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New Resource Conservation Paradigms on DoD Lands

March 11, 2021

Welcome and Introductions

Jennifer Nyman, Ph.D., P.E.
Webinar Facilitator

SERDP
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Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Jennifer Nyman, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Kurt Preston, SERDP and ESTCP
- **Managing for Non-Stationary Changes in Aquatic and Riparian Ecosystems** (25 minutes + Q&A)
  Dr. David Lytle, Oregon State University
- **Spatially Explicit Population Models to Predict Conservation Reliant Species in Future Environments** (25 minutes + Q&A)
  Dr. Brian Hudgens, Institute for Wildlife Studies
- **Final Q&A session**

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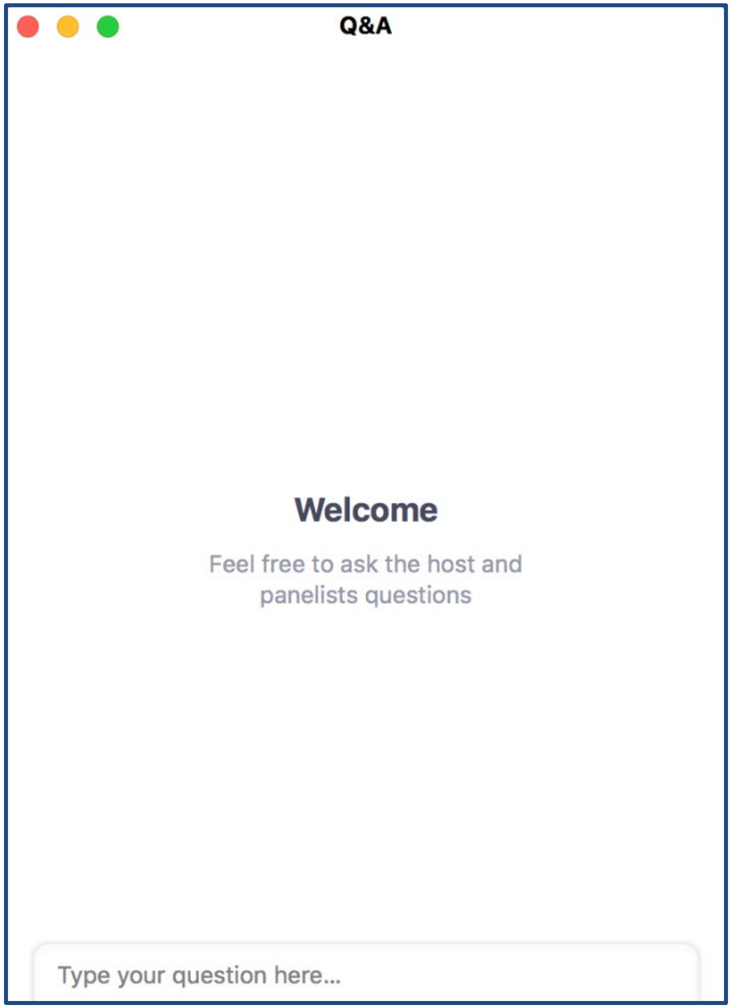

SERDP and ESTCP Overview

Kurt Preston, Ph.D.
SERDP and ESTCP

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SERDP

- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

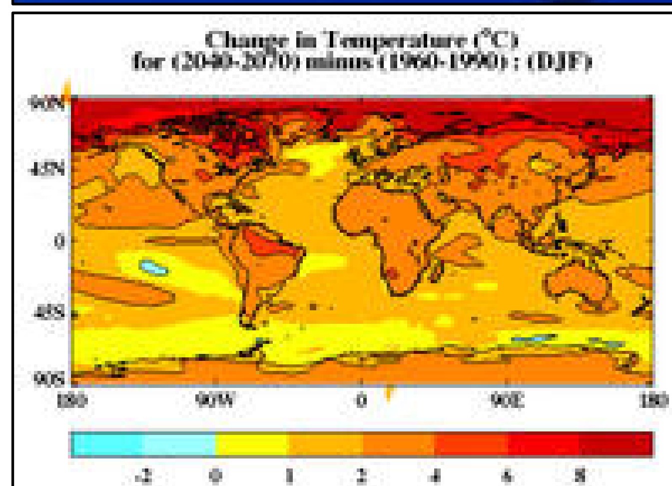
- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

Program Areas

- Environmental Restoration
- Installation Energy and Water
- Munitions Response
- Resource Conservation and Resiliency
- Weapons Systems and Platforms

Resource Conservation and Resiliency

- Natural resources
  - Ecological forestry
  - Arid lands ecology and management
  - Cold regions ecology and management
  - Pacific island ecology and management
  - Coastal and estuarine ecology and management
  - Living marine resources ecology and management
  - Species ecology and management
  - Watershed processes and management
- Resilience
  - Vulnerability and impact assessment
  - Adaptation science
  - Land use and carbon management
- Air quality
  - Wildland fire dynamics
  - Fugitive dust



SERDP and ESTCP Webinar Series

Date	Topic
March 25, 2021	Safer Alternatives for Surface Engineering and Structural Materials in Weapons Systems and Platforms: A Fred Lafferman Tribute Webinar
April 8, 2021	Advances in Understanding PFAS Ecological Risks
April 22, 2021	Innovative Approaches to Monitor and Survey At-Risk Species on DoD Lands
May 6, 2021	Fate, Transport and Treatment of Munitions Constituents in Soil and Groundwater
May 20, 2021	Advancing Microgrid Solutions
June 3, 2021	PFAS Analytical Challenges and Opportunities
June 17, 2021	Changes in Pathogen Exposure Pathways Under Non-Stationary Conditions
July 8, 2021	Energetic Materials and Munitions

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

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Managing for Non-Stationary Changes in Aquatic and Riparian Ecosystems

David A. Lytle, Ph.D.
Oregon State University

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Agenda

- Problem statement
- Solution
- Technical approach
- Results
- Technology transfer
- Conclusions
- Benefits to DoD

Problem Statement

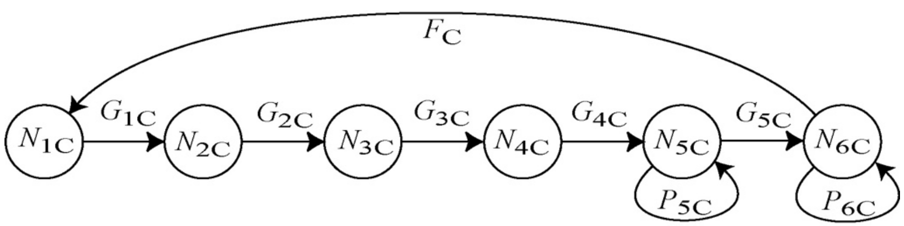
- Climate change will affect aquatic organisms (fish, invertebrates, riparian vegetation) as well as stream-dependent birds, reptiles, and mammals
- Current population models do not adequately handle the non-stationary dynamics produced by shifting climate regimes
- There is a gap between our ability to model changes in streamflow regime and our ability to forecast population-level changes to management-sensitive aquatic and riparian organisms

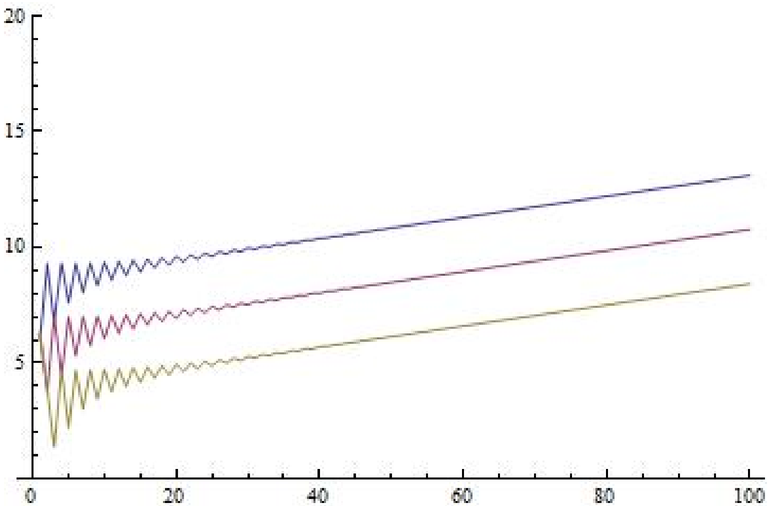
Solution

- Developed, parameterized, and tested flow-population models that forecast how aquatic and riparian organisms respond to changing streamflow regimes
- Mechanistic models allow managers to examine scenarios that have not yet occurred on the landscape
- Results and tools assist management decisions

Technical Approach

- Demographic models are powerful and well-understood, but not suited to handle dynamic streamflow data
  - Use empirical information on birth, death, fecundity, and growth rate to project population changes
  - Structured population models: data-hungry; include stage- or age-specific information
  - Logistic growth models: simpler; utilize growth rate, carrying capacity
  - While stochastic DMs exist, most are poorly-suited to capturing flow regime dynamics





Example of a stage-structured population model (left) projected through time (right)

Technical Approach

- Three types of organism
  - Riparian vegetation
    - Long lifespan (several to >100 years)
    - Dynamics evaluated in annual time steps
  - Aquatic invertebrates
    - Short lifespan (1 year or less)
    - Boom-bust population dynamics over short timescales
  - Fish
    - Medium lifespan (1-5 years)
    - Population dynamics intermediate between invertebrates and vegetation

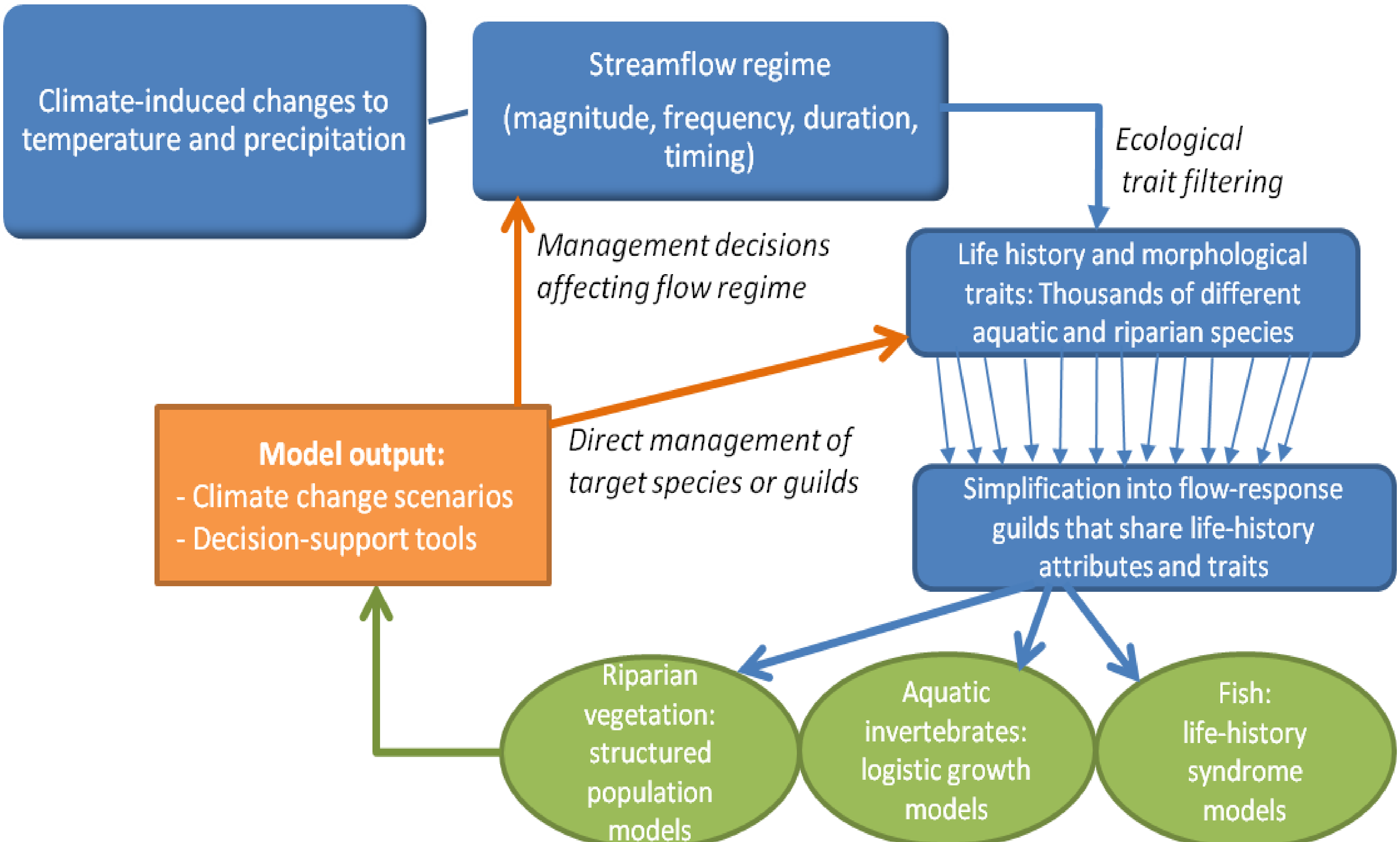


Technical Approach

- Study region
  - Military installations in arid lands of western U.S.
    - Camp Pendleton and Fort Hunter Liggett, CA; Piñon Canyon Maneuver Site, CO; Fort Huachuca, AZ
  - Riverine habitats (riparian and aquatic) are disproportionately important for habitat, threatened and endangered species
  - Streamflow regime is a known driver of species abundance and distribution
  - Established track record of researchers working on installations and with base biologists

