Spatial models of grassland quality and risk of conversion for evaluating CRP enrollment

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HAPET
Habitat And Population Evaluation Team

Prairie Pothole
JOINT VENTURE

USDA FSA
FARM SERVICE AGENCY

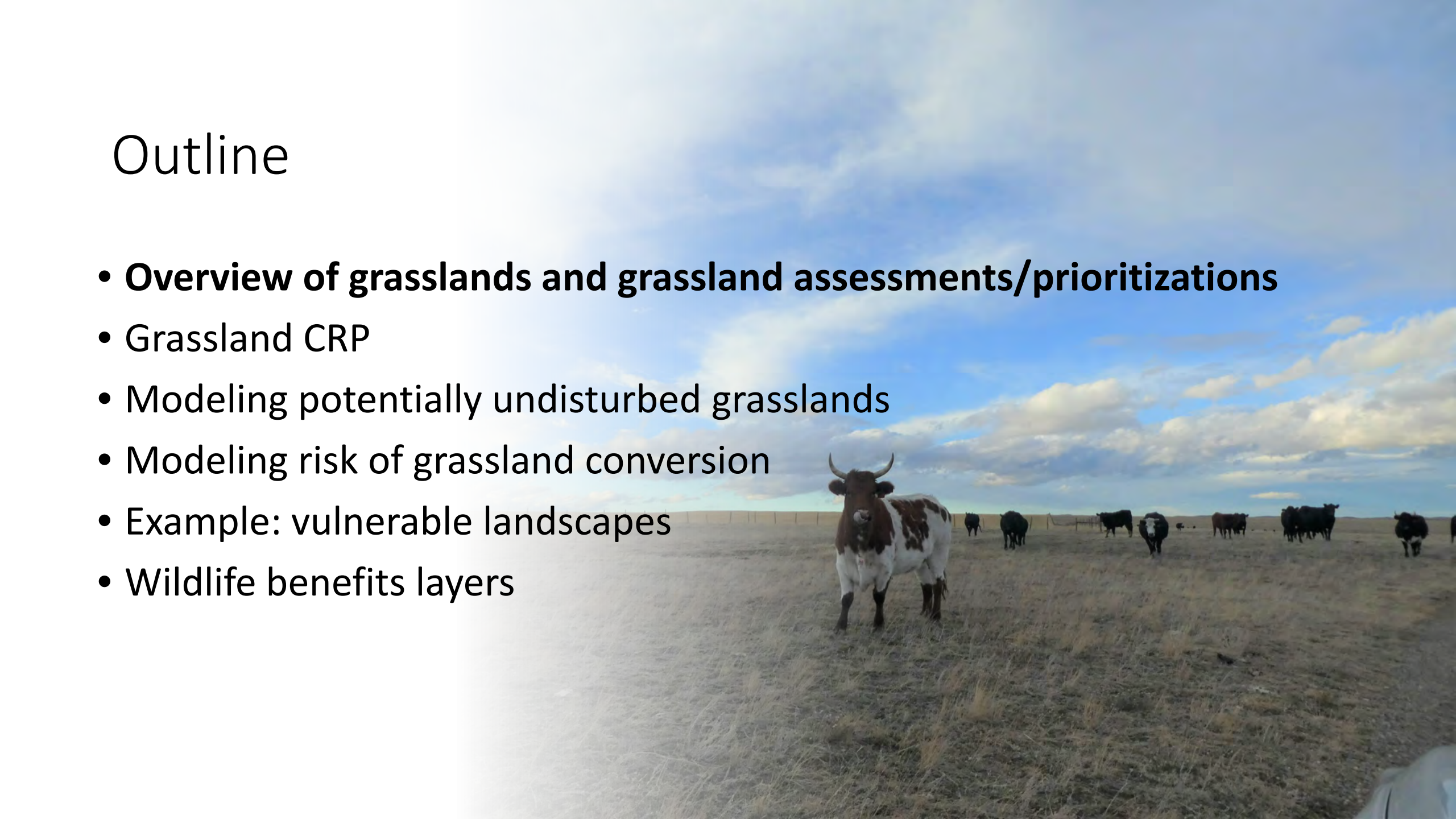
Photo credit: Rick Bohn

We Thank The Many Partners Who Have Supported These Efforts

Agreement # FBC201RA00110561

Outline

- **Overview of grasslands and grassland assessments/prioritizations**
- Grassland CRP
- Modeling potentially undisturbed grasslands
- Modeling risk of grassland conversion
- Example: vulnerable landscapes
- Wildlife benefits layers

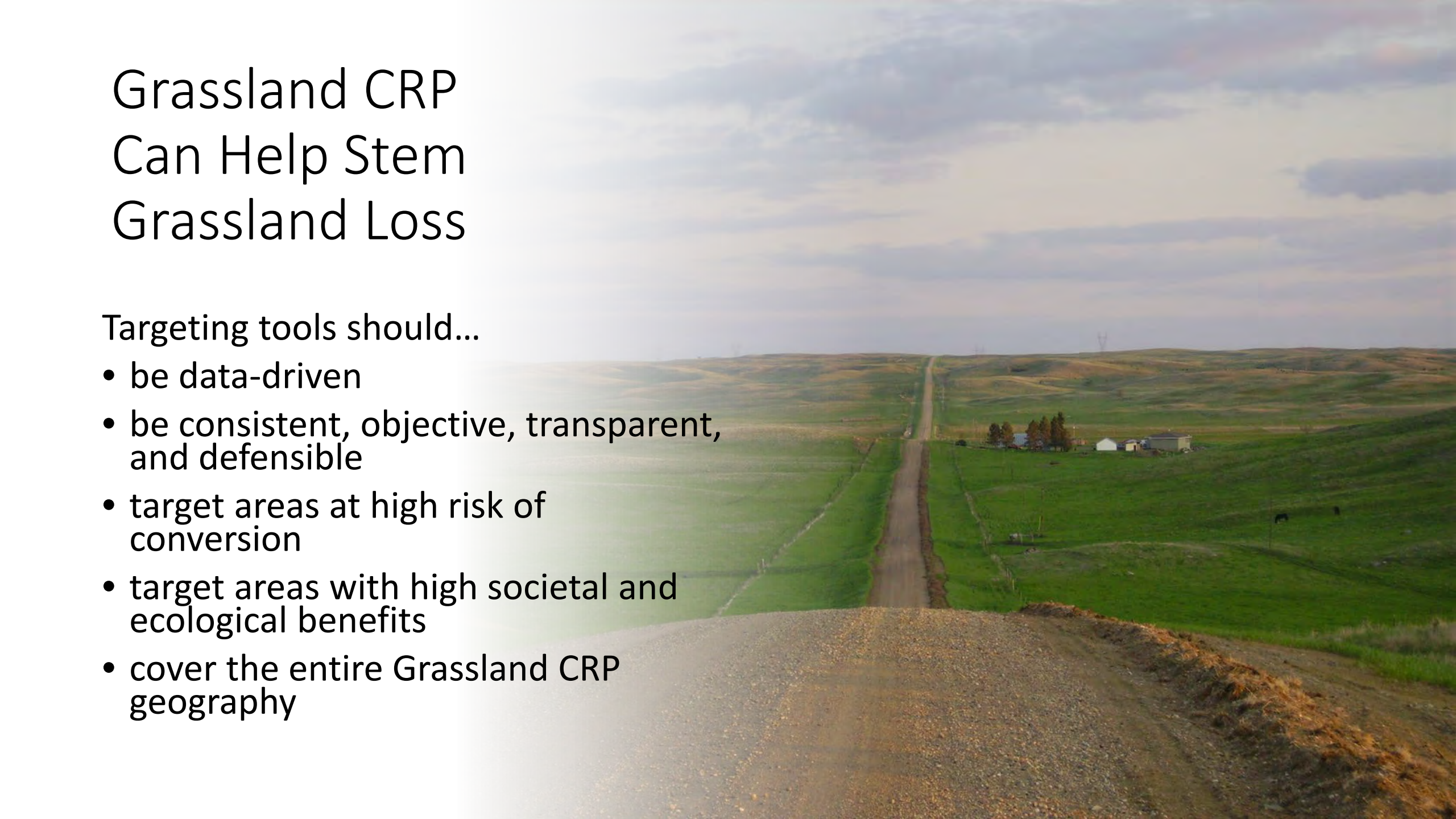


Grasslands Provide Many Societal and Ecological Benefits

- Increased wildlife populations
- Increased pasture availability
- Increased production of flowering crops
- Increased apiary sites
- Increased water infiltration
- Decreased flooding
- Lower agricultural subsidies and price supports
- Decreased soil erosion
- Improved soil health
- Storage and retention of carbon
- Increased water quality
- Increased recreational opportunities
- Increased biodiversity

Ag Intensification and Human Development are the Primary Drivers of Grassland Loss

Grassland CRP Can Help Stem Grassland Loss



Targeting tools should…

- be data-driven
- be consistent, objective, transparent, and defensible
- target areas at high risk of conversion
- target areas with high societal and ecological benefits
- cover the entire Grassland CRP geography

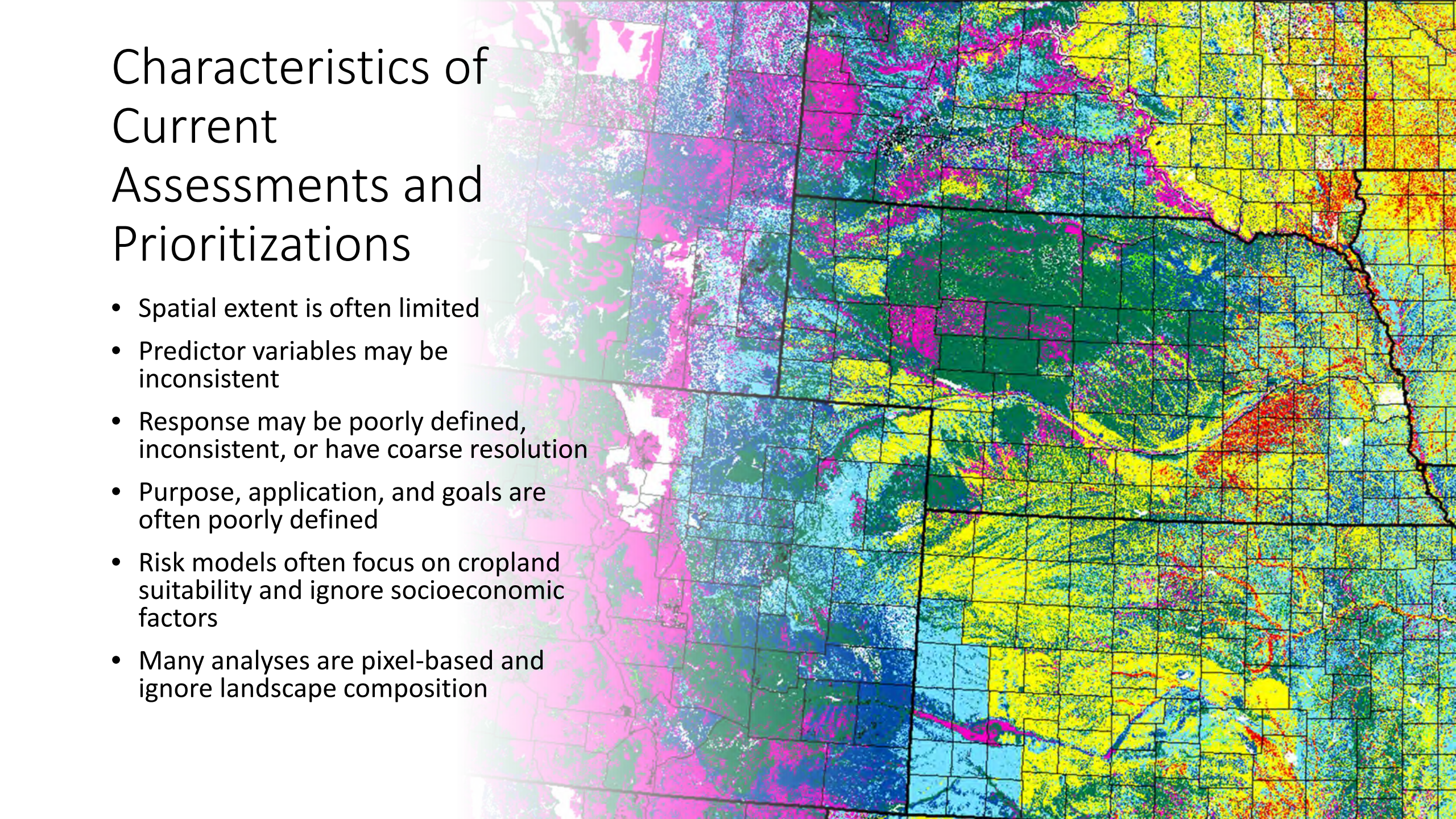
Current Assessments and Prioritizations

- Criteria include cores (multiple types), anchor grasslands, measures of intactness, amount of grass in the landscape, patch size, socioeconomic functionality, ecological functionality, homogeneity, conversion risk, woody encroachment risk, vegetation representation, biodiversity, etc.
- Some prioritizations mix criteria or identify no explicit criteria

