The Art and Science of Weed Mapping

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Jim Graham, Greg Newman, Sunil Kumar, Alycia Crall, Paul Evangelista,
David Barnett and John Norman (CSU), Mingyang Li (China), with help from . . .
Rick Shory, Mohammed Kalkhan, Hilary Drucker, Jon Freeman, Ginger Bradshaw,
Sara Simonson (NREL), John Kartesz (BONAP), Bruce Peterjohn,
Sharon Gross, Annie Simpson, Pam Fuller (USGS), Curt Flather (USFS),
John Schnase, Jeff Morisette, Ed Sheffner, Woody Turner (NASA) and many others!

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

Created Jan. 2008

Tools Needed

1. Enthusiasm and taxonomic skills
2. Ability to conform to accepted standards
3. Proper field equipment and training
4. Database/information infrastructure
5. A “professional layer” for plot-level iterative field surveys, data analysis, and modeling.
6. Willingness to share data and results

1. Enthusiasm and taxonomic skills

2. Ability to conform to accepted standards

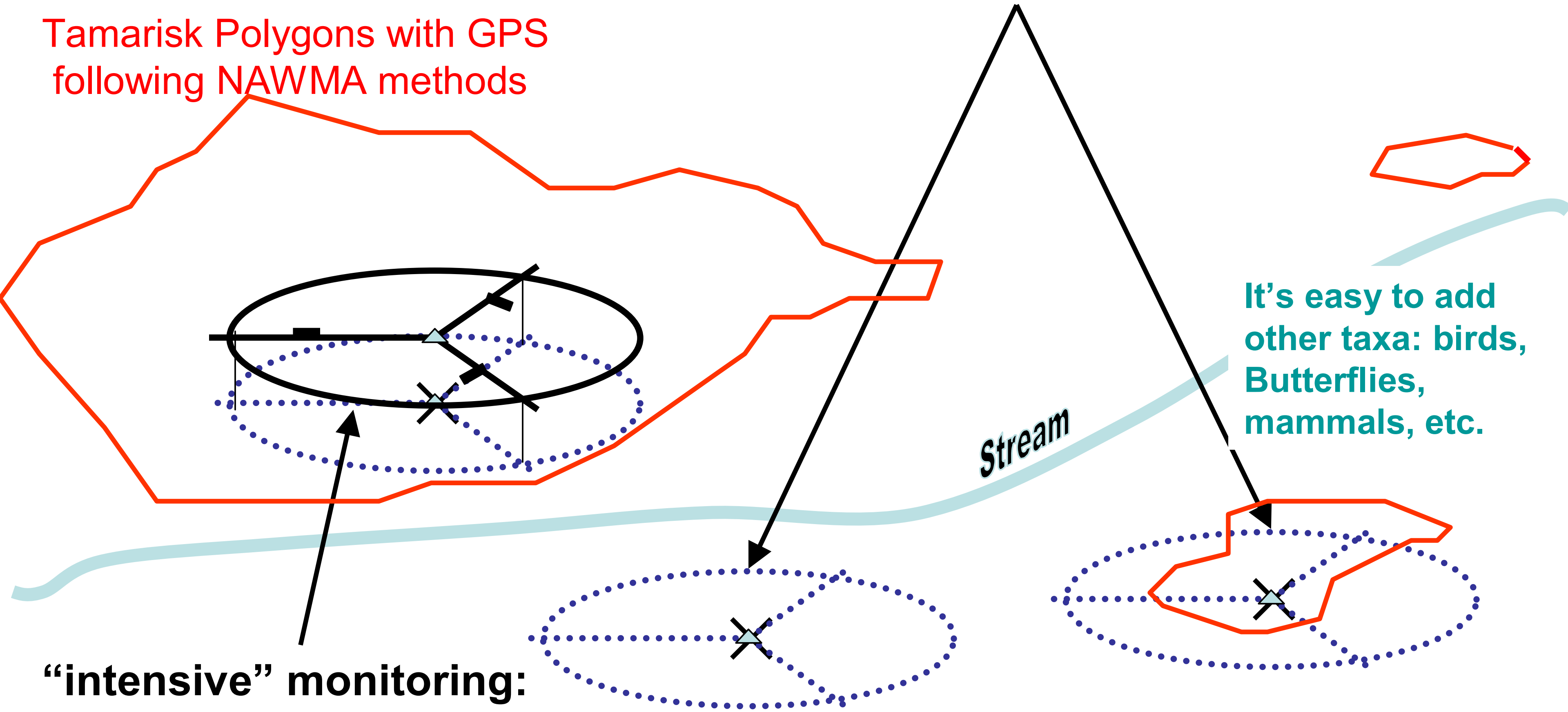
Survey and Monitoring Design *(7.3-m radius plots)*

"extensive" sampling:

See www.NAWMA.org
USDA FIA design

- 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:

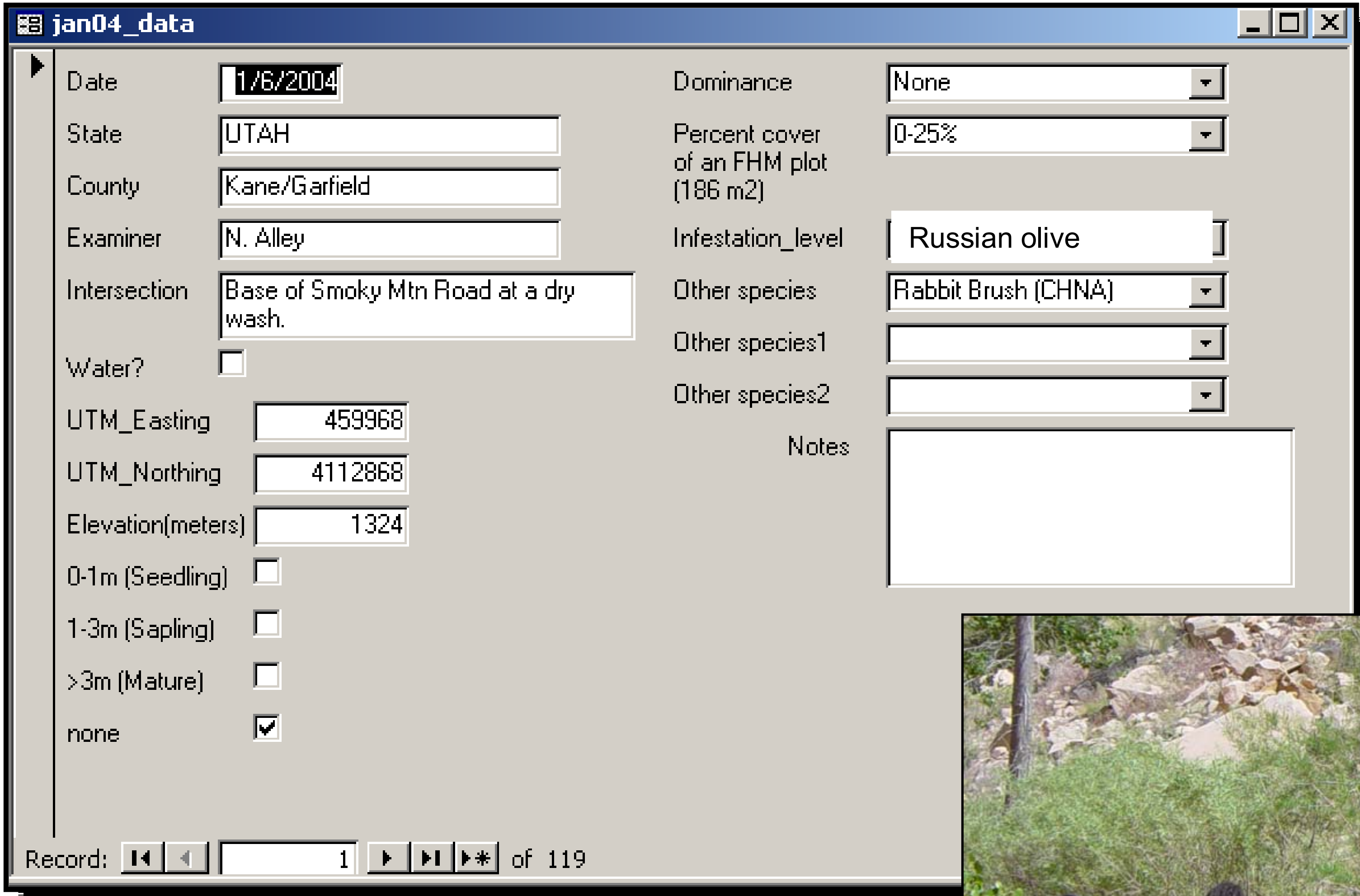
-multi-scale circular plot collect quantitative and ancillary data on pre- and post control and restoration efforts.
- quality control of extensive sampling effort following "Beyond NAWMA methods"

3. Proper field equipment and training

+ Manual entry

+ Automatic upload

4. Database/Information Infrastructure (more standards!)


jan04_data

Date	1/6/2004	Dominance	None
State	UTAH	Percent cover of an FHM plot (186 m2)	0-25%
County	Kane/Garfield	Infestation_level	Russian olive
Examiner	N. Alley	Other species	Rabbit Brush (CHNA)
Intersection	Base of Smoky Mtn Road at a dry wash.	Other species1	
Water?	☐	Other species2	
UTM_Easting	459968	Notes	
UTM_Northing	4112868		
Elevation(meters)	1324		
0-1m (Seedling)	☐		
1-3m (Sapling)	☐		
>3m (Mature)	☐		
none	☑		

Record: 1 of 119

Standardized reporting formats improves data comparability and sharing.

USGS
science for a changing world

National Bison Range

The Art

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”

5. Add Professional “Layer” (the Science)

- 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.

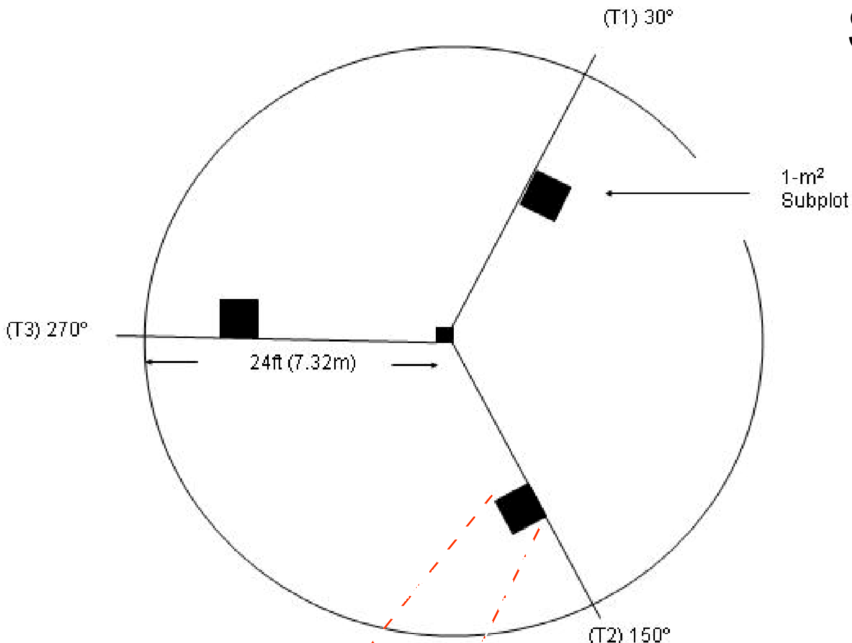
San Pablo Bay NWR

USGS
science for a changing world

The Hart Mountain Example

Survey and Monitoring Design

(7.3-m radius plots)



Mapping Data

Plot Data

The Hart Mountain Example

Survey and Monitoring Design *(7.3-m radius plots)*

See www.NAWMA.org
USDA FIA design

"extensive" sampling:

- Verify and validate current and potential distribution maps.
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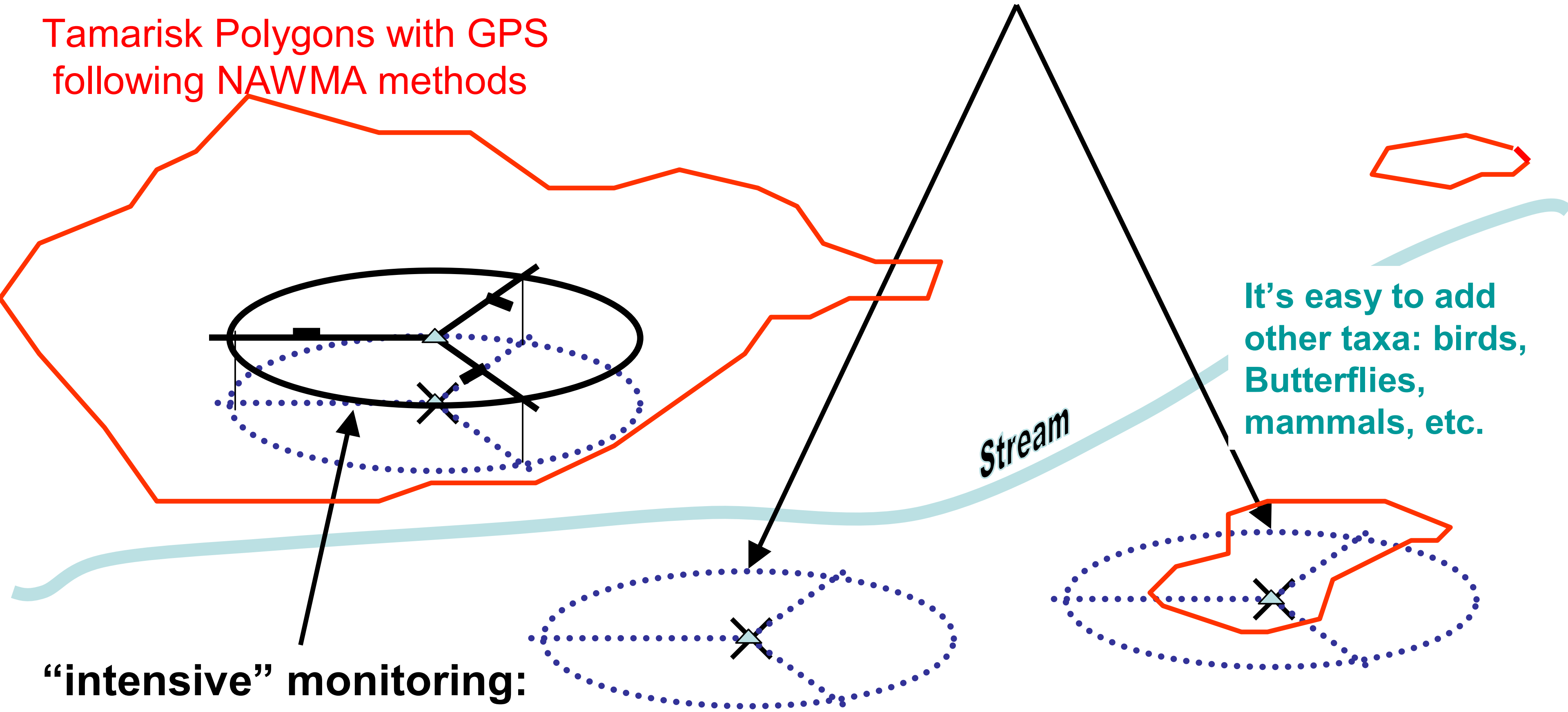
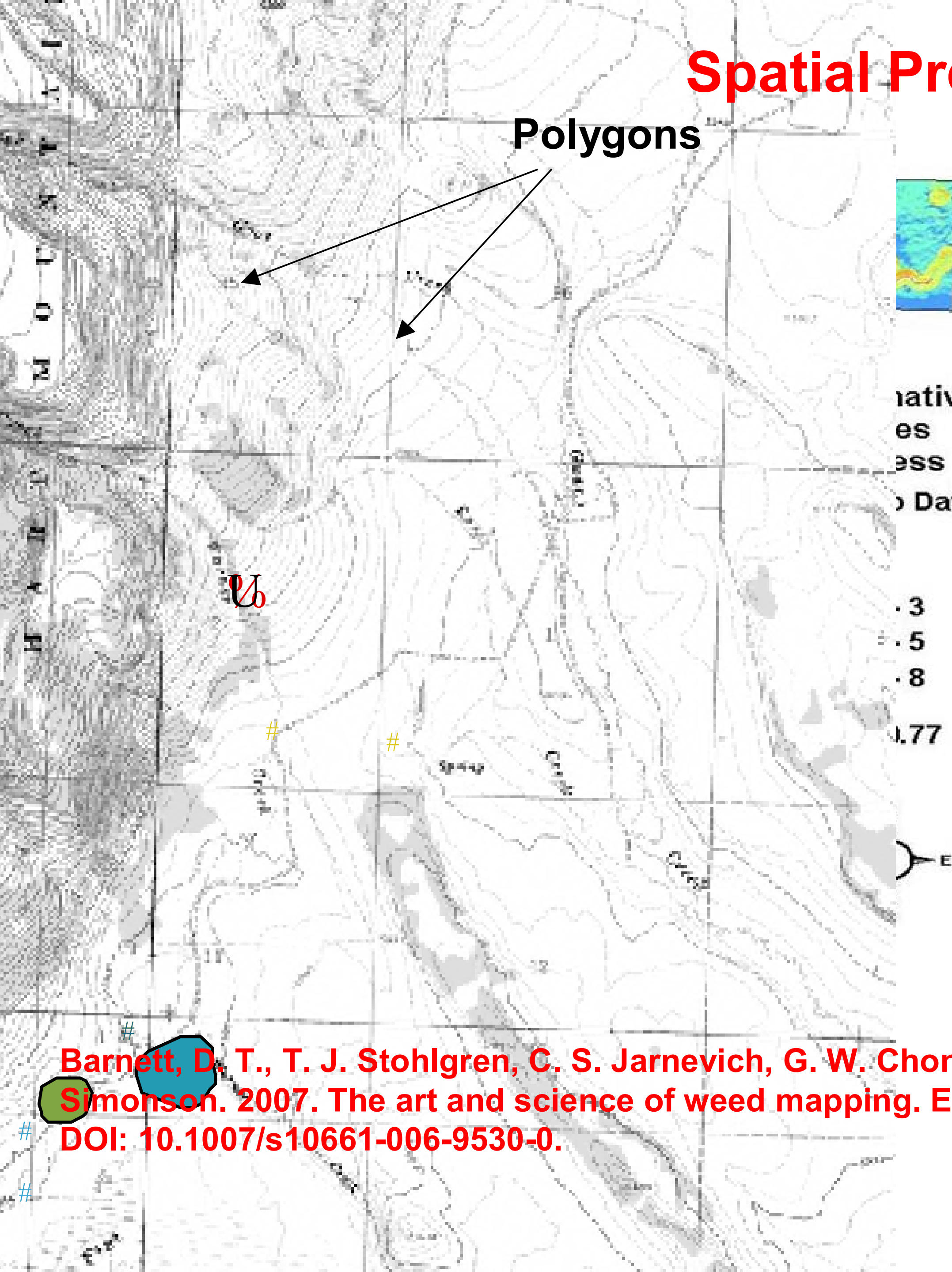
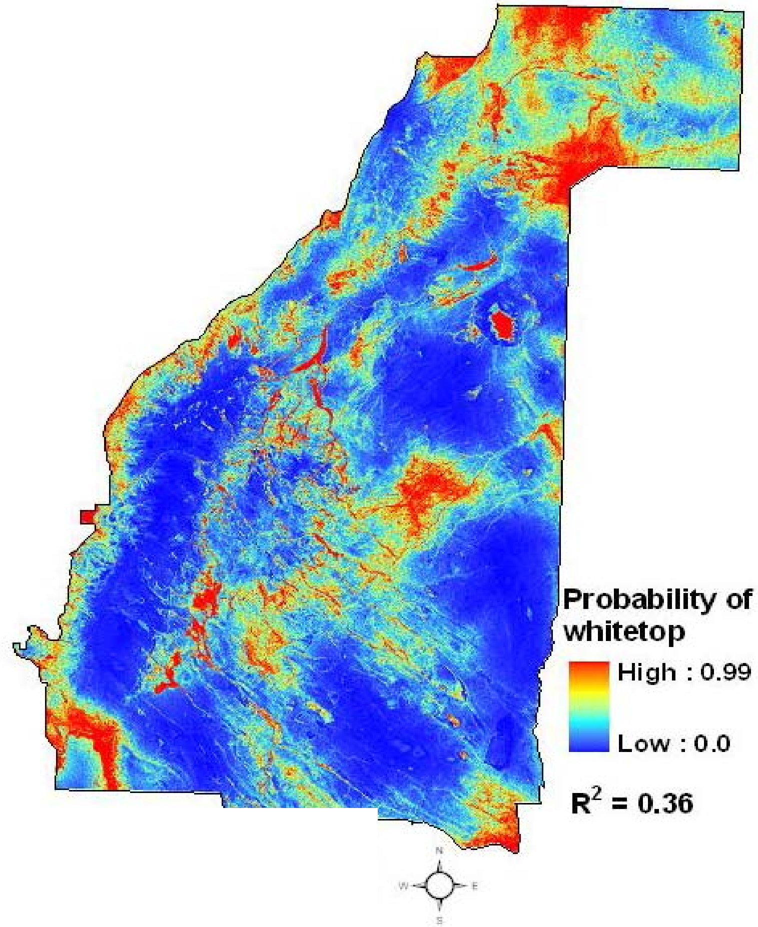


"intensive" monitoring:

-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"

Spatial Predictions





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.

The science behind the scenes!

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

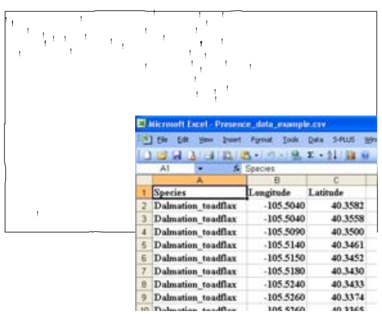
Model evaluation → Model validation

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

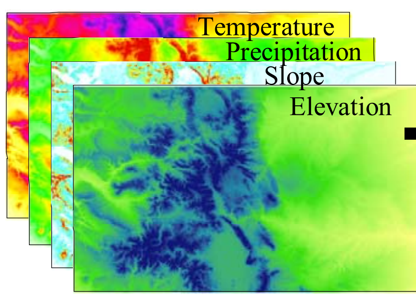


Microsoft Excel - Presence_data_example.csv

	A	B	C
1	Species	Longitude	Latitude
2	Dalmation_toadflax	-105.5040	40.3582
3	Dalmation_toadflax	-105.5040	40.3558
4	Dalmation_toadflax	-105.5090	40.3500
5	Dalmation_toadflax	-105.5140	40.3461
6	Dalmation_toadflax	-105.5150	40.3452
7	Dalmation_toadflax	-105.5180	40.3430
8	Dalmation_toadflax	-105.5240	40.3433
9	Dalmation_toadflax	-105.5260	40.3374

+

Environmental layers



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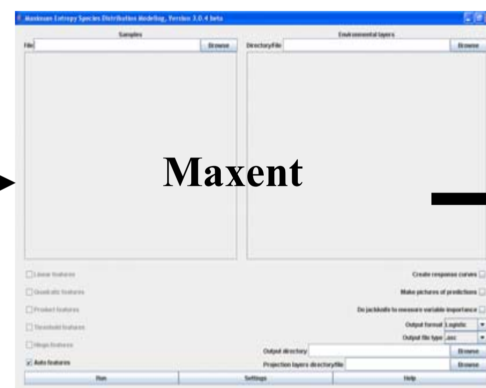

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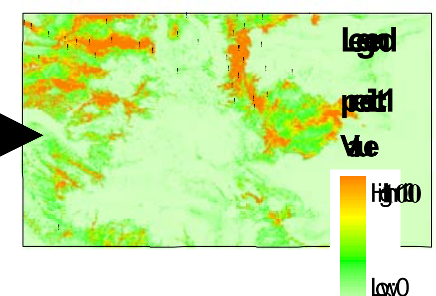
Predicted probability



National Institute of Invasive Species Science (*www.NIISS.org*)

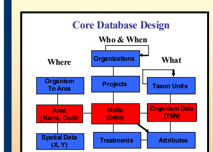
What is the NIISS?

The National Institute of Invasive Species Science is a USGS-led consortium of governmental and non-governmental partners whose *vision* is to provide national leadership in the area of invasive species science and work with others to disseminate and synthesize current and accurate data and research to detect, predict, and reduce the effects of harmful non-native plants, animals, and diseases in ecosystems and natural areas throughout the United States. Our *mission* is to develop cooperative approaches for invasive species science to meet the urgent needs of land managers and the public.

1. From the field . . .

- Providing “toolkits” to citizen scientists, agencies, non-government groups, states, and Tribes.
- Providing training.
- Assisting with integrated assessments and quality control.

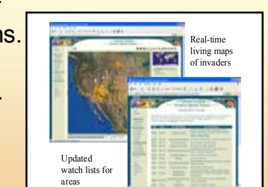
2. To the database . . .



- “Users” input data into the Global Organism Detection and Monitoring System, which accepts, stores and integrates data on species locations and abundance, habitat data, and treatments.
- It’s a global, web-based system for real time accessibility to data.

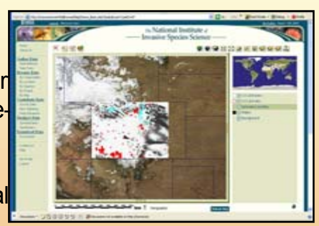
3. To the Web . . .

