Gap Analysis Program National Land Cover Data

Alexa McKerrow
amckerrow@usgs.gov

Anne Davidson
adavidson@uidaho.edu

Todd Earnhardt
tsearnha@ncsu.edu

Overview

- Gap Analysis Program (GAP)
  - Land cover
  - Species models
  - Protected areas
- Land cover development
  - Data sources and coverage
  - Classification system
  - Data development
- Land cover viewer
- Data applications

USGS
science for a changing world

GAP concept – Lark Bunting Example

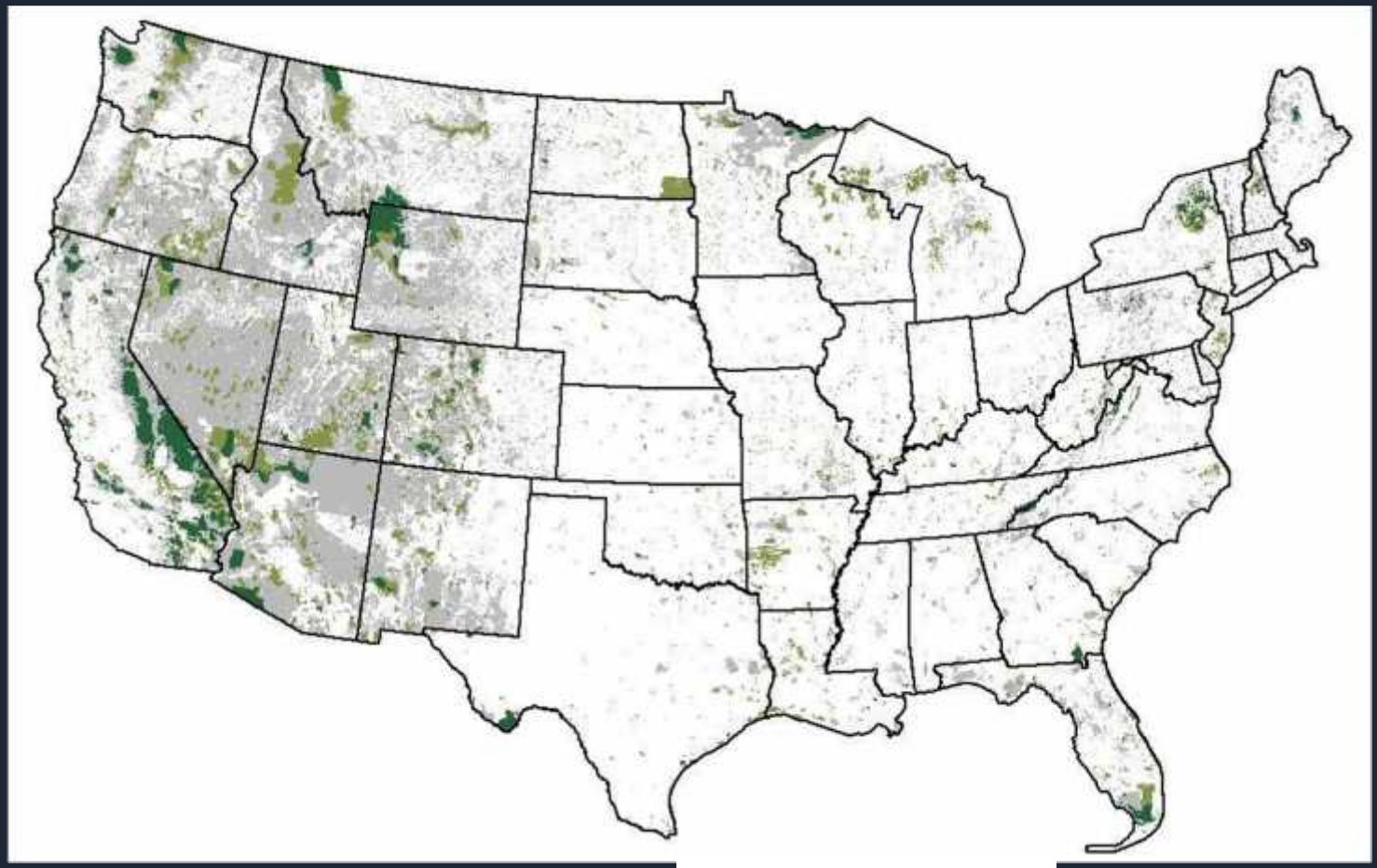
Protected on 2.6% of its distribution

Species Data

Deductive models are used to determine species distribution within range
Variables include land cover, elevation, distance to water, slope, distance to edge…

USGS
science for a changing world

Protected Areas Database of the US (PAD-US)



Protection status

GAP Status Code

- 1 - Permanent Protection -- ecological disturbance events allowed to proceed
- 2 - Permanent Protection -- ecological disturbance events suppressed
- 3 - Permanent Protection -- multiple use lands (e.g. mining, logging, OHV use)
- 4 - No known mandate for protection

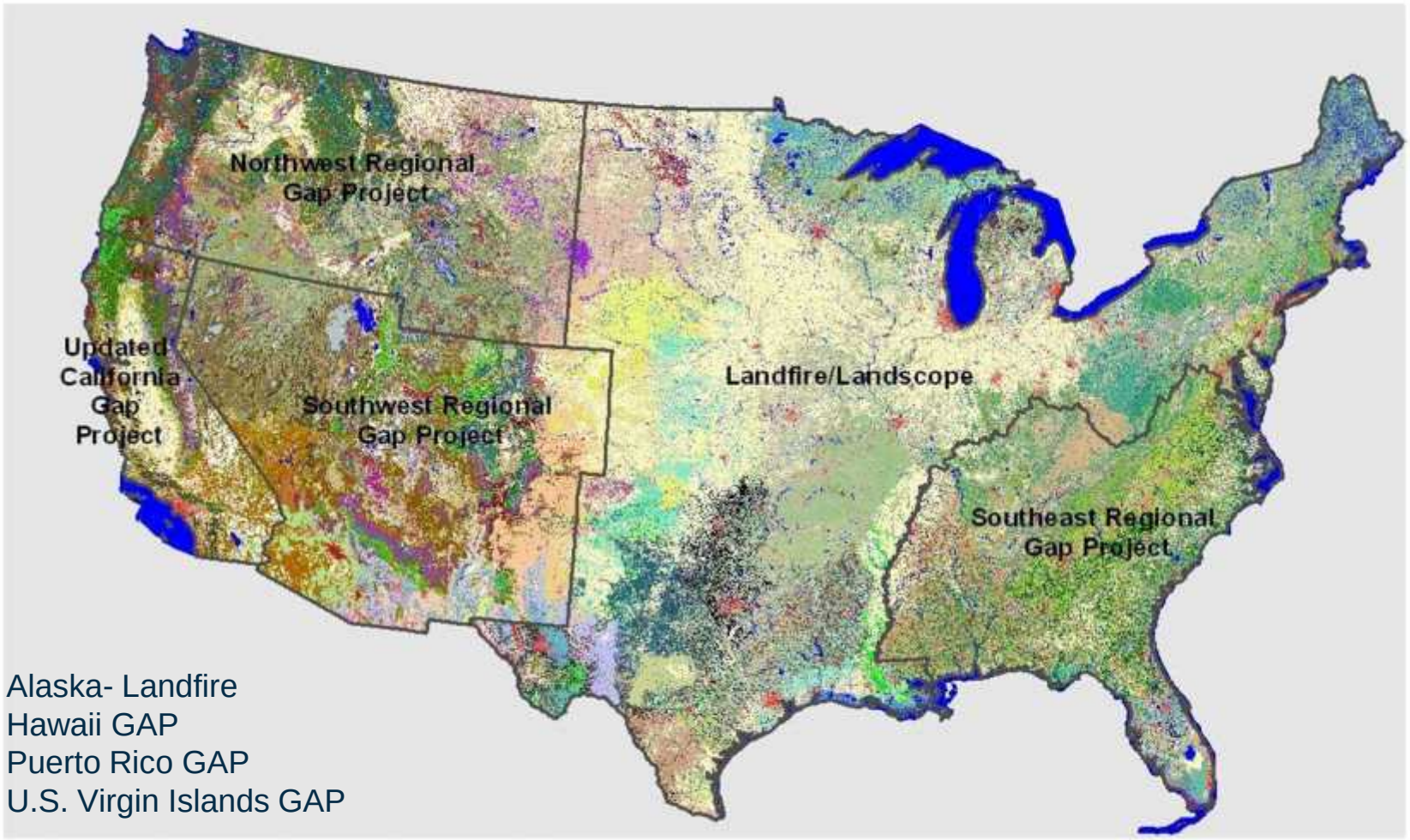
USGS
science for a changing world

GAP Land Cover

- 30 meter resolution
- Based on circa 2001 Landsat imagery
- Ecological Systems Classification
- Combines data from multiple data sources
  - 3 regional GAP projects
  - LANDFIRE
  - State or territory specific GAP projects

USGS
science for a changing world

Sources used in GAP Land cover data



Alaska- Landfire
Hawaii GAP
Puerto Rico GAP
U.S. Virgin Islands GAP

USGS
science for a changing world

Southeast Approach

- Imagery NLCD 2001
- Masking with NLCD 2001
- Reference data
  - Heritage datasets, state GAP projects, aerial videography and photography
- Map zones
  - sub-zones within MRLC zones
- Ancillary data

  landform, climate, geology, hydrology data
- Modeling allowed to vary
- Review

USGS
science for a changing world

SE-GAP Land Cover Map Units

Ecological Systems - NatureServe

- Matrix, Large Patch, and Linear Types
- Small patch on a case by case basis

“Modifiers” to the systems

- Where phenology or structure vary
  - Southern Piedmont Dry Oak (Pine) Forest – Hardwood
  - Southern Piedmont Dry Oak (Pine) Forest – Loblolly pine

Additions to the NLCD Classes

- Where useful for vertebrate modeling
  - Unconsolidated shore - ocean
  - Unconsolidated shore - riverine

USGS science for a changing world

Three Seasons of Landsat Imagery Mosaicked by MRLC

Leaf-off

Zone 58

Northern Coastal Plain

Spring

Leaf-on

USGS
science for a changing world

Approach – Detailed Land Cover Mapping

Hybrid Approach

- Image segmentation (sub-zones based on ecoregion)
- Decision Tree Modeling
- Expert derived rules
- Pattern Recognition - Image objects

Depending on the

- amount of reference data,
- resolution of ancillary data,
- and the Ecological Systems being mapped

