

Forecasting Invasions and Communicating Risks

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John Kartesz (BONAP), Becky Kao, Steve Aulenbach, Michael Keller, David Schimel (NEON)
Sharon Gross, Chandra Giri, Pam Fuller (USGS), Curt Flather (USFS),
Woody Turner (NASA) and many others!



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Created April 6, 2010

Thinking beyond your area, about multiple stressors, and into the future.

Climate Change

Land Use Change



They steal our ranch lands!



They steal our water!

Invasions from Coast to Coast

High Costs:

- Lost productivity
- More herbicides and pesticides
- Poor wildlife habitat
- Noxious weeds
- Increase labor costs
- Disease vectors

Total Costs:

\$120 Billion each year – and the problem is growing!



They can kill people!



They can steal headlines!

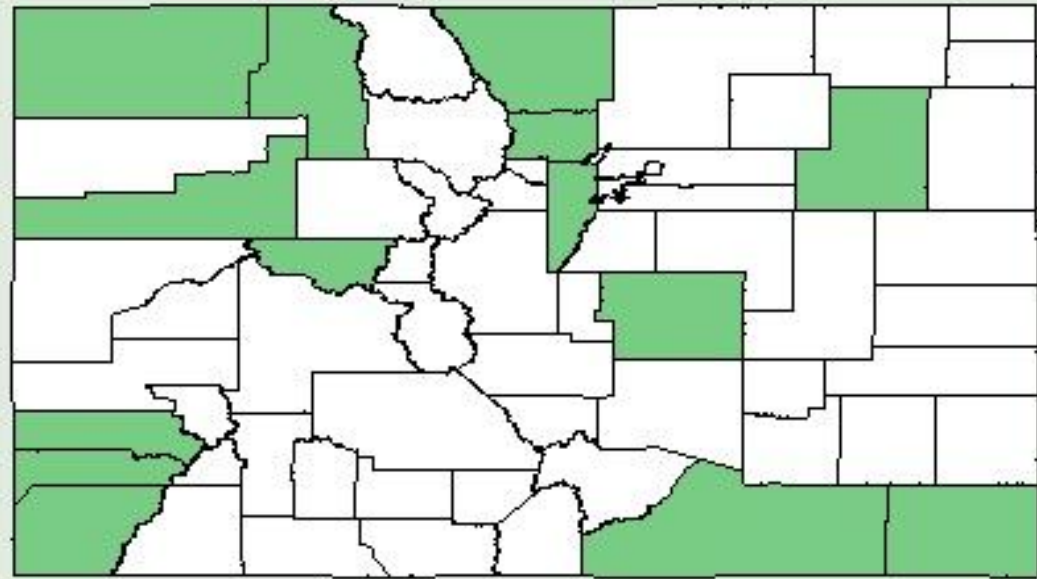
Other Invasive Plants, Animals, And Diseases

Disturbance Regimes Change

Examples of Point Distributions Maps and Species "Range" Maps on the Web

A screenshot of a web browser displaying the EDDMapS website. The page title is "kudzu (Pueraria montana) - EDDMapS Distribution". The URL is "http://www.eddmaps.org/florida/distribution/viewmap.cfm?sub=2425". The page features the EDDMapS logo and navigation tabs for "Distribution Maps", "Report Sightings", "Species Information", "Tools & Training", "My EDDMapS", and "About". The main content area shows "kudzu" with the scientific name "Pueraria montana var. lobata (Lour.) Merr." and a map of Florida with numerous red pins indicating sighting locations. The browser interface includes a search bar with "point distribution maps" and various toolbars.

Dalmation Toadflax Distribution in Colorado



PLANTS
Database

LIDA

A screenshot of the Robert W. Freckmann Herbarium website. The page title is "Lythrum salicaria L.: UW-Stevens Point Freckmann Herbarium: Detailed Distribution Map". The URL is "http://wisplants.uwsp.edu/scripts/maps.asp?spCode=LYTSAL". The page features the herbarium logo and navigation tabs for "Vascular Plants", "Plants of Wisconsin", "Home", and "New Search". The main content area shows "Lythrum salicaria L.: Detailed Distribution" with a map of Wisconsin showing green squares indicating distribution points. The browser interface includes a search bar with "point distribution maps" and various toolbars.

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NEON



neon

National Ecological Observatory Network, Inc.

Search this site: Search

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Welcome to NEON

The National Ecological Observatory Network (NEON) will collect data across the United States on the impacts of climate change, land use change and invasive species on natural resources and biodiversity. NEON is a project of the U.S. National Science Foundation, with many other U.S. agencies and NGOs cooperating.

NEON will be the first observatory network of its kind designed to detect and enable forecasting of ecological change at continental scales over multiple decades. The data NEON collects will be freely and openly available to all users.

For more information, go to [About NEON, Inc.](#) Thanks for visiting!

Start | Inbox - Microsoft Outlook | Mail - Windows Internet ... | NEON - Windows Inter... | 11:42 AM

CLICK ON: SCIENCE then Science Overview

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National Ecological Observatory Network, Inc.

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Science Overview
Data Products
Organisms
Atmosphere, Soil, and Water
Airborne Observations
Maps and Historical Data
Stream Experiment

Overview

In an era of rapid environmental change, and other human activities, we must understand how the biosphere – the living part of earth – is changing and how humans depend on a diverse set of biosphere services and products, including air, water, food, fiber, and fuel. These services could alter the quality of human life in many parts of the world.

To help us understand our quality of life on this planet, we must develop a more holistic understanding of how biosphere services are affected by human impacts. This cannot be investigated using disconnected studies on individual sites or over short periods. Long-term monitoring programs that collect data to meet natural resource management objectives are not designed to address these new, complex environmental challenges.

NEON, the first continental-scale ecological observatory, will provide comprehensive data that will allow scientists to address these issues.

The First Continental Ecological Observatory

NEON will be the first observatory designed to detect and enable forecasting of ecological change at continental scales over multiple decades.

NEON will use distributed sensor networks, coordinated airborne observations and experiments, linked by advanced cyberinfrastructure, to collect ecological data across the continental United States, Alaska, Hawaii and Puerto Rico. More in-depth detail about NEON's design and strategy plans can be found in "[The NEON Strategy](#)".

http://www.neoninc.org/science/overview

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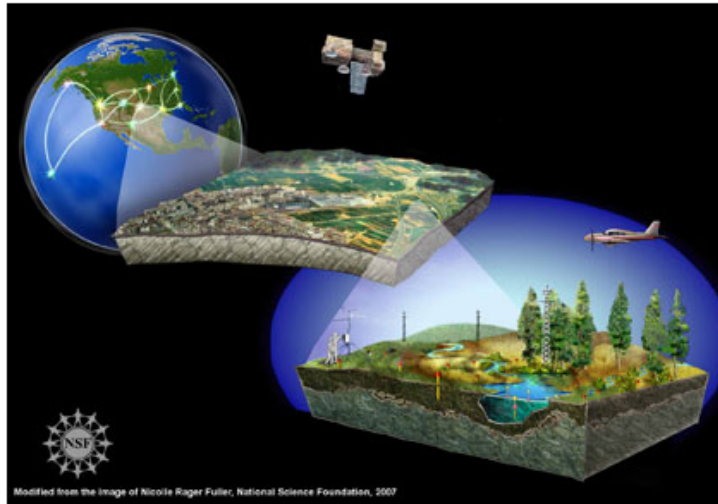
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Overview of NEON Science | NEON

The First Continental Ecological Observatory

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NEON has partitioned the U. S. into **20 eco-climatic domains**, each of which represents different regions of vegetation, landforms, climate, and ecosystem performance. In those domains, NEON will collect site-based data about **climate and atmosphere, soils and streams and ponds**, and a **variety of organisms**. Additionally, NEON will provide a wealth of regional and national-scale data from **airborne observations** and **geographical data** collected by Federal agencies and processed by NEON to be accessible and useful to the ecological research community. NEON will also manage a long-term multi-site **stream experiment** and provide a platform for future observations and experiments proposed by the scientific community.

The data collected and generated across NEON's network – all day, every day, over a period of 30 years — will be synthesized into information products that can be used to describe changes

in the nation's ecosystem through space and time. It will be readily available in many formats to scientists, educators, students, decision makers and the general public.

Benefits to the Nation

Click on: DOMAINS then Overview

Overview of NEON Domains and Observatory Sites | NEON - Windows Internet Explorer

http://www.neoninc.org/domains/overview

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Overview of NEON Domains and Observatory Sites | ...

12: Northern Rockies
13: Southern Rockies-Colorado Plateau
14: Desert Southwest
15: Great Basin
16: Pacific Northwest
17: Pacific Southwest
18: Tundra
19: Taiga
20: Pacific Tropical

Taken together, the core sites represent a baseline for ecological conditions that can be compared to one another or to the conditions at the relocatable sites. These comparisons at both the domain and national levels will provide critical information that can be used to test ecological models and to identify the impacts of land use change and invasive species on ecology.