- Interactive “living maps” of invasive species distributions.
- Query the database by species, project, or location.
- Browse species profiles, maps, photographs, or control information for species or areas of interest.



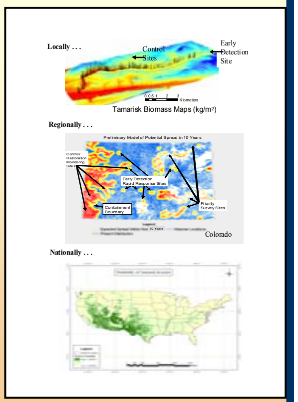
4. To the Invasive Species Forecasting . . .

- The database will be linked to Invasive Species Forecasting capabilities, a web-based decision support environment that combines field data with satellite and other environmental data to generate landscape- and regional-scale tools for statistical analysis, predictive maps, and models of invasive species distributions and potential habitat.



To Fight Invasive Species . . .

- The website integrated with forecasting capabilities will provide a decision support system for adaptive management to prioritize species and areas through iterative analysis as new data are uploaded.
- This system will allow communities to engage in cooperation with government and non-government organizations.



Join the Partnership!

CONTACT INFORMATION

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Fax 970.491.1965, tom_stohlgren@usgs.gov

U.S. Department of the Interior
U.S. Geological Survey

Invasive species = $120 Billion/yr; 42% of T&E; Human health effects

What clients want:
- tools to collect/store field data
- data management help on the web
- simple GIS – see my points
- simple mapping tools
- some predictive modeling
- "watch lists"
- strategies: which species, which areas, and HOW DO I KILL IT! And restore native species.
- all this help and information FREE, on the Web!

All Taxa – All Habitats
Terrestrial and aquatic!
Plants animals, and pathogens!
Remote Sensing and ancillary data
Many modeling approaches
The proper infrastructure
Critical mass of expertise.

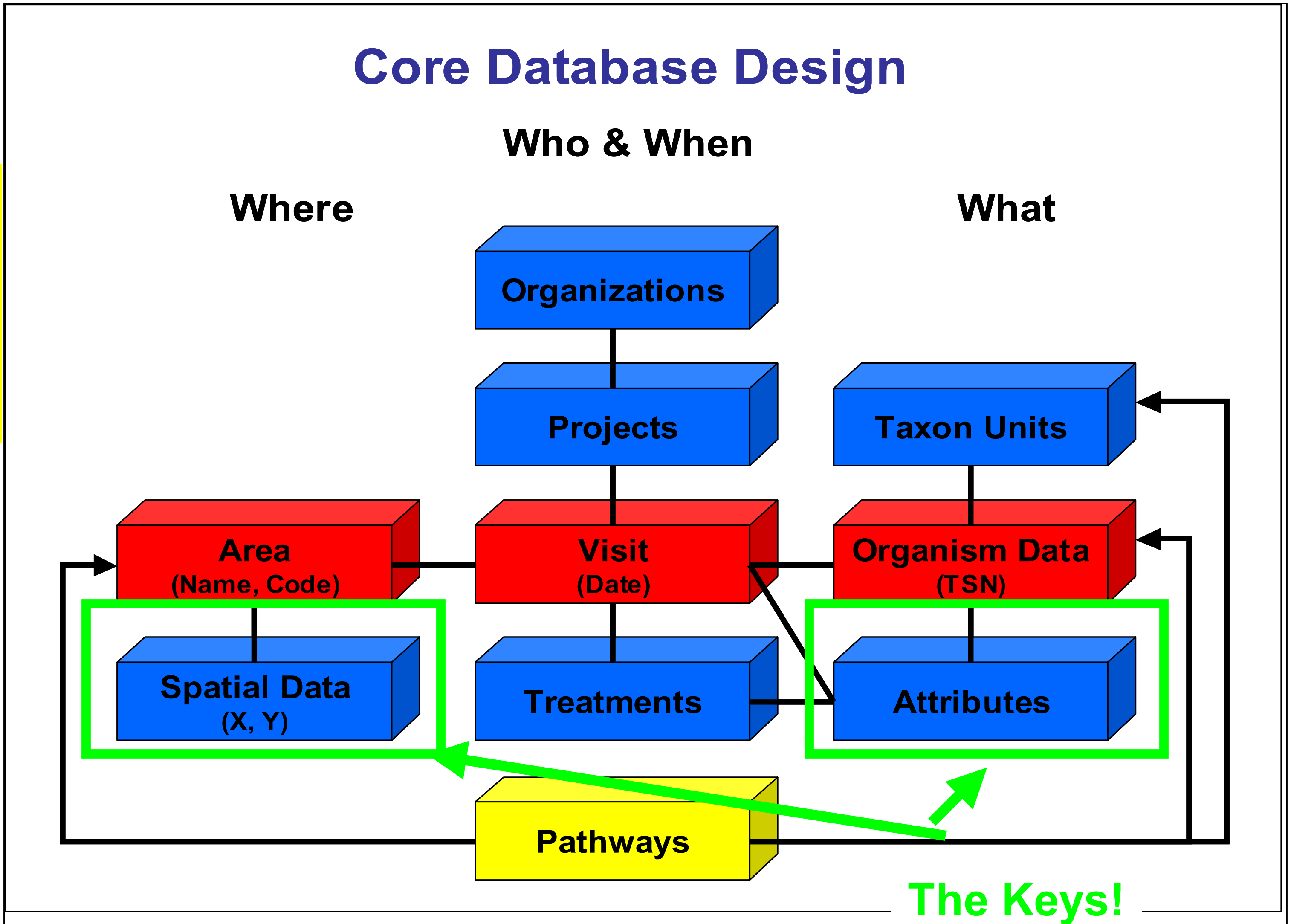
A Global Organism Detection and Monitoring (GODM) System