USGS
science for a changing world

Ancillary Data Development

Fine to Mid-scale

(1:24-1:100 k)

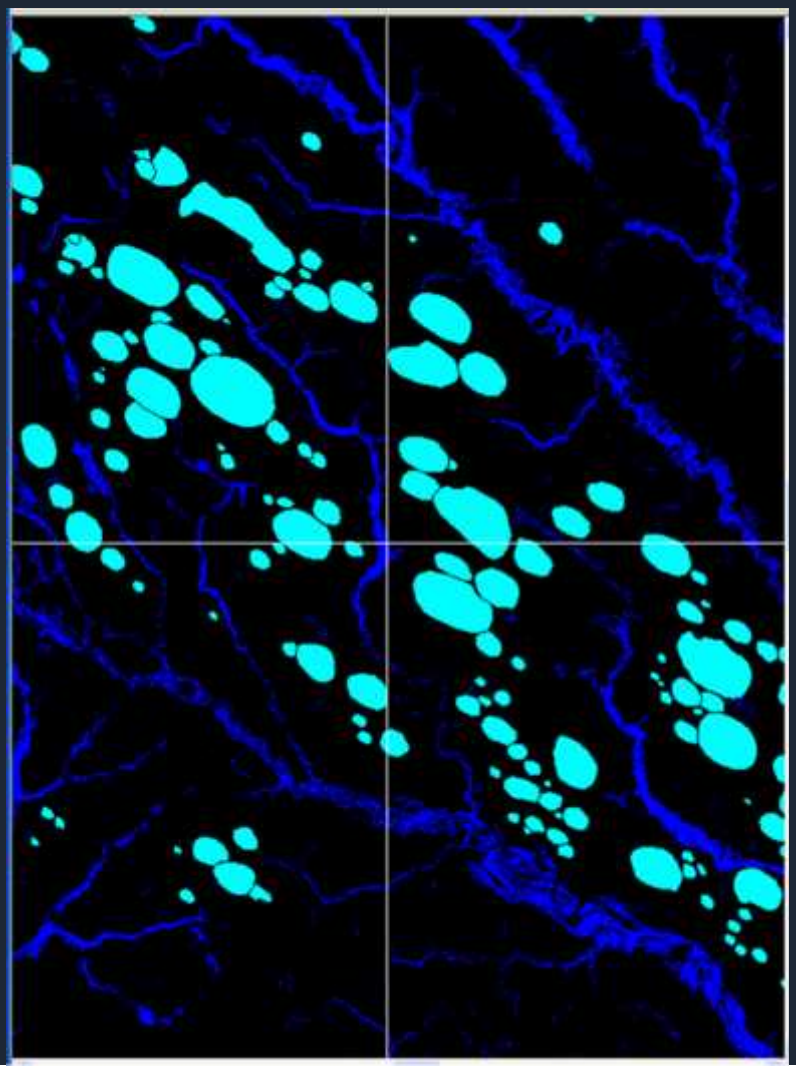
- Landform Model
- Riparian Model
- Aerial Photo Reference Data
- National Wetland Inventory
- NLCD 2001 Land cover
- National Hydrologic Dataset

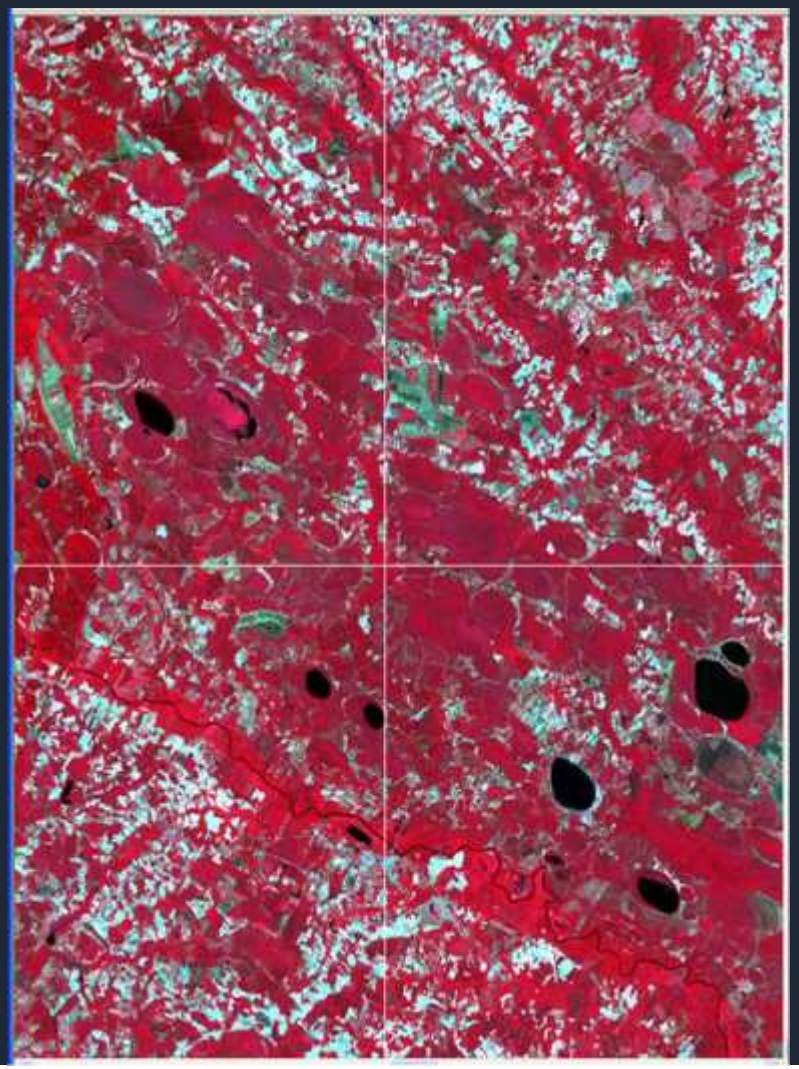
Coarse scale (1:250000)

- Ecological System Ranges
- STATSGO & SSURGO soils
- Omernick's Ecoregions

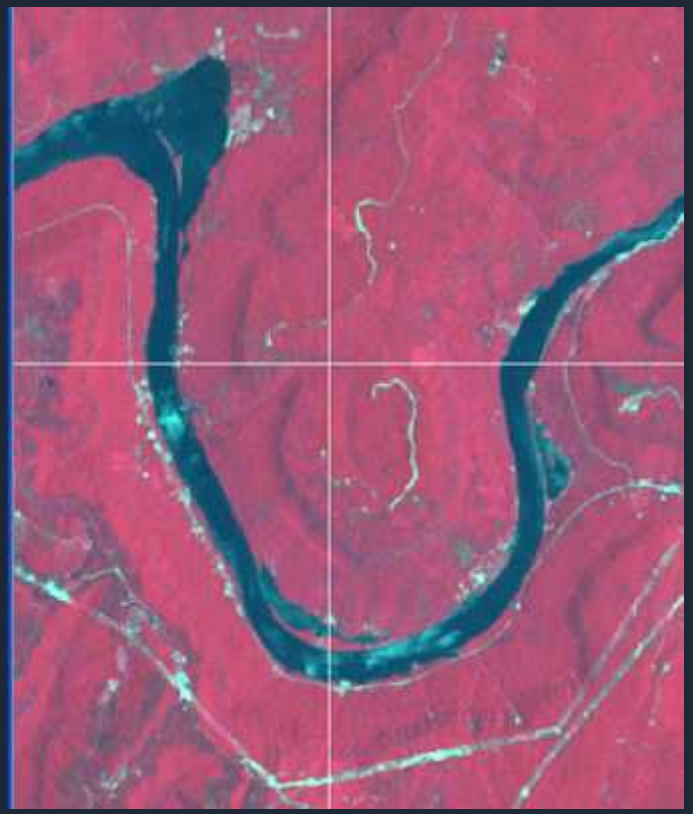
Mapping Managed Pine
pattern recognition and decision tree modeling

Coastal Plain Floodplain
(image objects & National Hydrologic Data) and Carolina Bays (manual delineation)





Cumberland Plateau Systems
Landform & geology and expert rules



National Vegetation Classification

12 Classes

27 Subclasses

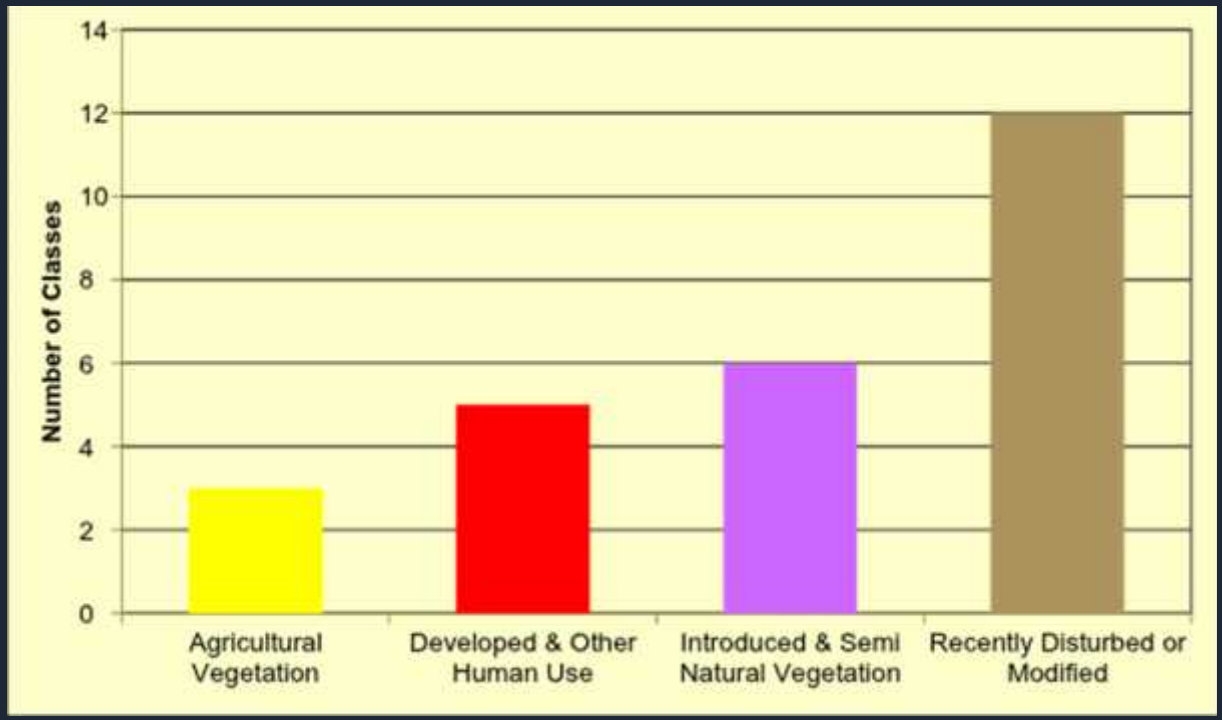
39 Formations

58 Divisions

122 Macrogroups

577 Ecological Systems and Land use classes

Classes for Human use, introduced and disturbed



Continental U.S.

