Forecasting Invasions and Communicating Risks

Tom Stohlgren, Catherine Jarnevich, Tracy Holcombe, Jeff Morisette
Gordon Rodda, Bob Reed, Lea Bonewell (USGS)
Jim Graham, Sunil Kumar, Paul Evangelista, Dave Barnett, Greg Newman, Nick Young,
Patty York, Alycia Crall, Sara Simonson (NREL),
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!

Tom_Stohlgren@usgs.gov **Web Page** **http://www.NIISS.org**

USGS science for a changing world

Colorado State University Knowledge to Go Places

Natural Resource Ecology Laboratory

neon National Ecological Observatory Network, Inc.

Created April 6, 2010

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

Climate Change

Land Use Change

Other Invasive Plants, Animals, And Diseases

Disturbance Regimes Change

Invasions from Coast to Coast

They steal our ranch lands!

They steal our water!

High Costs:

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

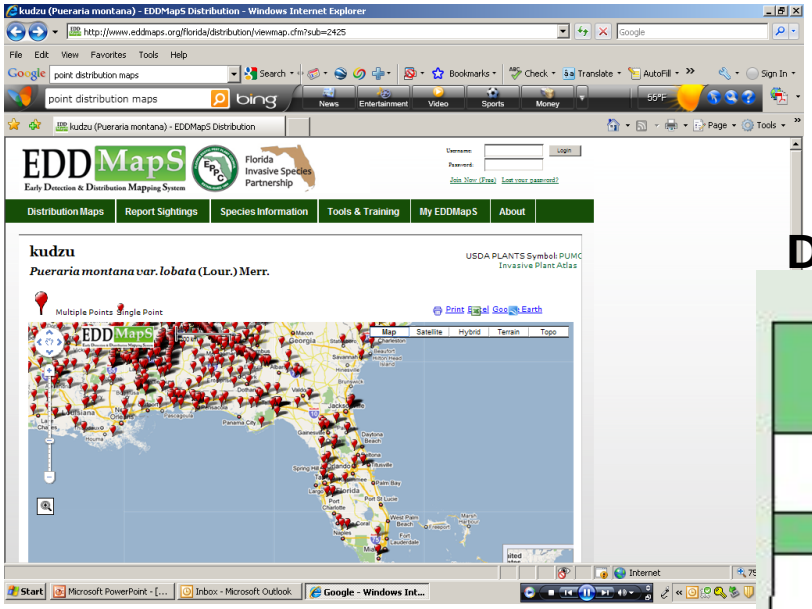
Total Costs:

$120 Billon each year – and the problem is growing!

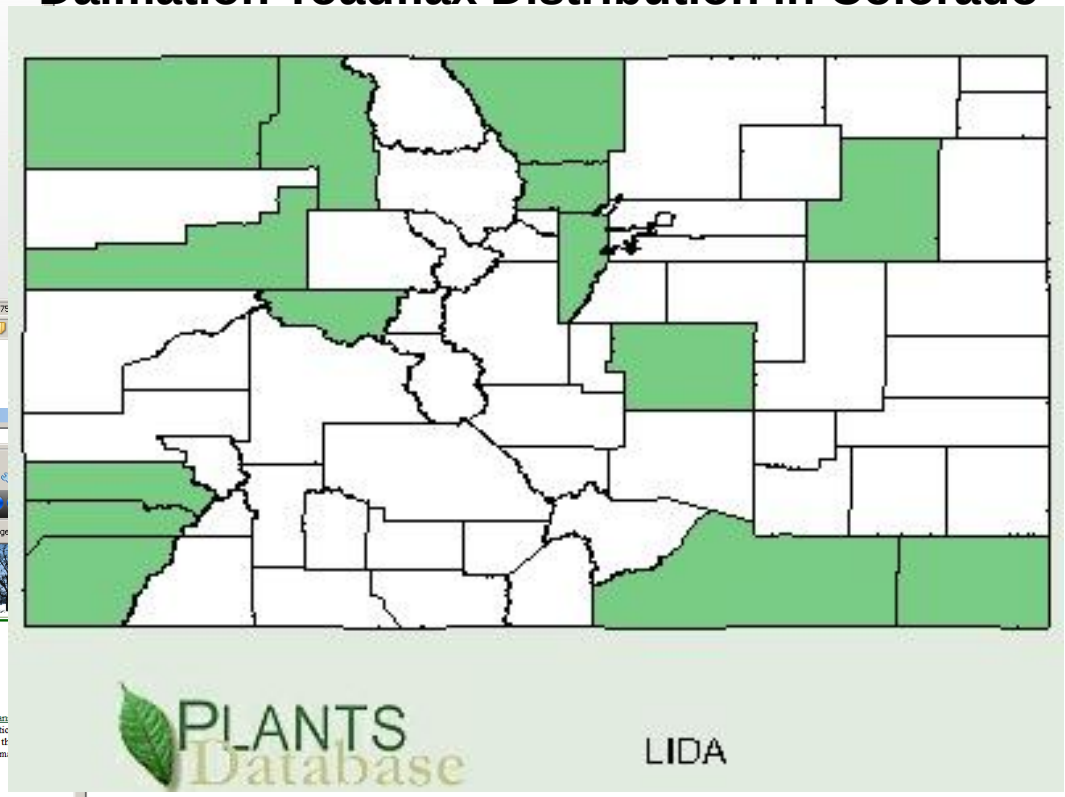
They can kill people!

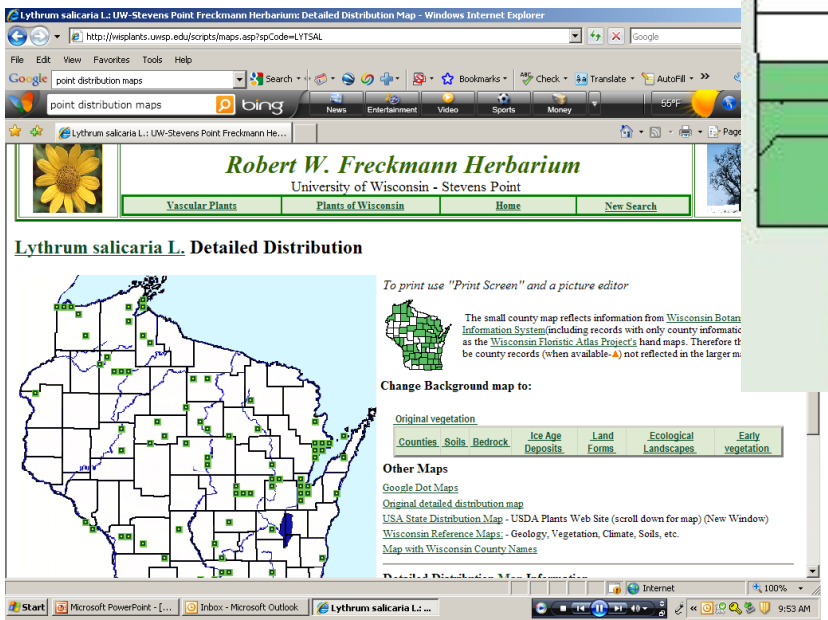
They can steal headlines!

Examples of Point Distributions Maps and Species “Range” Maps on the Web



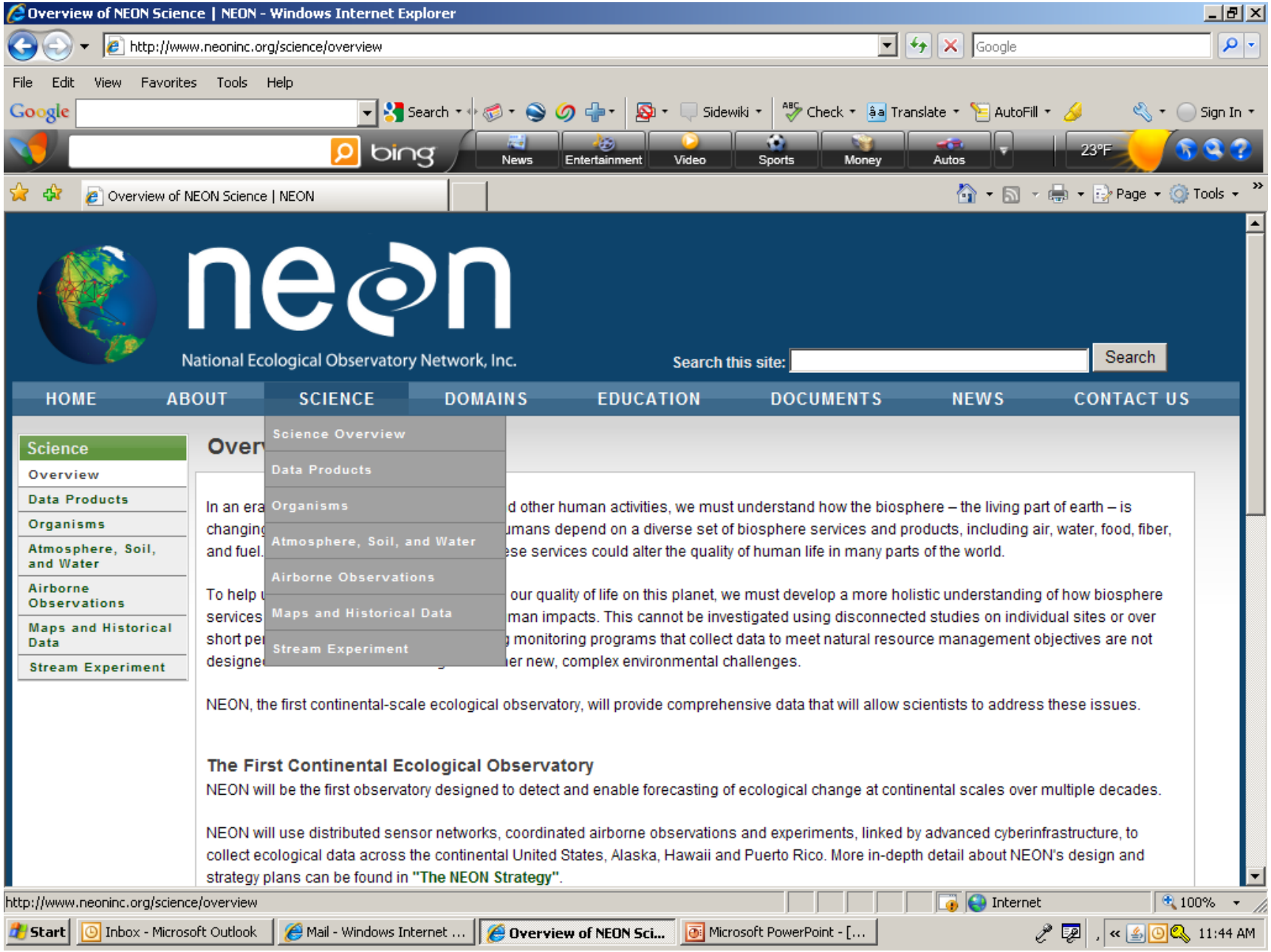
Dalmation Toadflax Distribution in Colorado