for Plants, Animals, and Pathogens

Cultural Change

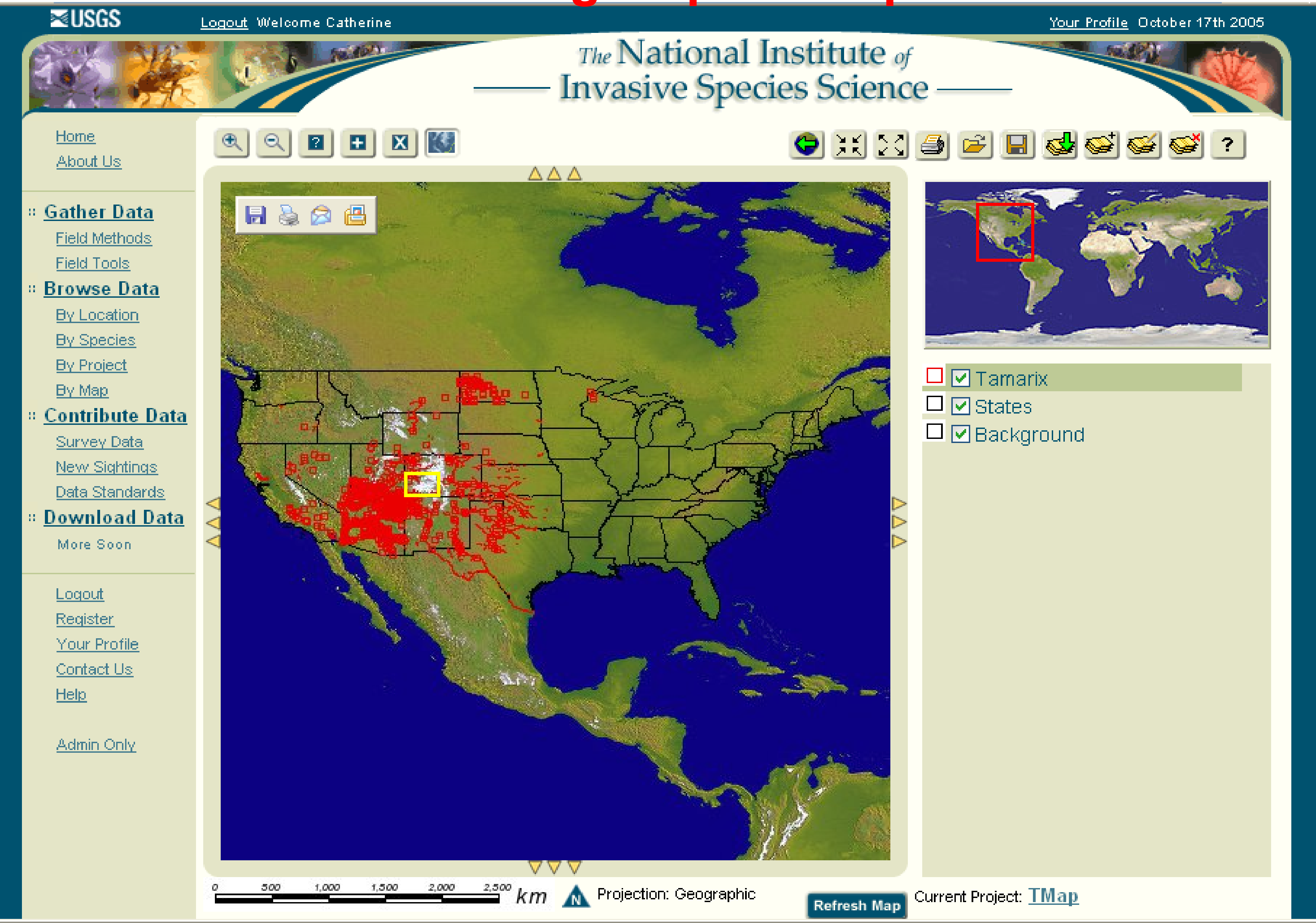
IT Infrastructure

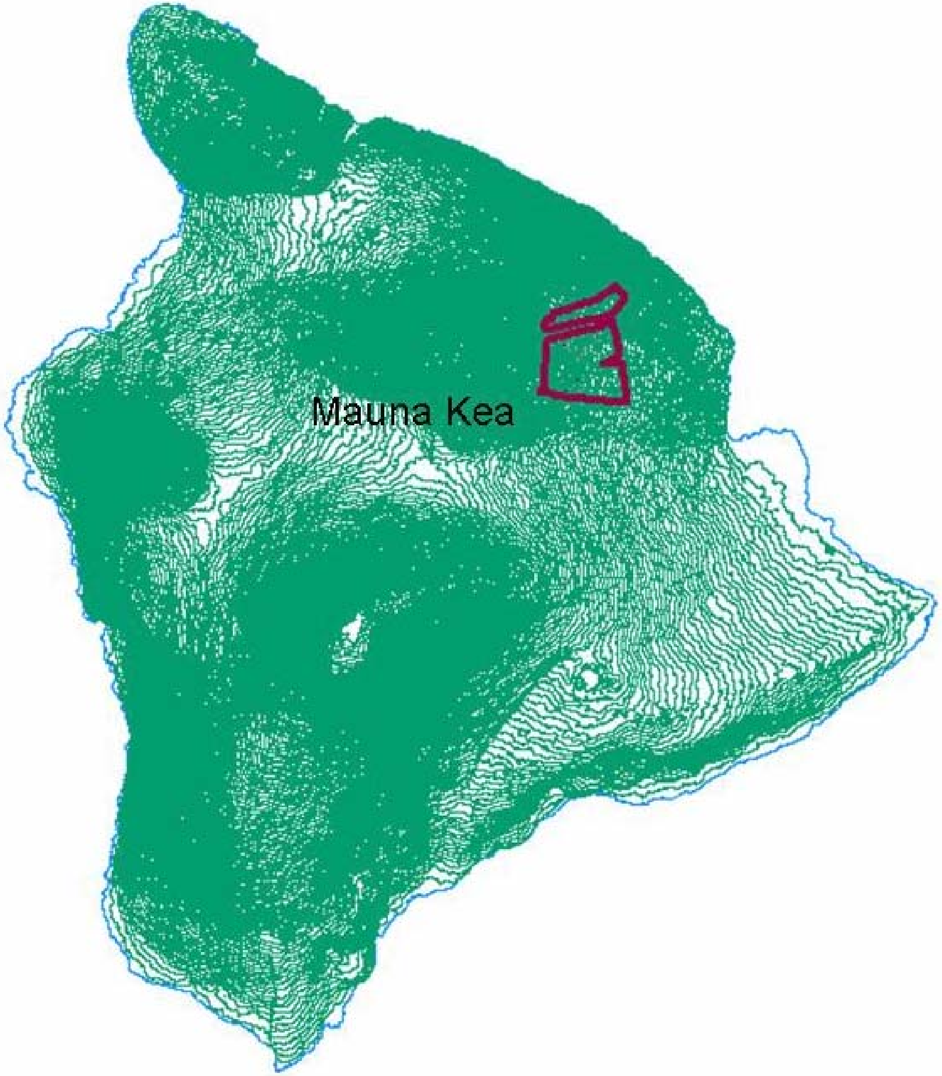
Expertise



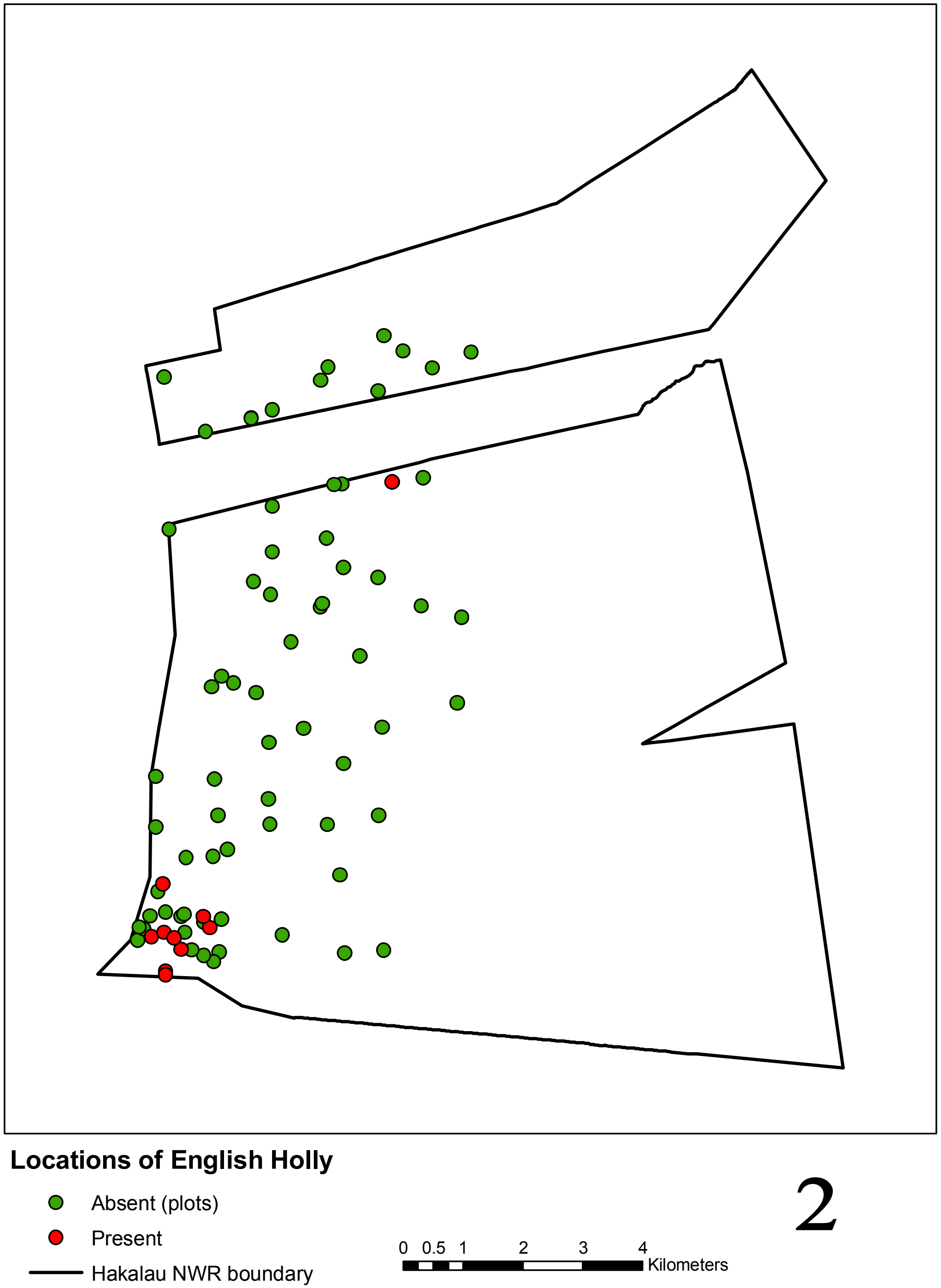
Graham, J., G. Newman, C. Jarnevich, R. Shory, T. Stohlgren. 2007. A Global Organism Detection and Monitoring system for Non-native species. Ecological Informatics 2:177-183.

Online “Living Maps” of Species





Big Island, Hawaii



2

An Example from Hawaii:

Purpose:

Understand current distributions of dominant invasive species for more strategic control efforts.

Methods:

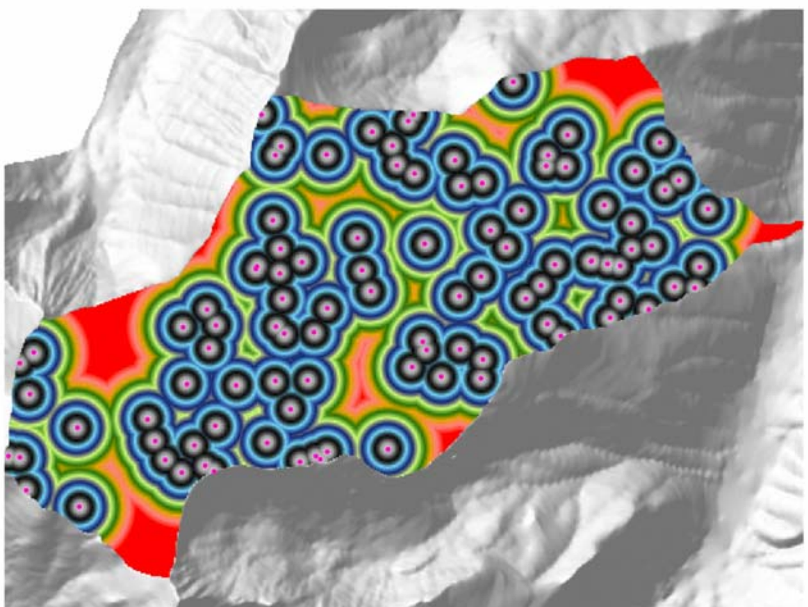
1. **Stratified Random Sampling design**
2. **PDA data collection**
3. **Standardized FHM-type plots**
4. **GIS layers (veg type, elev, rainfall, land (pig) use)**
5. **Site selection (road access)**
6. **Number of samples per type (iterative process based on species accumulation)**
7. **Modeling to predict next sample sites.**

Total time: 2 weeks, 4 people

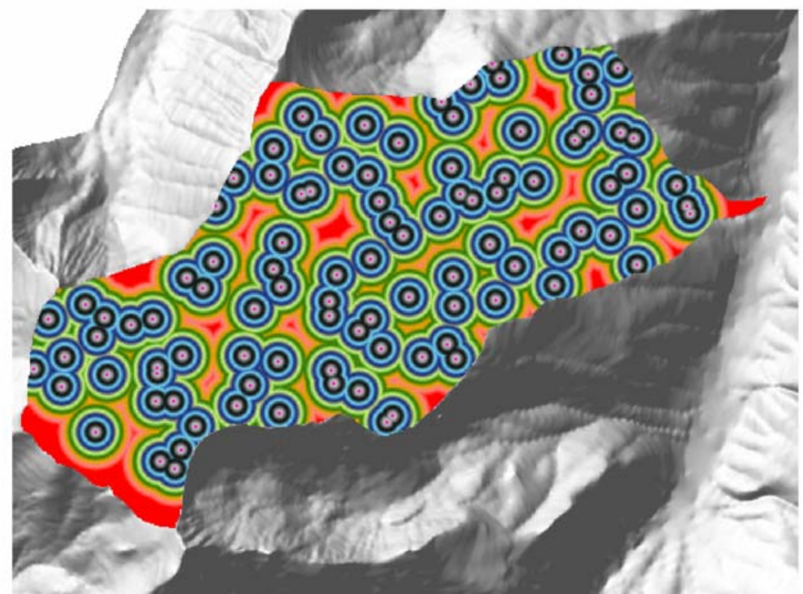
Survey Design:

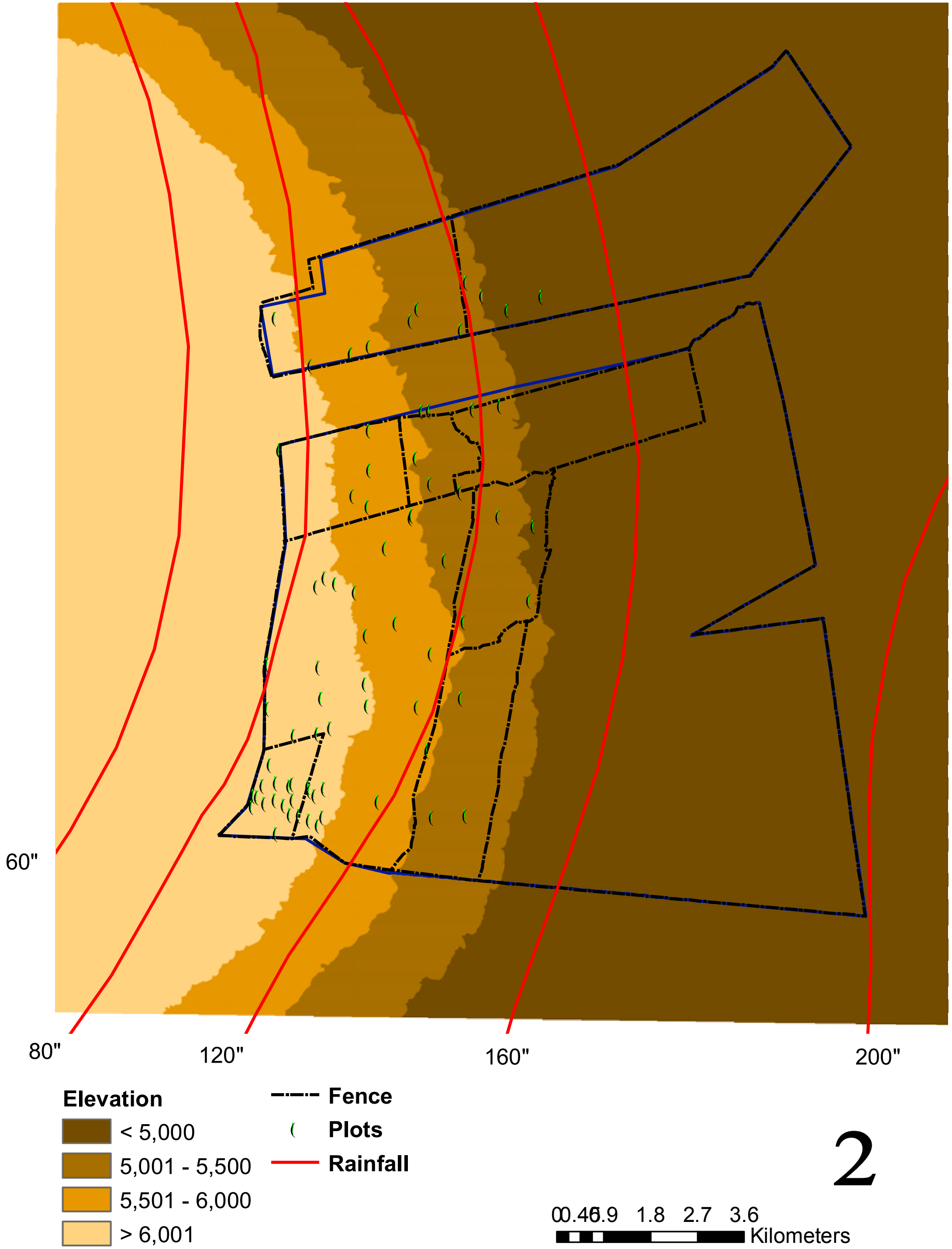
Reversed Randomized Quadrant-Recursive Raster (RRQRR) is a probability-based survey design that produces sample locations that are spatially-balanced with sequenced sampling order.

