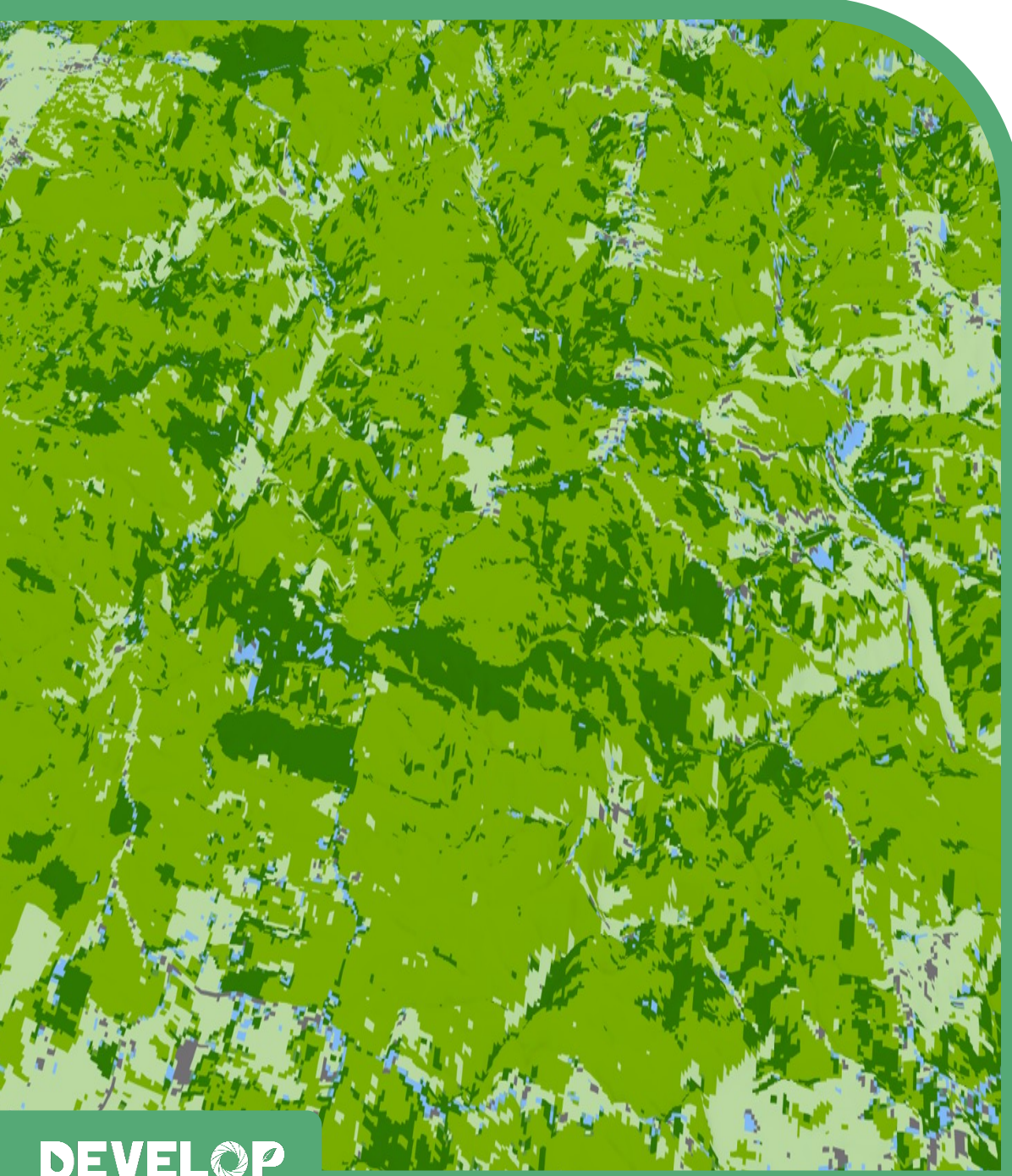


National Aeronautics and Space Administration

Mark Twain National Forest

Ecological Forecasting

Using NASA Earth Observations to Classify Ground Cover Types in the Mark Twain National Forest

Kaitlyn Bretz, Madison Bradley, Sarah Hafer, Grant Verhulst

DEVELOP

Idaho – Pocatello | Summer 2020

Road Map

Image Credit: Nancy Feakes (USFS)

- Project Partners
- Mark Twain National Forest
  - History
  - Current restoration efforts
  - Community Concerns
  - Study Period
  - Study Objectives
  - Satellites & Sensors
- Methodology
- Results & Conclusions
- Errors & Uncertainties
- Future Work

Project Partners

- **USDA, US Forest Service**
  Mark Twain National Forest (MTNF)

- **USDA, US Forest Service**
  Geospatial Technology and Applications Center

Image Credits: US Forest Service; Jeff Hamm

Mark Twain National Forest

- 1.5 million acres
- Diverse landscapes
  - Shortleaf pine-oak woodlands
  - Glades
- Native species
  - 750 native animal species
  - 2000+ native plant species

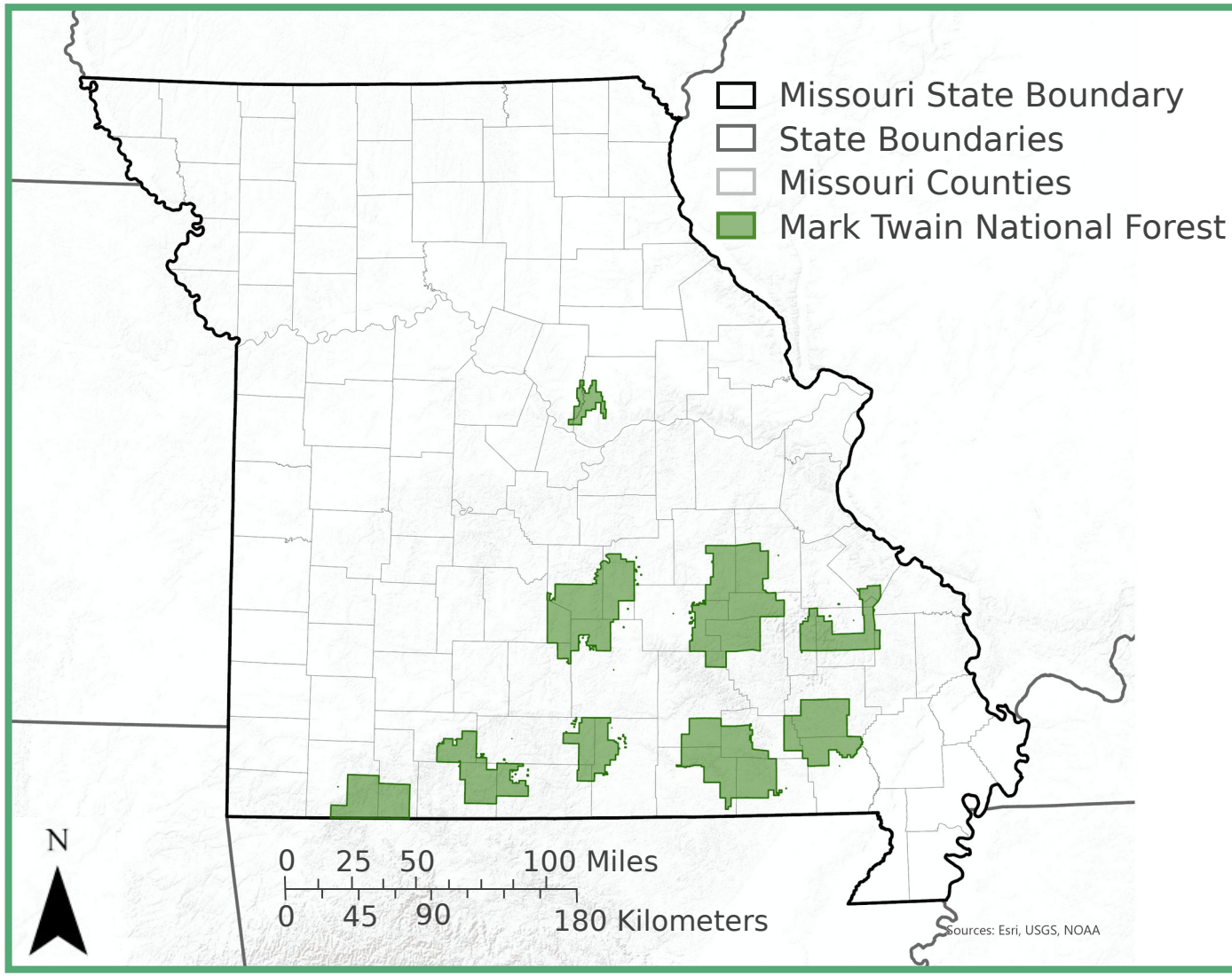


Image Credits: US Forest Service; Nancy Feakes (USFS)

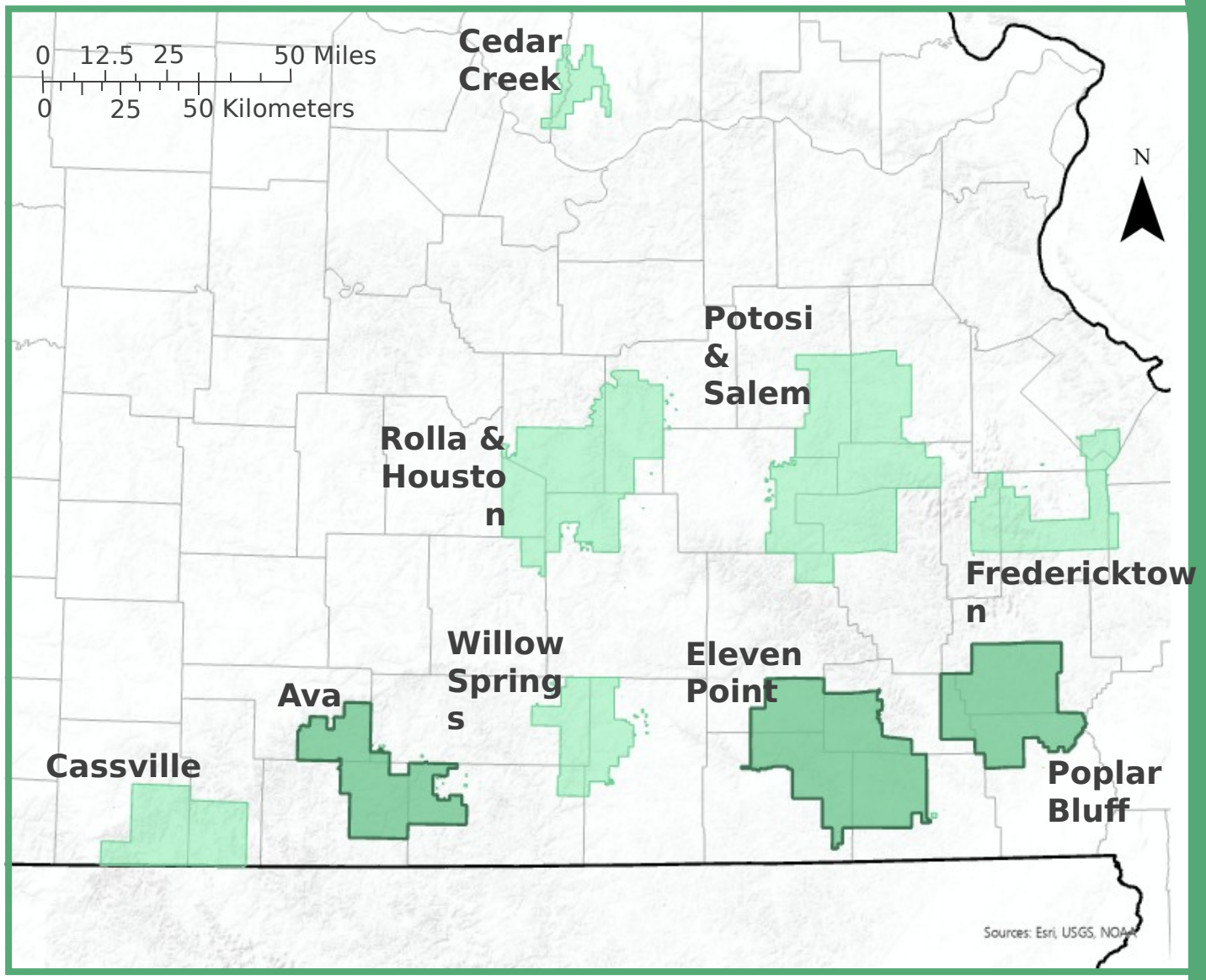
Mark Twain National Forest - Historical

- Logging & fire suppression
  - late 1800s – early 1900s
- Only 10% of historic pine-oak woodlands remain today

Image Credits: US Forest Service; W.R. Werner (USFS); Paul D. Kelleter (USFS)