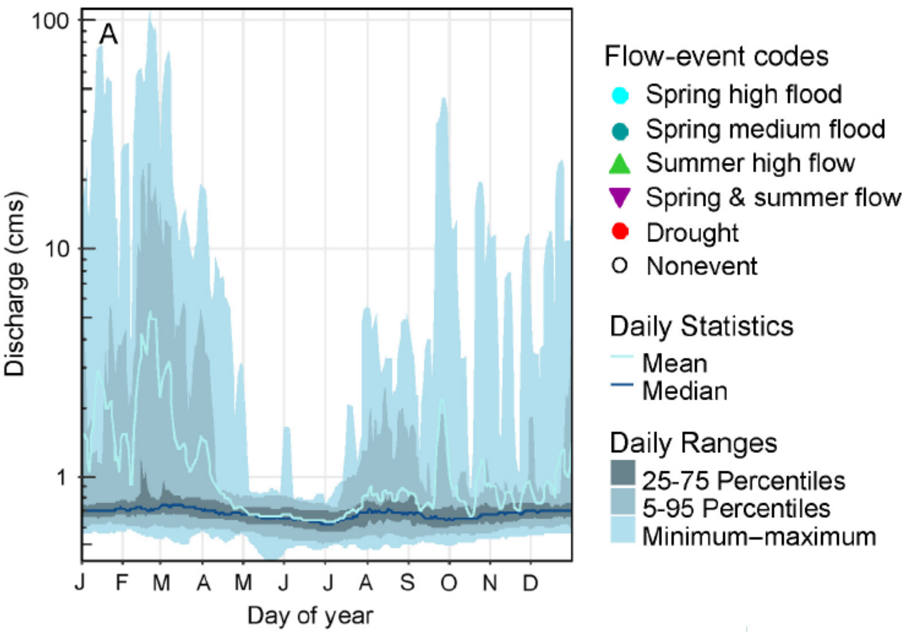
Technical Approach

Study Organization



Results

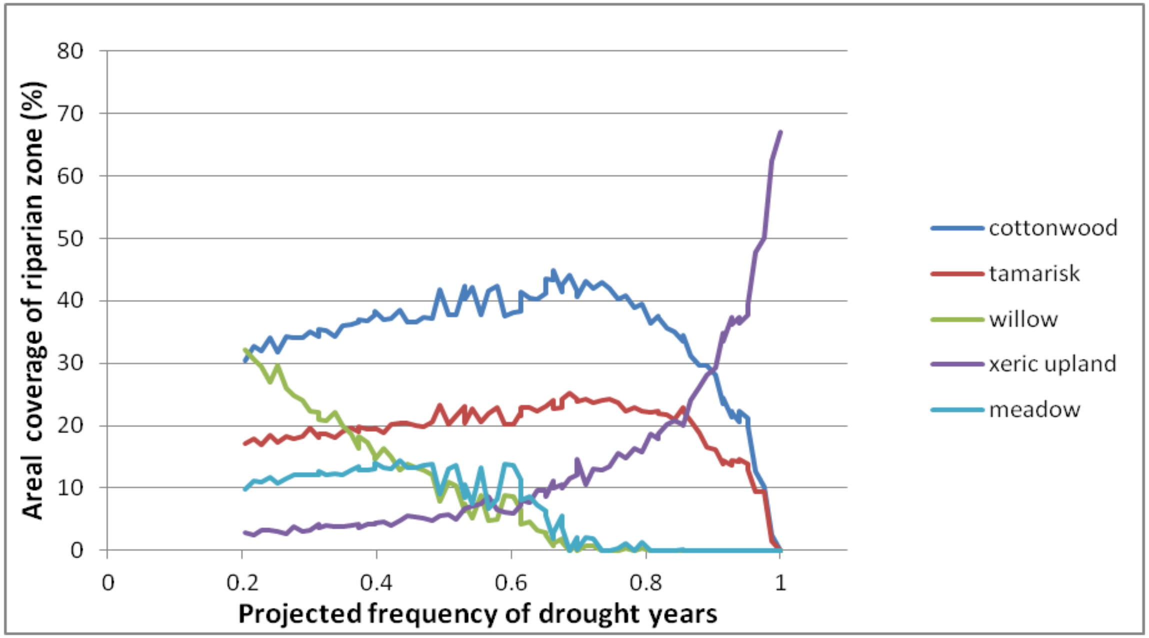
- Scoping: Site visits with base managers, trait data, and surveys
- Modeling: Develop core flow-population models
  - Riparian vegetation: Stage-structured population modeling approach
  - Aquatic invertebrates: Stochastic logistic growth model
  - Fish: Stage-structured population models
- Testing: Parameterization and testing



Results

Riparian Vegetation Model

- Model accommodates
  - Individual disturbances (major flood or drought events)
  - Altered disturbance regimes (changes in event frequency, magnitude)
  - Management actions (dam operations, water allocation)



Model output: The effect of altered **drought frequency** on riparian vegetation. Current drought frequency is 0.2 (2 out of 10 years are drought years)

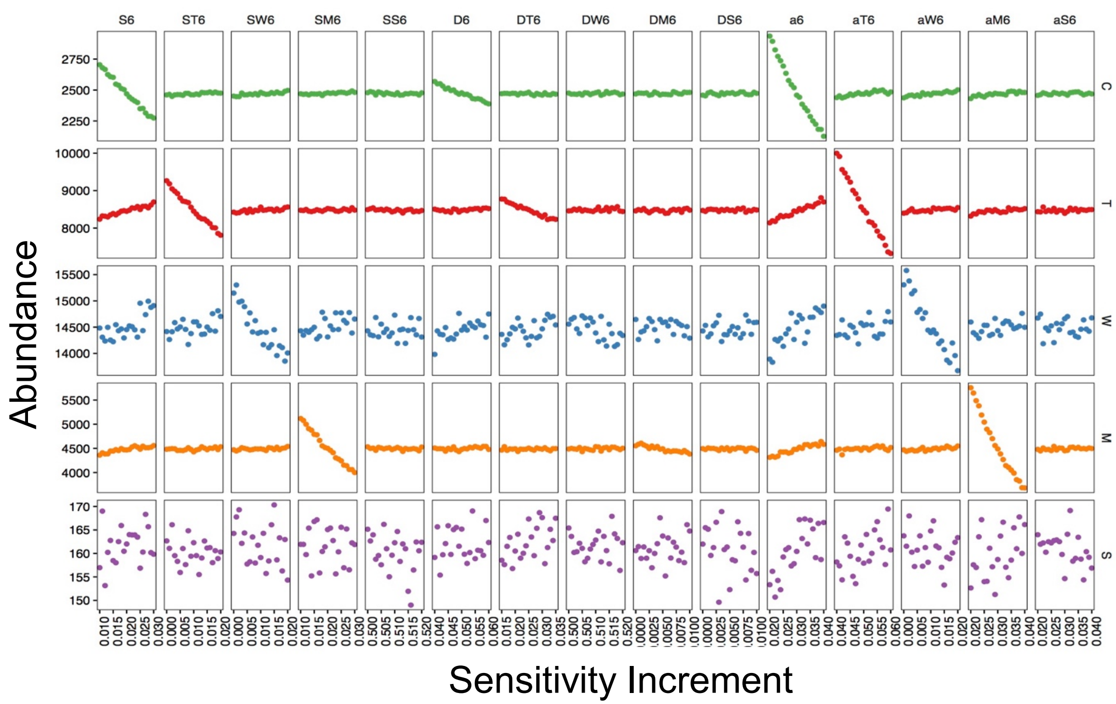
Results

Riparian Vegetation Model

- Novel approach: “interaction-neutral” model of community dynamics
  - Model does not assume biotic interactions, although space is finite
  - Interactions (competition, facilitation) arise out of the model itself
  - These can be quantified by sensitivity analysis

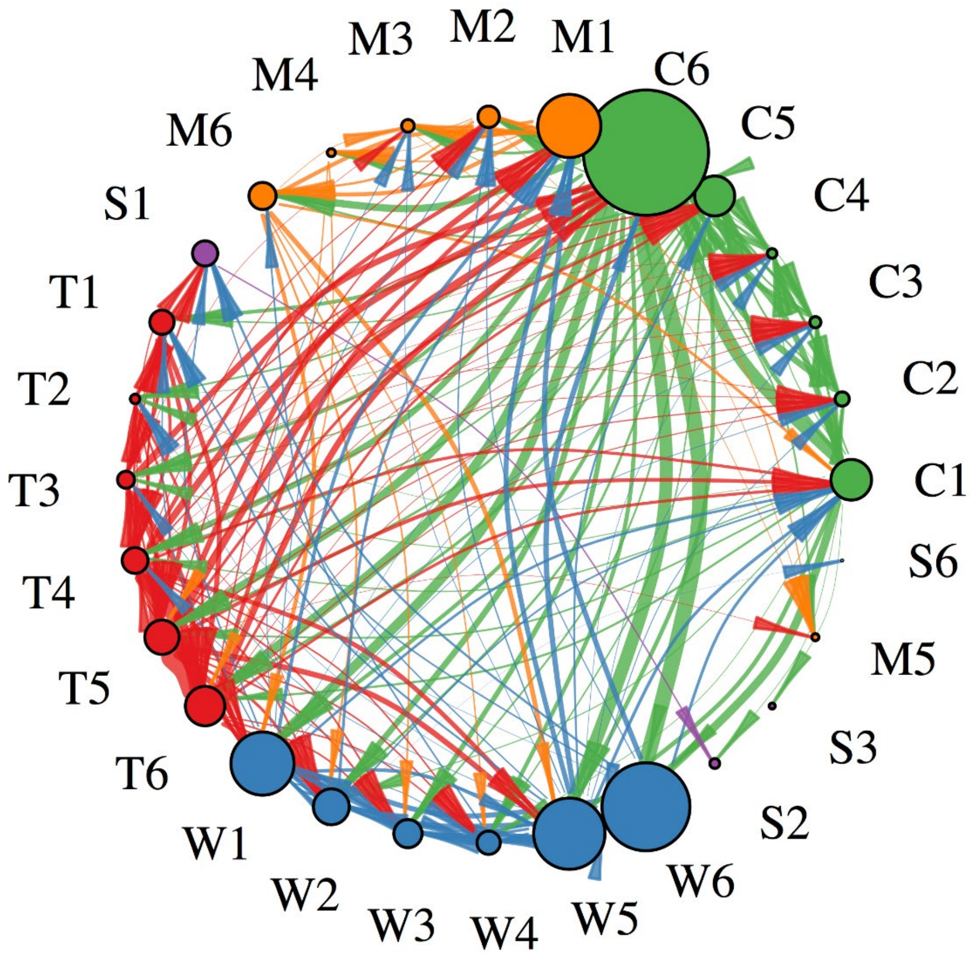
Sensitivity of flow-response guilds to changes in model parameters