551 Ecological Systems or other natural classes

26 Human use, introduced and disturbed types (termed land use classes)

Ongoing and Future Work

Involved in LANDFIRE's Improvements Project
- expert labeling of plots

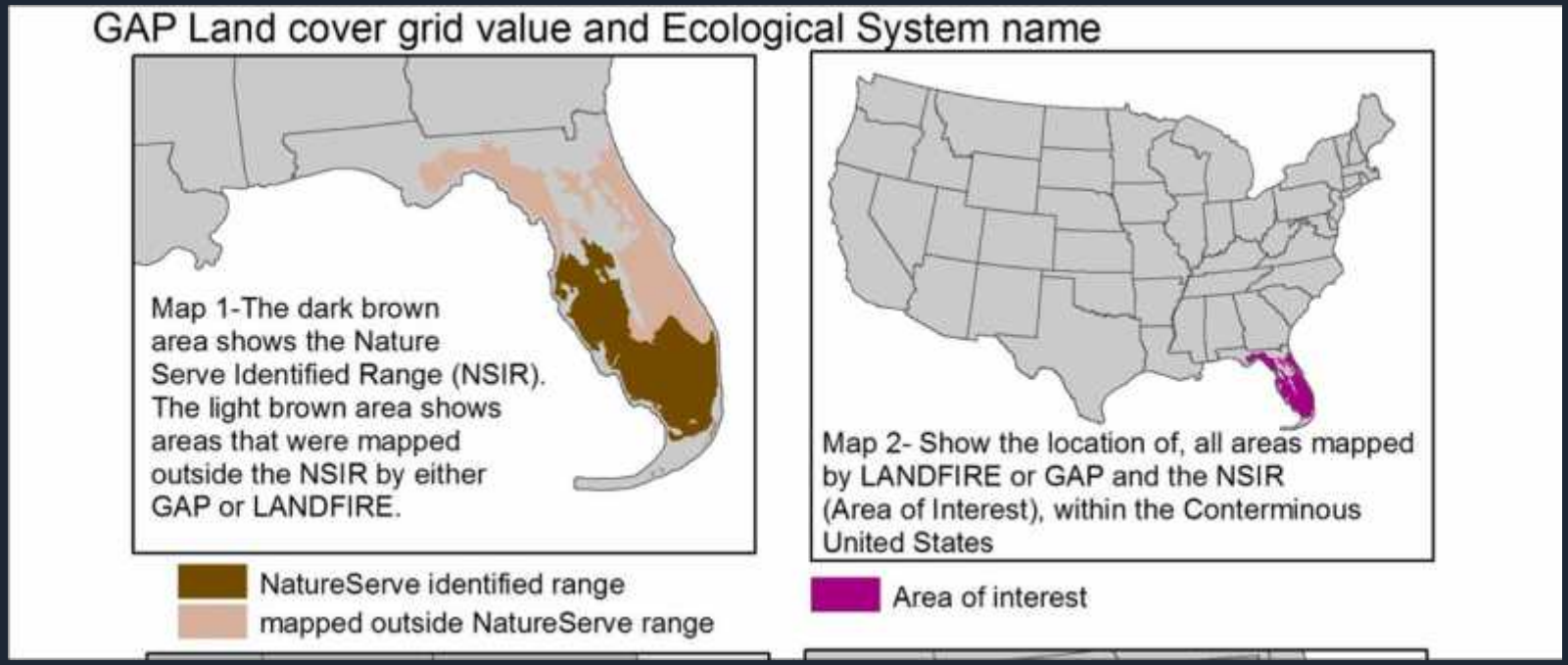
FY2012
- Map Legend Comparisons
  - match, naming convention, aggregate systems, modifiers, NASS categories etc…
- Mapped Distribution & Range Map Comparison
- Testing the impact of incorporating updates & LANDFIRE existing vegetation height and existing vegetation cover on habitat modeling.

USGS science for a changing world

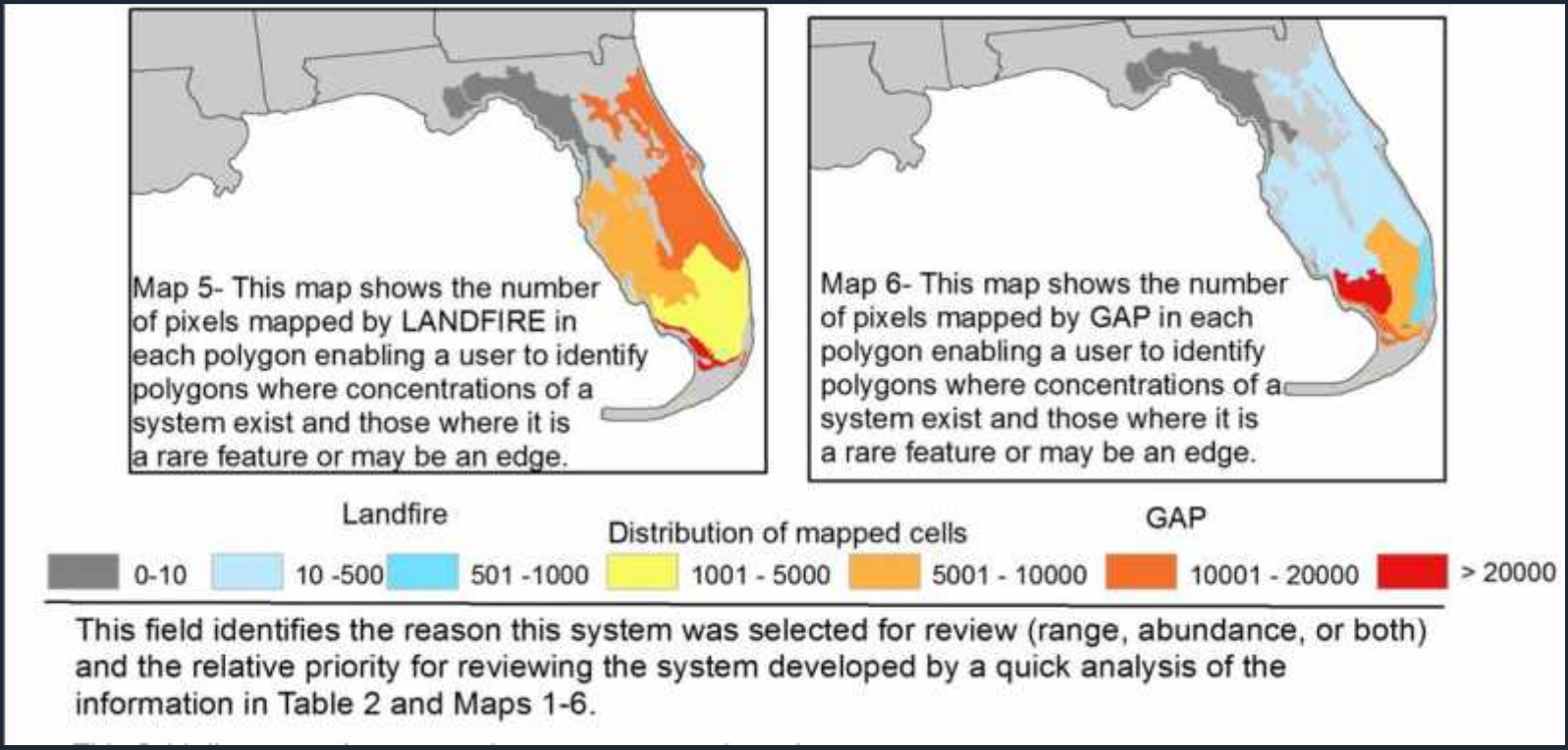
Ongoing and Future Work

Comparison of mapped distributions (LANDFIRE and GAP) and NatureServe Ranges to identify potential conceptual issues in our application of Ecological Systems.

Result a list of moderate and high priority ecological systems to evaluate.



Ongoing and Future Work



Ongoing and Future Work

Update the 2001 habitat map to 2010 conditions

NLCD 2011 and

disturbance information collected by Landfire

Remap using Landsat 8 base imagery

Collaboration with LANDFIRE

- Consensus on common legend elements
- Improve process for assigning training data plots to Ecological Systems and USNVC Macrogroups/Groups (autokeys)
- Clarifying Ecological system concepts and ranges
- Integrating structure/ closure in select species models

