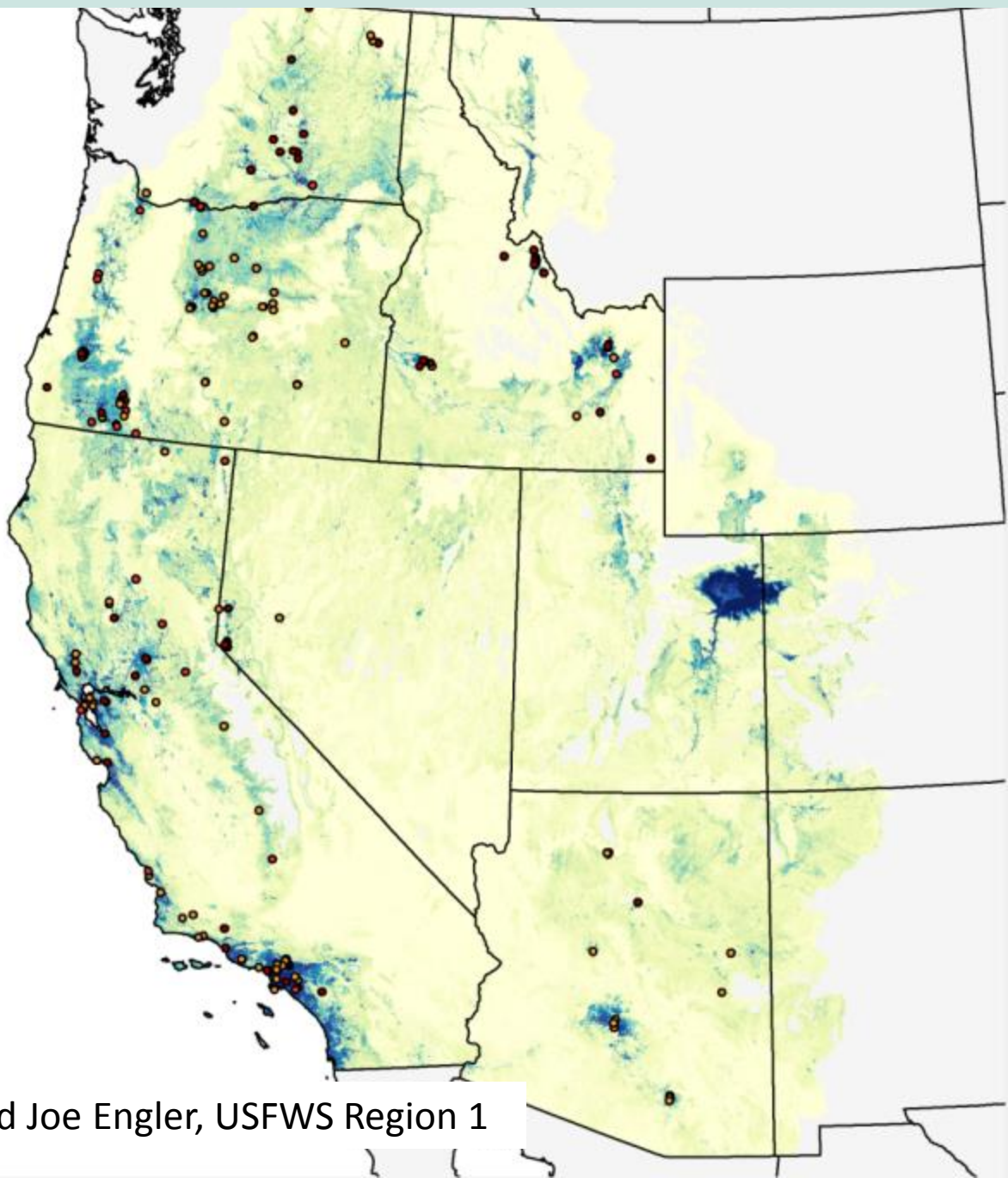
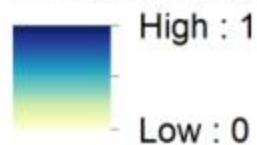
USFWS / Xerces Western Monarch & Milkweed Habitat Suitability Assessment

Monarch breeding,
projected across
large unsampled
areas

Points by accuracy class

- High
- Medium-High
- Medium

Relative Habitat Suitability



Slide courtesy of Madeline Steele and Joe Engler, USFWS Region 1

Conservation: Natal & Migratory Habitat Research

Major data gaps remain in the Intermountain West and Rocky Mountain West, which limit the ability to model habitat suitability for monarchs in these areas of the West

Summer 2016: USFWS, Xerces, and partners are collecting data to improve this model in NV, UT, WY, MT, CO, ID, WA, and OR

To contribute data to the model, visit: www.xerces.org/milkweedsurvey/



Conservation: Natal & Migratory Habitat Research

Integrating Strategic Conservation Approaches into the State Wildlife Action Plans for Idaho and Washington