NEON Domains

1 Northeast	5 Great Lakes	9 Northern Plains	13 Southern Rockies/Colorado Plateau	17 Pacific Southwest
2 Mid Atlantic	6 Prairie Peninsula	10 Central Plains	14 Desert Southwest	18 Tundra
3 Southeast	7 Appalachians/Cumberland Plateau	11 Southern Plains	15 Great Basin	19 Taiga
4 Atlantic Neotropical	8 Ozarks Complex	12 Northern Rockies	16 Pacific Northwest	20 Pacific Tropical

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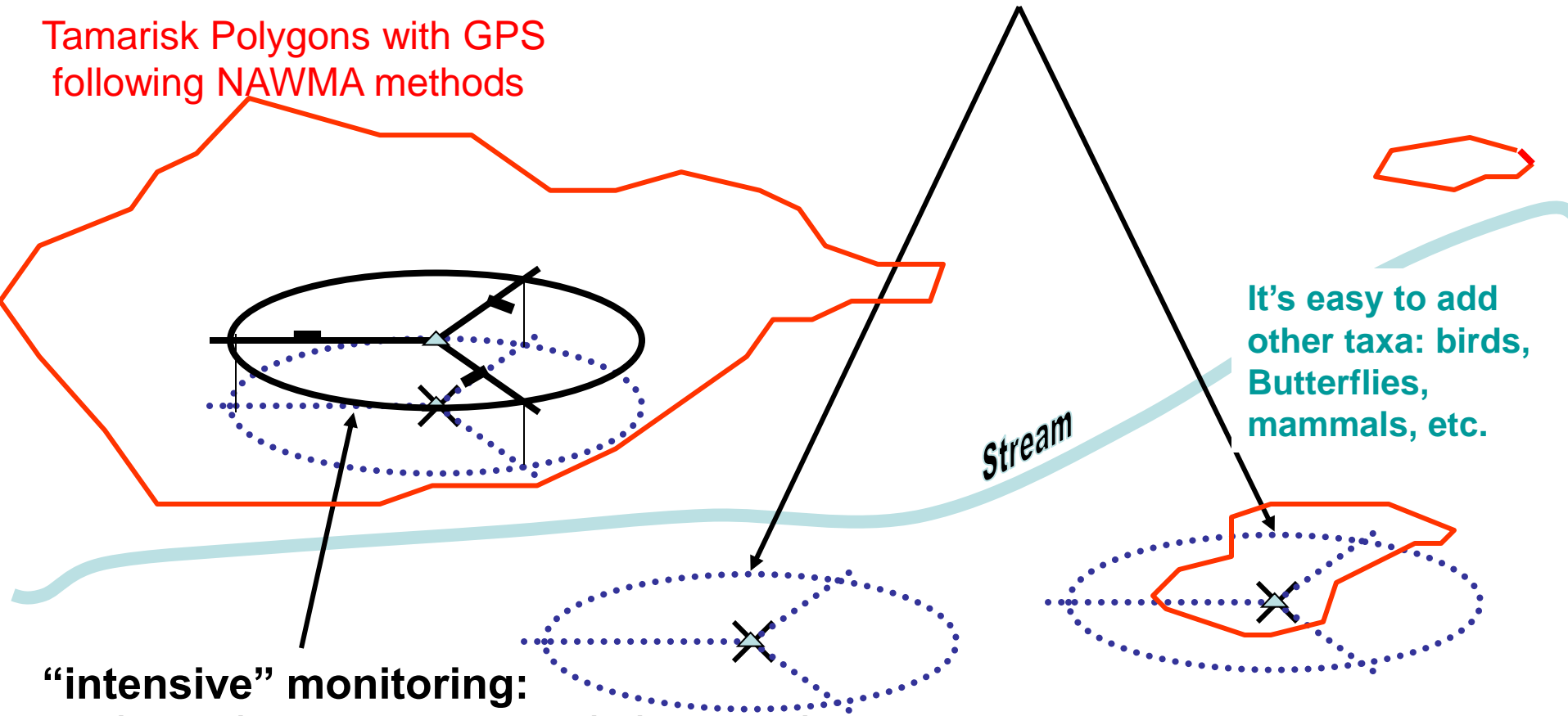
Standard Survey and Monitoring Design (7.3-m radius plots plus ancillary data)

See www.NAWMA.org
USDA FIA design

“extensive” sampling:

- Verify and validate current and potential distribution maps.
- To map and model tamarisk (and other invaders) presence, absence and estimated cover of tamarisk from local to regional and national scales

Tamarisk Polygons with GPS
following NAWMA methods



It's easy to add
other taxa: birds,
Butterflies,
mammals, etc.

“intensive” monitoring:

- multi-scale circular plot collect quantitative and ancillary data on pre- and post control and restoration efforts.
- quality control of extensive sampling effort following “Beyond NAWMA methods”

More Getting the Data from Citizen Scientists



National Bison Range

Add Professional “Layer”

- Verify observations
- Evaluate sources of error
- Add vegetation plots (stratified random and gradient plots) **or other taxa!**
- Integrate data, maps, and models.
- Share results and make recommendations for future surveys, control, and restoration.

Mapping with Volunteers

- Explain objectives, limitations
- GPS training
- Structured datasheets (palmtops)
- Species ID tools and pictures
- one professional in each group
- provide test sessions
- data input to larger database
- “see the dots, maps, and models”



San Pablo Bay NWR

<http://ibis-live.nrel.colostate.edu/NEON/>

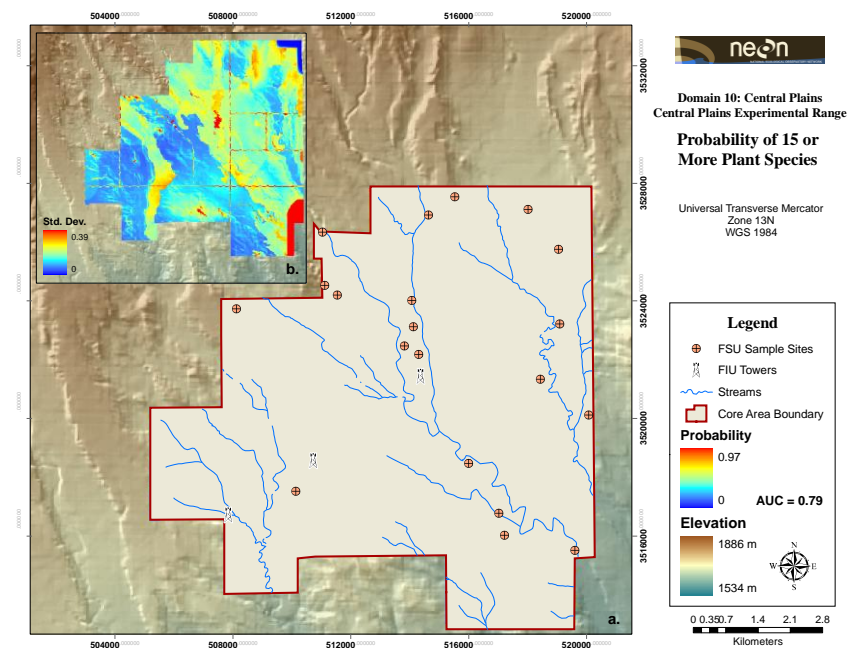
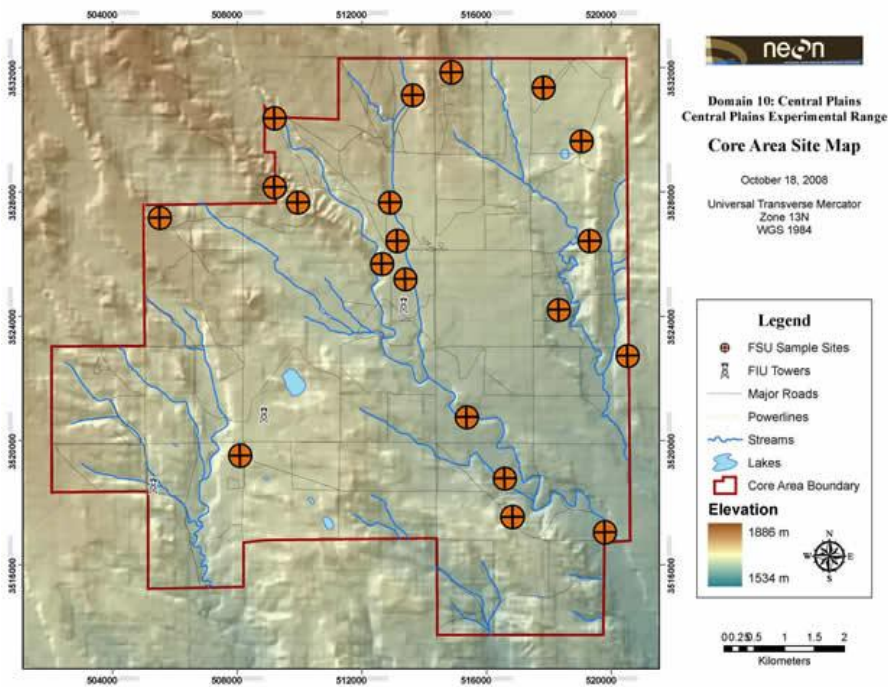
Tools for Data Exploration,
Mapping, and Modeling

• Take a virtual field trip

• Capture vegetation data

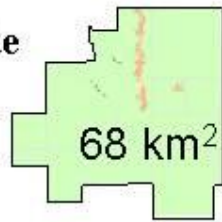
Vegetation Type:	Plant List	Average Cover
Cultivated Crops	<i>Atriplex canescens</i>	23.33
	<i>Bouteloua gracilis</i>	5.00
	<i>Carex stenophylla</i> ssp.	1.57
	<i>Koeleria gracilis</i>	1.17
	<i>Lappula redowskii</i>	0.50
	<i>Sarcobatus vermiculatus</i>	31.67
	<i>Salsola pestifer</i>	18.50
	<i>Sporobolus cryptandrus</i>	1.57

Vegetation Type:	Plant List	Average Cover
Cultivated Crops	<i>Atriplex canescens</i>	4.57
	<i>Carex stenophylla</i> ssp.	5.57
	<i>Koeleria gracilis</i>	42.00
	<i>Pascopyrum smithii</i>	19.00
	<i>Salsola pestifer</i>	0.17
	<i>Sisymbrium officinalis</i>	1.00
	<i>Sporobolus cryptandrus</i>	0.17

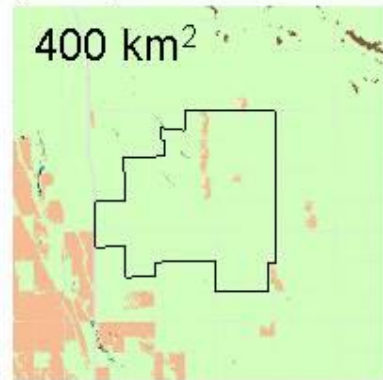


Barnett, D. T., T. J. Stohlgren, C. S. Jarnevich, G. W. Chong, J. A. Ericson, T. R. Davern, and S. A. Simonson. 2007. The art and science of weed mapping. Environmental Monitoring and Assessment. DOI: 10.1007/s10661-006-9530-0.

