Climate change Vulnerability of Sagebrush-Associated Wildlife

Sagebrush & Climate Training Series

Virtual Classroom

April 4, 2024

Lindsey Thurman, USGS NWCASC
Janet Rachlow, Univ. Idaho
Cameron Aldridge, USGS FORT

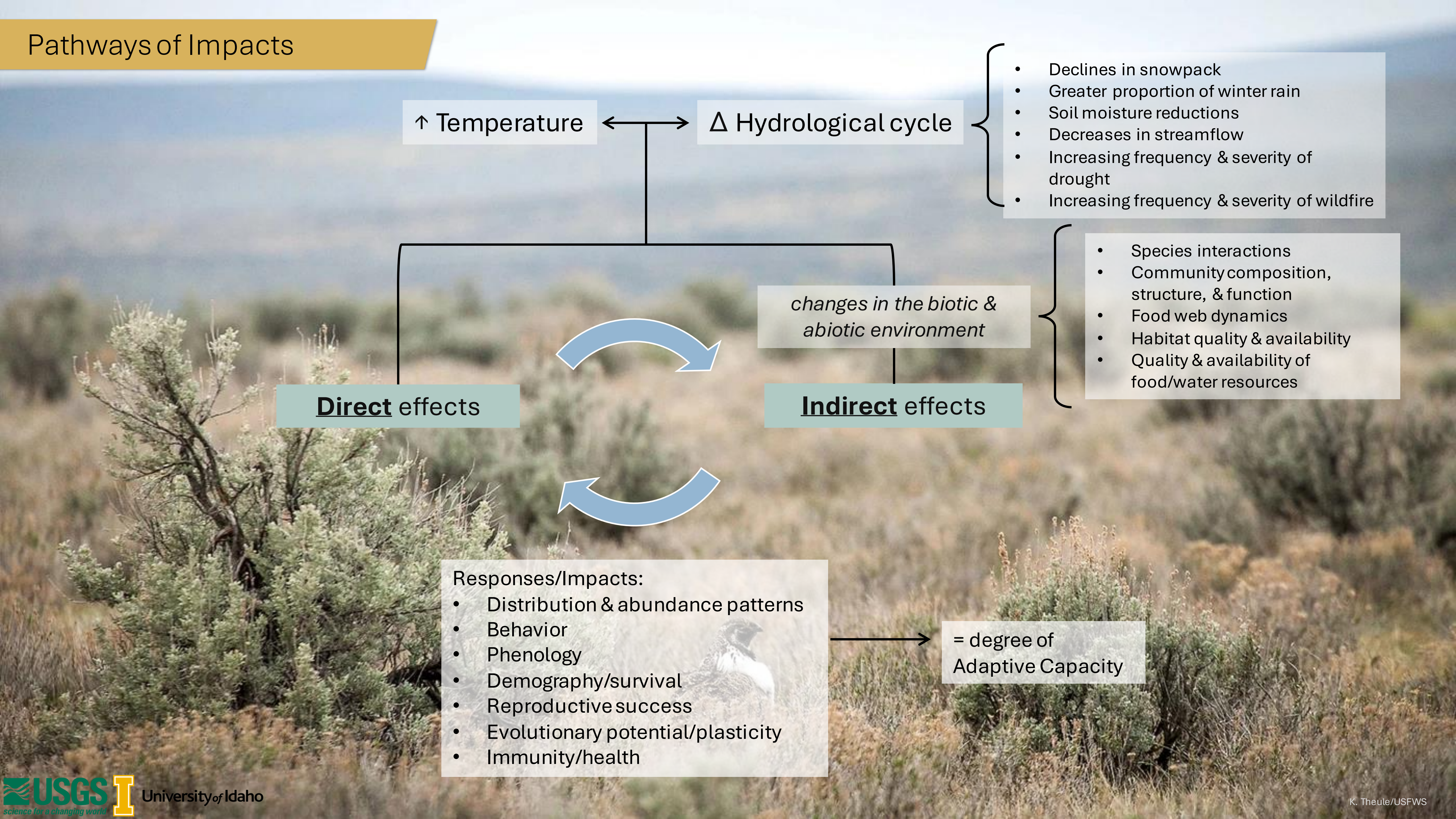
USGS science for a changing world

University of Idaho

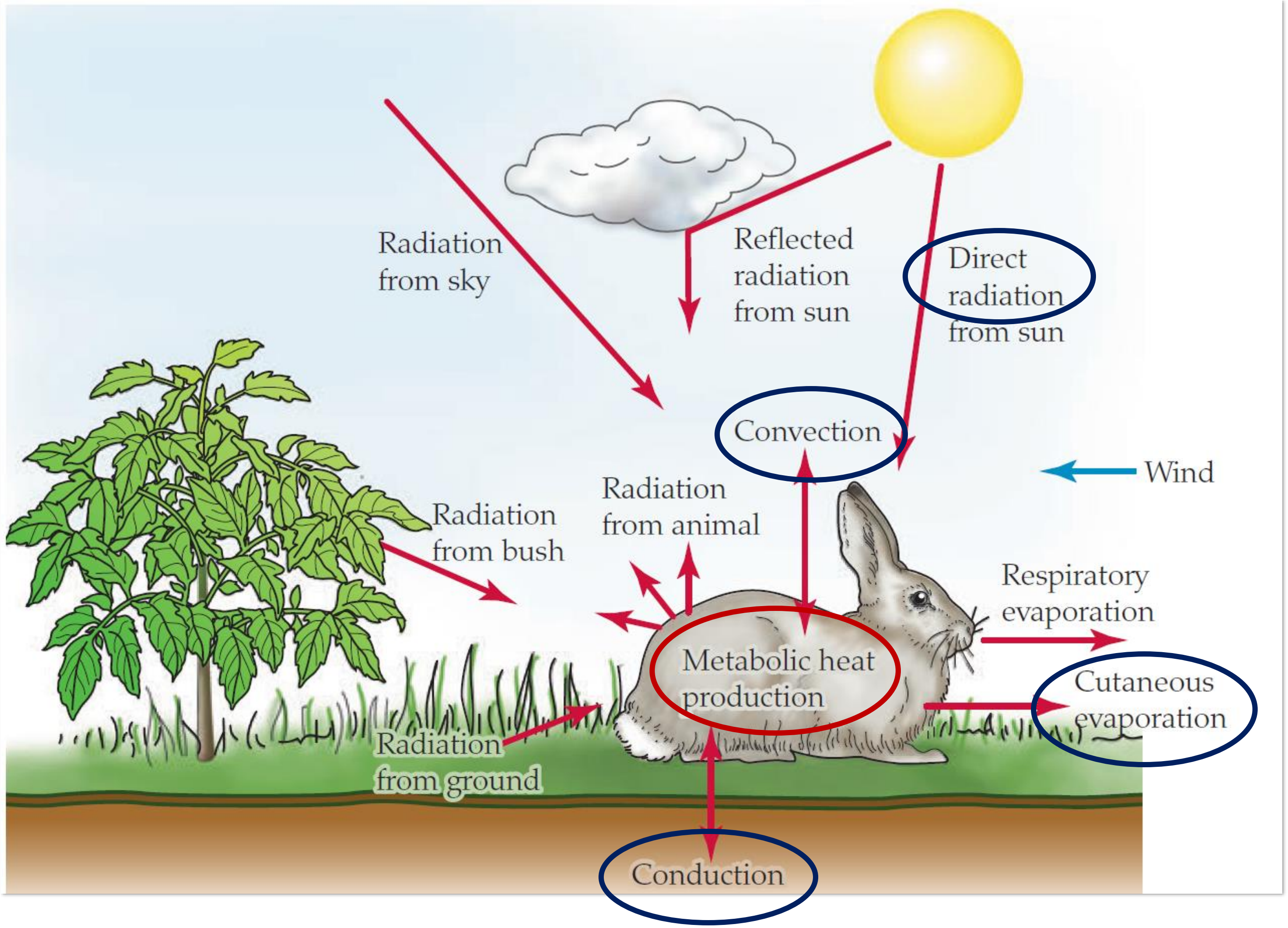
USFWS

Road Map

I. Overview: wildlife response to climate change
II. Measuring response through Vulnerability Assessments
III. Case studies


Pathways of Impacts
↑ Temperature
Δ Hydrological cycle
Declines in snowpack
Greater proportion of winter rain
Soil moisture reductions
Decreases in streamflow
Increasing frequency & severity of drought
Increasing frequency & severity of wildfire
Species interactions
Community composition, structure, & function
Food web dynamics
Habitat quality & availability
Quality & availability of food/water resources
changes in the biotic & abiotic environment
Direct effects
Indirect effects
Responses/Impacts:
Distribution & abundance patterns
Behavior
Phenology
Demography/survival
Reproductive success
Evolutionary potential/plasticity
Immunity/health
= degree of Adaptive Capacity
USGS science for a changing world
University of Idaho
K. Theule/USFWS

Heat exchange mechanisms

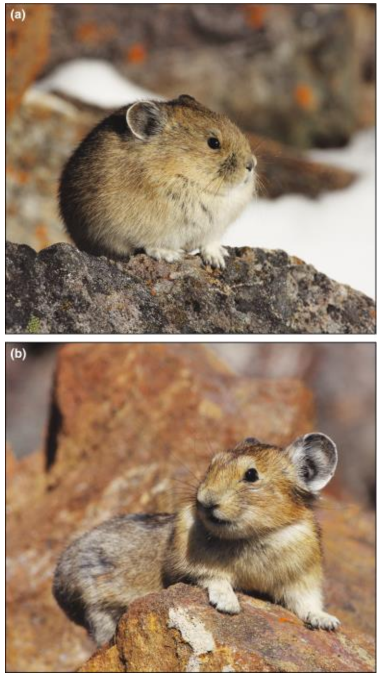


- Radiant heat exchange can be a strong influence
- Only convection depends on air temperature
- Evaporative cooling can be effective/efficient
- Metabolic heat is significant contribution

USGS science for a changing world | University of Idaho

(Hill et al. 2021. Animal Physiology. Oxford Univ. Press)

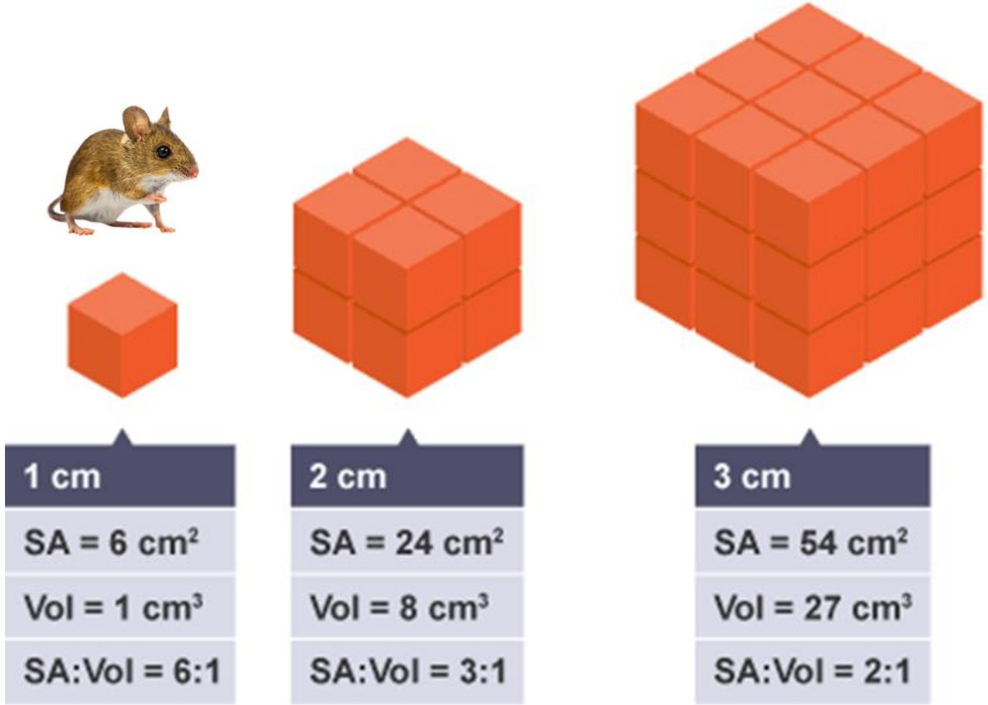
Surface to volume ratio



(Beever et al. 2017. Front. Ecol. Env.)

Posture

Shape



Size

Direct Effects

Direct effects on species

Lethal effects

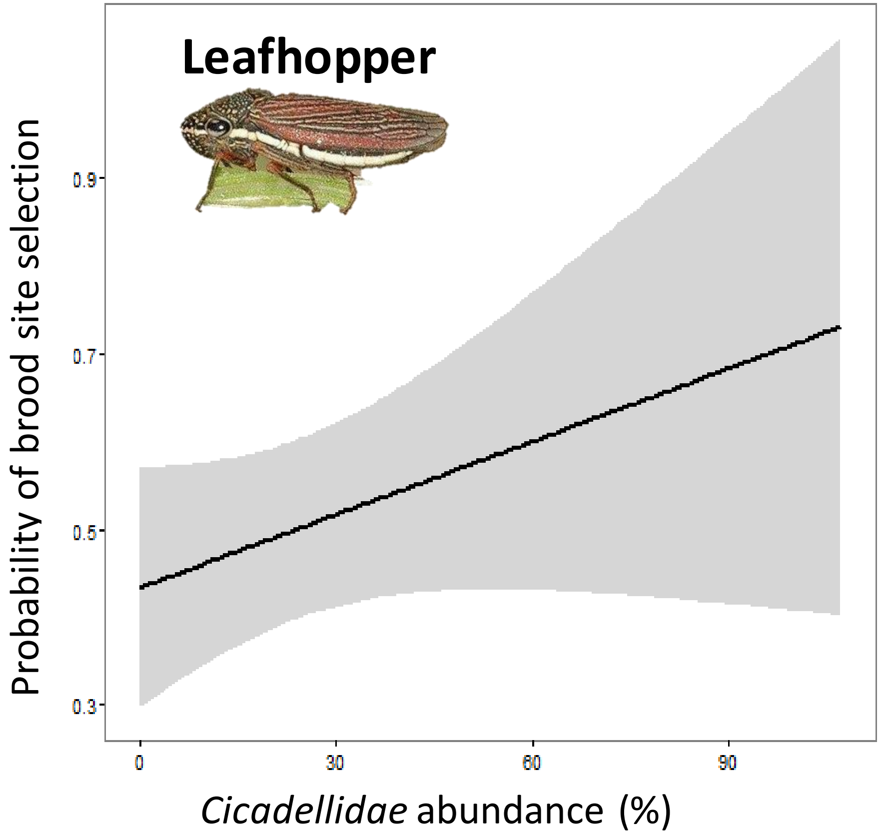
>23,000 spectacled flying foxes died in Nov. 2018 heat wave

Sub-lethal effects

- Impaired regulation of body temp & water balance
- Reduced energy intake -- growth, survival & reproduction
- Reproduction disruption -- hormone imbalances, abnormal gamete production, fetal growth & lactation
- Compromised immunocompetence -- parasite/pathogen resistance