- Collect additional historical data on monarchs and milkweed
- Launch a website to provide a centralized location for citizen scientists and agency staff to report and access western milkweed occurrence data throughout the West
- Provide short courses for land managers and citizen scientists

Project Partners: Idaho Department of Fish & Game, Washington Department of Fish & Wildlife, Xerces Society
Funding provided by US Fish & Wildlife Service through a State Wildlife Grant

Conservation: Natal & Migratory Habitat Management

Filling Information Gaps and Developing Best Management Practices to Sustain Monarchs and Milkweeds in Public Lands of the Western US

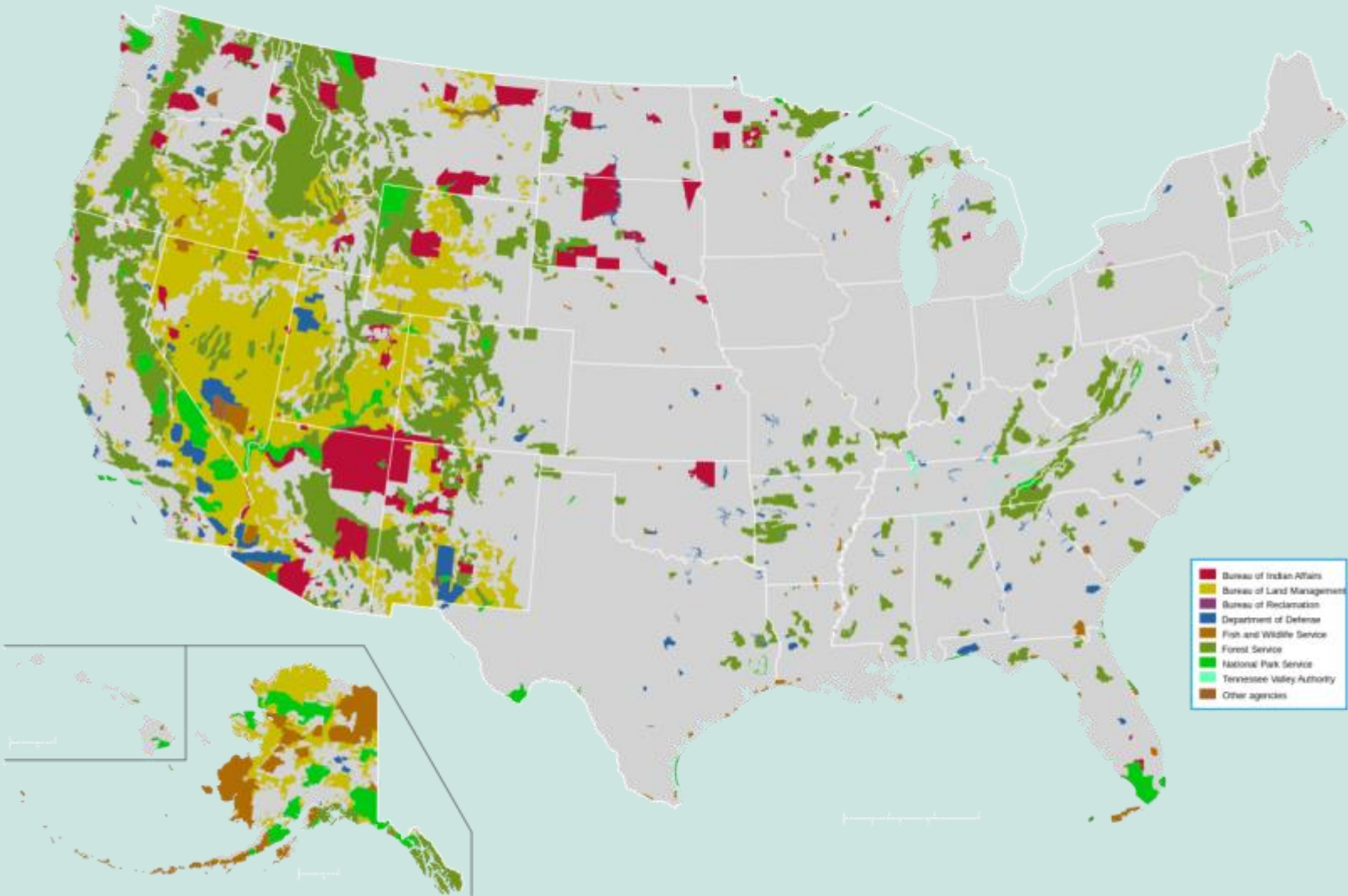
- Conduct milkweed and monarch breeding surveys in the Great Basin in 2016
- Interview land managers in western states to better understand how land management practices affect monarch habitat, especially on rangelands
- Develop BMPs to improve habitat for milkweed and monarchs on western public lands
- Conduct short courses for public land managers on monarch habitat management