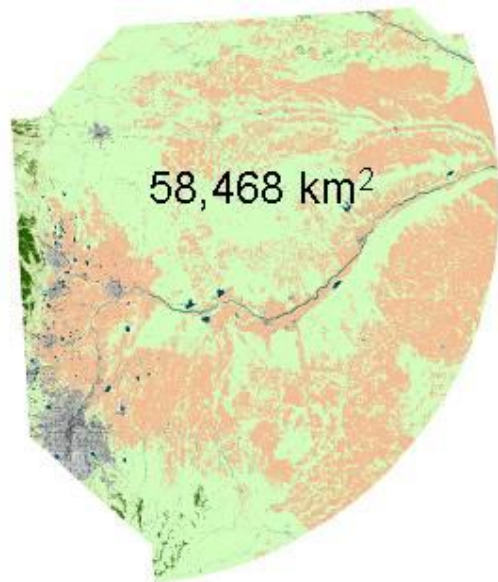
Core site



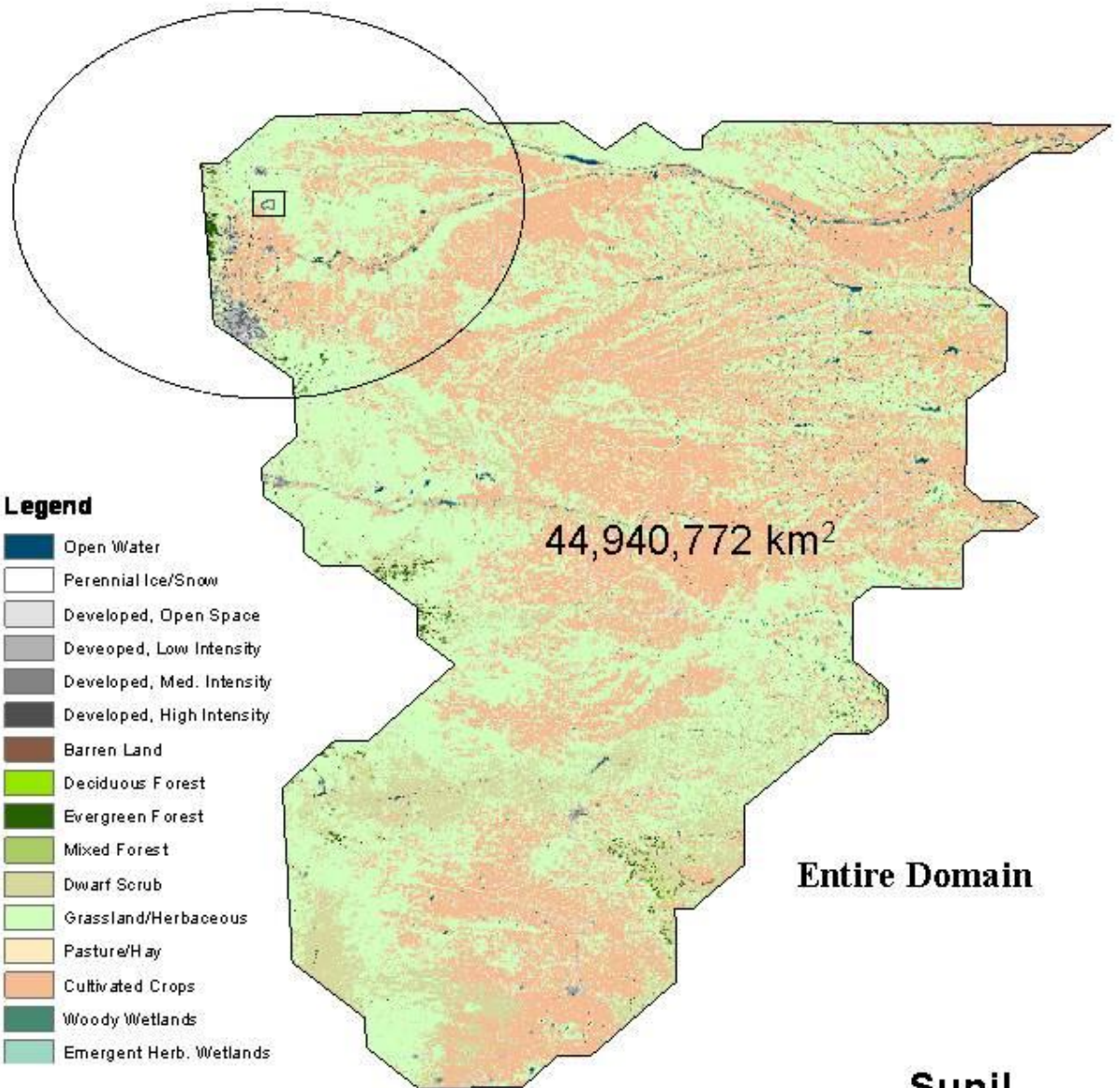
20x20 km (AOP)



200 km radius



Domain#10: Central Plains_CPER



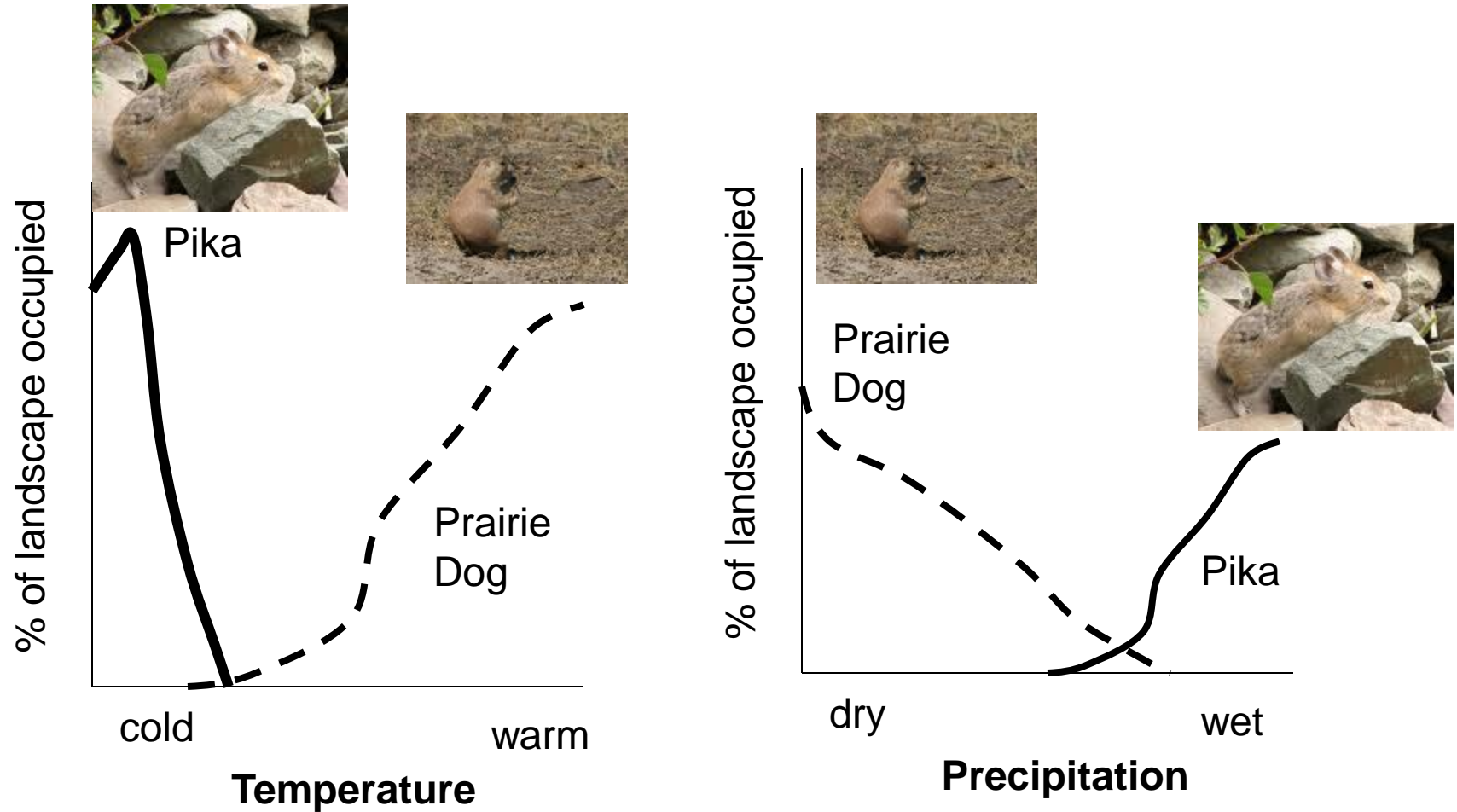
Legend

- Open Water
- Perennial Ice/Snow
- Developed, Open Space
- Developed, Low Intensity
- Developed, Med. Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Dwarf Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herb. Wetlands

Entire Domain

Sunil

Modeling Species Habitats



What happens if the climate becomes warmer and drier?

NEON is after the drivers!