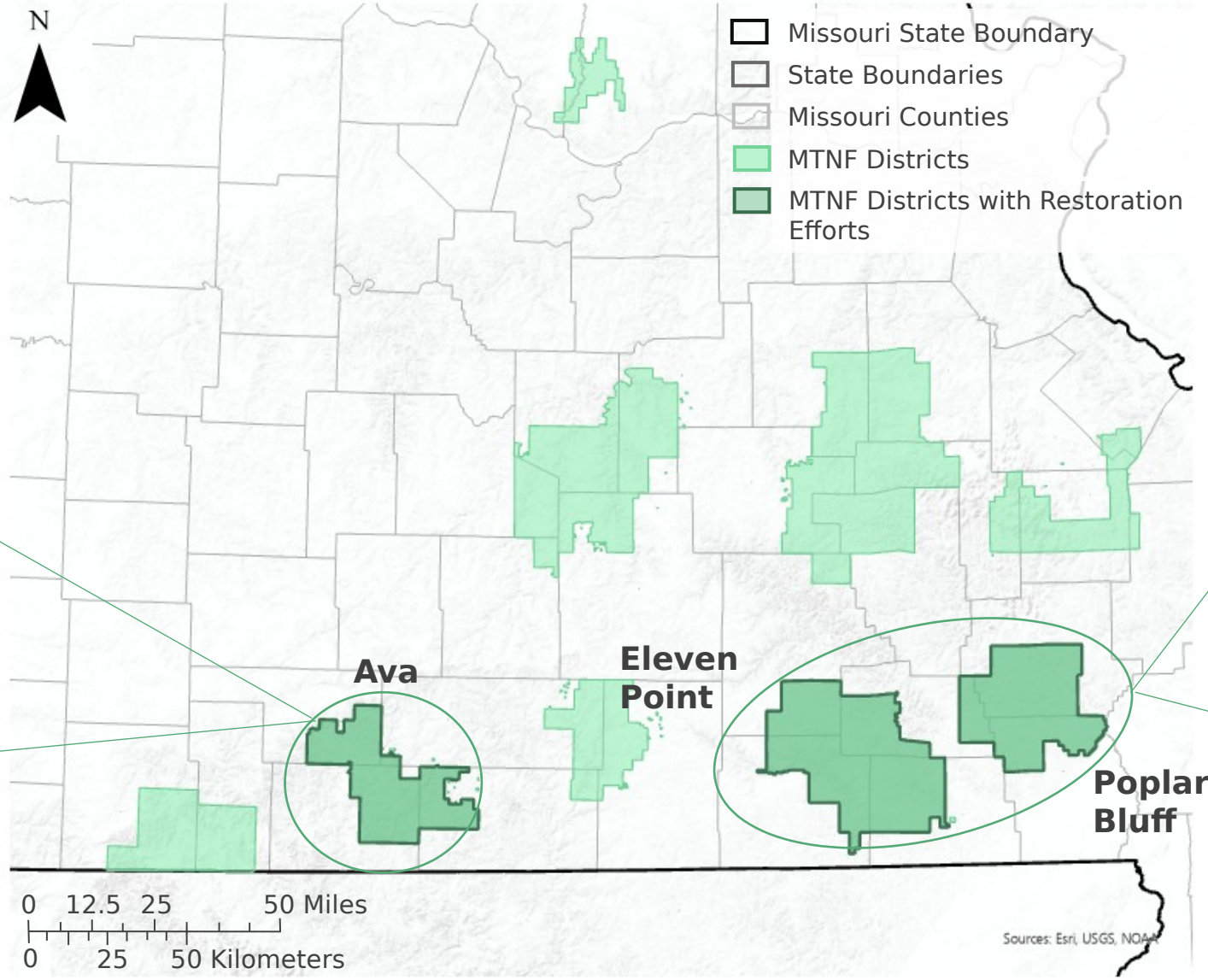
Mark Twain National Forest

- 9 areas, 11 Ranger District
- Eleven Point & Poplar Bluff districts
  - Collaborative Forest Landscape Restoration Project (CFLRP, 2012)
- Ava district
  - Glade restoration



Community Concerns

Glade Restoration



Shortleaf Pine-Oak Woodland Restoration

Image Credits: US Forest Service

Study Period

2012: Collaborative Forest Restoration Project

2015: Prescribed Fire Introduced in Ava District glades

Forecasting out to 2040

1980 | 1990 | 2000 | 2010 | 2020 | 2030 | 2040

Oct 1986: Study Period Begins

2014: Eastern Red Cedar Removal in Ava District glades

1986 Land Cover Classification

2019 Land Cover Classification

2040 Land Cover Forecast

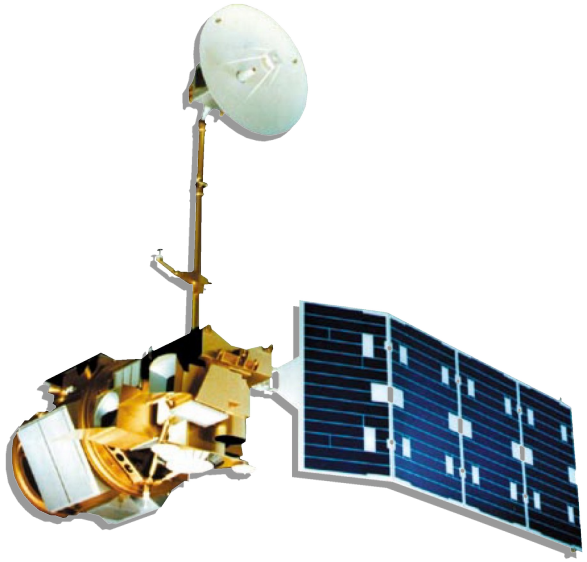
Image Credits: Jim Guldin (USFS); USDA-NRCS PLANTS Database

Objectives

- **Classify**
  - Create a land cover type analysis of MTNF that can be used to assist with species-level classifications
- **Forecast**
  - Forecast out to the year 2040 to determine changes in land cover type based on current management practices

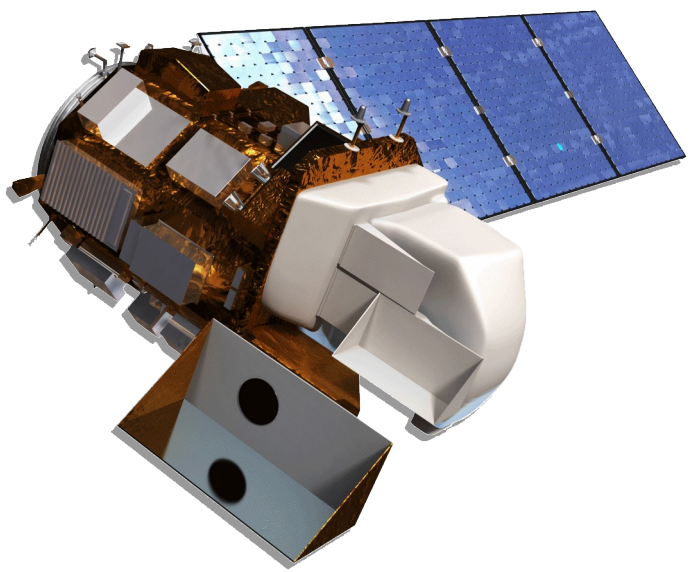
Image Credits: US Forest Service

Satellite and Sensors



Landsat 5 TM

Thematic Mapper



Landsat 8 OLI

Operational Land Imager

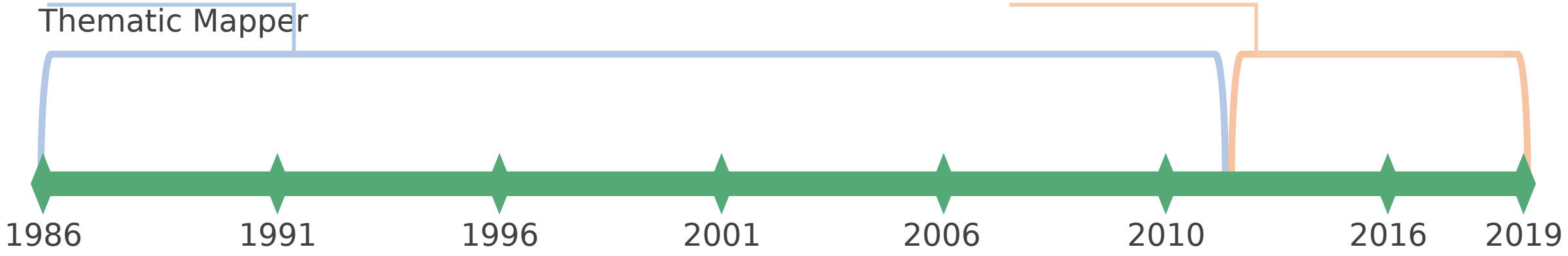


Image Credits: NASA

Methods

Data Acquisition

- Google Earth Engine
  - Landsat 5 TM
  - Landsat 8 OLI
- National Elevation Data

Image Processing

- Composite Images & Indices (NDVI, EVI, NDWI)
- Digital Elevation Model
- Aspect
- Slope

Supervised Classification

- 5 Land Cover Classes
  - Conifer forest, deciduous forest, meadow (grassland/cropland), urban, water

Ecological Forecasting

- Land Change Modeler
  - 2019 - 2040
  - Business As Usual (BAU)

Methodology: Image Processing

National Elevation Data

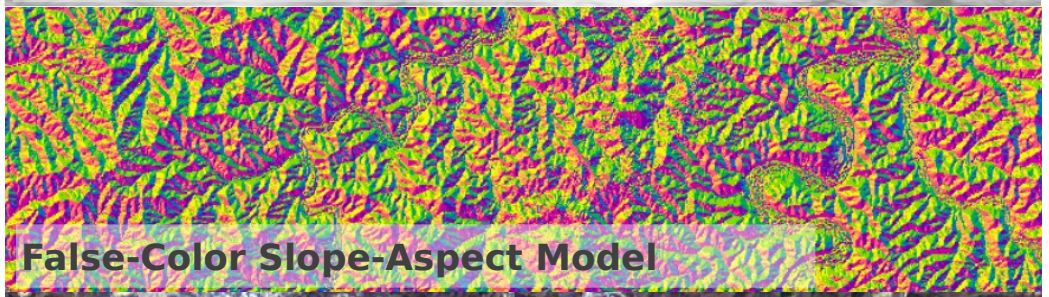
- Mosaicked DEM
- Calculated slope/aspect

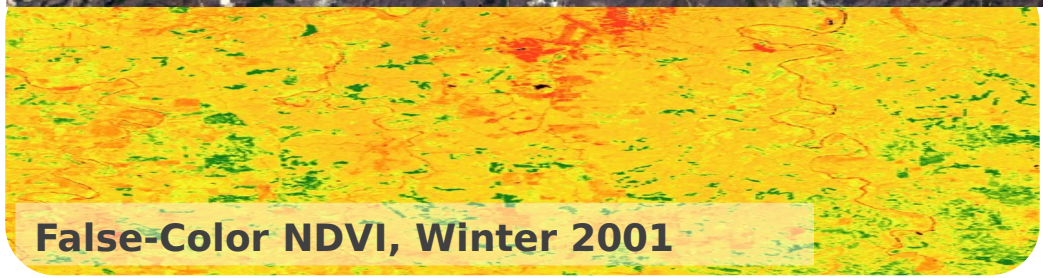
Google Earth Engine

- Filtered Landsat images
- Applied cloud/snow masks
- Calculated derivatives
- Clipped & exported

ArcGIS Pro

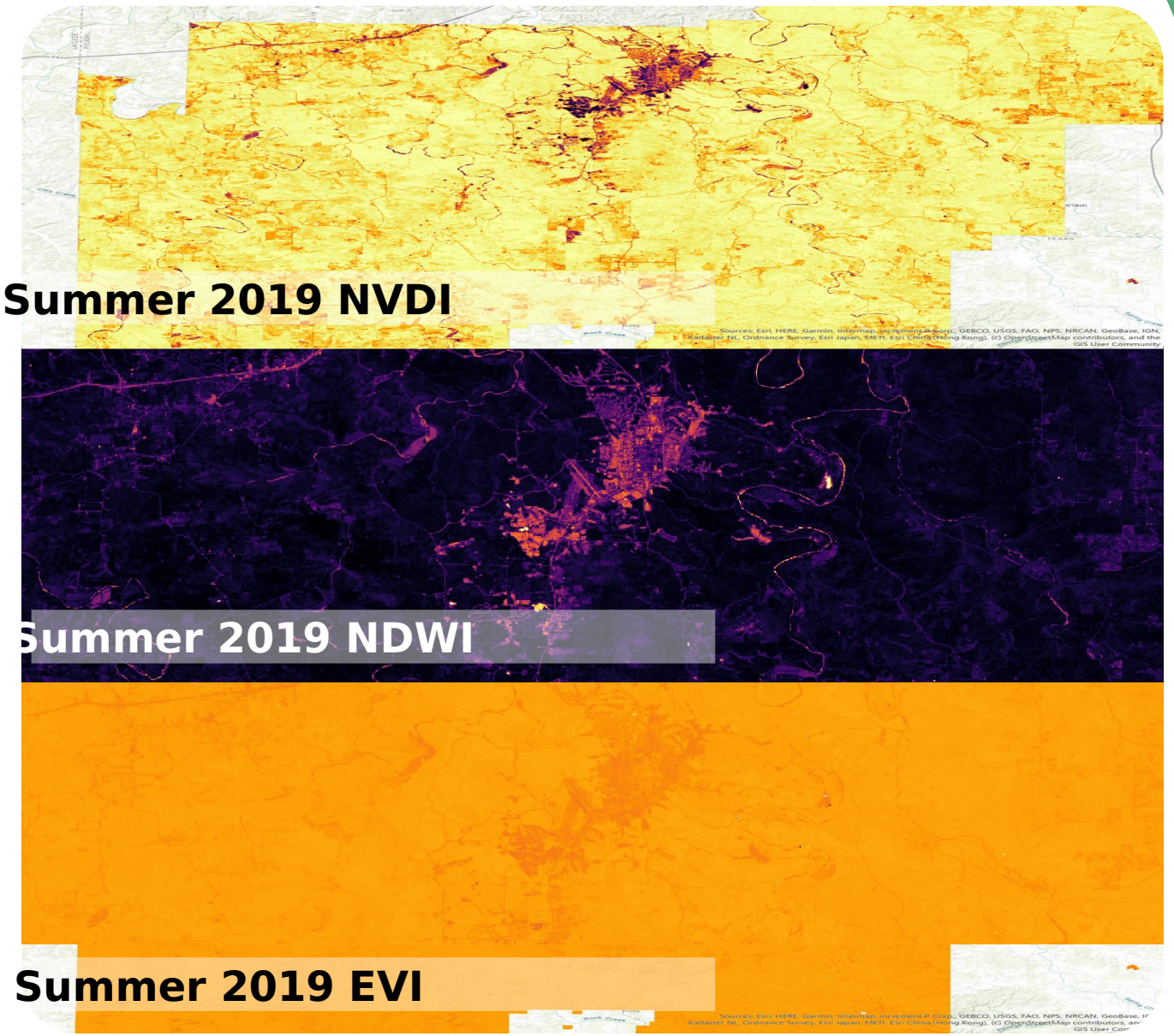
- Mosaicked composite images
- Resampled to DEM's resolution (10m)
- Extracted all layers by mask to unify extents and number of columns/rows