Sample and Mossman (1997), Coppedge et al. (2001), Reynolds et al. (2006), Haufler and Vodehnal (2007), Wilsey et al. (2016), Niemuth et al. (2017), Comer et al. (2018), Olimb and Robinson (2019), Uden et al. (2019), Juarena et al. (2021), Nunes et al. (2021), Niemuth et al. (2022), Roberts et al. (2022), Tack et al. (2023)

Characteristics of Current Assessments and Prioritizations

- Spatial extent is often limited
- Predictor variables may be inconsistent
- Response may be poorly defined, inconsistent, or have coarse resolution
- Purpose, application, and goals are often poorly defined
- Risk models often focus on cropland suitability and ignore socioeconomic factors
- Many analyses are pixel-based and ignore landscape composition



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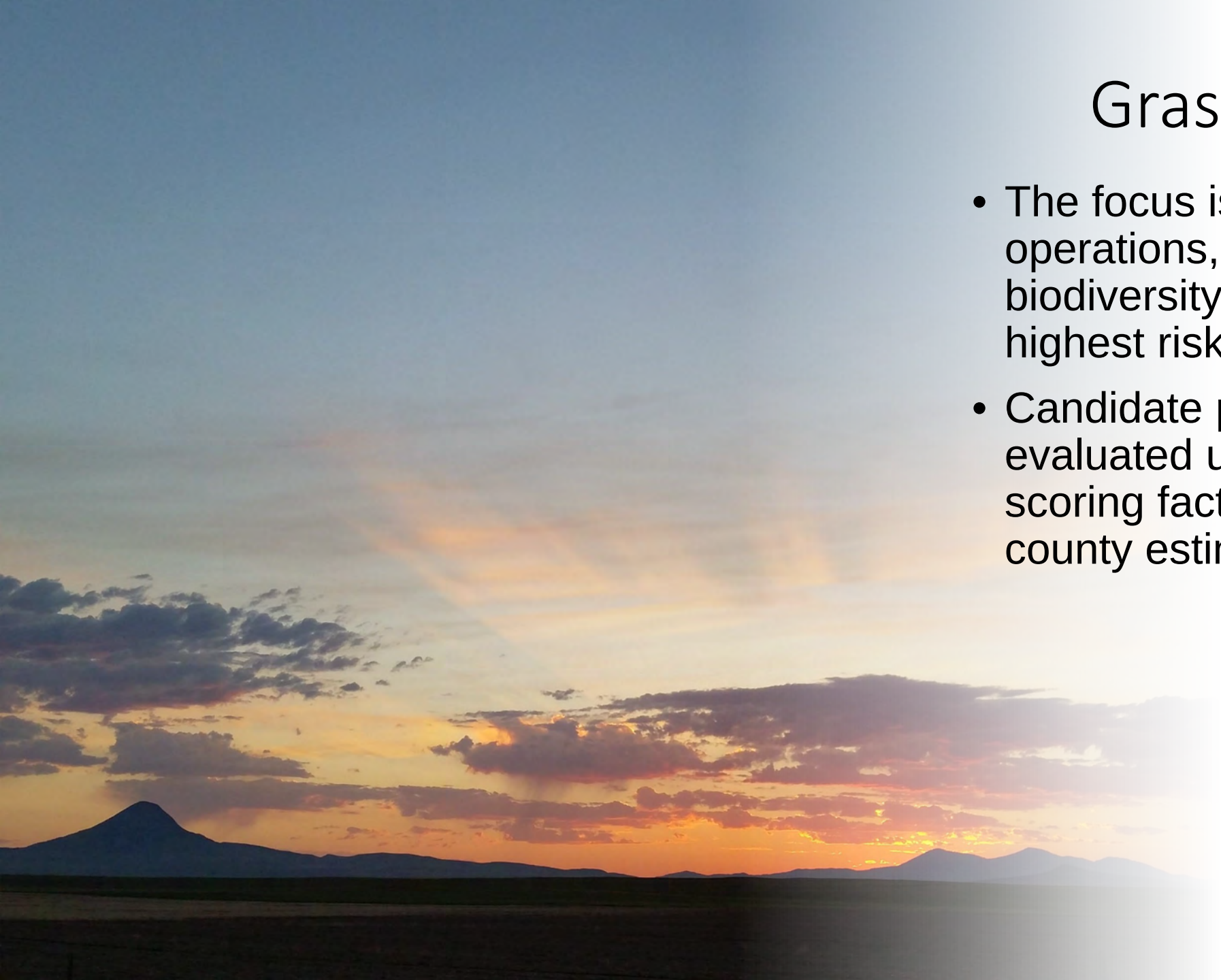

Grassland CRP

- The focus is on supporting grazing operations, plant and animal biodiversity, and grasslands at the highest risk of conversion.
- Candidate parcels are currently evaluated using a ranking index, with scoring factors such as slope and county estimates of % grass.

Grassland CRP

- The focus is on supporting grazing operations and promoting biodiversity in areas of high risk of grassland conversion.
- Candidate parcels are currently evaluated using a ranking index, with scoring factors, such as slope and county estimates of % grass.

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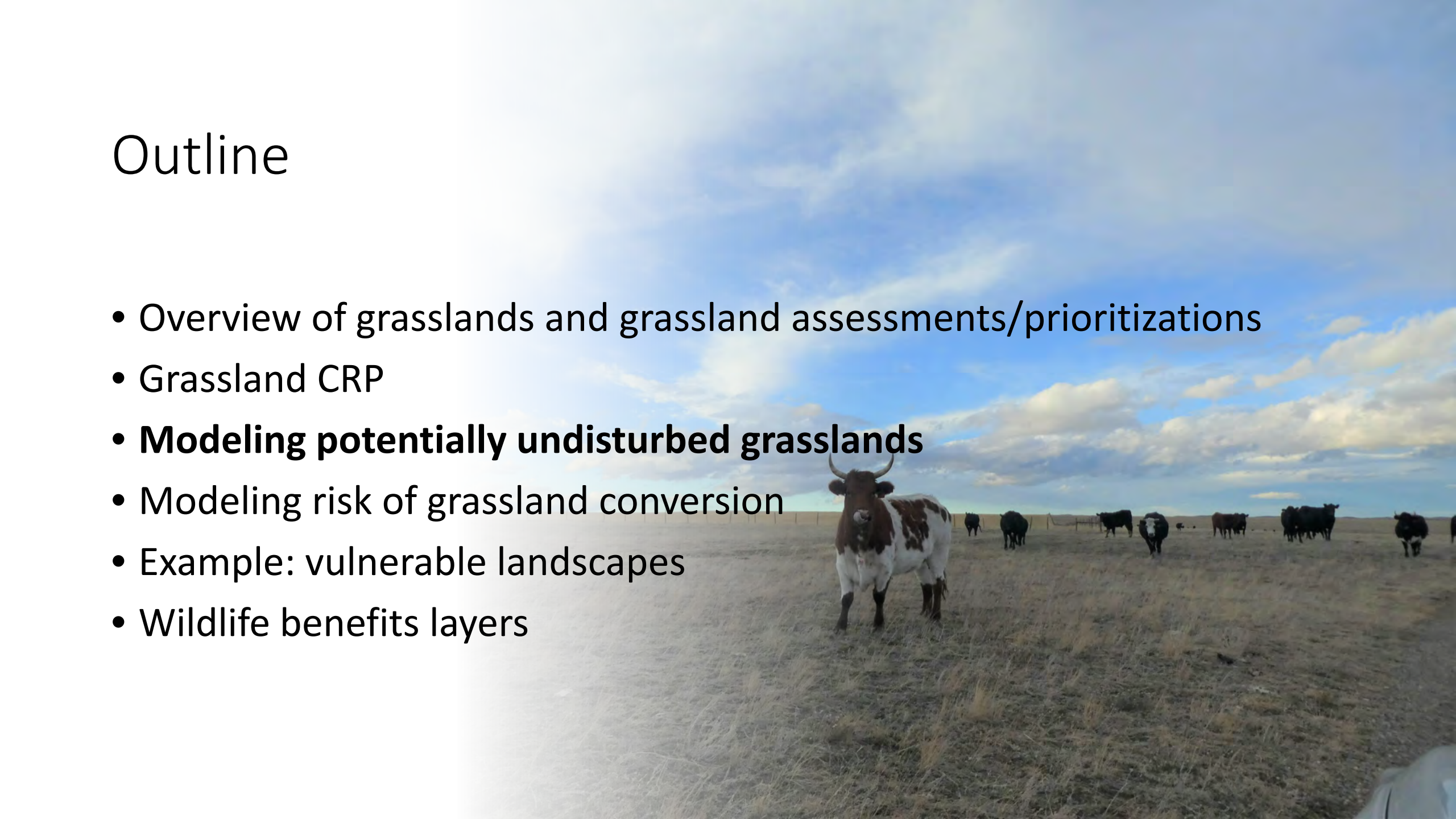
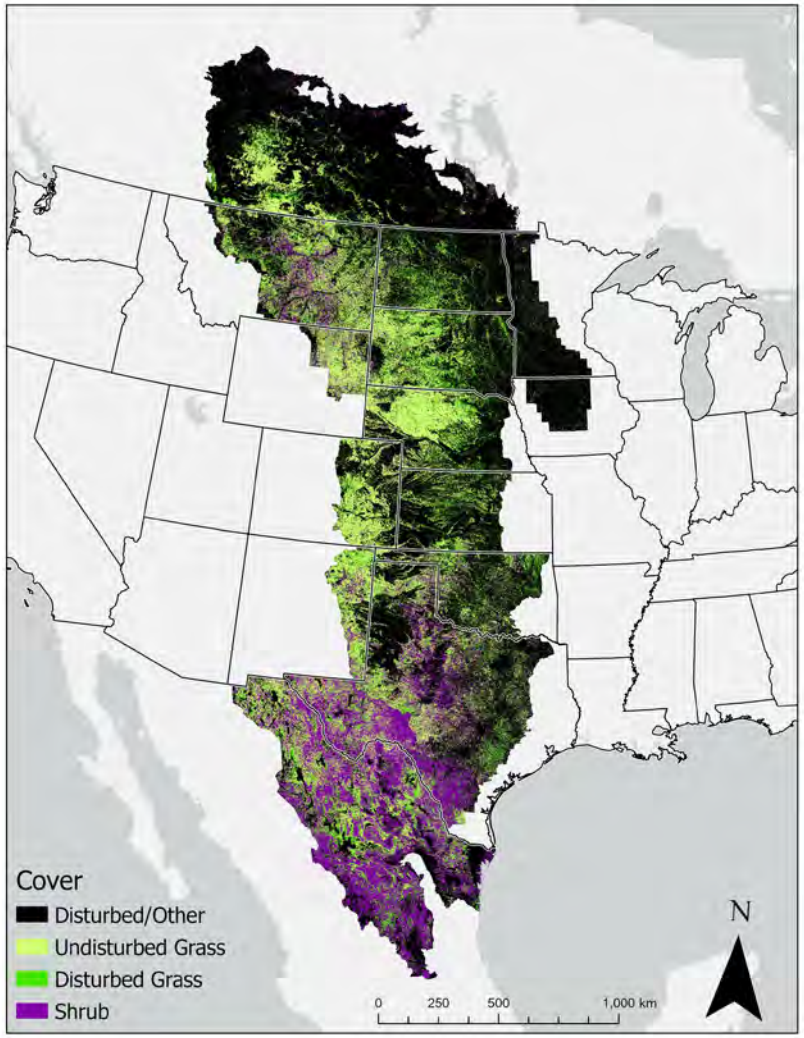