Response variable

- Presence only
- Presence with pseudo-absence
- Presence-absence
- Count/abundance



Predictor variables

Different environmental variables such as:

- Topographic
- Climatic
- Soil
- Geology
- Disturbance



Model algorithm

Different modeling methods such as:

- Maxent
- GARP
- Multiple regression
- Logistic regression
- CART

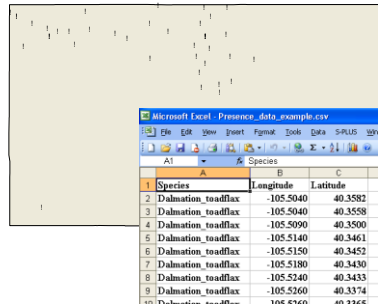
Model evaluation
Model validation

Model predictions

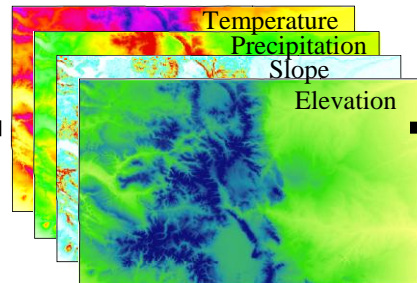
- Map of probability of occurrence
- Map of predicted count/abundance

Example: Potential habitat distribution of invasive plant dalmation toadflax (*Linaria dalmatica*) in Colorado, USA

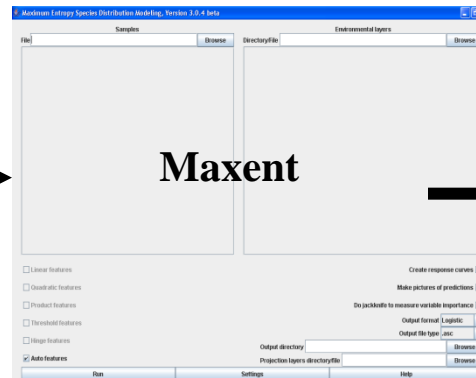
Presence data



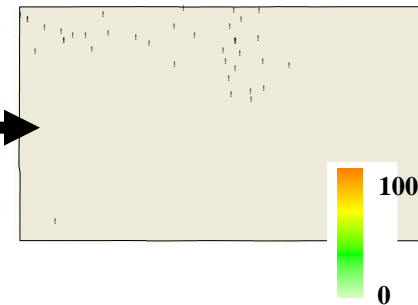
Environmental layers



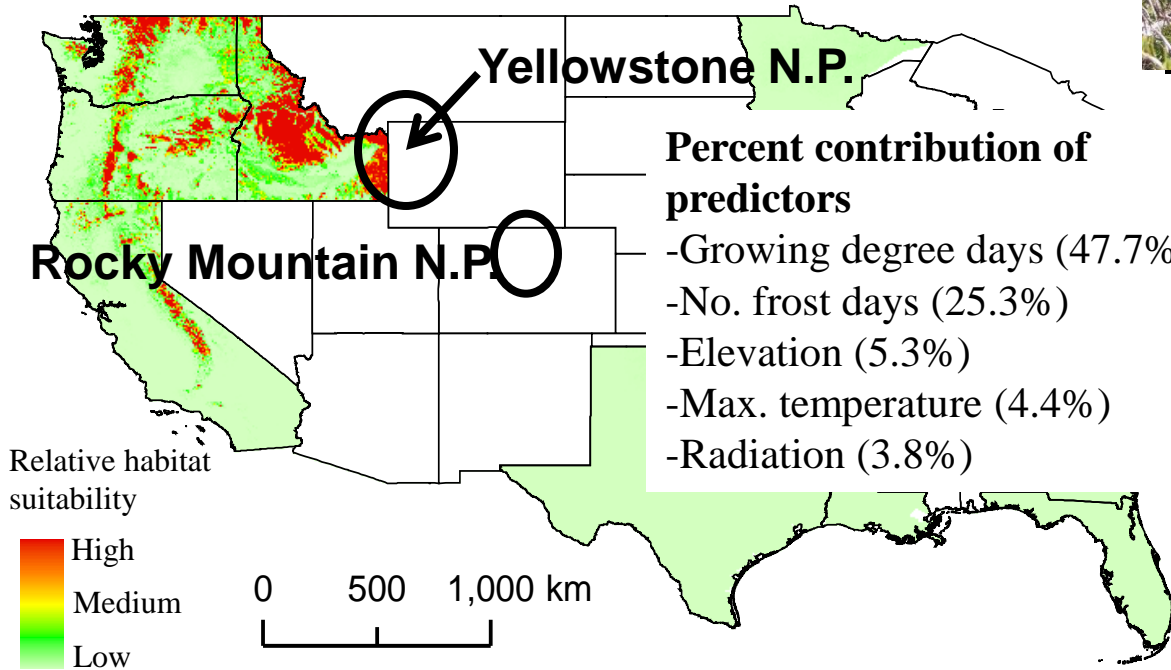
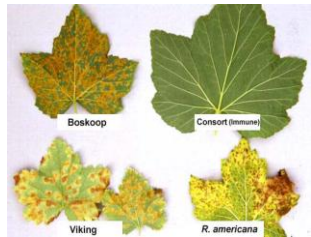
Maxent



Predicted probability

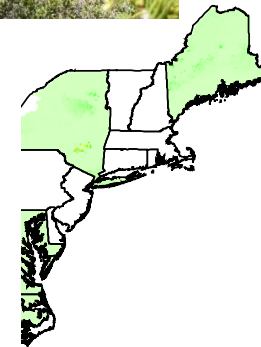


Potential habitat distribution for White Pine Blister Rust (*Cronartium ribicola*) in the Western United States



Percent contribution of predictors

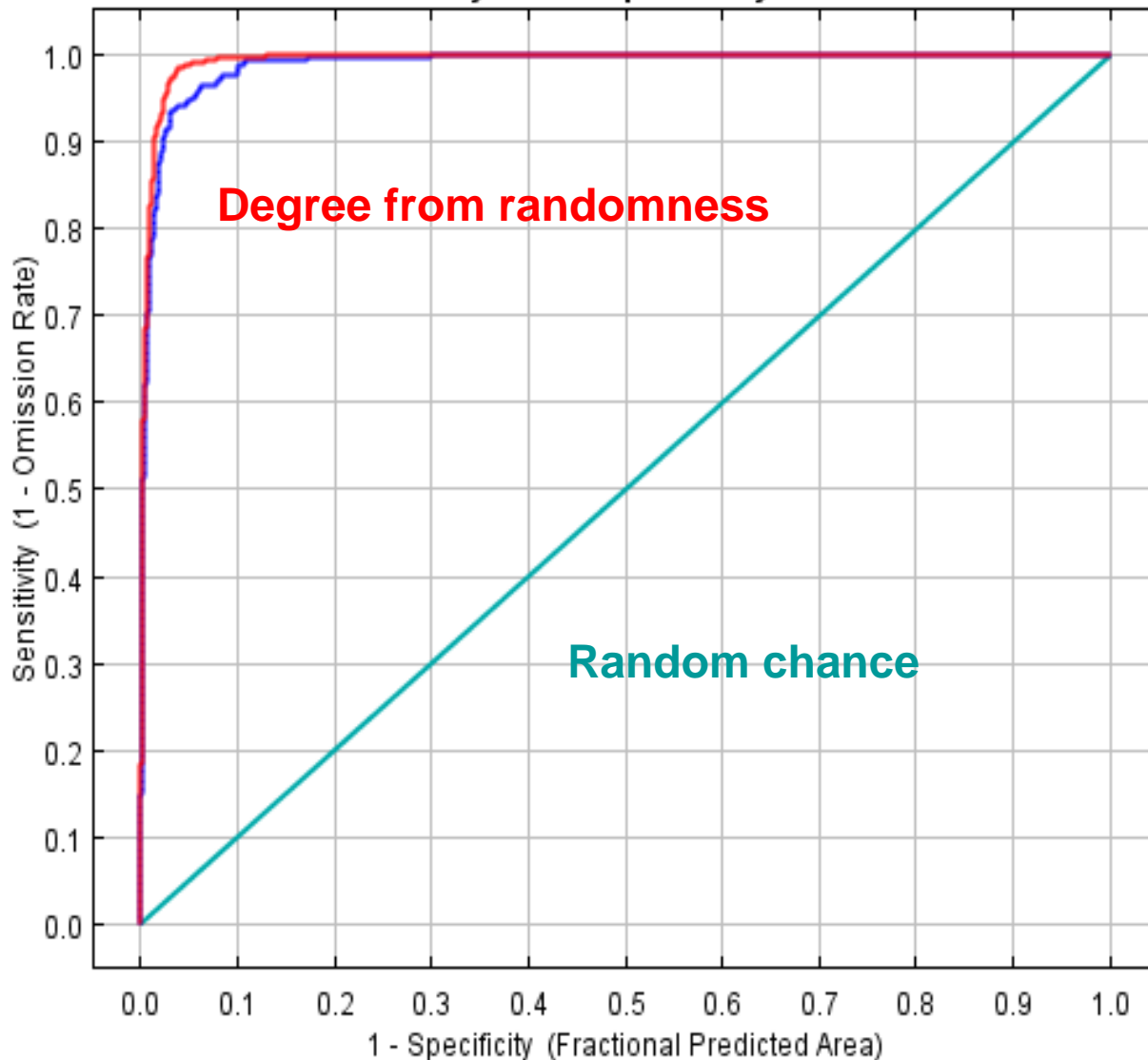
- Growing degree days (47.7%)
- No. frost days (25.3%)
- Elevation (5.3%)
- Max. temperature (4.4%)
- Radiation (3.8%)