www.NEONINC.ORG

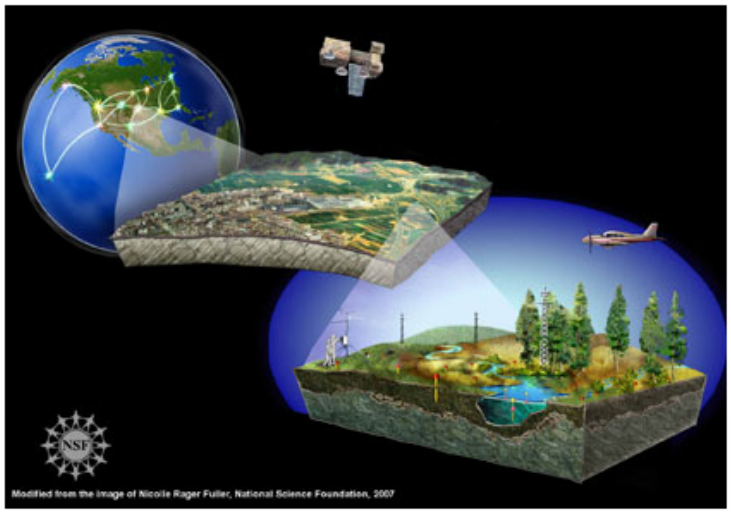
CLICK ON: SCIENCE then Science Overview



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"**.

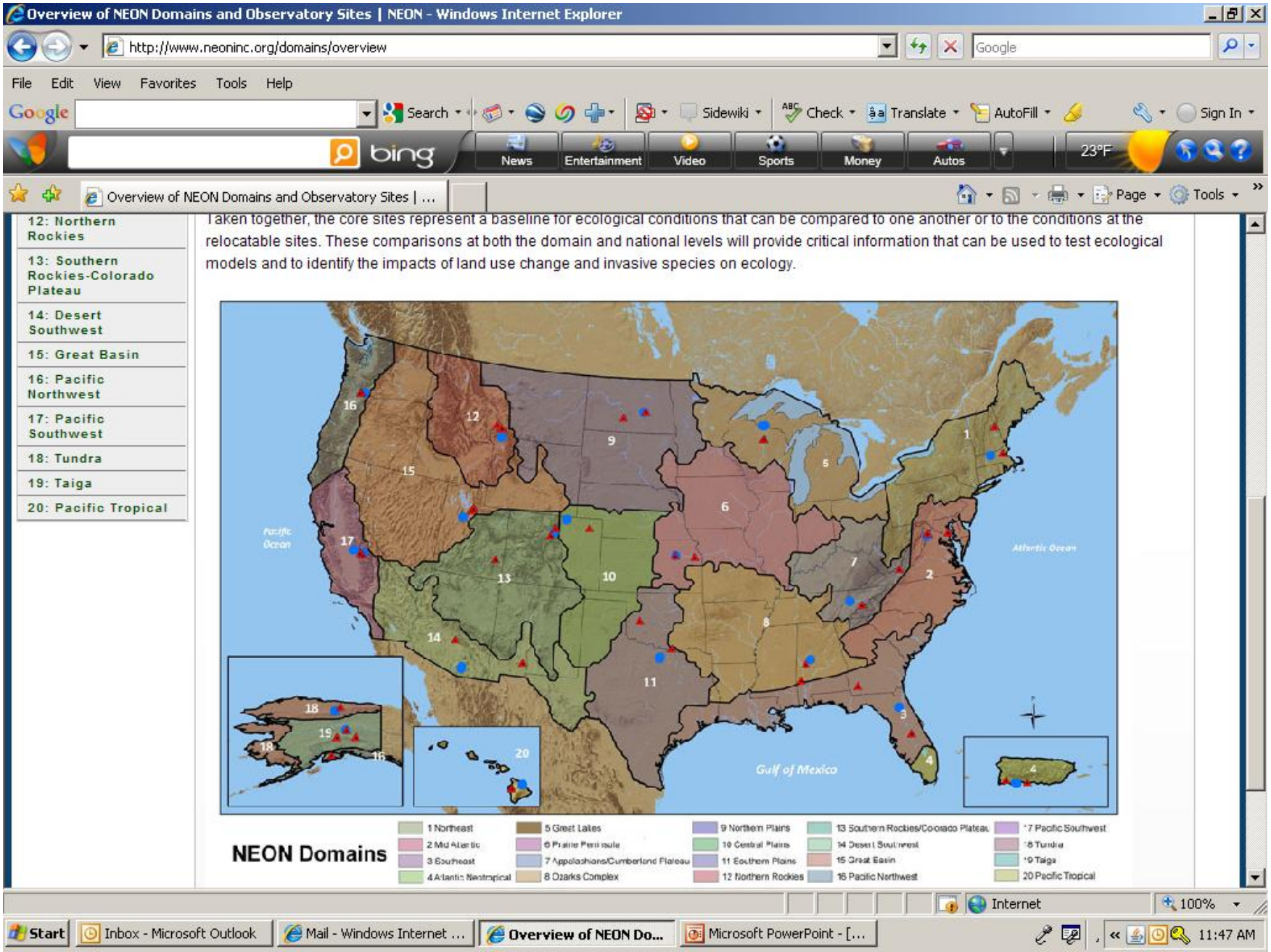


NEON has partitioned the U. S. into **20 eco-climatic domains**, each of which represents different regions of vegetation, landforms, climate, and ecosystem performance. In those domains, NEON will collect site-based data about **climate and atmosphere**, **soils and streams and ponds**, and a **variety 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



Standard Survey and Monitoring Design

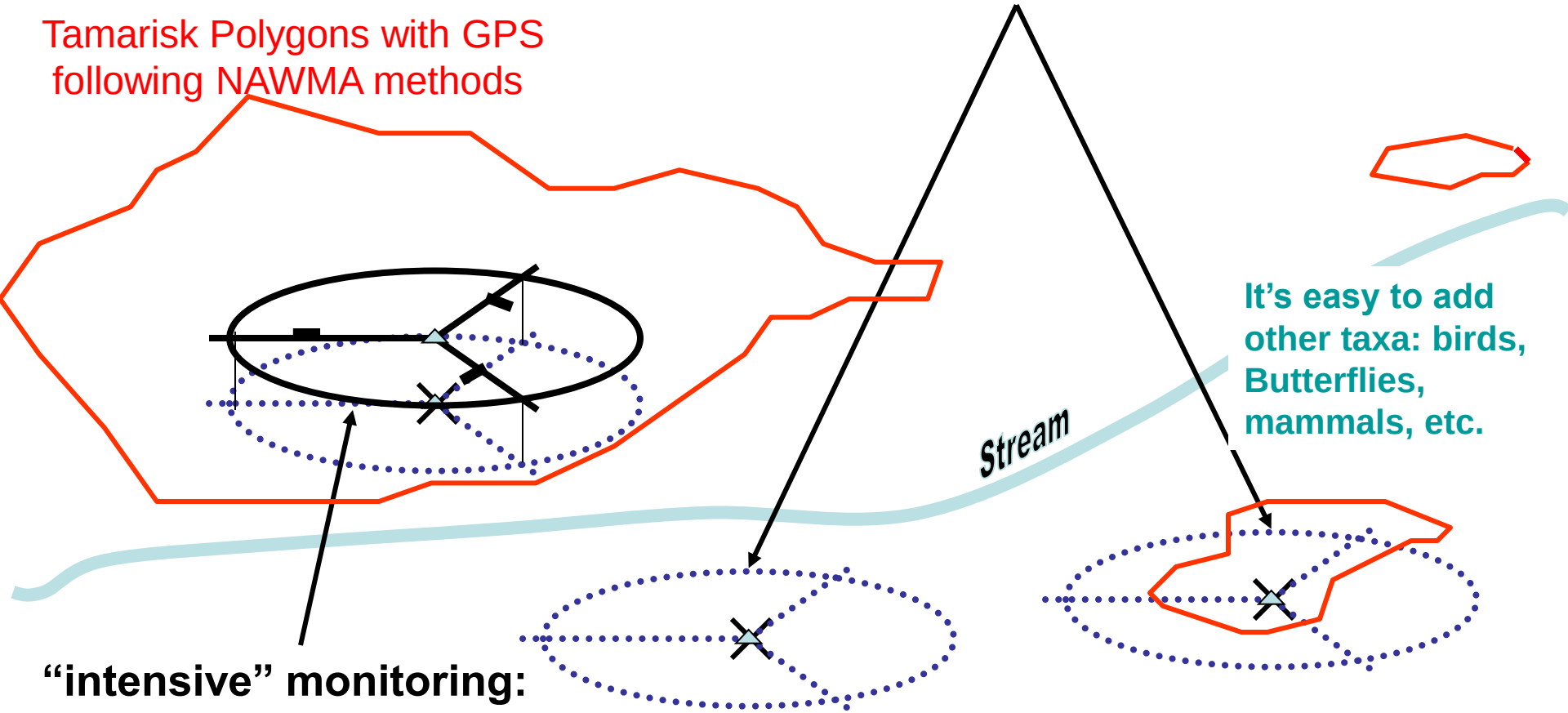
(7.3-m radius plots plus ancillary data)

"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

See www.NAWMA.org
USDA FIA design

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

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”

Add Professional “Layer”

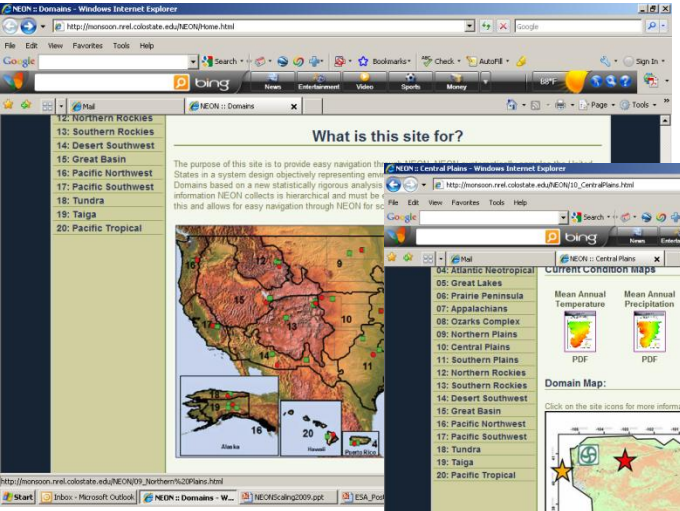
- Verify observations
- Evaluate sources of error
- Add vegetation plots (stratified random and gradient plots) **or other taxa!**
- Integrate data, maps, and models.
- Share results and make recommendations for future surveys, control, and restoration.