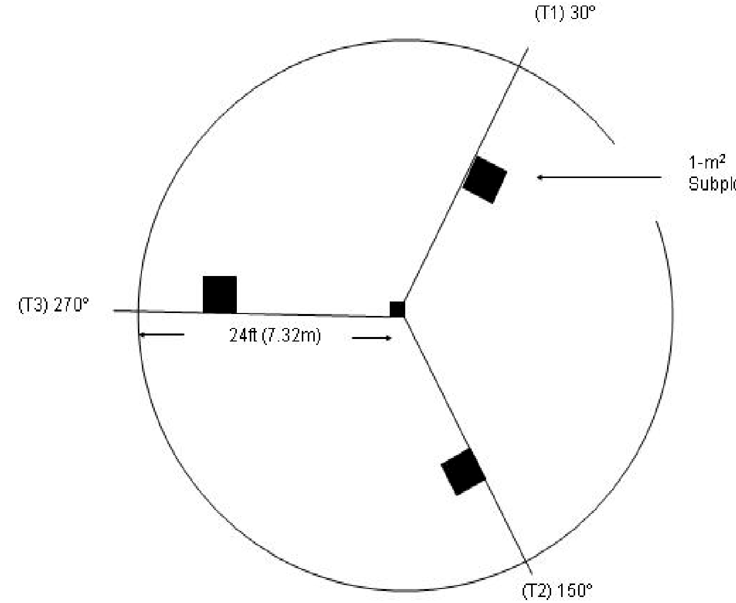
Spatially Random



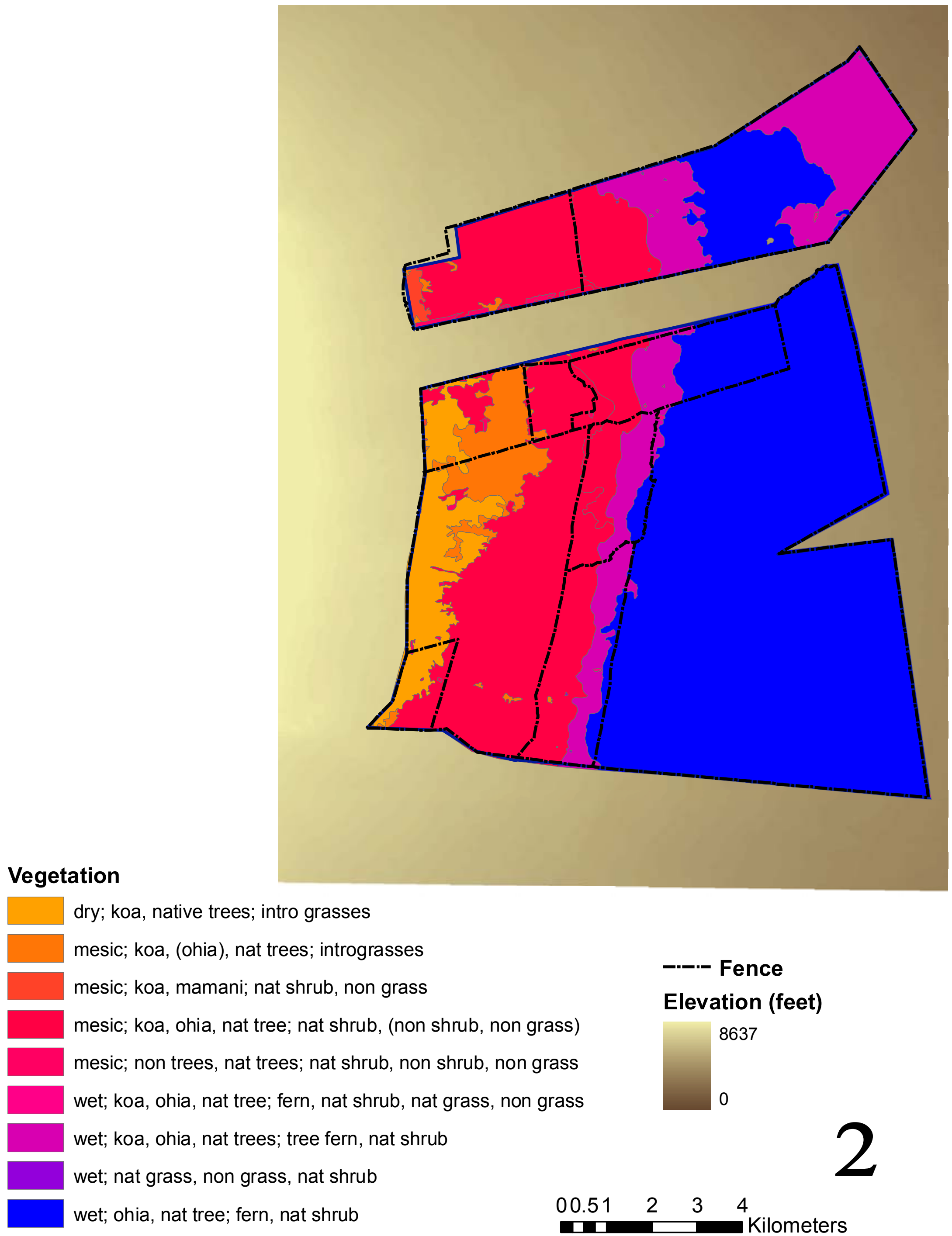
Spatially Balanced



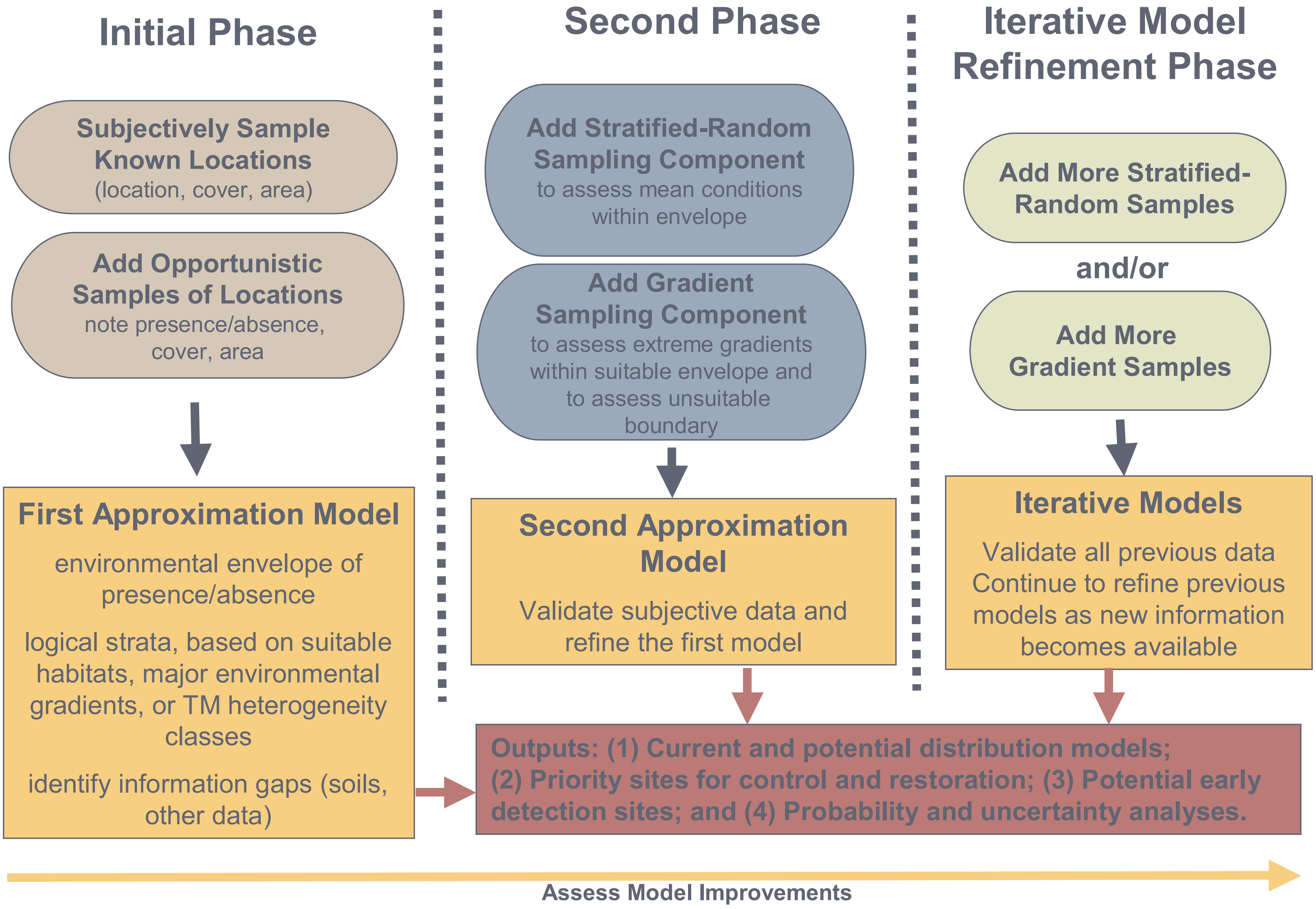

60"
80"
120"
160"
200"
Elevation
< 5,000
5,001 - 5,500
5,501 - 6,000
> 6,001
Fence
Plots
Rainfall
0 0.45 0.9 1.8 2.7 3.6
Kilometers


(T1) 30°
1-m²
Subplot
(T3) 270°
24ft (7.32m)
(T2) 150°

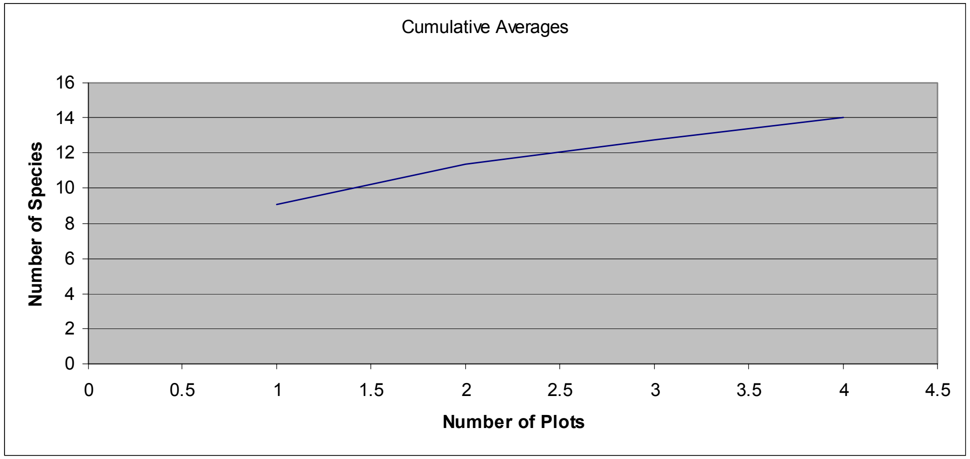
2


Vegetation
dry; koa, native trees; intro grasses
mesic; koa, (ohia), nat trees; intrograsses
mesic; koa, mamani; nat shrub, non grass
mesic; koa, ohia, nat tree; nat shrub, (non shrub, non grass)
mesic; non trees, nat trees; nat shrub, non shrub, non grass
wet; koa, ohia, nat tree; fern, nat shrub, nat grass, non grass
wet; koa, ohia, nat trees; tree fern, nat shrub
wet; nat grass, non grass, nat shrub
wet; ohia, nat tree; fern, nat shrub
Fence
Elevation (feet)
8637
0
2
0 0.5 1 2 3 4
Kilometers