250 years, 150-year burn-in, 1000 iterations per parameter



Results

Flow Regime Scenarios



Network analysis of model results demonstrate that some species are “keystones” that are disproportionately important on the landscape

C – cottonwood
T – tamarisk
W – willow
M – meadow
S – sagebrush

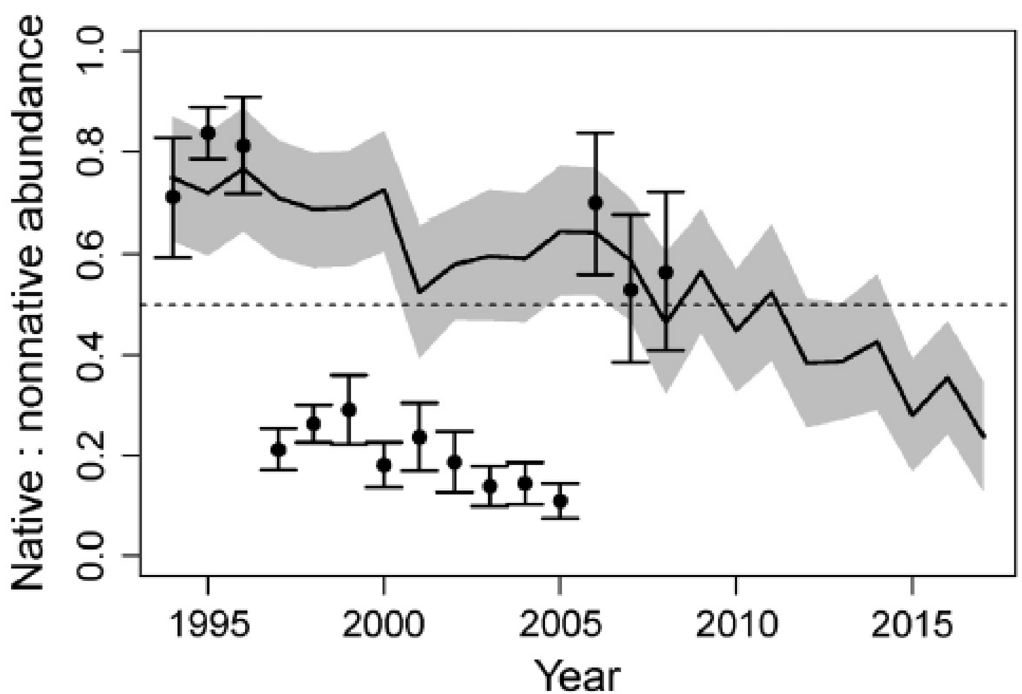
Results

Fish Life History Model

- Based on 7 species common in western rivers
- Incorporates fecundity, biomass of adults, growth and adult survival
- Successfully recovered increase in non-native species observed in fish surveys

Natives

Non-natives

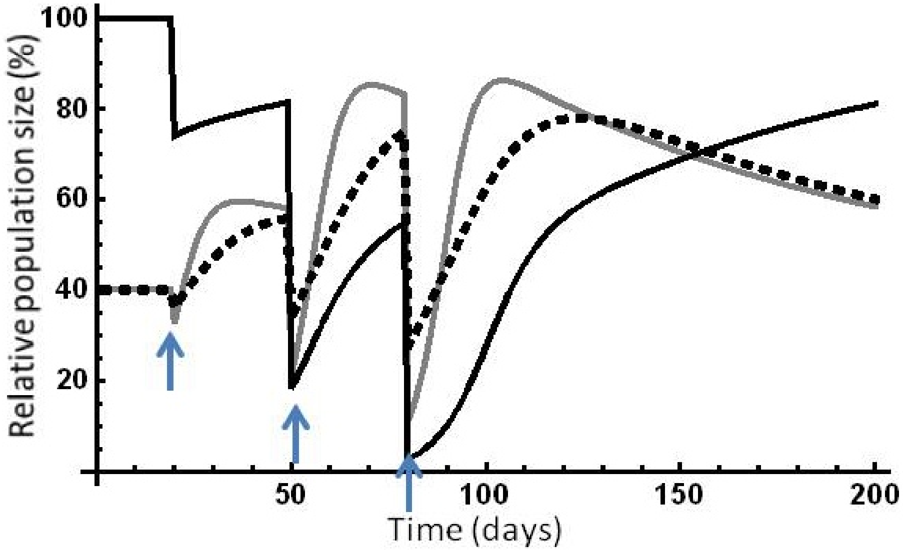


Results

Aquatic Invertebrate Model

- Logistic population growth models are relatively parameter-free
  - r = intrinsic rate of population increase
  - K = carrying capacity
  - Challenge is to incorporate changing values of r and K

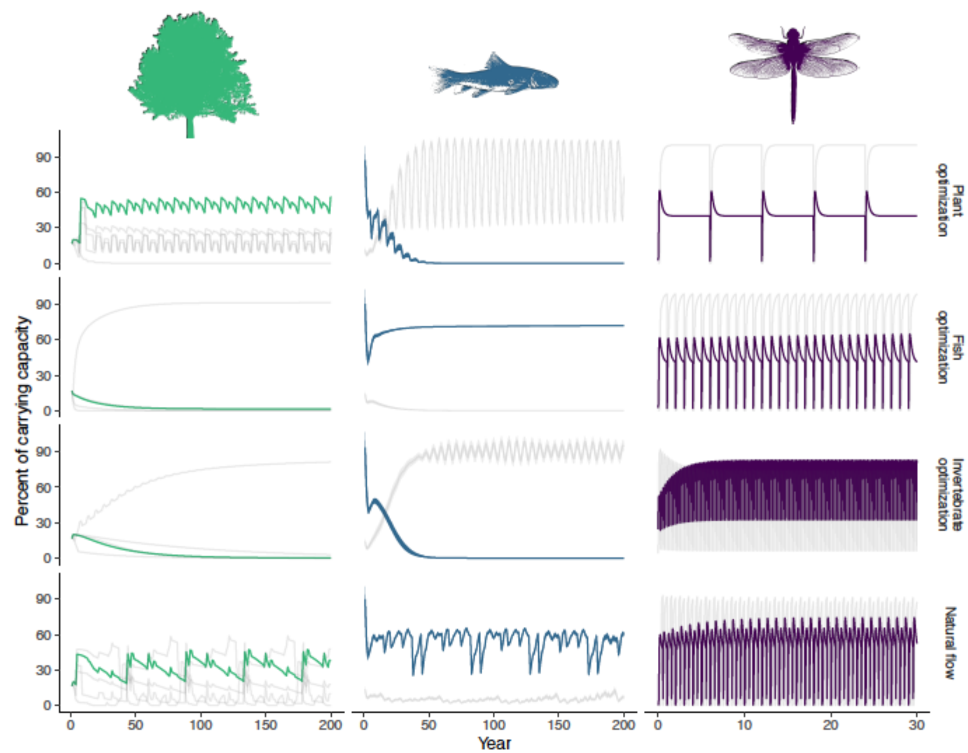
Logistic population model output, showing how individual flood events (blue arrows) affect aquatic insect populations that are flood-adapted (gray and dashed lines) or flood-averse (solid lines)



Results

- How does management for one organism type affect other types?
  - Targeted management one organism type has unintended negative consequences for the other organism types

Flow regime management for a one organism type ("designer flows") can produce favorable results under specific optimization criteria



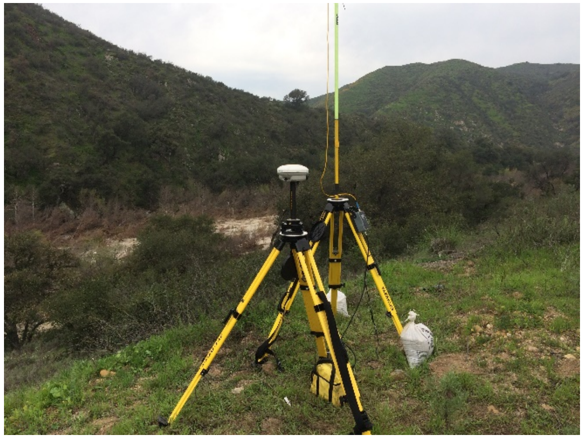
Results

- Management designed from natural flow regime principles never achieves optimization-level criteria, but it does balance objectives across all organism types

Tradeoffs: single-organism type management generally harms other ecosystem sectors. The natural flow regime never achieves optimization-level criteria, but it does balance objectives across all ecosystem sectors

Technology Transfer

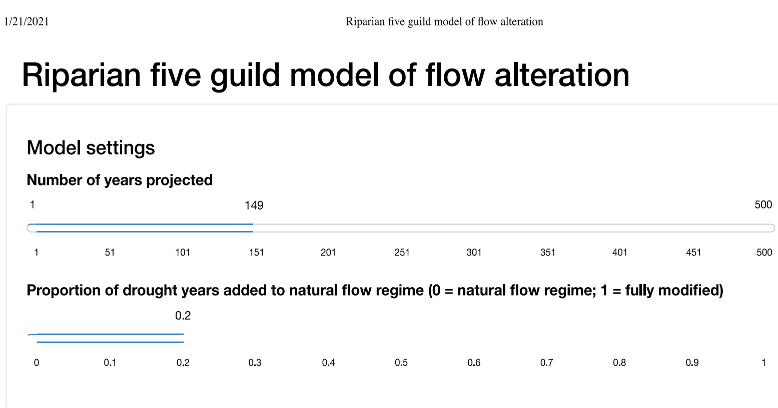
- Graphical user interface (GUI) for exploring riparian model output
- Species occurrence maps for individual bases
- Presentation at meetings of professional societies, peer-reviewed publication

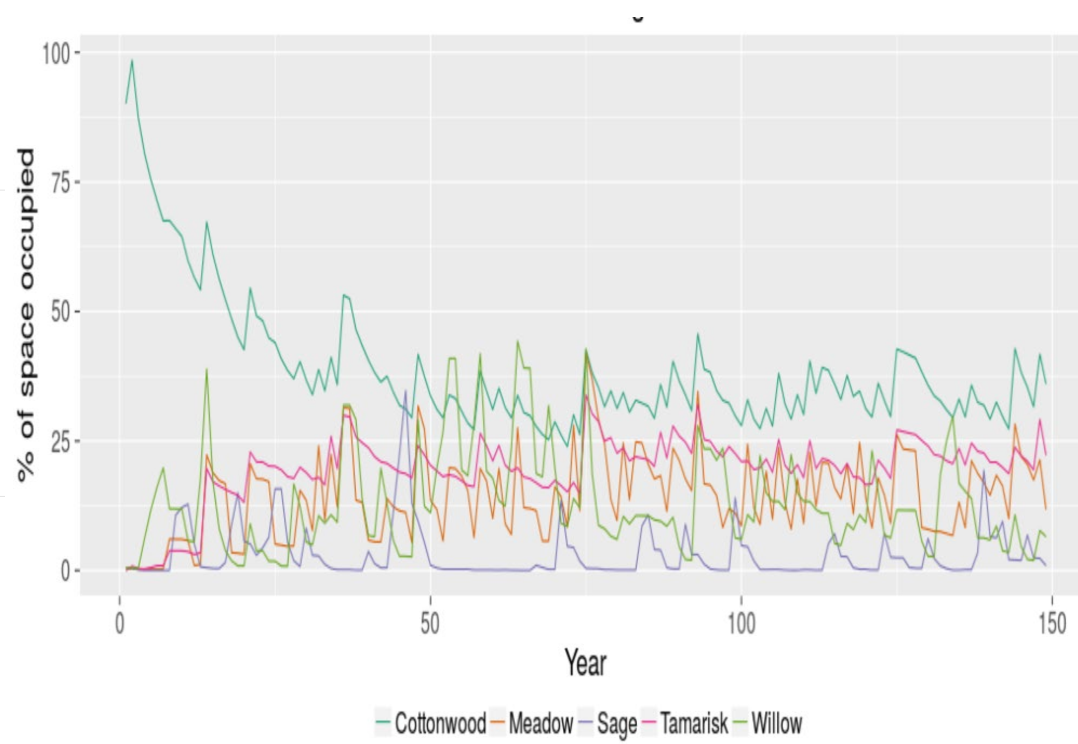


Technology Transfer

Graphical User Interface (GUI)