Partners: Xerces Society, USFWS, USFS, BLM, Matt Forister (University of Nevada, Reno);
Funding provided by National Fish & Wildlife Foundation from USFWS, USFS, BLM



Conservation: Natal & Migratory Habitat Management

~Half of the land-base in the Western US is managed by Federal agencies, presenting a major opportunity for monarch habitat conservation



Conservation: Natal & Migratory Habitat Management

To aid in habitat management and restoration efforts, we are developing 15 regional monarch nectar plant lists for land managers and restoration practitioners

- Monarch attractive
- Native
- Commercially available
- Hardy, non-weedy, and appropriate for large-scale restoration
- In bloom during the time period when monarchs are in a particular region



In partnership with the Monarch Joint Venture, Natural Resources Conservation Service, and National Wildlife Federation

Photo: *Baccharis pilularis* in SE California, Shelley Ellis

Conservation: Natal & Migratory Habitat Enhancement

Across the US, restoration of 0.5-1.5 million acres/year of habitat with milkweed and nectar plants is needed

- Native, locally appropriate milkweed is not available in key areas of the monarch's breeding range
- Where it is available, it is expensive




Conservation: Natal & Migratory Habitat Enhancement

Project Milkweed

- Mass seed increase in California, Great Basin, Southwest, Texas, and Florida
- Seed production guidelines
- Over 35 million seeds of 11 milkweed species have been produced so far



In partnership with USDA Natural Resources Conservation Service's Plant Materials Program, Monarch Joint Venture, multiple seed companies

A close-up photograph of a milkweed stem. The stem is light-colored and has several brown, elongated seeds attached to it. The seeds are arranged in a cluster, and some are in focus while others are blurred in the background. A white, papery seed pod is visible at the top of the stem.

Milkweed seed finder: a national directory of milkweed seed vendors to help restoration practitioners find locally appropriate sources of seed.

www.xerces.org/milkweed-seed-finder

Milkweed Seed — FINDER —

Conservation: Natal & Migratory Habitat Enhancement

In partnership with NRCS and private landowners, we have restored >200,000 acres of flower rich habitat, including tens of thousands of acres with milkweed.



Conservation: Natal & Migratory Habitat Enhancement

Milkweed within a native pollinator restoration planting adjacent to an almond orchard in Arbuckle, California



Conservation: Natal & Migratory Habitat Enhancement

Milkweed within a hedgerow planting at a Muir Glen farm in northern California



Conservation: Overwintering Habitat



Photo: Carly Voight, the Xerces Society

Conservation: Overwintering Habitat

In the fall and winter, monarchs are found clustering in >300 coastal California groves.

Some sites host >20,000 monarchs, but only ~45 sites regularly have more than 1,000 monarchs.



Conservation: Overwintering Habitat

Western Monarch Thanksgiving Count

- Annual monitoring of California monarch groves centered around Thanksgiving
- 100+ volunteers in 2015 surveyed >185 sites