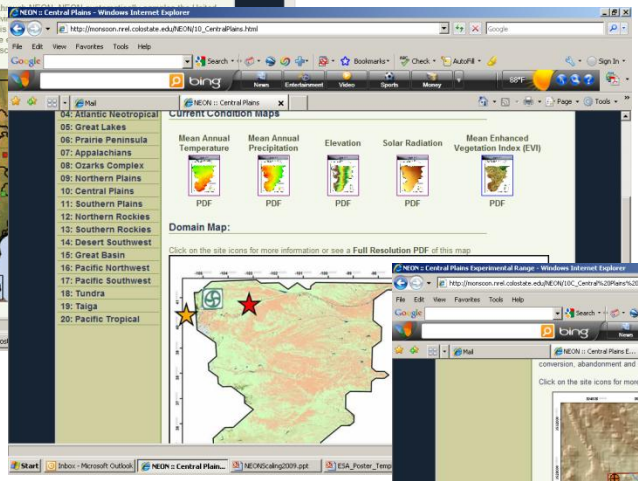
San Pablo Bay NWR

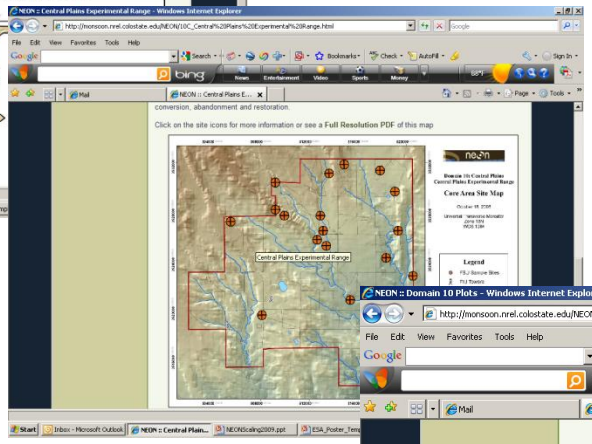
USGS science for a changing world

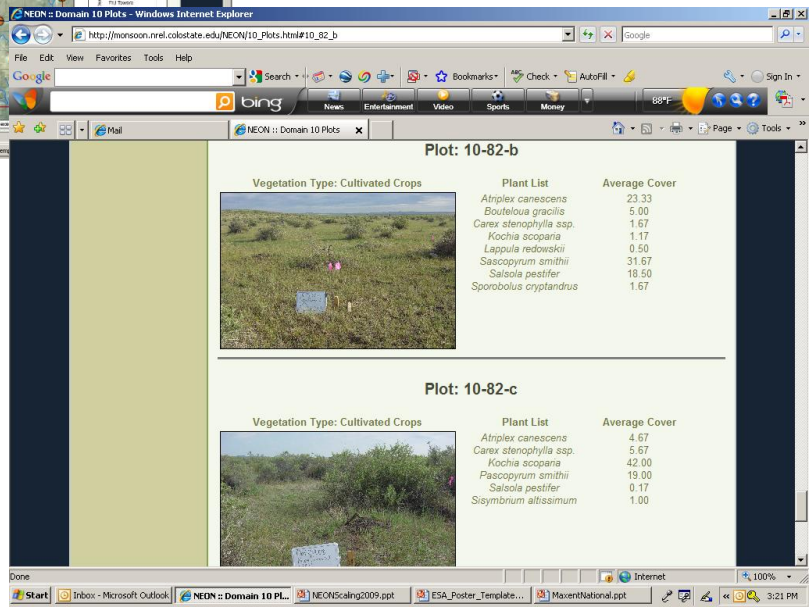
http://ibis-live.nrel.colostate.edu/NEON/

Tools for Data Exploration, Mapping, and Modeling

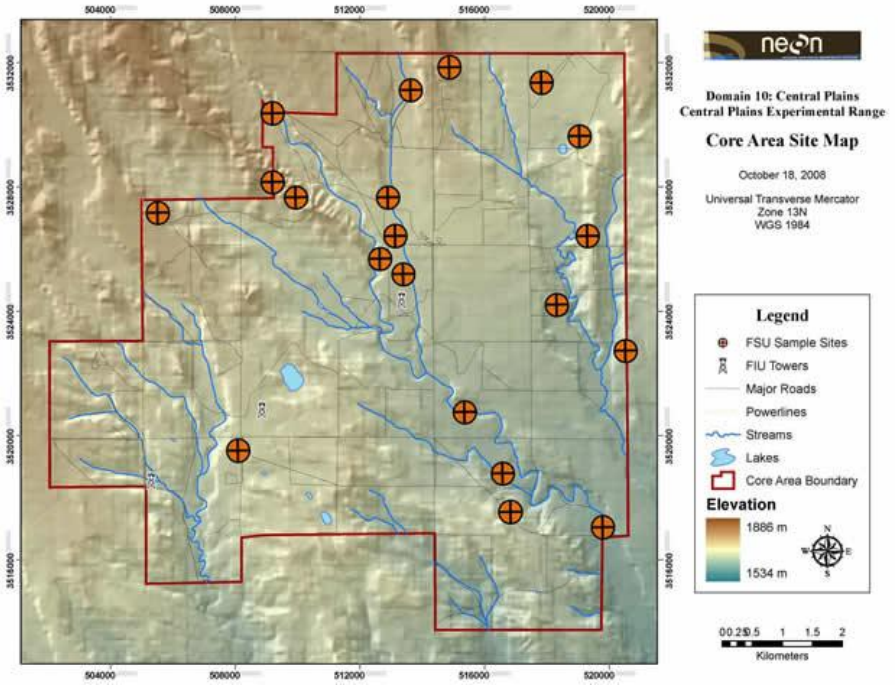


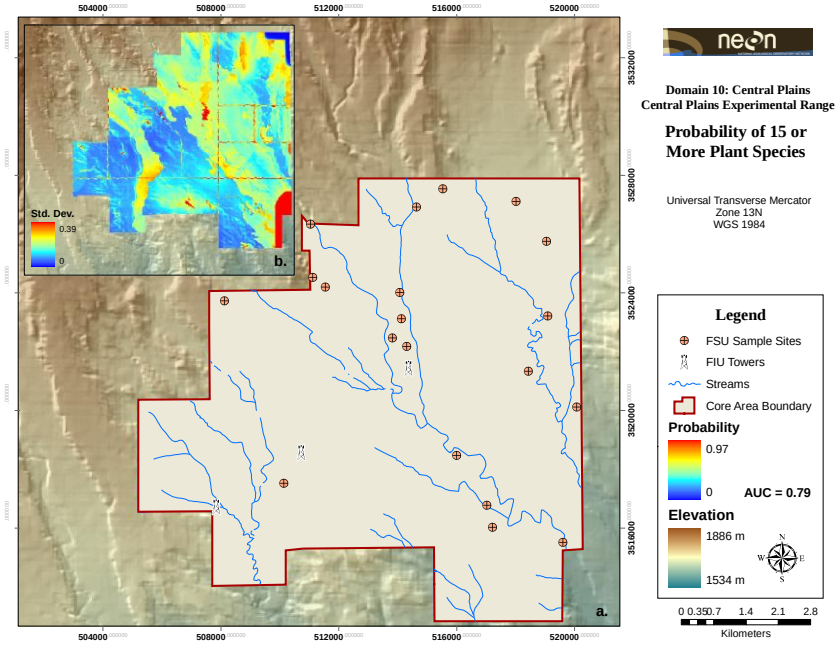






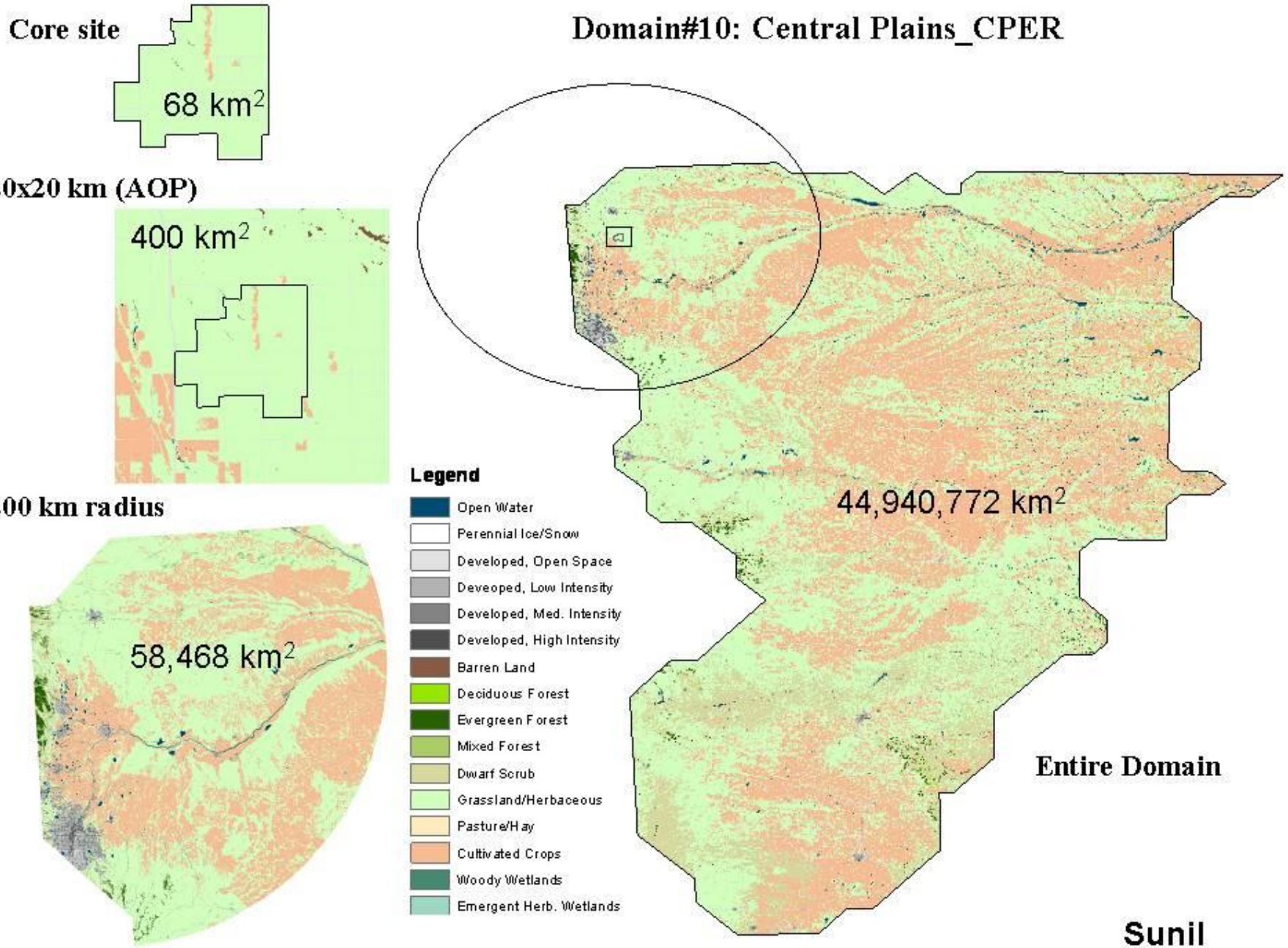
- Take a virtual field trip
- Capture vegetation data