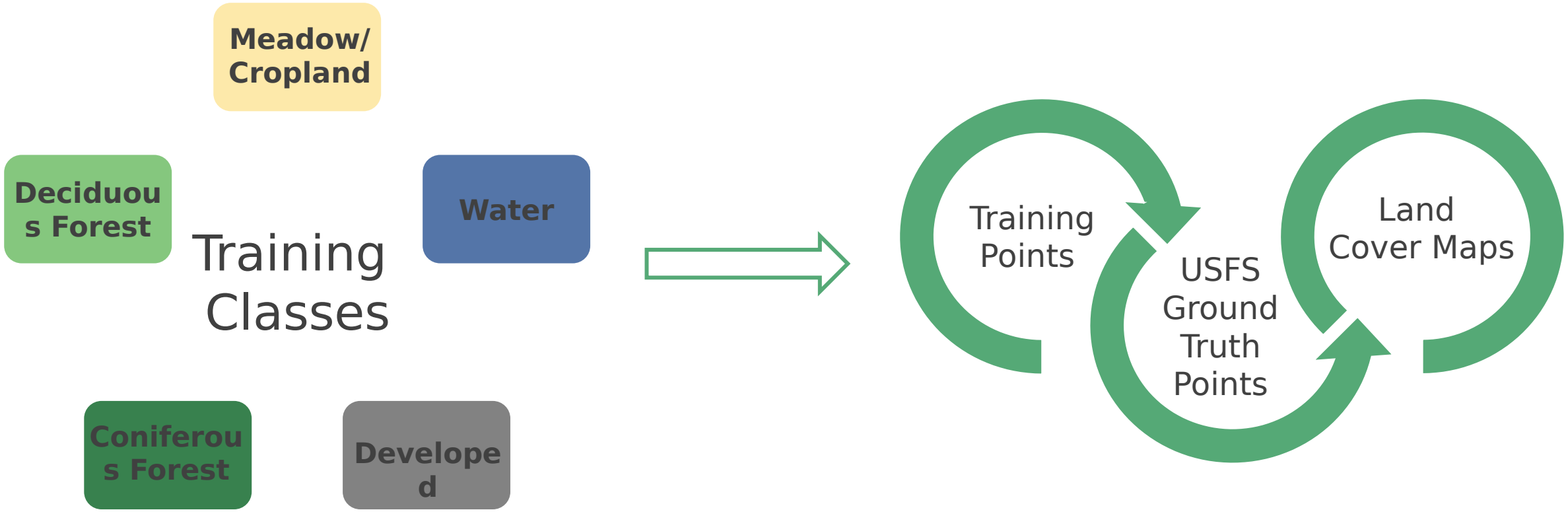
Methodology: Image Processing

- Calculated Derivatives
  - NDVI
  - NDWI
  - EVI
- Important for Classification
  - Seasonal
  - Differentiates vegetation
  - Isolates waterbodies



Methodology: Supervised Classification

- ArcPro Supervised Classification

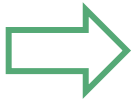


Methodology: Species Modeling

- ArcPro Forest-Based Classification & Regression

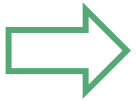
Variable to Predict

- Shortleaf Pine & Eastern Red Cedar Presence Points
  - Training polygons
  - In-situ data



Explanatory Training Rasters

- 2018 NAIP imagery
- Conifer Classification
- Elevation
- Aspect
- Slope
- Slope-Aspect

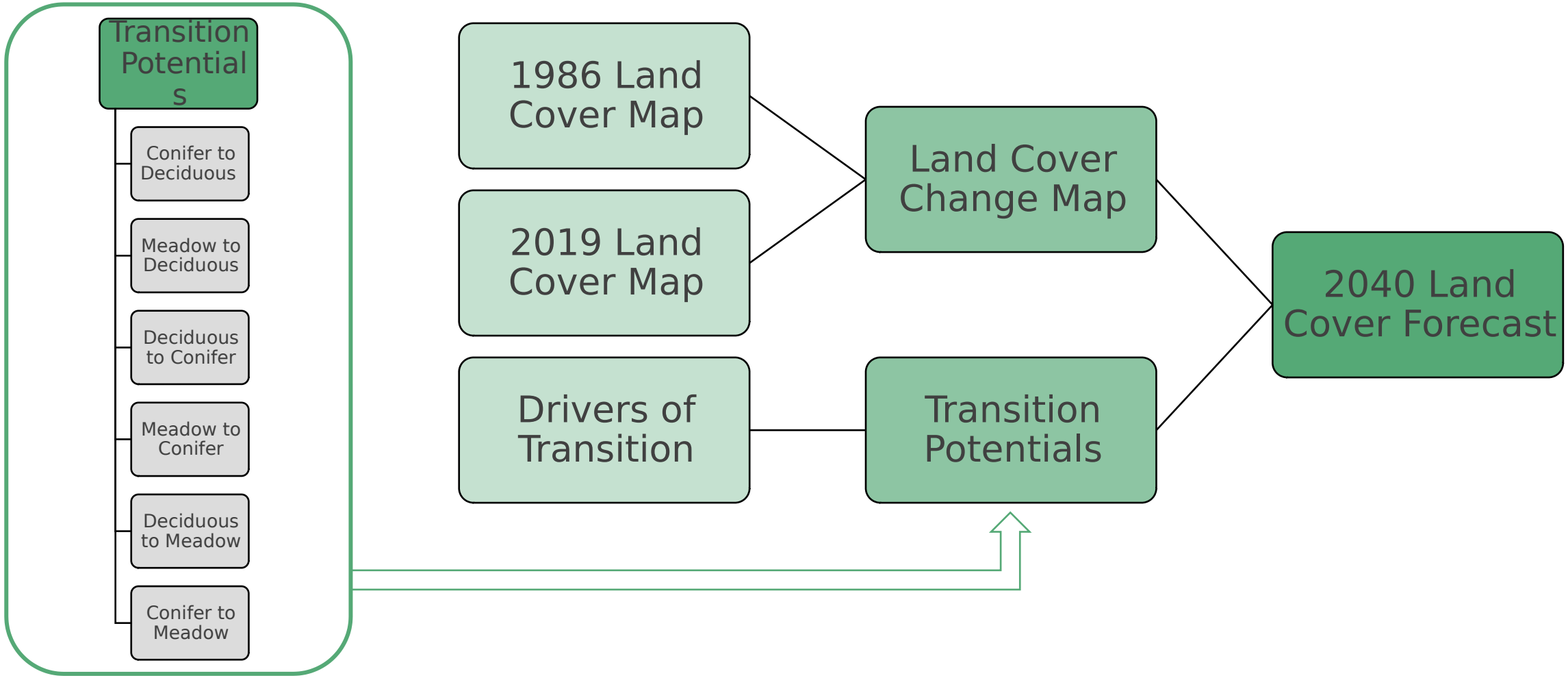


Training/Running Models

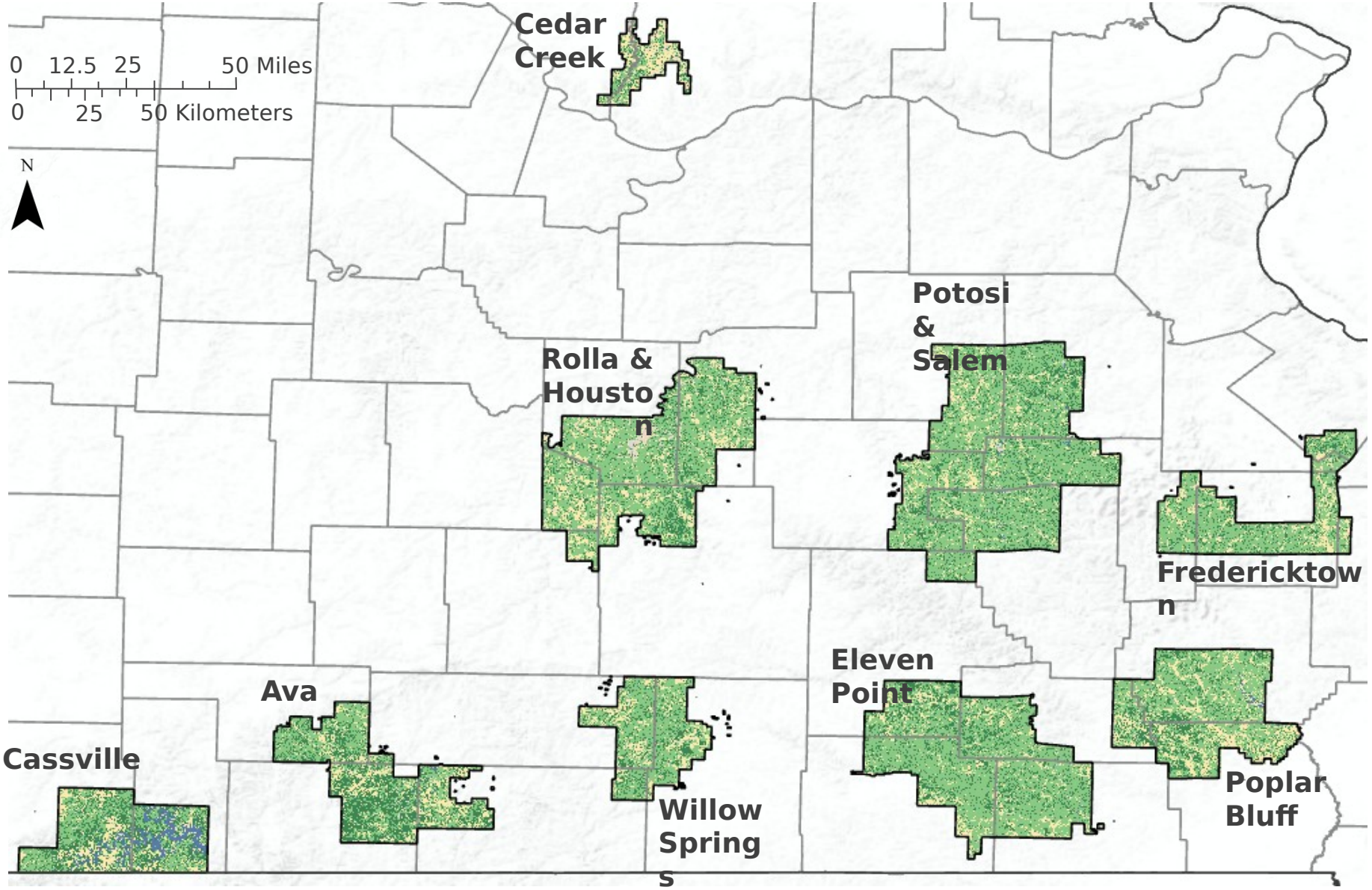
- Shortleaf Pine models
- Eastern Red Cedar models

Methodology: Ecological Forecasting

- Idrisi TerrSet Land Change Modeler



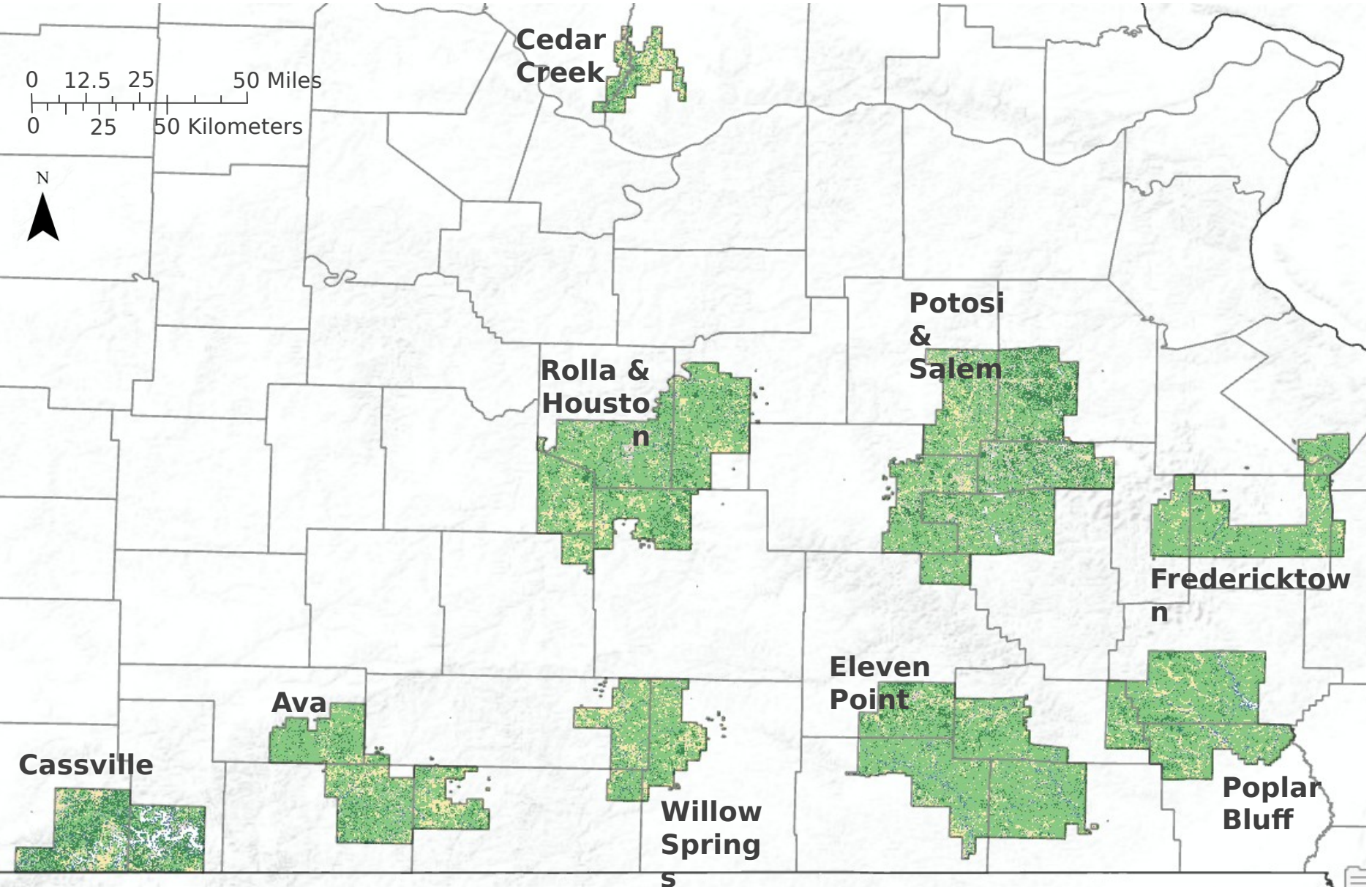
Results and Conclusions



1986 Land Cover Classification

- Missouri State
- Missouri Counties
- Water
- Developed
- Deciduous
- Conifer
- Meadow