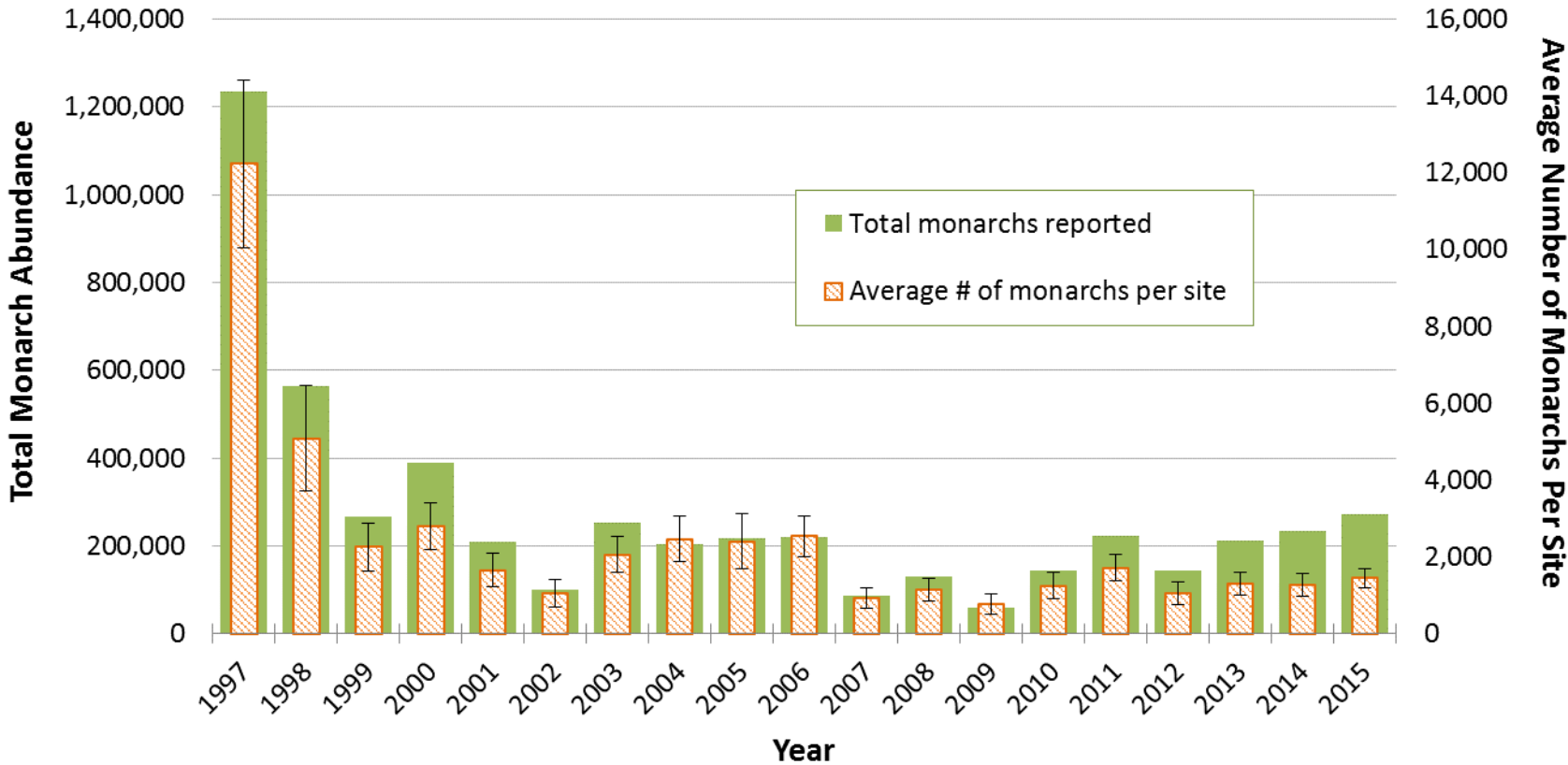
Conservation: Overwintering Habitat

www.westernmonarchcount.org

Western Monarch Thanksgiving Count

Total and Average Abundance Estimates w/ Standard Error of the Means
at 76-187 Overwintering Sites from 1997-2015
(Monroe *et al.* 2016)

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Conservation: Overwintering Habitat

Overwintering Site Database

Aggregated data from California Natural Diversity Database, Xerces Thanksgiving Counts and other sources including: yearly counts, spatial boundaries, habitat quality, threats, land ownership

Data uses:

- Identify conservation needs and data gaps
- Prioritize sites for restoration
- Evaluate impacts of developments, past use by monarchs, coastal zone

In partnership with California Natural Diversity Database, Monarch Joint Venture

Photo: Candace Fallon, the Xerces Society

Conservation: Overwintering Habitat

State of the California Overwintering Sites: A project of USFWS and Xerces Society

We ranked the top 50 highest
priority monarch overwintering
sites for conservation action
based upon:

- Decline (comparing 1997-2001 count average to 2010-2014 count average)
- Proportion of the remaining total population in 2010-2014