White-tailed Ptarmigan

Brood Habitat Selection

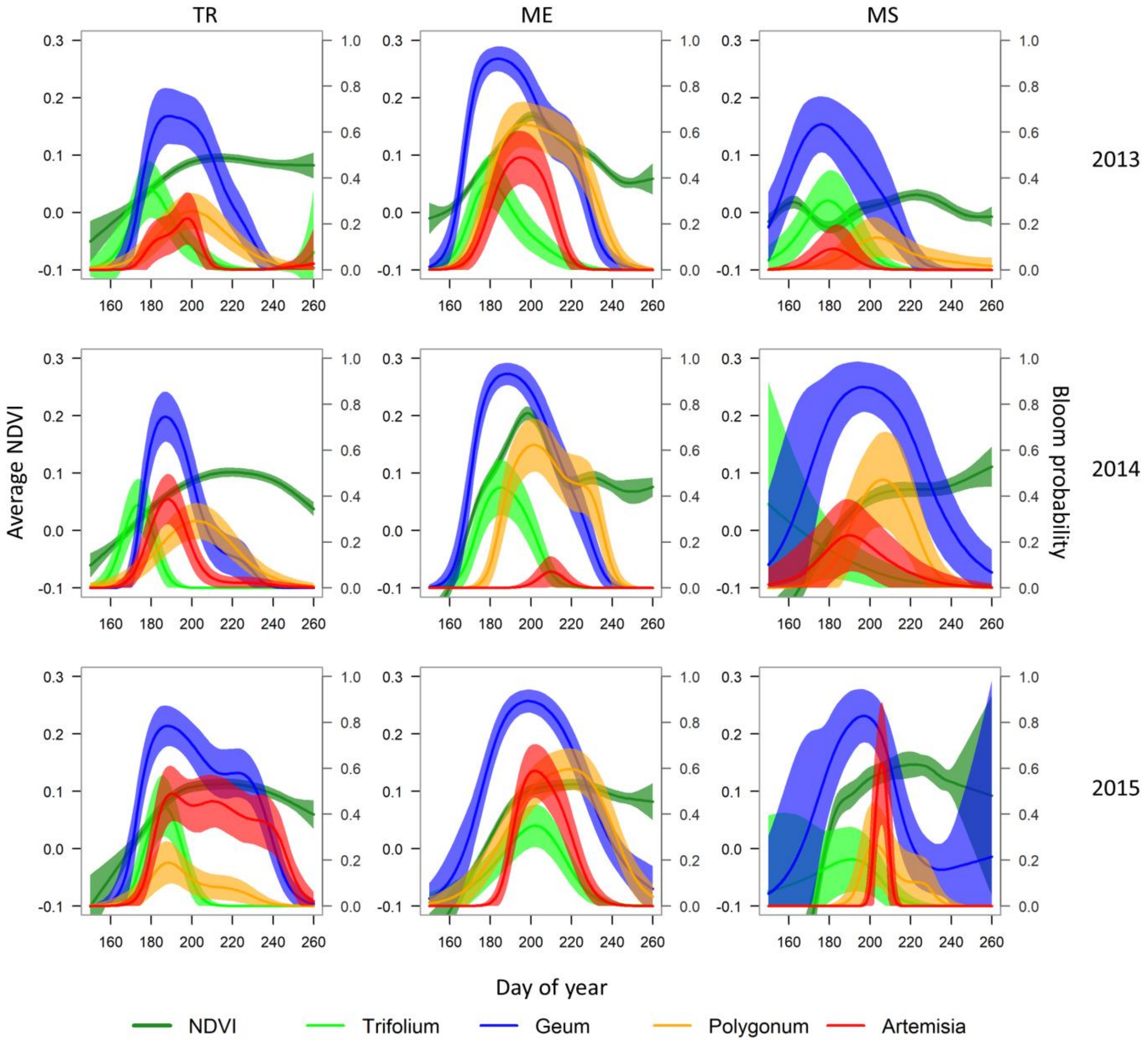


B. Dooling

Spear, Aldridge, Wann, and Braun. (2019). JWM.

Indirect Effects

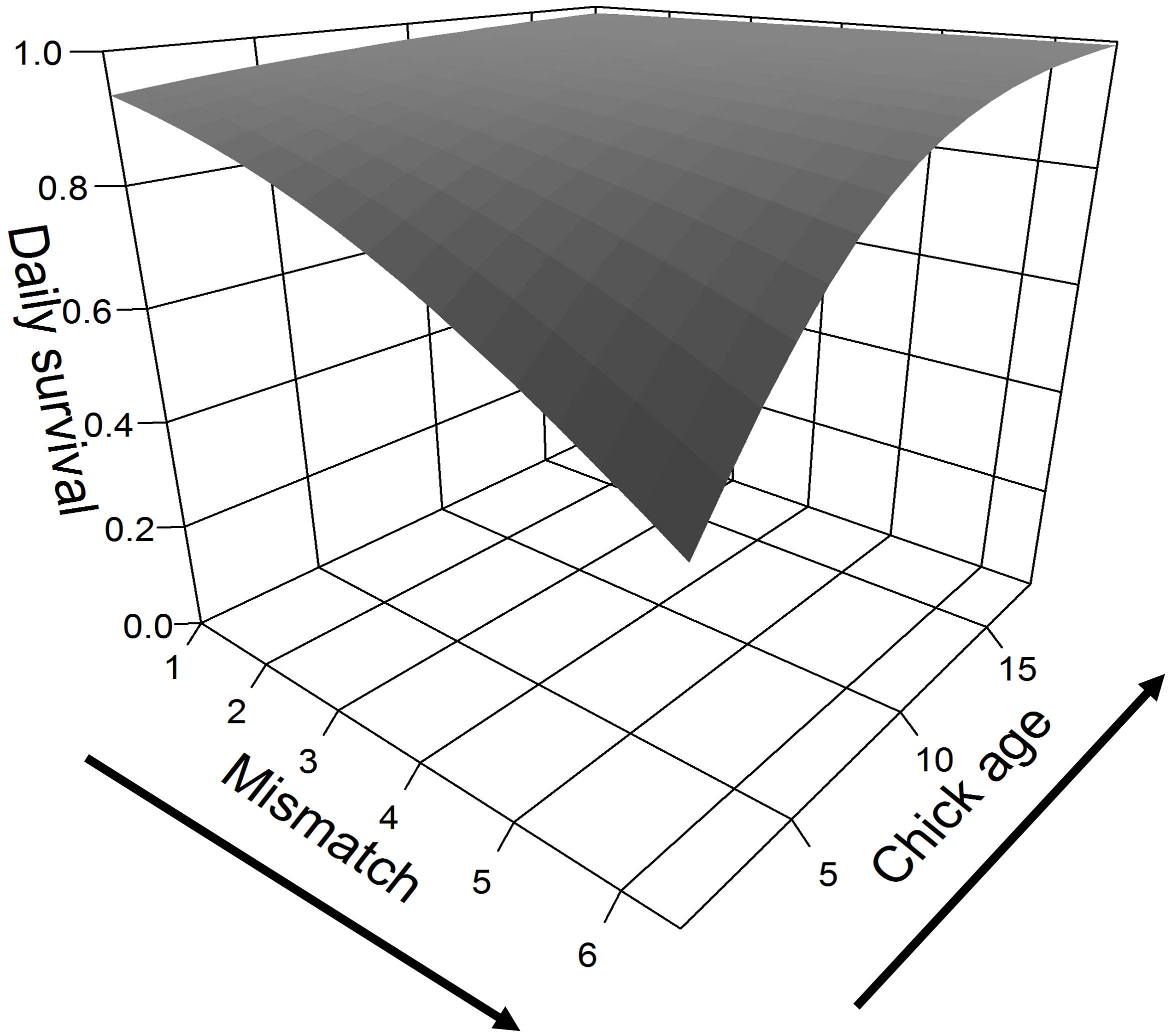
Vegetation Food Resource Phenology



Wann, Aldridge, Seglund, Oyler-McCance, Kondratieff, Braun. 2019. *Ecology and Evolution*.

USGS science for a changing world | University of Idaho

Mean of 15% lower chick survival/day at high mismatch

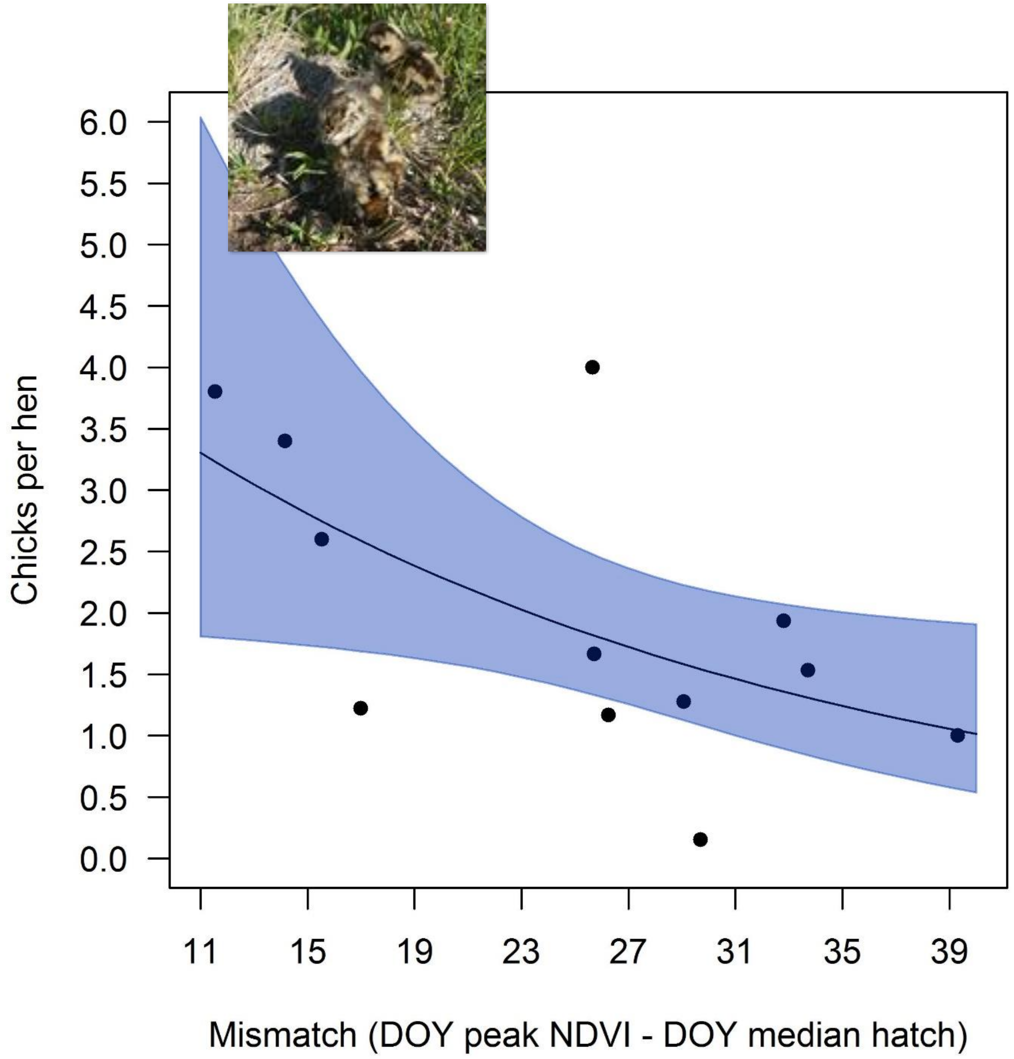


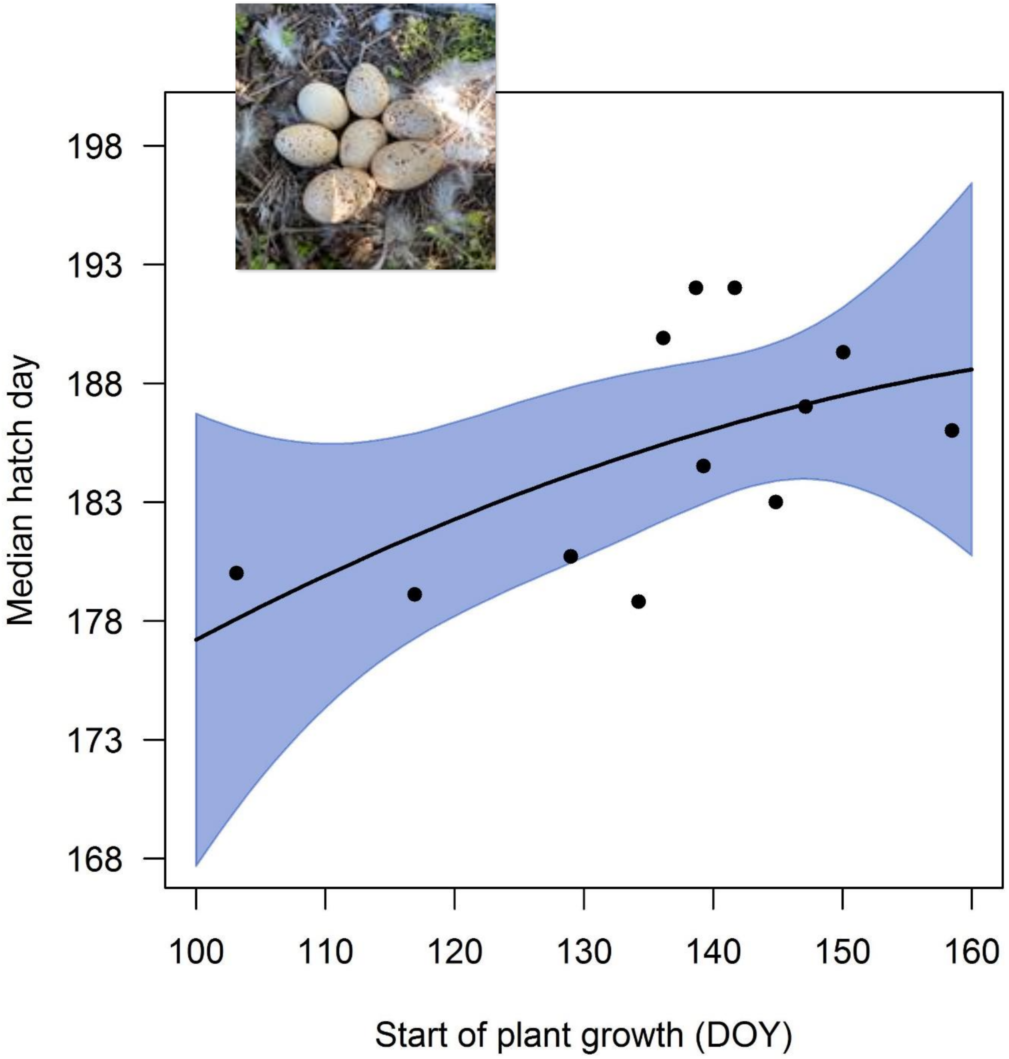
Wann, Aldridge, Seglund, Oyler-McCance, Kondratieff, Braun. 2019. *Ecology and Evolution*.

USGS science for a changing world University of Idaho

Phenological Mismatch = Reduction in Productivity

Indirect Effects





Wann, Aldridge, Seglund, Oyler-McCance, Kondratieff, Braun. 2019. *Ecology and Evolution*.