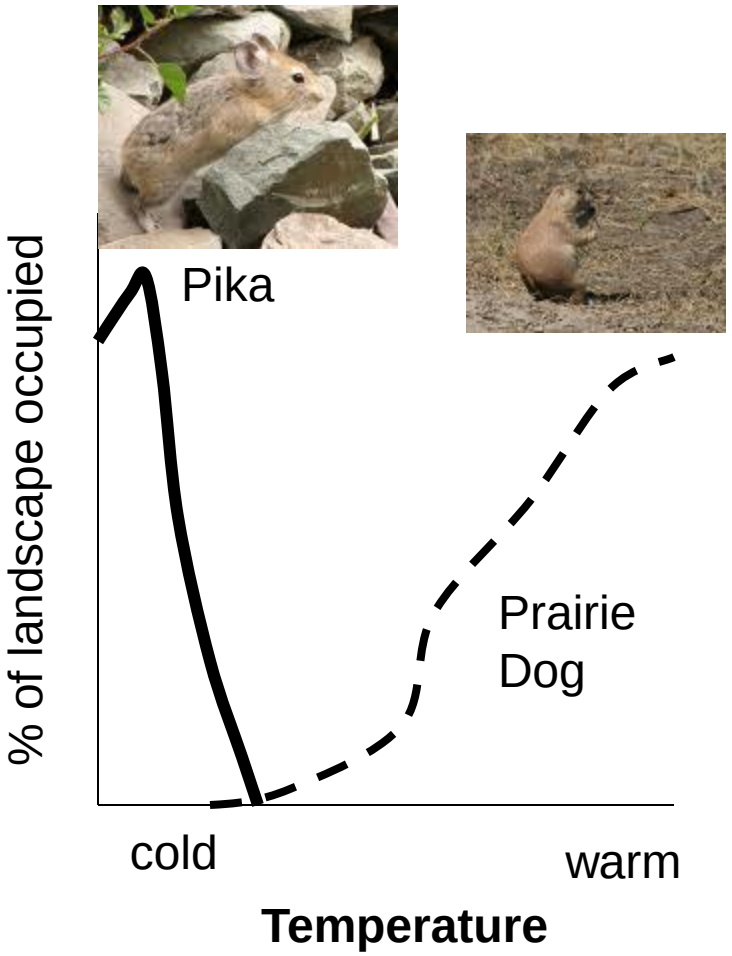
Barnett, D. T., T. J. Stohlgren, C. S. Jarnevich, G. W. Chong, J. A. Ericson, T. R. Davern, and S. A. Simonson. 2007. The art and science of weed mapping. Environmental Monitoring and Assessment. DOI: 10.1007/s10661-006-9530-0.

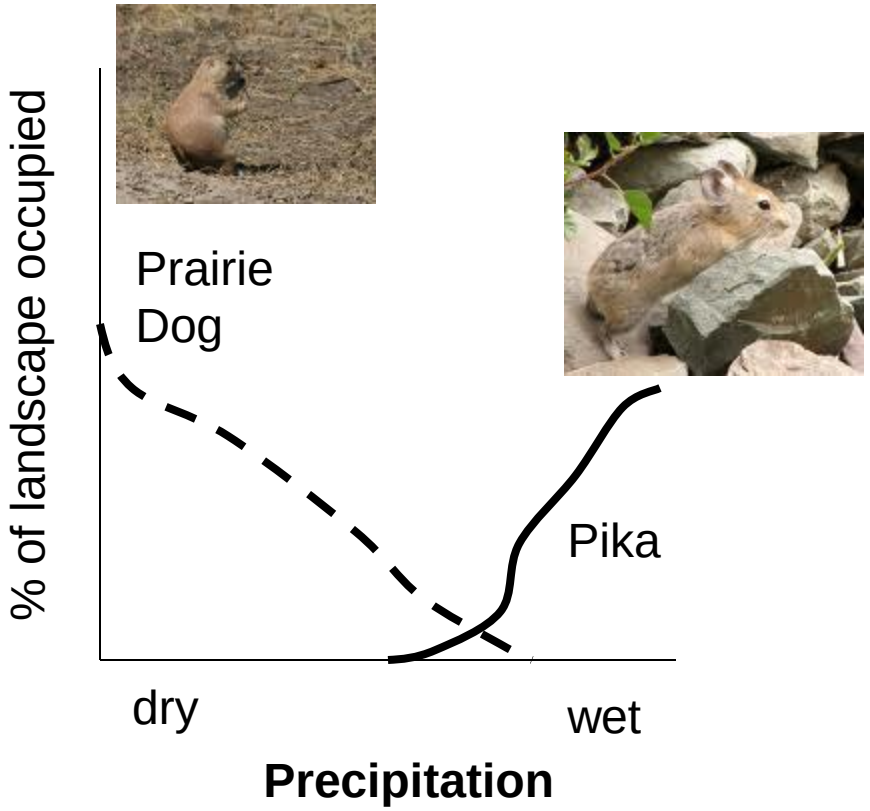
Domain#10: Central Plains_CPER



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

→

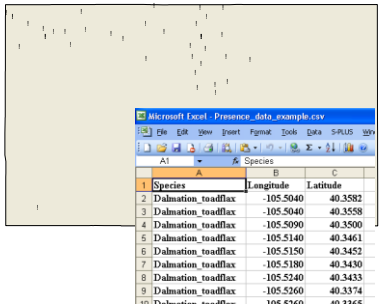
Model validation

Model predictions

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

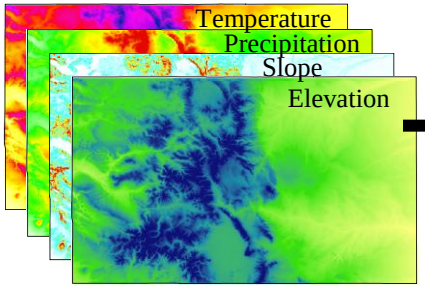
Example: Potential habitat distribution of invasive plant dalmation toadflax (*Linaria dalmatica*) in Colorado, USA