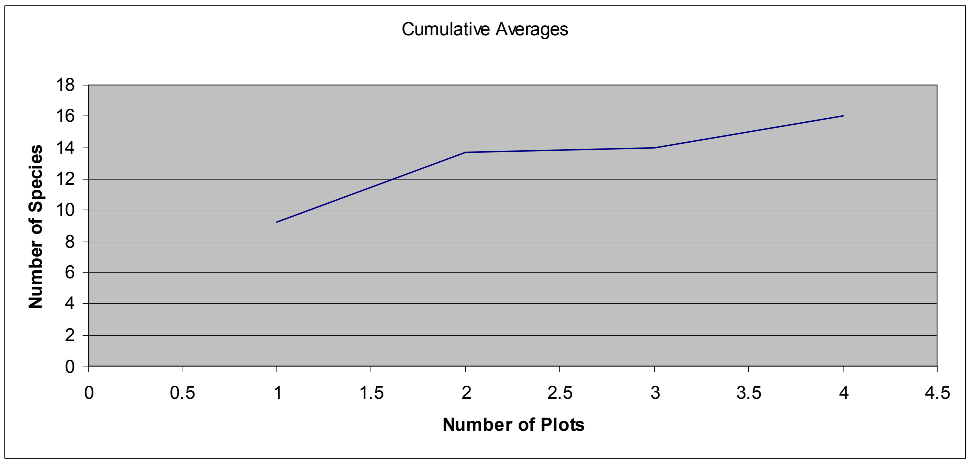
Iterative Sampling for Invasive Species



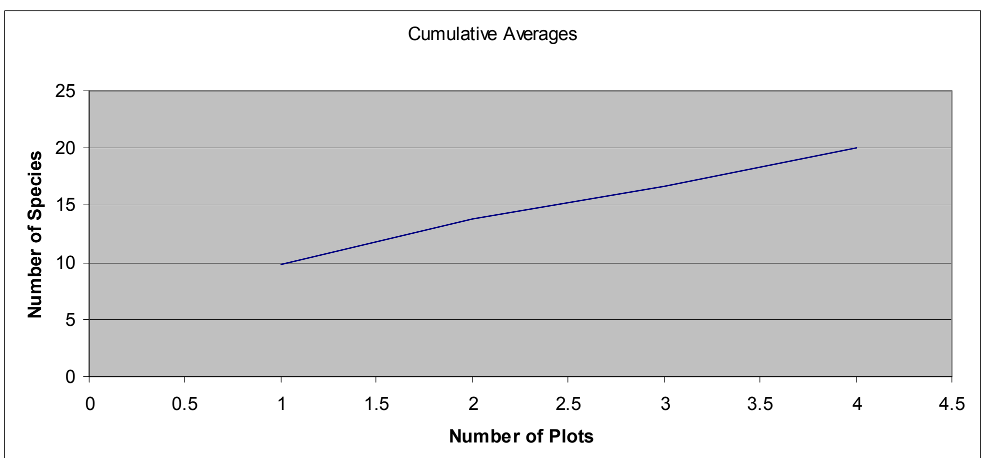
Non-native Species



Dry Koa and Invasive Grasses
4 Plots, 14 species



Mesic Koa, Ohia, Inv Grasses
4 Plots, 14 species



Mesic Koa, Ohia, Shrub
4 Plots, 20 species

dryer
Moisture
wetter

Distribution of Bull Thistle - Maxent Model

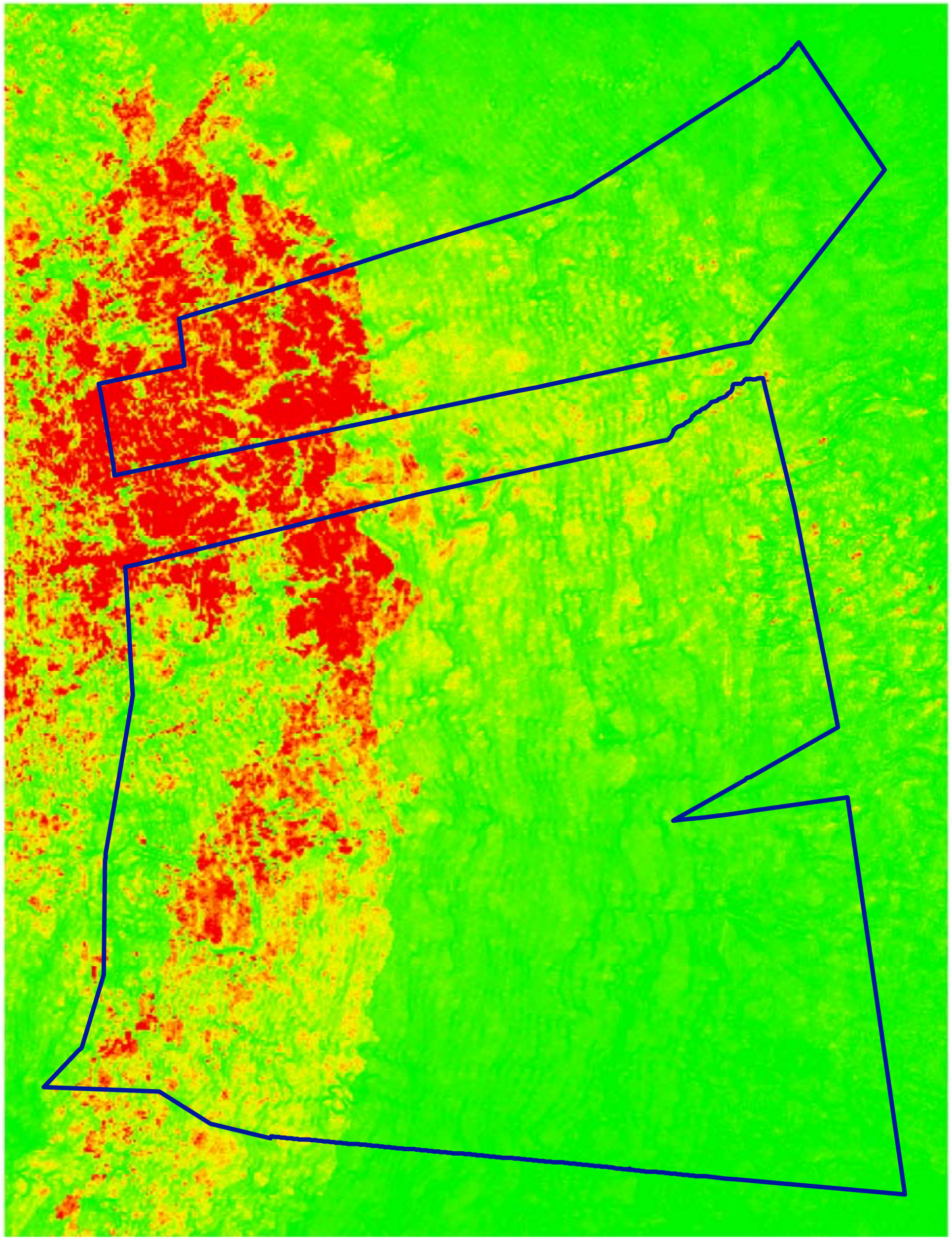