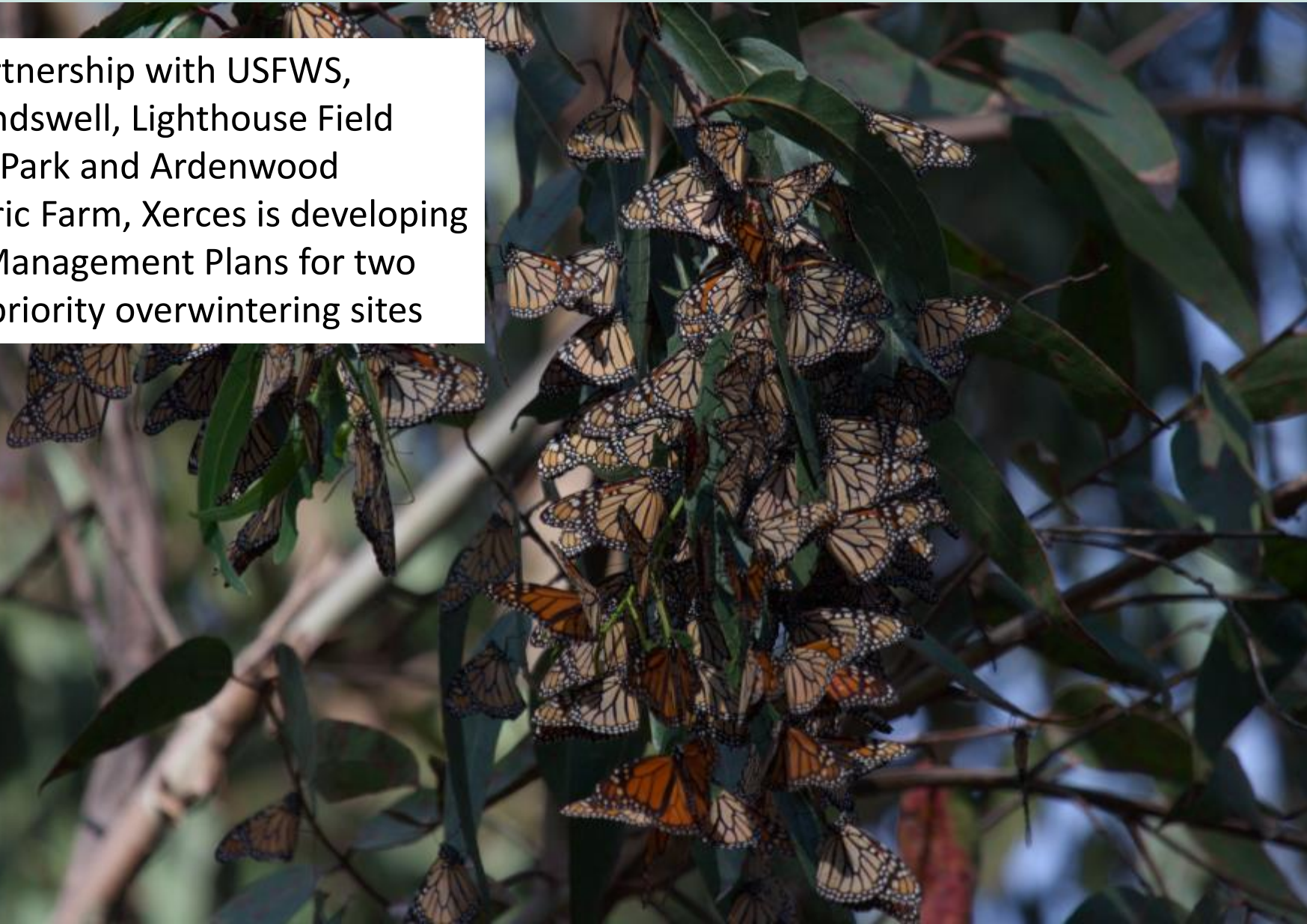
Conservation: Overwintering Habitat

Top 10 highest priority overwintering sites for restoration or active management

Rank	Xerces Database Site ID	County	Site Name	Current Population (2010-2014 average)	Decline (from 1997-2001 average)
1	3060	San Luis Obispo	Pismo Beach State Park	25,494	64.8 %
2	2732	Santa Barbara	Private Site 2732	12,686	67.6 %
3	2920	Monterey	Private Site 2920	16,362	48.7 %
4	2751	Santa Barbara	Ellwood Main	12,142	58.0 %
5	3056	San Luis Obispo	Morro Bay Golf Course	11,306	61.2 %
6	2935	Monterey	Pacific Grove Sanctuary	11,914	51.8 %
7	3000	Santa Cruz	Lighthouse Field State Beach	7,360	83.6 %
8	2833	Alameda	San Leandro Golf Course	5,350	63.0 %
9	2983	Santa Cruz	Moran Lake	3,915	74.7 %
10	3043	San Luis Obispo	Pecho Road, Los Oso	4,321	64.3 %

Conservation: Overwintering Habitat

In partnership with USFWS, Groundswell, Lighthouse Field State Park and Ardenwood Historic Farm, Xerces is developing Site Management Plans for two high priority overwintering sites