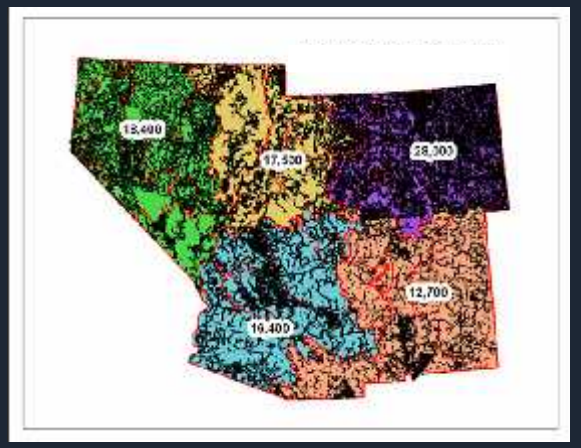
USGS
science for a changing world

USGS
science for a changing world

http://gapanalysis.usgs.gov/gaplandcover/viewer/

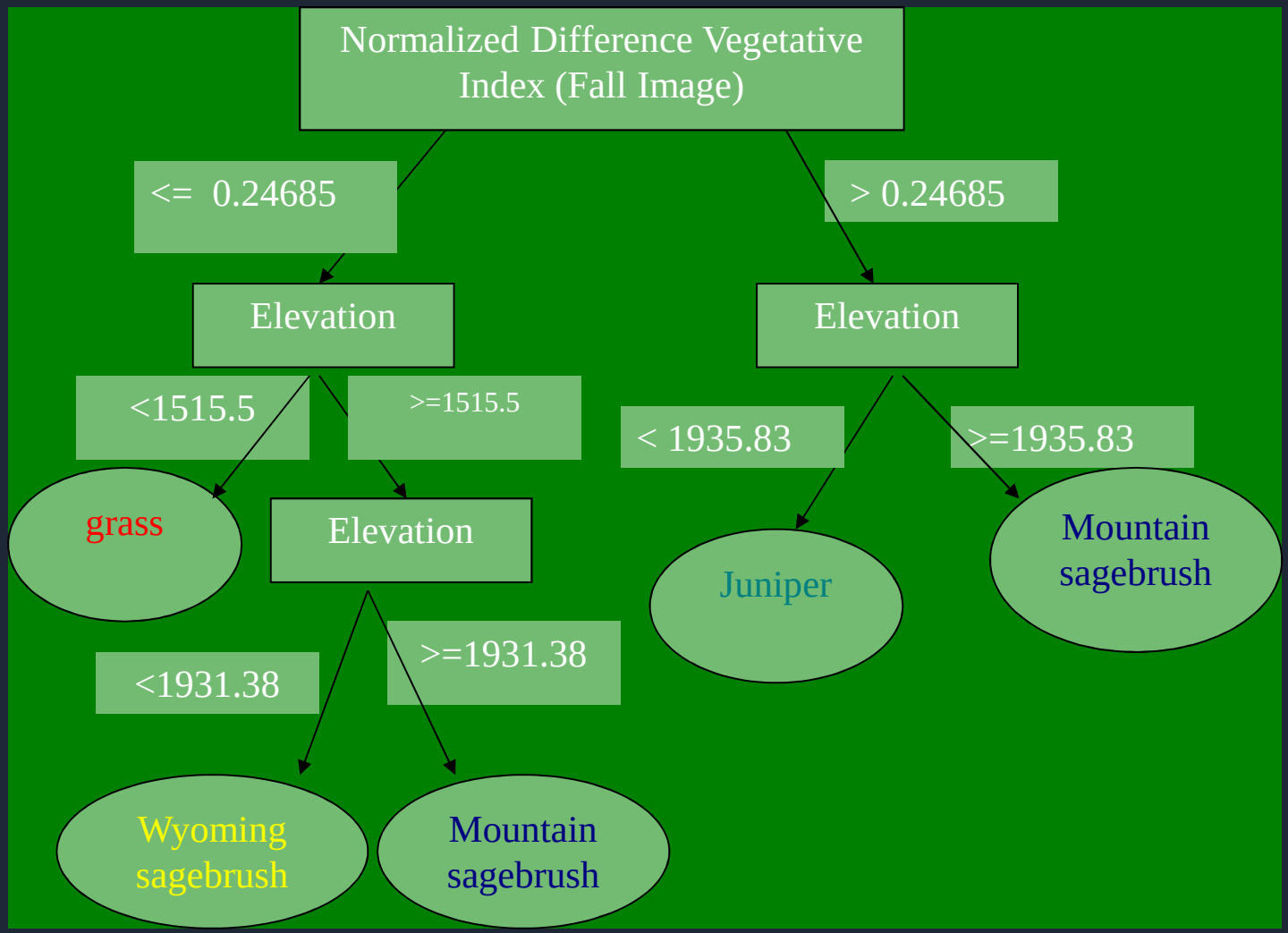

USGS
science for a changing world

Southwest Approach

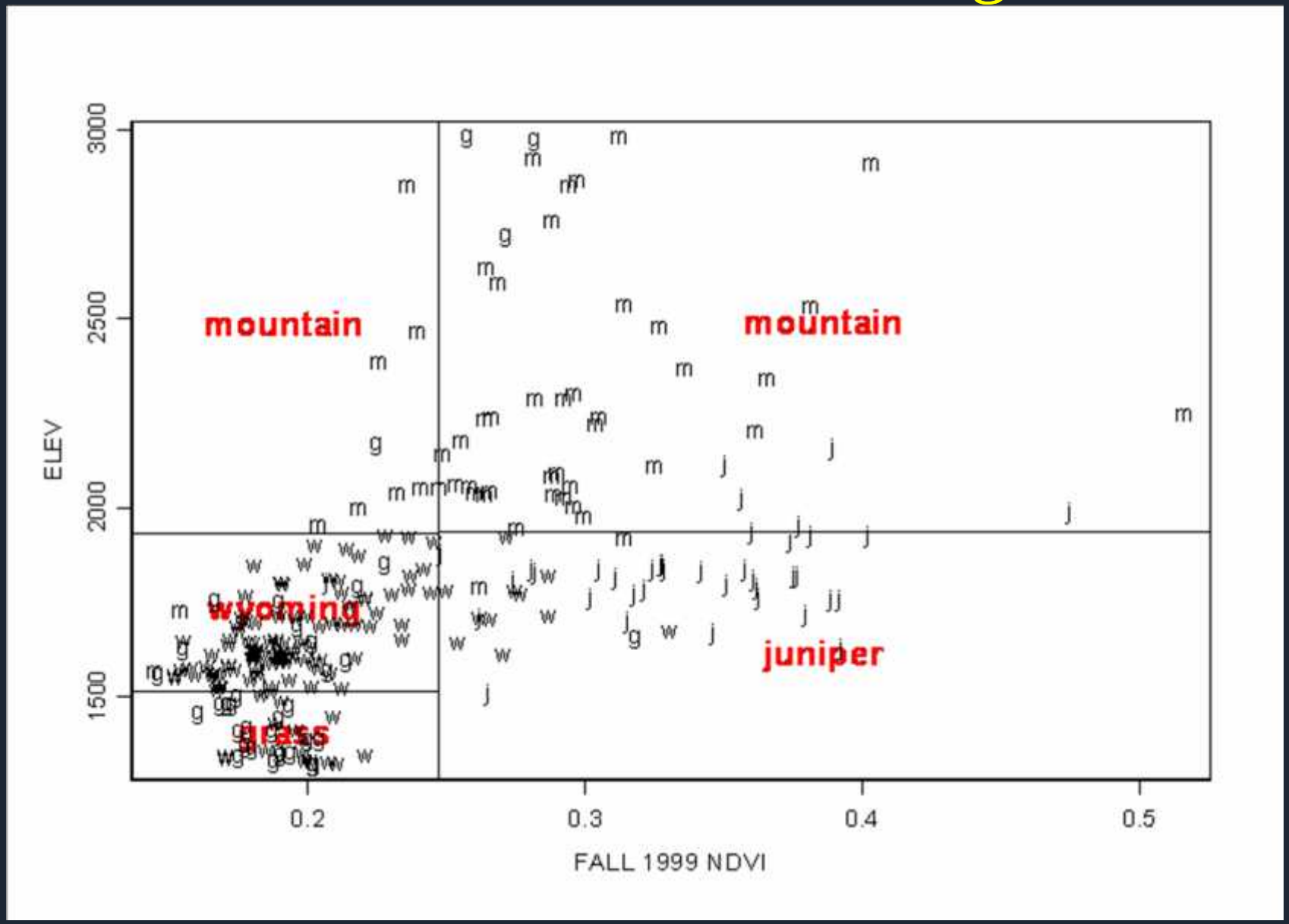


- Imagery and mapping
  pre-NLCD 2001
- Reference data
  >93,000 training points
- Map zones
  project specific, much smaller than MRLC map zones
- Ancillary data
  - landform, climate, geology
- Decision tree modeling
  a single model/ map zone
- Accuracy assessment
  set aside of reference points

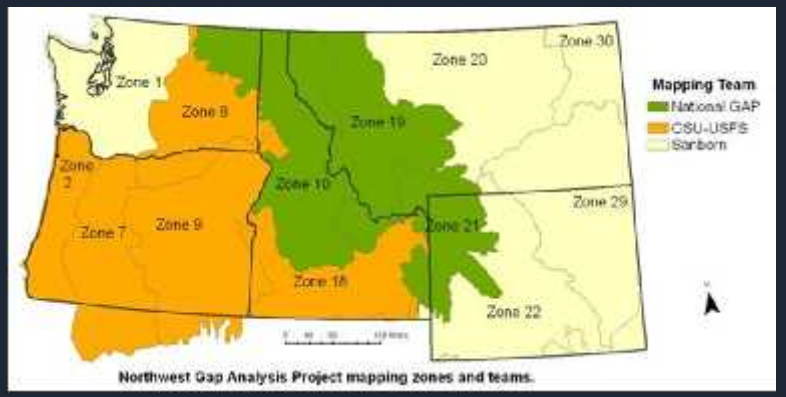
Decision tree modeling
Southwest GAP Example



Decision Tree Modeling



Northwest & California Approach



- Imagery NLCD 2001
- Masking with NLCD 2001
- Reference data
  - Existing plot data and additional field work
- Map zones
  - sub-zones within MRLC zones
- Ancillary data

  landform, climate, geology
- Modeling allowed to vary
- Assessment
  - Reference points set aside in advance

NW GAP - Modeling Techniques

- Different modeling techniques were used in different zones of the Northwest
- Allowed modelers to explore developing technologies
- Allowed for the evaluation of the effectiveness of modeling methods for mapping Ecological Systems
- Coordination between mapping teams ensured seamless coverage across the Northwest and with neighboring regions