Pathways of Impacts

↑ Temperature ↔ Δ Hydrological cycle

- Declines in snowpack
- Greater proportion of winter rain
- Soil moisture reductions
- Decreases in streamflow
- Increasing frequency & severity of drought
- Increasing frequency & severity of wildfire

Direct effects

changes in the biotic & abiotic environment

Indirect effects

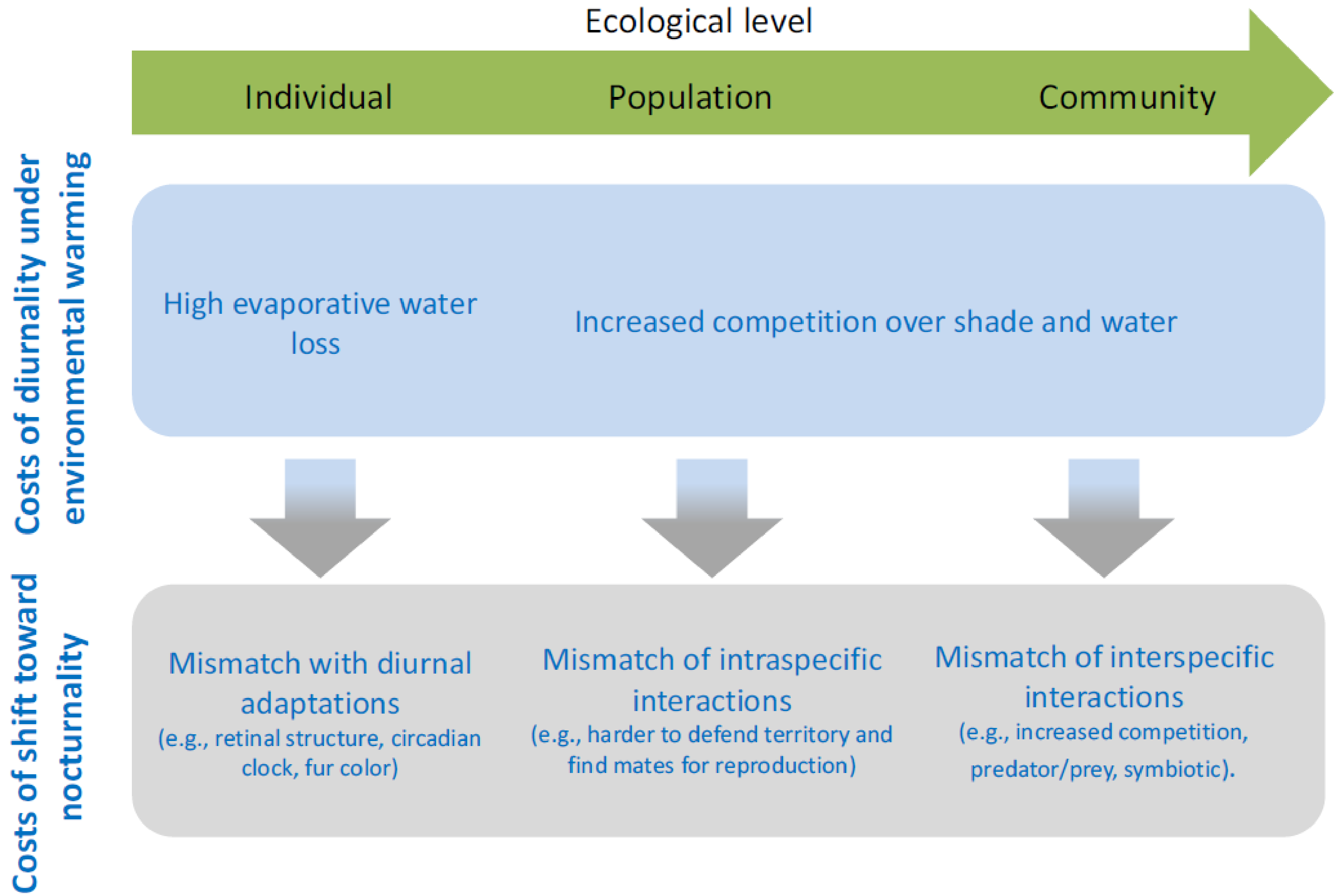
- Species interactions
- Community composition, structure, & function
- Food web dynamics
- Habitat quality & availability
- Quality & availability of food/water resources

Responses/Impacts:

- Distribution & abundance patterns
- Behavior
- Phenology
- Demography/survival
- Reproductive success
- Evolutionary potential/plasticity
- Immunity/health

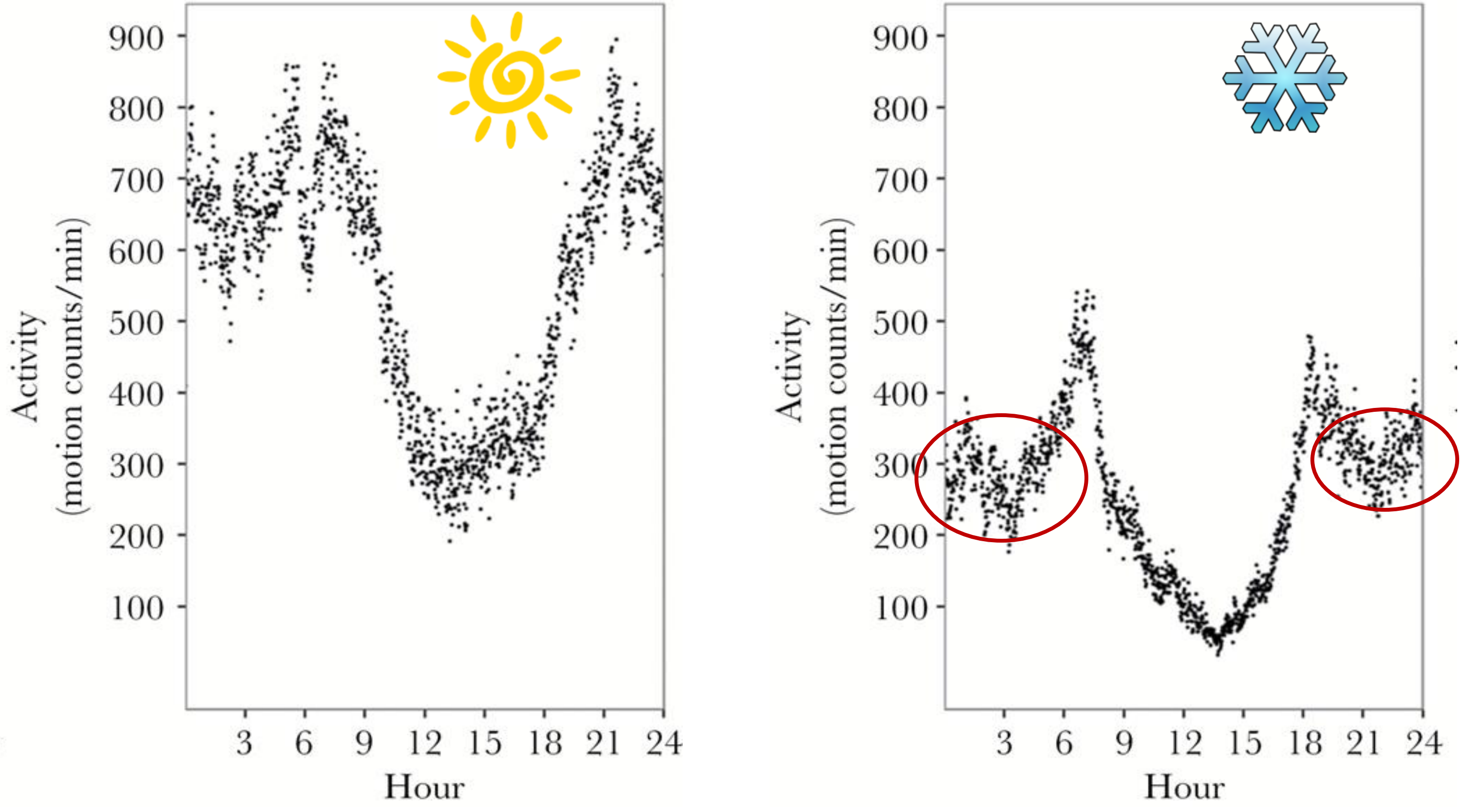
→ = degree of Adaptive Capacity

Key Response: Behavioral Changes



(Levy et al. 2019. Ecol. Monographs)

Key Response: Behavioral Changes



Day activity ~ sex + reproductive status

Night activity ~ temperature + moon phase + date

(Milling et al. 2018. Behav. Ecol.)

Key Response: Behavioral Changes

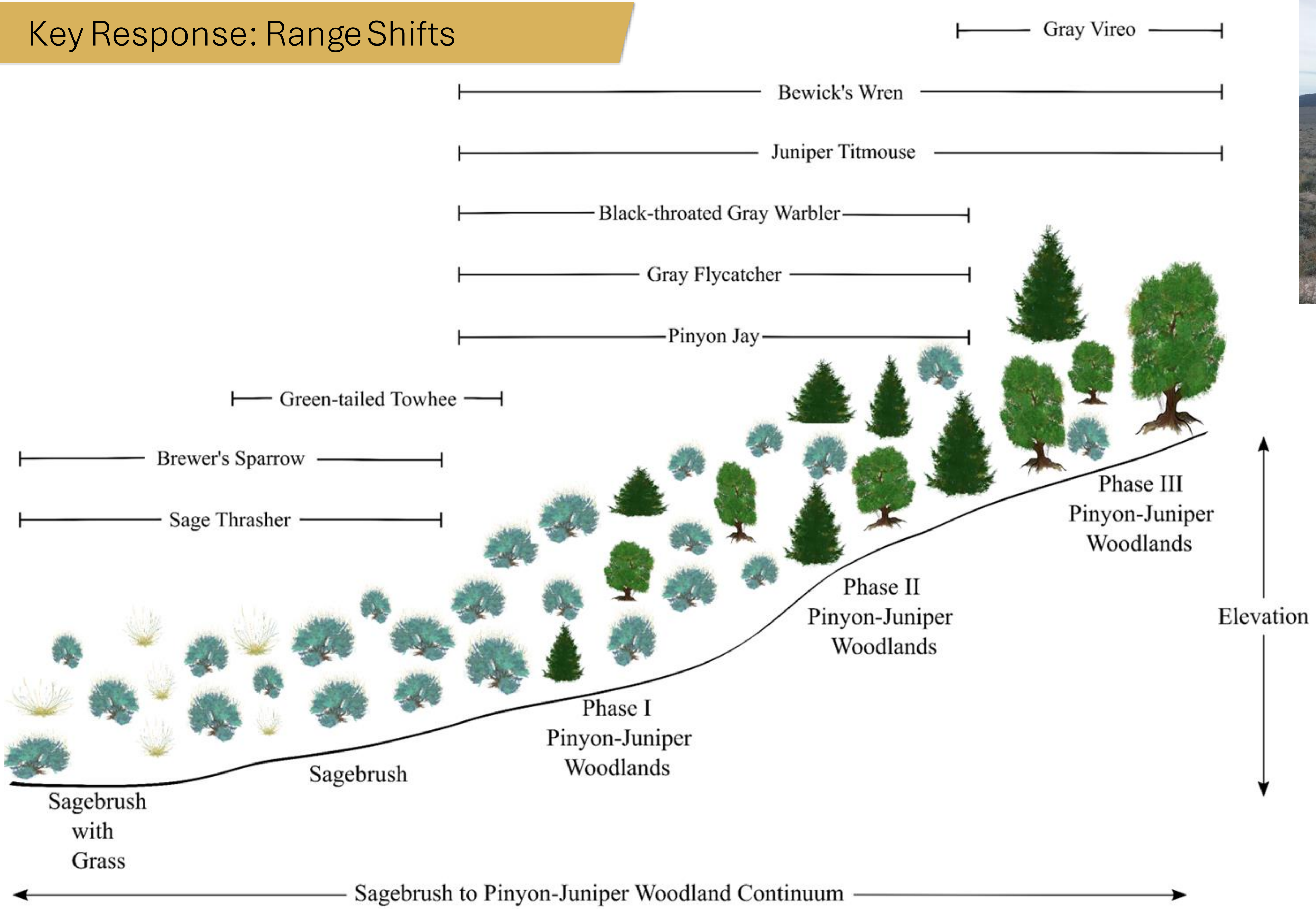
Use of thermal refugia

Arctic ground squirrels, north of the Arctic Circle in Alaska

- Forage until body temp > 39°C
- Enter burrow to shed heat
- Emerge & forage when cooled
- “Shuttling thermoregulation”

(Long et al. 2005. J. Mamm.)

Key Response: Range Shifts



Van Lanen, Monroe, & Aldridge (2023) Ecol & Evol

Van Lanen, Monroe, & Aldridge (2023) Biol Conserv

USGS science for a changing world

University of Idaho

White-tailed Ptarmigan

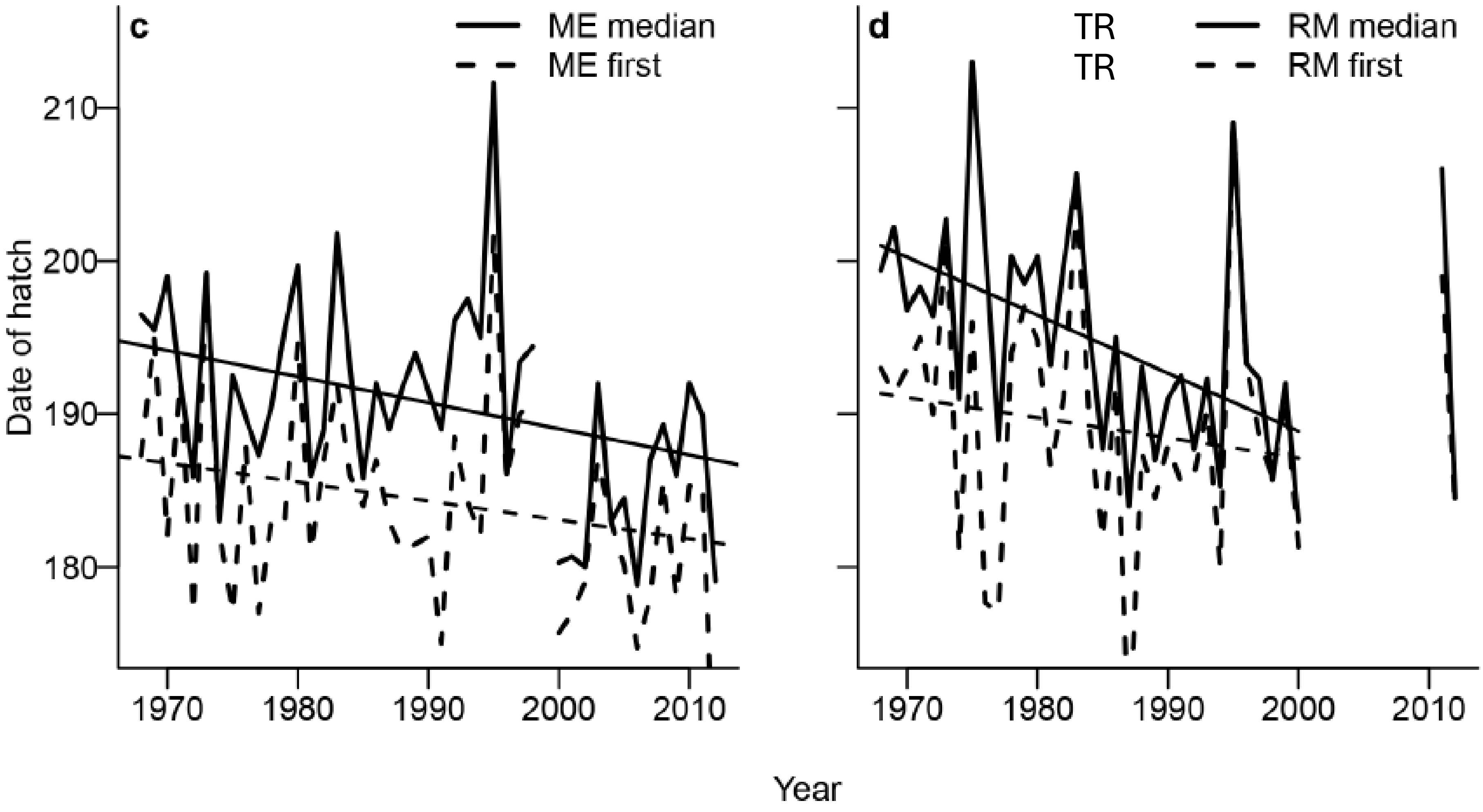
- Physiological stress at temps > 21 C (May 1975)
- Seek N slopes, permanent snow/ice fields
- With Climate Change, no longer permanent