Explore riparian model output from ShinyApp interface
https://jdtonkin.shinyapps.io/CotTam/

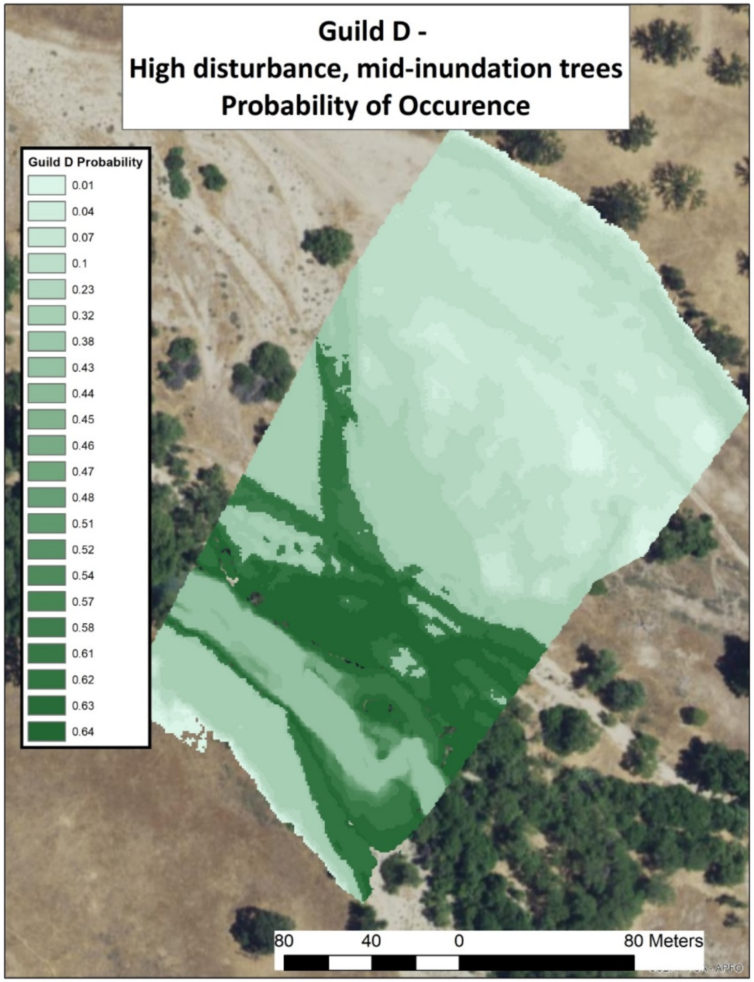




Technology Transfer

Species Occurrence Maps for Individual Bases

- Probability of species occurrence for high disturbance, mid-inundation trees on the San Antonio River, Fort Hunter-Liggett in an increased drought scenario



Technology Transfer

Other Resources

- Project final report, including a supplementary document detailing digital and web tools developed during this project
- Base-specific reports, delivered to each installation along with adjacent National Forest management units
- Presentation at meetings of professional societies
- Publication in peer-reviewed journals including *Ecology*, *Ecology Letters*, and *Nature*

Conclusions

- In non-stationary ecosystems, we need mechanistic rather than statistical models to make predictions beyond observed conditions
- Different segments of the river ecosystem (riparian vegetation, fish, invertebrates) require flow events at different characteristic frequencies to maintain healthy populations
- Management tactics that optimize conditions for a single group risk compromising other groups in the ecosystem
- While natural flow regime conditions may not be achievable in many systems, beginning from these principles is most likely to ensure whole-ecosystem protection

Benefits to DoD

- General framework for managing aquatic populations under non-stationary climate change
- Guidance for understanding how management for one organism type may affect others (positively and negatively)
- Installation-specific maps and predictions for future climate scenarios

Additional Resources

- (in press). Tonkin, J.D., J.D. Olden, D.M. Merritt, L.V. Reynolds, J.S. Rogosch, D.A. Lytle. Designing flow regimes to support entire river ecosystems. **Frontiers in Ecology & the Environment**.
- 2019. Tonkin, J.D., Poff, N.L., Bond, N.R., Horne, A., Merritt, D.M., Reynolds, L.V. and Olden, J.D., Ruhi, A., Lytle, D.A. Prepare river ecosystems for an uncertain future. **Nature** 570: 301-303.
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- 2018. Tonkin, J.D., D.M. Merritt, J.D. Olden, L.V. Reynolds, & D.A. Lytle. Flow regime alteration degrades ecological networks in riparian ecosystems. **Nature Ecology & Evolution** 2(1): 86-93.
- 2018. Tonkin, J.D., F. Altermatt, D.S. Finn, J. Heino, J.D. Olden, S.U. Pauls, D.A. Lytle. The role of dispersal in structuring riverine metacommunities: patterns, processes, and pathways. **Freshwater Biology** 63(1): 141-163.
- 2017. McMullen, L.E., P. De Leenheer, & D.A. Lytle. High mortality and enhanced recovery: modeling the countervailing effects of disturbance on population dynamics. **Ecology Letters** 20(12): 1566-1575. *profiled in Faculty1000
- 2017. Tonkin, J.D., M.T. Bogan, N. Bonada, B. Rios-Touma, D.A. Lytle. Seasonality and predictability shape temporal species diversity. **Ecology** 98(5): 1201-1216.
- 2017. Lytle, D.A., D.M. Merritt, J.D. Tonkin, J.D. Olden, L.V. Reynolds. Linking river flow regimes to riparian plant guilds: a community-wide modeling approach. **Ecological Applications** 27(4): 1338-1350.

For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Species-Ecology-and-Management/RC-2511

Speaker Contact Information

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Q&A Session 1

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Spatially Explicit Population Models to Predict Conservation Reliant Species in Future Environments

Brian Hudgens, Ph.D.
Institute for Wildlife Studies

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Agenda

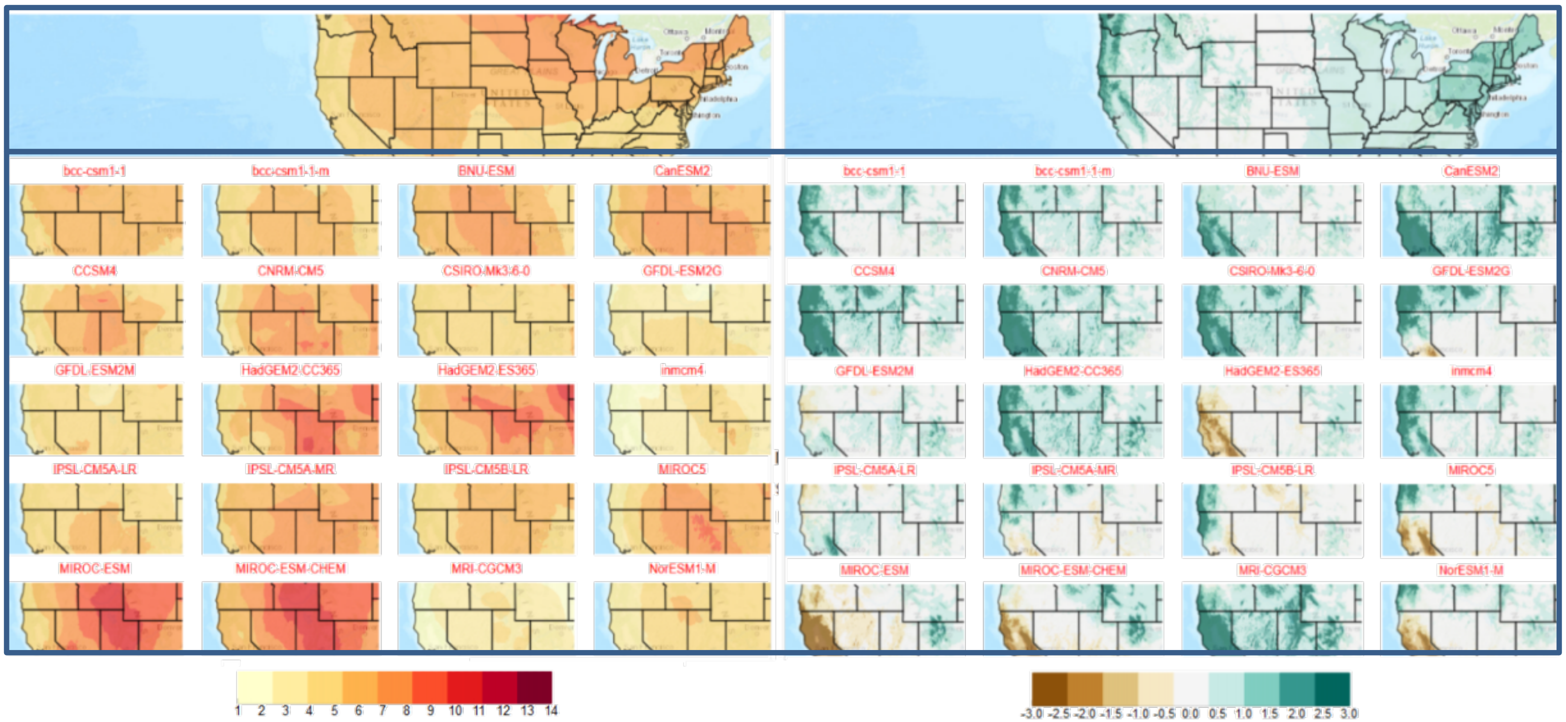
- Conservation challenges in future climates
- Approach
  - Seven SEED (**S**patially **E**xplicit **E**nvironmental **D**rivers) models
- How climate influences populations
- Anticipated climate winners and losers
- Conclusions
- Benefits to DoD

Background

The Climate is Expected to Change

20 model average

20 individual global climate models



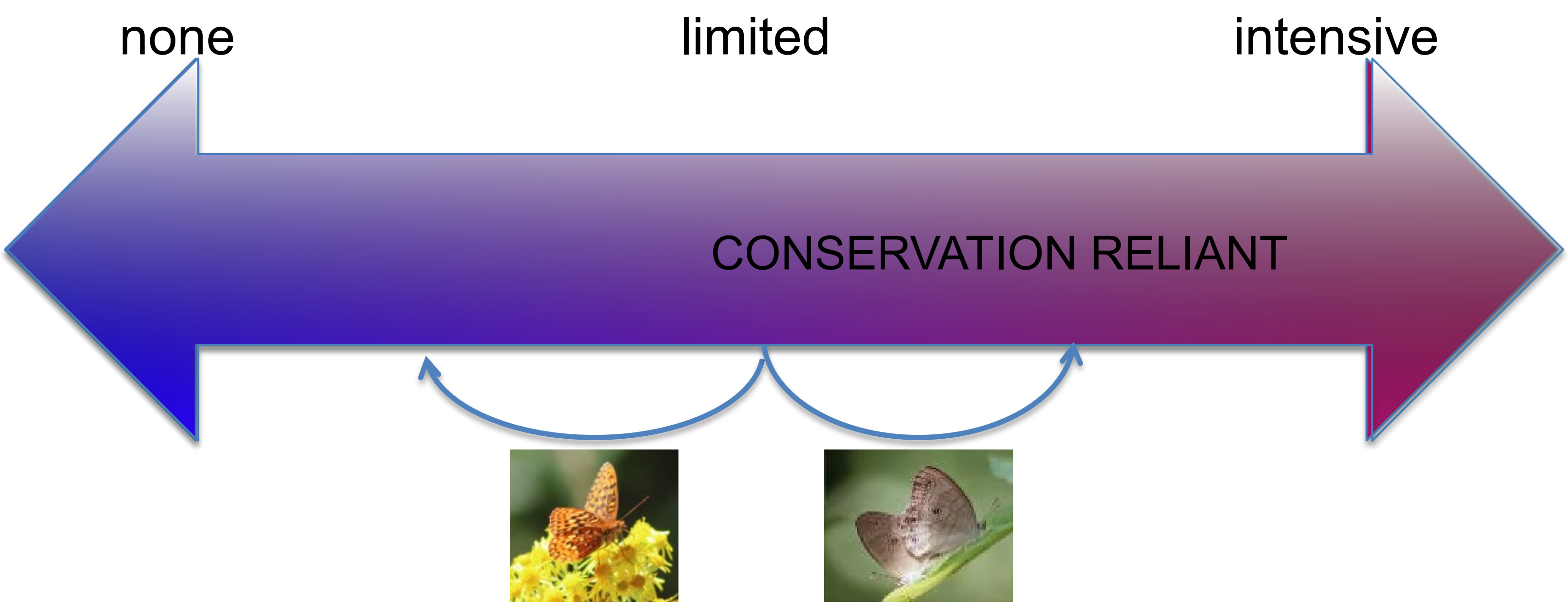
Projected change in mean temperature 2040-2069 vs. 1971-2000