100

0

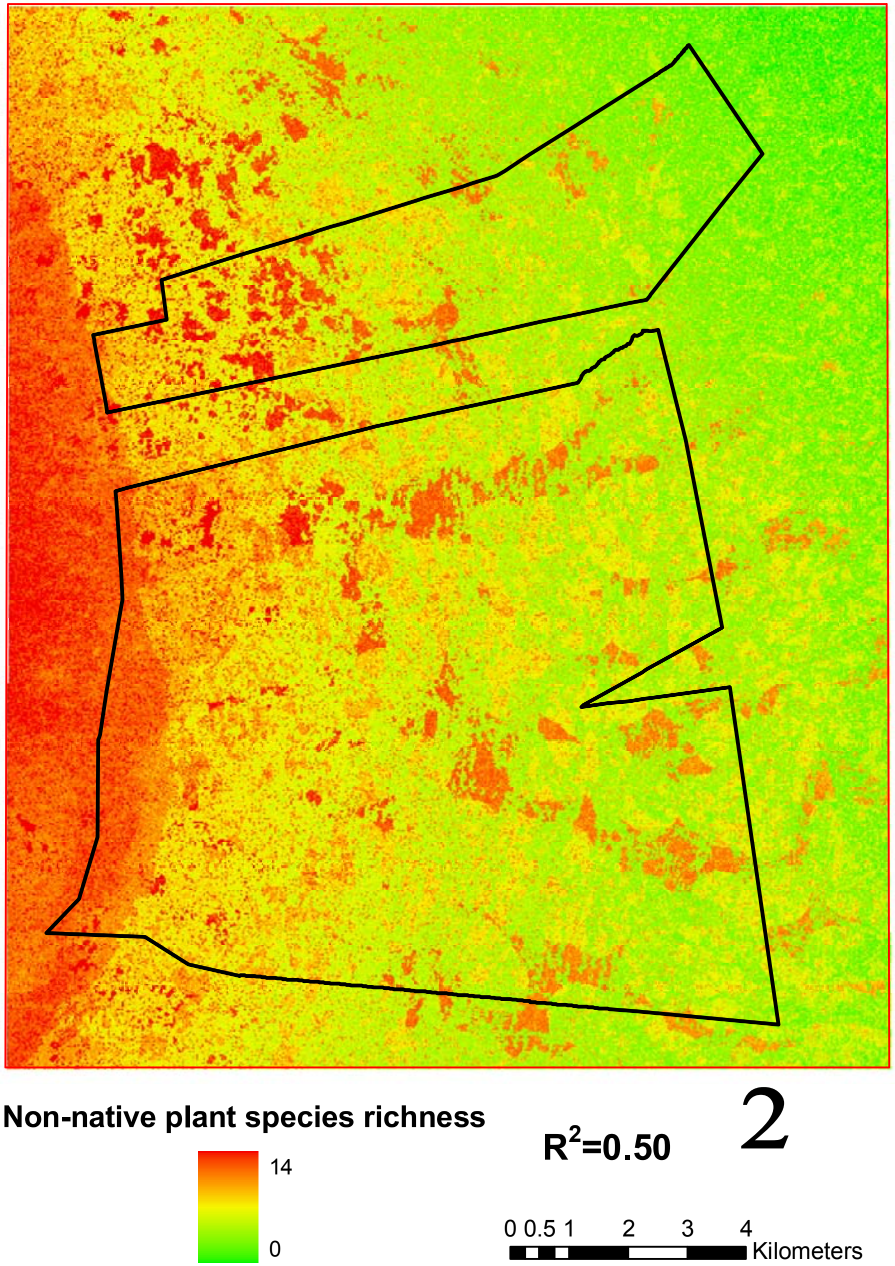
AUC = 0.98

2

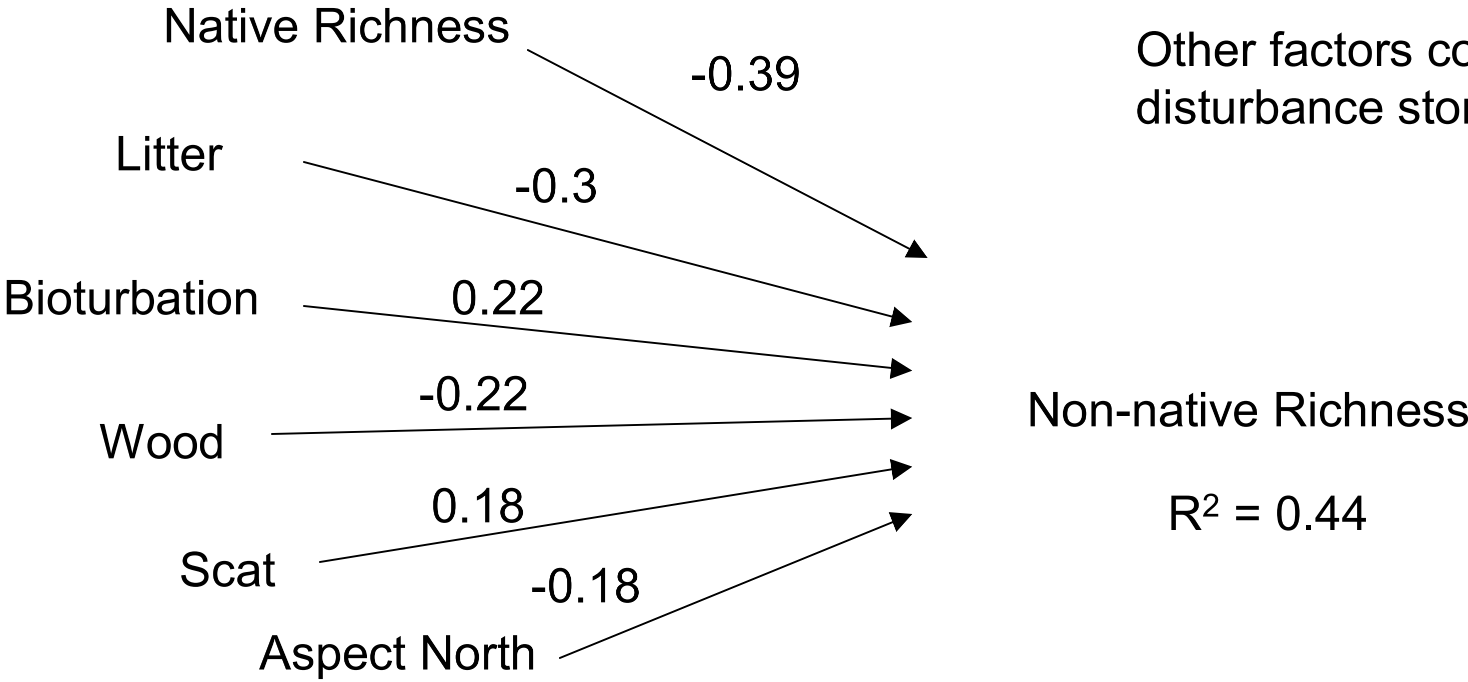
0.37751.52.25 3
Kilometers

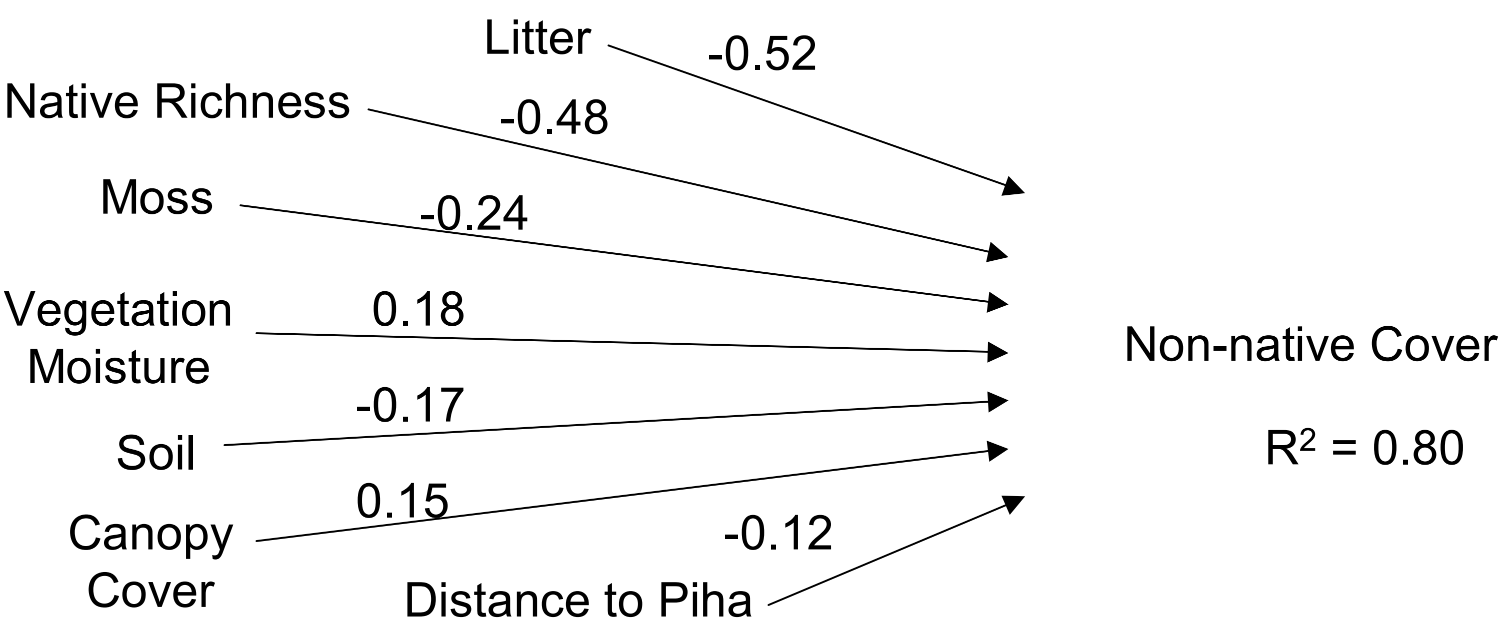


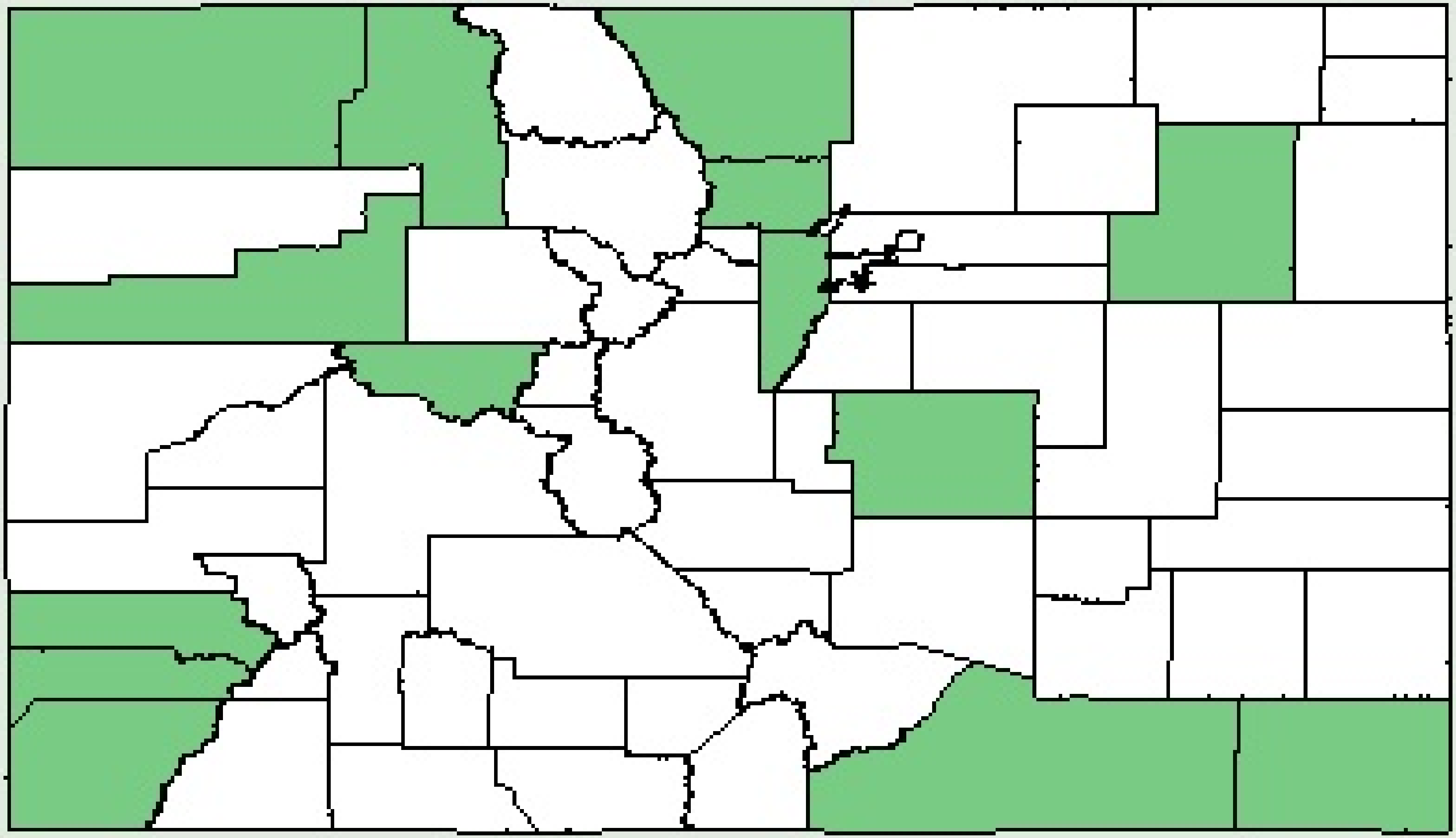
Pig disturbance and historical human disturbance may help non-natives spread and persist at lower elevations.



Other factors confirm the disturbance story!



