Invasion of non-native plants to the forests of the Cumberland Plateau and Mountain Region

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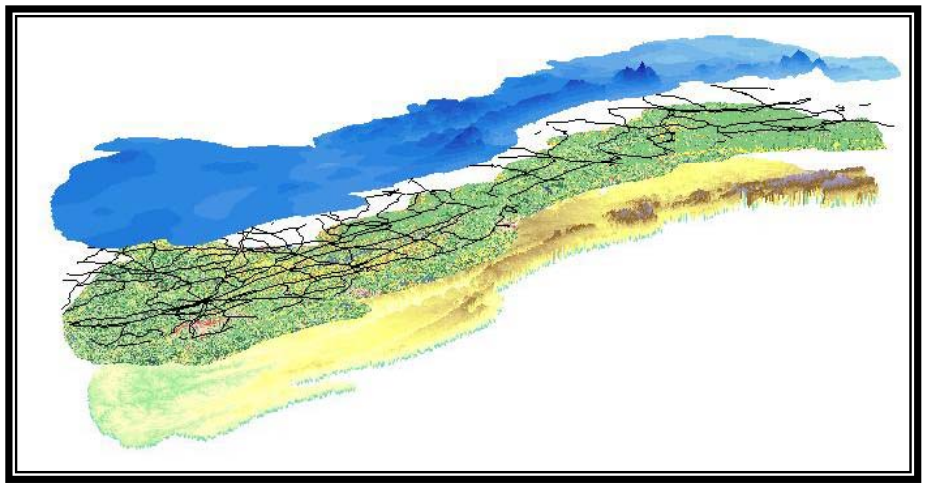
INTRODUCTION:

Assessing Invasive Plants

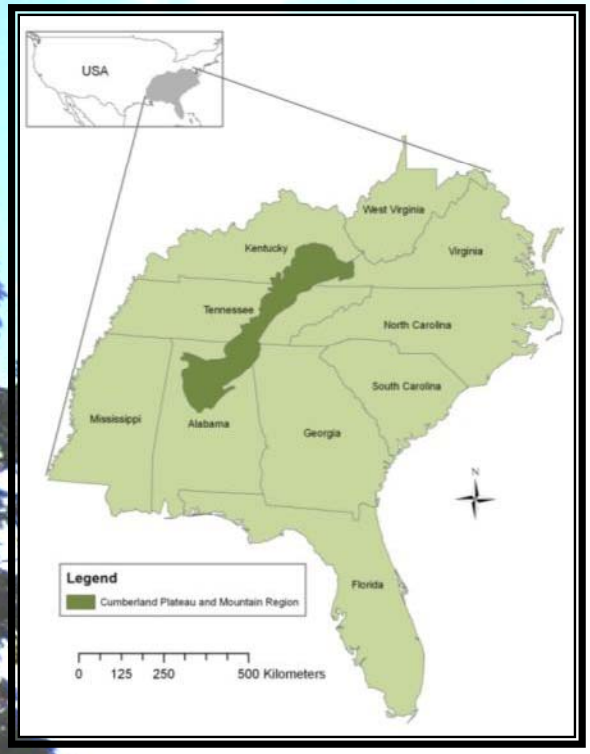
- Invasion is not new phenomena; it is part of an evolutionary process.
- However, recently invasions have been greatly accelerated due to human influences.
- They are now considered a form of global change as they are occurring at an unprecedented rate across the globe.
- As our impact on the landscape changes the composition of 'natural' areas, it is important that we integrate technology to assist in active management.

INTRODUCTION:

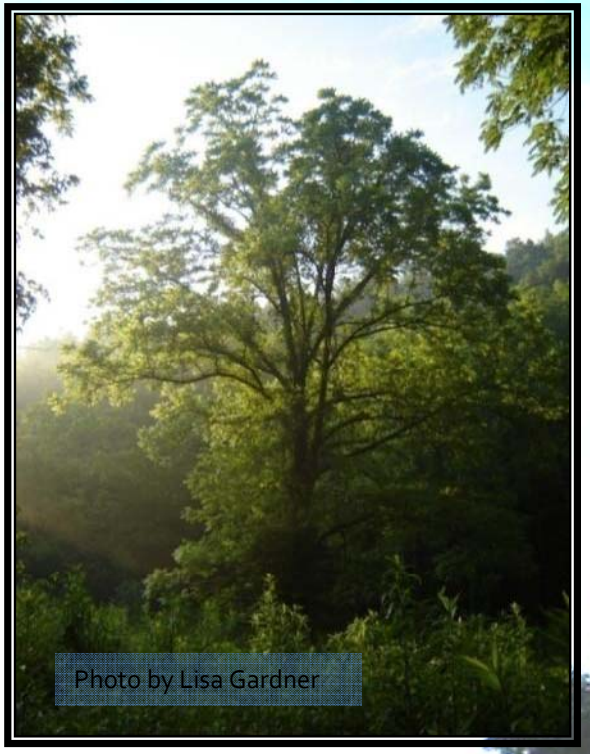
GIS and Statistical Modeling



- Invasions are influenced by landscape pattern and scale.
- Tools that integrate space, time and scale are essential to understanding the underlying processes.
- Geographical Information Systems (GIS) is a tool that integrates these components and can be used to manage, analyze and disseminate spatial information.
- Relationships often not linear thus non-parametric modeling techniques are need.



Cumberland Plateau & Mountain Region



- 59,000 square kilometres
- One of the most diverse woody plant communities in the eastern United States.
- Forest resources are a major part of the economy.
- 70% of the land in this area is forested, with over 75% of this in hardwoods.