Zone 1, 10, 18,19, 20 ,21, 22, and 29

Decision Tree Modeling

Zone map zones 2, 7, 8, 9

Gradient Nearest Neighbor (GNN) and Random Forest (RF) Modeling

All zones

Hand modeling to improve mapping of small patch and rare Ecological Systems

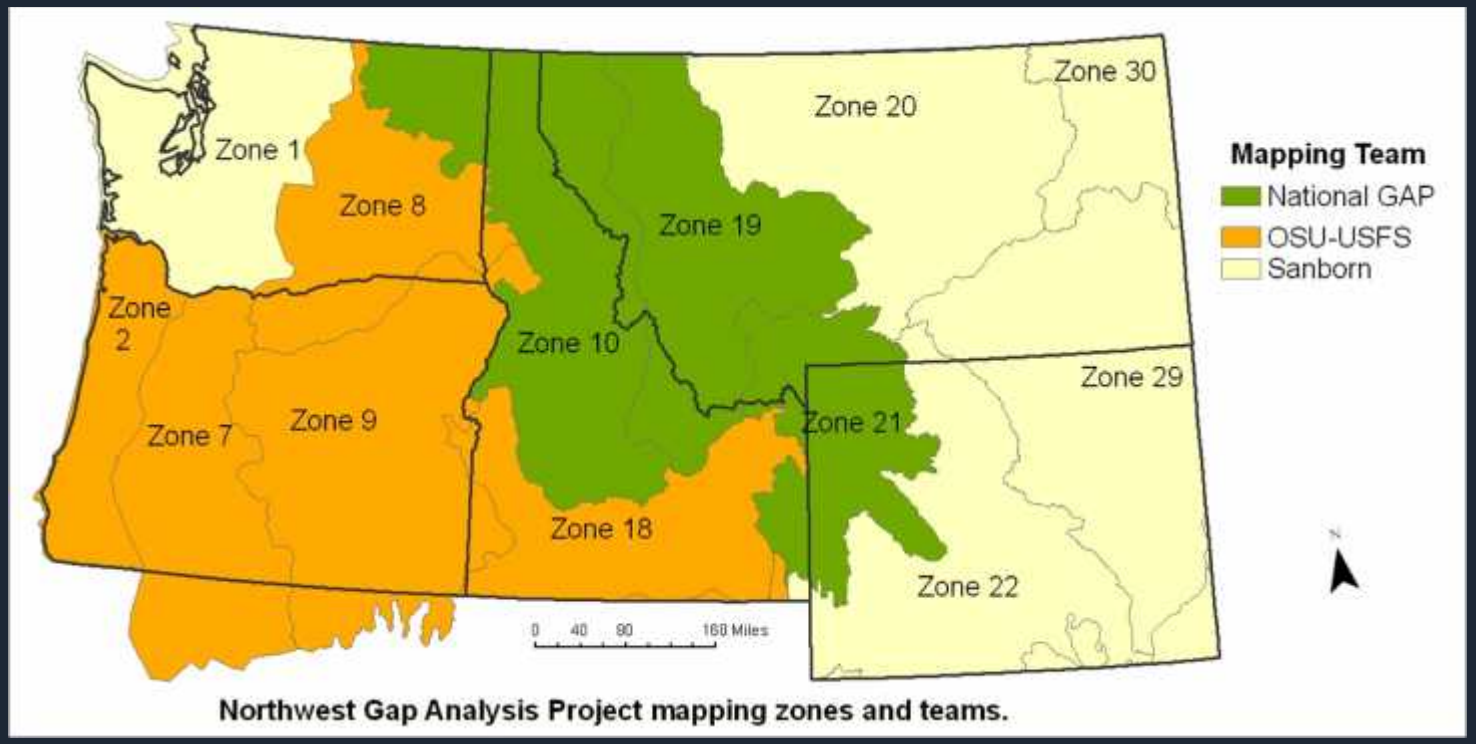
Basic steps used in mapping process

- Selected classification system
- Collected descriptive layers containing spectral, topographic and other site specific information
- Collected training data
- Modeled matrix systems using Classification and Regression Tree (CART) modeling techniques
- Modeling of rare or difficult systems through alternative methods or area specific CART models
- Review Southeast, Assessment Southwest, Northwest

USGS
science for a changing world

GAP – Northwest Region

Mapping Zones and Teams

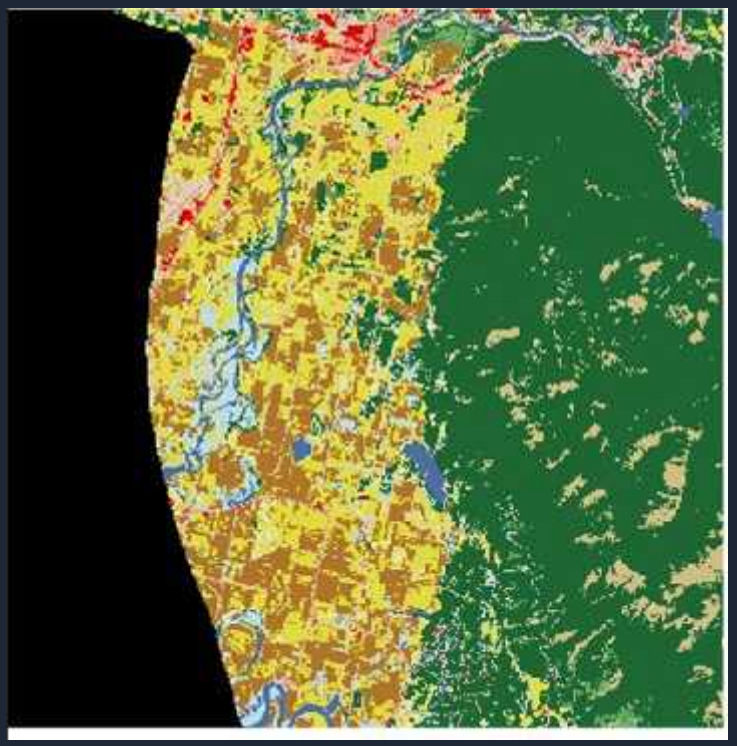


Northwest Gap Analysis Project mapping zones and teams.

Land cover mapping effort divided among three mapping teams

- Sanborn Mapping Company, Portland Oregon
- Oregon State University and U.S. Forest Service, Corvallis Oregon
- National Gap Analysis Program, University of Idaho, Moscow, Idaho.

Classification System
Human Influenced Areas



- Used data from National Land Cover Dataset (NLCD) 2001, which focused on mapping human influenced areas.
- We used the agricultural and developed areas identified in the NLDC map directly in our map
- Created classes to account for harvested, burned, and non native (introduced) vegetation types.

Modeling Techniques

- Different modeling techniques were used in different zones of the Northwest
- Allowed modelers to explore developing technologies
- Allowed for the evaluation of the effectiveness of modeling methods for mapping Ecological Systems
- Coordination between mapping teams ensured seamless coverage across the Northwest and with neighboring regions

Zone 1, 10, 19, 20,21 and 29

•Classification and Regression Tree (CART) Modeling

Zone map zones 2, 7, 8,

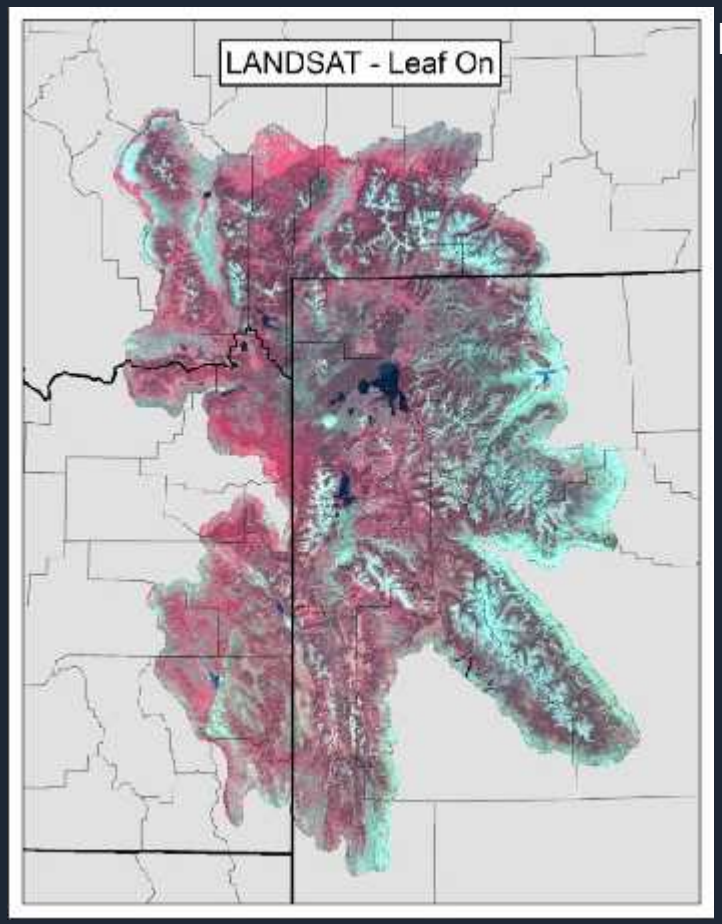
Gradient Nearest Neighbor (GNN) and Random Forest (RF) Modeling