Key Response: Phenology

White-tailed Ptarmigan

Mt. Bluesky: **1.9** days per decade

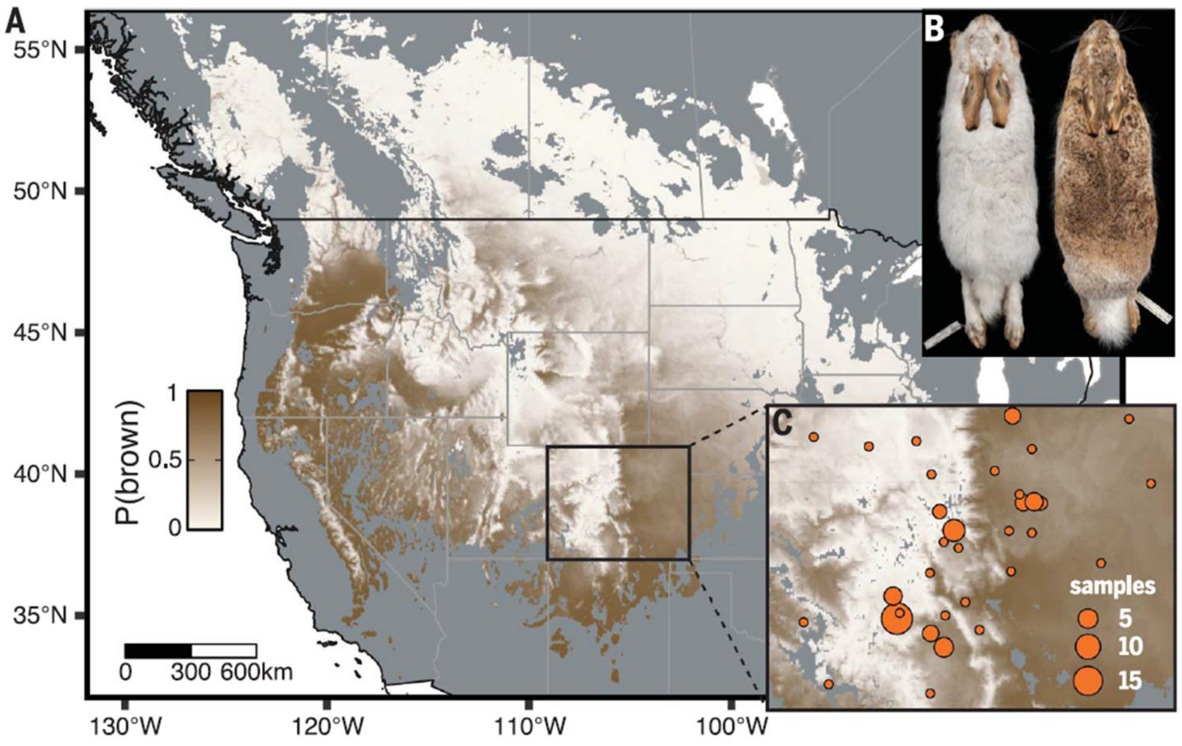
Trail Ridge: **3.7** days per decade



Wann, Aldridge, & Braun. (2016) PLOS ONE.

Key Response: Evolutionary adaptation

- WT jackrabbits have polymorphic winter coat colors
- 3 genes control
- Projected changes in snow likely lead to widespread mismatch
- Simulations suggest that populations can adapt rapidly



(Ferreira et al. 2023. Science)

Key Response: Species Interactions

Deer mice
(*Peromyscus maniculatus*)

neg (-)

Columbia Plateau pocket mice
(*Perognathus parvus*)

pos (+)

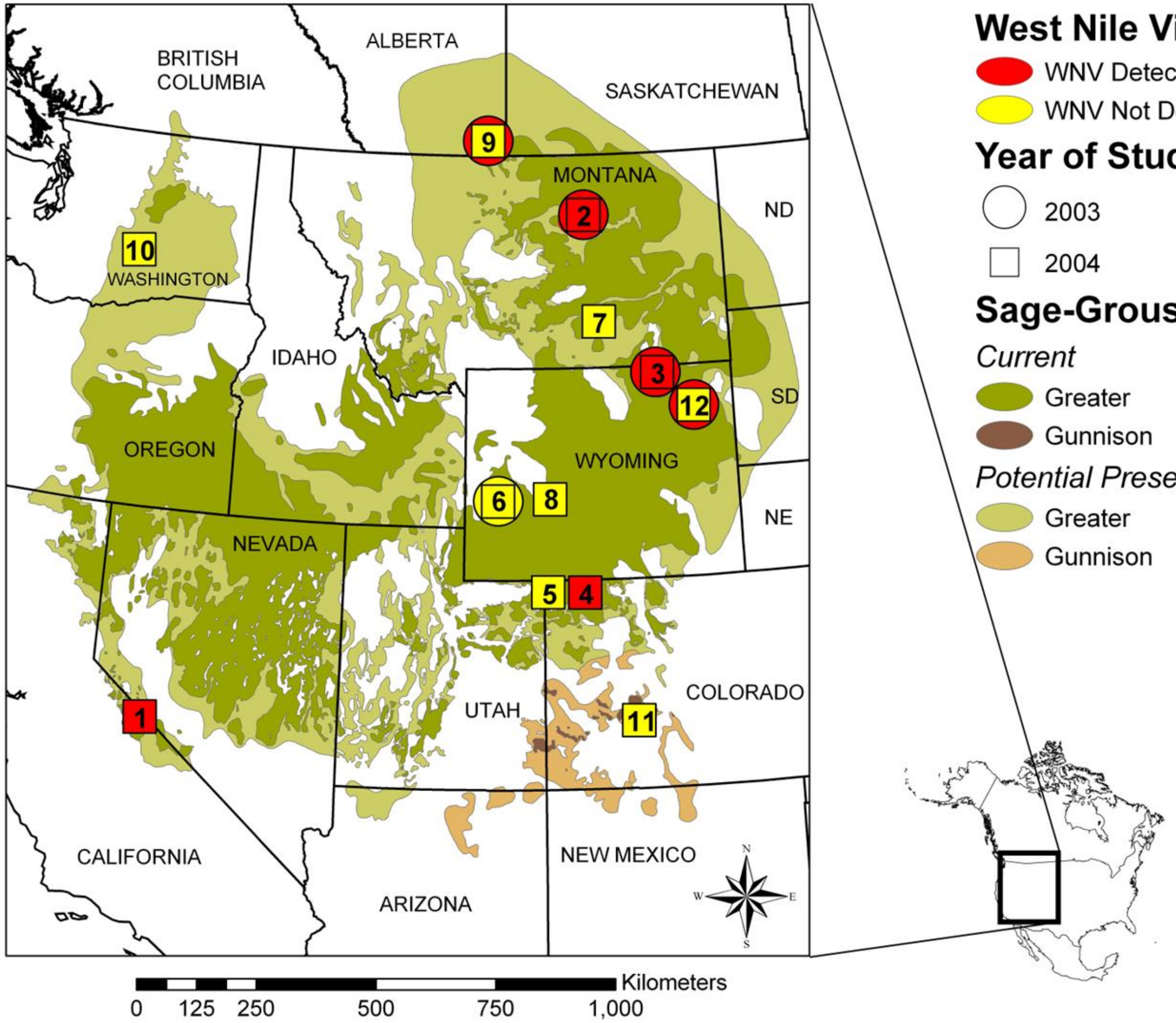
neg (-)

Brewer's sparrow
(*Spizella breweri*)

Young & Johnson (2024)
https://doi.org/10.1002/jwmg.22548

USGS science for a changing world | University of Idaho

Key Response: Disease Dynamics



Naugle, Aldridge, Walker, et al. 2004. West Nile virus: Pending crisis for Greater Sage-Grouse. *Ecology Letters*

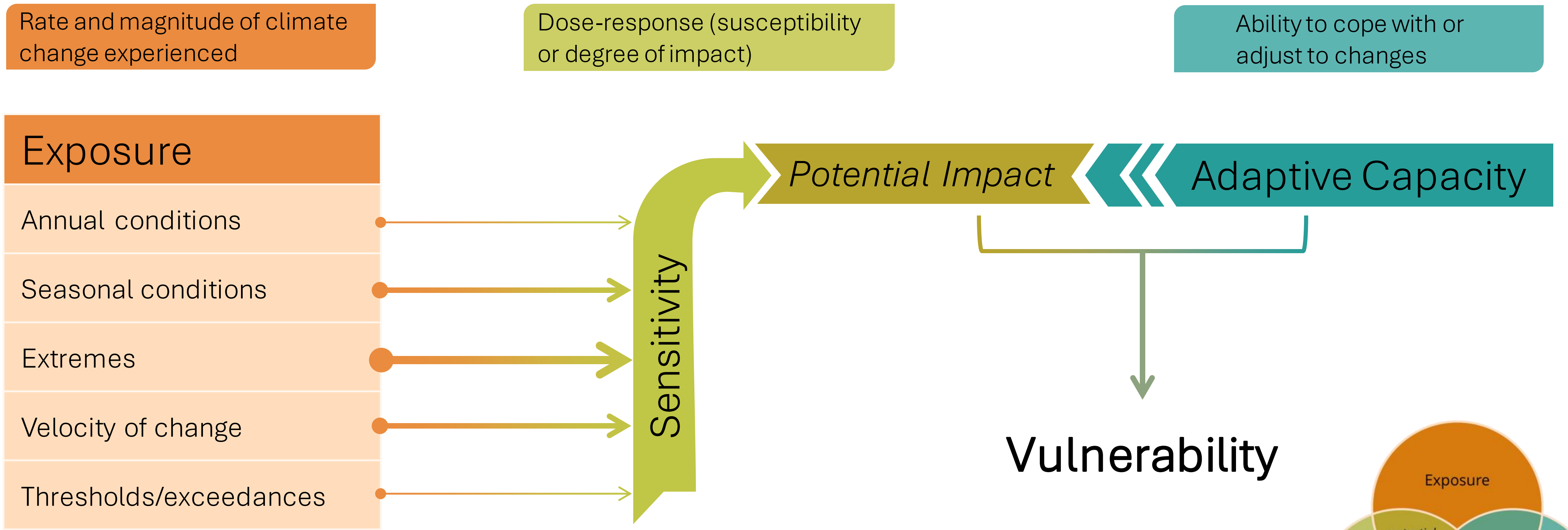
University of Idaho

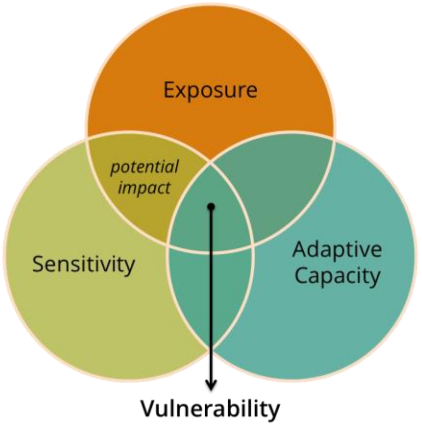

USFWS

Road Map

I. Overview: wildlife response to climate change
II. Measuring response through Vulnerability Assessments
III. Case studies

Climate Change Vulnerability





Adaptive Capacity

Intrinsic ability to accommodate climate change without significant genetic losses, large range contractions or extinction, or intensive management intervention.

Depends on:

- phenotypic plasticity, evolutionary potential
- dispersal and colonization abilities
- life-history traits

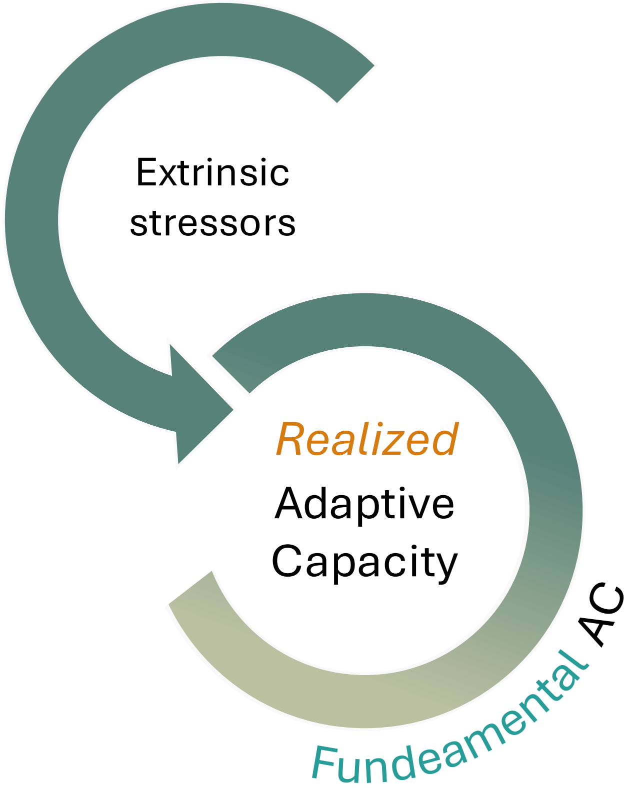
Fundamental Adaptive Capacity

Improving conservation outcomes with a new paradigm for understanding species adaptive capacity.
Beever et al (2016) *Conserv Lett*
https://doi.org/10.1111/conl.12190

Adaptive Capacity

Reflects extrinsic factors that affect or constrain the species' fundamental AC

Anthropogenic stressors are more likely to *limit* the full expression of the fundamental AC than enhance

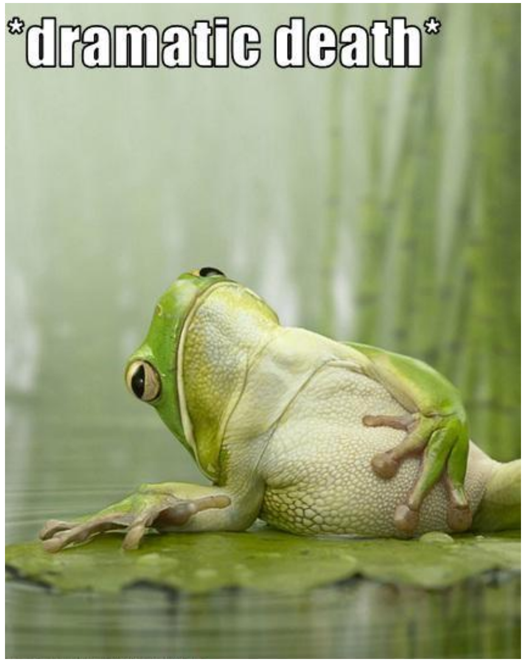


Improving conservation outcomes with a new paradigm for understanding species adaptive capacity.
Beever et al (2016) *Conserv Lett*
https://doi.org/10.1111/conl.12190

Adaptive Capacity

I. Meshcheryakovova

S. McMillan



ICanHasCheezburger.com

Persist in place
(adapt *in situ* /acclimate)

Shift in space
(move to track suitable climate)

Perish
(local/rangewide extinction)

Persist in place or shift in space? Evaluating the adaptive capacity of species to climate change.
Thurman et al (2020) *FrEE*
https://doi.org/10.1002/fee.2253