Building on Past Work

- Prairie Pothole Joint Venture Grassland Assessment (Fields and Barnes 2018)
  - Used Farm Service Agency's Common Land Unit data to define potentially undisturbed boundary.
  - Used potentially undisturbed boundary and other spatial data to develop training data for supervised landcover classification.
    - Random Forest classification model at 10m using Sentinel-2 data
    - Undisturbed grass, restored grass, shrub, crop, forest, developed/bare, open water



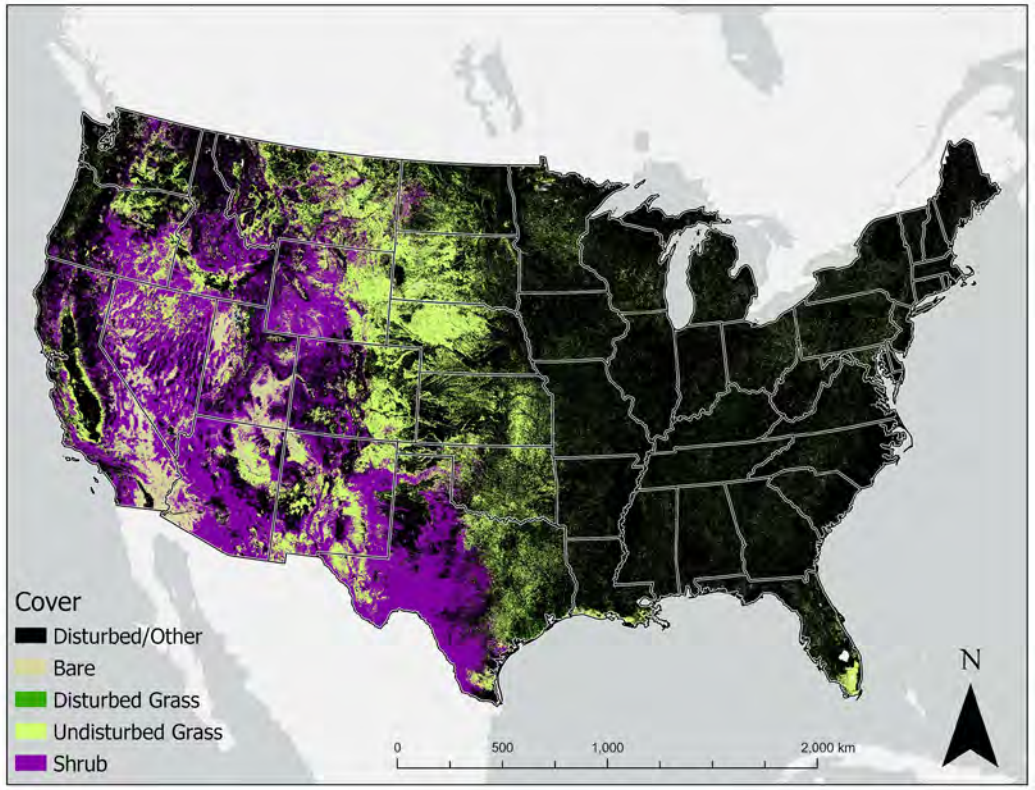
Pros and Cons

- Pros
  - High-resolution output (10 m) of potentially undisturbed grasslands
  - A common resource for conservation planning that spans three countries
- Cons
  - File too big to easily share
  - Does not cover lower 48
  - Developing training data was laborious

- So we built on this concept utilizing a US National Resource Inventory data for training the model and developed models at 90-m.

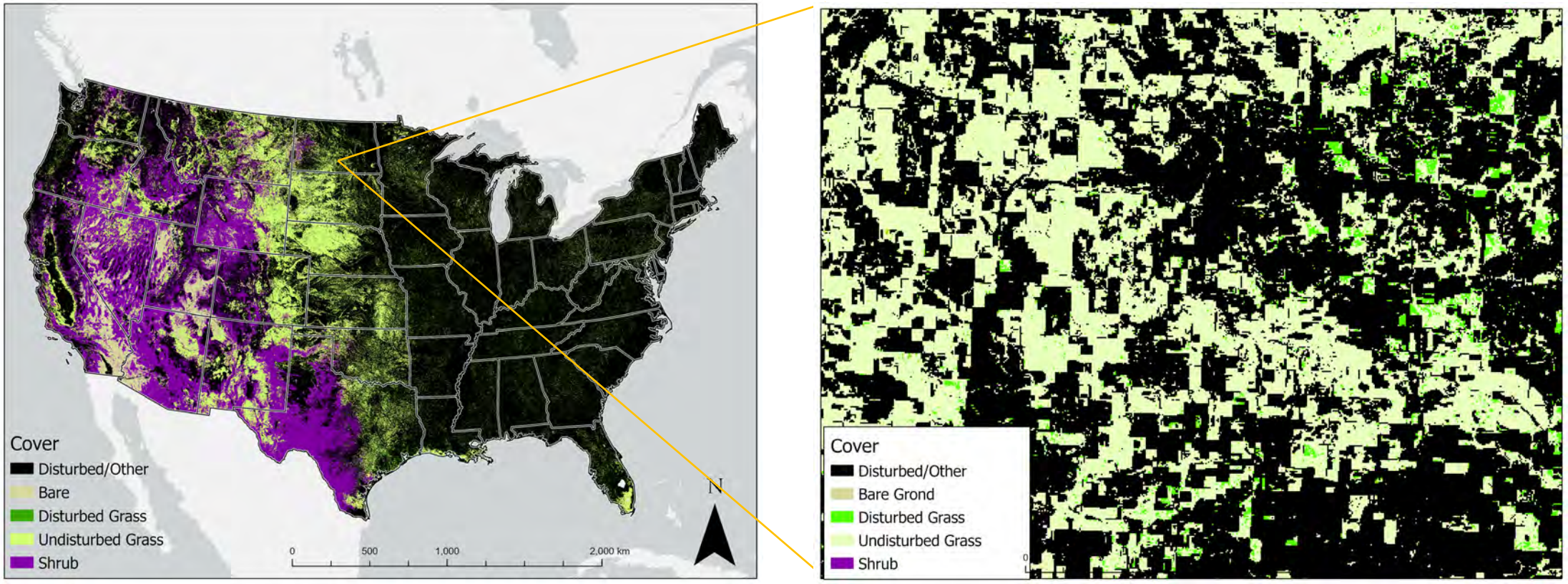
Modeling Potentially Undisturbed Grasslands

- Predictions of potentially undisturbed grass cover
  - Undisturbed grass = not previously cropped, and/or currently crop, developed, forest, or open water



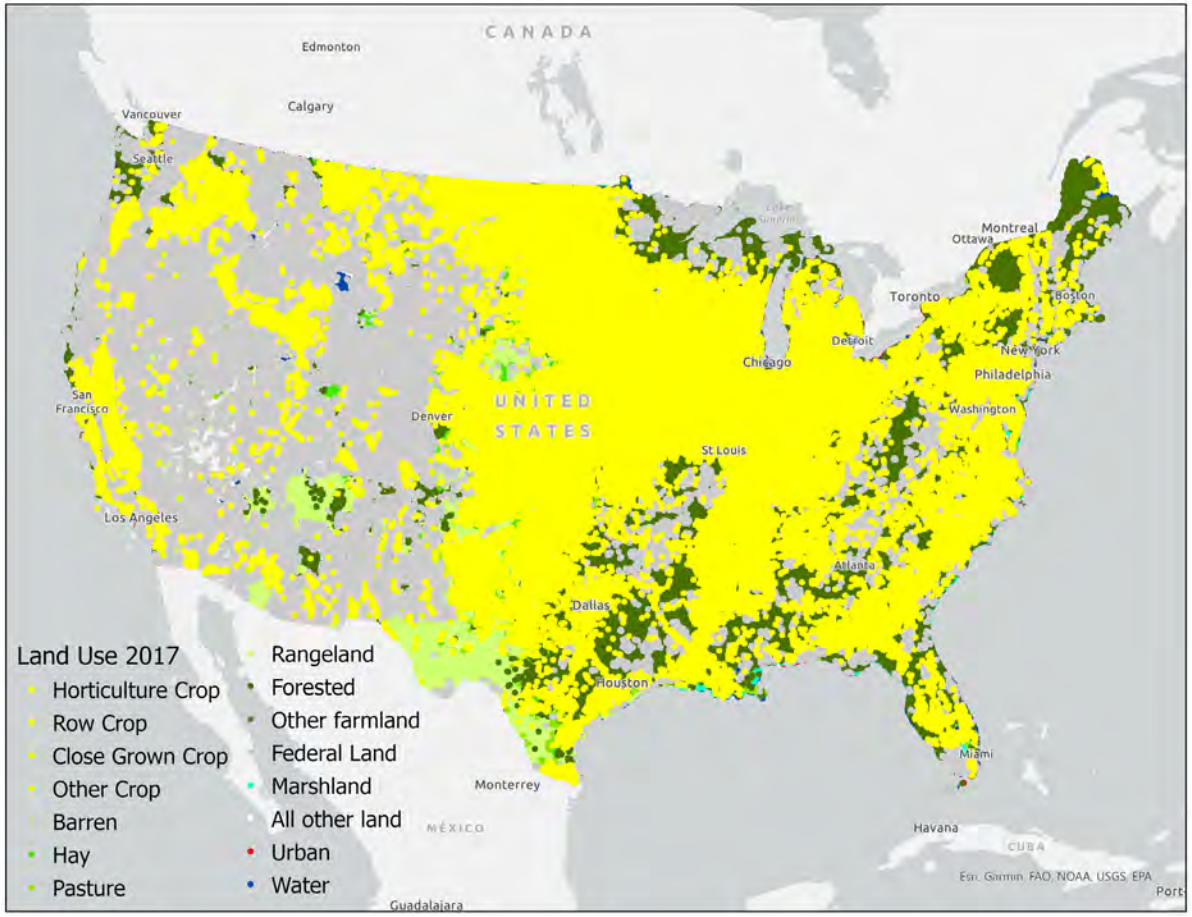
Results

- Predictions of potentially undisturbed grass, restored grass, shrub, bare cover within the potentially undisturbed lands layer.