All zones

Hand modeling to improve mapping of small patch and rare Ecological Systems

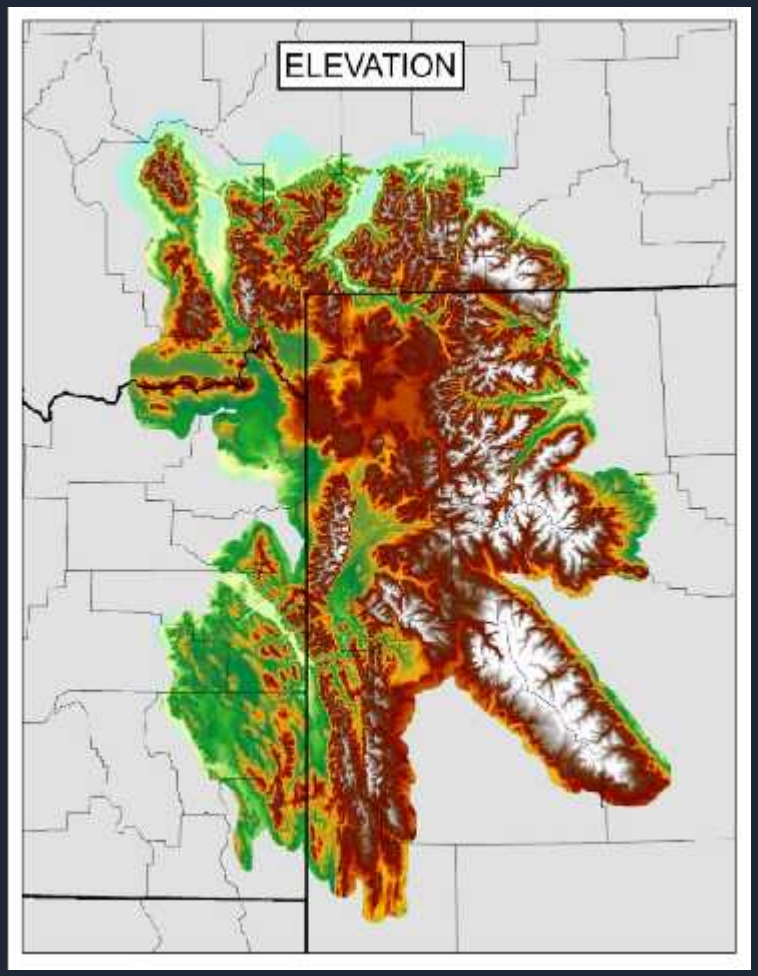
USGS science for a changing world

Selection of descriptive layers



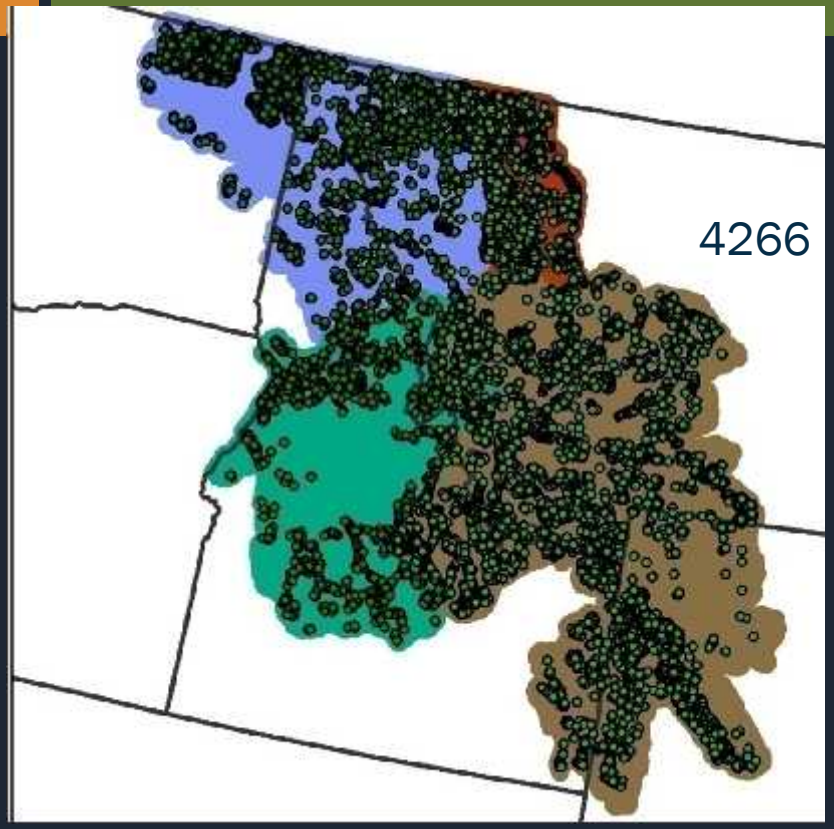
- LandSat TM 2001
  - Preprocessed mosaics available through the Multi-Resolution Land cover Consortium (MRLC)
  - 30 meter scale appropriate mapping most ecological systems
  - Three dates (spring, leafon, and leafoff)
  - Tasseled cap transformed indices (greenness, wetness, brightness)

Selection of descriptive layers

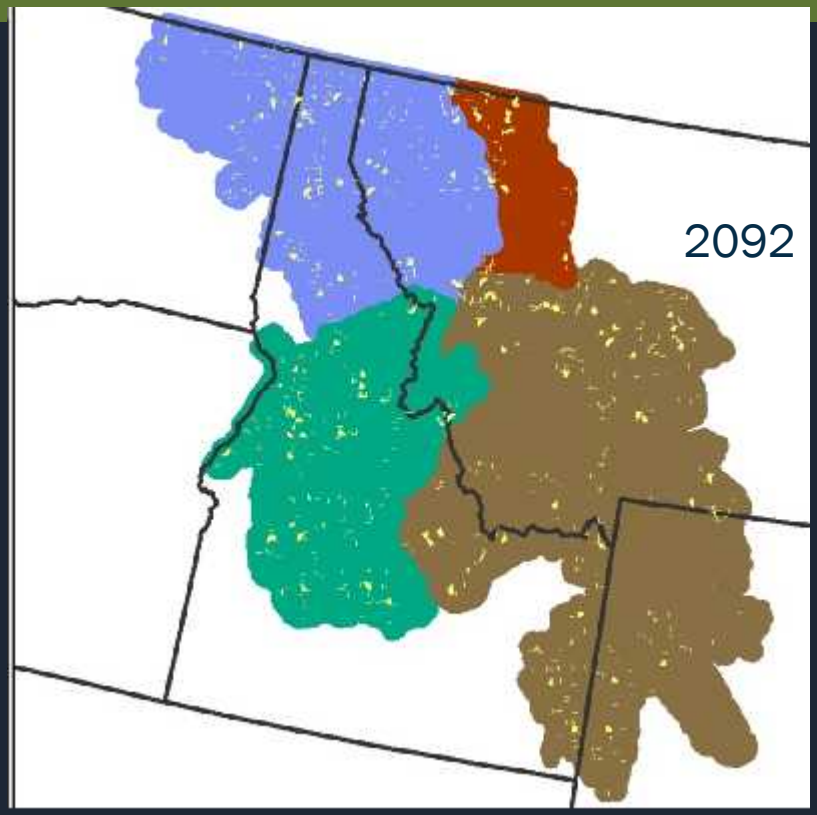


- Topographic variables
  - DEM, positional index, slope, aspect
- Additional layers used for special areas and models
  - soils data,
  - area specific information on rare community locations,
  - weed location information,
  - fire history databases
  - stream and wetland location information

Distribution of training data



LANDFIRe data points



GAP collected
field data polygons

Development of Area Specific Models

- Used Area specific models to predict the distribution of ES or land cover classes not well predicted with the predictive layers used in CART alone
  - Riparian and wetlands
  - Harvested areas
  - Introduced (non-native- vegetation)
  - Burned areas
  - Rare systems
    - Poor site lodgepole pine
    - Sand dunes

Ecological systems classification

Groups of vegetation communities occurring together in similar environments and influenced by similar processes and environmental gradients (Comer et al. 2003)

Rocky Mountain Foothill Limber Pine-Juniper Woodlands

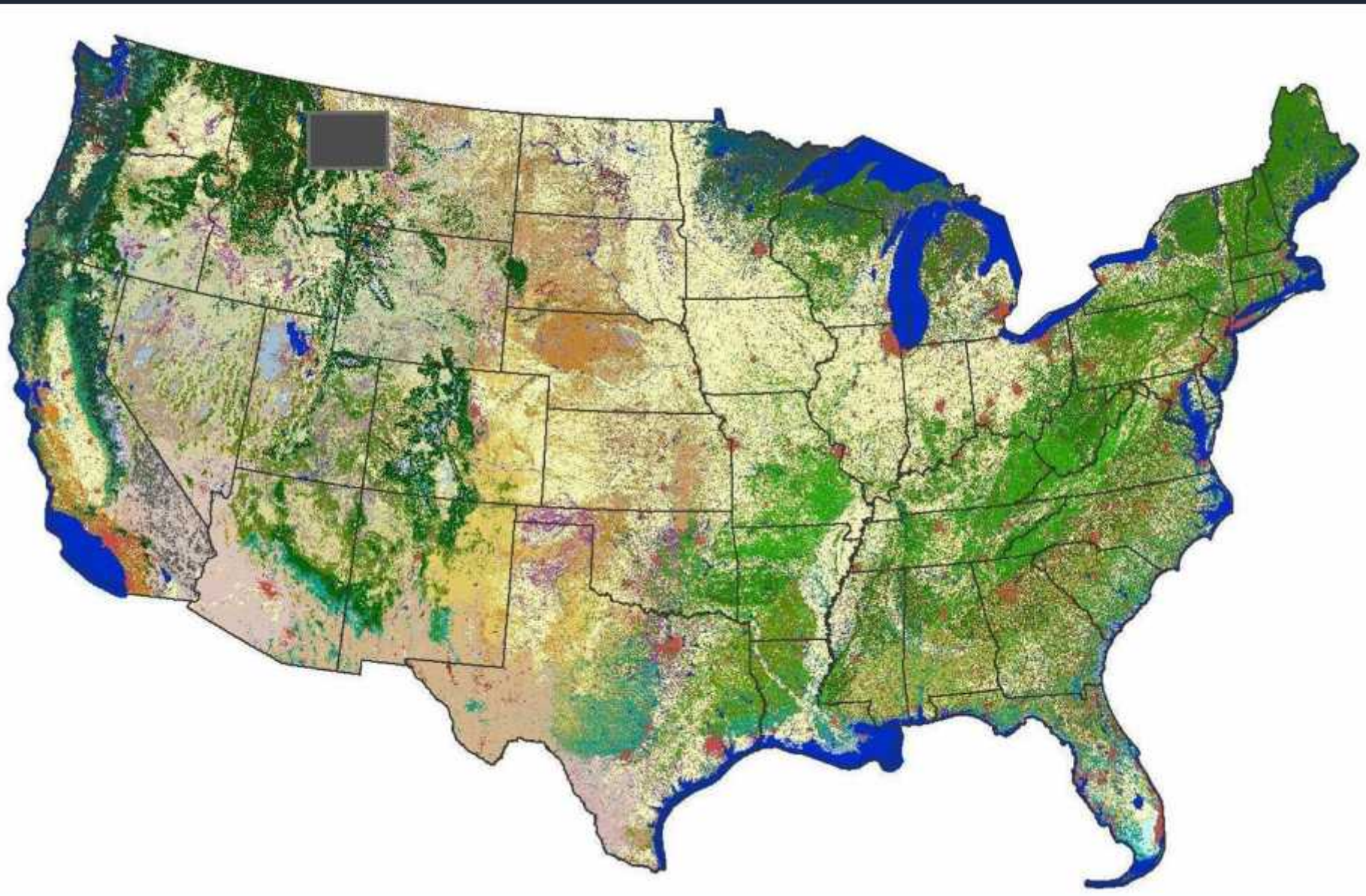
Rocky Mountain Aspen Forest and Woodland