AUC = 0.99
75% data Training
25% data Testing

Maxent

Sensitivity vs. 1 - Specificity for WPBR

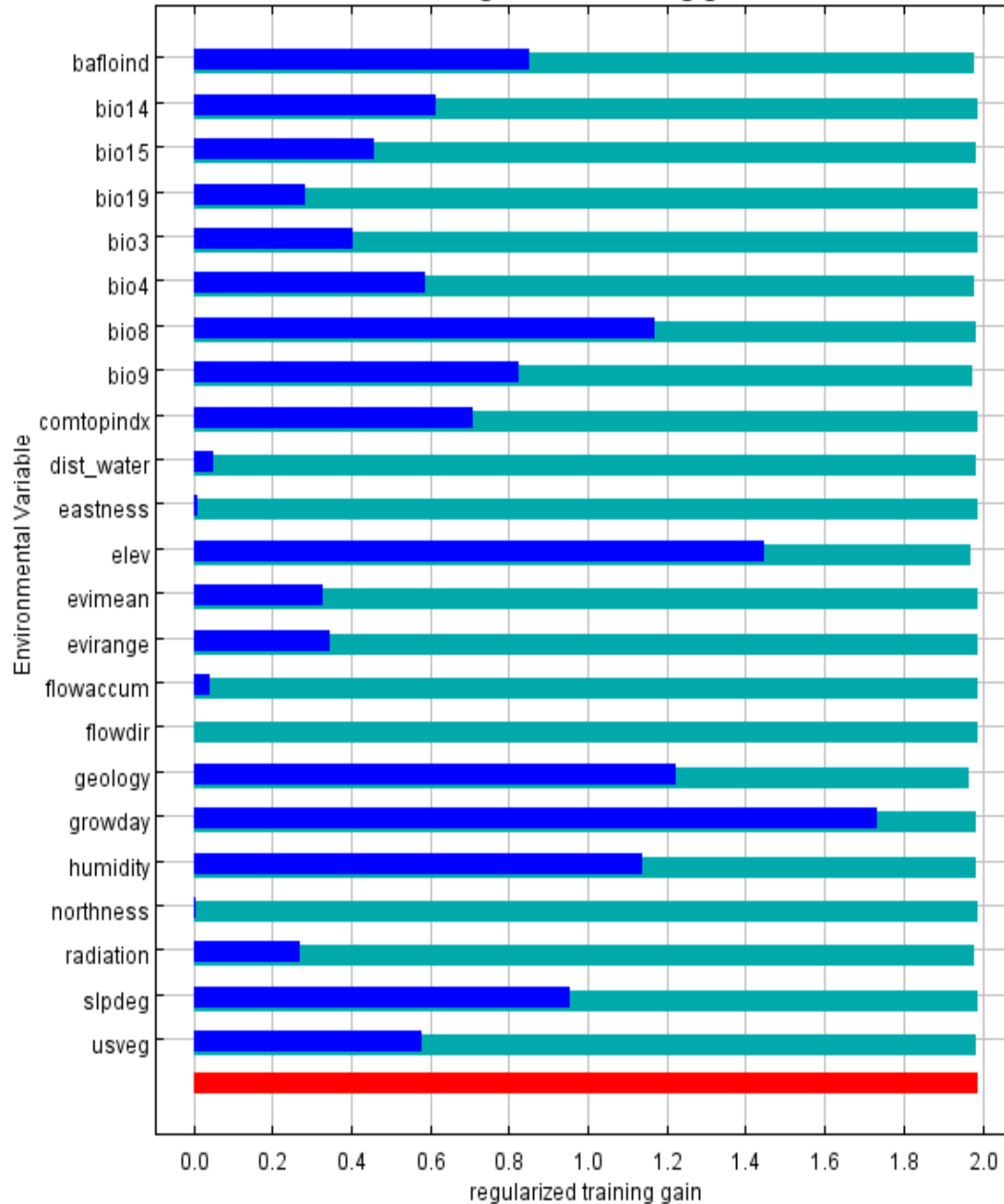


Wow, 99% accuracy!

- Training data (AUC = 0.994) ■
- Test data (AUC = 0.989) ■
- Random Prediction (AUC = 0.5) ■

75% data for Training (720)
25% data for Testing (240)