Adaptive Capacity

Species' attributes that may confer *greater* adaptive capacity

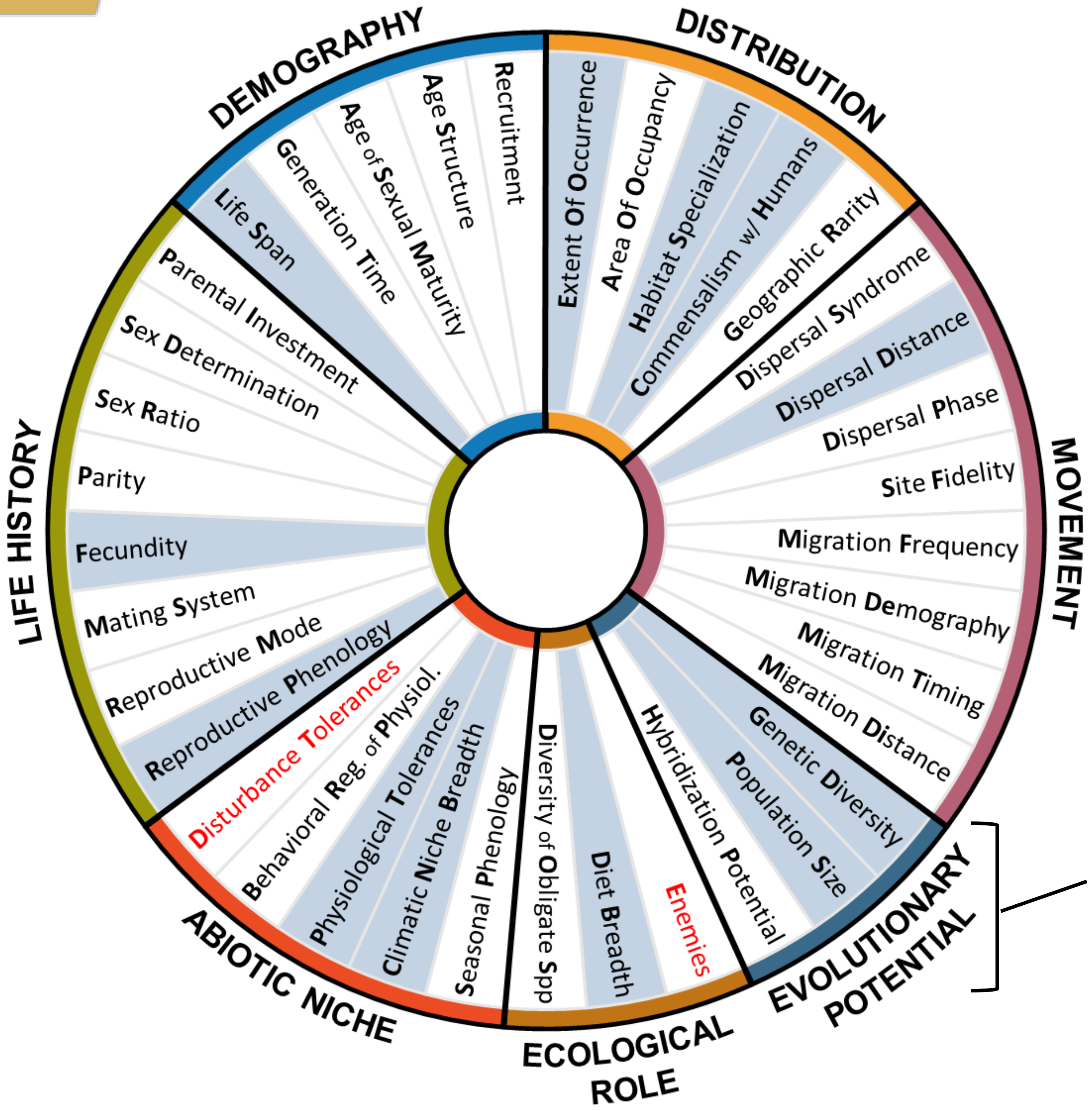
- Shorter generation time
- Higher fecundity
- Greater genetic diversity
- Ecological "generalists"
- Greater dispersal capacity
- Broad spatial distribution
- Populations where climatic changes are of intermediate magnitude

M. Thompson

Nicotra et al (2015) https://doi.org/10.1111/cobi.12522

Adaptive Capacity

- 37 attributes (2 new!)
- 7 complexes (groups)
- 12 core attributes

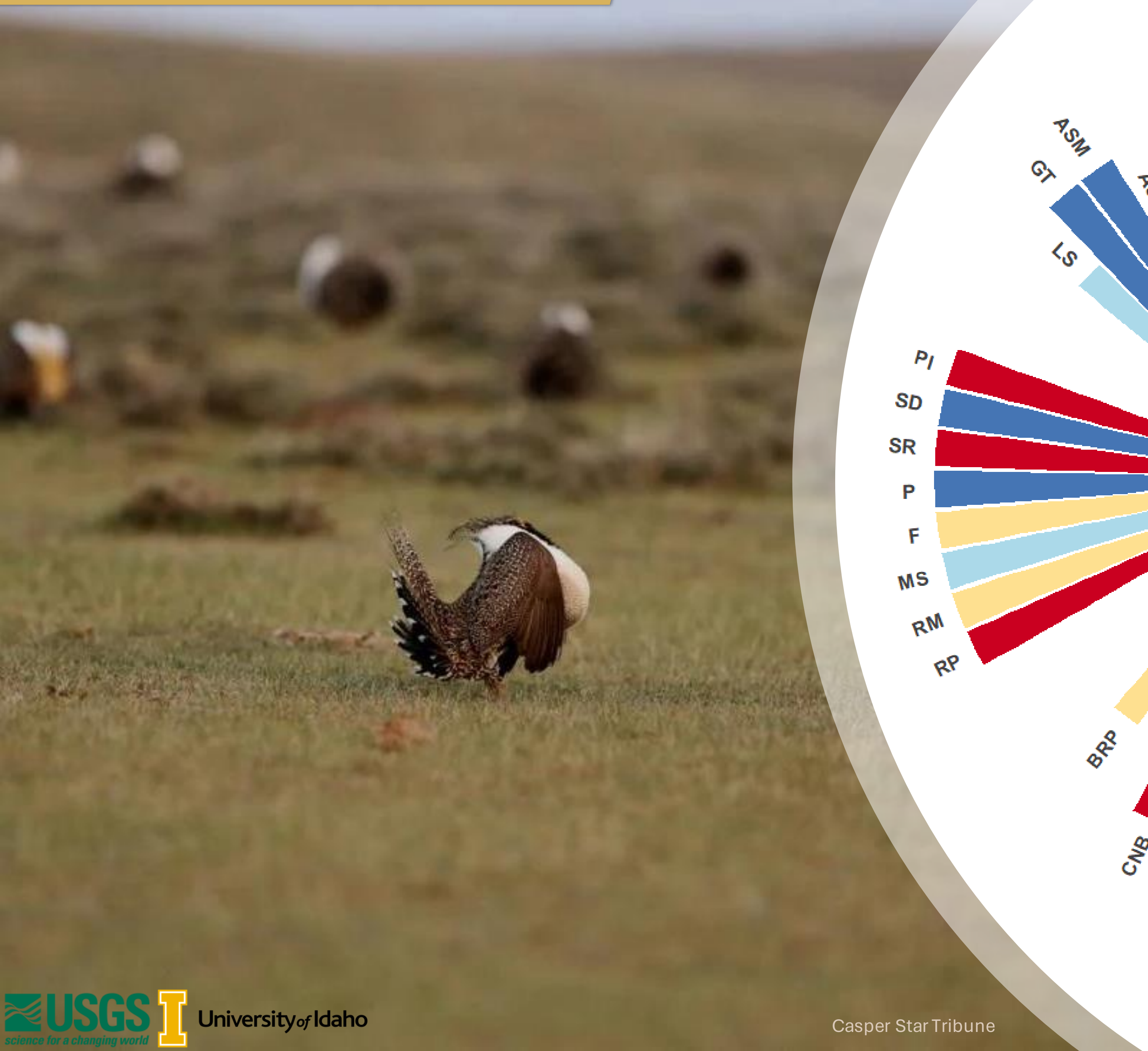


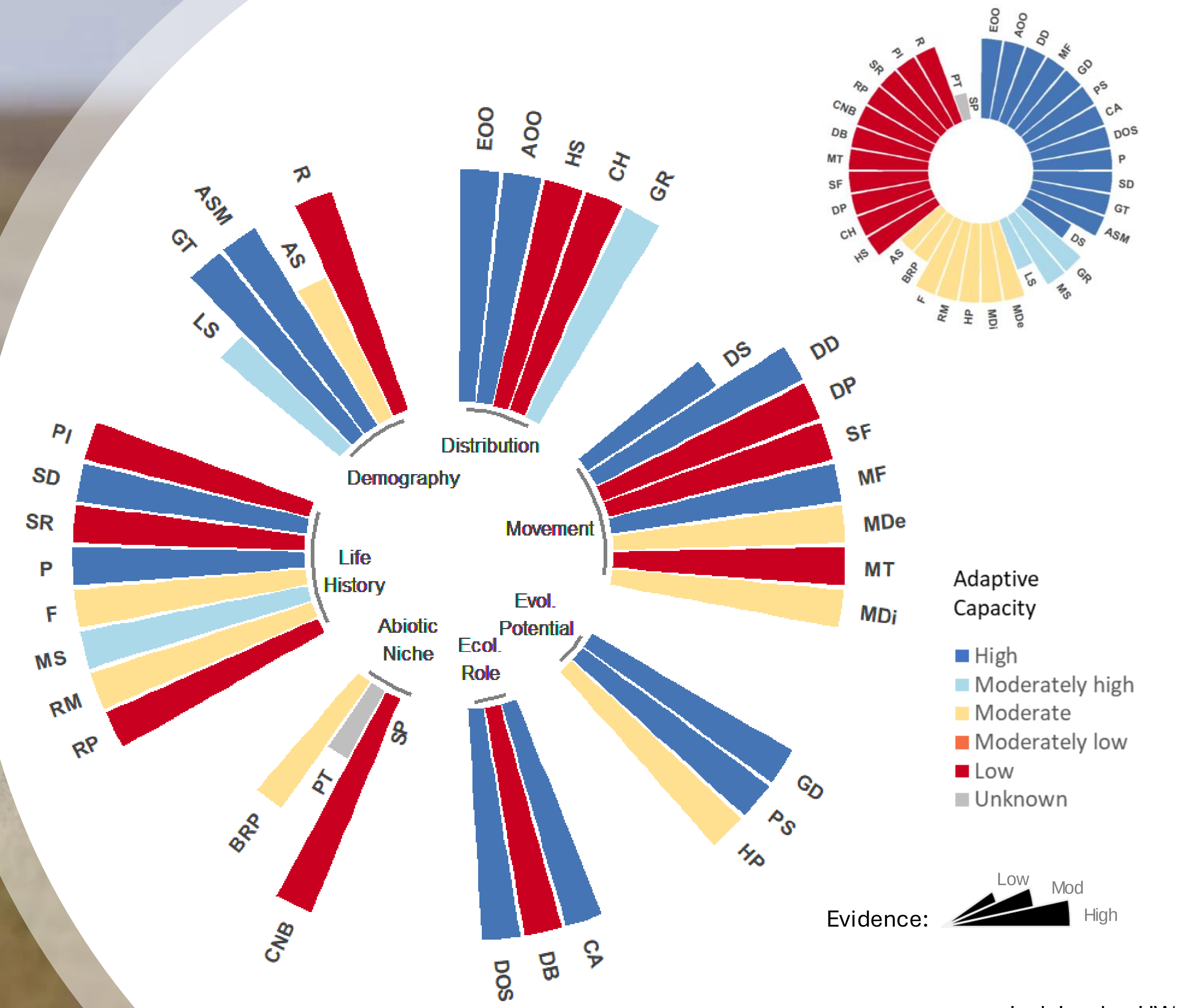
Connecting research and practice to enhance the evolutionary potential of species under climate change. Thompson et al (2023) *Conserv Sci Prac* https://doi.org/10.1111/csp2.12855