Methods

- Training data built from…
  - **Proprietary FSA datasets**
    - **National Resource Inventory Dataset**
    - Common Land Unit Dataset
    - Conservation Reserve Program Dataset
  - Supporting datasets
    - 2019 National Land Cover Database
    - 2020 ESA WorldCover
    - 2021 Cropland data layer
    - Shrub layer (>20% cover)
    - Sentinel-2 s2cor water classification
    - OpenStreetMap developed areas



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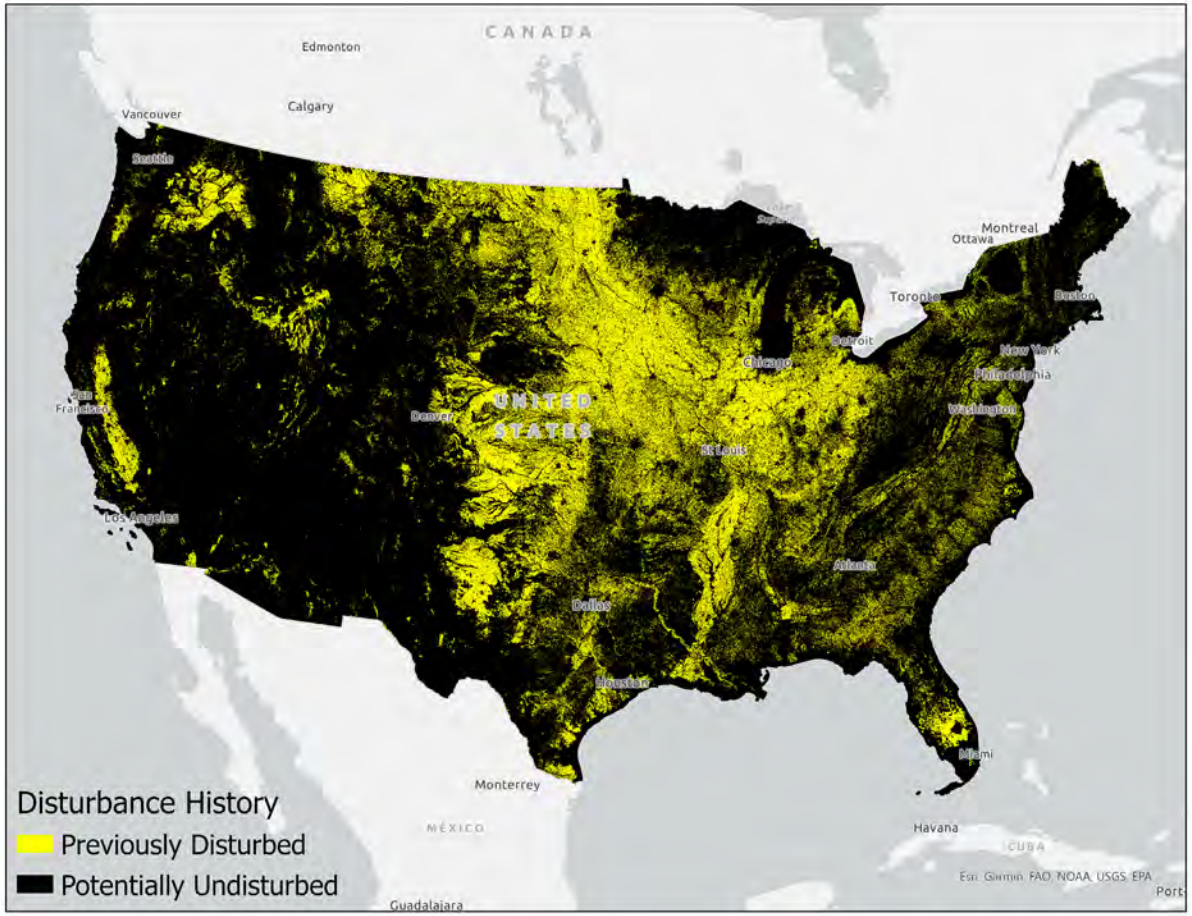

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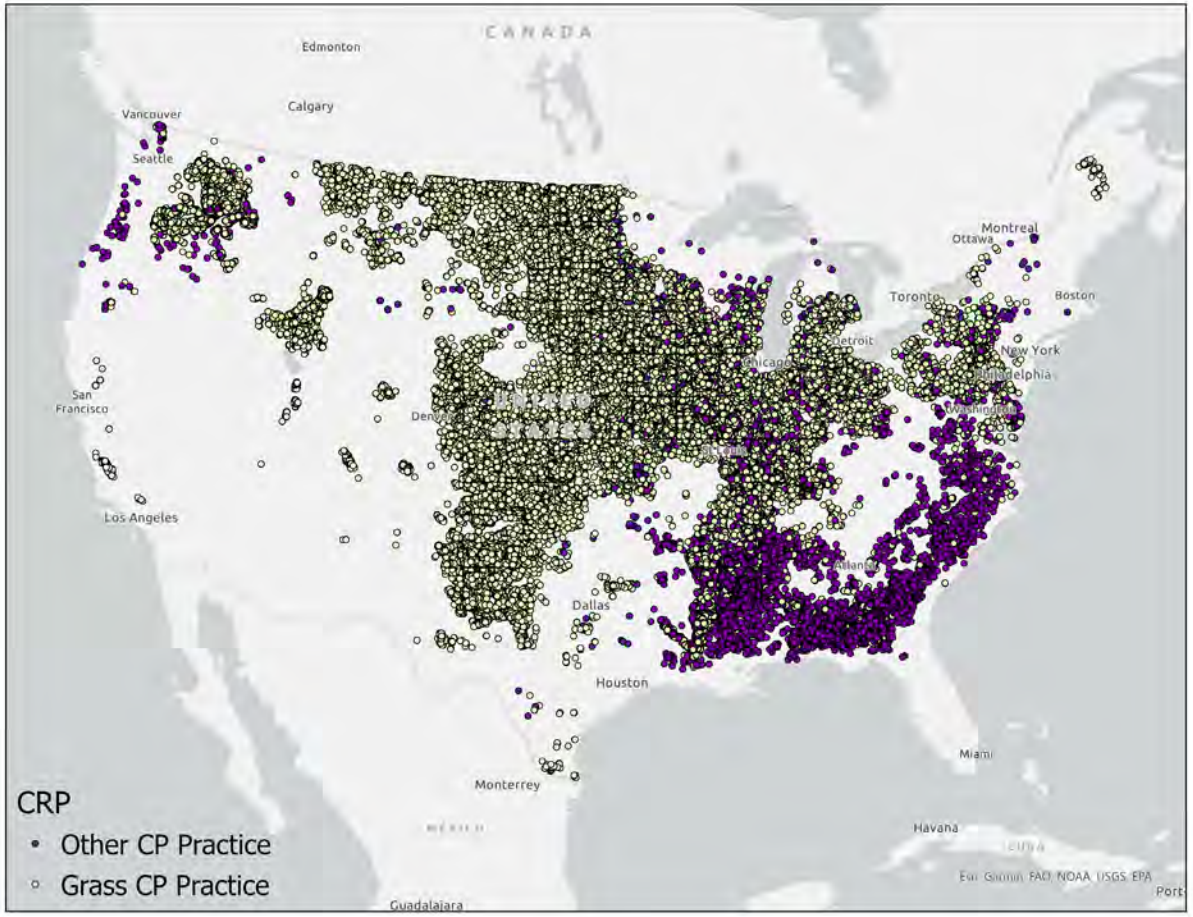

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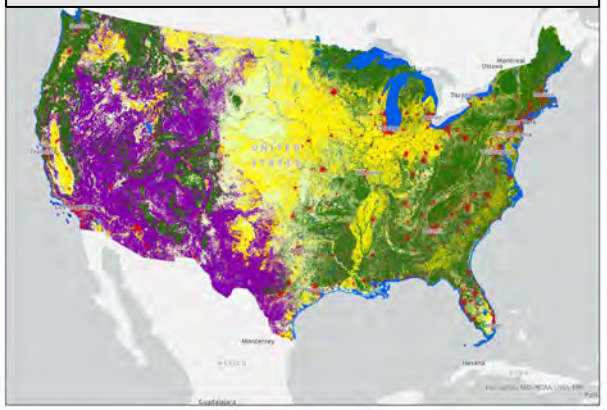
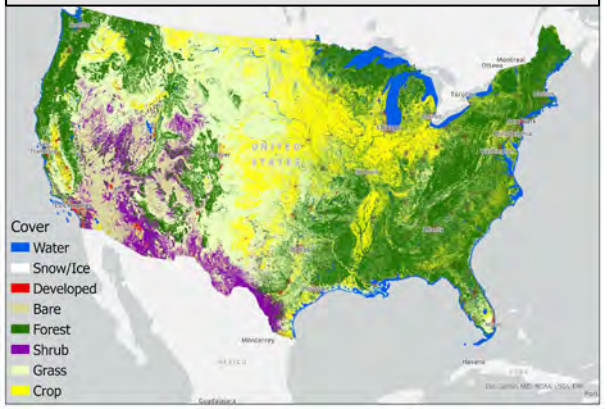
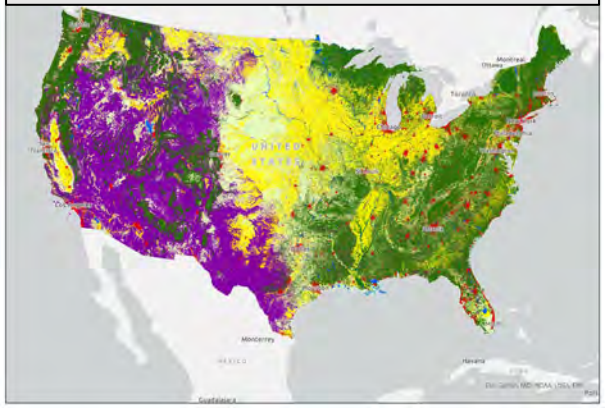
NLCD



ESA



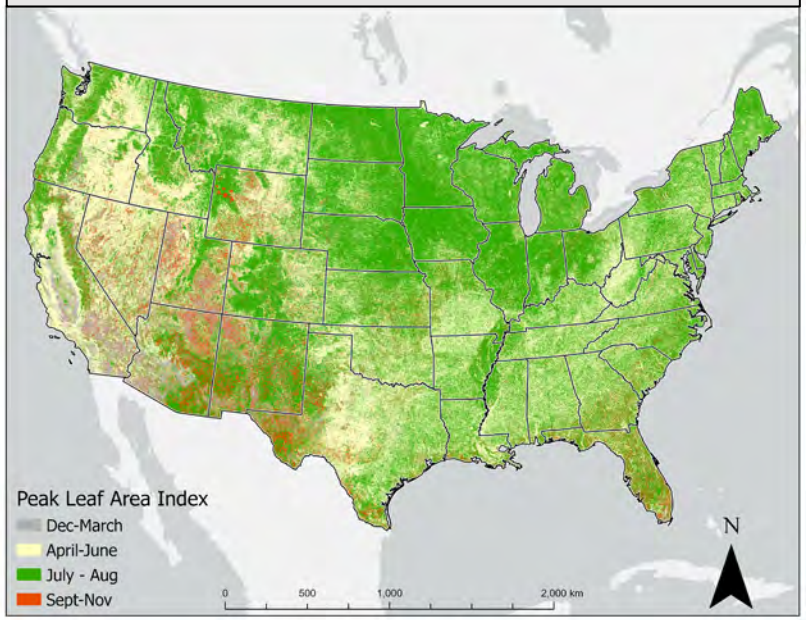
CDL



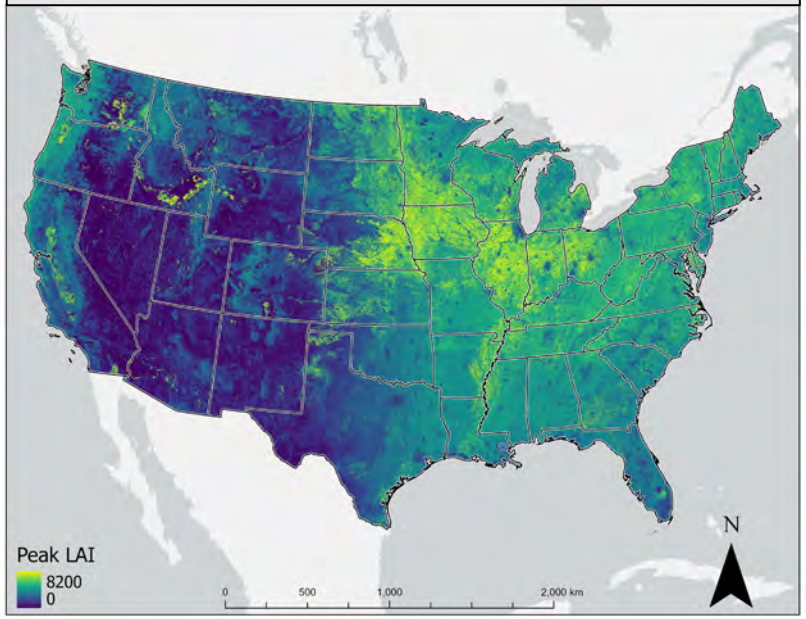
Methods

- Predictor data derived from…
  - Sentinel-2 Surface Reflectance Data (10 m)
    - 2018-2021
    - Seasonal Indices
    - Vegetation Phenology
  - Soils data
  - Topographic data
  - Climatic data