Jackknife of regularized training gain for WPBR



3. Seasonality

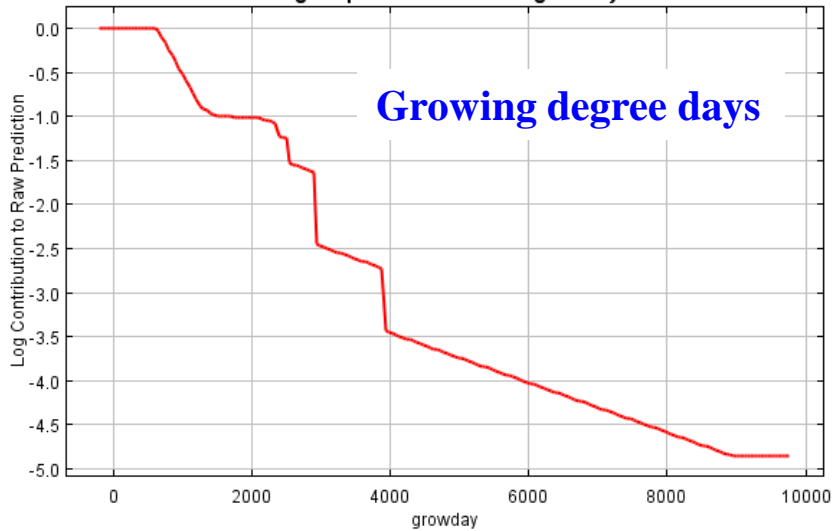
2. Elevation

4. Geology

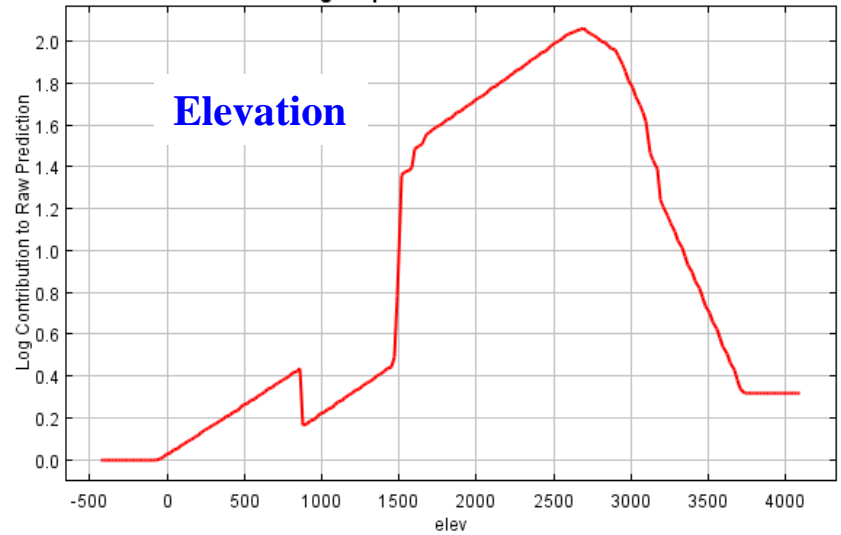
1. Growing degree days

5. Humidity

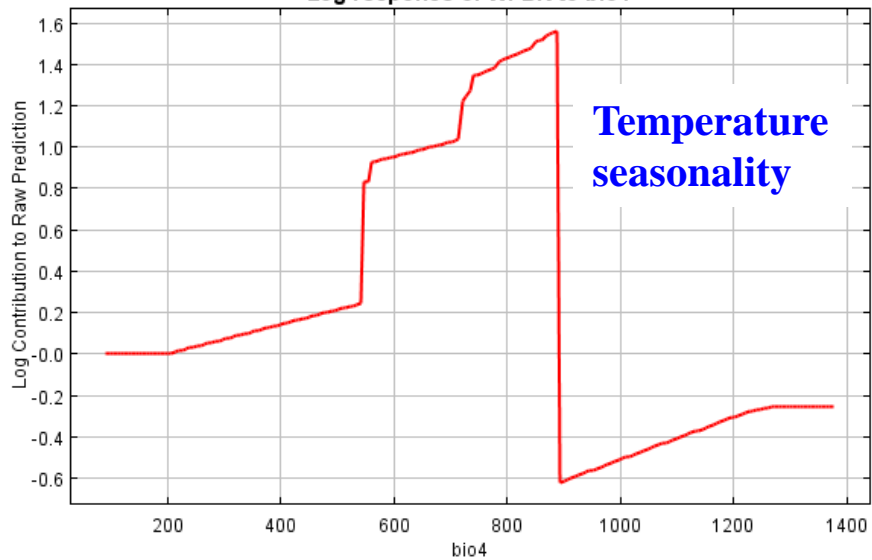
Log response of WPBR to growday



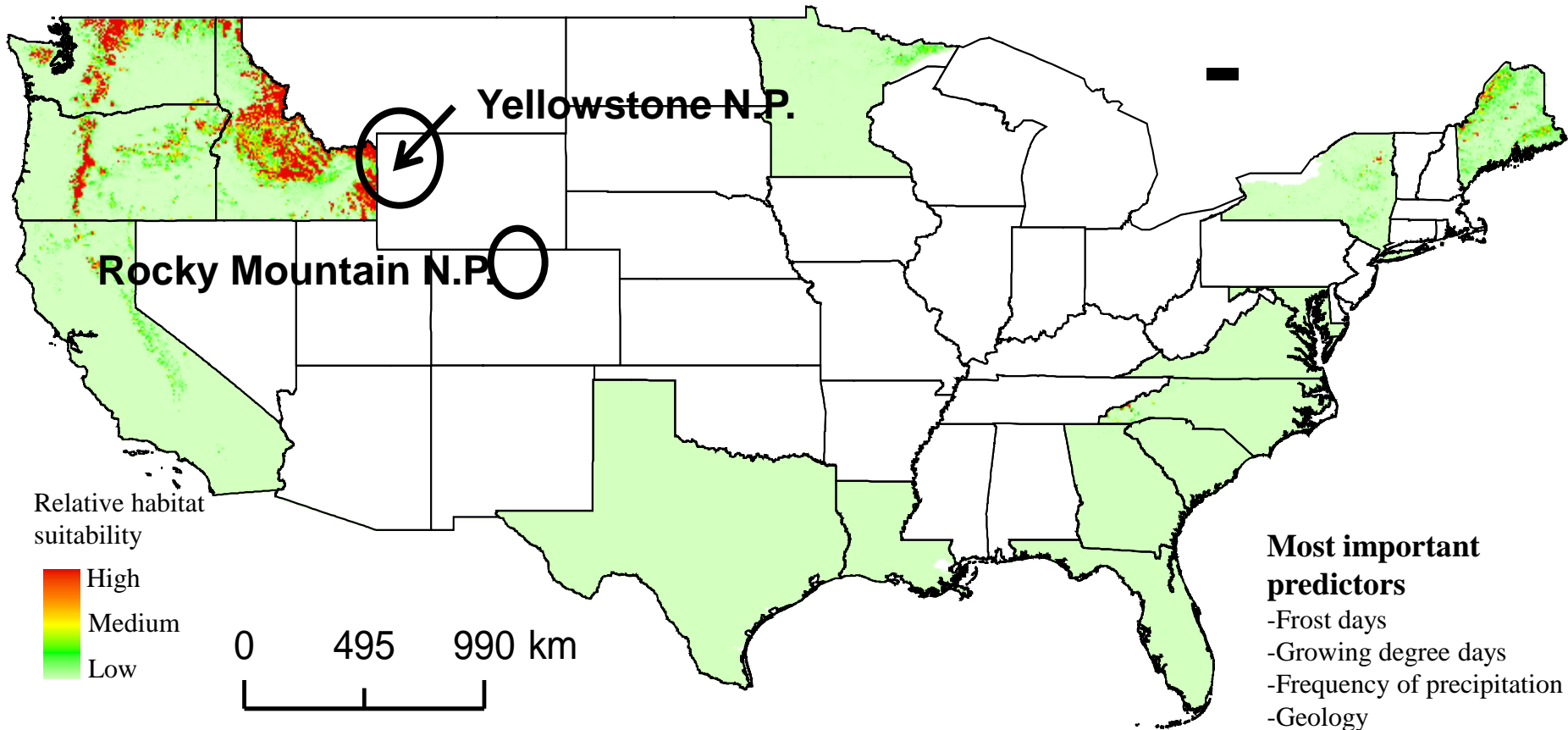
Log response of WPBR to elev



Log response of WPBR to bio4



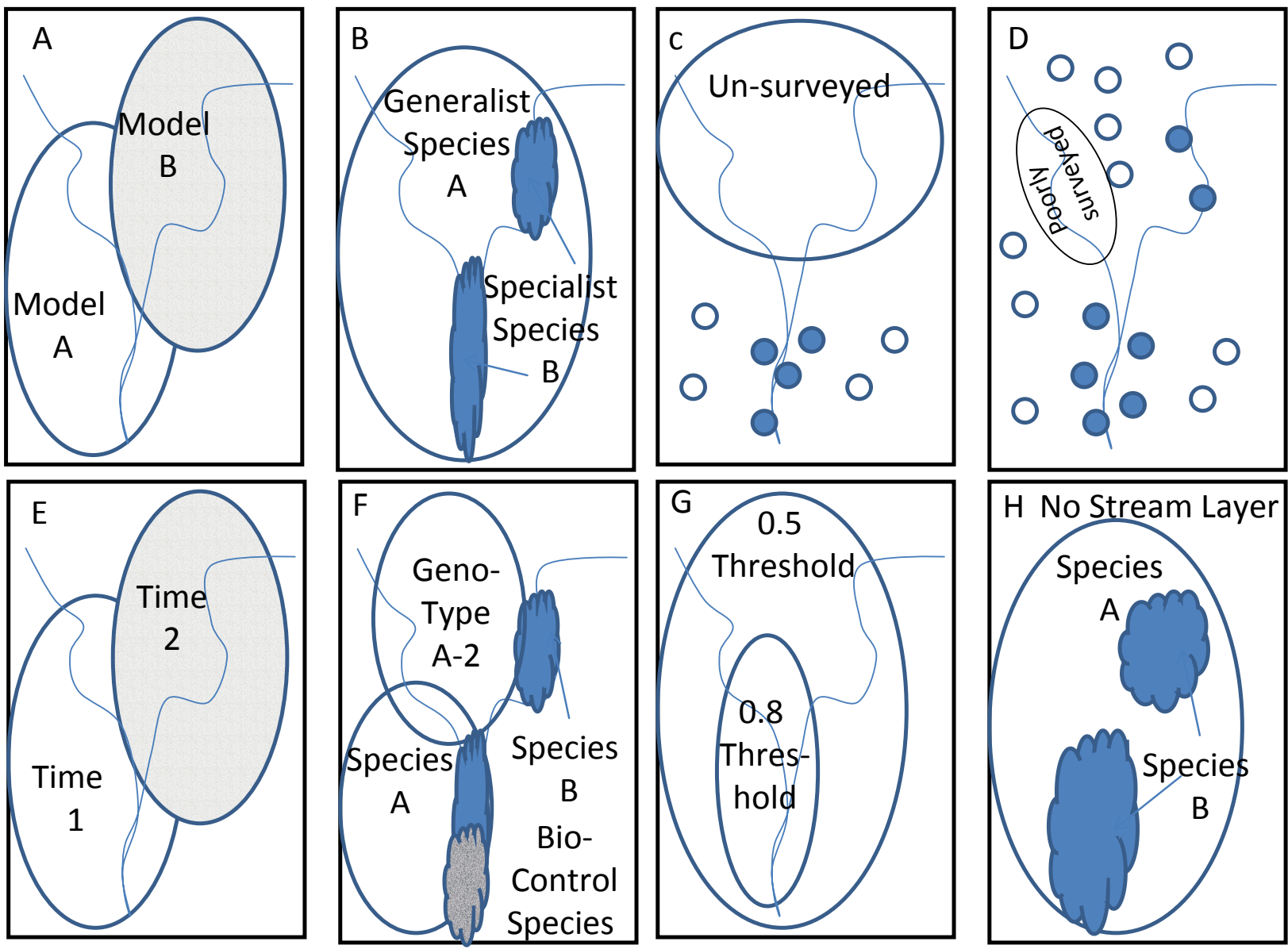
Potential habitat distribution for $\geq 90\%$ infected trees (by White Pine Blister Rust)



[Http://www.NIISS.org](http://www.NIISS.org)

- Let's run a model in real time.
- **In the actual webinar, I demonstrated a Beta Version of our online system for running and teaching scalable models in ecology, presenting introductions to species-environmental mapping, integration of mathematics and statistics with geographic information systems, and “investigations” in drivers of change such as climate change, land use change and invasion.**

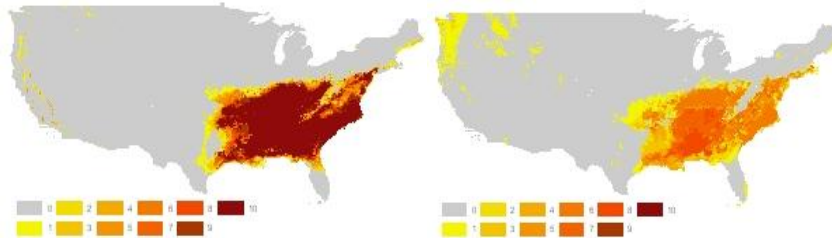
Caveats and Issues, Warts and all!



Jarnevich, CS, S Kumar, TJ Stohlgren, and J Morisette. 2009. Caveats for species distribution modeling. *Ecography*. In Review.

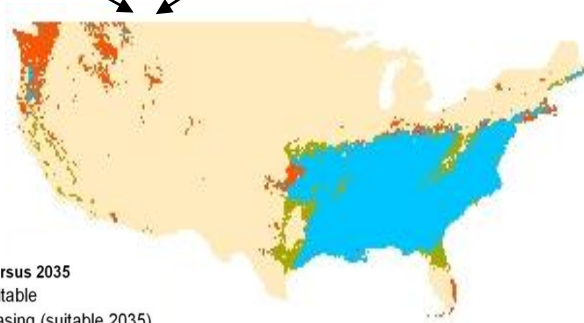
Climate Change Examples:

Risk analysis for northern expansion of Kudzu



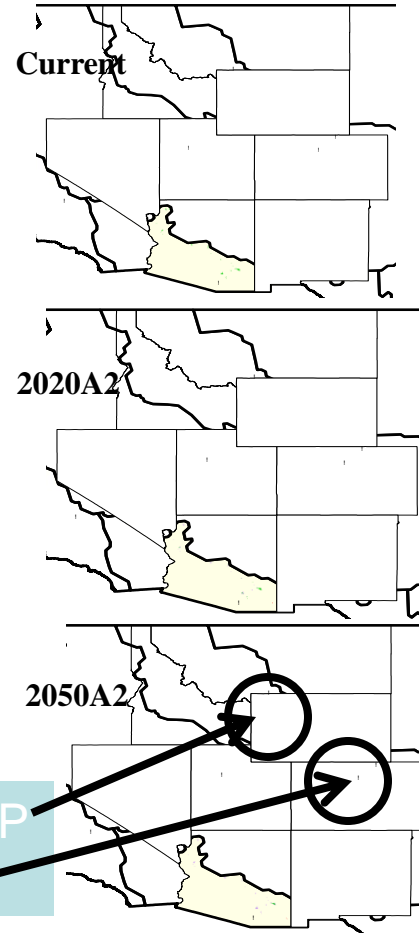
Current versus 2035

- Unsuitable
- Increasing (suitable 2035)
- Decreasing (suitable current)
- Stable (suitable both)



Yellowstone NP
Rocky Mt. NP

Mountain Pine Beetle



Average Test AUC = 0.898 (± 0.003)

- Unsuitable
- Decreasing
- Stable
- NEON Core Site



Jarnevich, C. S. and T. J. Stohlgren. 2009. Near term climate projections for invasive species distributions. *Biological Invasions* 11:1373-1379.



Where we can help. . .

Potential *Python molurus* range in US based on native range



Don't set your pet free here!

Suitability classification

	Suitable		Too dry in clim3
	Too dry		Too cold in clim4
	Too cold		Too cold in clim3
	States		

Current Distribution



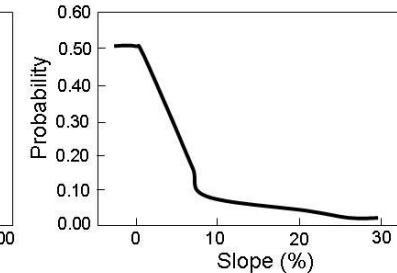
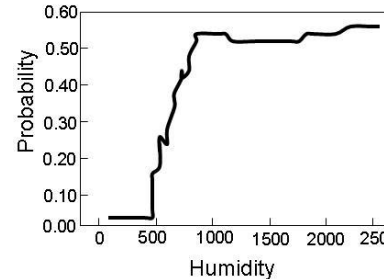
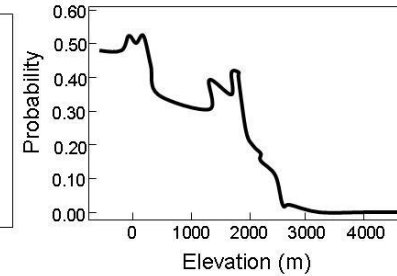
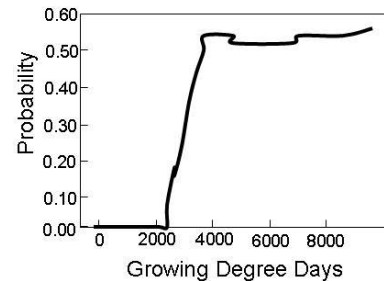
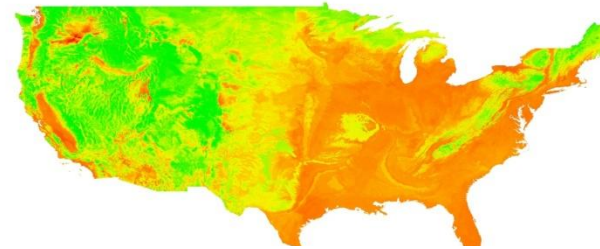
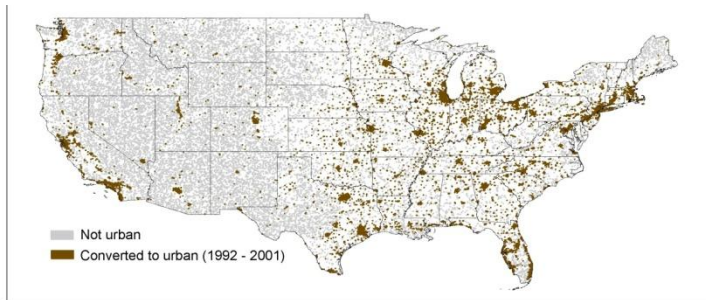
Rodda et al. 2009.
 What parts of the US
 mainland are
 climatically suitable
 for invasive alien
 pythons spreading
 from Everglades
 National Park?
 Biological Invasions
 11:241-252.