RESEARCH QUESTIONS:

1. What is the probable distribution of three invasive species (Japanese honeysuckle, tall fescue and mimosa) in Cumberland Plateau and Mountain region?
2. What is the relative importance of landscape drivers on the distribution of these invasive plants?
    a) environment (e.g.. elevation, water sources etc.)
    b) anthropogenic (e.g. distance to human features, management etc.)
3. How does plant occurrence affect our ability to model the probable distribution?

DATA: Forest Inventory Analysis

- USDA Forest Service program: collects, analyses, and reports information on the status, trends and conditions of forests within the U.S.
- There is an extension of the Forest Inventory Analysis database that focuses on invasive plants.
- Invasives identified: four tree species of invasives, seven shrubs, seven vines, five grasses and two forbs, for a total of 25 invasive plants in the Cumberland Plateau and Mountain region.

Name	Occurrence
Tree of Heaven	39
Mimosa	45
Princess Tree	8
Russian Olive	1
Autumn Olive	9
Burning Bush	1
Chinese Privet	234
Japanese Privet	71
Bush Honeysuckles	10
Sacred Bamboo	5
Nonnative Roses	141
Asian Bittersweet	1
Chinese Yam	7
Winter Creeper	2
Japanese Honeysuckle	579
Kudzu	11
Periwinkles	1
Japanese Wisteria	2
Tall Fescue	93
Cogongrass	1
Nepalese Browntop	49
Chinese Silvergrass	10
Nonnative Bamboos	9
Shrubby Lespedeza	9
Chinese Lespedeza	25

FOCAL SPECIES:

Japanese Honeysuckle

Tall Fescue

Mimosa

Three species were chosen to study, based on:

- Overall number of sites of occurrence
- Life forms

Species chosen were:

- Japanese honeysuckle (*Lonicera japonica*) [*n* = 579][Vine]
- Tall fescue (*Lolium arundinaceum*)[*n* = 93][Grass]
- Mimosa (*Albizia julibrissin*), [*n* = 45][Tree]

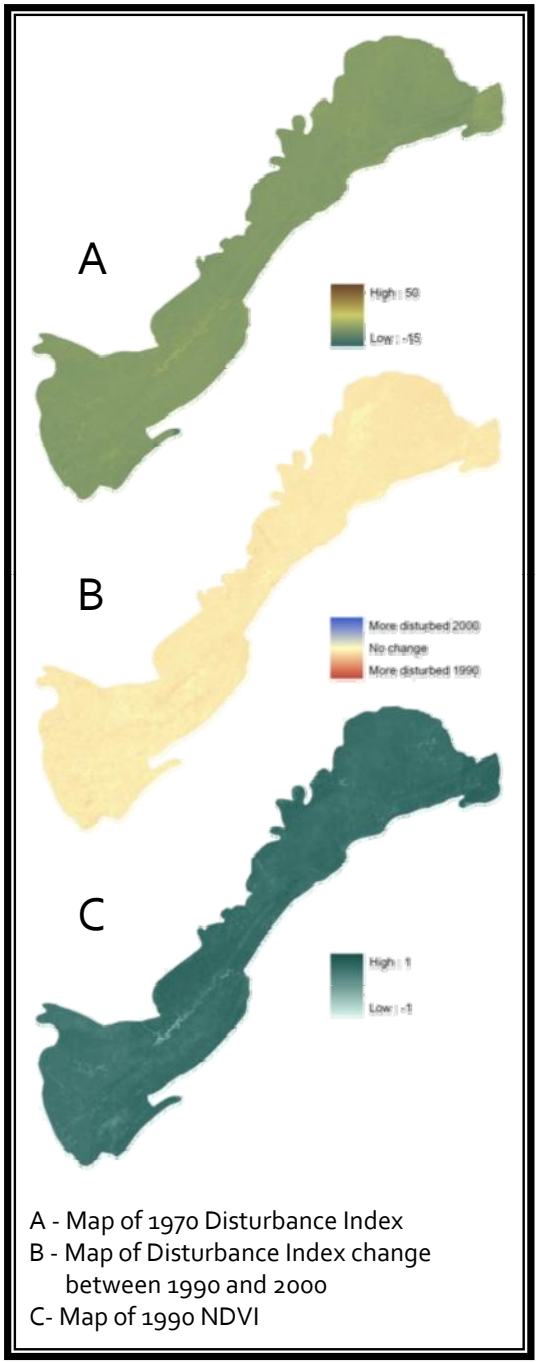
DATA: Landscape Variables

- Landscape associated variables were derived from digital information.
- Landscape variables were categorized into six groups:
  - Landsat
  - Anthropogenic
  - Landform
  - Climate
  - Land use
  - Water
- Correlation within each group was assessed, and those with high correlation (>0.80) were removed.