Thurman et al (2020) https://doi.org/10.1002/fee.2253

USGS science for a changing world · University of Idaho

Adaptive Capacity

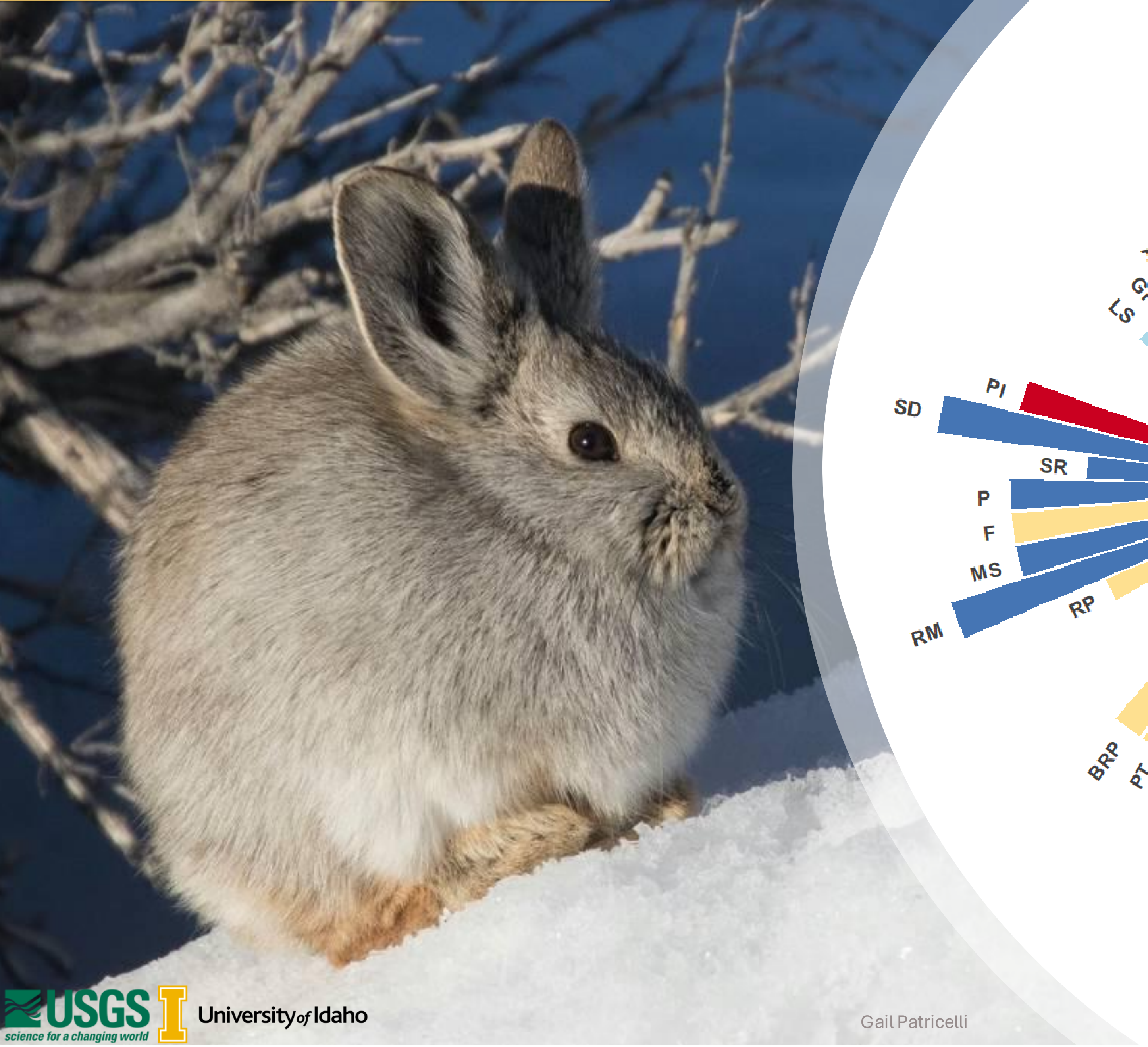




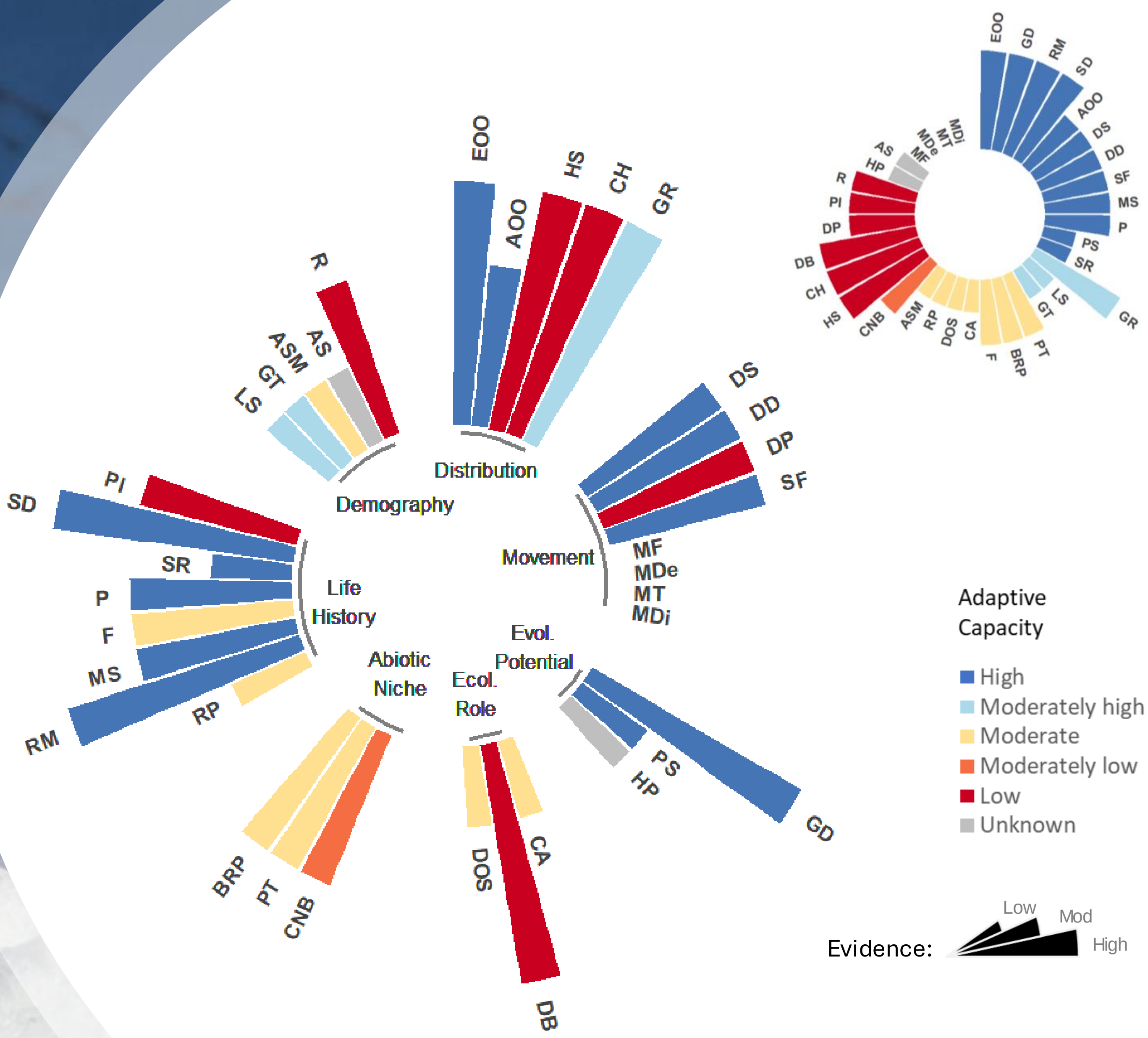
Josh Lawler, UW
Julie Heinrichs, CSU
Lindsey Thurman, USGS

Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Adaptive Capacity



Gail Patricelli

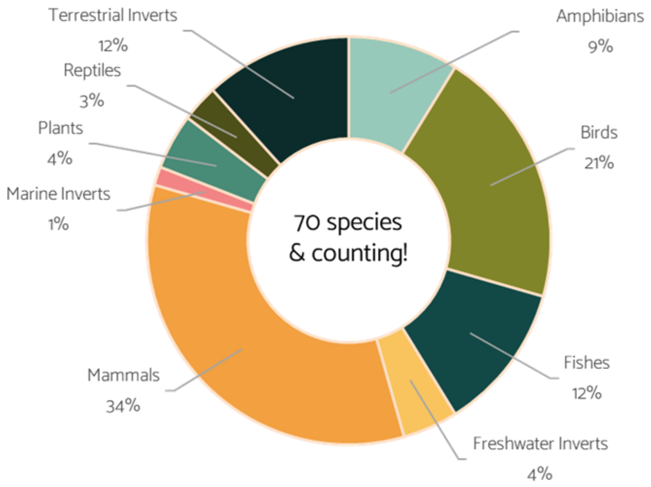


Fiona McKibben, U Idaho
Janet Rachlow, U Idaho

Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Adaptive Capacity

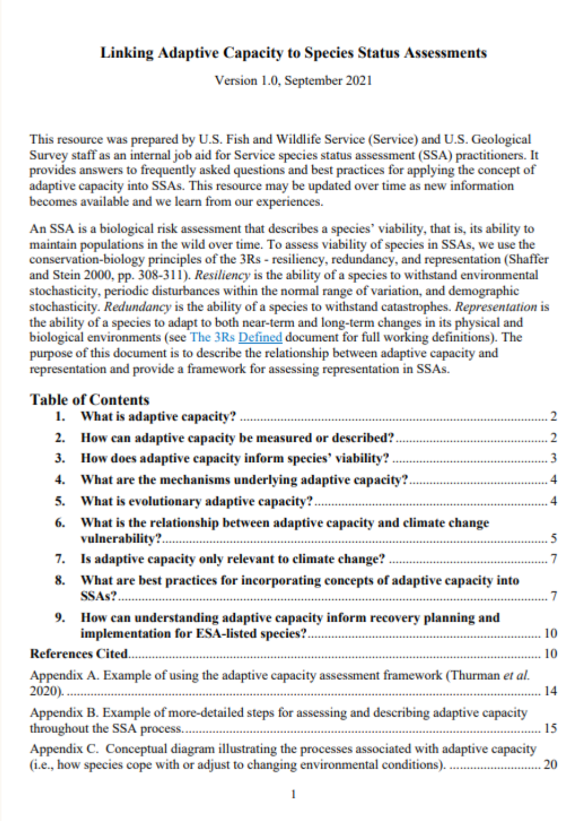
AC Quick Reference Guide & Resources
https://tinyurl.com/AC-how-to



500+ more species planned by 2025

USGS science for a changing world
University of Idaho

Adaptive Capacity



Linking Adaptive Capacity to Species Status Assessments

Version 1.0, September 2021

This resource was prepared by U.S. Fish and Wildlife Service (Service) and U.S. Geological Survey staff as an internal job aid for Service species status assessment (SSA) practitioners. It provides answers to frequently asked questions and best practices for applying the concept of adaptive capacity into SSAs. This resource may be updated over time as new information becomes available and we learn from our experiences.

An SSA is a biological risk assessment that describes a species' viability, that is, its ability to maintain populations in the wild over time. To assess viability of species in SSAs, we use the conservation-biology principles of the 3Rs - resiliency, redundancy, and representation (Shaffer and Stein 2000, pp. 308-311). *Resiliency* is the ability of a species to withstand environmental stochasticity, periodic disturbances within the normal range of variation, and demographic stochasticity. *Redundancy* is the ability of a species to withstand catastrophes. *Representation* is the ability of a species to adapt to both near-term and long-term changes in its physical and biological environments (see The 3Rs Defined document for full working definitions). The purpose of this document is to describe the relationship between adaptive capacity and representation and provide a framework for assessing representation in SSAs.

Table of Contents

1

Developing a next-generation Climate Change Vulnerability Index in support of climate-informed natural-resource management

CLIMATE CHANGE IS IMPACTING OUR NATION'S PLANTS and animals in numerous ways. The biologists at state fish and wildlife agencies who are charged with managing public lands need to know how climate change threatens which species so they can take countermeasures to prevent declines.

A new collaboration between NatureServe and the USGS Climate Adaptation Science Centers will modernize the Climate Change Vulnerability Index (CCVI), one of the most popular tools for assessing species vulnerability to climate change, for a new generation of natural resource managers. With its new release, the CCVI will make leading-edge climate science even easier for practitioners to leverage while providing important information for prioritizing and planning conservation.

Since the last version of the CCVI was released in 2015, there have been numerous advances in both our understanding of how climate affects wildlife and the technology for developing user-friendly tools. In this project, researchers and software programmers at NatureServe will work in collaboration with CASC scientists to develop a revised version of the Index. The new version will feature:

- A web-hosted platform that facilitates collaboration among users
- New metrics for how species can adapt to or cope with climate change
- The latest downscaled climate exposure data for across the United States

This new release is especially timely as it will be available in time for state biologists to use it for revisions to their State Wildlife Action Plans (SWAPs), federally mandated conservation plans, that are due in 2025. The work will also include further usability testing and refinements in collaboration with CCVI end-users.

Phase 1 (targeted completion: Q2 2024)

The first phase will improve the functionality and robustness of the tool in a relatively short timeline to support its usage in ongoing and planned 2025 SWAP revisions. It will focus on strategic updates to address previously identified requests for improvements from stakeholders: the creation of the web-based platform, more recent climate data, and new adaptive capacity factors.

Phase 2 (targeted completion: Q2 2025)

The second phase will collaboratively explore, pilot, and test ongoing improvements to the CCVI algorithm, working directly with state and other end-user partners to refine the tool for the greatest benefit. Improvements may include expanded uncertainty metrics, statistical sensitivity analyses, and the inclusion of additional climate exposure variables and scenarios planning features.

Opportunities for Involvement

If you would like to be considered for a participatory role in the project, please email the project contacts. There are two options for participation:

User Group

Receives notifications about new features and products as they are released

Technical Advisory Group

Meets regularly to advise on, and ground-test, new features of the CCVI

Contact

USGS
Dr. Lindsey Thurman
lthurman@usgs.gov

Dr. Marta Lyons
mlyons@usgs.gov

NatureServe
Dr. Bruce Young
bruce_young@natureserve.org

Collaborators

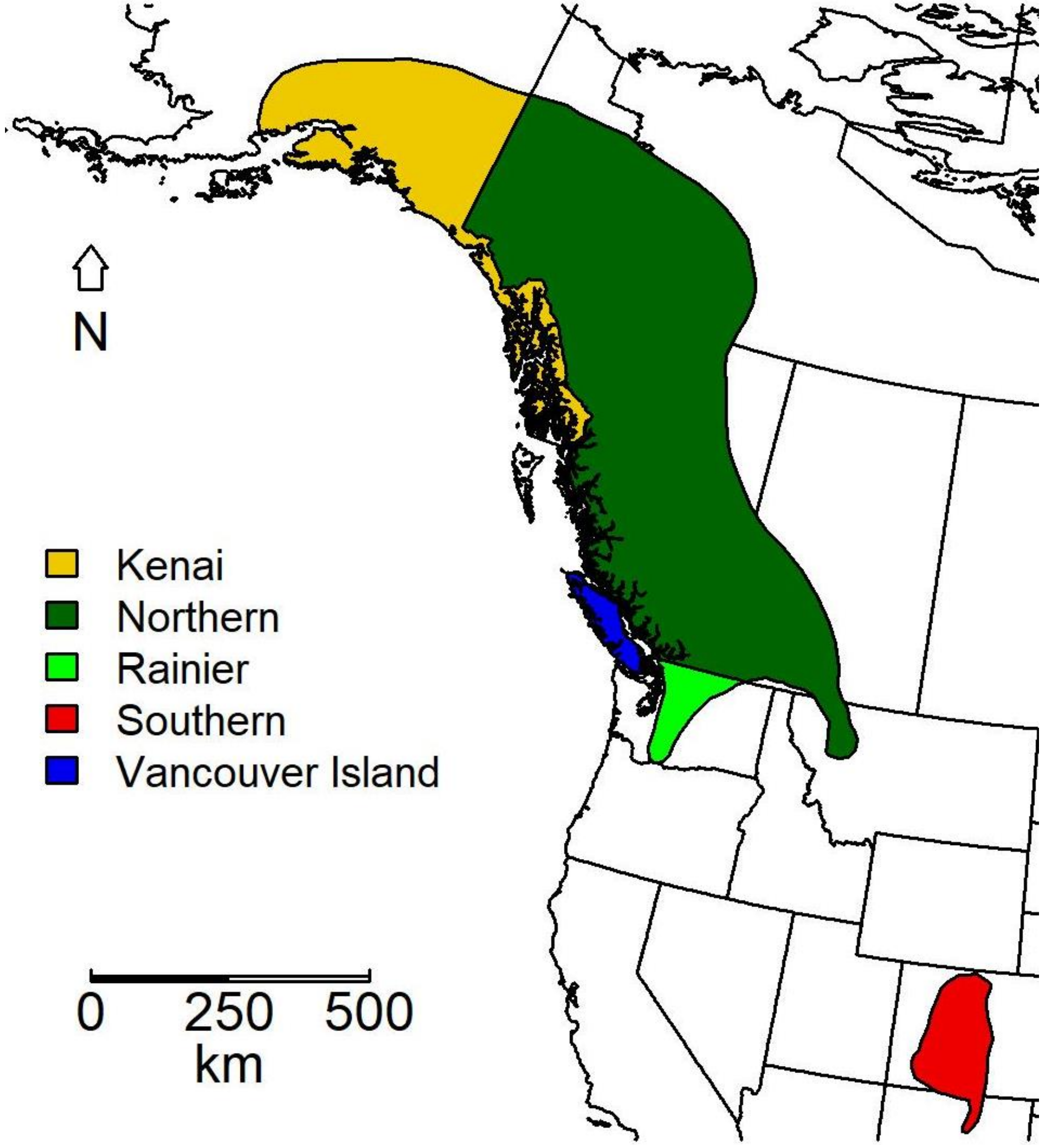
Southwest Climate Adaptation Science Center
SOUTHEAST Climate Adaptation Science Center
NECASC
MIDWEST Climate Adaptation Science Center
North Central Climate Adaptation Science Center
NORTHWEST Climate Adaptation Science Center
SOUTH CENTRAL CLIMATE ADAPTATION SCIENCE CENTER