Projected change in winter precipitation 2040-2069 vs. 1971-2000

Background

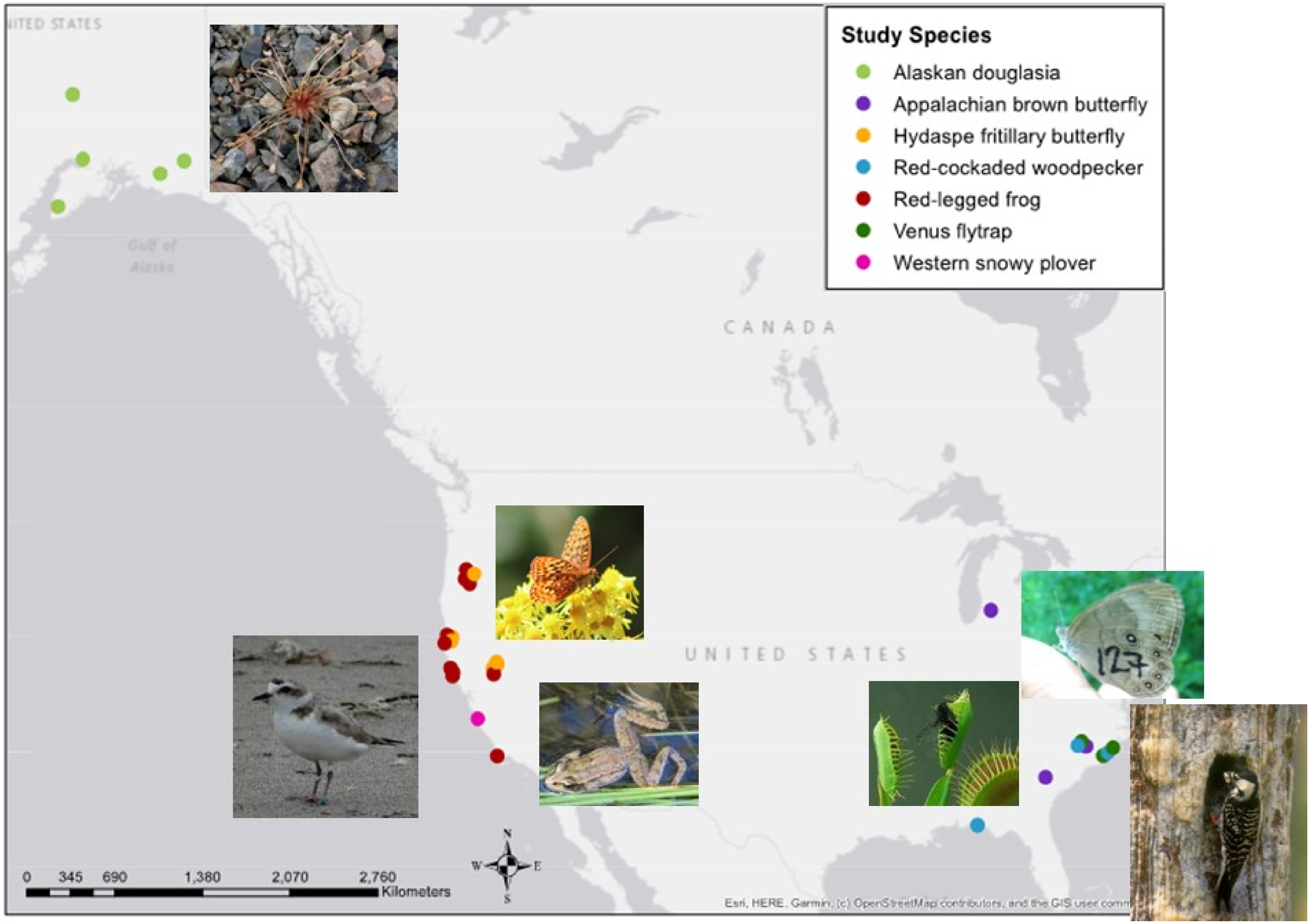
Changing Climate Changes Conservation Needs

Management Effort Required



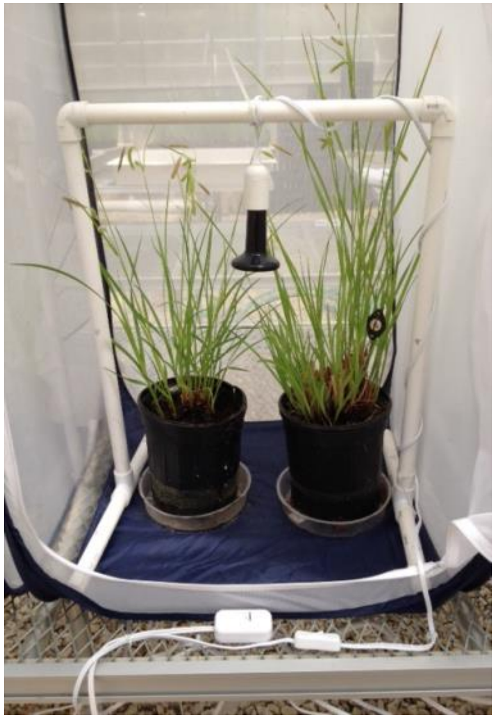
Approach

Parallel Studies on 7 Taxa



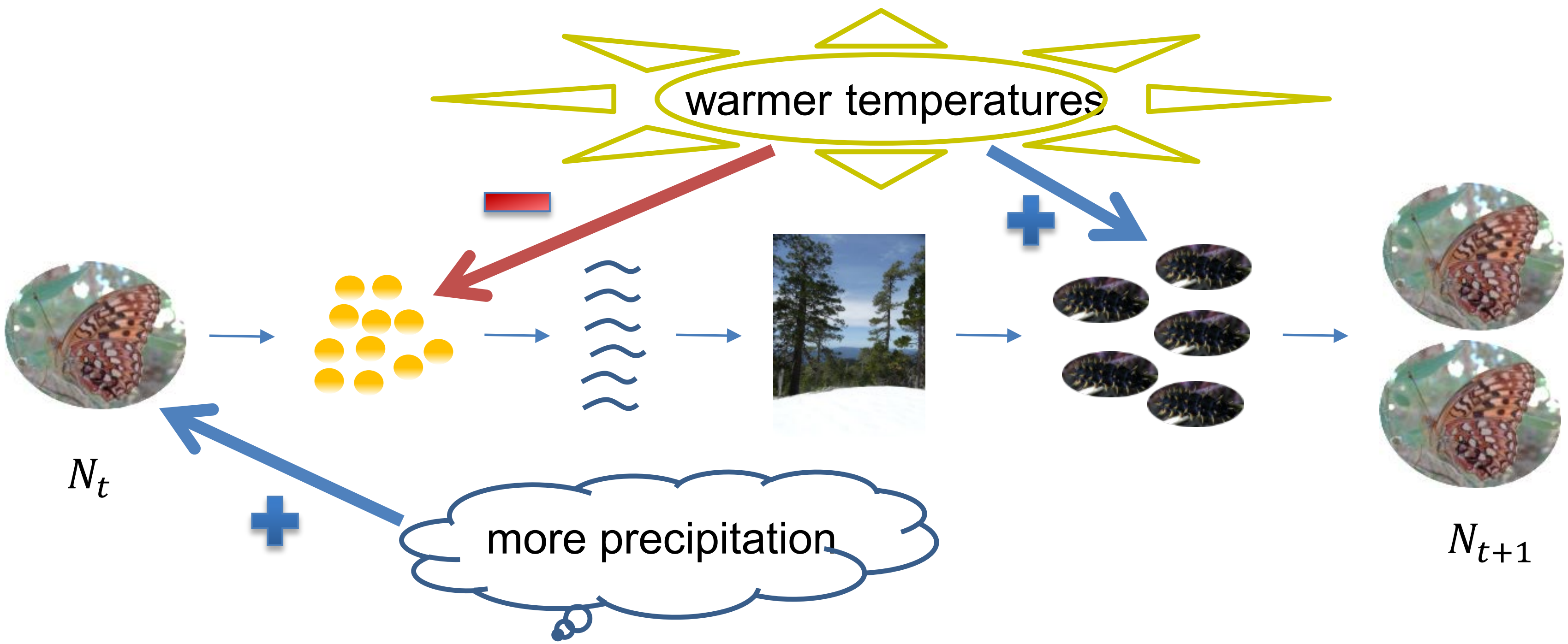
Approach

Experimentally Create Climate Extremes



Approach

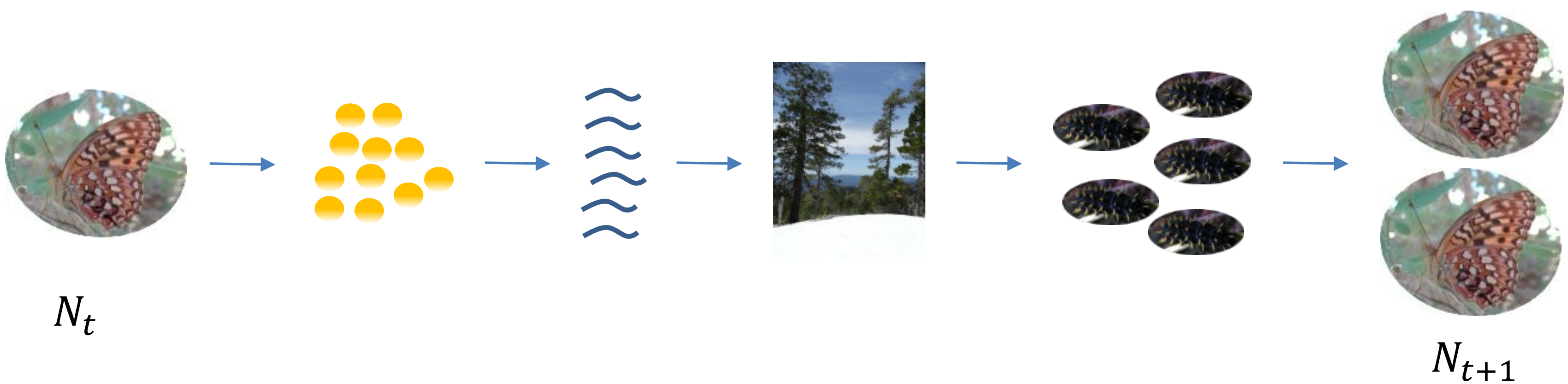
- Population models that:
  - Account for different climate effects
  - Integrate effects over entire life cycle