DATA: Landsat

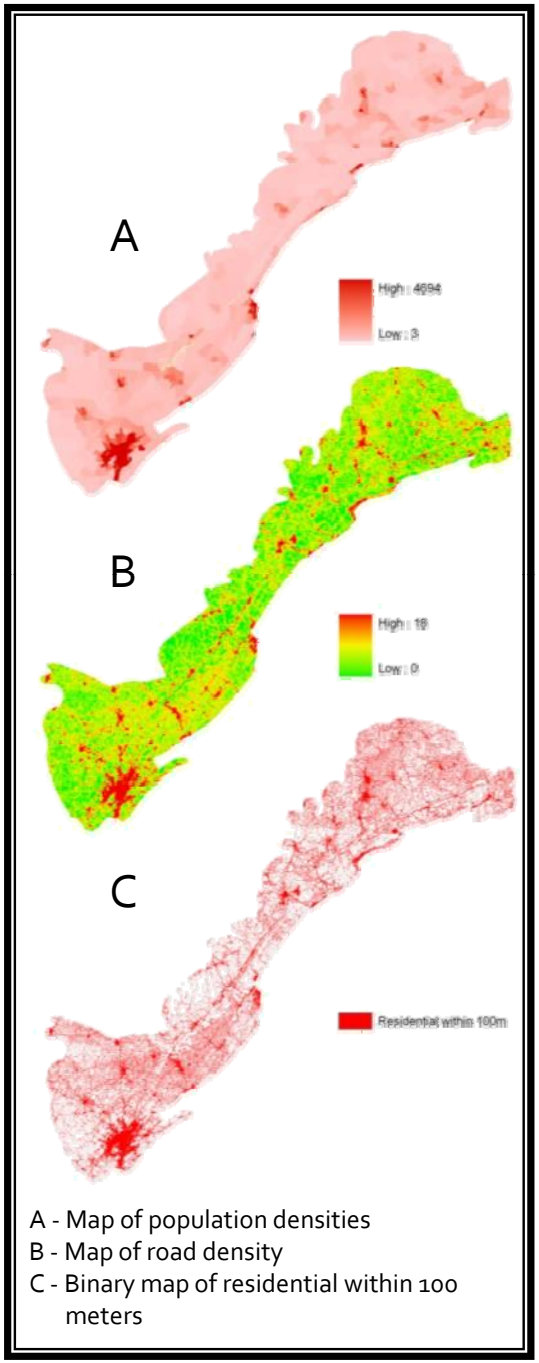
- Landsat imagery was used to assess forest disturbance.
- Two indices were calculated:
  - Normalized Difference Vegetation Index (NDVI)
  - Disturbance Index (DI)
- This was done for three time periods: 1970, 1990 and 2000.
- Landsat variables:
  - DI70
  - DI90
  - DI00
  - DI00-90
  - NDVI90
  - NDVI00



A - Map of 1970 Disturbance Index
B - Map of Disturbance Index change between 1990 and 2000
C- Map of 1990 NDVI

DATA: Anthropogenic

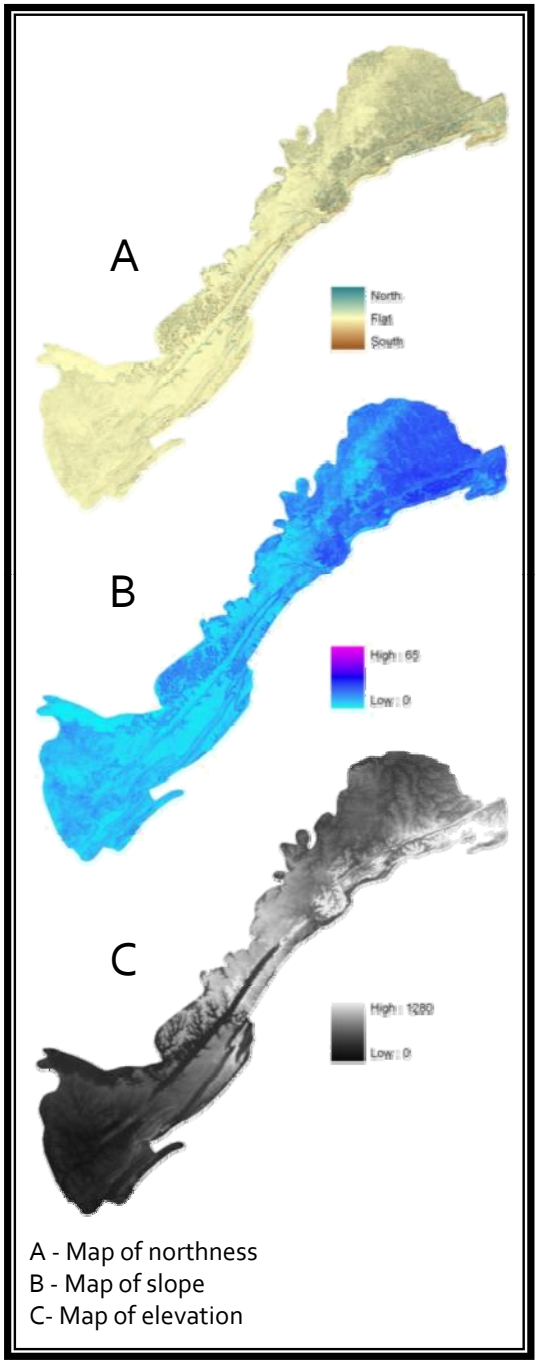
- Invasive plants are often introduced and spread by people.
- Variables that represent human use were derived from road, census and land use data.
- Anthropogenic variables
  - Population
  - Road distance
  - Road dentistry
  - Main road distance
  - Amount of developed area within 100m and 500 m buffer



A - Map of population densities
B - Map of road density
C - Binary map of residential within 100 meters