Presence data

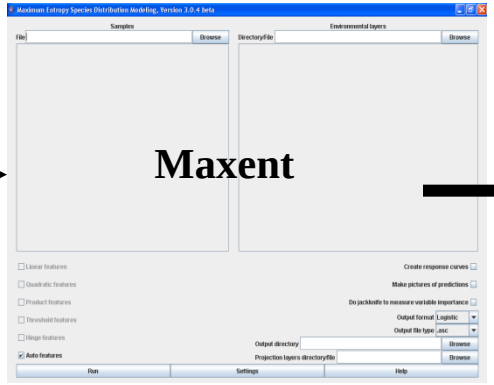


+

Environmental layers

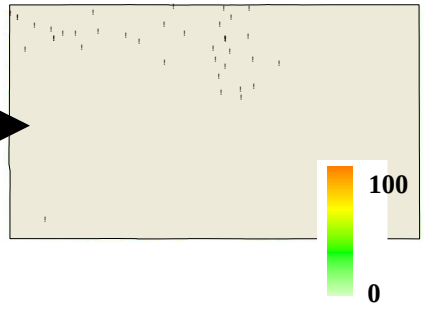


→

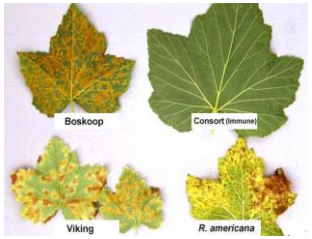


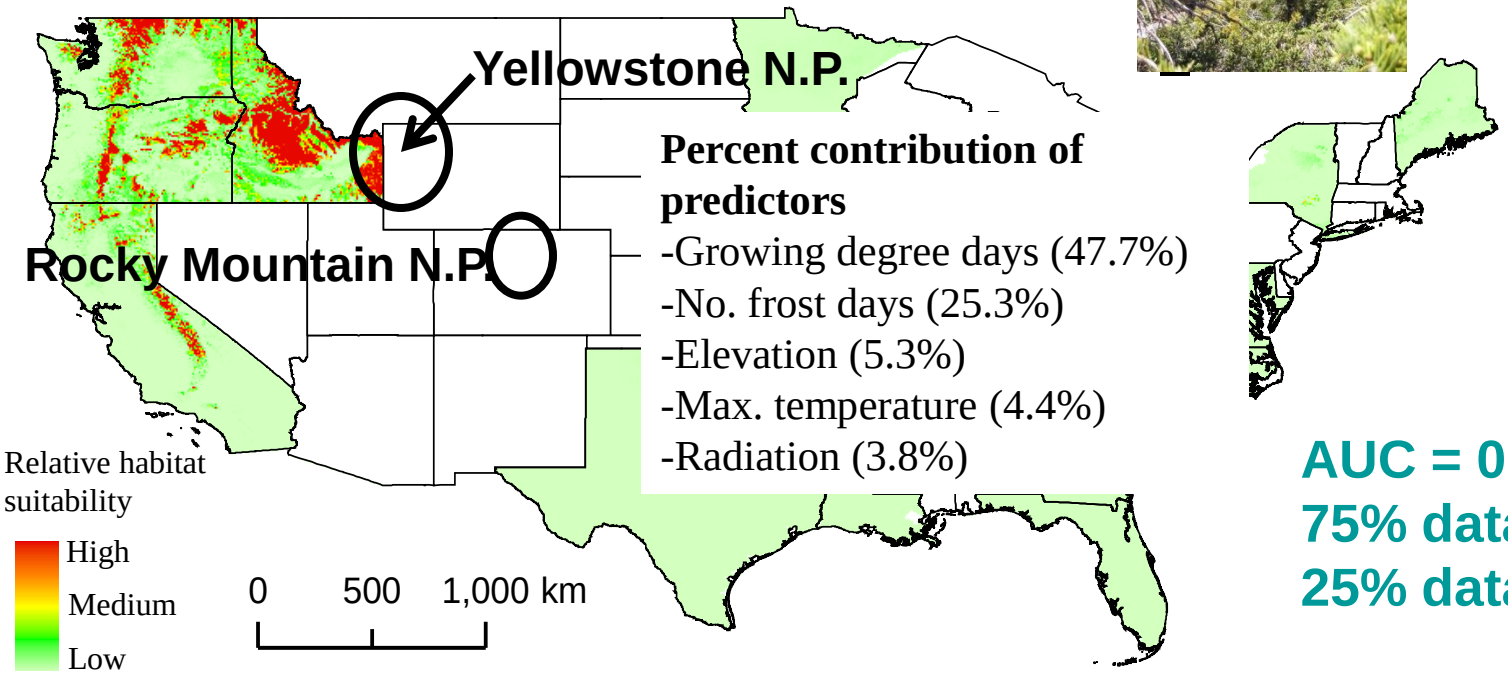
→

Predicted probability



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



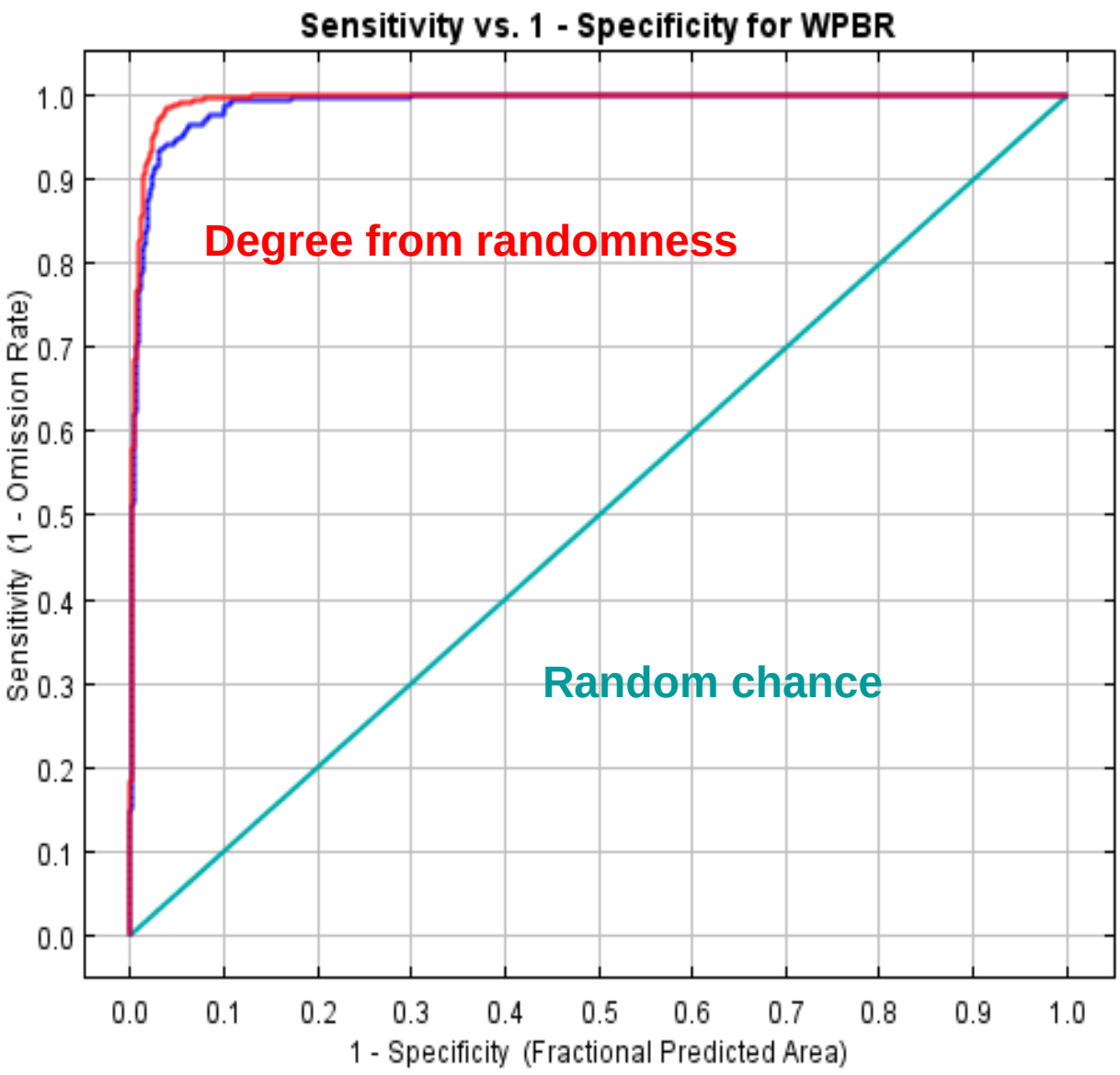


Percent contribution of predictors

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

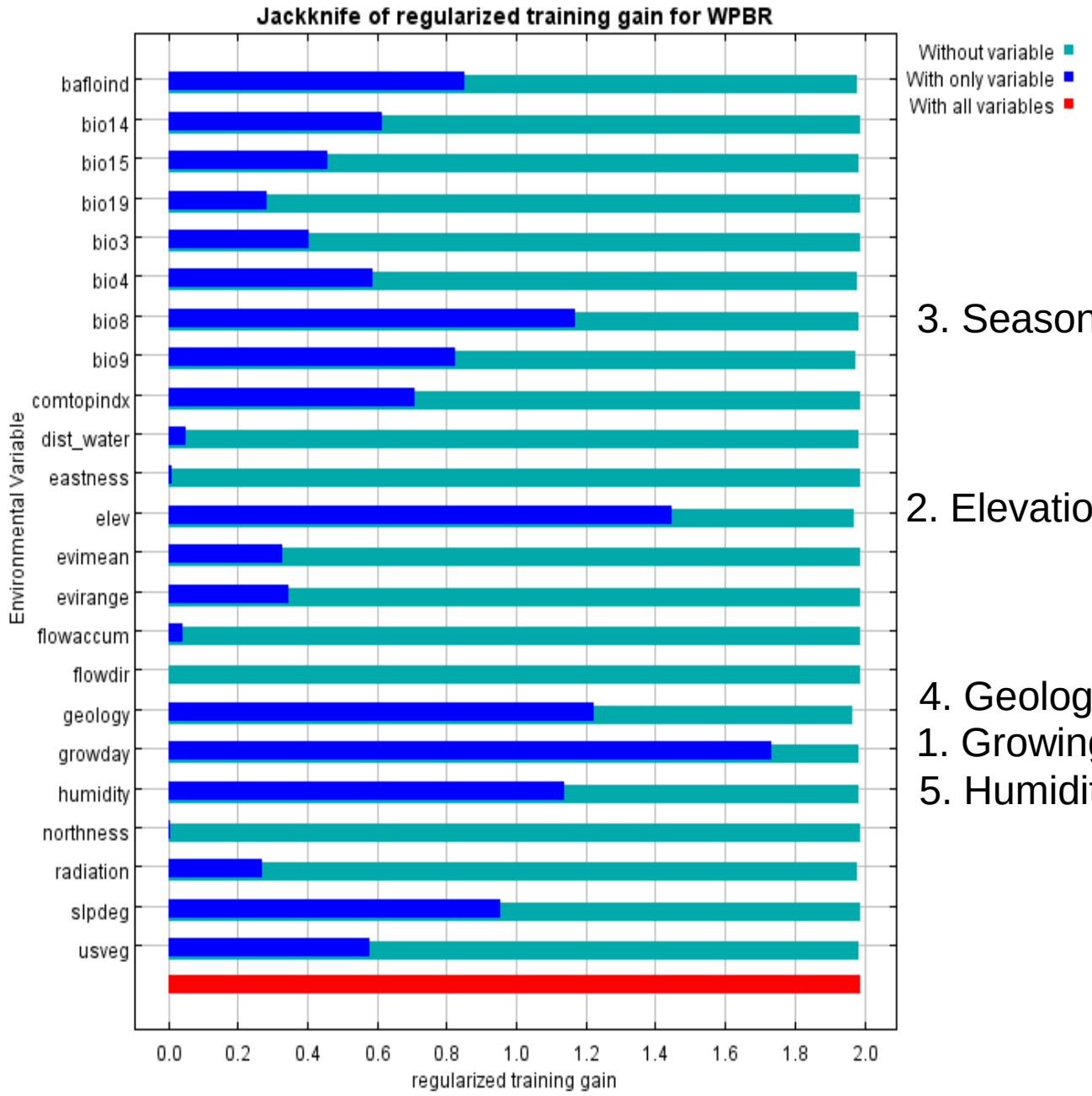
AUC = 0.99
75% data Training
25% data Testing

Maxent



Wow, 99% accuracy!