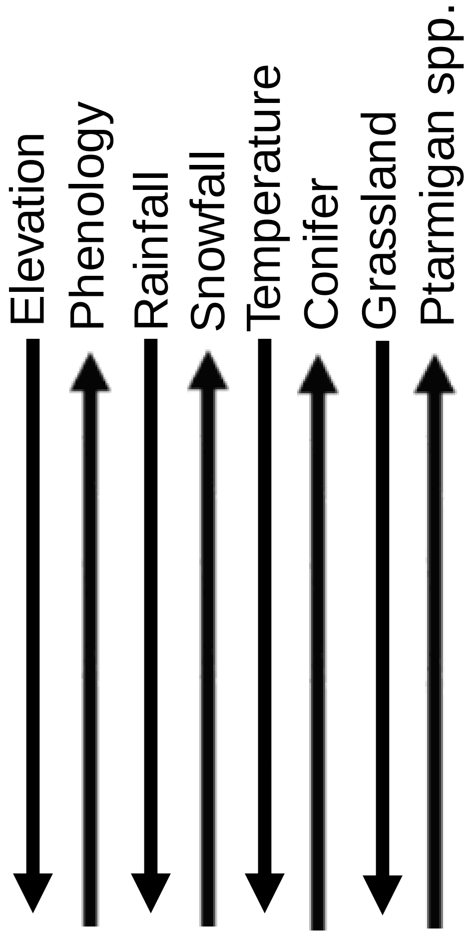
Climate Science for SSAs
and ES Decision-Making

Linking AC to SSAs 20210716.docx

USGS science for a changing world | University of Idaho

White-tailed Ptarmigan

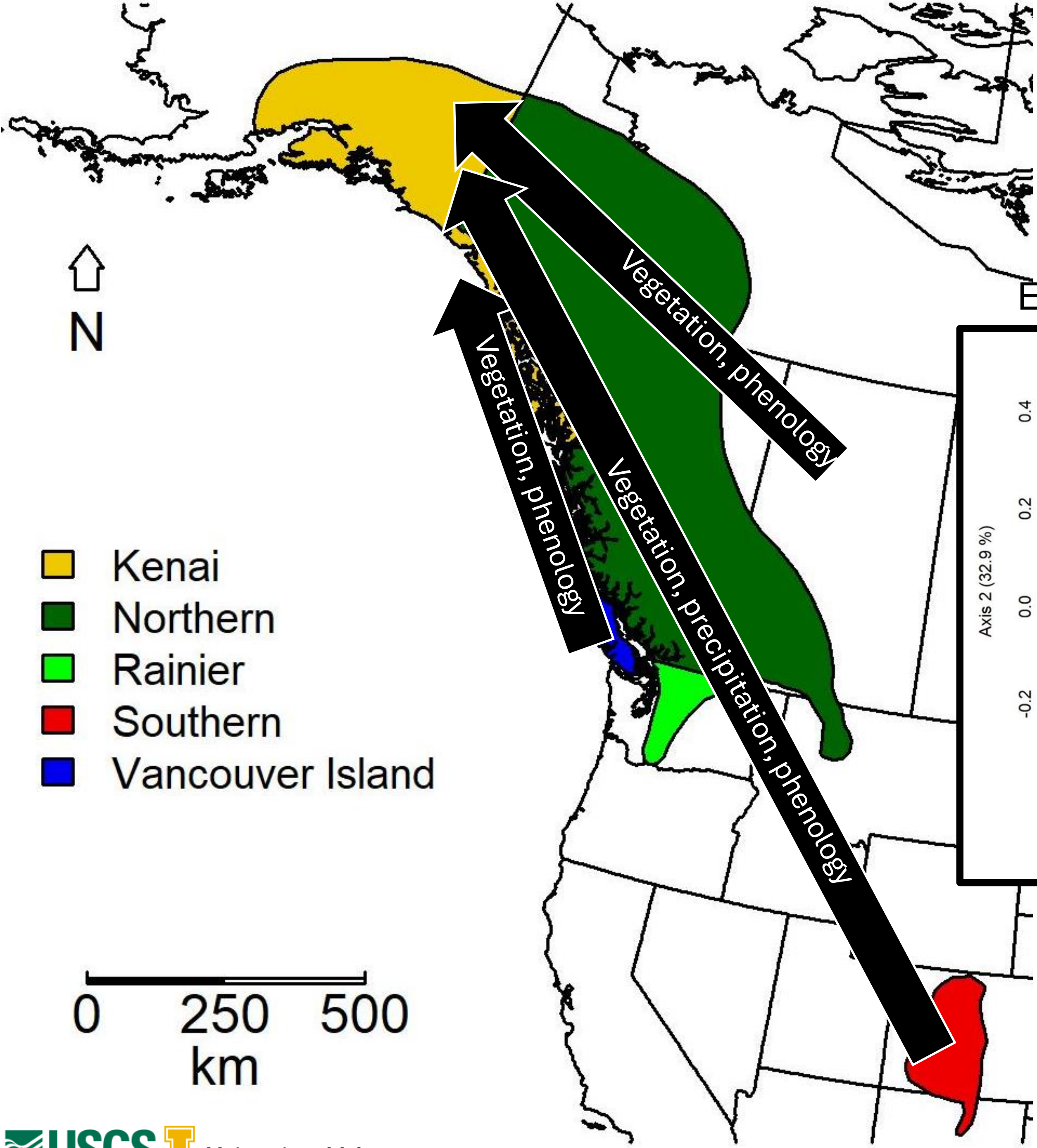




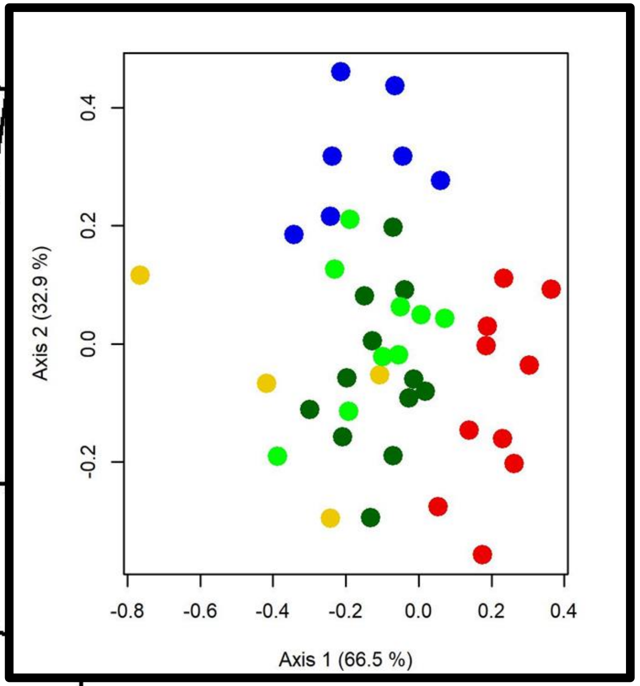
Keith Williams

Zimmerman et al. (2021). Heredity 126: 117-131

White-tailed Ptarmigan



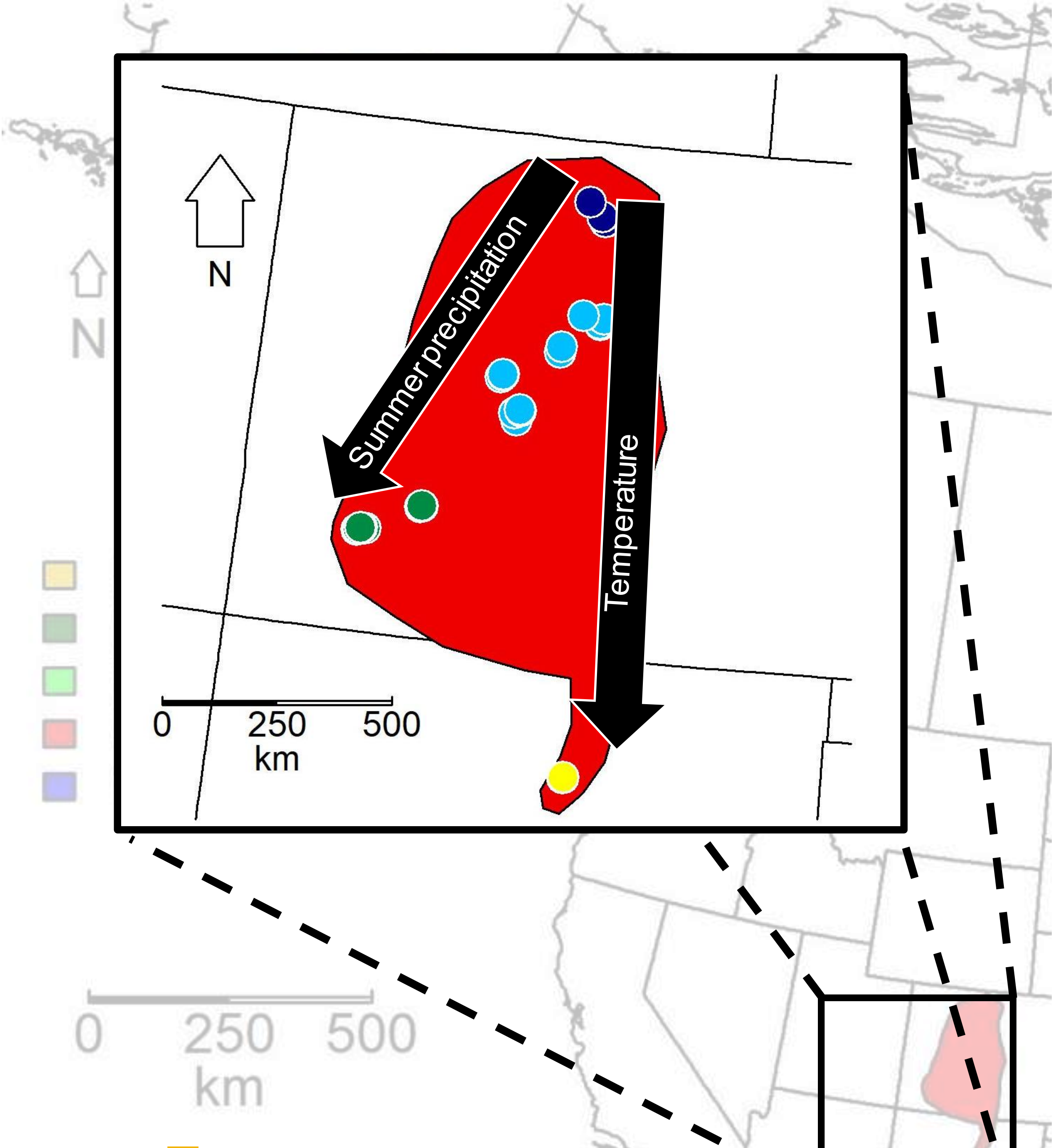
EGF-domain Divergence



Keith Williams

Zimmerman et al. (2021). Heredity 126: 117-131

USGS science for a changing world University of Idaho



White-tailed Ptarmigan

Keith Williams

- Temperature and precipitation associated divergence.

Zimmerman et al. (2021). Heredity 126: 117-131

Vulnerability Assessment: How-To

Correlative

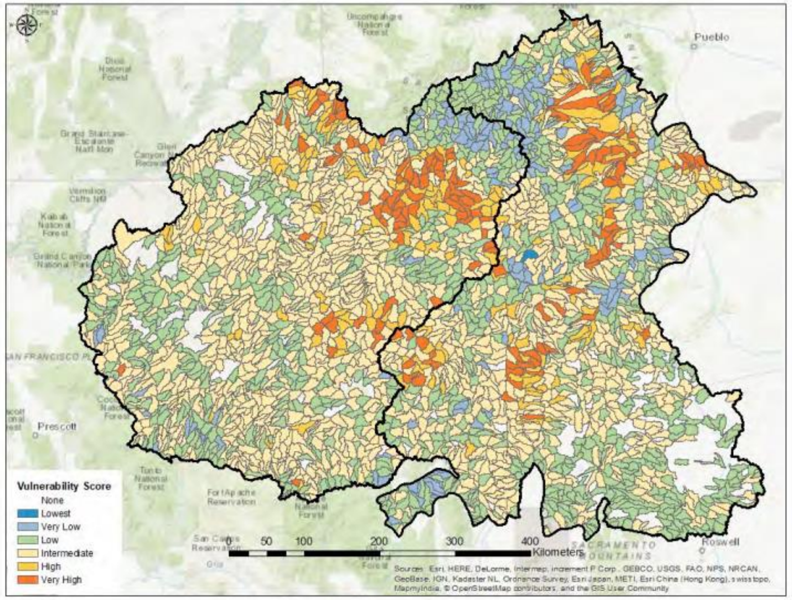


Fig. 12 in Williams & Friggens (2017)