Day of Year Peak LAI

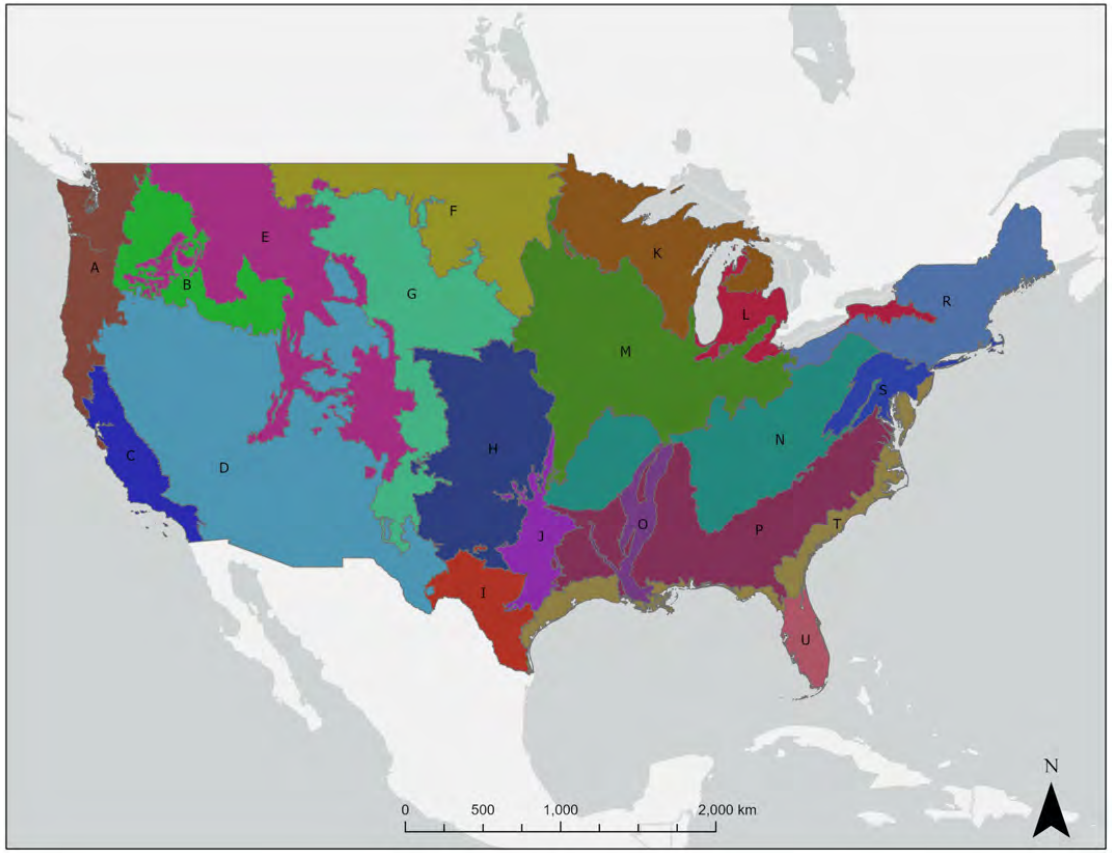


Peak LAI



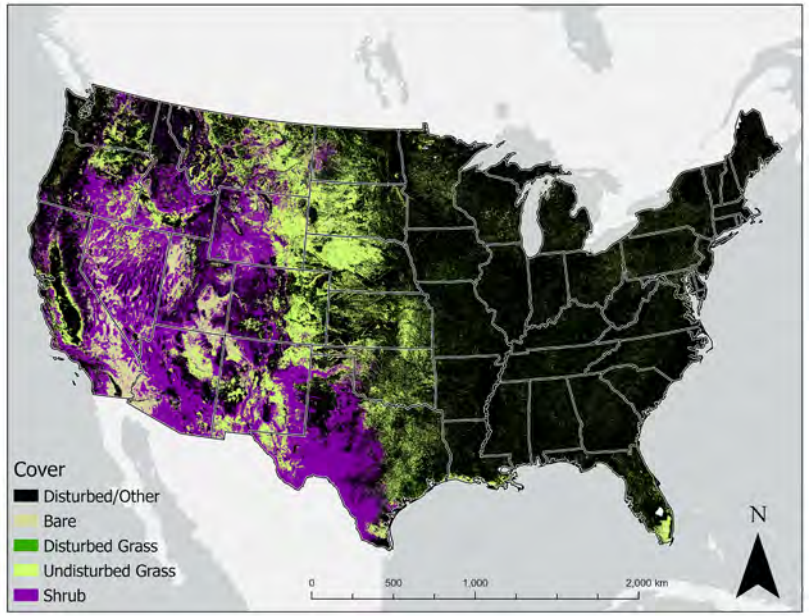
Methods

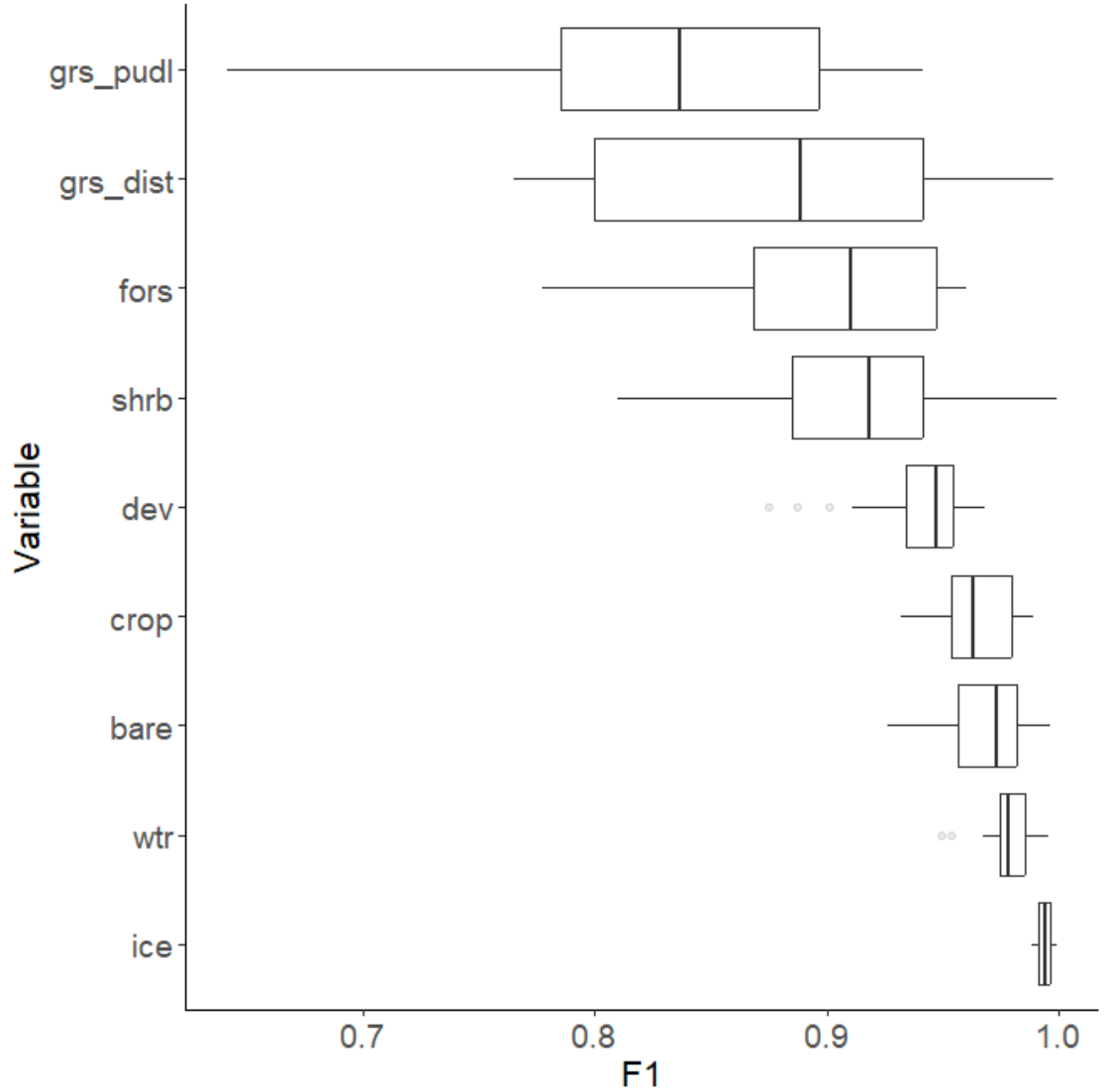
- Model
  - Random Forest Classification Model
    - Developed for MLRA ecoregions



Results

- Overall model performance was good.
  - Mean Kappa = 0.90
  - Mean F1 Score =0.92