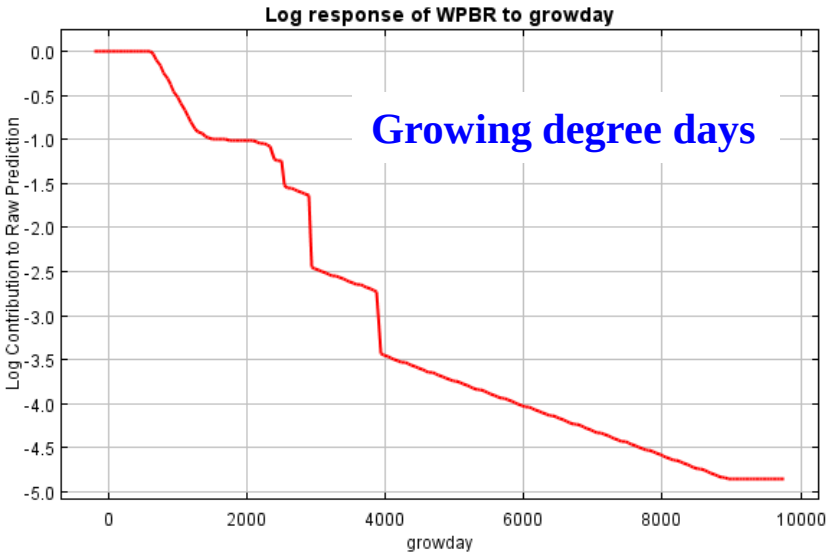
75% data for Training (720)
25% data for Testing (240)

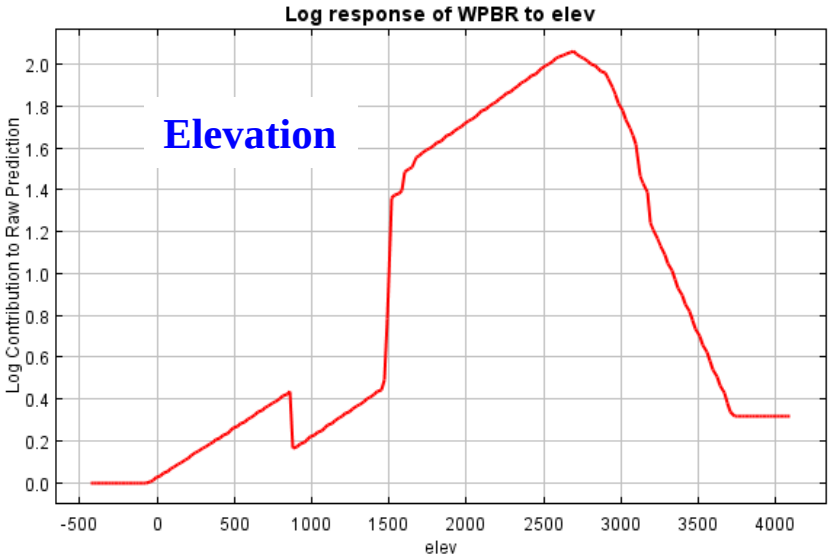


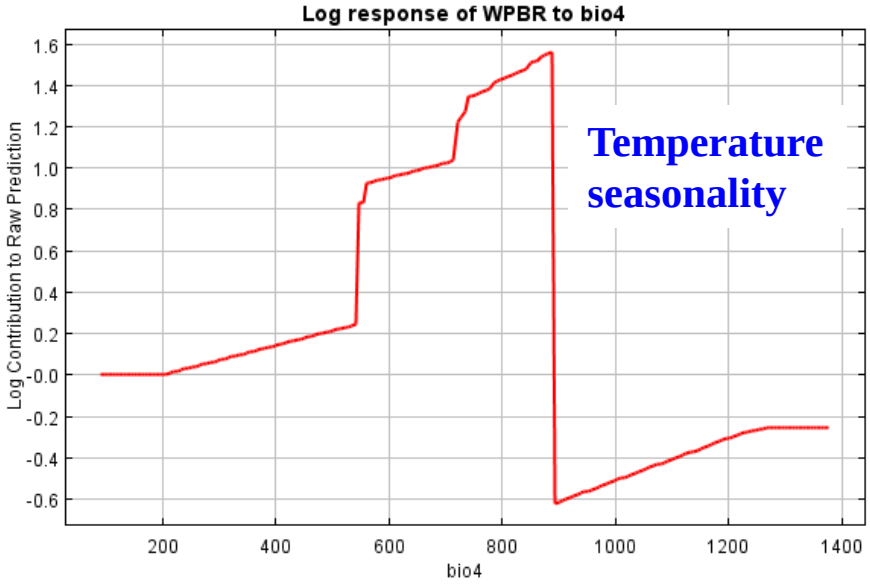
3. Seasonality

2. Elevation

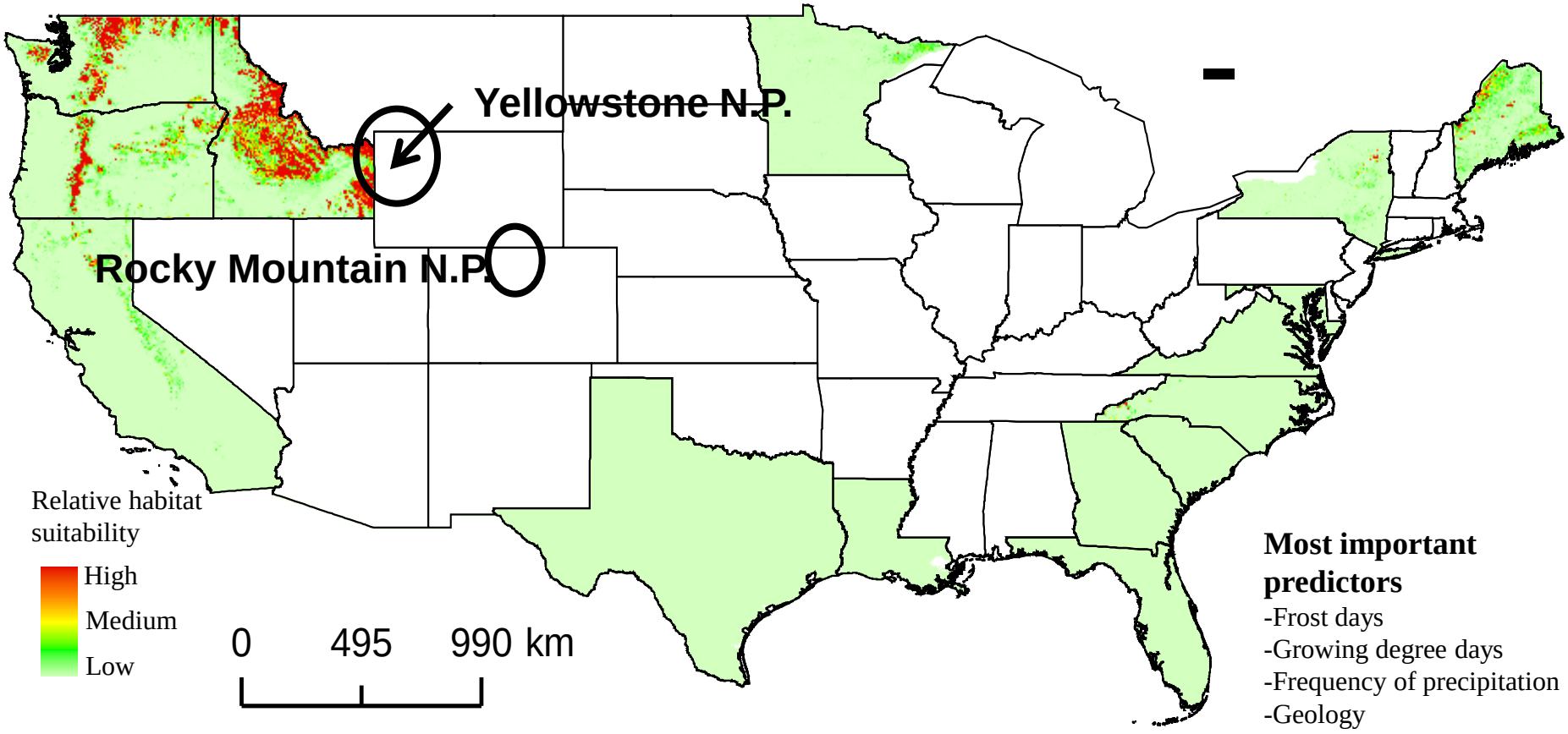
4. Geology
1. Growing degree days
5. Humidity


Log response of WPBR to growday
Growing degree days
Log Contribution to Raw Prediction
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
0
2000
4000
6000
8000
10000
growday


Log response of WPBR to elev
Elevation
Log Contribution to Raw Prediction
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-500
0
500
1000
1500
2000
2500
3000
3500
4000
elev


Log response of WPBR to bio4
Temperature seasonality
Log Contribution to Raw Prediction
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-0.0
-0.2
-0.4
-0.6
200
400
600
800
1000
1200
1400
bio4