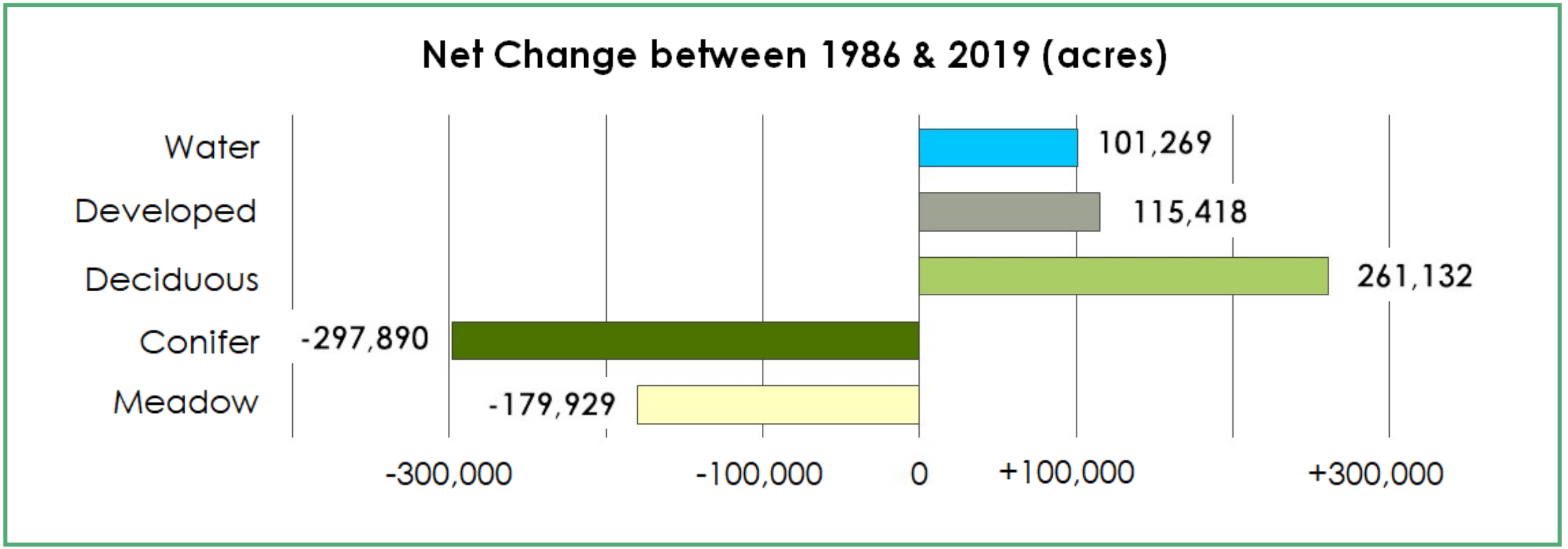
Results and Conclusions



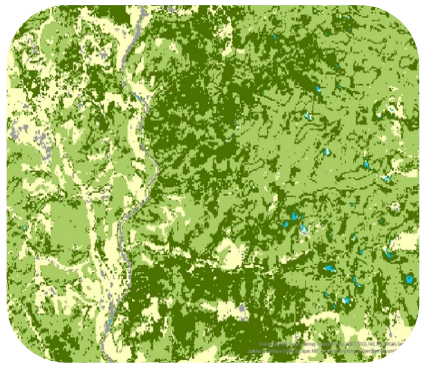
2019 Land Cover Classification

- Missouri State
- Missouri Counties
- Water
- Developed
- Deciduous
- Conifer
- Meadow

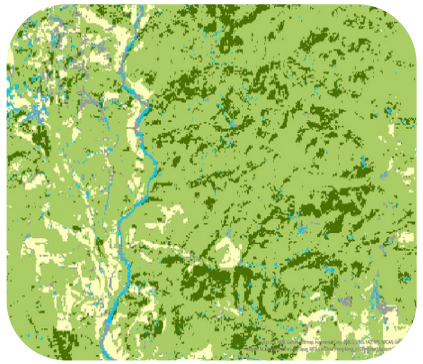
Results and Conclusions



1986 supervised classification



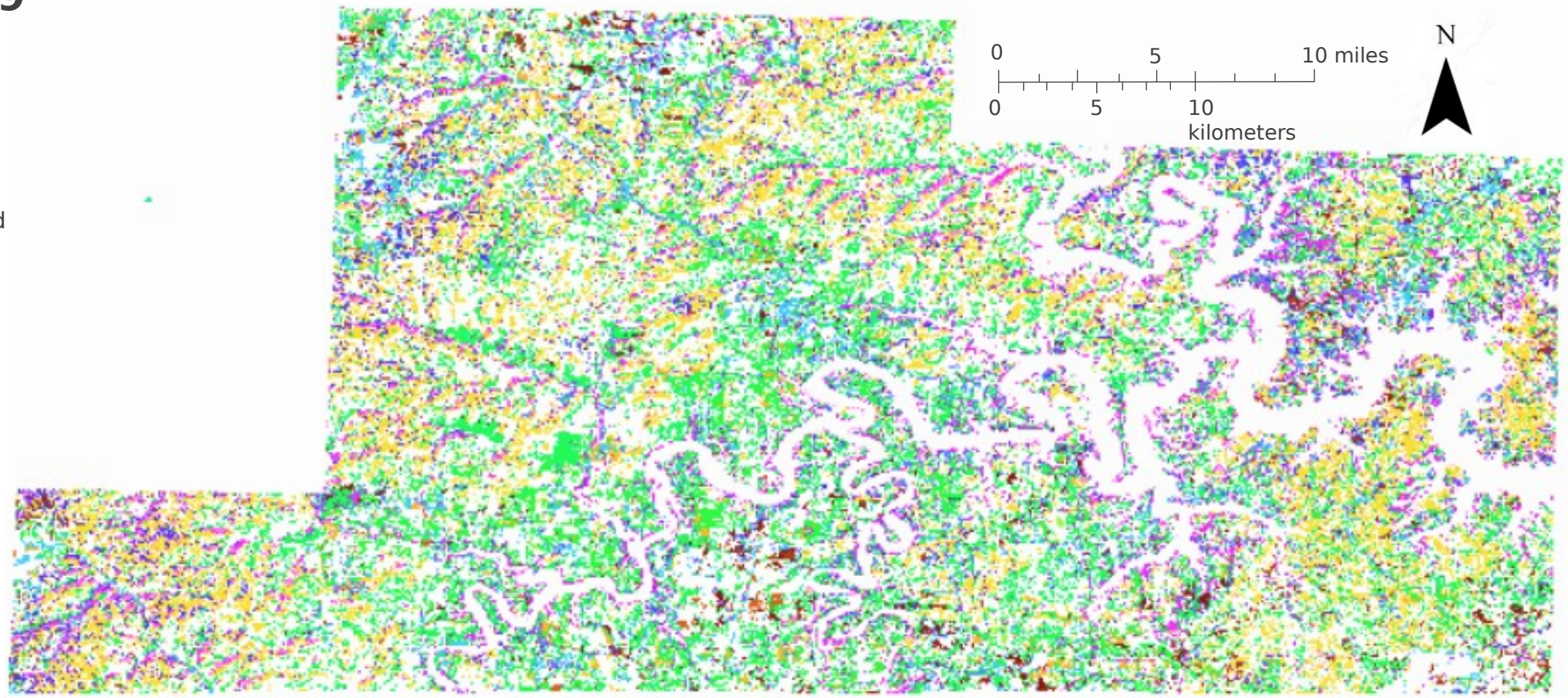
2019 supervised classification



Results and Conclusions

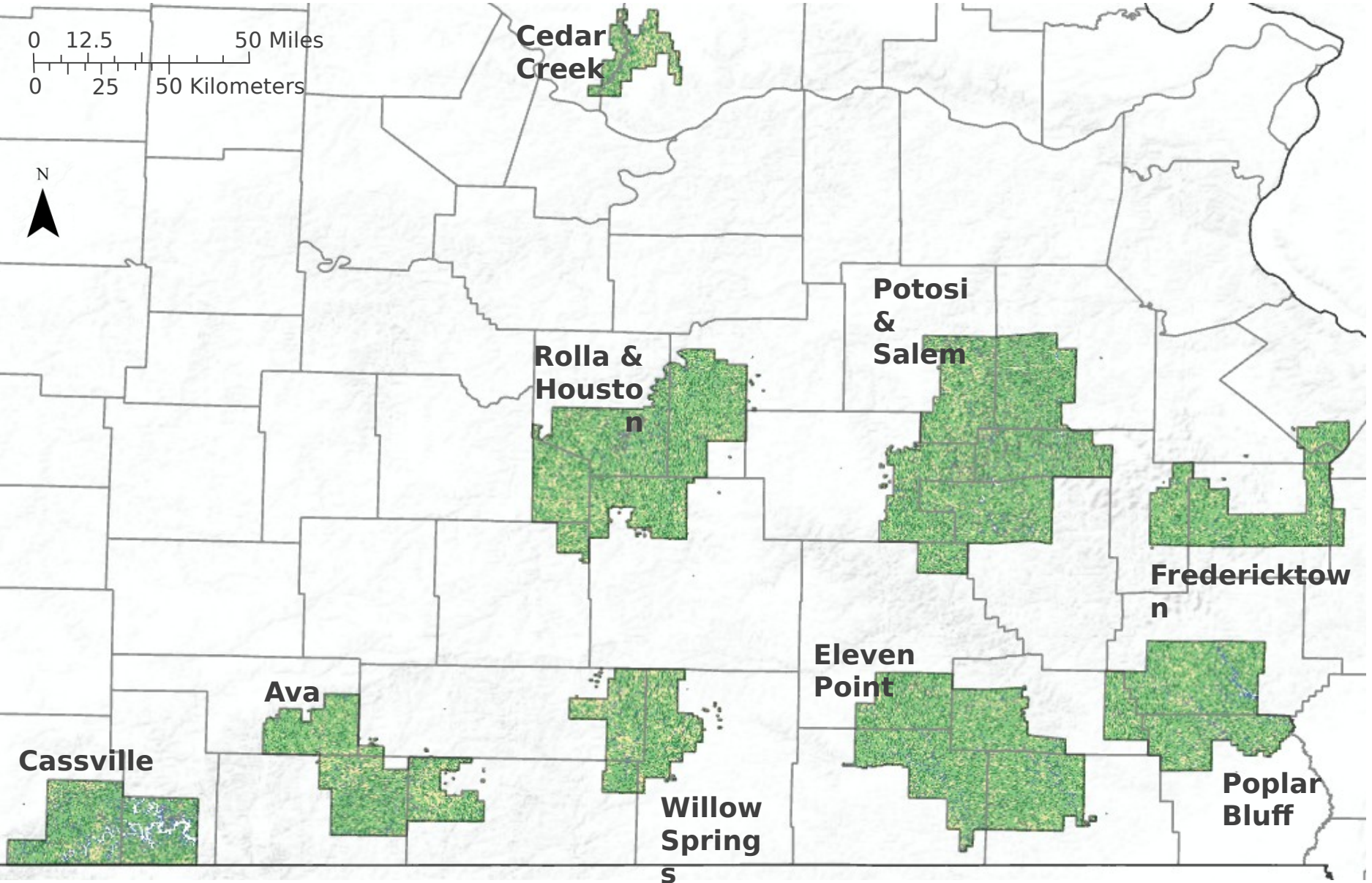
Land Cover Change, 1986-2019

- Developed to Water
- Deciduous to Water
- Conifer to Water
- Meadow to Water
- Water to Developed
- Deciduous to Developed
- Conifer to Developed
- Meadow to Developed
- Water to Deciduous
- Developed to Deciduous
- Conifer to Deciduous
- Meadow to Deciduous
- Water to Conifer
- Developed to Conifer
- Deciduous to Conifer
- Meadow to Conifer
- Water to Meadow
- Developed to Meadow
- Deciduous to Meadow
- Conifer to Meadow