Approach

Integrating SEED Models

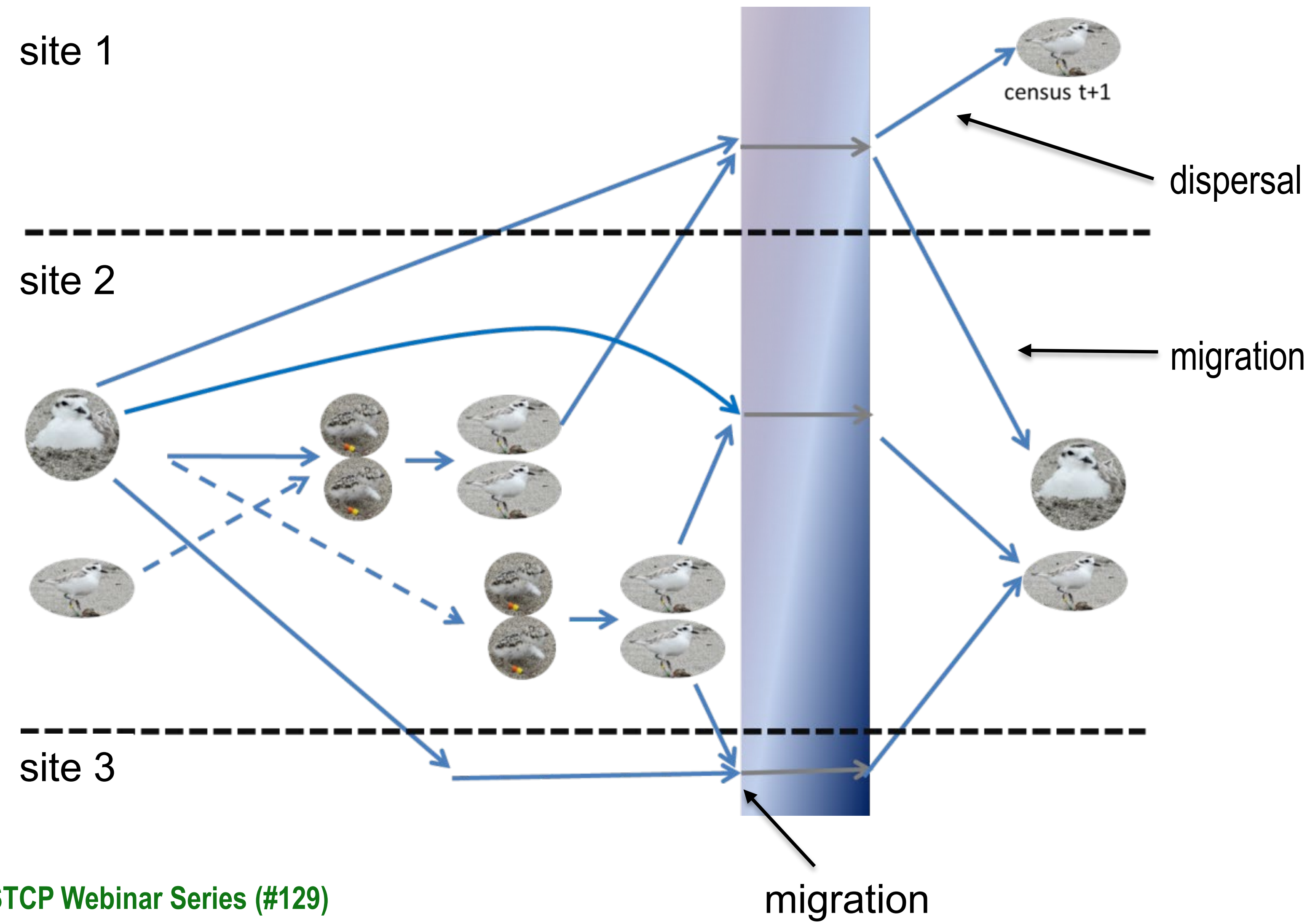
SEED = Spatially Explicit Environmental Drivers



$$N_{t+1} = N_t * eggsperday * adultlifespan(pcp_t, min.temp_t) * hatch.rate(min.temp_t) * \left(1 - egg.pred(site)\right) * winter.surv * spring.surv(max.temp_t)$$