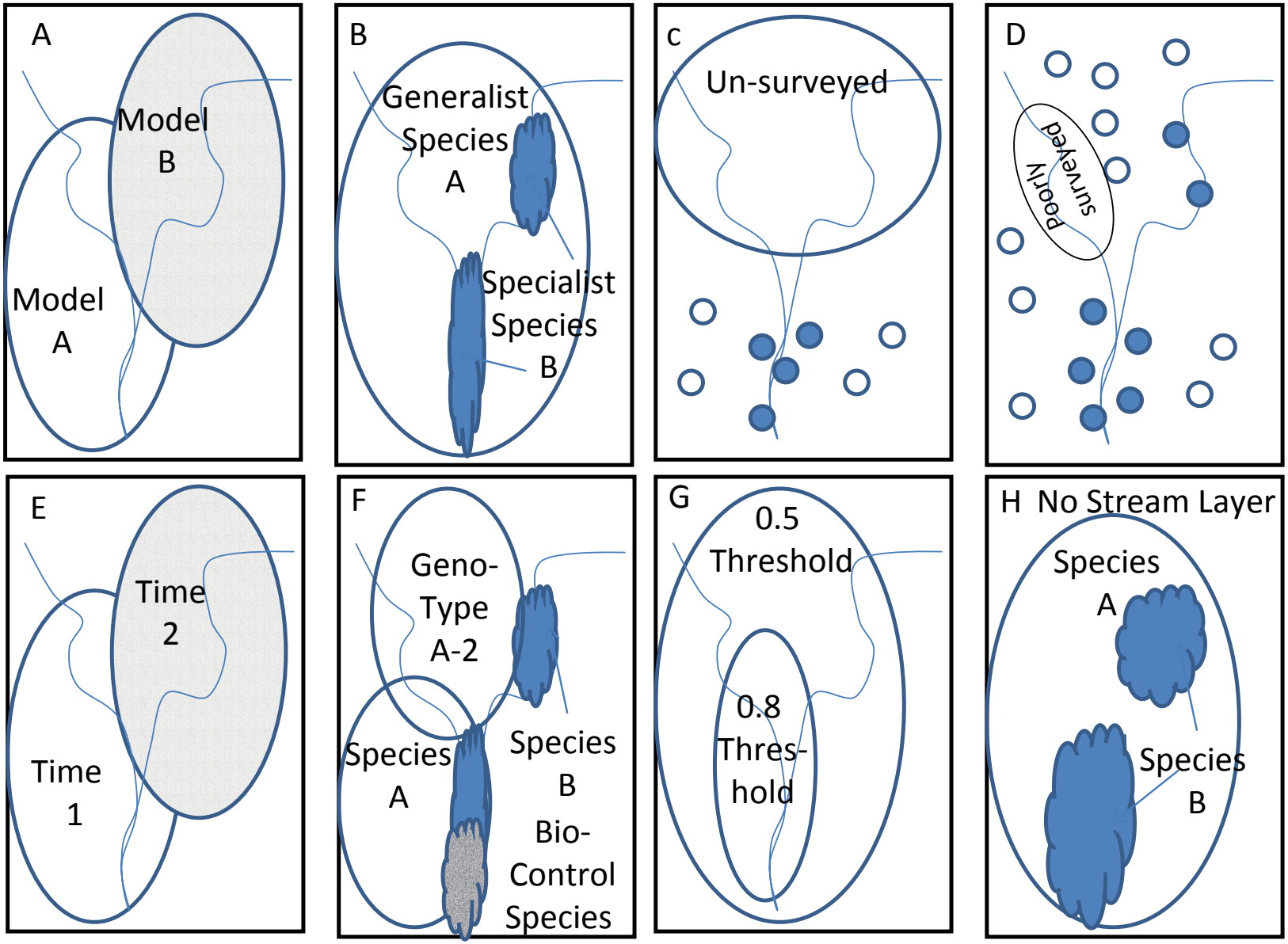
Potential habitat distribution for ≥ 90% infected trees (by White Pine Blister Rust)



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!

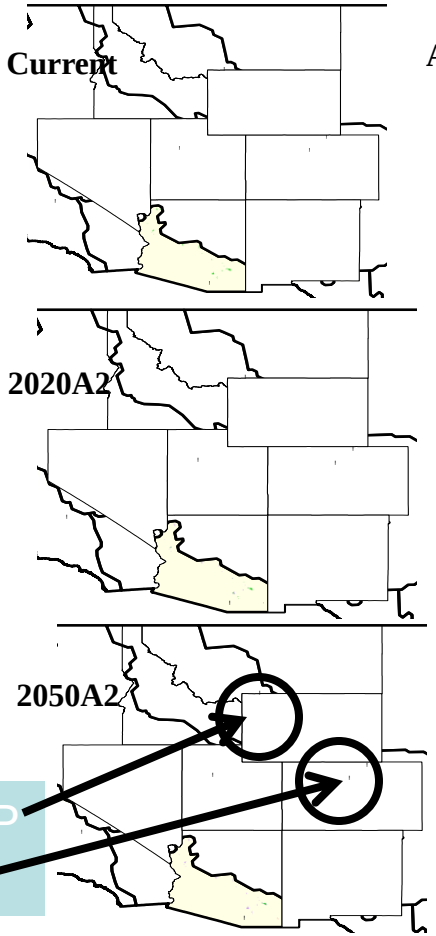


Jarnevich, CS, S Kumar, TJ Stohlgren, and J Morisette. 2009. Caveats for species distribution modeling. Ecography. In Review.

Climate Change Examples:

Risk analysis for northern expansion of Kudzu

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
- Too cold
- States
- Too dry in clim3
- Too cold in clim4
- Too cold in clim3

Current Distribution

N

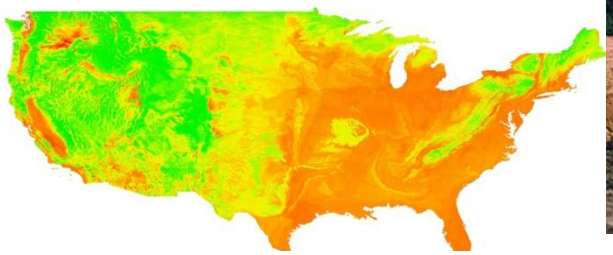
0 750 1,500 km

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.

USGS
science for a changing world

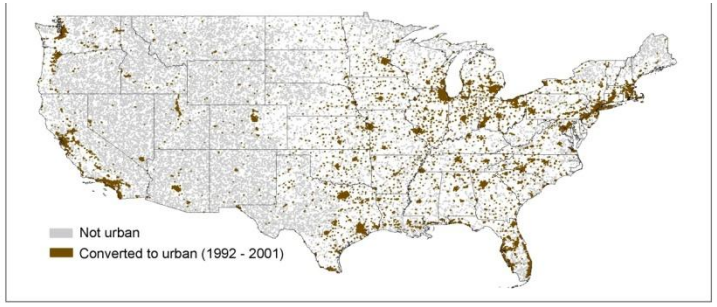
Modeling the Human Invader

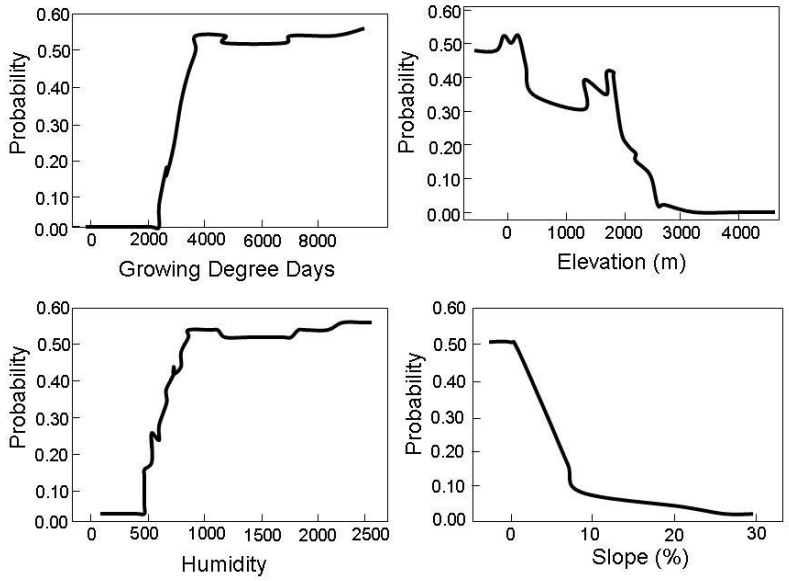
We looked at changes in "urban" 30m cells from LANDSAT from 1992 to 2001.



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.

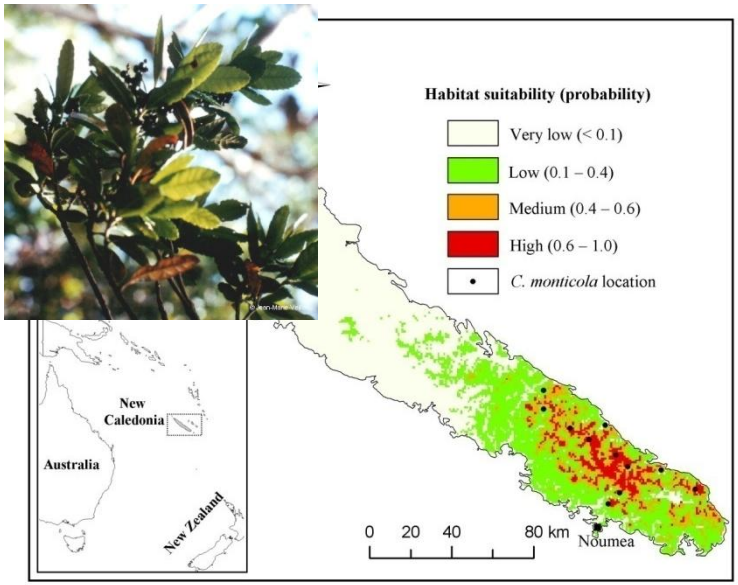




Stohlgren, TJ, C.S. Jarnevich, and C. Giri. Modeling the spread of the human invader in the United States using remote sensing time series. J. Applied Remote Sensing (In Press).

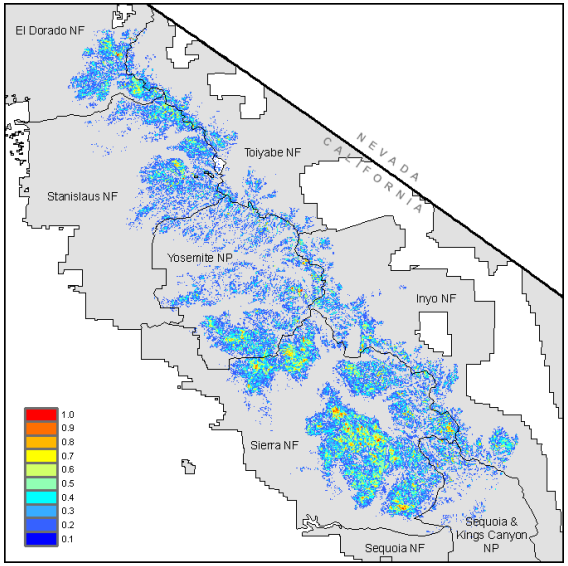
T&E Species Examples:

Threatened and endangered tree *Canacomyrica monticola* in New Caledonia



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

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



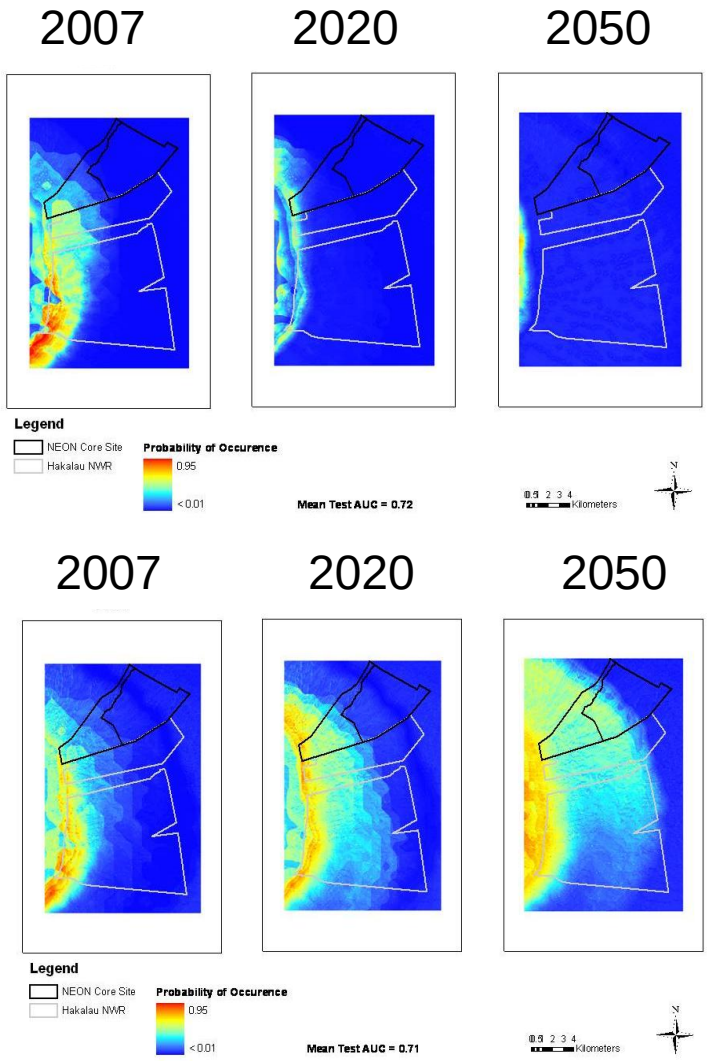
Land use interactions with forest harvests and fire perimeters

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.

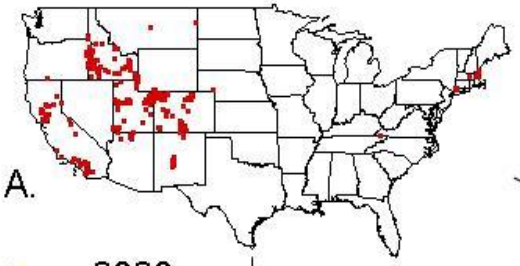


Hakalau Forest National Wildlife Refuge*, *Hawaii

Barnett, D.T. and T. J. Stohlgren. 2009. Improving spatio-temporal hypotheses for monitoring ecological change. (Draft manuscript)

Risk analysis for invading species under changing climates

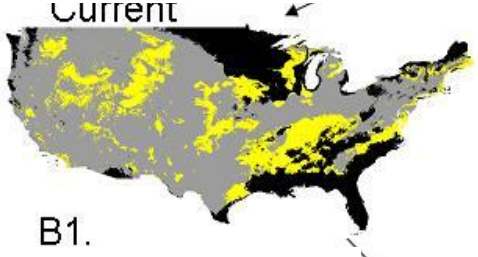
Presence Locations



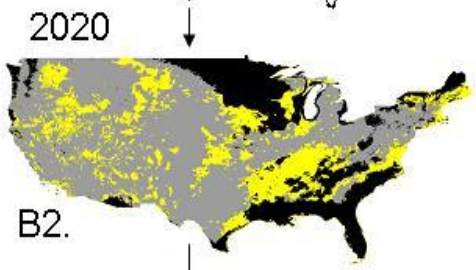
A.

Modeled Distributions:

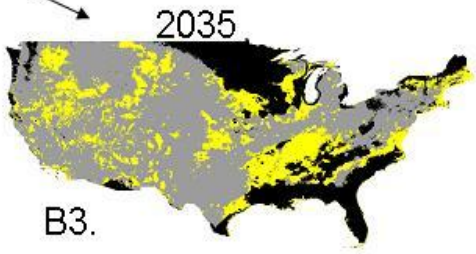
Future Distributions:



B1.

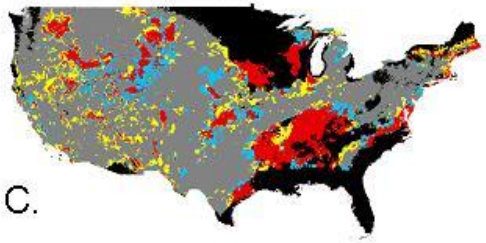


B2.

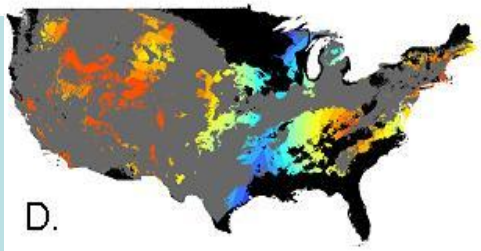


B3.

Lepidium latifolium
(Perennial pepperweed)



C.



D.

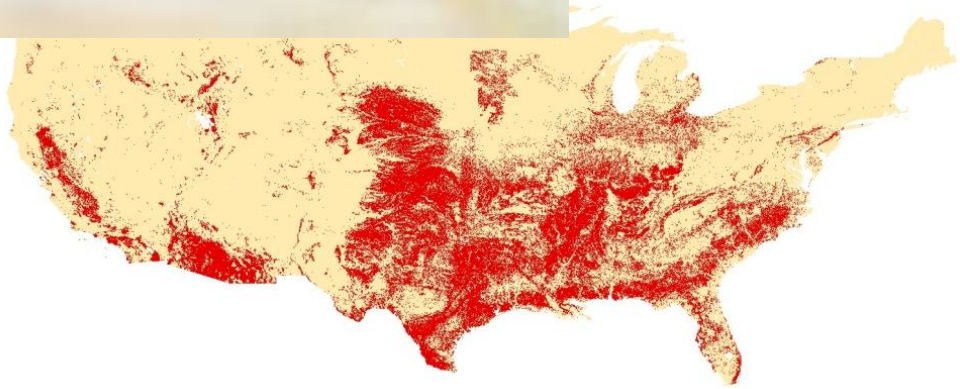
Changes in habitat suitability
Red = Increasing
Yellow = Stable
Blue – Decreasing
Grey = Unsuitable
Black = Clamping (need data)

Information on seed-source locations and changing climates is the key to accurate risk analysis of invasion potential.

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!

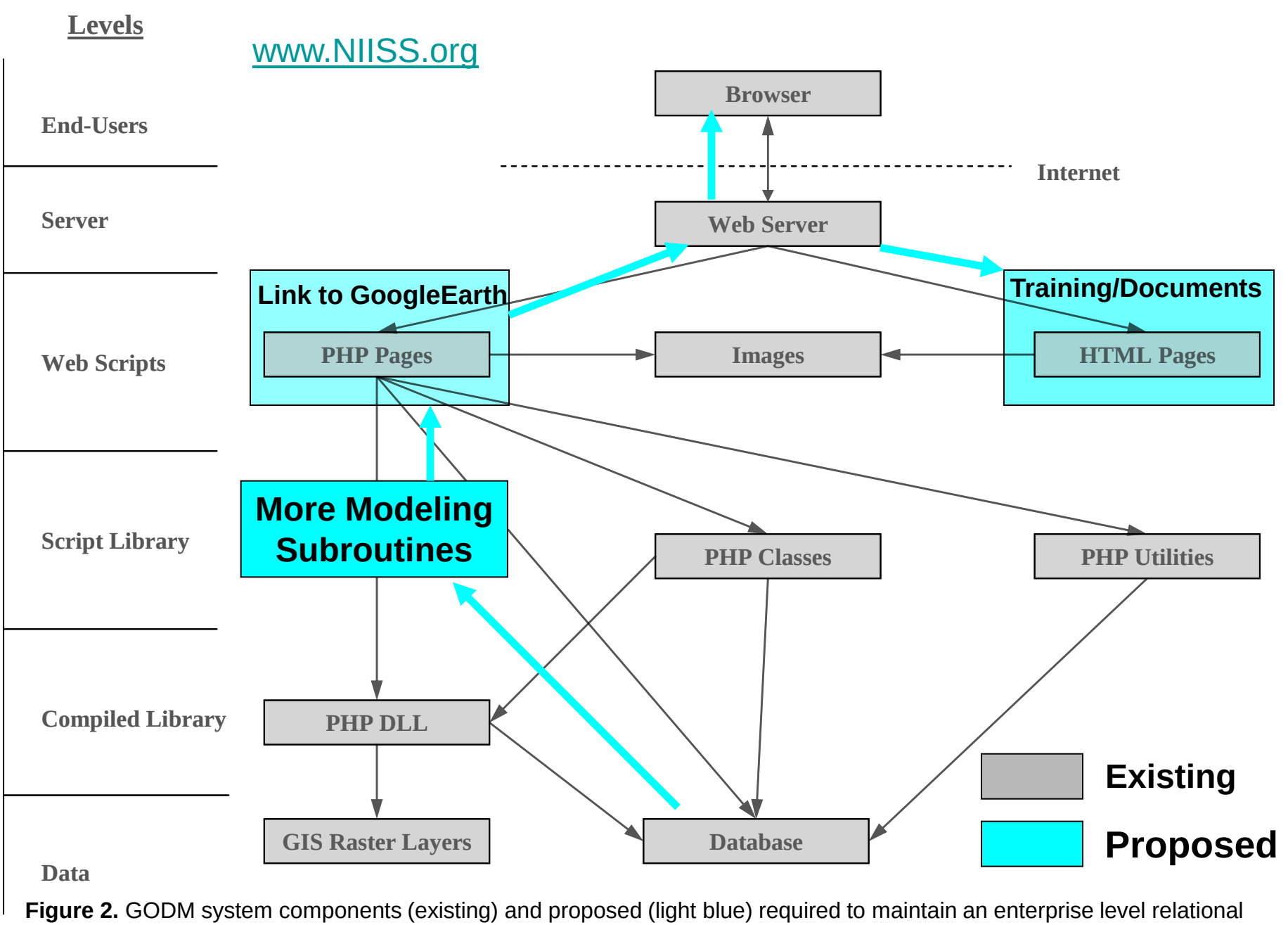


Figure 2. GODM system components (existing) and proposed (light blue) required to maintain an enterprise level relational ecological database, perform high performance global scale analysis, and make all services available to standard internet browsers. The web server architecture shows the major areas 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

Anyone is free to contact me:

Email: stohlgrent@USGS.gov

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