Mechanistic

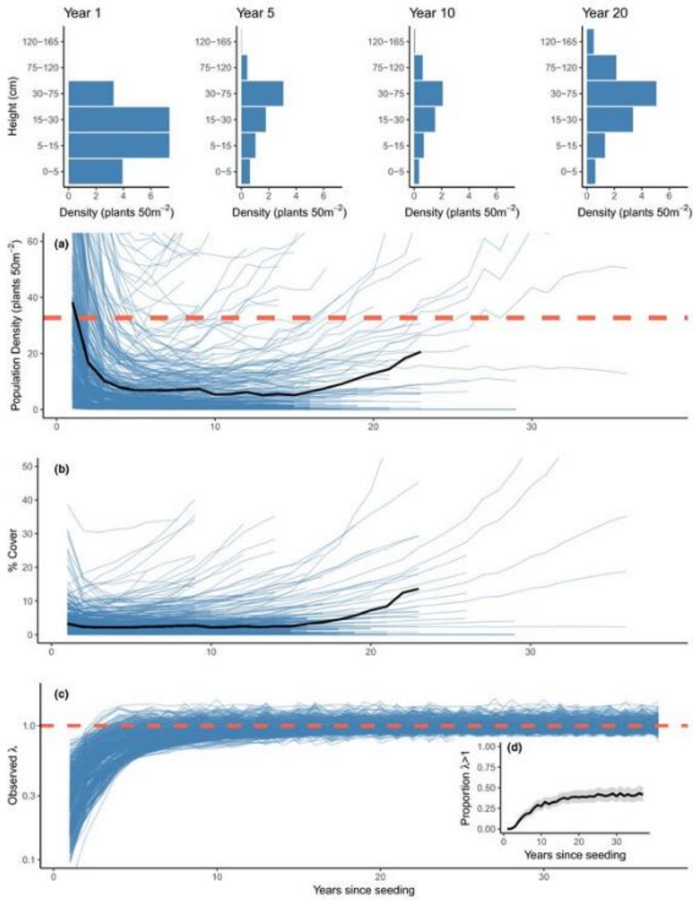
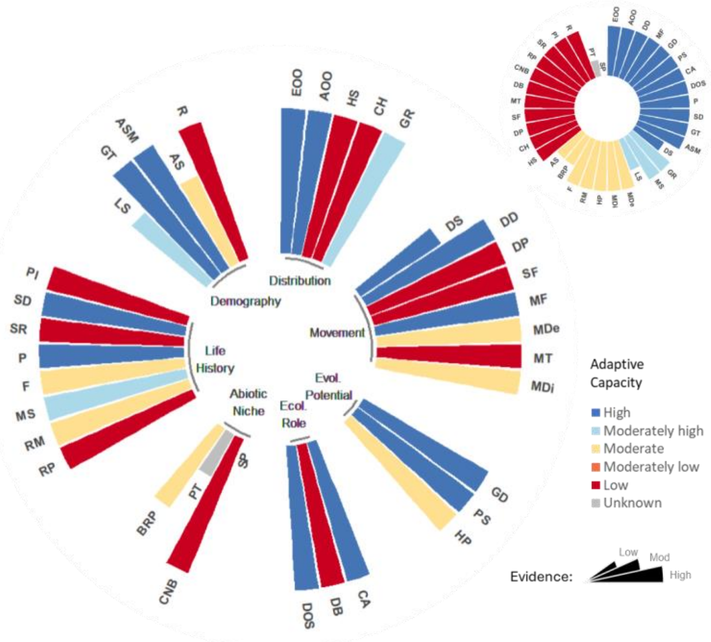
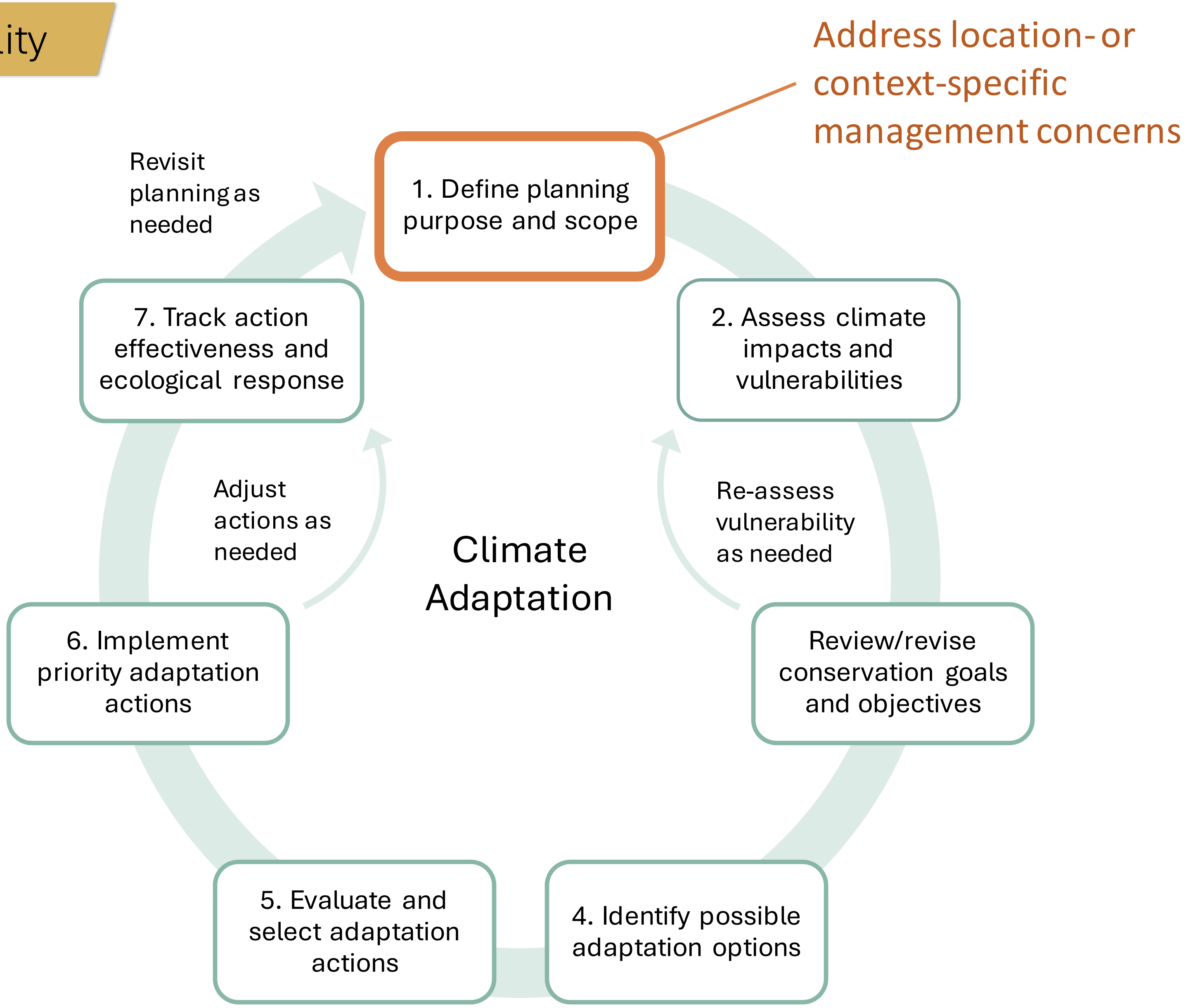


Fig. 3 in Shriver et al (2019)

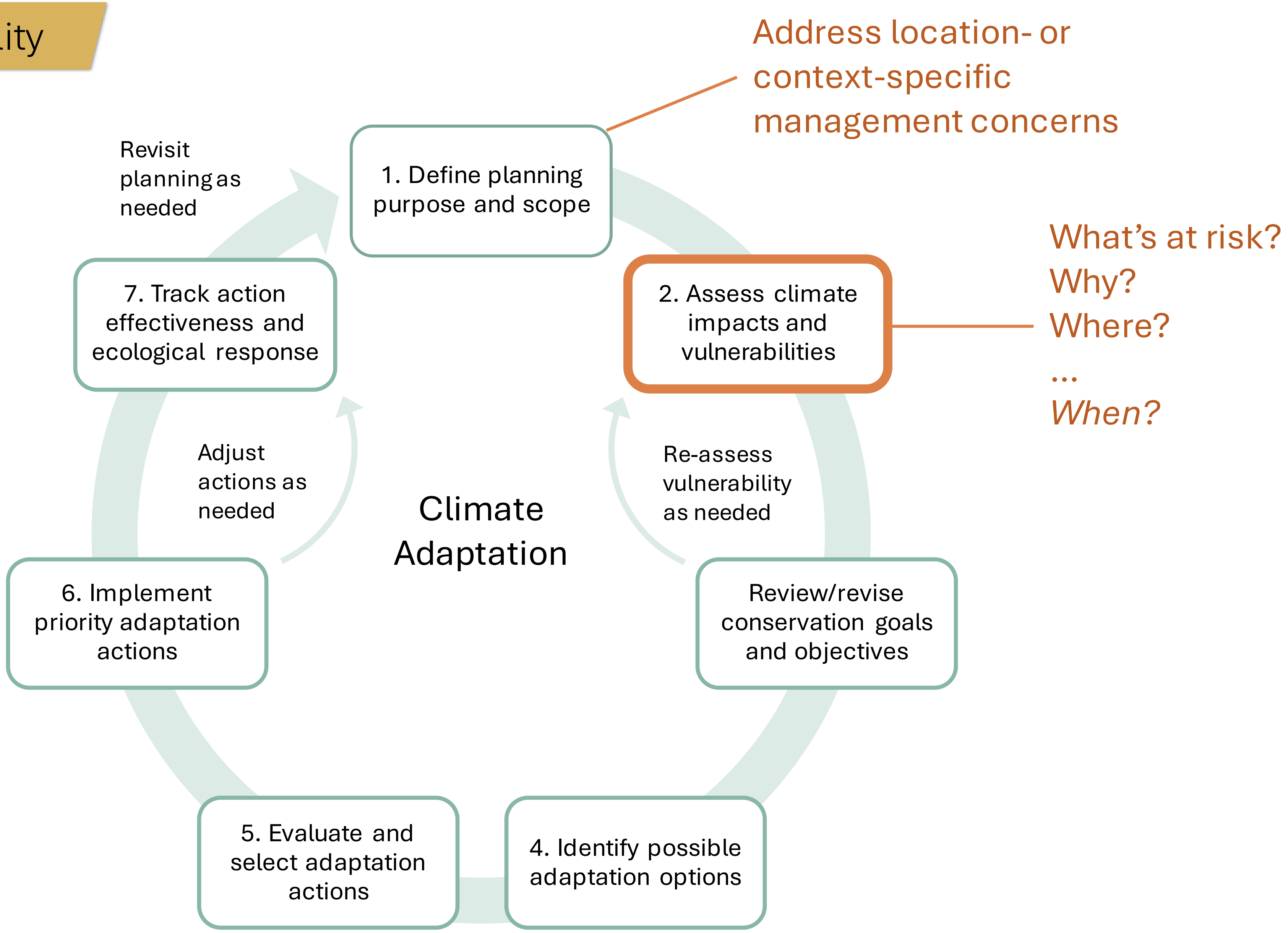
Trait-based



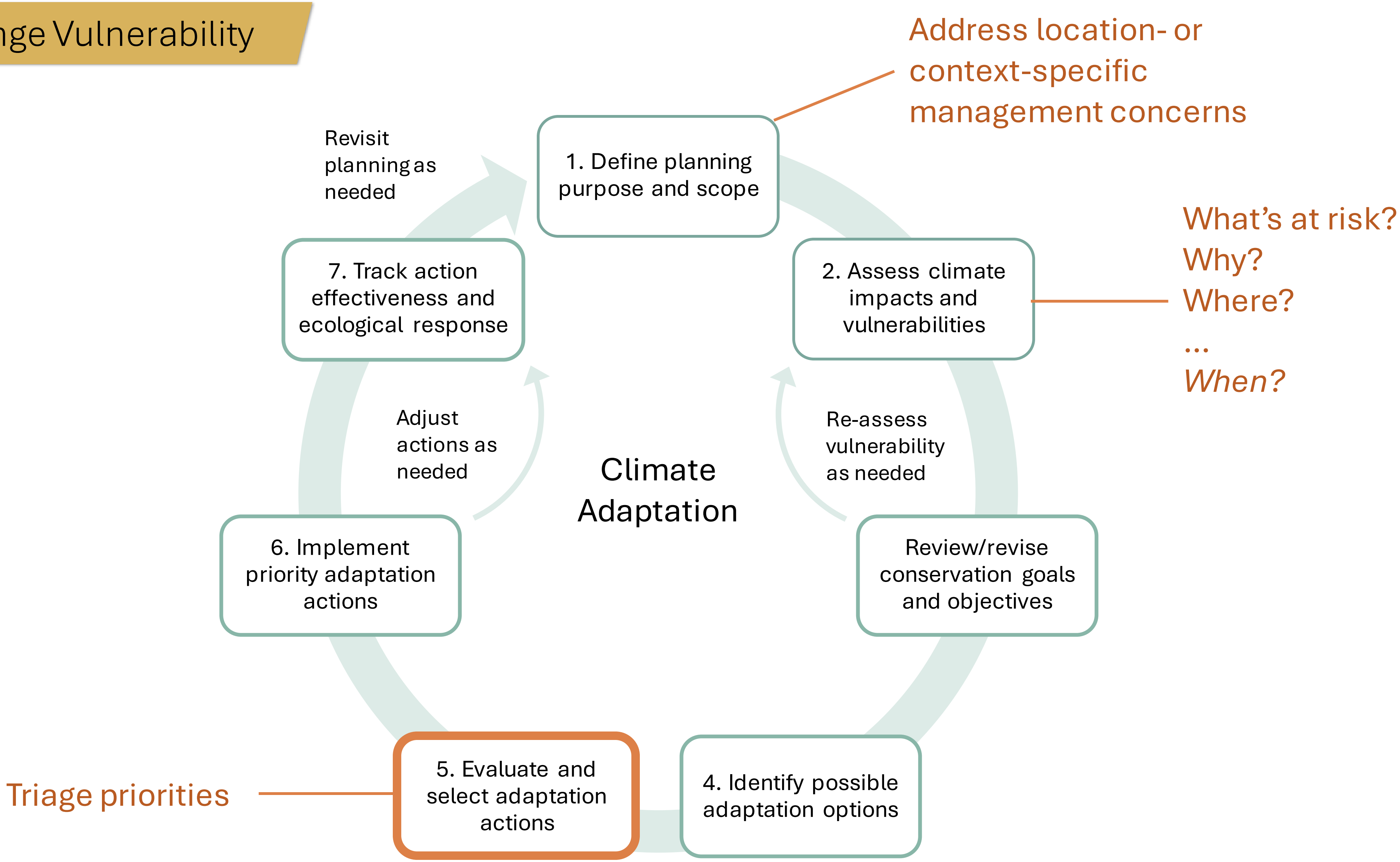
Climate Change Vulnerability



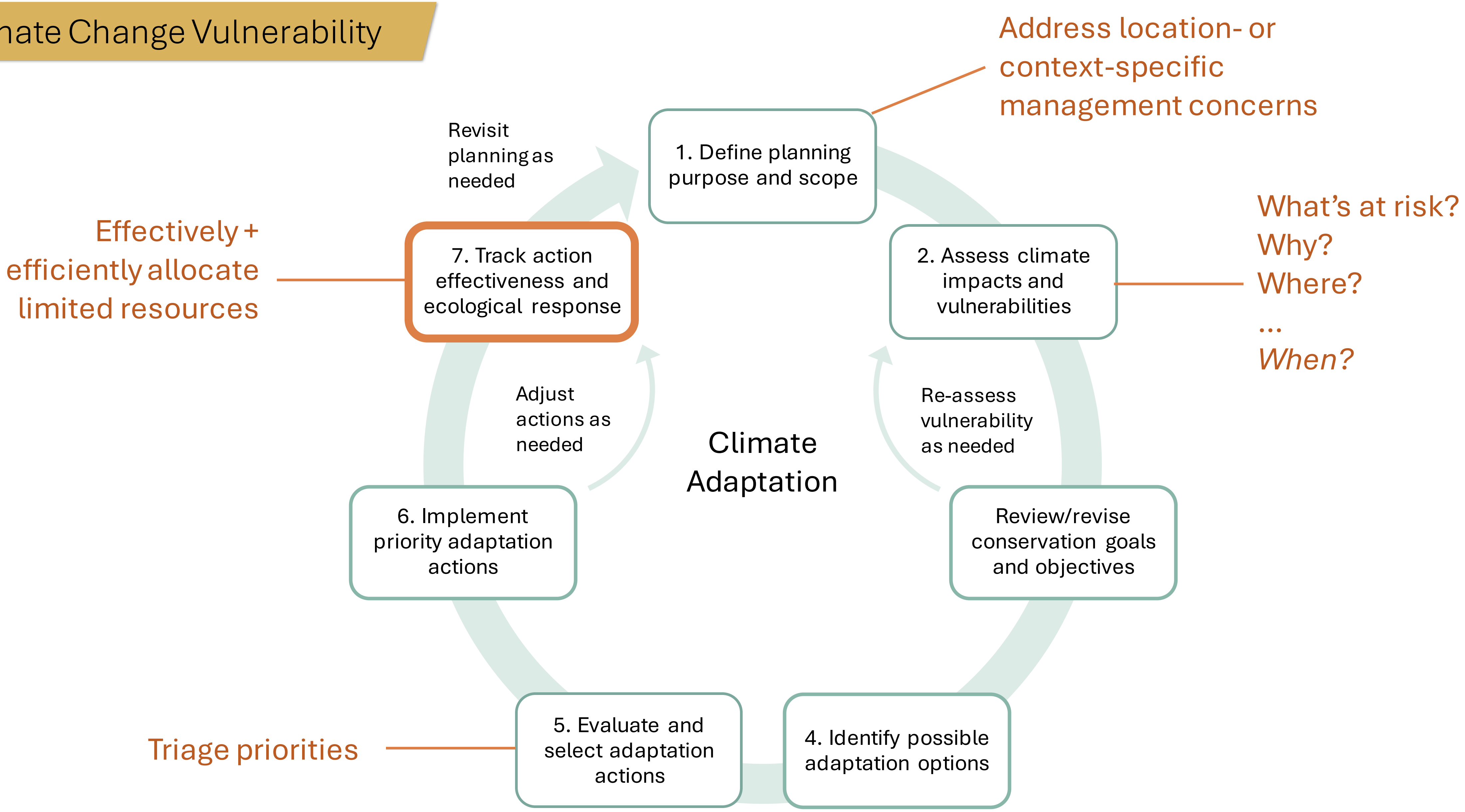
Climate Change Vulnerability



Climate Change Vulnerability



Climate Change Vulnerability




USFWS

Road Map

I. Overview: wildlife response to climate change
II. Measuring response through Vulnerability Assessments
III. Case studies


Thank you!