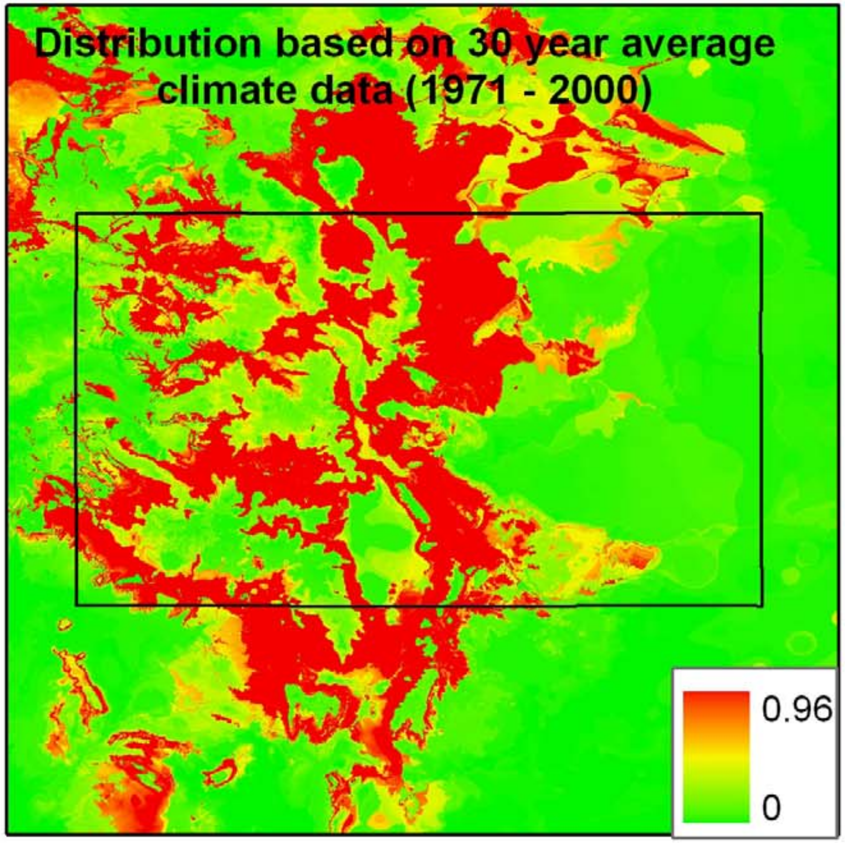


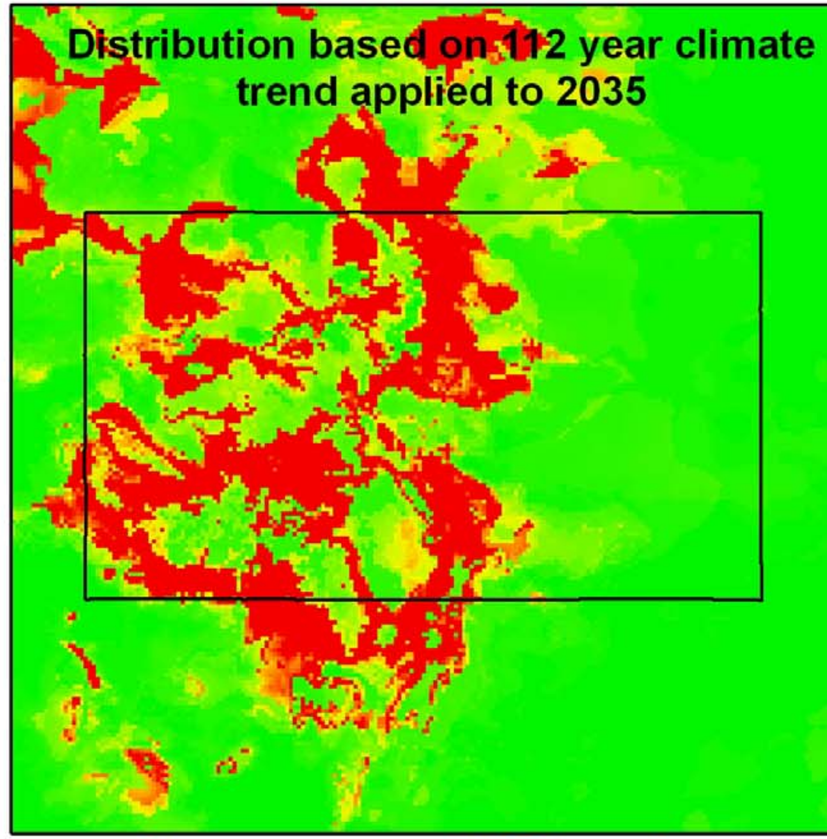


PLANTS Database

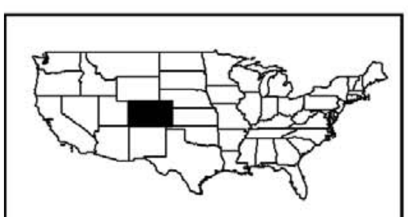
LIDA

Dalmation toadflax distribution in Colorado

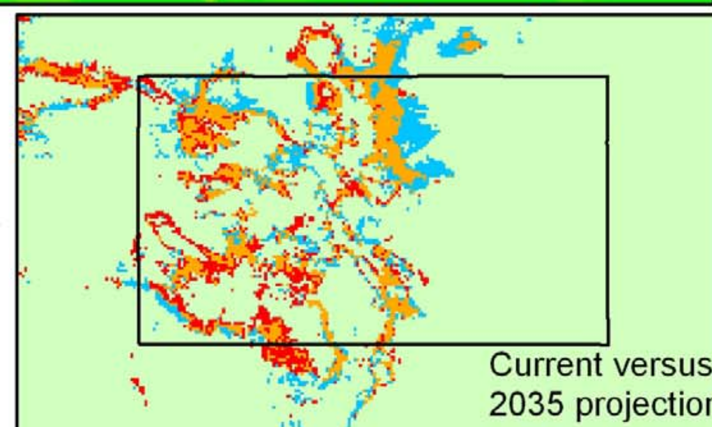


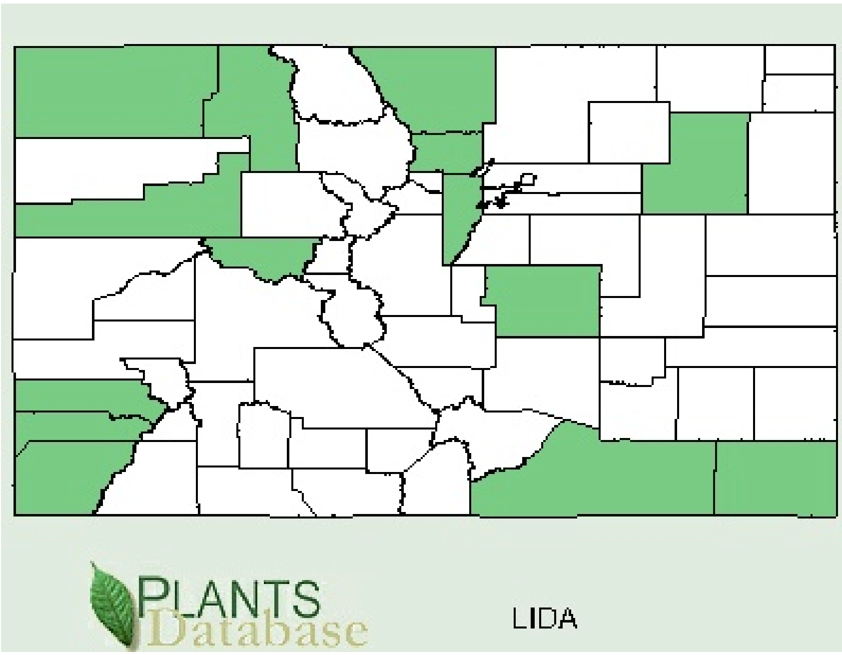


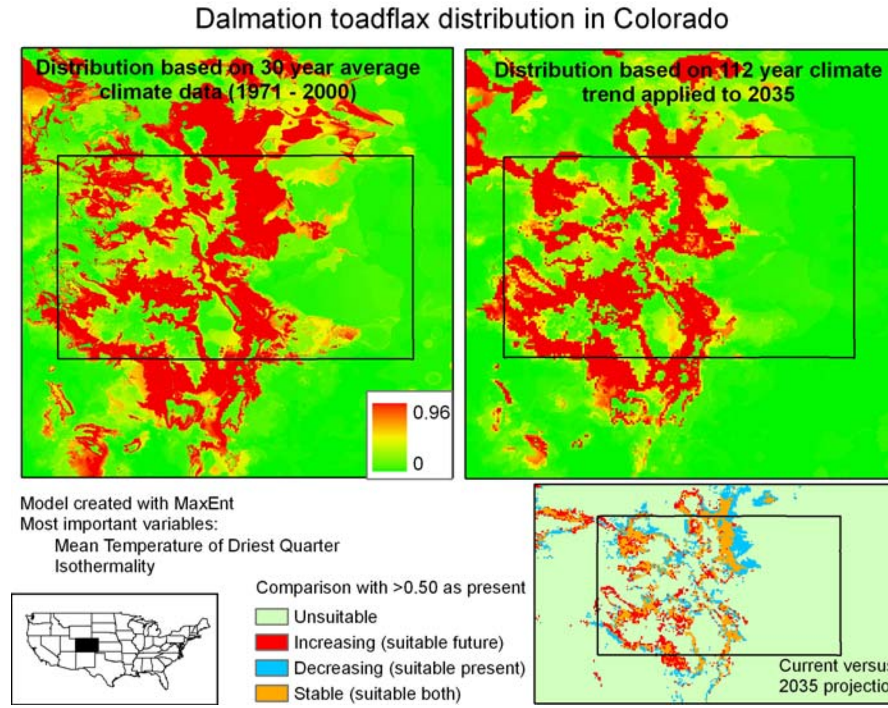
Model created with MaxEnt
Most important variables:
- Mean Temperature of Driest Quarter
- Isothermality



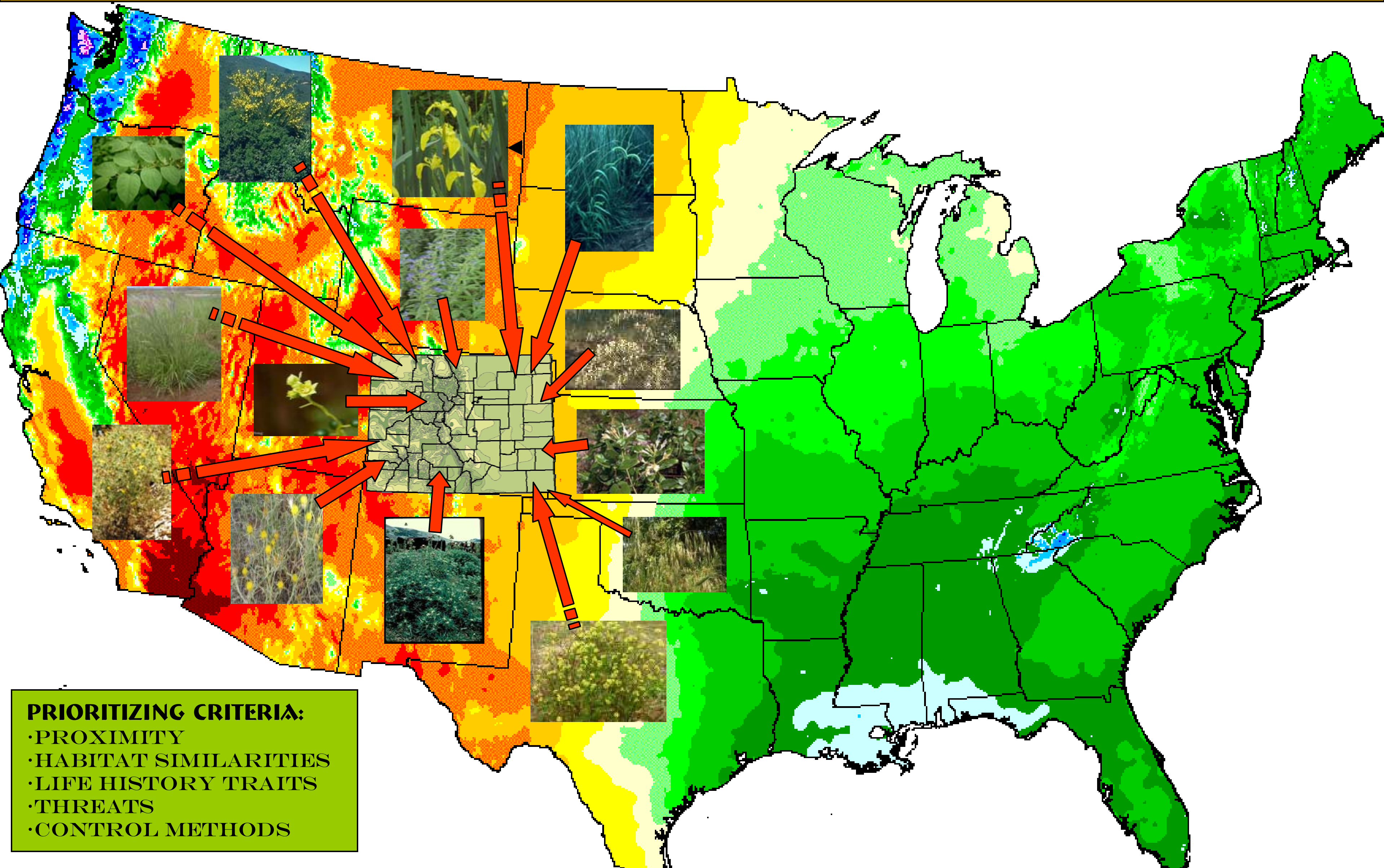
Comparison with >0.50 as present
- Unsuitable
- Increasing (suitable future)
- Decreasing (suitable present)
- Stable (suitable both)




PLANTS
Database
LIDA


Dalmation toadflax distribution in Colorado
Distribution based on 30 year average climate data (1971 - 2000)
0.96
0
Distribution based on 112 year climate trend applied to 2035
Model created with MaxEnt
Most important variables:
Mean Temperature of Driest Quarter
Isothermality
Comparison with >0.50 as present
Unsuitable
Increasing (suitable future)
Decreasing (suitable present)
Stable (suitable both)
Current versus
2035 projection

Predicting Invasive Species Into New Territory: Colorado as a case study



Prioritizing criteria:
- Proximity
- Habitat similarities
- Life history traits
- Threats
- Control methods

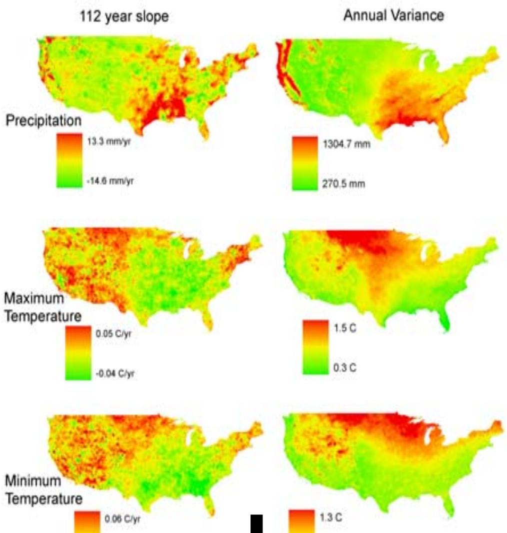
Drucker, Hilary. 2007, **DEVELOPING REGIONAL INVASIVE SPECIES WATCH LISTS: COLORADO AS A CASE STUDY** Master's Thesis. Colorado State University.

Tools Needed

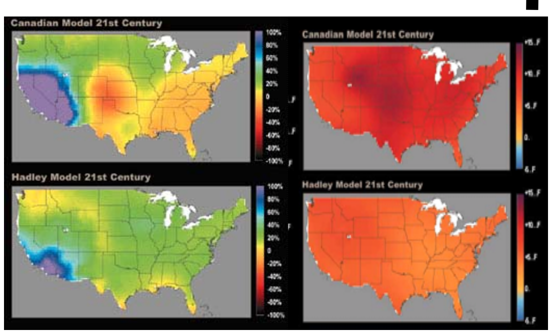
1. Enthusiasm and taxonomic skills
2. Ability to conform to accepted standards
3. Proper field equipment and training
4. Database/information infrastructure
5. A “professional layer” for plot-level iterative field surveys, data analysis, and modeling.
6. Willingness to share data and results

Invasive Species and Climate Change

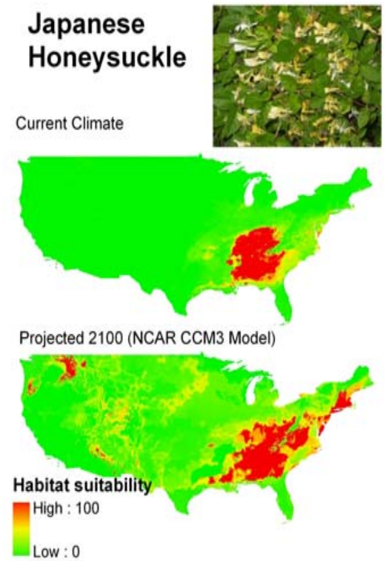
1. Quantifying past climate trends



2. Bracketing future climate change scenarios from existing or new models

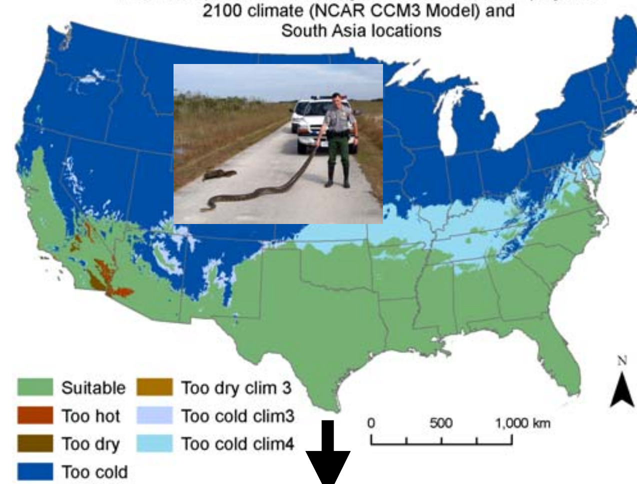


3. Forecasting species range shifts based on current distributions and interdisciplinary datasets from Biology, Water, Mapping, and Geology.

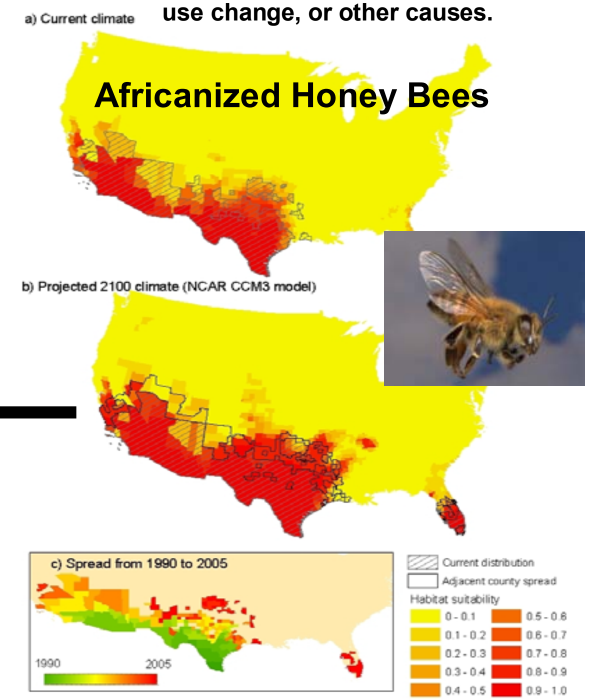


4. Testing various models on many species at multiple spatial scales

Potential *Python molurus* range in the US based on projected 2100 climate (NCAR CCM3 Model) and South Asia locations



5. Isolating background rates of spread from those caused by climate change, land use change, or other causes.



6. Getting the information to on-the-ground managers for prevention, "watch lists," risk assessments, early detection, rapid response, control, and restoration.