Modeling the Human Invader

We looked at changes in “urban” 30m cells from LANDSAT from 1992 to 2001.

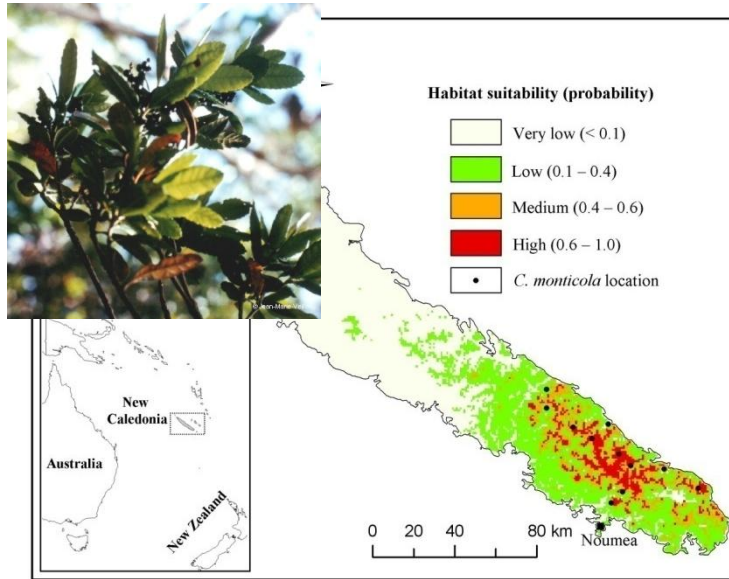
Urbanization increased 7.5% (18,112 km²) in the nine year period--an area the size of Massachusetts.

The spread of humans is easily predicted from growing degree days, elevation, humidity, and slope.

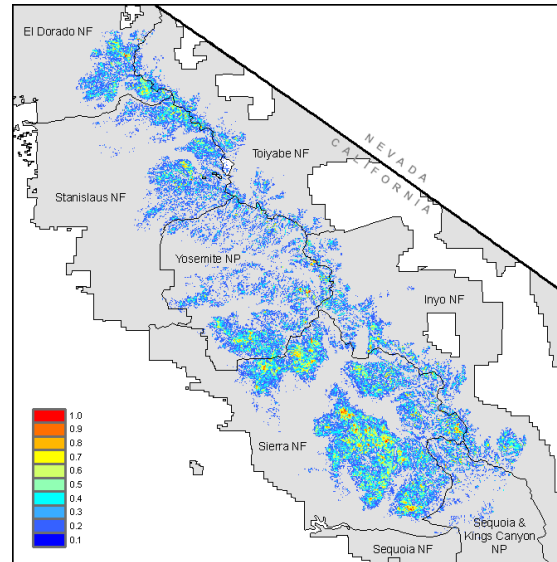


Stohlgren, T.J, C.S. Jarnevich, and C. Giri. Modeling the spread of the human invader in the United States using remote sensing time series. *J. Applied Remote Sensing* (In Press).

Threatened and endangered tree *Canacomyrica monticola* in New Caledonia



Mapping and modeling metapopulations: a case study of the Yosemite toad



Land use
interactions with
forest harvests
and fire
perimeters

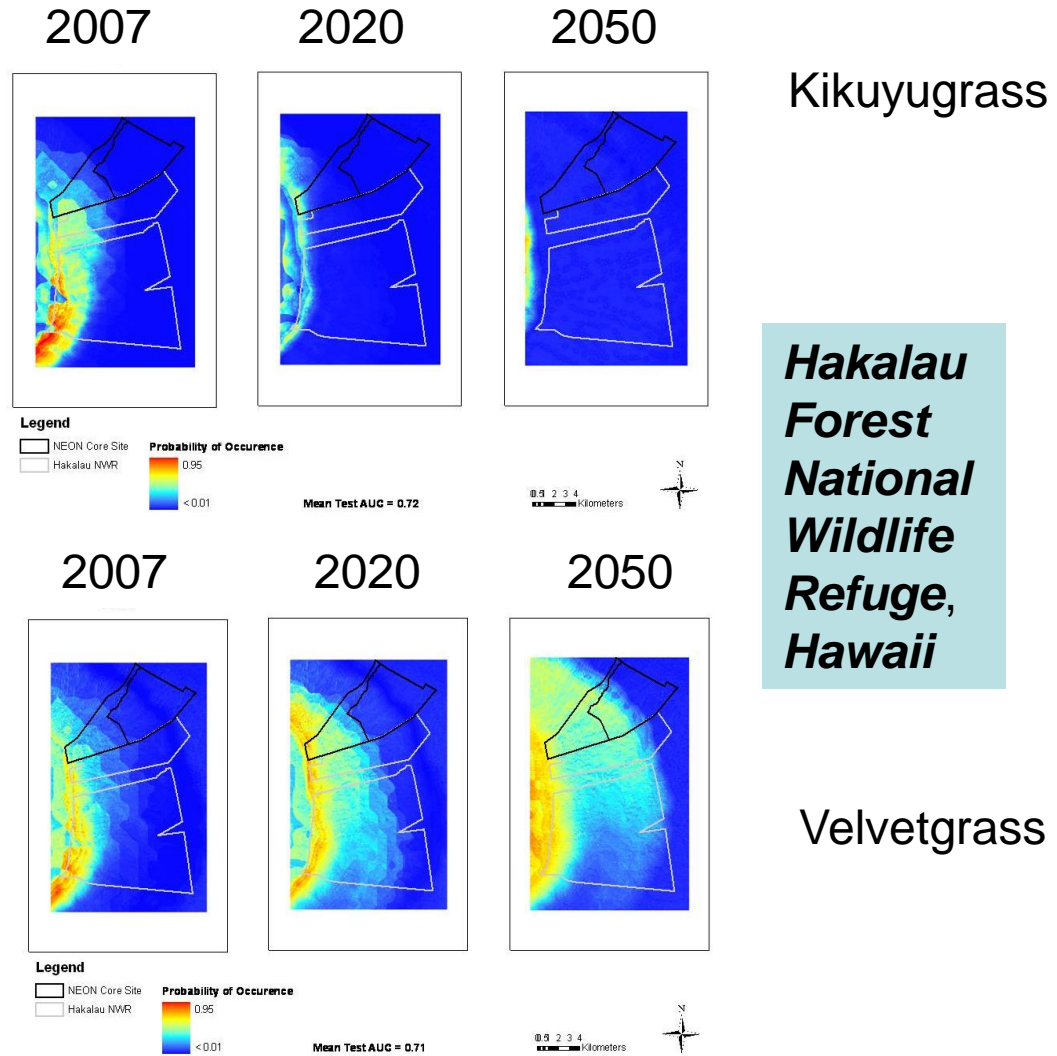
Sunil Kumar and Thomas J. Stohlgren, 2009. *Journal of Ecology and Natural Environment* Vol. 1(4), pp. 094-098, July, 2009

Liang, C. T., and T.J. Stohlgren. 2009. Mapping and modeling metapopulations: a case study of the Yosemite toad. For *Conservation Biology*. (In Review).