DATA: Landform

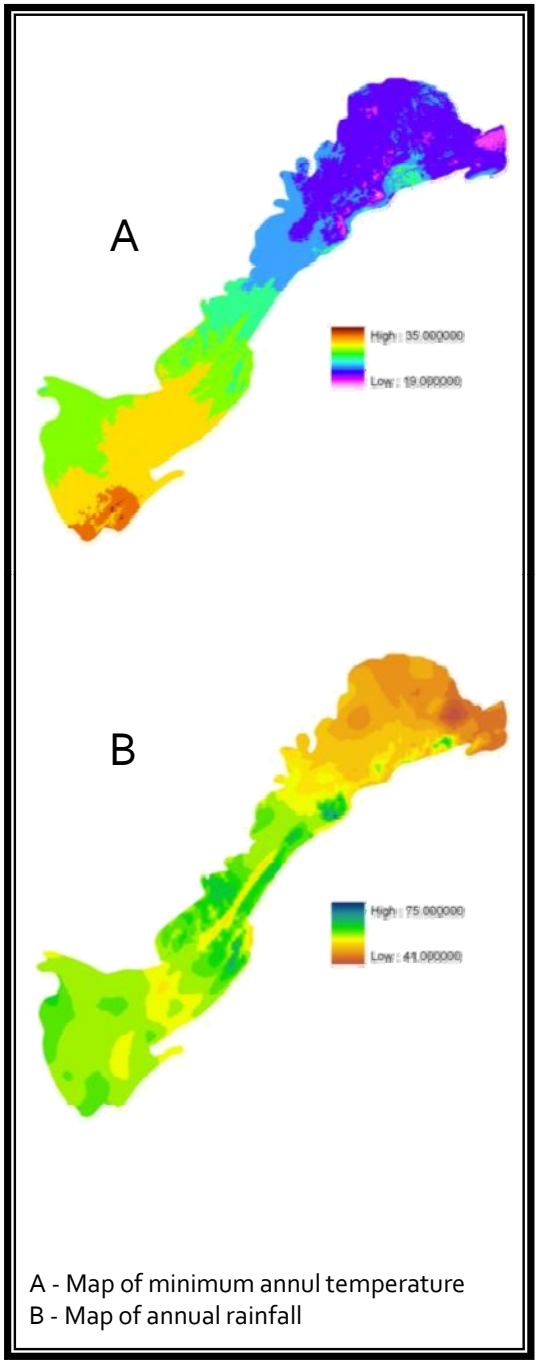
- The landform variables were selected based on their biological significance and correlation with other studies to plant distribution.
- 30m digital elevation model
- Environmental variables:
  - Northness
  - Eastness
  - Slope
  - Solar radiation
  - Curvature
  - Elevation



A - Map of northness
B - Map of slope
C- Map of elevation

DATA: Climate

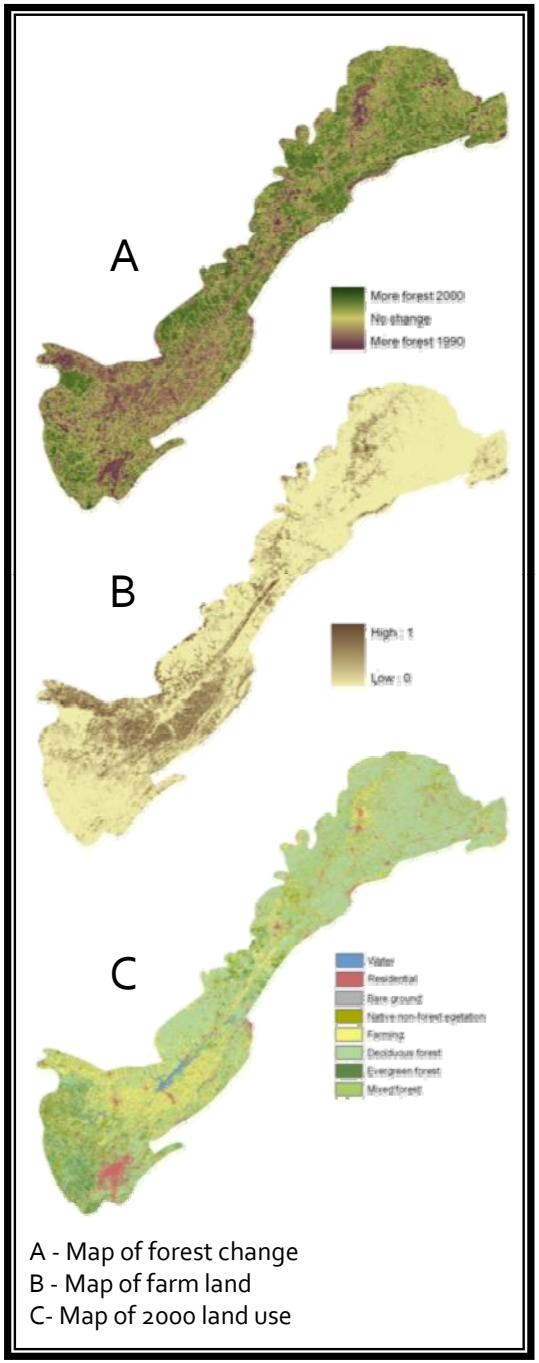
- Environmental limitations of distribution are often highly influenced by climate, particularly rainfall and temperature.
- Monthly and annual temperature and rainfall maps were downloaded from PRISM.
- Highly correlated
- Climate variables:
  - Minimum annual temperature
  - Average annual rainfall