Land Cover Change 1986-2019 in Cassville Ranger District

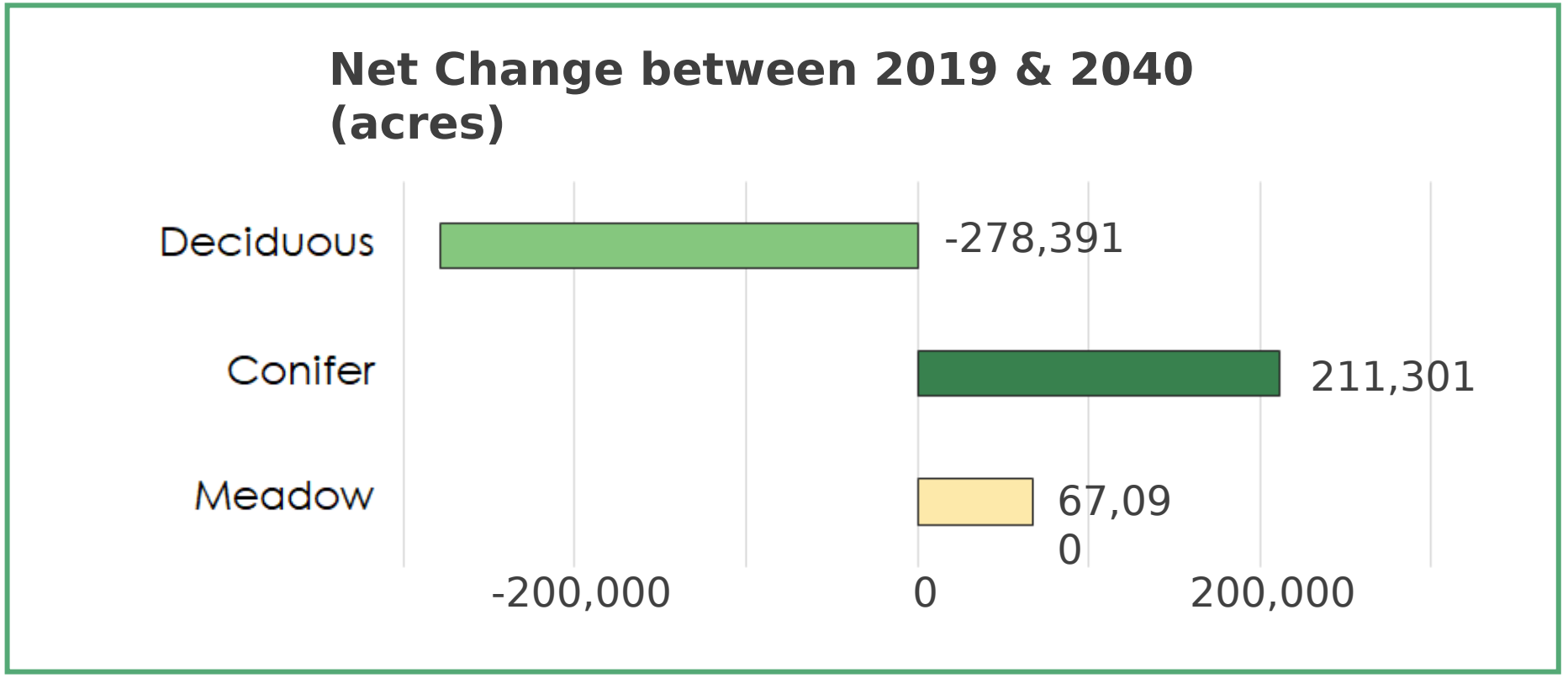
Results and Conclusions



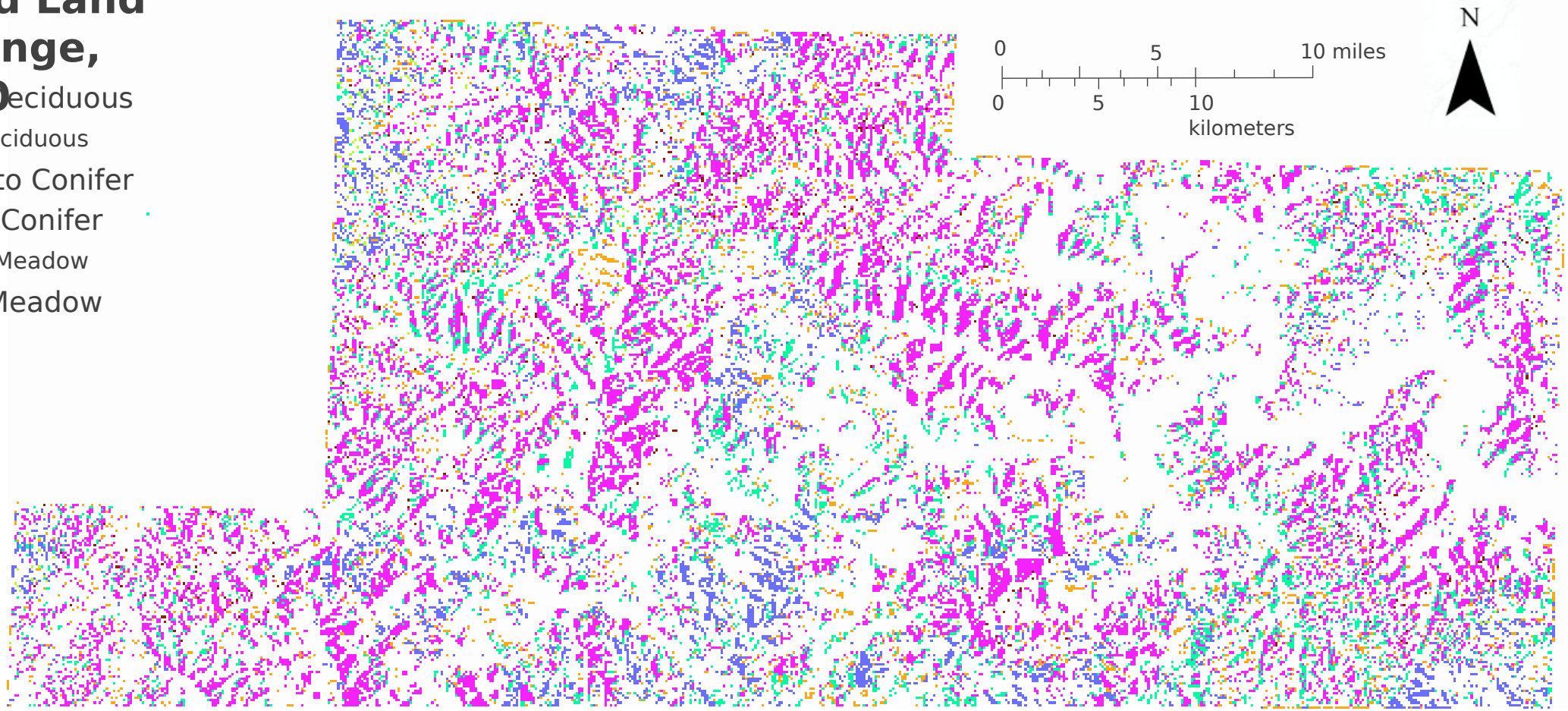
2040 Land Cover Forecast

- Missouri State
- Missouri Counties
- Water
- Developed
- Deciduous
- Conifer
- Meadow

Results and Conclusions



Results and Conclusions

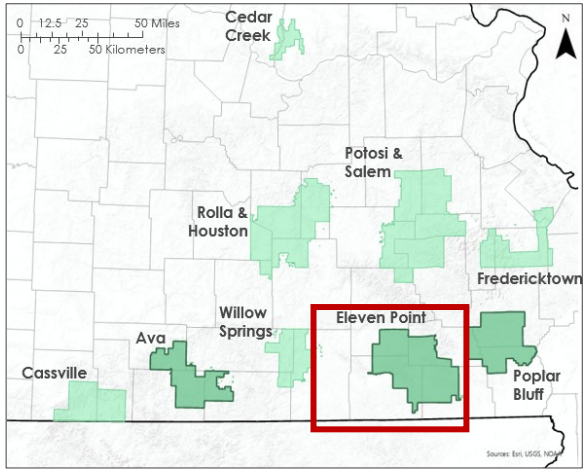


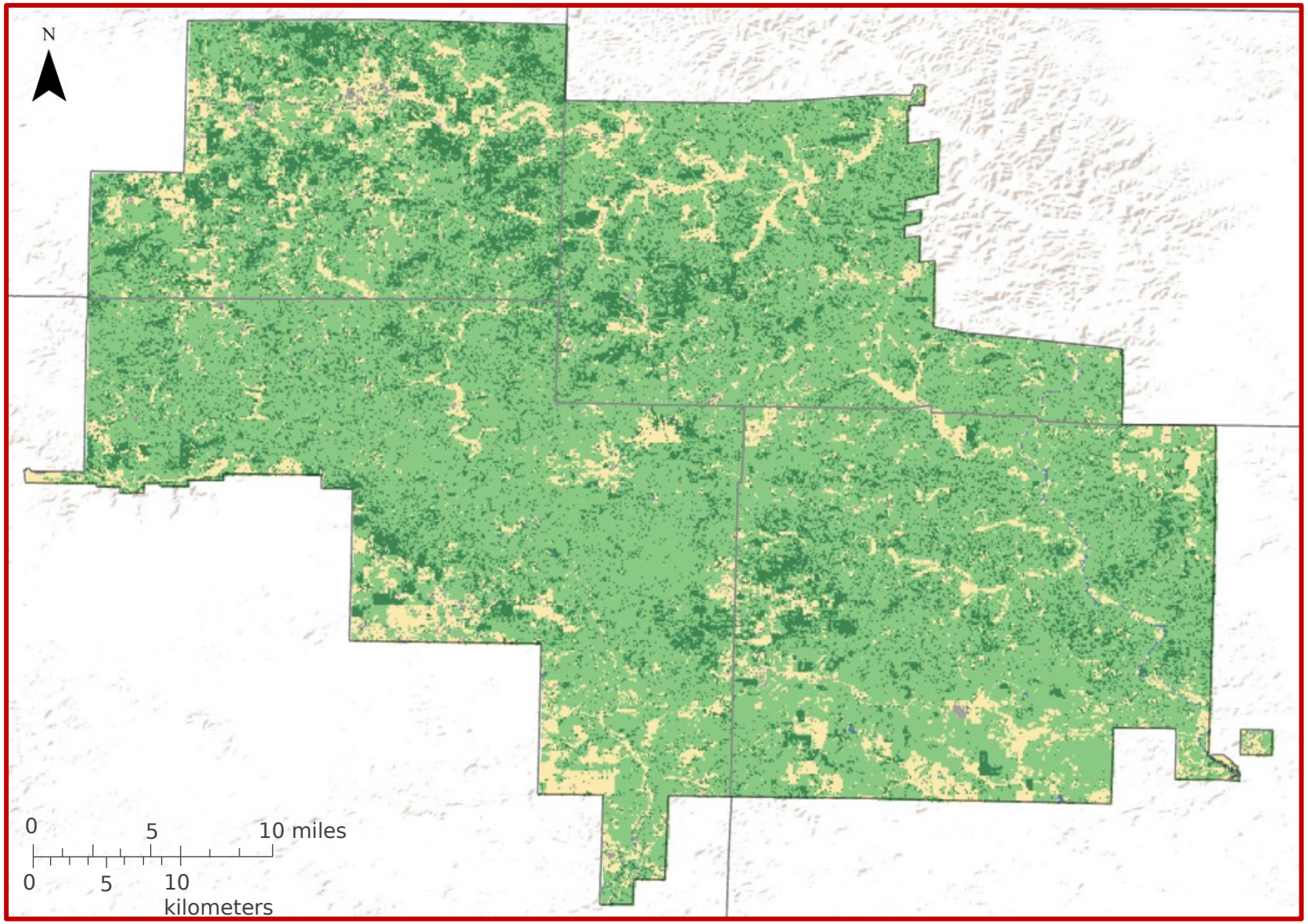
Land Cover Forecast 2019-2040 in Cassville Ranger District

Results and Conclusions

Eleven Point Ranger District:

1986 Land Cover Classification

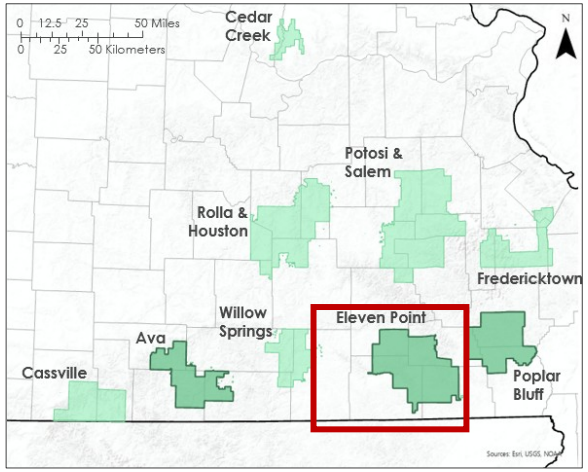


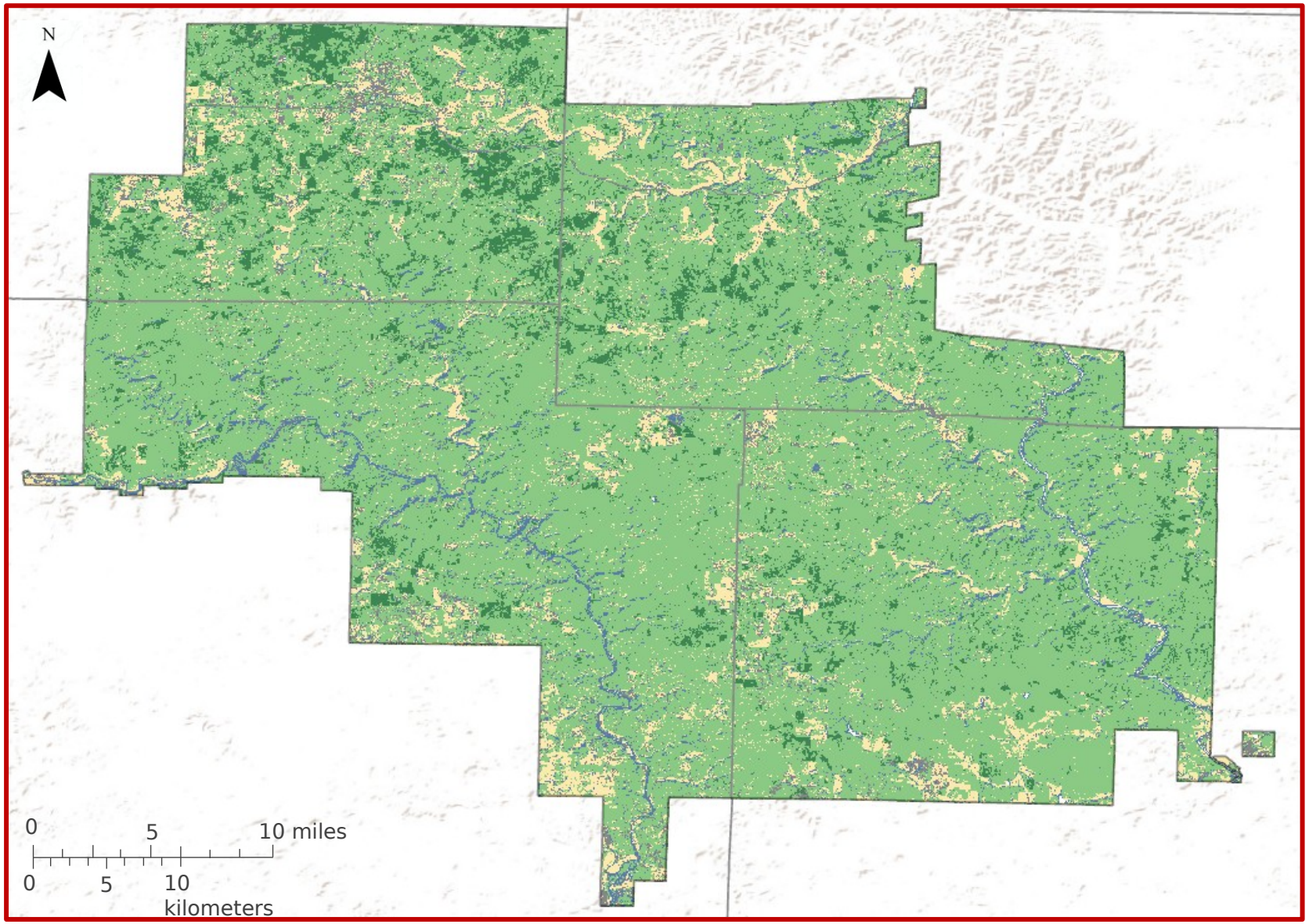


Results and Conclusions

Eleven Point Ranger District:

2019 Land Cover Classification

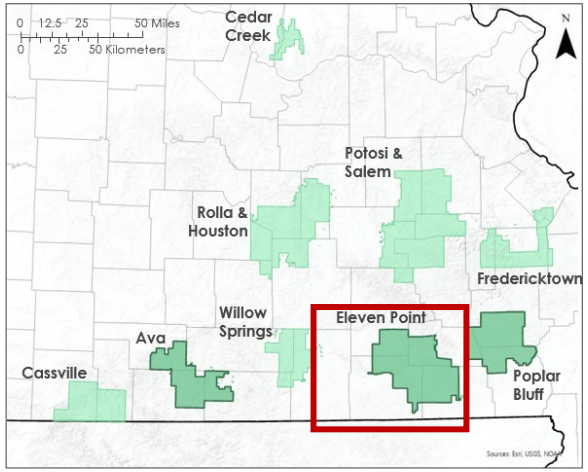


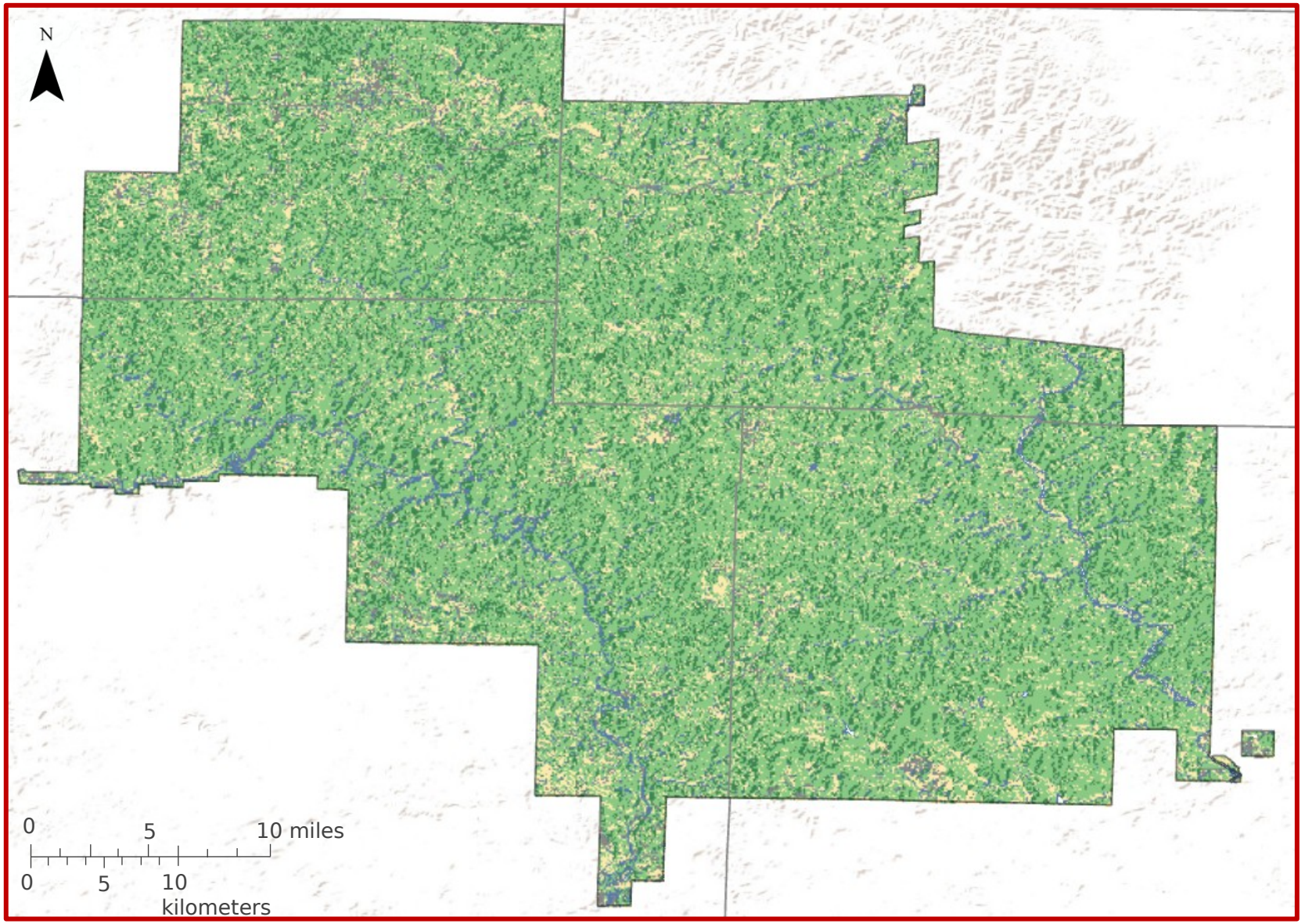


Results and Conclusions

Eleven Point Ranger District:

2040 Land Cover Forecast

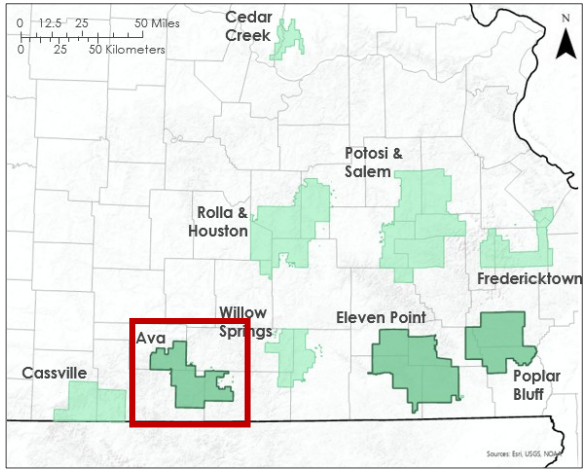


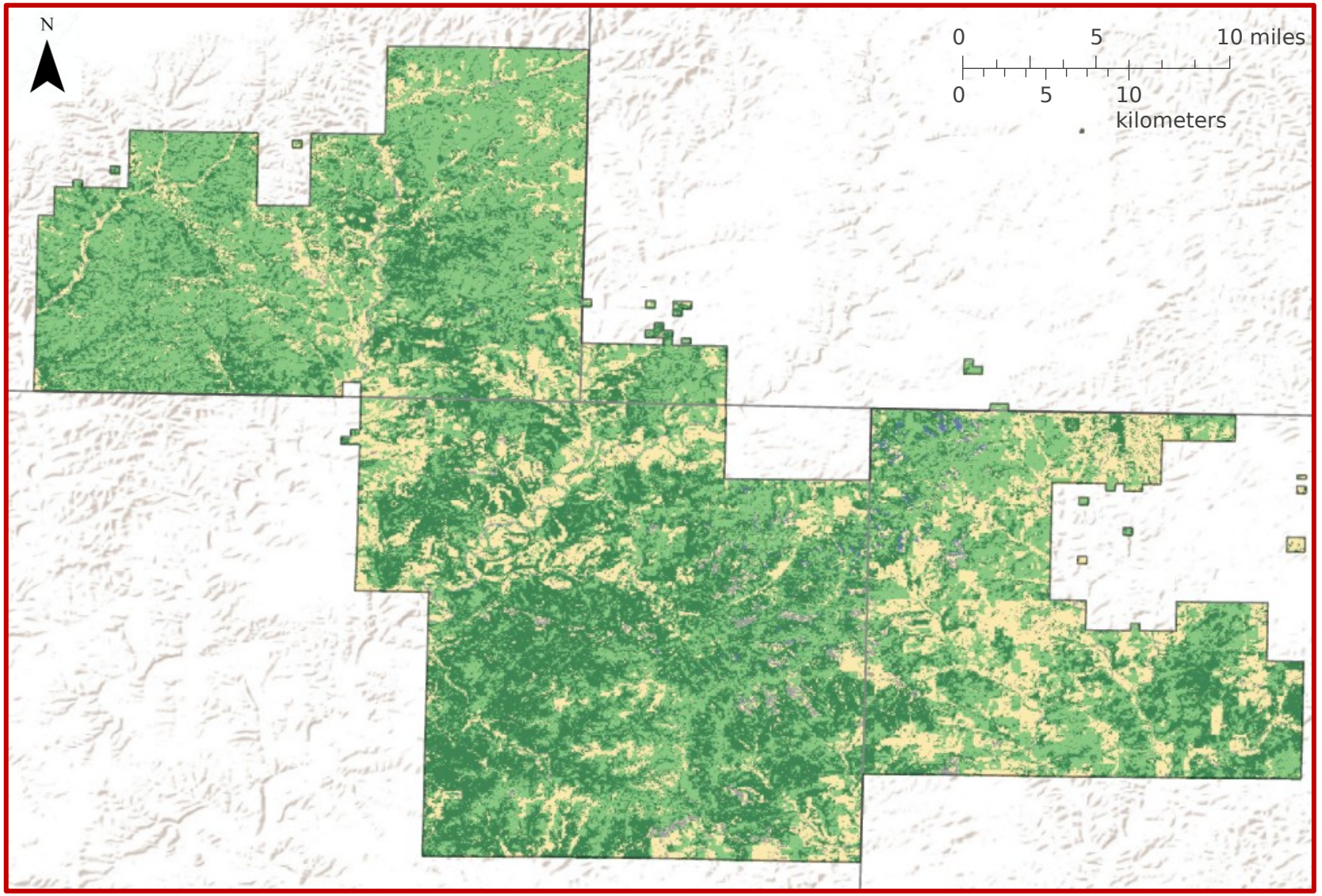


Results and Conclusions

Ava Ranger District:

1986 Land Cover Classification

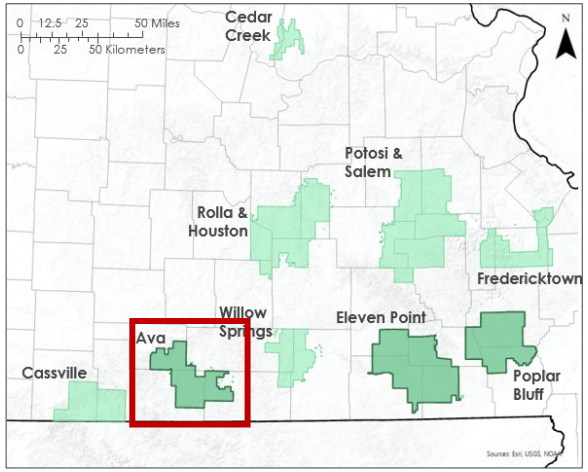


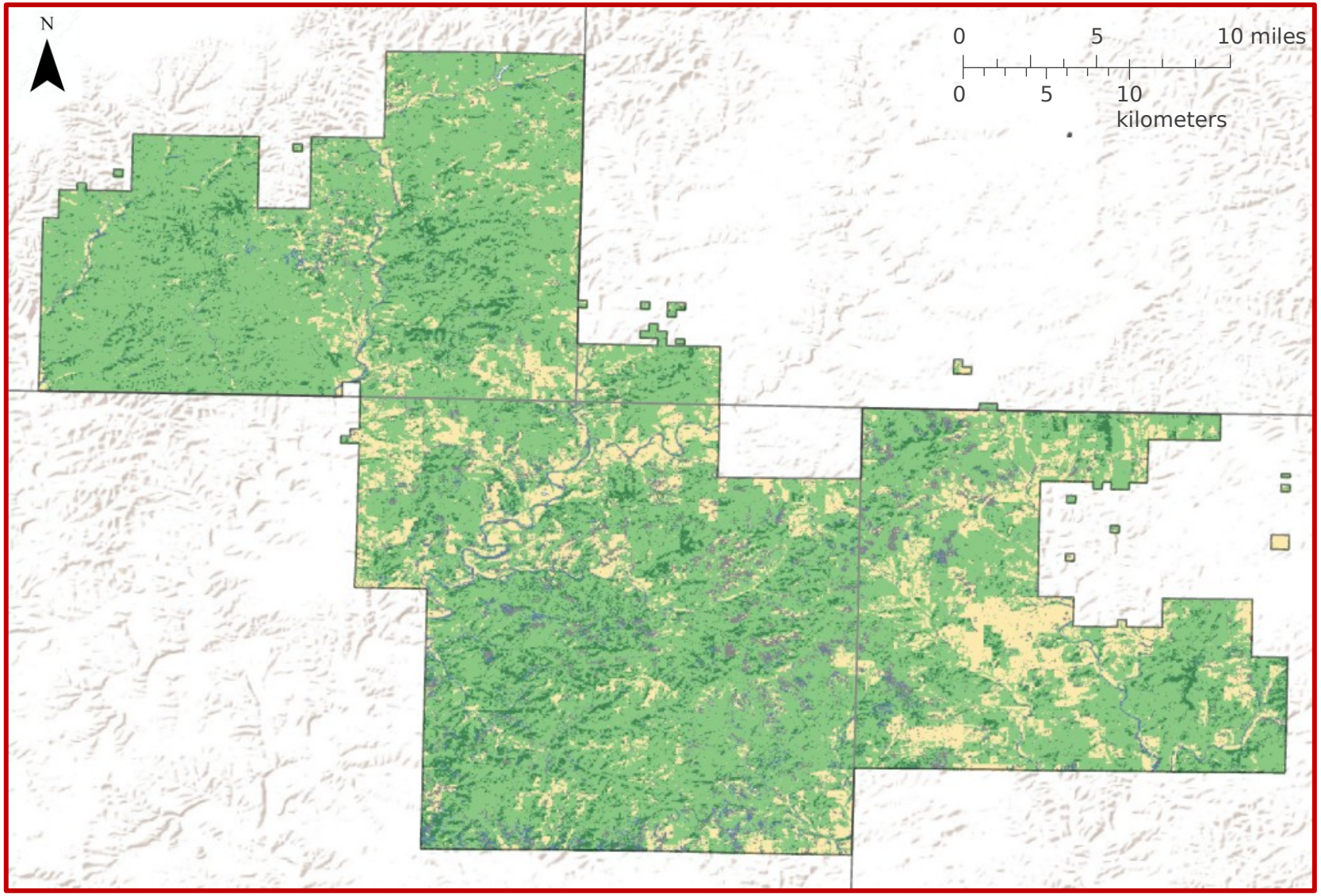


Results and Conclusions

Ava Ranger District:

2019 Land Cover Classification

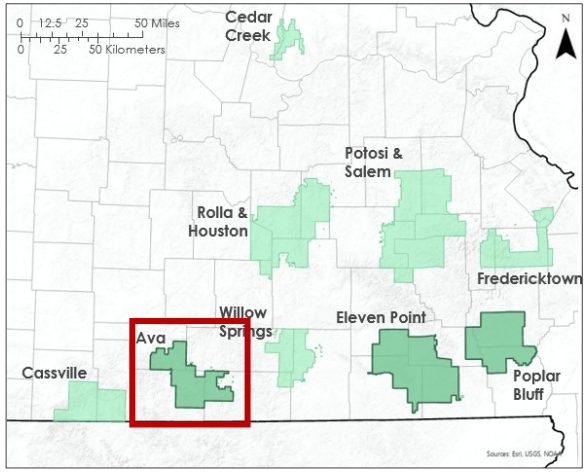


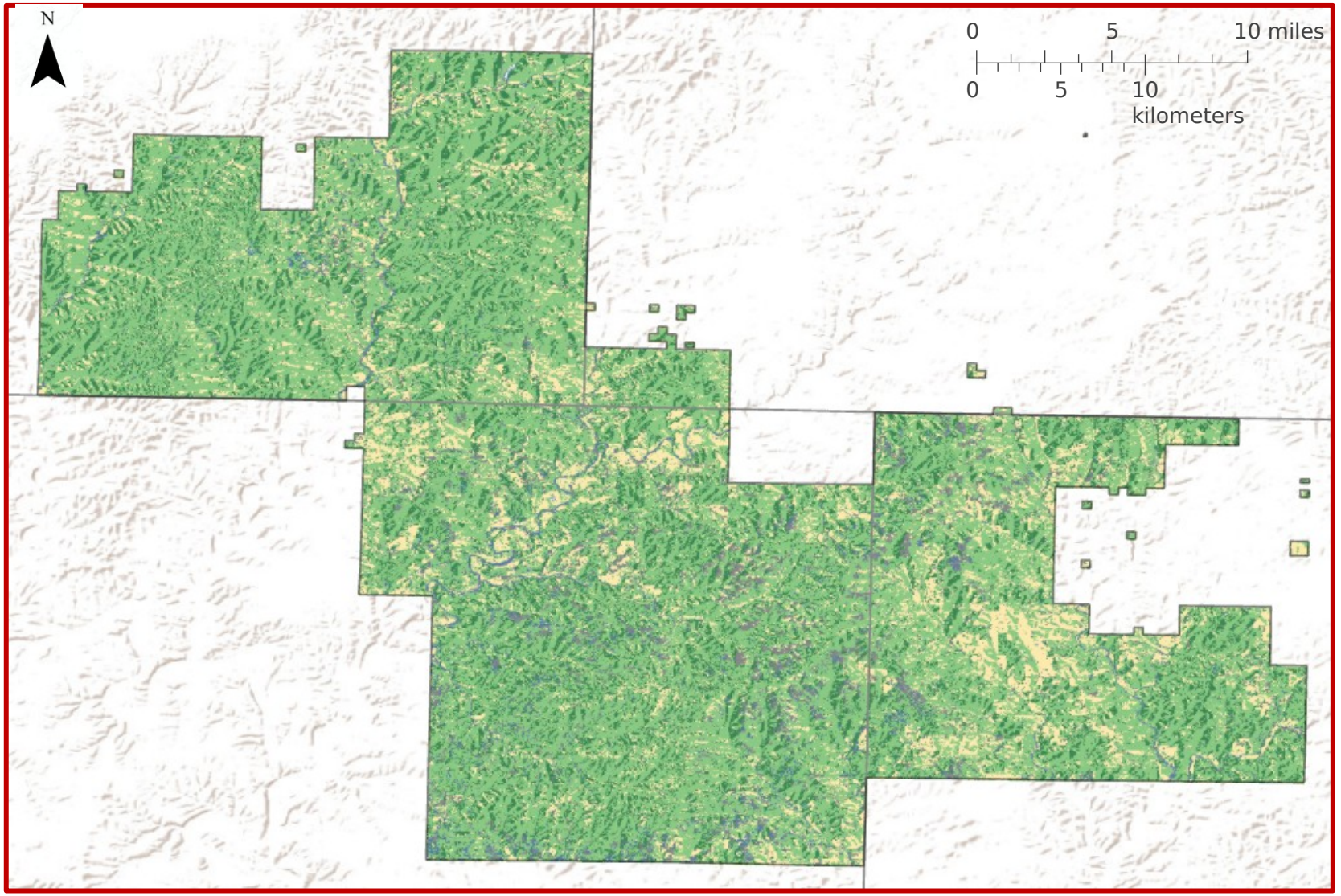


Results and Conclusions

Ava Ranger District:

2040 Land Cover Forecast



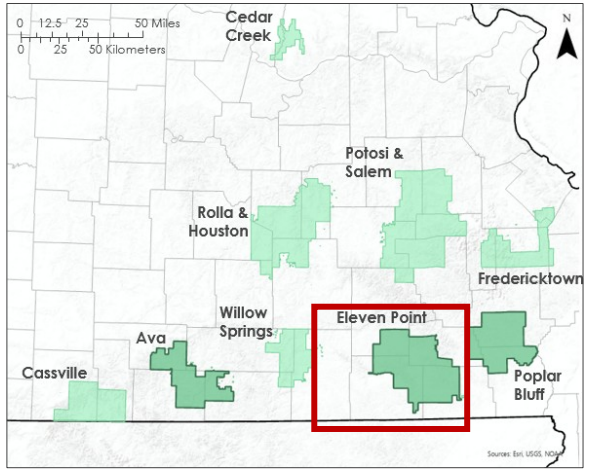


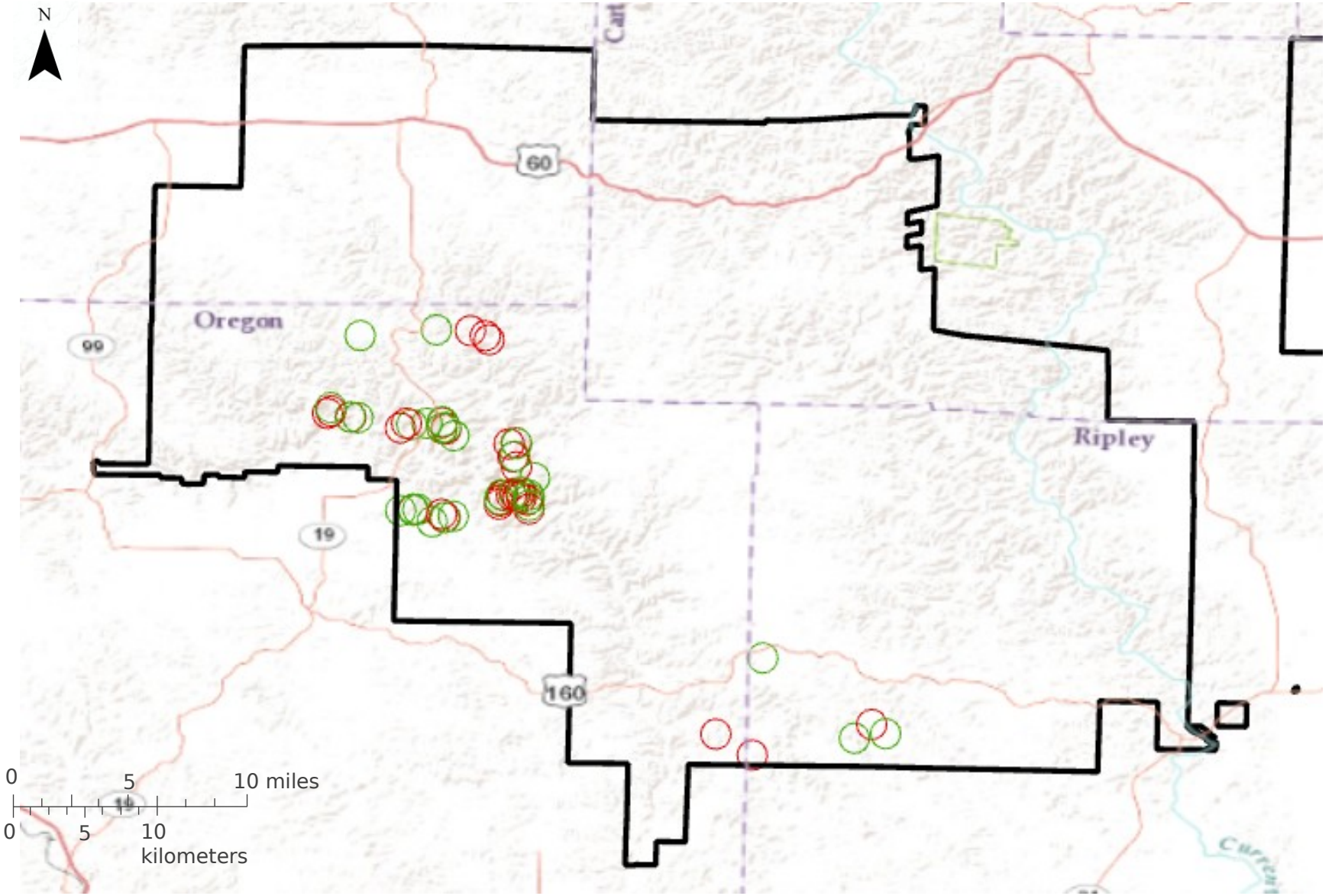
Results and Conclusions

Species Modeling

In-Situ data:

Shortleaf Pine & Eastern Red Cedar ground-truthed data

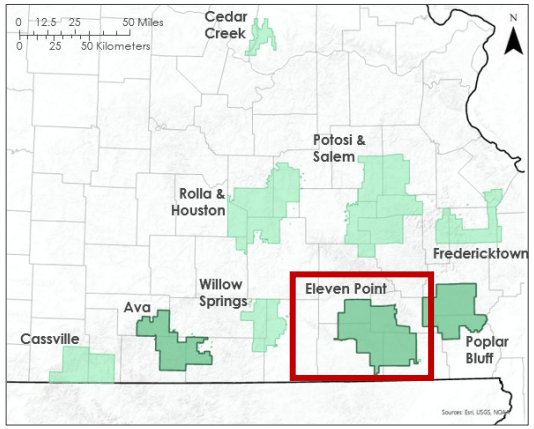


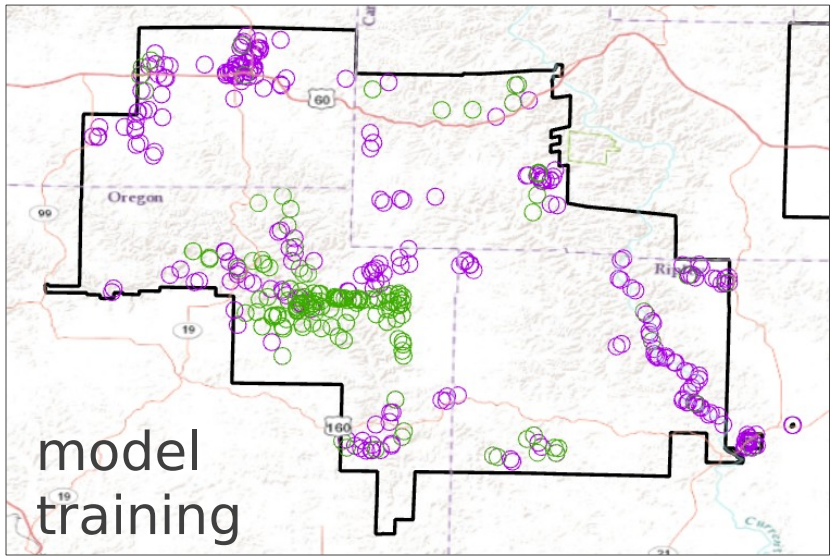


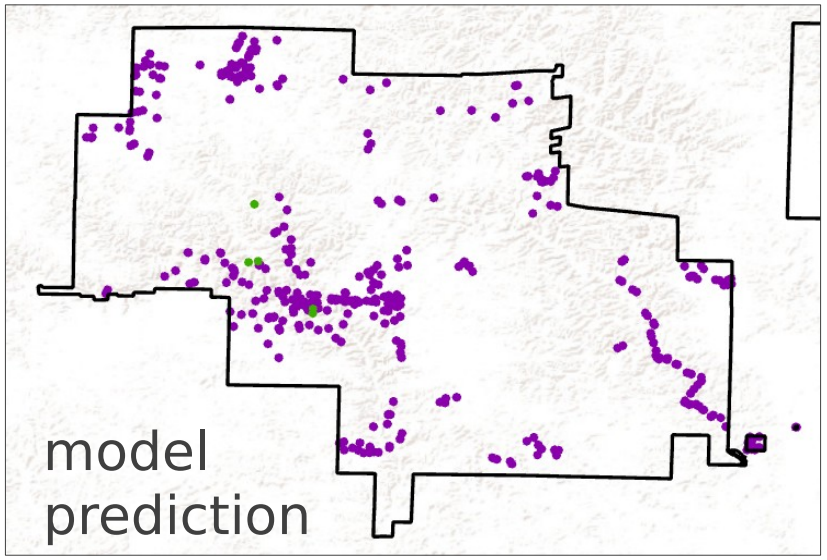
Results and Conclusions

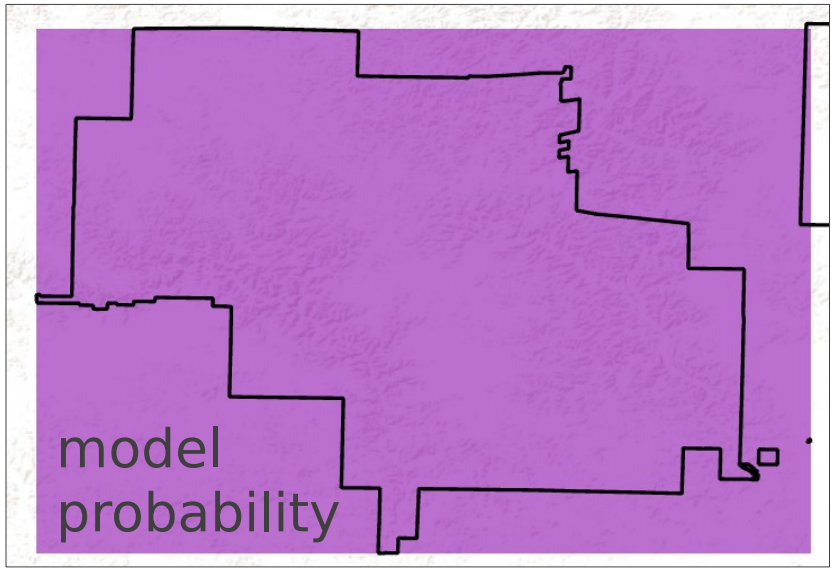
Shortleaf Pine Species Modeling

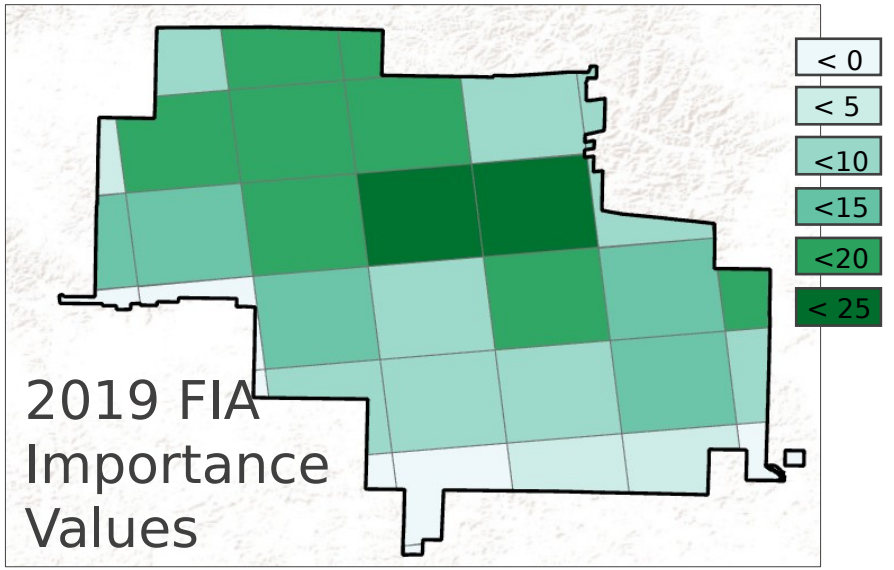
- Not present, training
- Not present, modeling
- Pine present, training
- Pine present, modeling