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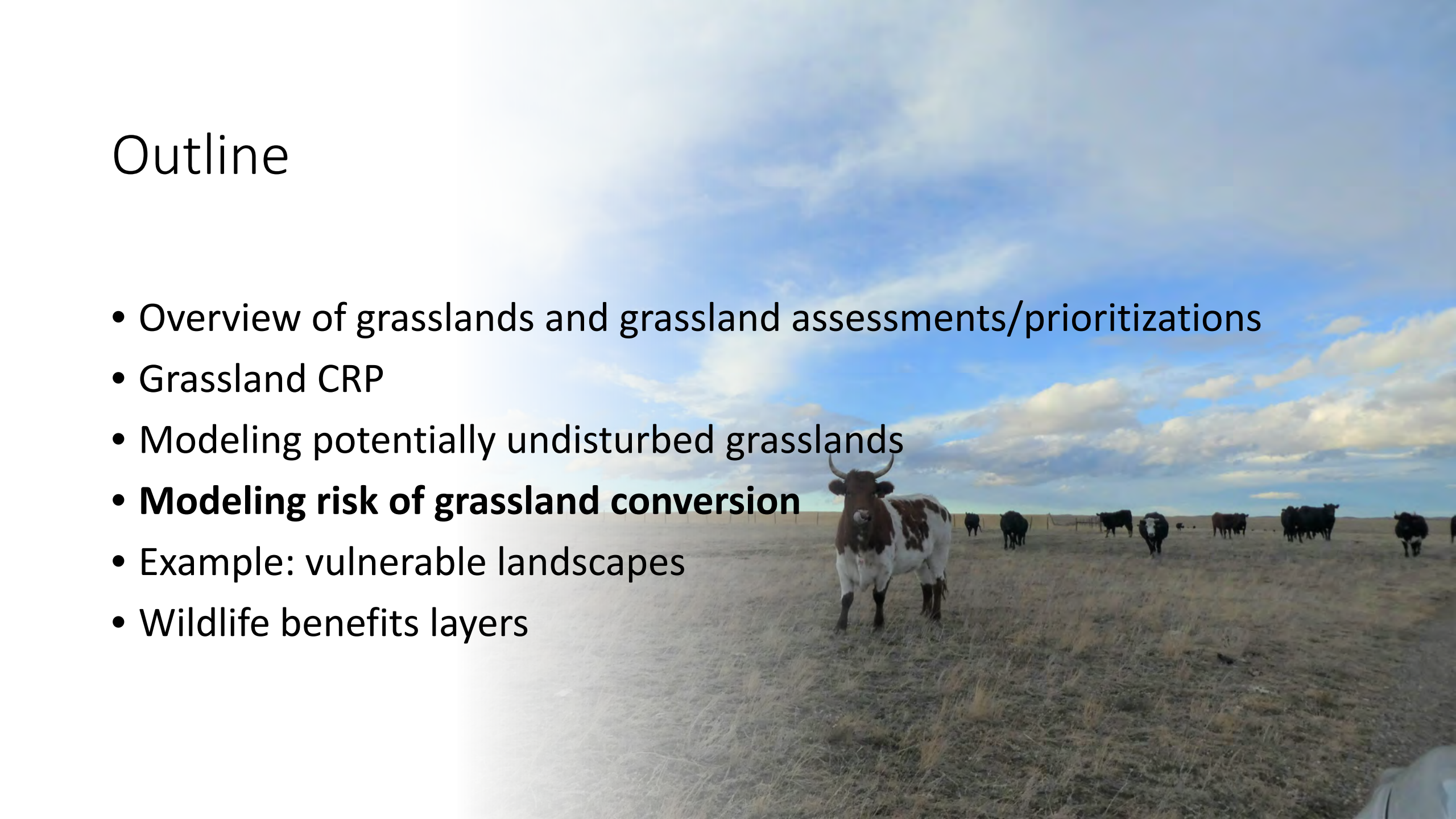
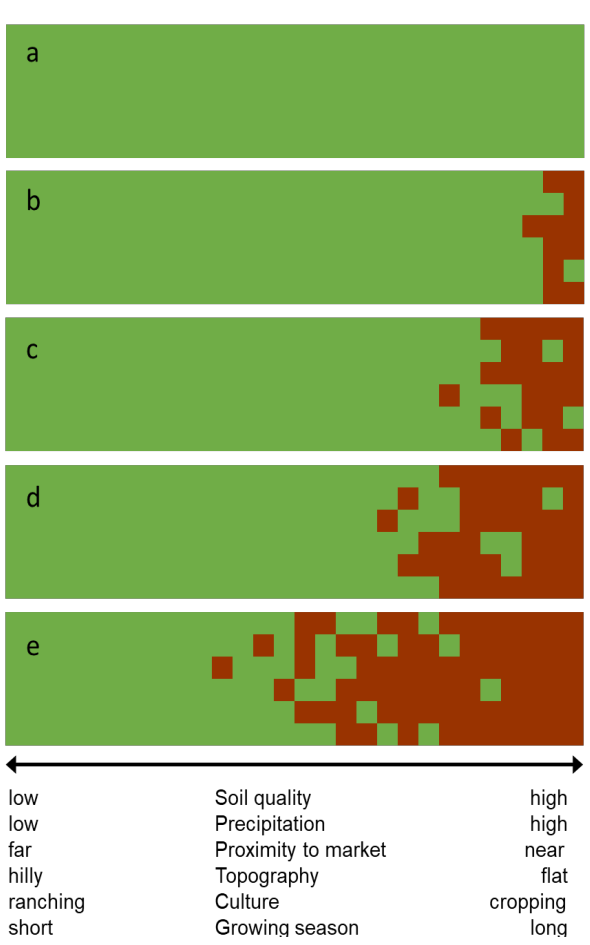
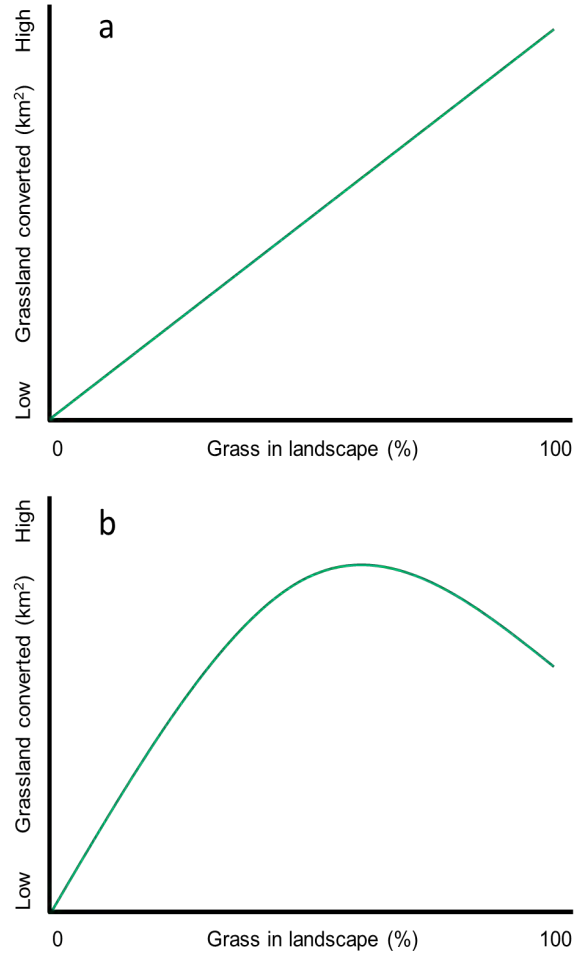


Building on Past Work

- Landscape-scale approach to predicting grassland conversion (Niemuth et al. 2022)
  - Cropland spreads into lower quality lands given socioeconomic stimuli.
  - Rate of loss is likely not constant across grass bins
  - % grass at a landscape scale can represent an economic margin and predictor of future loss.





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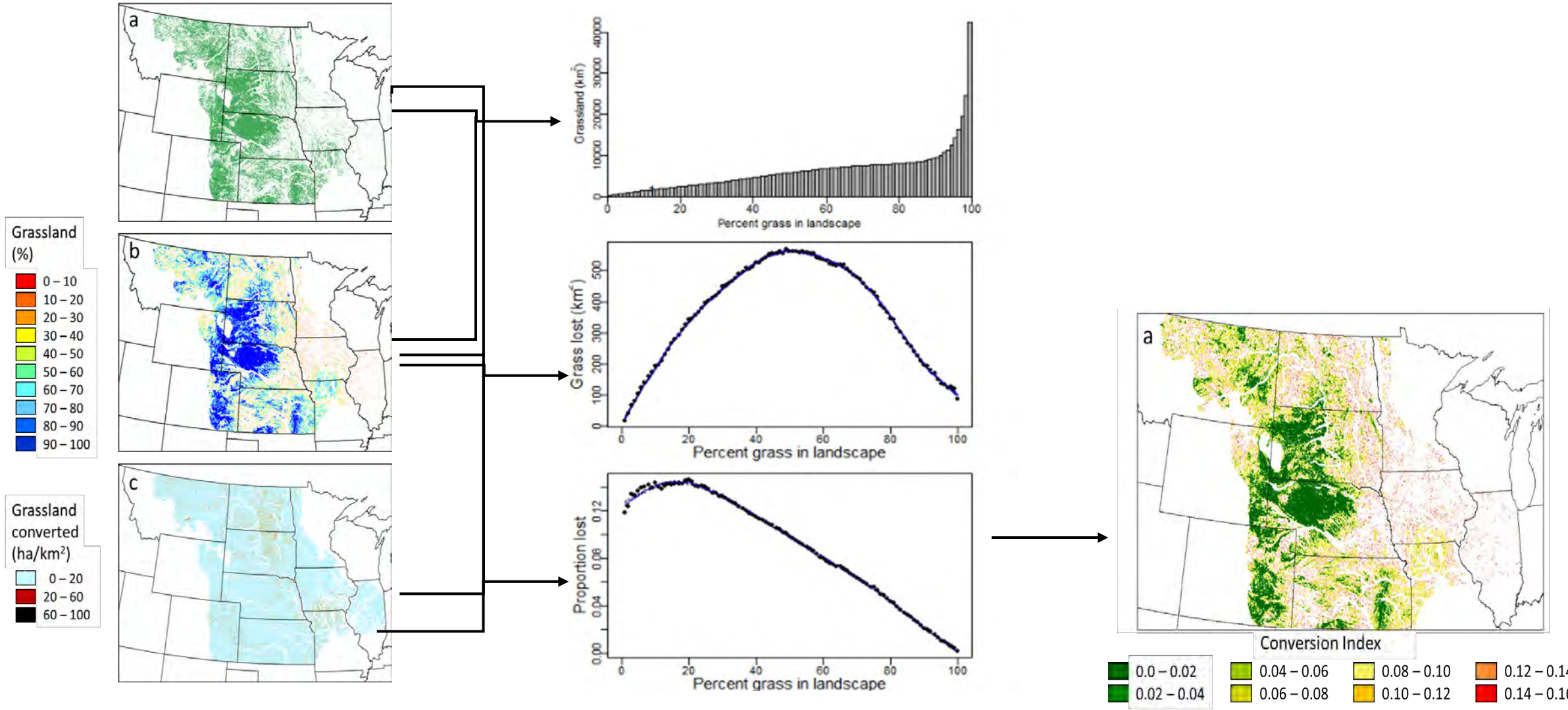