A - Map of minimum annul temperature
B - Map of annual rainfall

DATA: Land Use

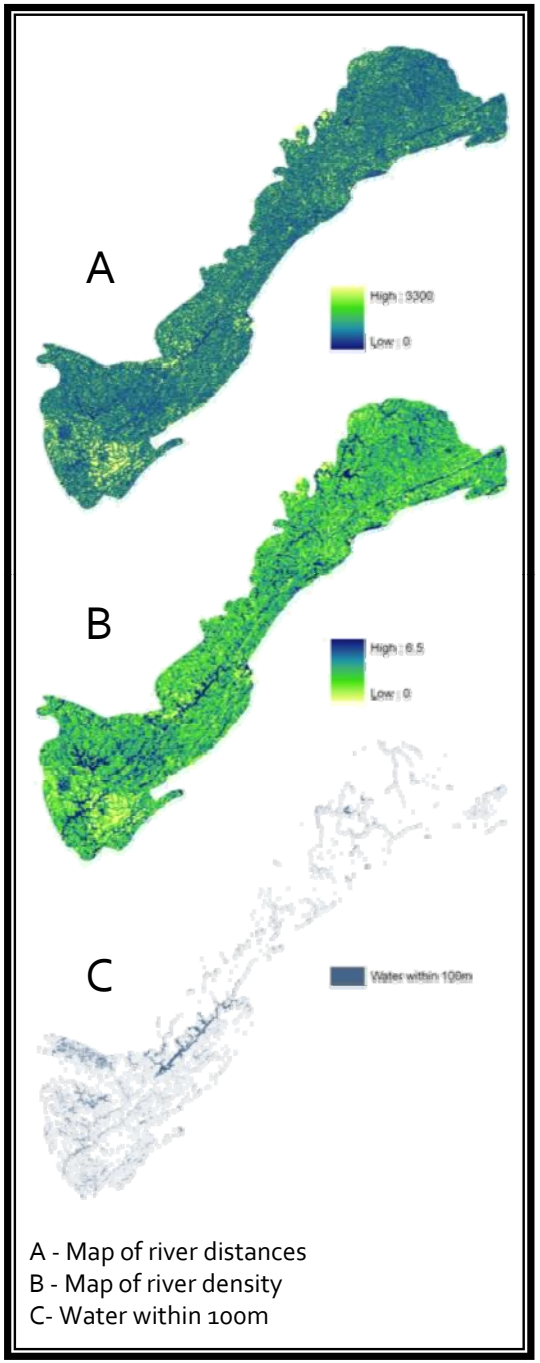
- Land use variables were extracted from the USGS national land cover data (NLCD) for 1992 and 2001.
- Reclassified to 8 land uses based on Anderson's groupings.
- Land use variables:
  - Forest change (1992-2001) within a 500m buffer
  - Forest cover in 2001 within 100m buffer
  - Farming in 2001 within 500m buffer
  - Categorical variables of land use in 1992
  - Categorical variables of land use in 2001



A - Map of forest change
B - Map of farm land
C- Map of 2000 land use

DATA: Water

- Streams may affect the distribution and establishment of plants by influencing seed dispersal and moisture availability.
- National river shape files and water bodies defined in the NLCD database.
- Water variables:
  - River distance
  - River density
  - Amount of water within 100m buffer
  - Amount of water within 500m buffer

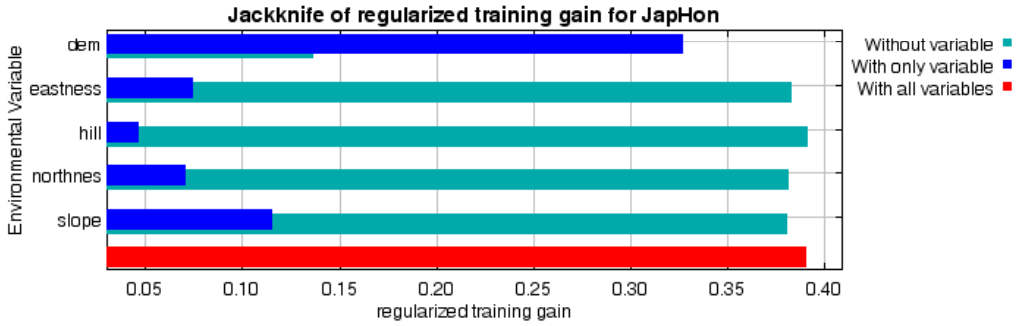


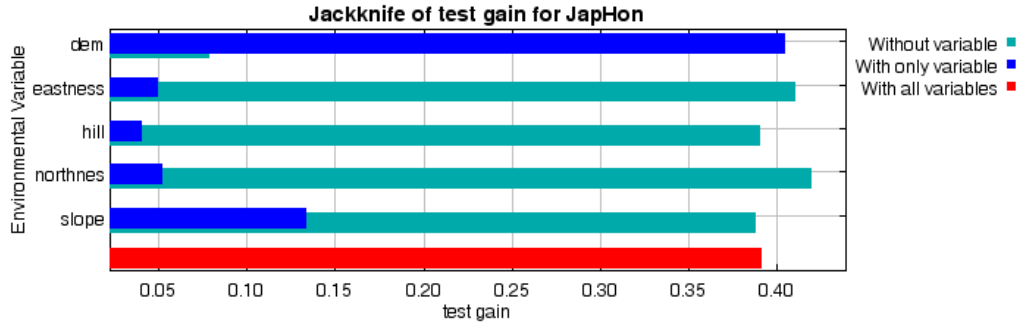
A - Map of river distances
B - Map of river density
C- Water within 100m

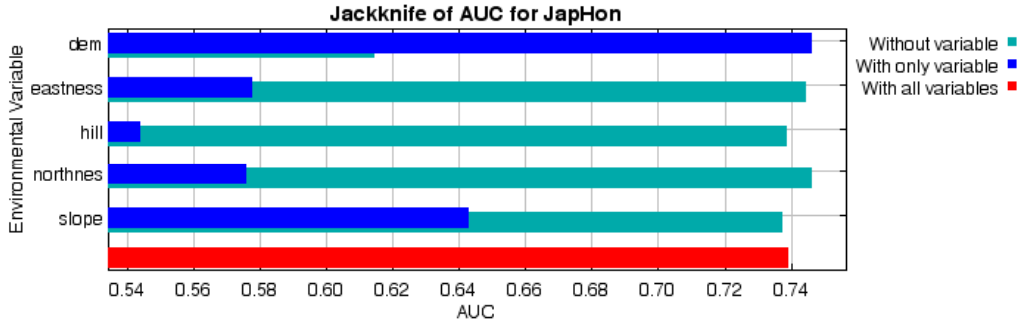
MAXENT MODELS:

- Each group of variables (i.e. Landsat) was modeled using backward selection techniques.
- Full model was developed from all selected for each group, with only the significant variables kept in the final model.