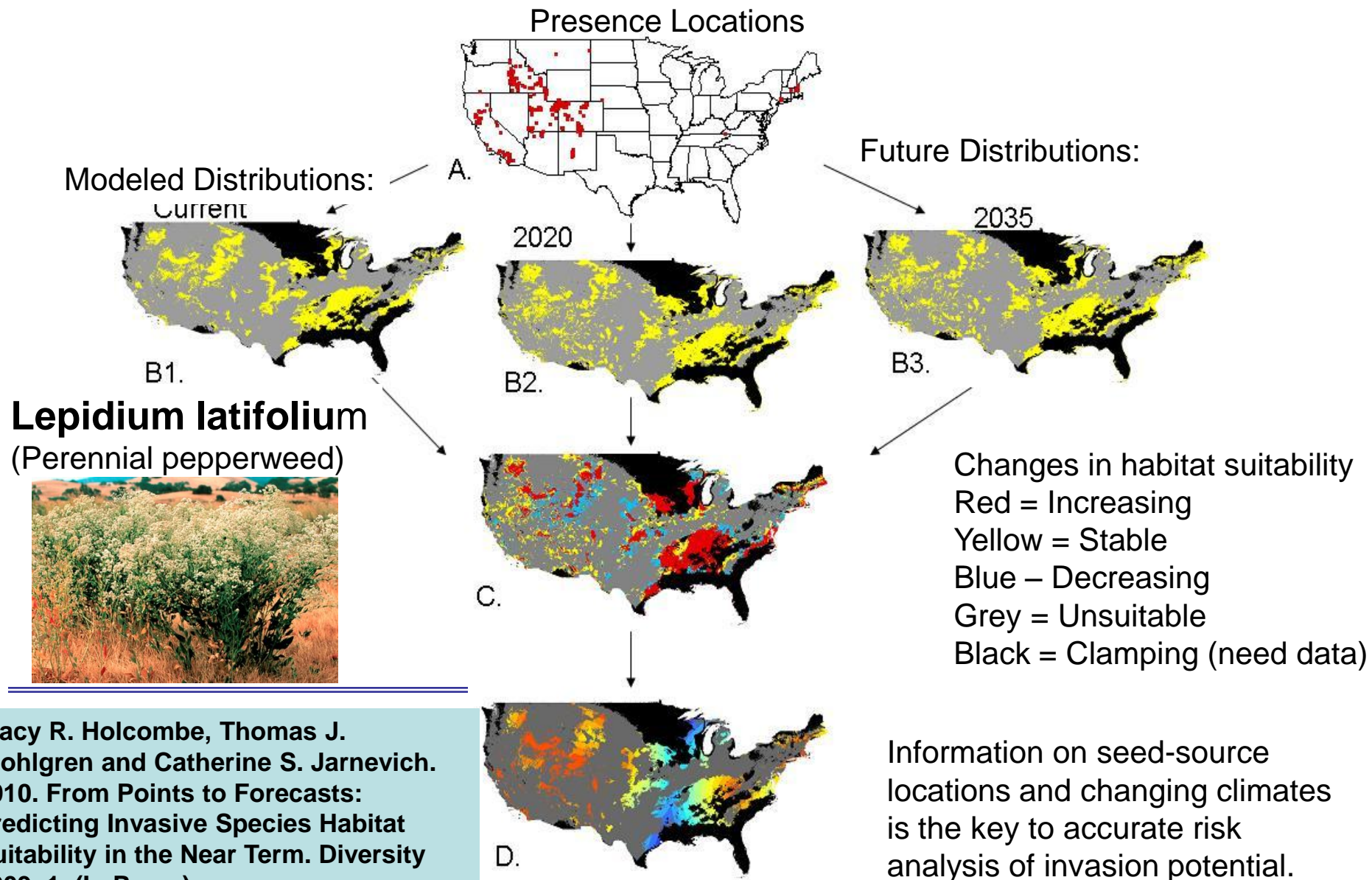
Improving Risk Assessments and Triage

Consider three simple hypotheses:
 (1) Species distributions and potential habitat suitability change predictably in space;
 (2) Species distributions and potential habitat suitability change predictably in time;
 and (3) spatial and temporal trends in invasion are best measured with a field sampling design that captures biotic and abiotic gradients.

We demonstrate the utility of an iterative process that combines field sampling and modeling species.



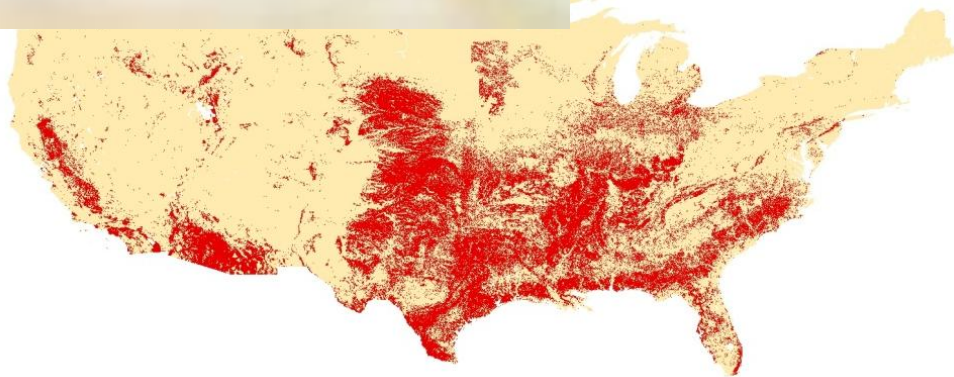
Risk analysis for invading species under changing climates



Tracy R. Holcombe, Thomas J. Stohlgren and Catherine S. Jarnevich. 2010. From Points to Forecasts: Predicting Invasive Species Habitat Suitability in the Near Term. Diversity 2009, 1, (In Press).

Africanized Honey Bee

Actual Size



We still have a lot to learn!



I give 'em a Bee plus!

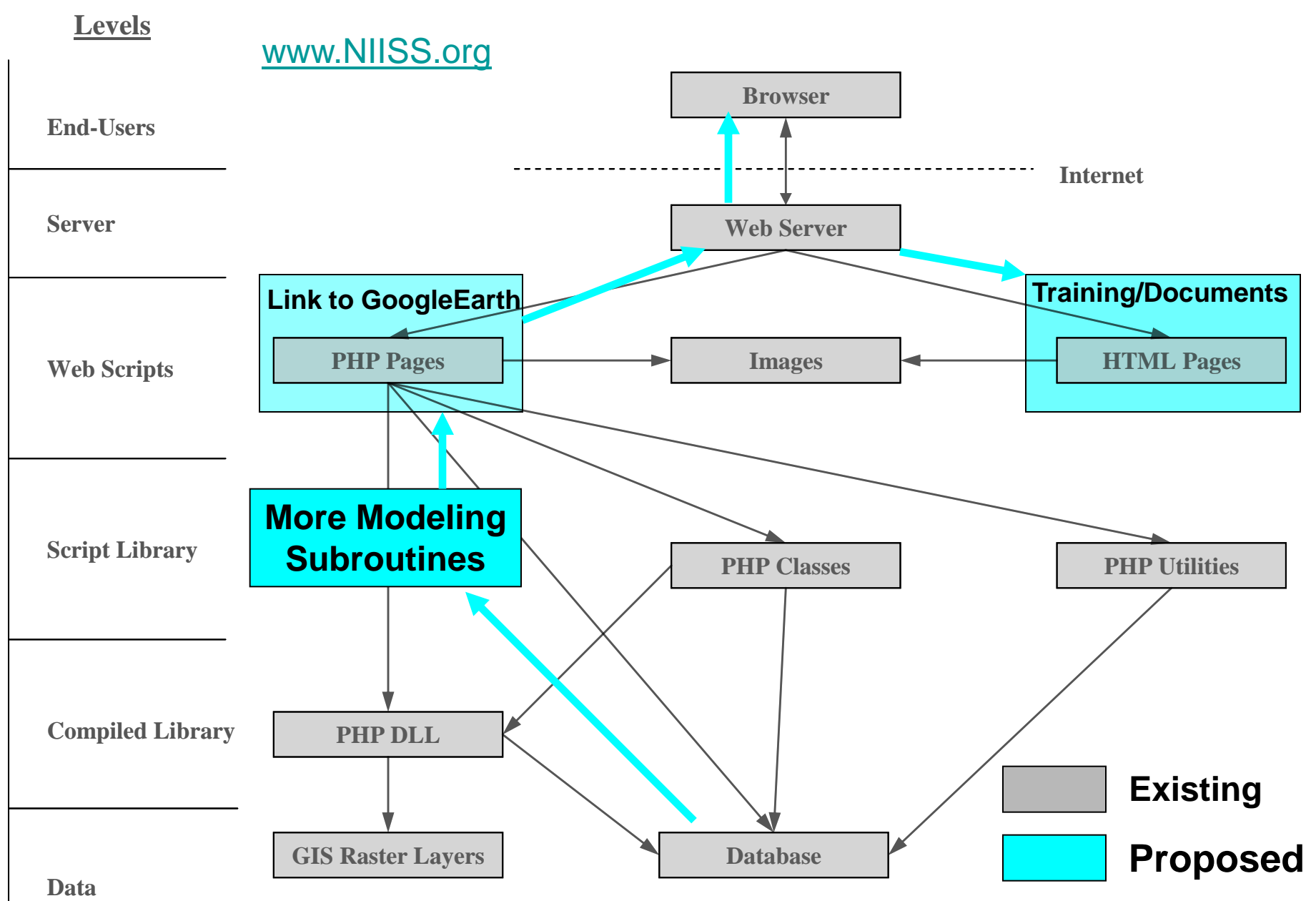


Figure 2. GODM system components (existing) and proposed (light blue) required to maintain an enterprise level relational ecological database, perform high performance global scale analysis, and make all services available to standard internet browsers. The web server architecture shows the major areas for development with a focus on web scripting, re-usable scripts, compiled libraries, and data management.

What you can do now. . .

(red parts added for non-participants)

- **In the webinar, we allowed participants to Practice modeling as an “ExpertGuest”** [use print-screen captures for class material]
- **Anyone can:** Join a group on www.CitSci.org or start a project with your class. **Project leaders will be allowed to Enter data and will have access to modeling tools to model away!**
- **Everyone is invited to Provide feedback to us** (what worked, what didn't?)
- **Everyone is invited to Use these Powerpoint slides** (we like to share).

The NGOss: Next Generation of Scientists

The screenshot shows the CitSci.org website interface. At the top right, it says "Welcome guest Login | My Profile | March 7th 2010". The logo "CitSci.org" is on the left with the tagline "Monitoring nature... through citizen science". A navigation menu on the left includes: Home, About Us, Find a Species, Find a Project, Collect Data, Make a Map, Tutorials, Links, Login, Register, and Contact Us. The main content area features a photo of a child looking at a field guide, with a caption "Photo By: Linda Hurt" and a "How you can help" button. Below the photo is a paragraph: "CitSci.org is website in support of citizen science. It allows citizens, school groups, and professionals to enter species observations into a global database. The observations are then used for natural resource management, scientific studies, and environmental education. CitSci.org provides an opportunity for students and volunteers to perform field studies that contribute to our collective biological understanding. Submit your observations today!". Below this are three columns: "Featured Project" with a link to "Pondicherry National Wildlife Refuge All Projects", "Featured Species" with a photo of a Musk Thistle (*Carduus nutans*) and a link to "All Species", and "New Discoveries" with a link to "January 26th, 2010 All Sightings". At the bottom, it says "An IBIS website" and "Updated 2/24/2010". The browser address bar shows "http://www.citsci.org/cwis438/websites/CitSci/IntroductionToInvasives.php".

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For more information see www.NIISS.org or www.CitSci.org