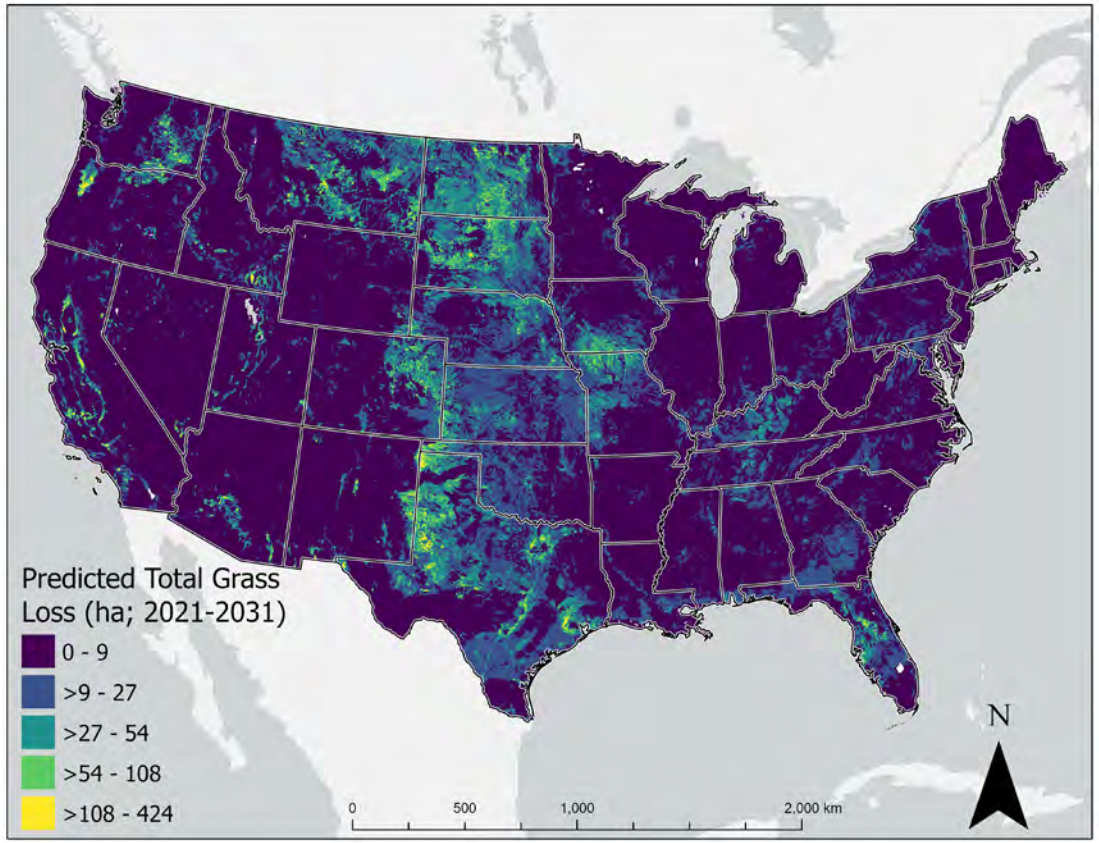
Pros and Cons

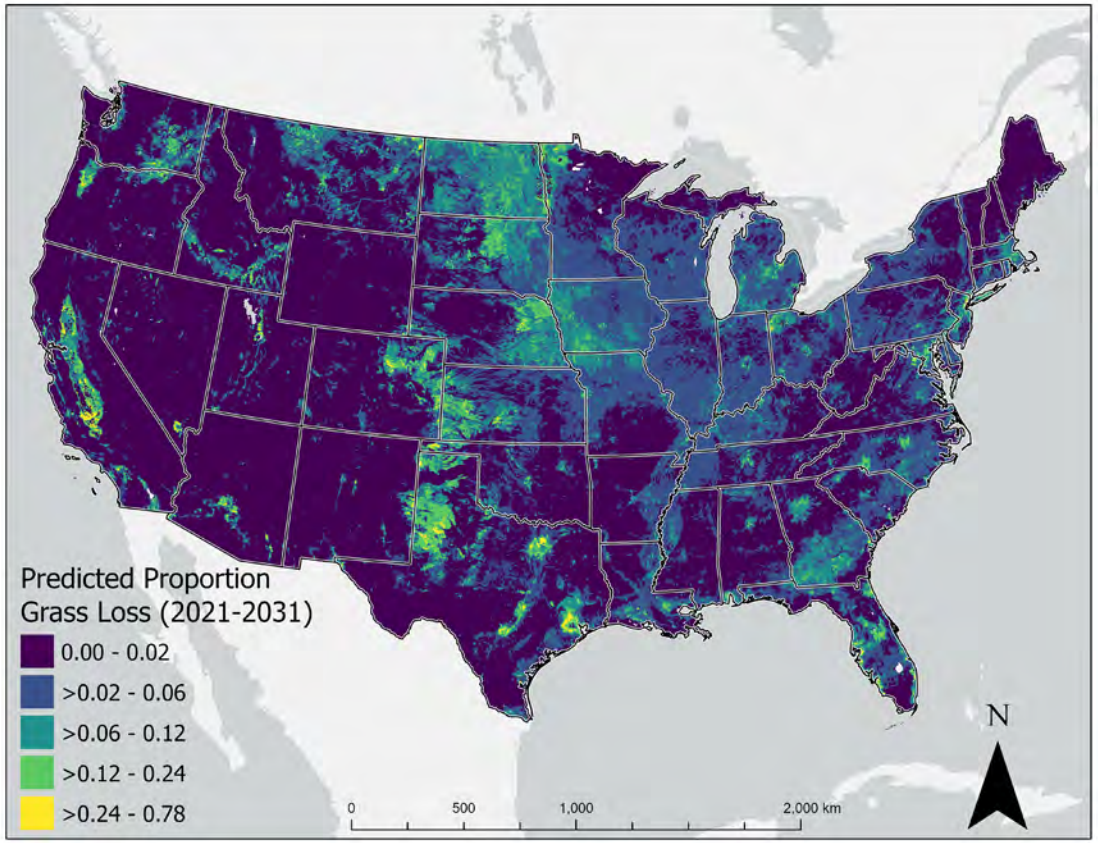
- Pros
  - Simple and intuitive
  - Easily updated
  - Great for broad-scale planning
- Cons
  - Limited understanding of loss at more local-landscape
  - Does not account for % crop, protected lands, restored lands, slope, etc.

- So we built on this concept and developed models that make predictions per pixel using its local landscape-scale variables.

Modeling Risk of Grassland Conversion

- Predictions of future grassland conversion to crop or development (2021-2031)

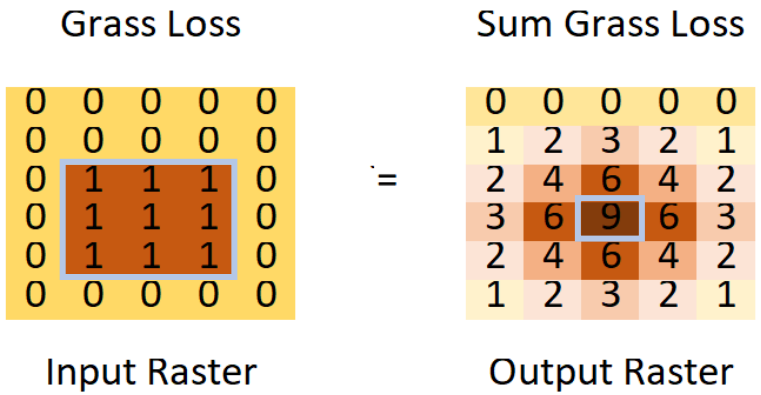




Methods Overview

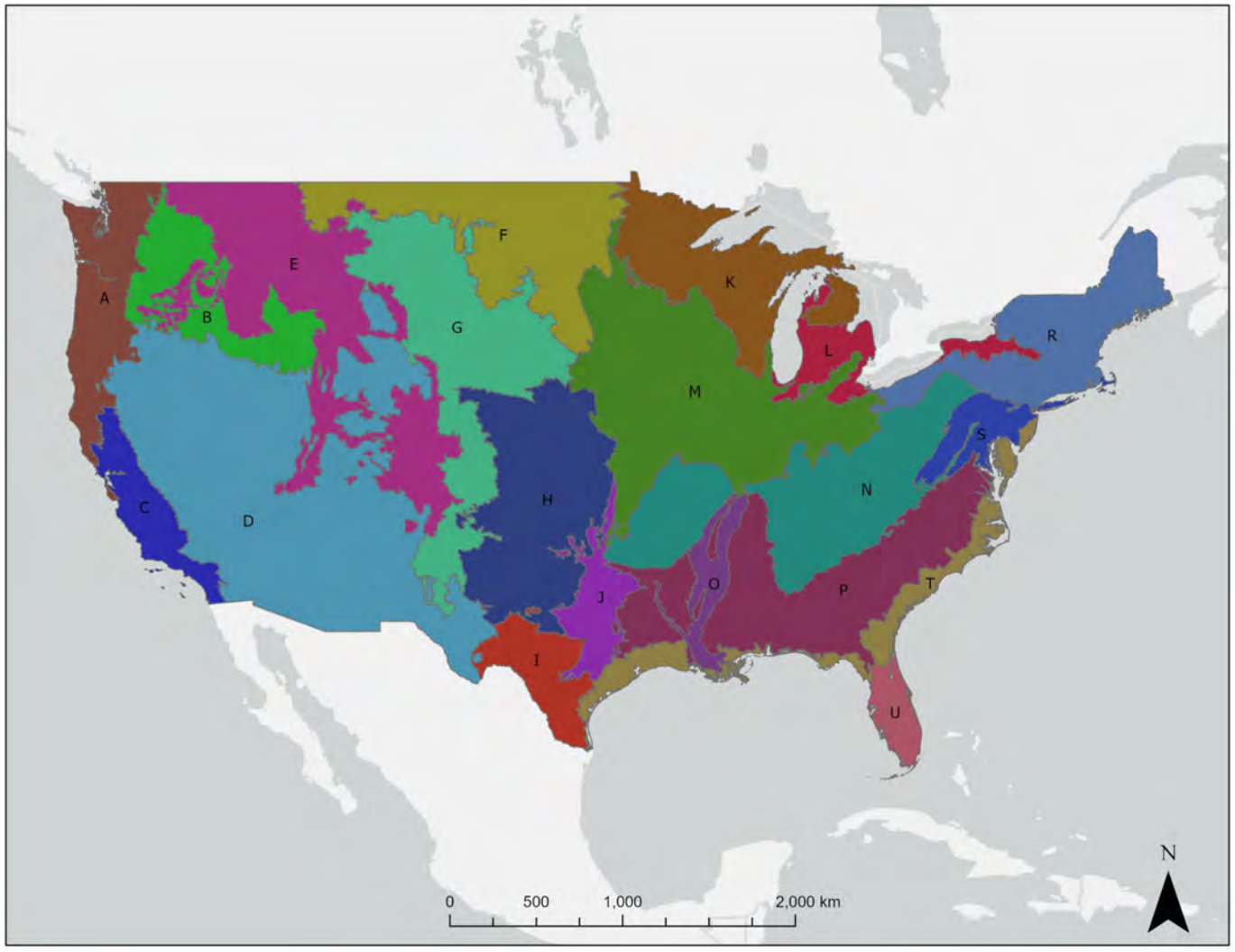
- Modeled grassland loss (2011-2021) at a landscape-scale using ~ 2011 predictor data
  - Grass loss: **unprotected** grass/shrub/herb. wetland cover classes in NLCD 2011 that were classified as crop or developed in NLCD 2021
  - Landscape-scale: 3.6 km square moving window
- We applied the models to updated surface data (~2021) to predicted future grassland loss (2021-2031)