Variable	Percent contribution
dem	80.5
slope	13.4
eastness	3
northnes	2.5
hill	0.6

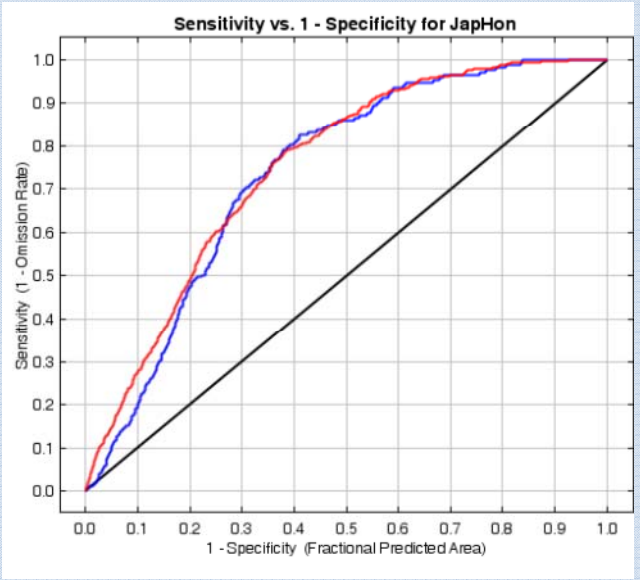






MAXENT MODELS:

- The omission rate, Cohen's Kappa and AUC were used to assess the reliability and validity of models.
- Evaluation statistics were calculated for both training (70%)and withheld (30%) data.
- Binary occurrence maps were developed using a threshold value that maximized the sum of sensitivity and specificity.



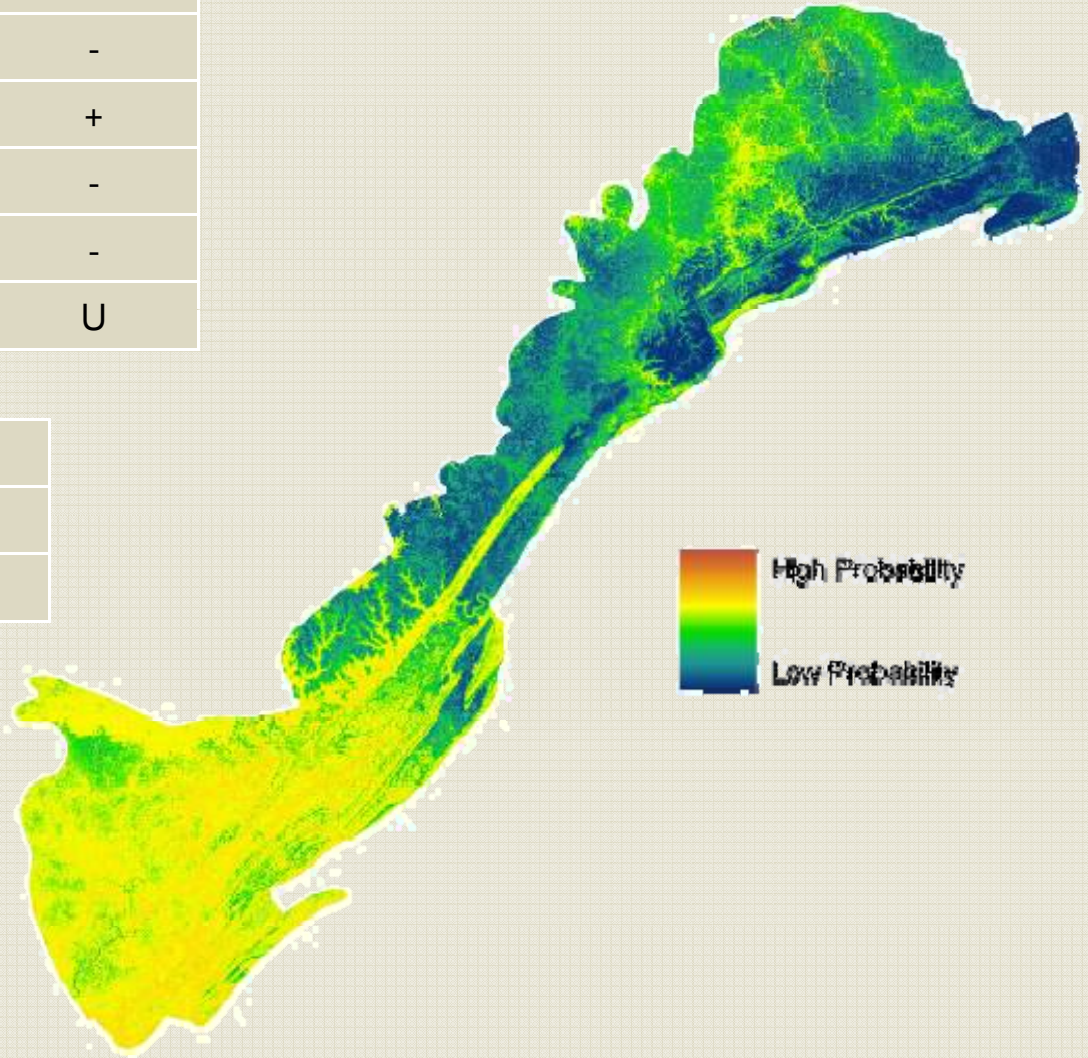
Cumulative threshold	Logistic threshold	Description	Fractional predicted area	Training omission rate	Test omission rate	P-value
1.000	0.082	Fixed cumulative value 1	0.845	0.007	0.000	9.186E-9
5.000	0.182	Fixed cumulative value 5	0.671	0.042	0.046	1.278E-15
10.000	0.286	Fixed cumulative value 10	0.562	0.084	0.098	1.097E-19
0.223	0.039	Minimum training presence	0.927	0.000	0.000	1.13E-4
11.052	0.305	10 percentile training presence	0.545	0.099	0.121	6.67E-19
33.294	0.473	Equal training sensitivity and specificity	0.315	0.315	0.289	1.894E-29
24.710	0.423	Maximum training sensitivity plus specificity	0.386	0.208	0.202	4.766E-29
35.149	0.485	Equal test sensitivity and specificity	0.301	0.337	0.301	1.571E-30
22.230	0.408	Maximum test sensitivity plus specificity	0.410	0.201	0.173	4.068E-29
1.448	0.102	Balance training omission, predicted area and threshold value	0.816	0.007	0.012	2.39E-9
4.858	0.181	Equate entropy of thresholded and original distributions	0.676	0.042	0.046	2.911E-15