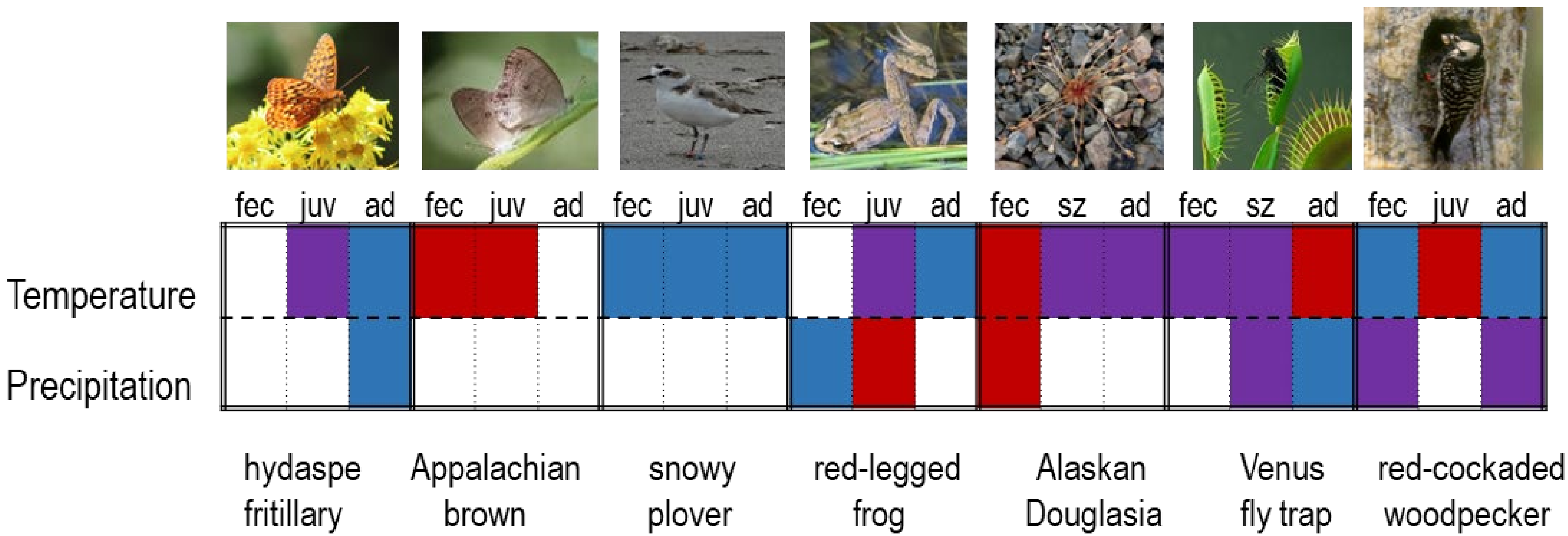
Approach

SEED Models: Spatially Explicit Accounting



Results

Climate-Demographic Rate Relationships are Complex



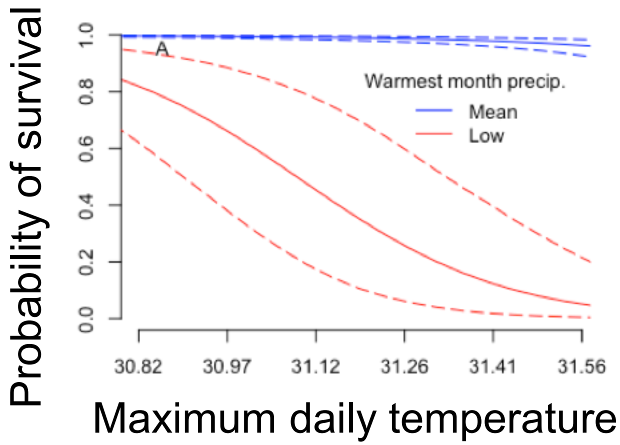
Positive association

Negative association

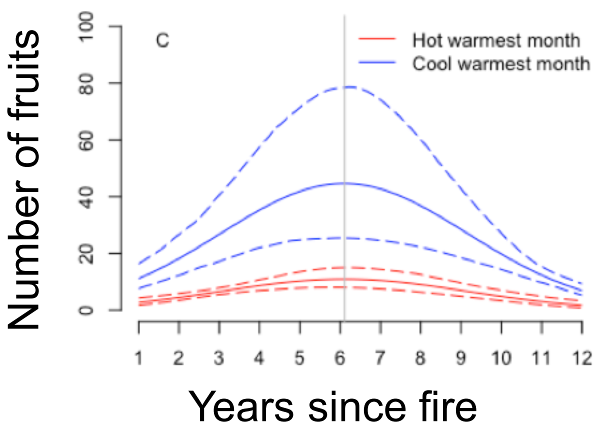
Both positive and negative associations

Results

Interactions Common



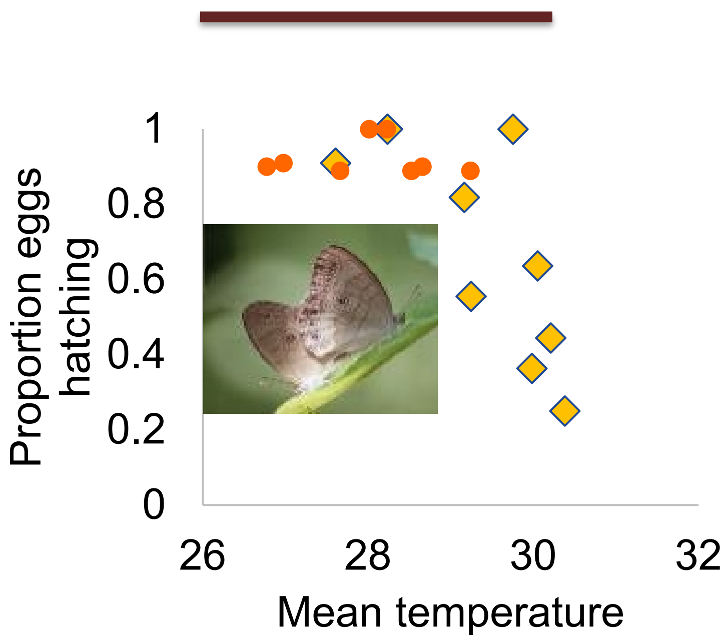
Between different climate variables

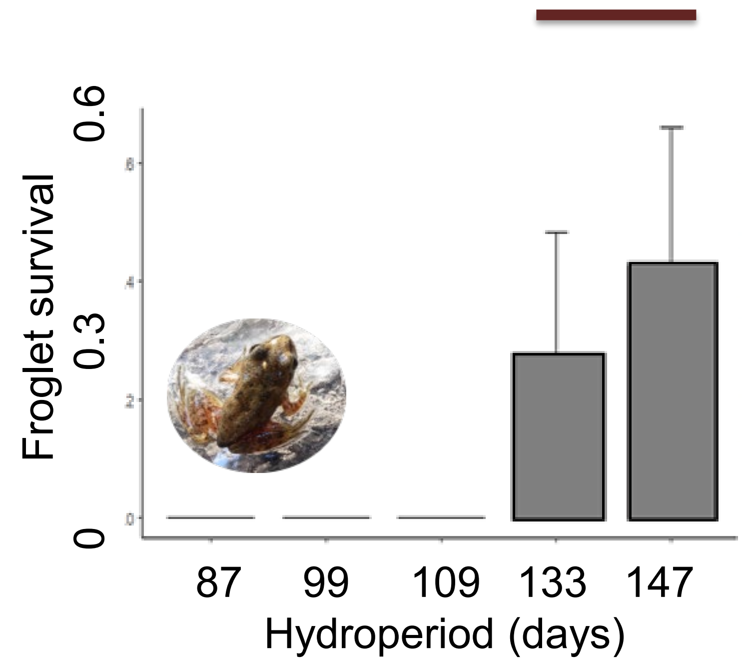


Between climate and non-climate variables

Results

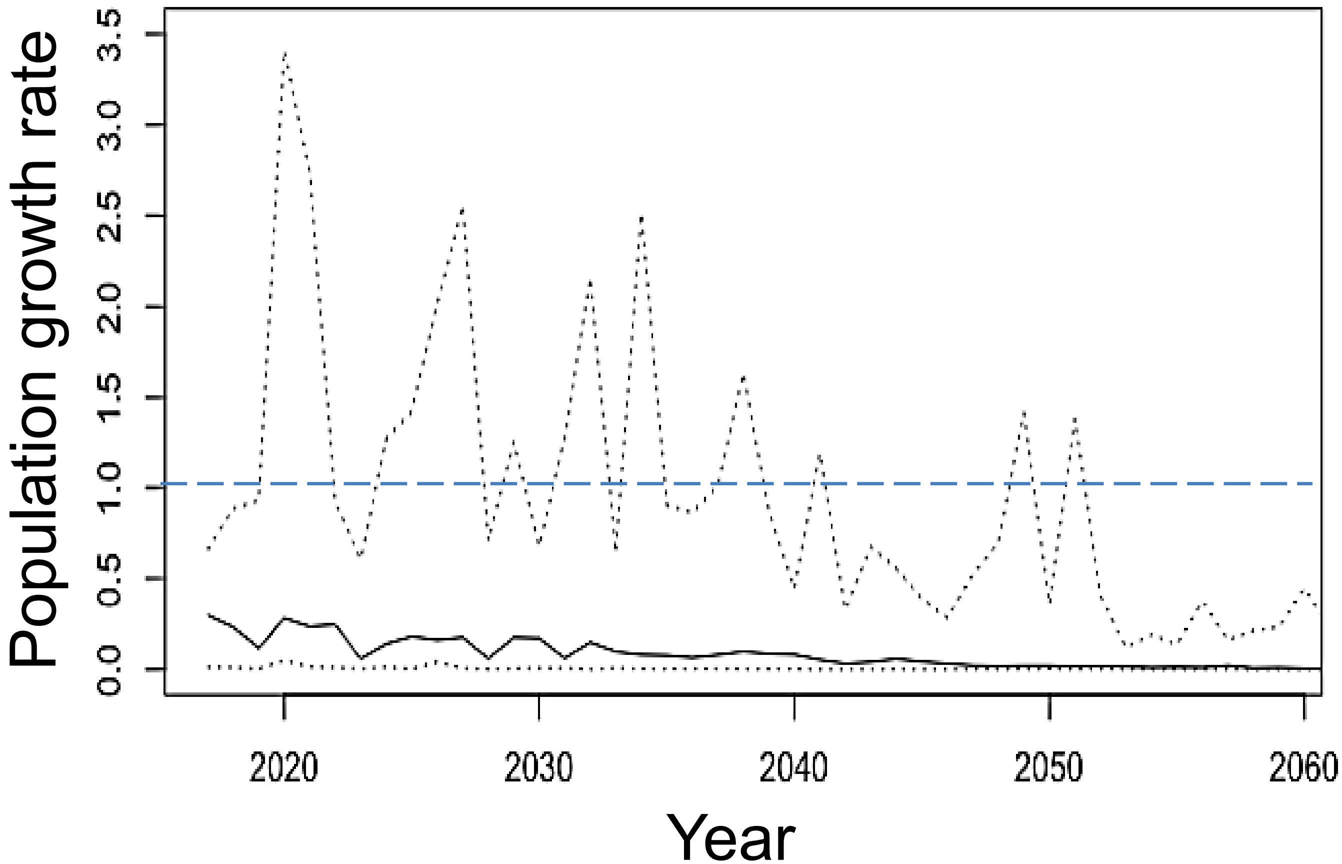
Threshold Effects Common





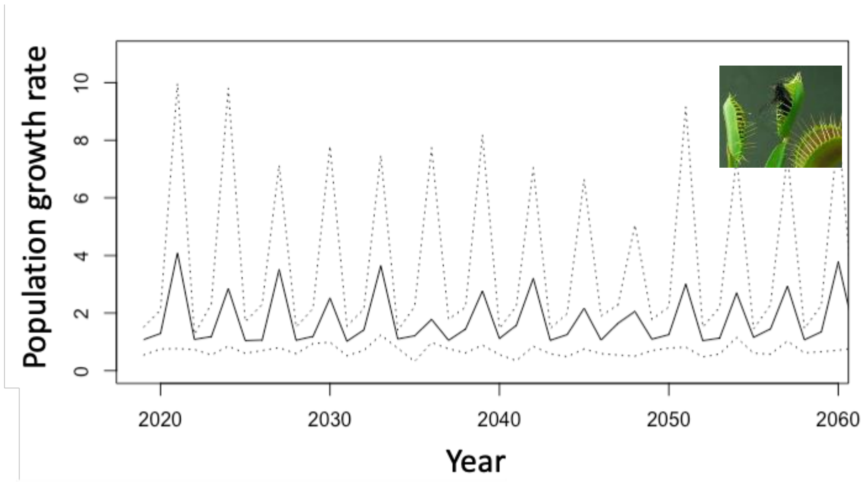
Results

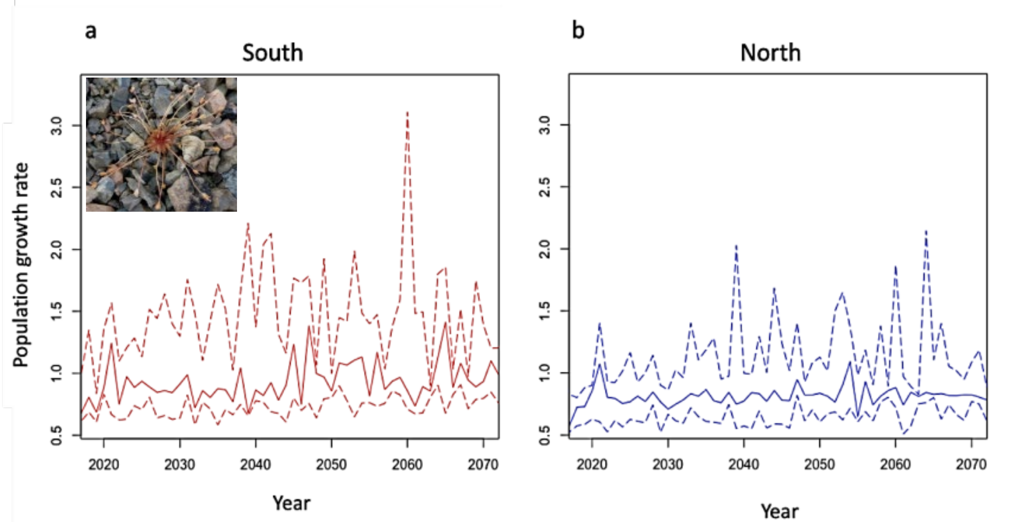
Threshold Effects Amplify Climate Uncertainty