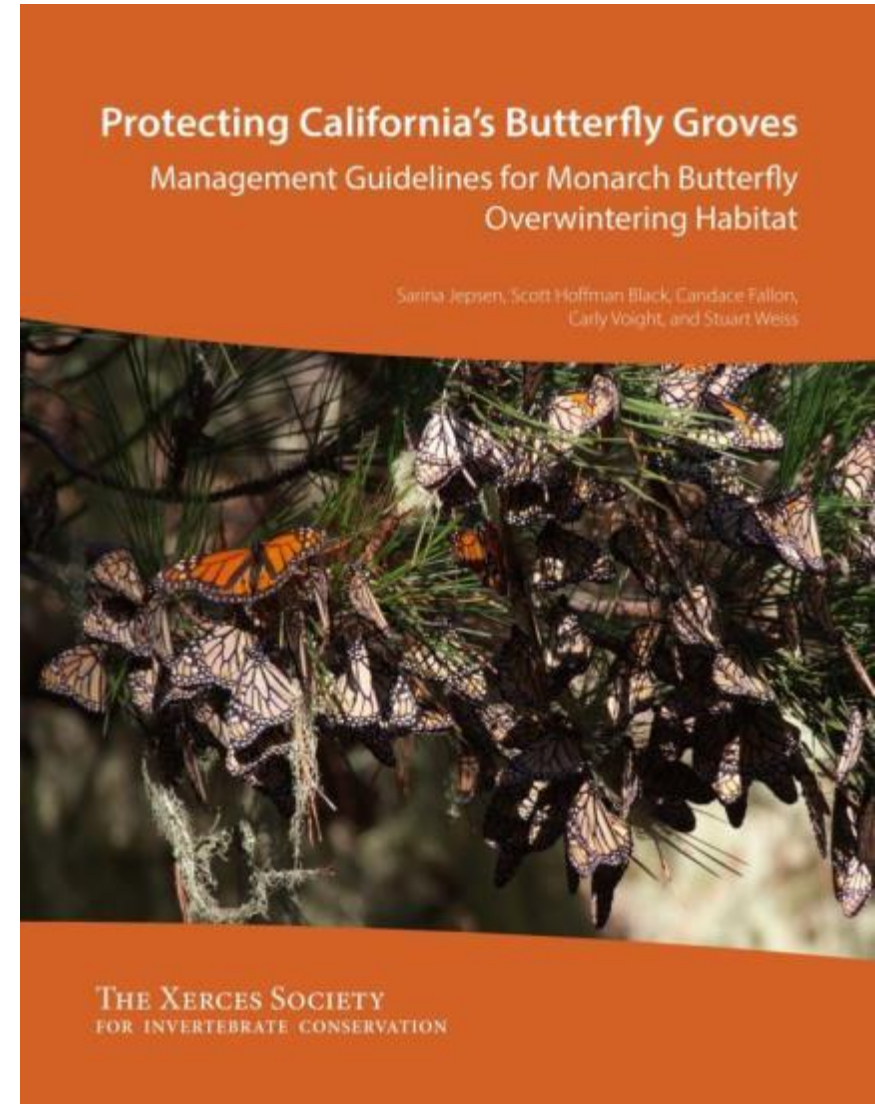


Conservation: Overwintering Habitat

Overwintering Site Management Guidelines

- Monarch overwintering habitat requirements
- Conducting a habitat assessment
- Developing a site specific management plan
- Hazard tree removal
- Planting and replacing trees
- Native monarch nectar plant recommendations

In partnership with Stu Weiss and Monarch Joint Venture



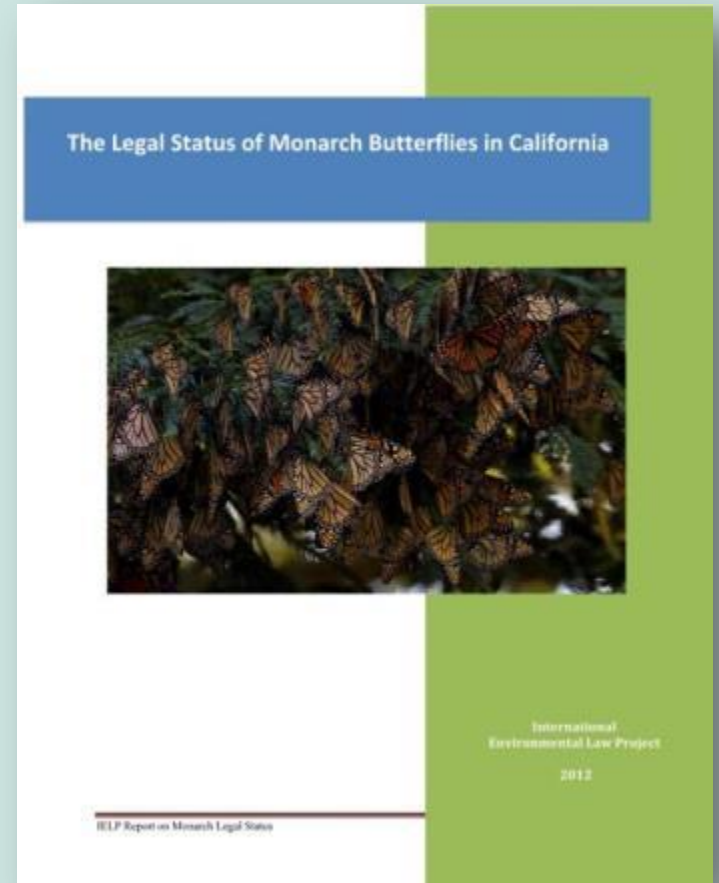
Conservation: Overwintering Habitat

Analysis of federal, state and local laws and regulations that affect California monarchs and monarch habitat