Japanese Honeysuckle

Variables	%	Direction
Elevation	58	-
Minimum Temperature	22	+
Amount of forest within 500m	10	-
Slope	6	-
Distance to Main Road	4	U

	Omission	Kappa	AUC
Training	0.20	0.50	0.87
Test	0.18	0.55	0.87

Cut off	0.42
Proportion of Occurrence	0.50

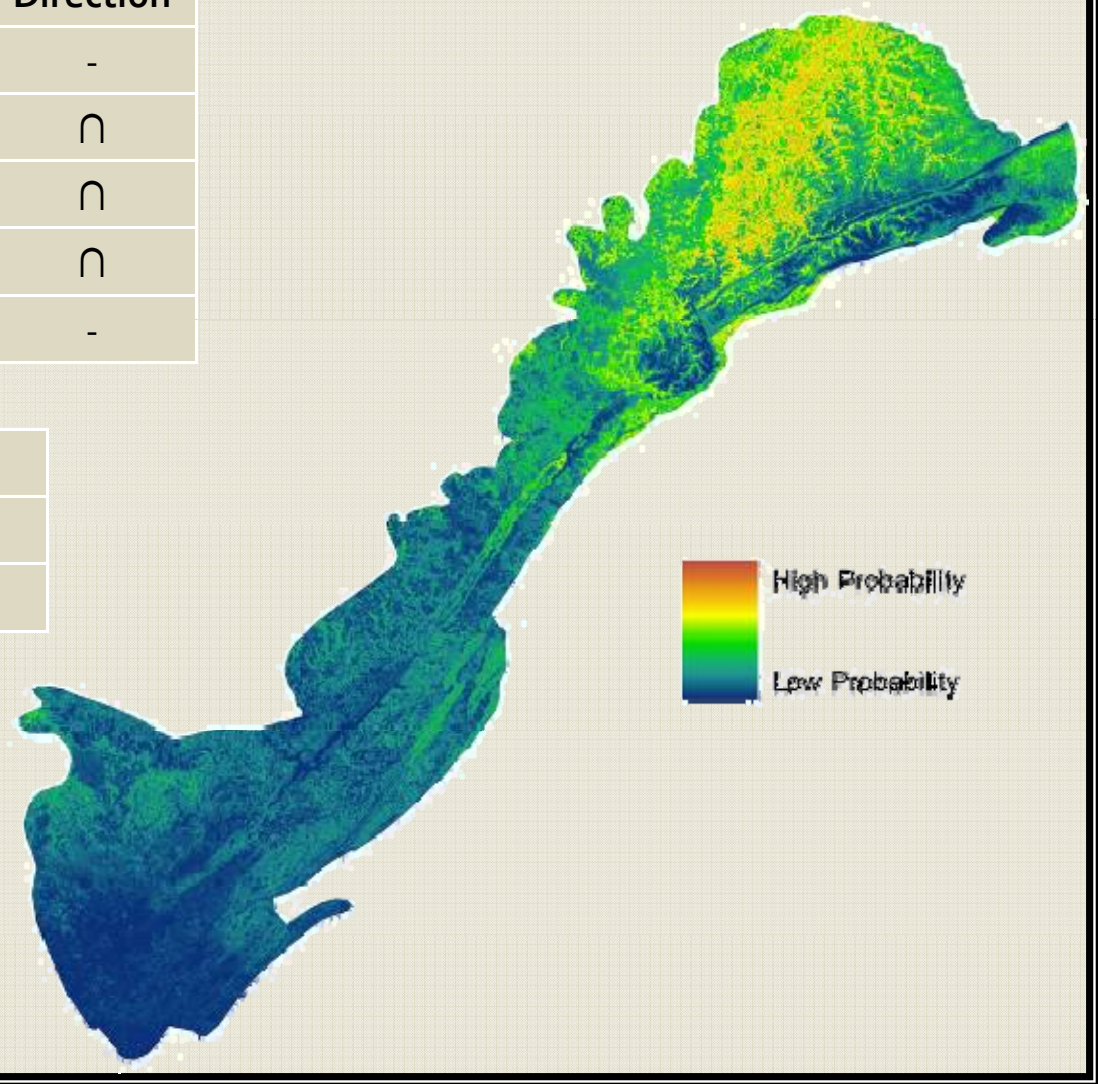


Tall Fescue

Variables	%	Direction
Minimum Temperature	54	-
Elevation	19	∩
Farming within 500m	10	∩
Annual Rainfall	10	∩
Northness	7	-