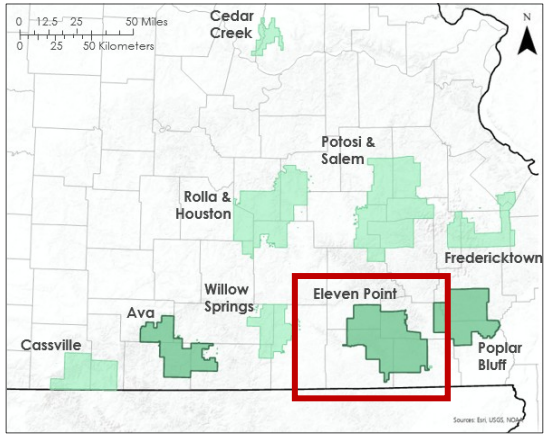


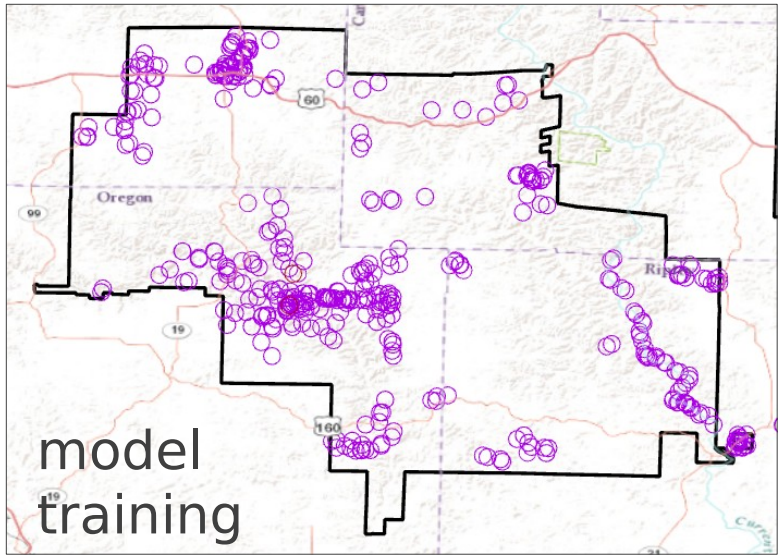
0 10 miles
0 10 kilometers
N

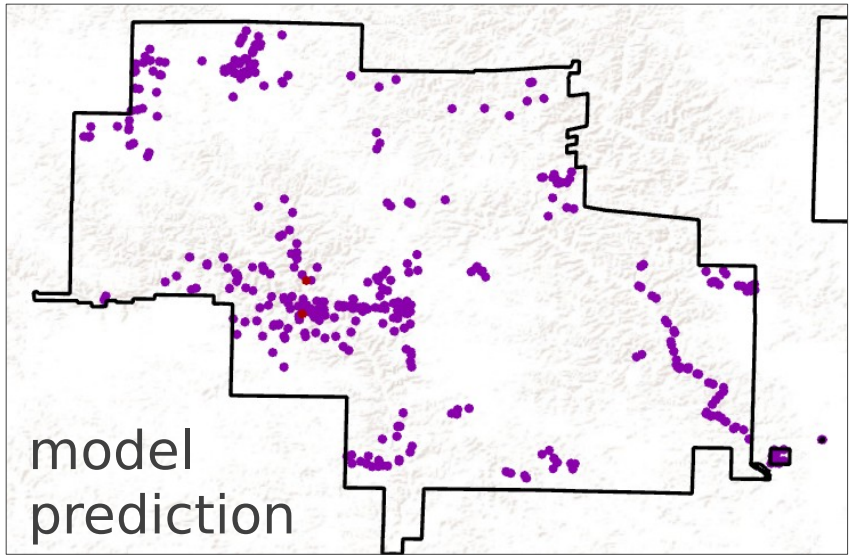
Results and Conclusions

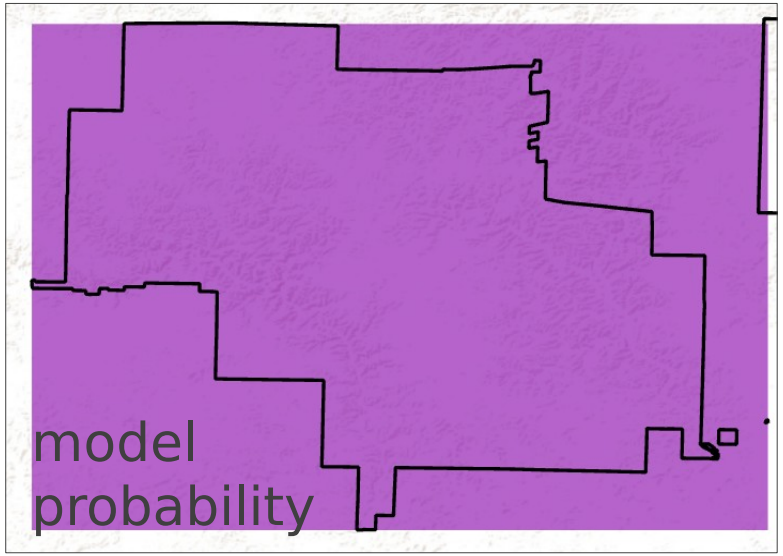
Eastern Red Cedar Species Modeling

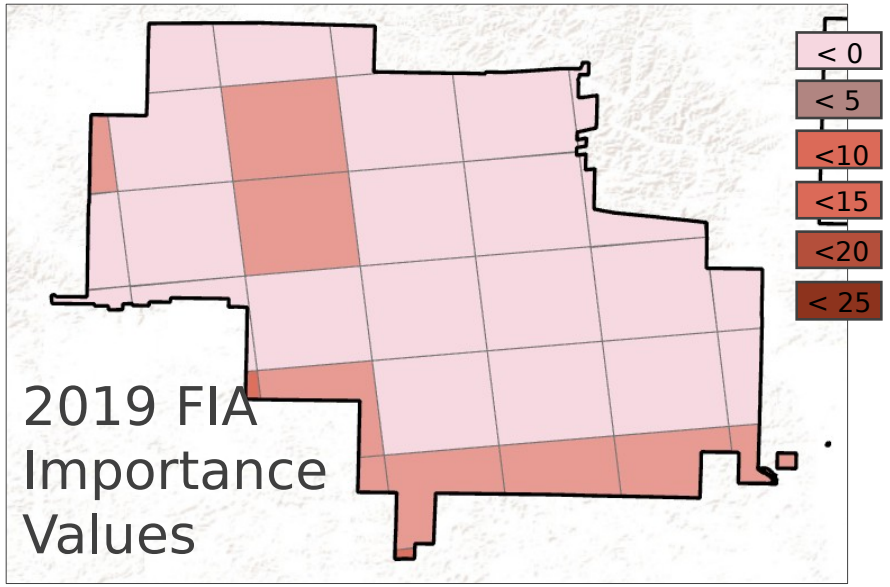
- Not present, training
- Not present, modeling
- Cedar present, training
- Cedar present, modeling





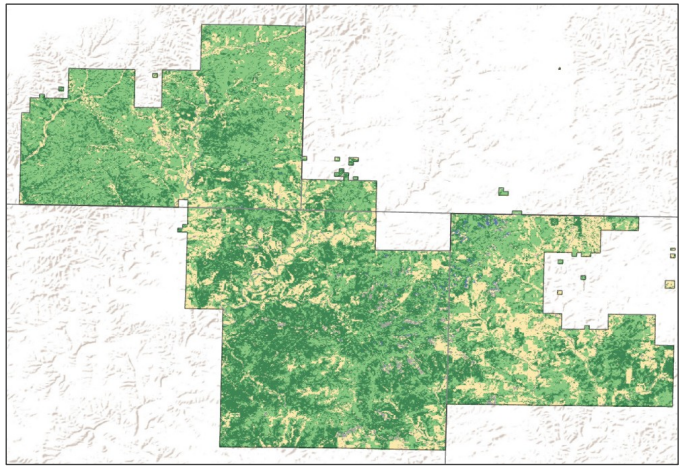


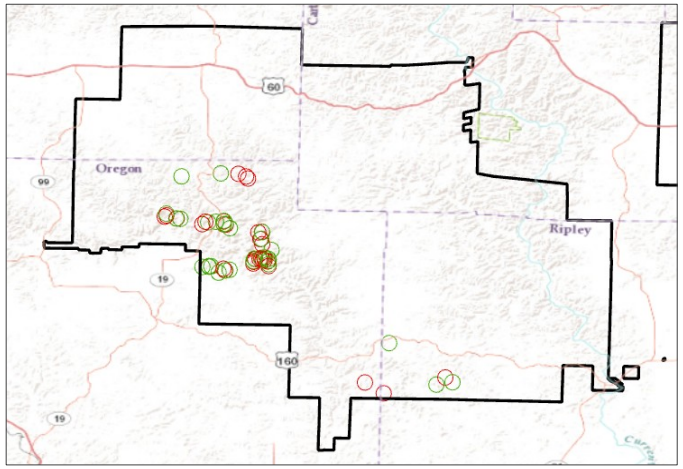




0 10 miles
0 10 kilometers
N

Results and Conclusions

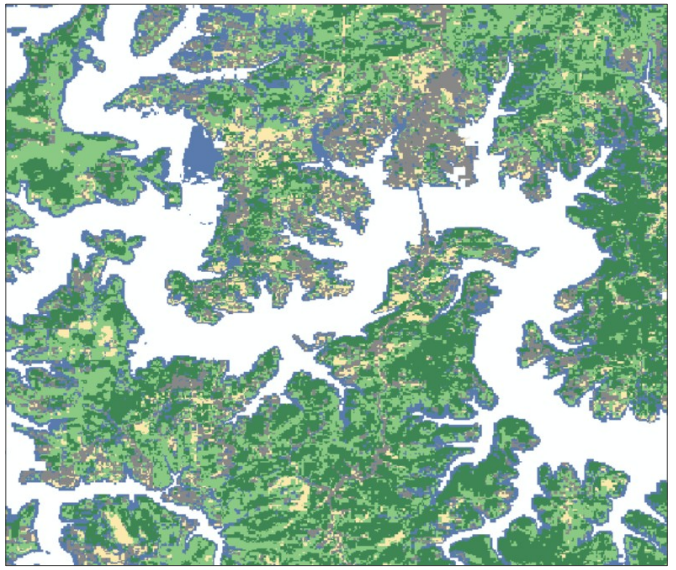




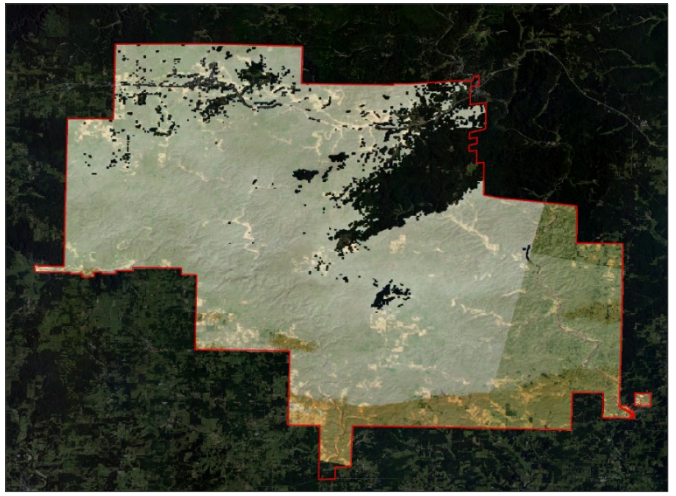
- Between 1986 and 2019
  - Loss of conifer forest and meadow/grasslands
  - Increase in hardwood deciduous
  - Greatest class conversion was from conifer/grassland to deciduous
  - Increase in water cover (2019 record floods)
- 2040 Forecast
  - Current management practices could promote conifer forest and meadow/grassland revival
- More data is needed for stronger prediction models, especially species-level statistics

Errors and Uncertainties

- Training & validation data
  - In-situ data not usable for species distribution
  - Water and developed land cover training points impacted by snow mask
- Landsat
  - Coarse spatial resolution hides detail
  - Large study area means we dealt with different swaths
  - Low image quality made years ineligible



2019 snow mask issues



2016 Imagery concerns

Future Work

- Incorporate high-resolution aerial imagery into classification (NAIP, DOQ)
- Expand number of classes to be identified
- Incorporate disturbances into forecasting model

Image Credits: US Forest Service; Nancy Feakes (USFS); Jeff Hamm

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