Available at:

www.xerces.org/monarchs

+additional resources



Opportunities for Monarch Conservation



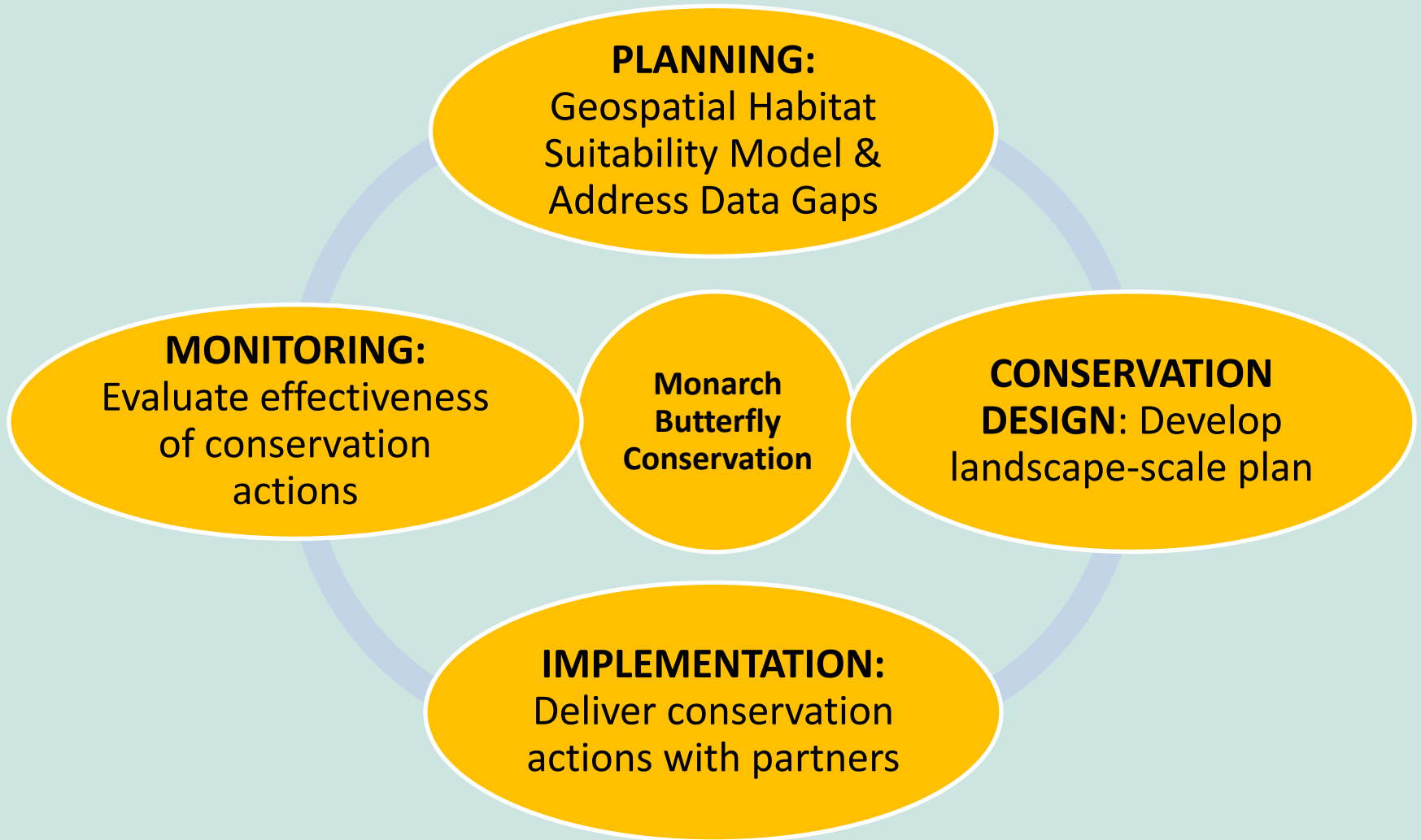
Photo by: Joanna Gilkeson, USFWS

Opportunities for Conservation

- Western Monarch & Milkweed Habitat Suitability Assessment
 - Monarch SOS app
 - Survey lands for milkweed & breeding monarchs
 - Visit www.xerces.org/milkweedsurvey to contribute data
- Locate & protect breeding areas, migration corridors, overwintering sites
- Thanksgiving Count
- Mayor's Monarch Pledge
- Streamline process for permitting
 - Monarch tagging, OE sampling, Research
- Develop Western Monarch Consortium and cohesive Landscape-Conservation Approach



Western Conservation Approach



Opportunities for Monarch Conservation in California

Documenting Known and Potential Monarch Breeding Areas in the Western US:

A Review of Milkweed and Breeding Records in California

Legend

- Monarch Breeding Records
- Milkweed Records

CDFW Public Access Lands

Property Type

- Ecological Reserve
- Wildlife Area
- Fish Hatchery
- Public Access

- State Boundaries
- USA_Counties



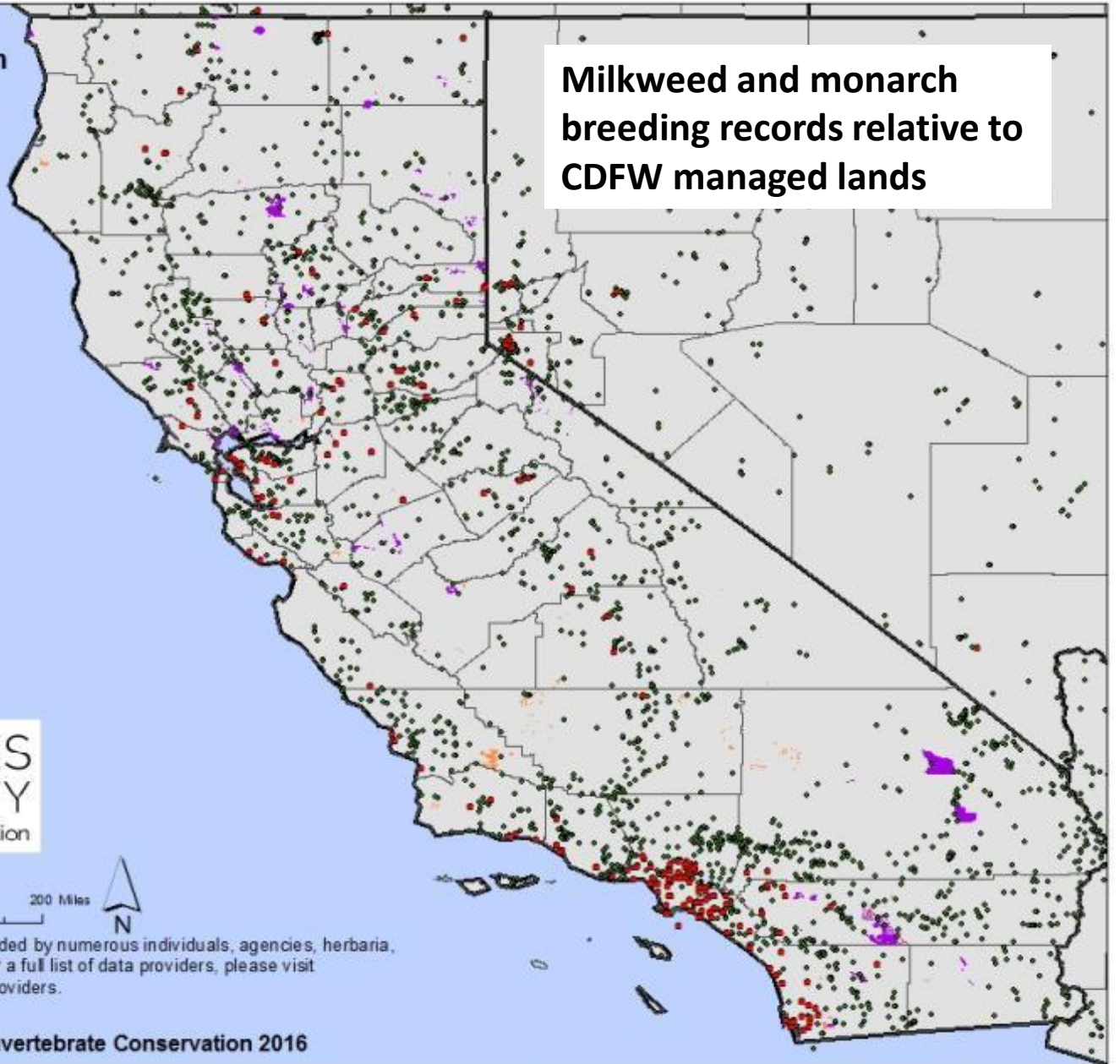
0 50 100 200 Miles



Data for this map have been provided by numerous individuals, agencies, herbaria, online databases, and reports. For a full list of data providers, please visit www.xerces.org/milkweed-data-providers.

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Milkweed and monarch breeding records relative to CDFW managed lands



Opportunities for Monarch Conservation in California

More than half of the 400+ overwintering sites are publicly managed:

- California Department of Fish and Wildlife manages 5 overwintering sites
- California Parks and Recreation manages 47 sites
- Department of Defense manages 37 sites
- National Park Service manages 11 sites
- University of California manages 11 sites
- Local governments manage 95 sites

Many more sites have mixed public-private ownership

Opportunities for Monarch Conservation in California

Local Governments and California Coastal Commission

- Many overwintering sites fall within the coastal zone
- Local Governments and the Coastal Commission have the authority to designate sites as Environmentally Sensitive Habitat Areas, which provide protection from development, however few sites are designated as such in Local Coastal Plans



Resources and Tools

- www.xerces.org/monarchs/
- www.xerces.org/milkweedsurvey/
- www.fws.gov/refuges/friends/monarchs
- [www.fws.gov/save the monarch](http://www.fws.gov/save%20the%20monarch)
- www.westernmonarchcount.org
- www.monarchjointventure.org
- www.monarchalert.calpoly.edu
- www.monarchparasites.org
- Monarch SOS Iphone app
- National Fish & Wildlife Foundation Grants

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Questions?

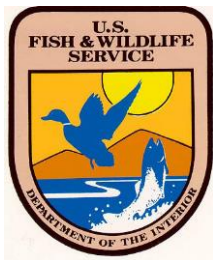


Photo by: Keenan Adams, USFWS