	Omission	Kappa	AUC
Training	0.25	0.19	0.82
Test	0.36	0.14	0.75

Cut off	0.42
Proportion of Occurrence	0.16

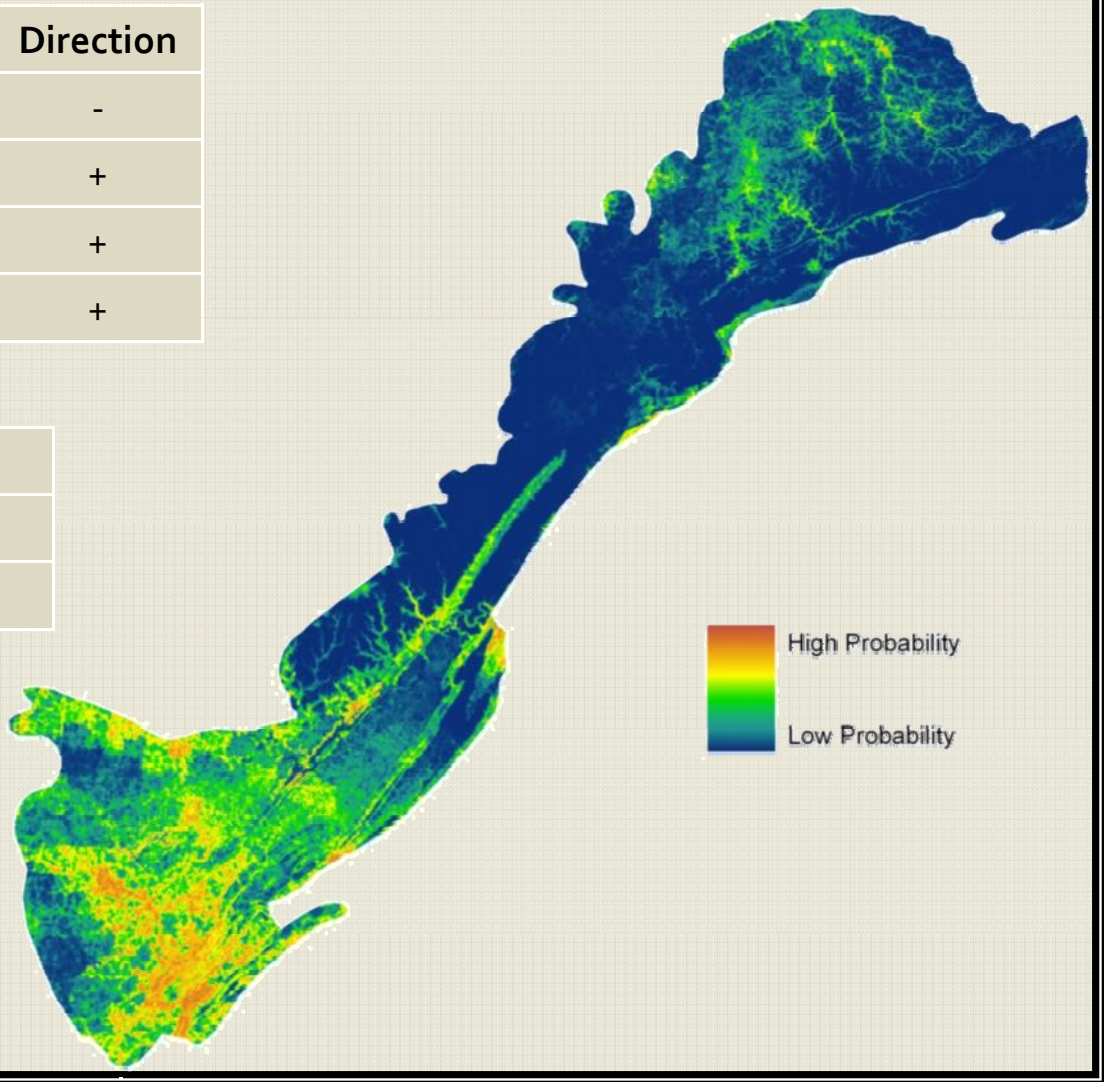


Mimosa

Variables	%	Direction
Elevation	48	-
Census	24	+
Road Density	16	+
Water within 500m	12	+

	Omission	Kappa	AUC
Training	0.06	0.14	0.91
Test	0.07	0.13	0.90

Cut off	0.27
Proportion of Occurrence	0.29



Variable comparison

- Environmental variables dominated the models.
- Elevation in was used for three species.
- The single dominant variable either elevation or minimum temperature, both environmental variable.
- Some anthropogenic effects in all models.

	Japanese honeysuckle		Tall Fescue		Mimosa	
Variables	**%**	**Direction**	**%**	**Direction**	**%**	**Direction**
Elevation	58	-	19	∩	48	-
Slope	6	-				
Northness			7	-		
Annual Rainfall			10	∩		
Minimum Temperature	22	+	54	-		
Water within 500m					12	+
Total	**86**		**90**		**60**	

	Japanese honeysuckle		Tall Fescue		Mimosa	
Variables	**%**	**Direction**	**%**	**Direction**	**%**	**Direction**
Forest within 500m	10	-				
Farming within 500m			10	∩		
Distance to Main Road	4	U				
Road Density					16	+
Census					24	+
Total	14		10		40	

Density comparison

- All models showed increasing spread of the species
- Omission rates were low, thus prediction of occurrence is good
- Kappa was good for Japanese honeysuckle but poor for tall fescue and mimosa, this takes into account absences, suggests these models don't predict absences well.
- AUC was reasonable for all models

	Proportion of sites with occurrence	Predicted Area	Omission	Kappa	AUC
Japanese honeysuckle	30%	50%	0.20	0.50	0.87
Tall Fescue	5%	16%	0.25	0.19	0.82
Mimosa	2%	29%	0.06	0.14	0.91

Main Conclusions:

- Japanese honeysuckle and mimosa were predominantly in the southern portion of the Cumberland Plateau and Mountain region.
- Tall fescue was predominantly in the northern portion of the Cumberland Plateau and Mountain region.
- All species were predicted to increase in occurrence.
- Models were dominated by habitat requirements (environmental) rather than anthropogenic activities.
- All models were good for occurrence but lower occurrence models did not predict current absents very well.

Future Work:

- Develop probability maps for other species including tree of heaven, privets, non native roses and Nepalese brown top.
- Hotspot modeling.
- Assess the response under differing climate change scenarios.
- Examine scalability of models (single county, Southeast).

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Questions?