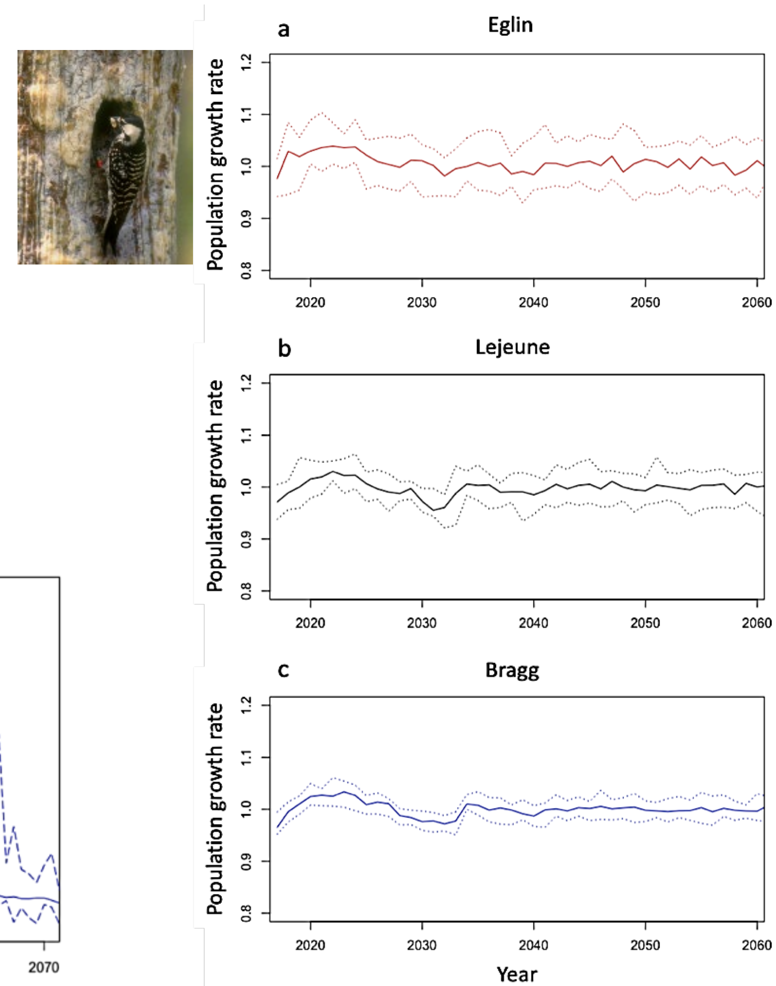


Results

Populations of Many Species Robust to Climate Change

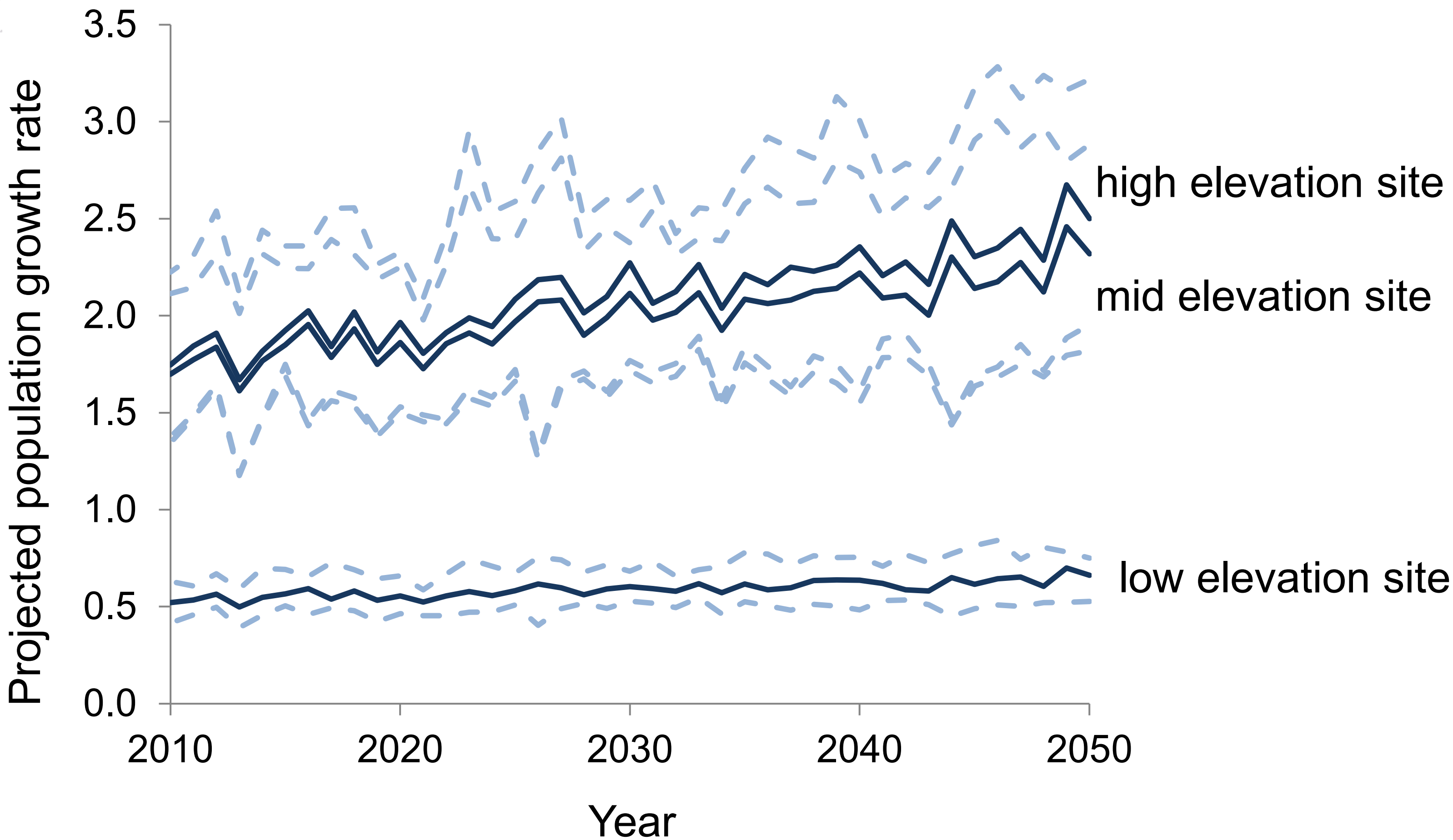






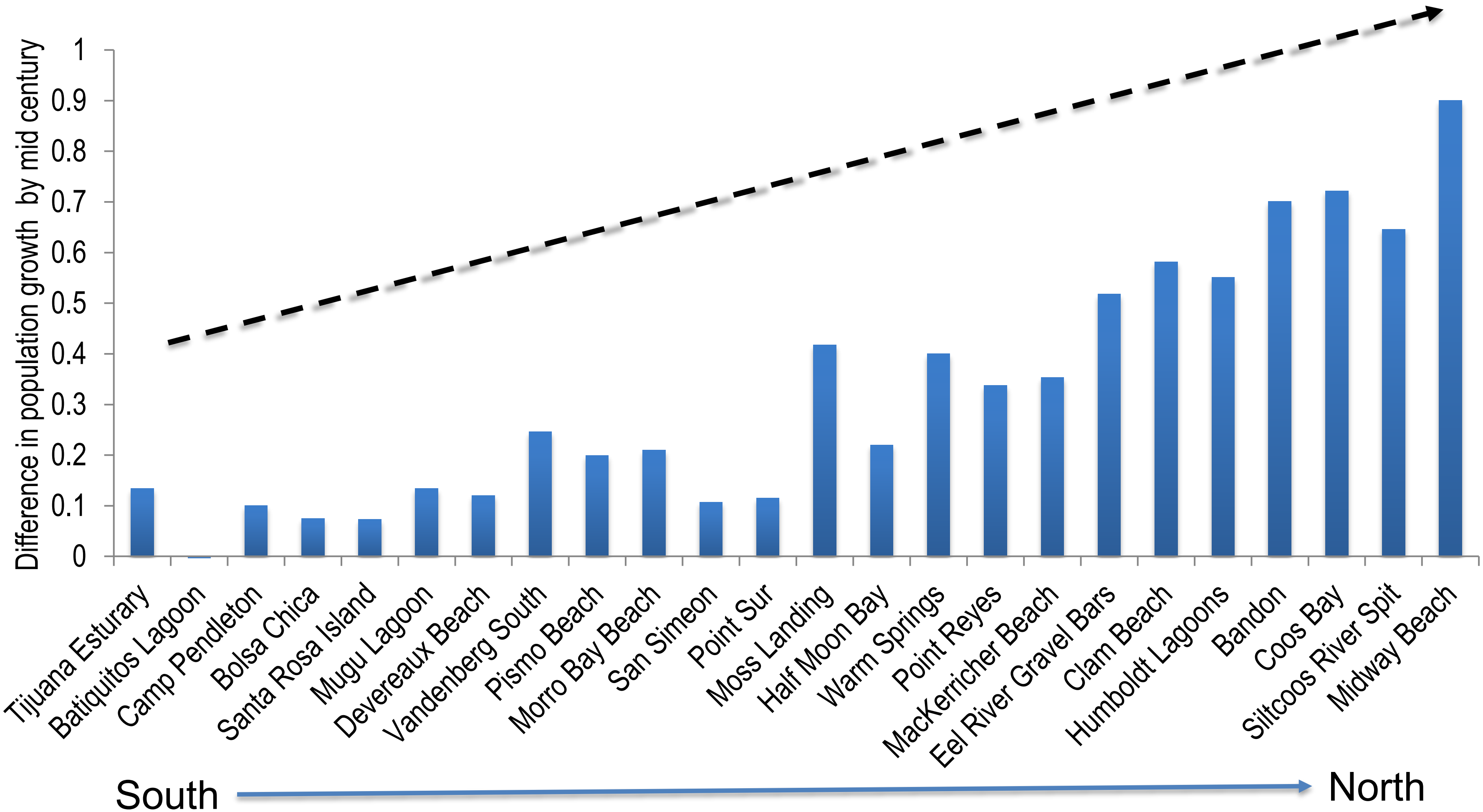
Results

Population Response Varies with Elevation



Results

Population Response Varies with Latitude



Results

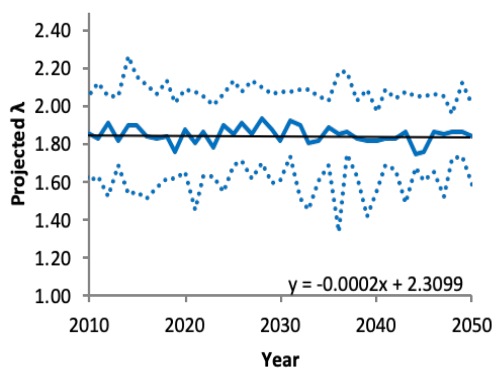
Population Response Varies by Geography

Rana aurora

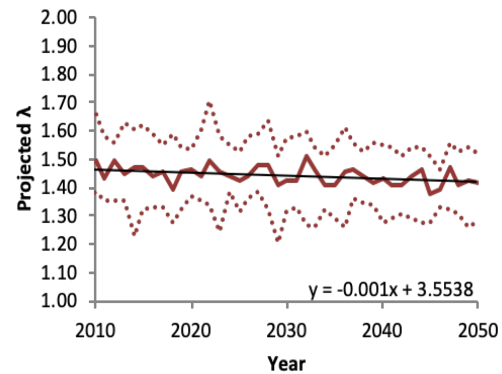
Rana draytonii

Coastal
Mild winter

Coastal NRLF 2

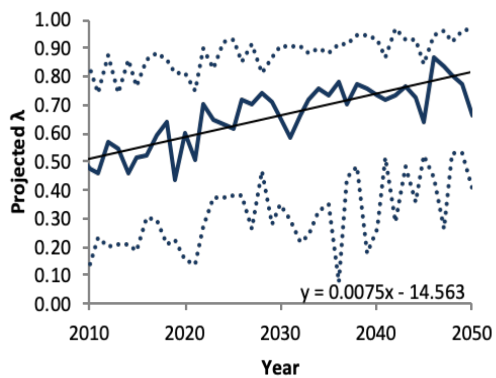


Coastal CRLF 2

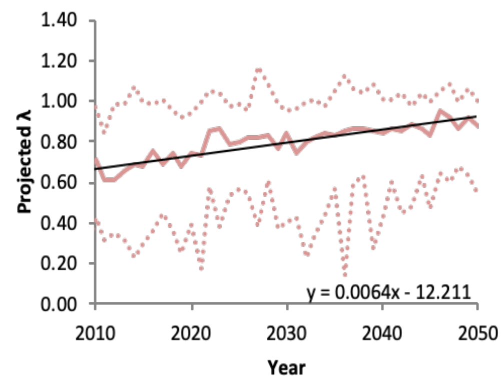


Interior
Cold winter

Inland NRLF 2

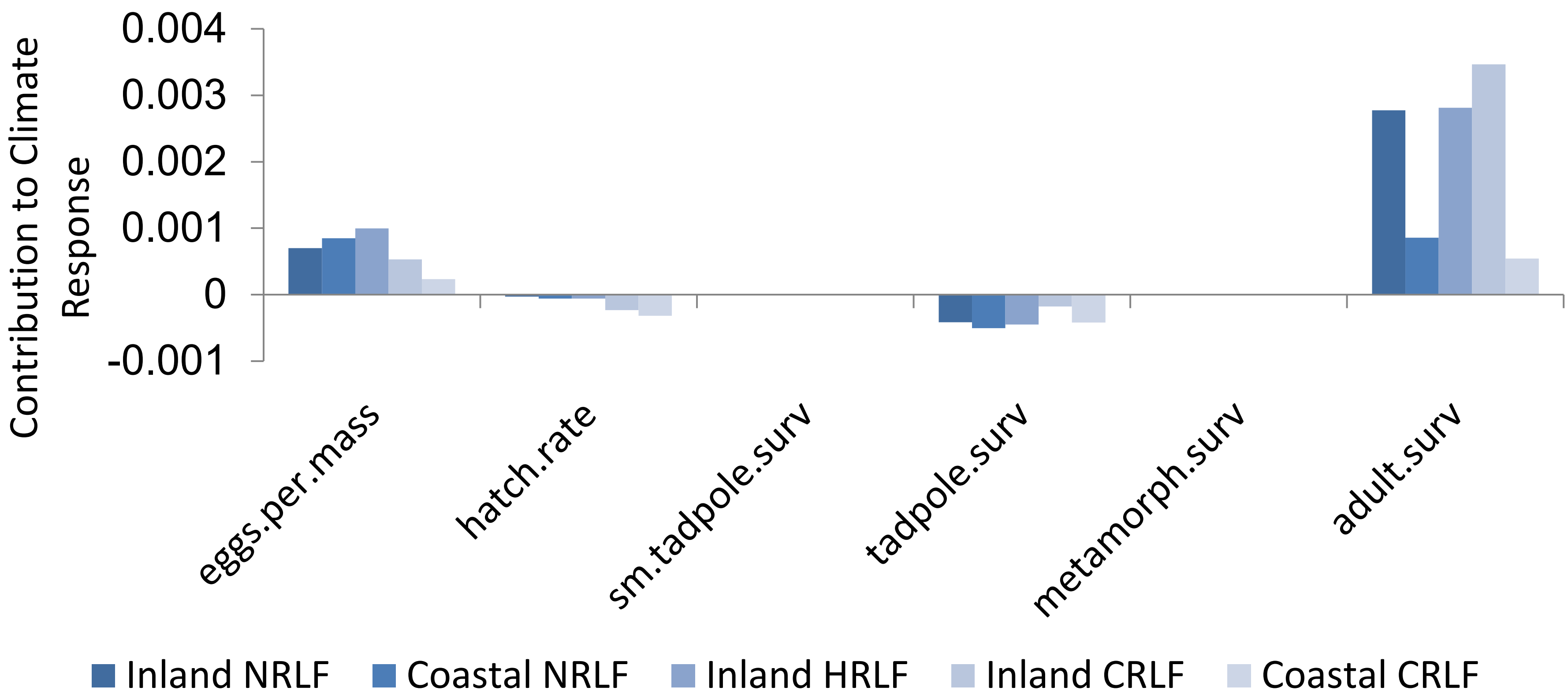


Inland CRLF 1



Results

Most Influential Life Stage Varies by Geography



Conclusions

- Predicting population specific risks requires integrating climate effects over entire life cycle
- Climate thresholds and interactions with non-climate variables common
- Most populations robust to climate change over next 20-30 years
- Geography better predictor of risk than taxonomy or ecology

Benefits to DoD

- Identified obstacles to determine projected climate change impacts
- Developed and demonstrated tools to overcome those obstacles
- Demonstrated that many North American species not likely to become conservation reliant due to climate change
- Demonstrated geographical patterns to which populations are likely to require greater conservation due to climate change

Acknowledgements

- Fort Bragg, Vandenberg Air Force Base, Camp Lejeune, Joint Base Elmendorf–Richardson, U.S. Army Corps of Engineers Portland District
- Humboldt Bay National Wildlife Refuge, Six Rivers National Forest
- U.C. Reserves, H.J. Andrews Experimental Forest
- PGE, MRC, GDRC

For additional information, please visit

https://serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Species-Ecology-and-Management/RC-2512

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Q&A Session 2

The next webinar is on March 25, 2021

Safer Alternatives for Surface Engineering and Structural Materials in Weapons Systems and Platforms

A Fred Lafferman Tribute Webinar

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