Inter-Mountain Basins Montane Sagebrush Steppe

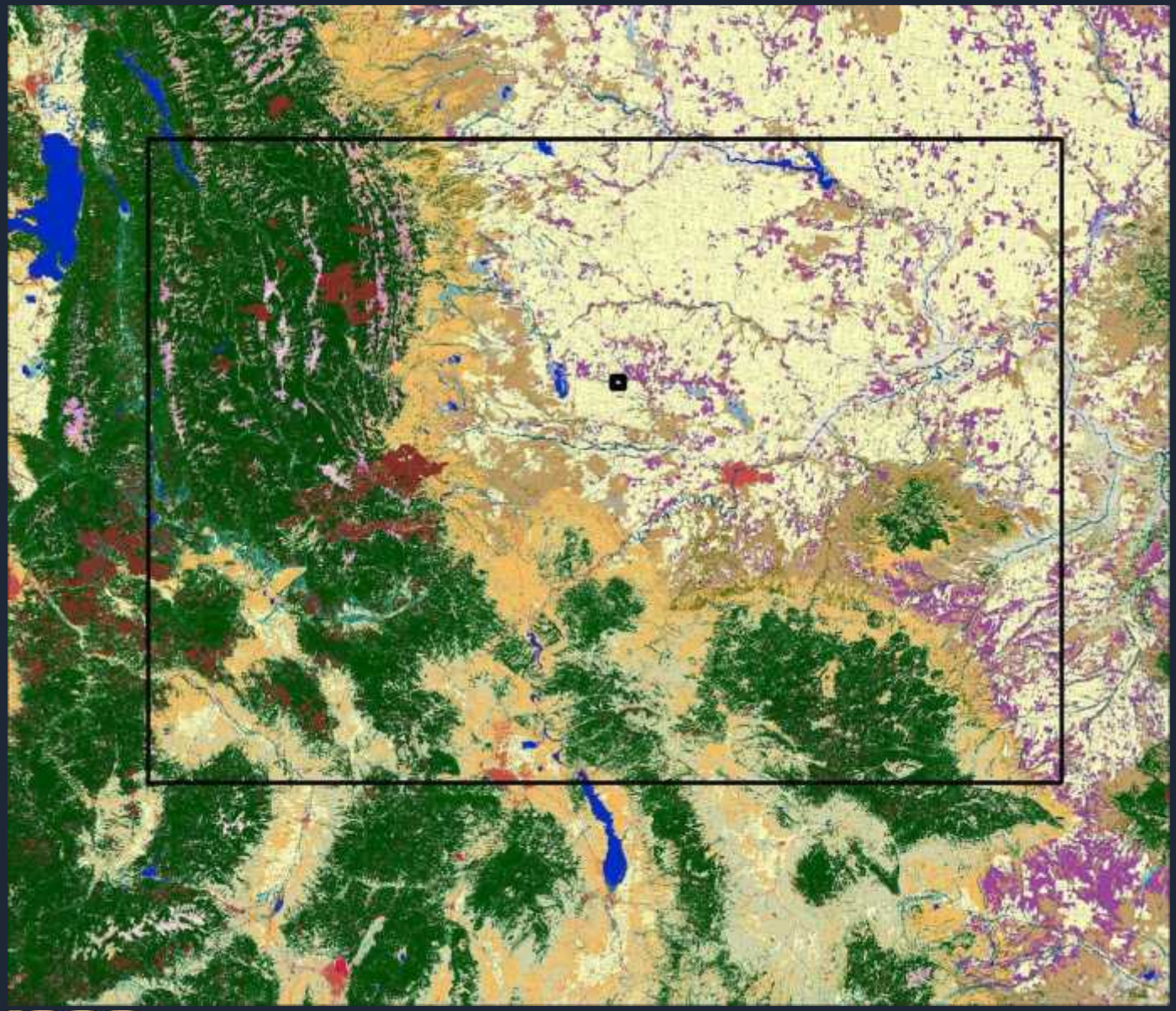
www.NatureServe.org\explorer

USGS science for a changing world

NatureServe



USGS
science for a changing world



USGS
science for a changing world

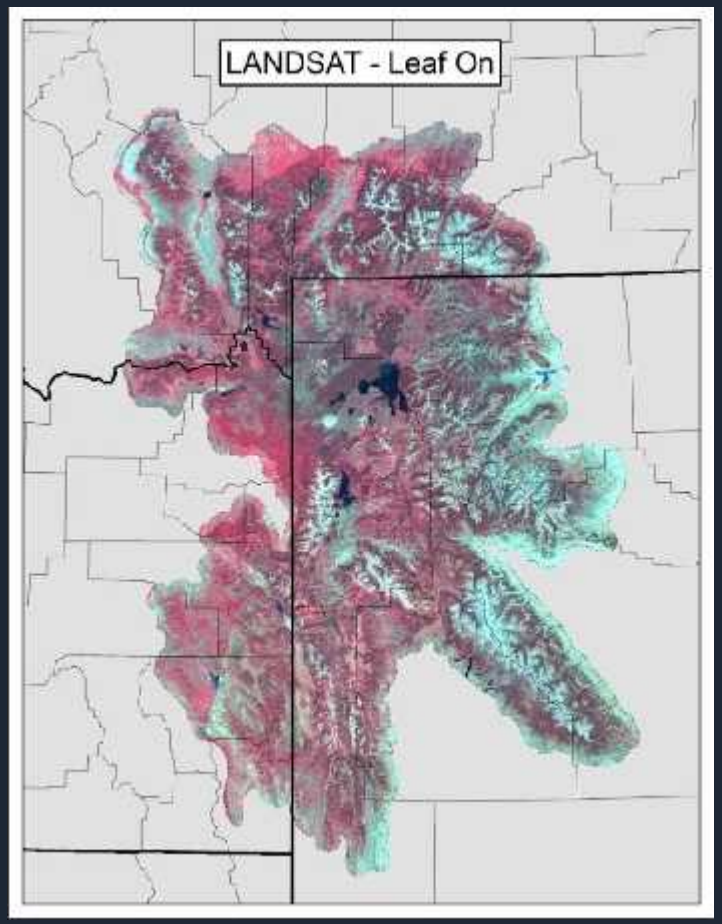
Class- Shrubland and Grassland
Subclass- Temperate & Boreal Shrubland and Grassland
Formation- Temperate &Boreal Freshwater Wet Meadow and Marsh
Division– Eastern North American Freshwater Wet Meadow, Riparian & Marsh
Macrogroup- Great Plains Wet Meadow, Wet Prairie & Marsh
Ecological System- Western Great Plains Open Freshwater Depression

USGS
science for a changing world

Class- Forest & Woodland
Subclass-Temperate Forest
Formation-Temperate Flooded &Swamp Forest
Division –Eastern North American Flooded & Swamp Forest
Macrogroup- Great Plains Floodplain Forest
Ecological System-Northwestern Great Plains Riparian

USGS
science for a changing world

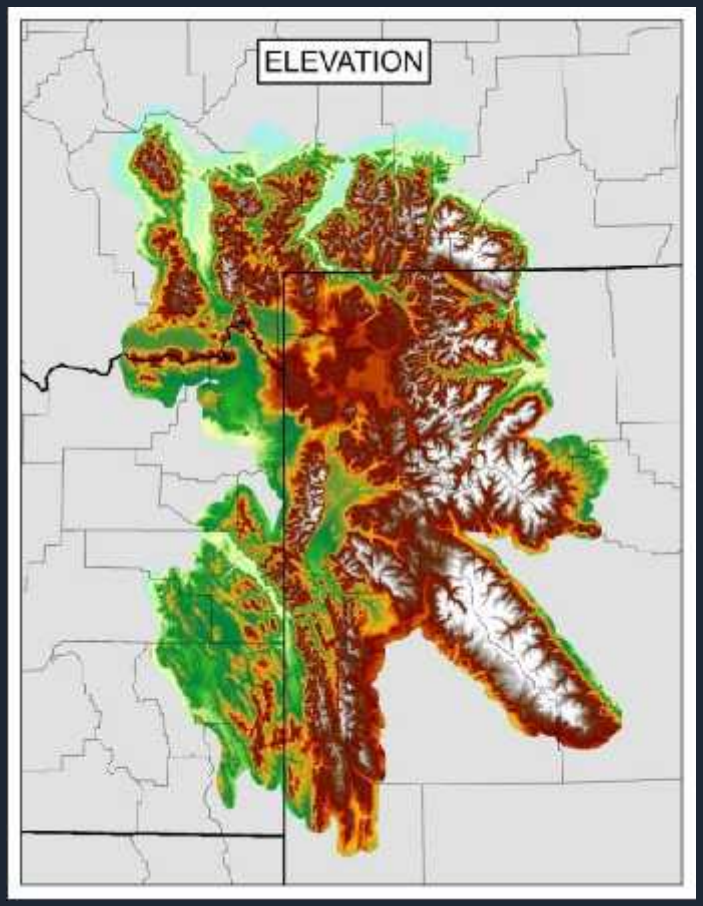
Land cover modeling process- Step 2 Selection of descriptive layers



- Landsat TM ~ 2001
  - Three dates of imagery (spring, leafon, and leafoff)
  - Tasseled cap transformed indices (greenness, wetness, brightness)

USGS
science for a changing world

Land cover modeling process- Step 2
Selection of descriptive layers



- Topographic variables
  - DEM,
  - positional index
  - slope
  - aspect
- Additional layers used for special areas and models
  - soil and geology information
  - rare habitat locations
  - introduced plant locations
  - fire history databases
  - stream and wetland location information

USGS
science for a changing world

Land cover modeling process- Step 3 Training data collection

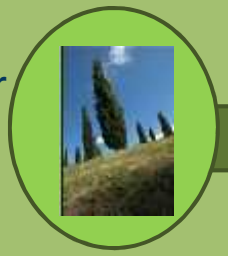
- Southwest and Northwest regions collected field training data to inform land cover models
- Additional sites collected through photo interpretation
- Utilized training data collected by other agencies and organizations
  - compiled by the Landfire project
  - Natural Heritage Databases

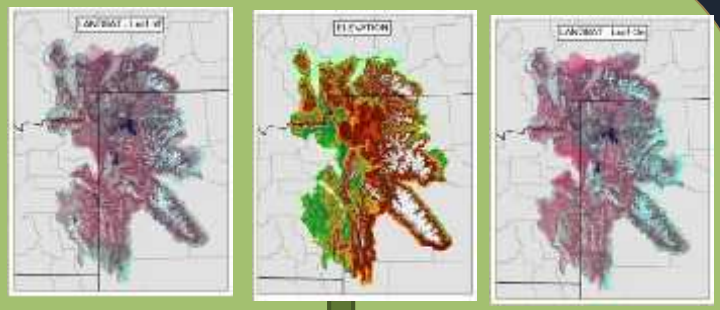
USGS
science for a changing world

Land cover modeling process- CART example

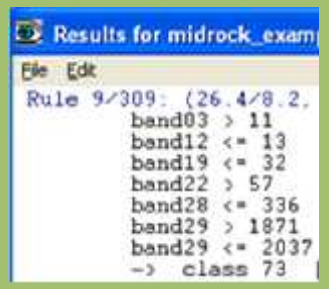
1. Training data points intersected with predictor data layers

ERDAS Imagine





2. Rules are derived to explain the patterns in the data See5



3. Rules are spatially applied and map of matrix classes is produced

ERDAS Imagine

Process guided by NLCD mapping tool
Available at www.MRLC.gov

GAP National Land Cover Viewer

http://gapanalysis.usgs.gov/gaplandcover/viewer/

Relationship between the NVC and the Ecological System Classification

Ecological System
Atlantic Coastal Plain Peatland Pocosin and Canebrake

1997 Standard

US NVC Formation
Saturated temperate or sub polar needle-leaved evergreen woodland

US NVC Alliances
Pinus serotina Saturated Woodland Alliance

2008 Standard

US NVC Group
Southeastern Coastal Plain Pocosin & Shrub Bog Group

US NVC Alliances
Pinus serotina Saturated Woodland Alliance

US NVC Association
Pinus serotina - Gordonia lasianthus / Lyonia lucida Woodland

Program	Target Map Units	Primary Use	Base Data	Mapping Extent	Approach
NPS National Park Service	National Vegetation Classification System	Inventory, planning, monitoring.	Aerial photography; Satellite imagery in Alaska	Park specific; polygon based	Photo interpretation with intensive field data collection
GAP	Ecological Systems (modifiers - habitat)	Biodiversity assessment	Landsat; NLCD, Abiotic variables	Mapping Zone, Regional, National; pixel based	Decision trees, pattern recognition, manual delineation, expert opinion; field plots & deductive
LANDFIRE	Ecological Systems (aggregates, modifiers)	Wildfire planning	Landsat; NLCD, Abiotic variables	Mapping Zones, Regional, National; pixel based	Decision trees; compilation of existing field plot data
Ecosystem Mapping	Ecological Footprints/ Ecological Systems	Geospatial Framework	Abiotic variables, NLCD	Ecoregions, National; patch (footprint)/ pixel	Deductive – expert knowledge classification
Northeast Habitat Mapping	Ecological Systems	Habitat modeling	Abiotic variables, NLCD	Ecoregions; 100 ha hexagon & landform/pixel	Random Forest – decision tree, compiled plot data, post processing

Comparison of the decision tree models

	Train Assess	Full	No STATSGO	No SSURGO	No STATSGO or SSURGO	No Vector
		Hectares modeled (% of area modeled)				
Sandhills Longleaf	t = 67	132,443	254,296	159,306	122,609	100,671
	n = 54	(19)	(36)	(23)	(17)	(14)
ACP Wet Longleaf	t = 109	213,149	157,629	267,535	239,963	270,624
	n = 87	(30)	(22)	(38)	(34)	(38)
Pocosin	t = 95	230,961	177,678	174,224	258,474	242,515
	n = 86	(33)	(25)	(25)	(37)	(34)
ACP Upland Longleaf	t = 12	21,007	356	2,147	8,553	1,146
	n = 9	(3)	(< 1)	(< 1)	1	(<1)
Nonriverine - Oak	t = 7	48,074	69,725	67,051	59,008	44,138
	n = 6	(7)	(10)	(9)	(8)	(6)
Nonriverine Taxodium	t =10	61,110	47,060	36,481	18,136	47,650
	n = 6	(9)	(7)	(5)	(3)	(7)
Total	t = 300	----------706,774 ha (100% of the area modeled) ----------				
	n = 248					
Overall Accuracy		65	51	63	63	54
Kappa		0.513 +-0.014	0.411 +- 0.011	0.325 +- 0.012	0.444 +-0.012	0.366 +-0.012

USGS science for a changing world | GAP | Biodiversity and Spatial BaSIC Information Center

Pattern Matters

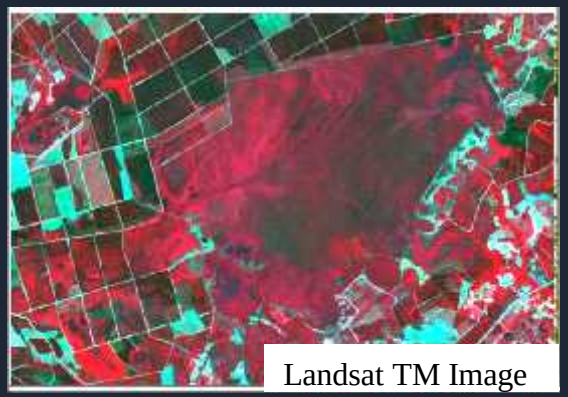
Full Model

No SSURGO or STATSGO

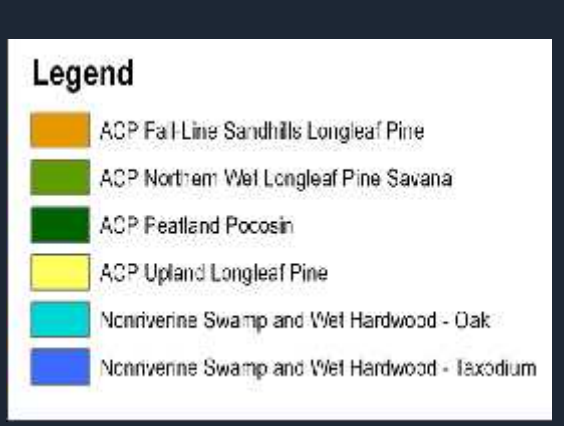
No STATSGO

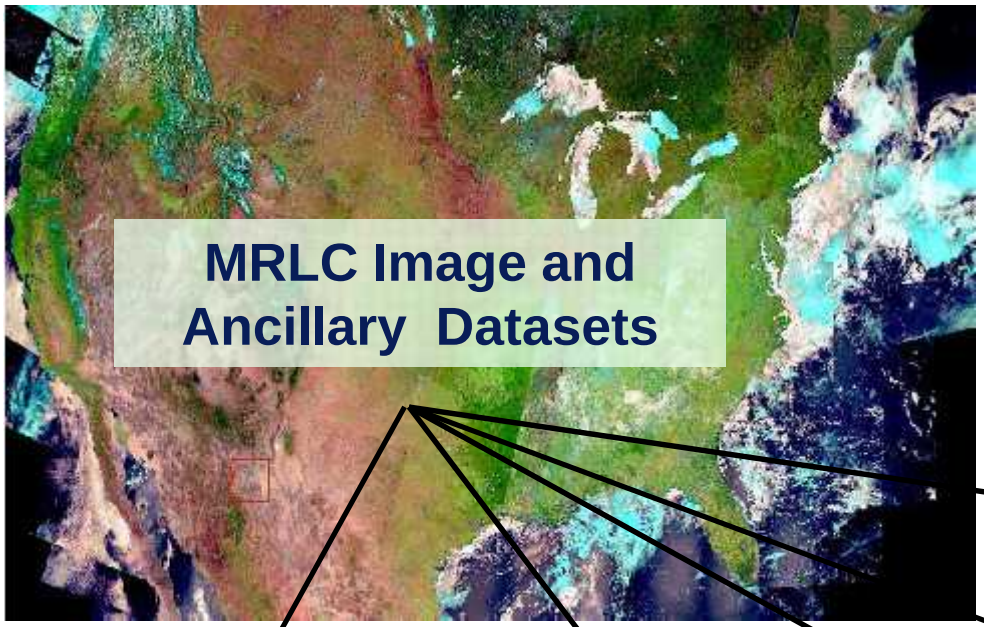
No VECTOR

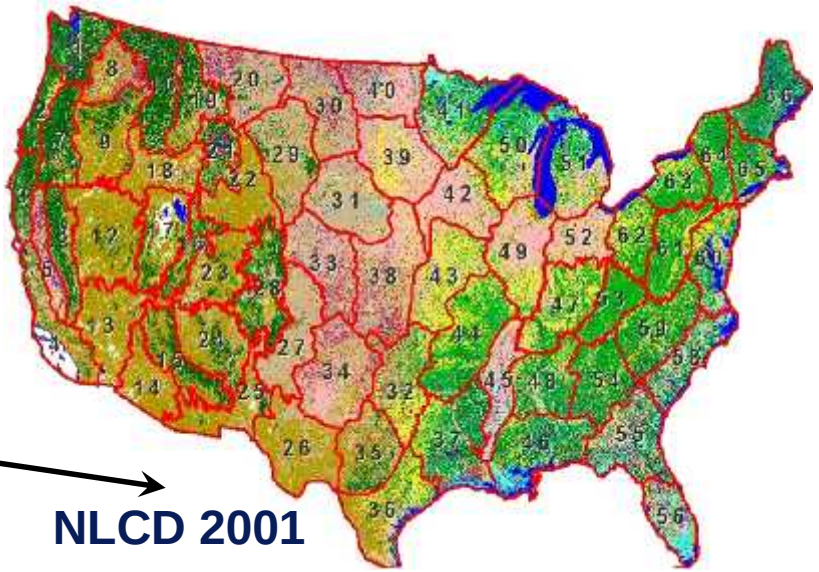
No SSURGO



Landsat TM Image

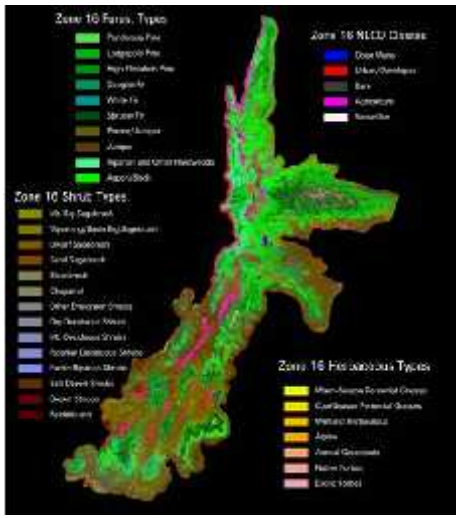




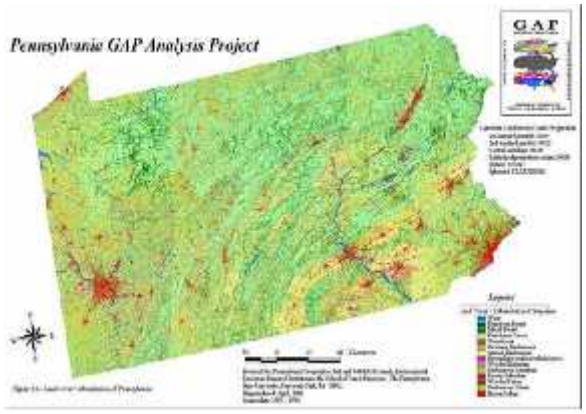


NLCD 2001

LANDFIRE



Gap Analysis



C-CAP

Land Cover Trends