Example Moving Window Analysis

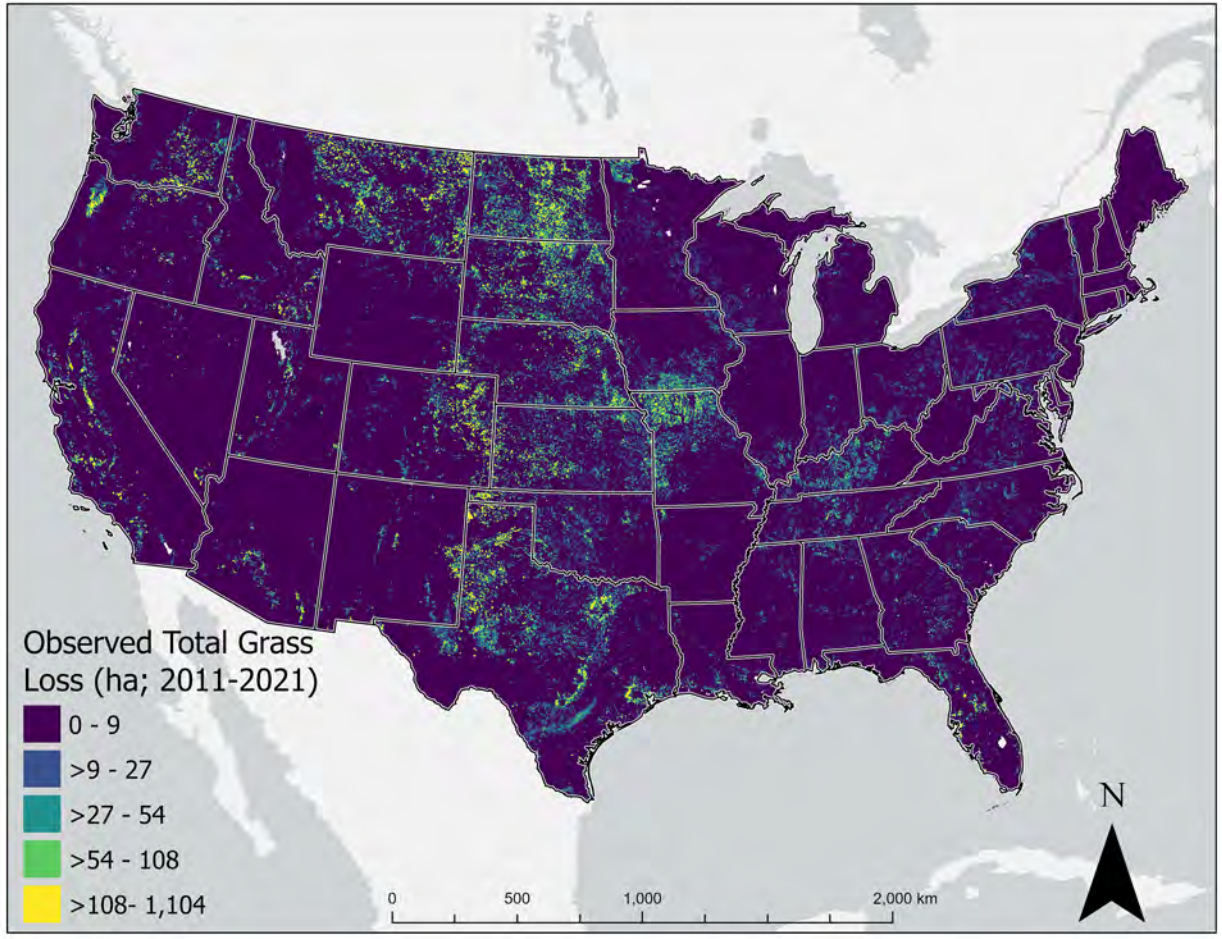


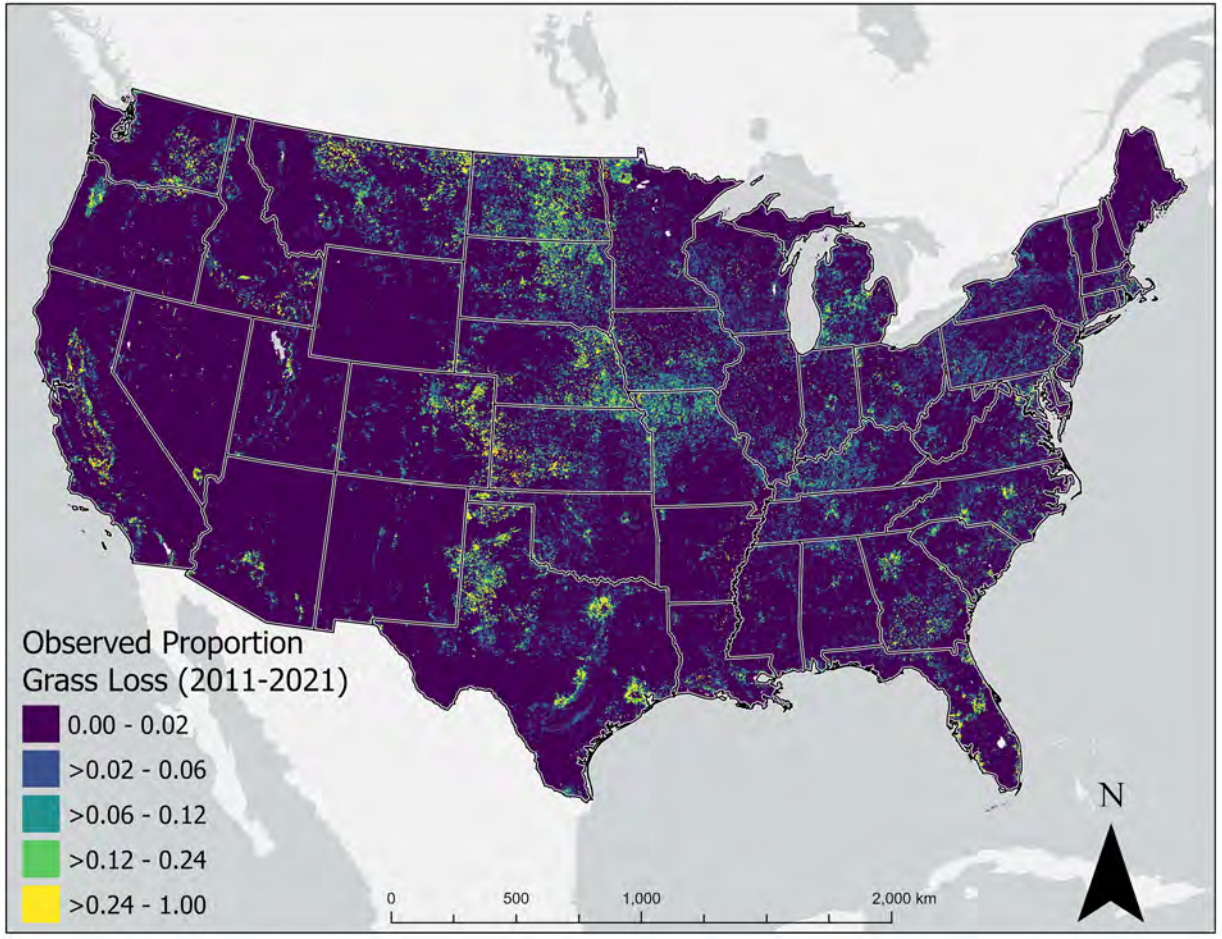
Models

- Random forest regression models
- We modeled loss separately for MLRA units and mosaiced outputs together
- Response variables
  - Total grass loss (2011-2021)
  - Proportion grass loss (2011-2021)
- Predictor variables
  - Landcover/land use
  - Socioeconomics
  - Climate
  - Topography
  - Soils

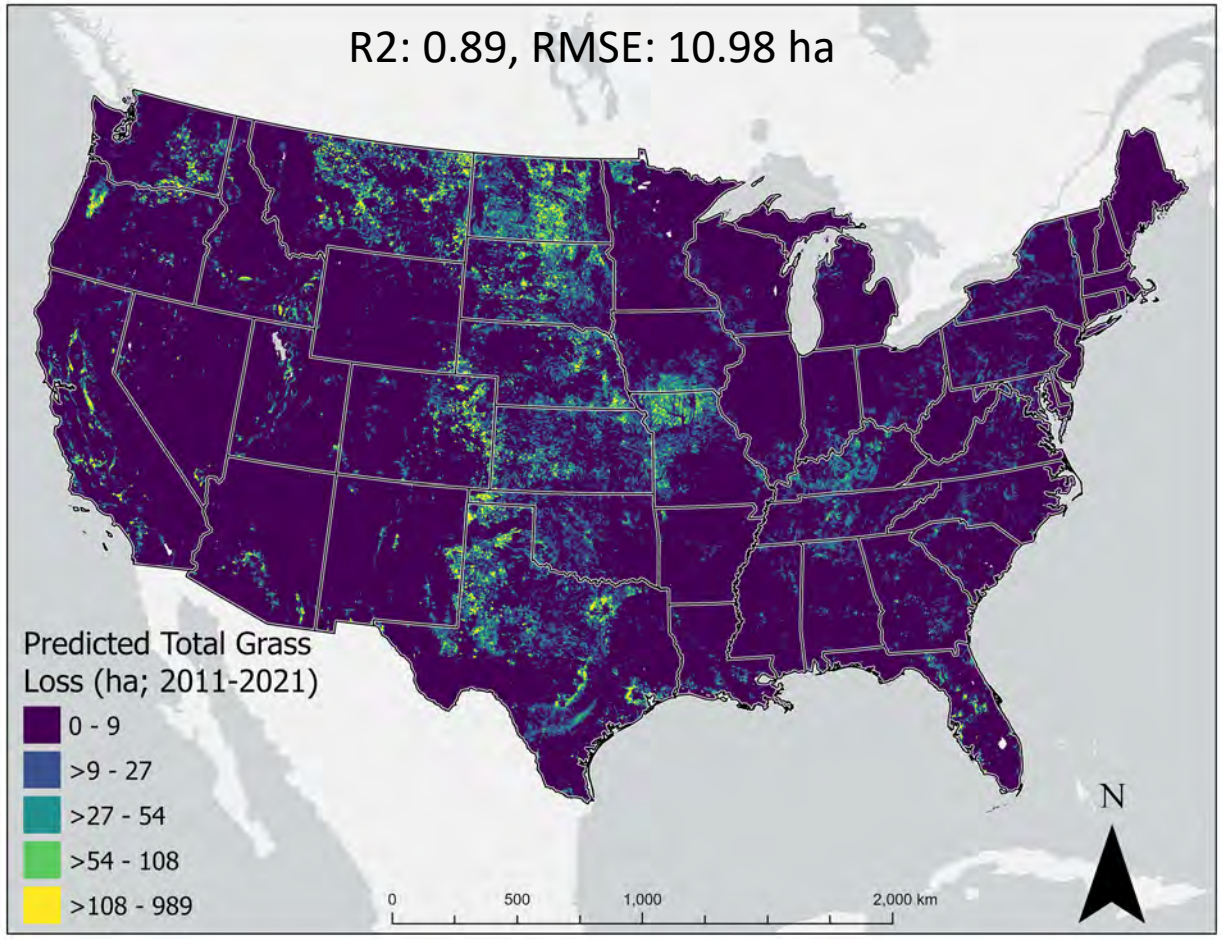


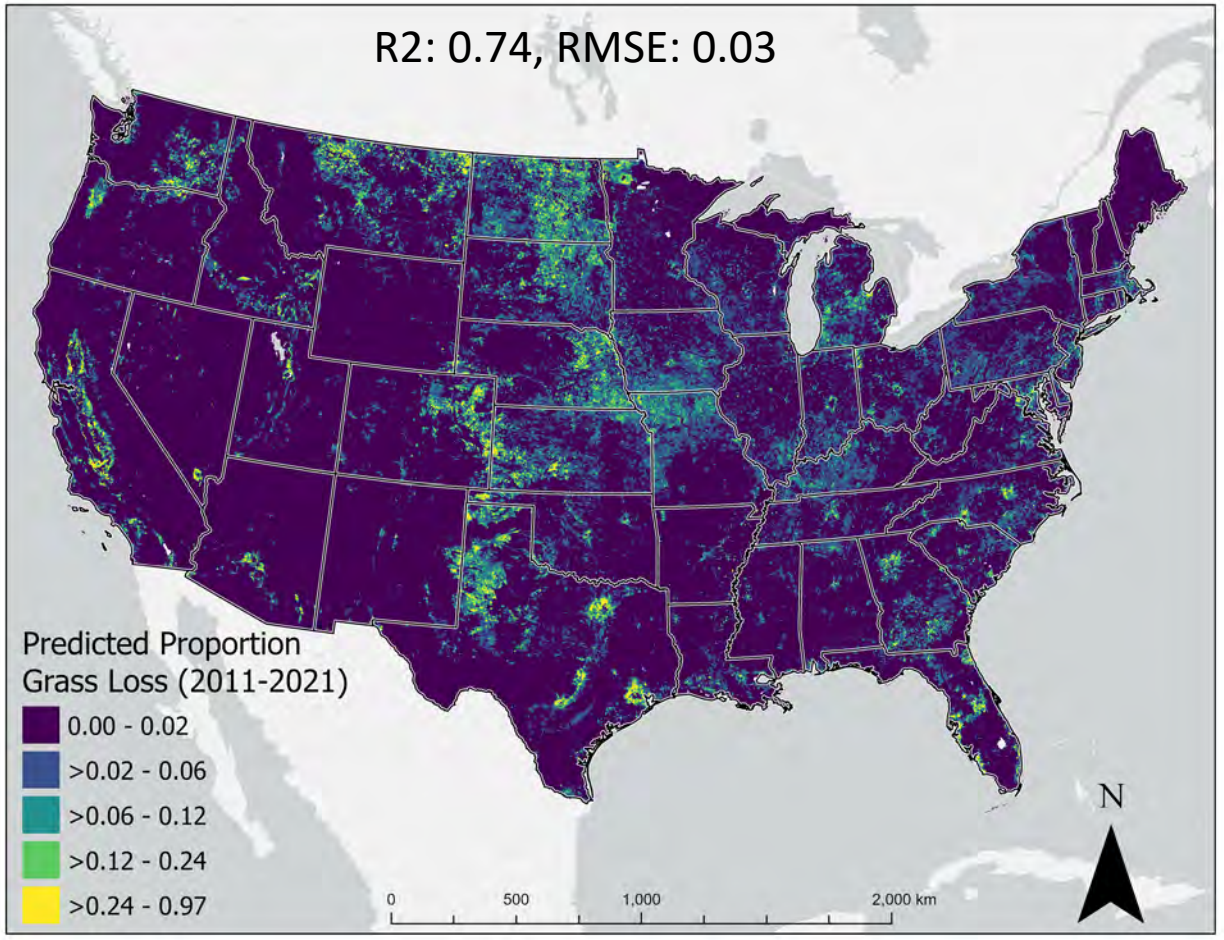
“Observed” Grassland Loss 2011-2021 (ha)



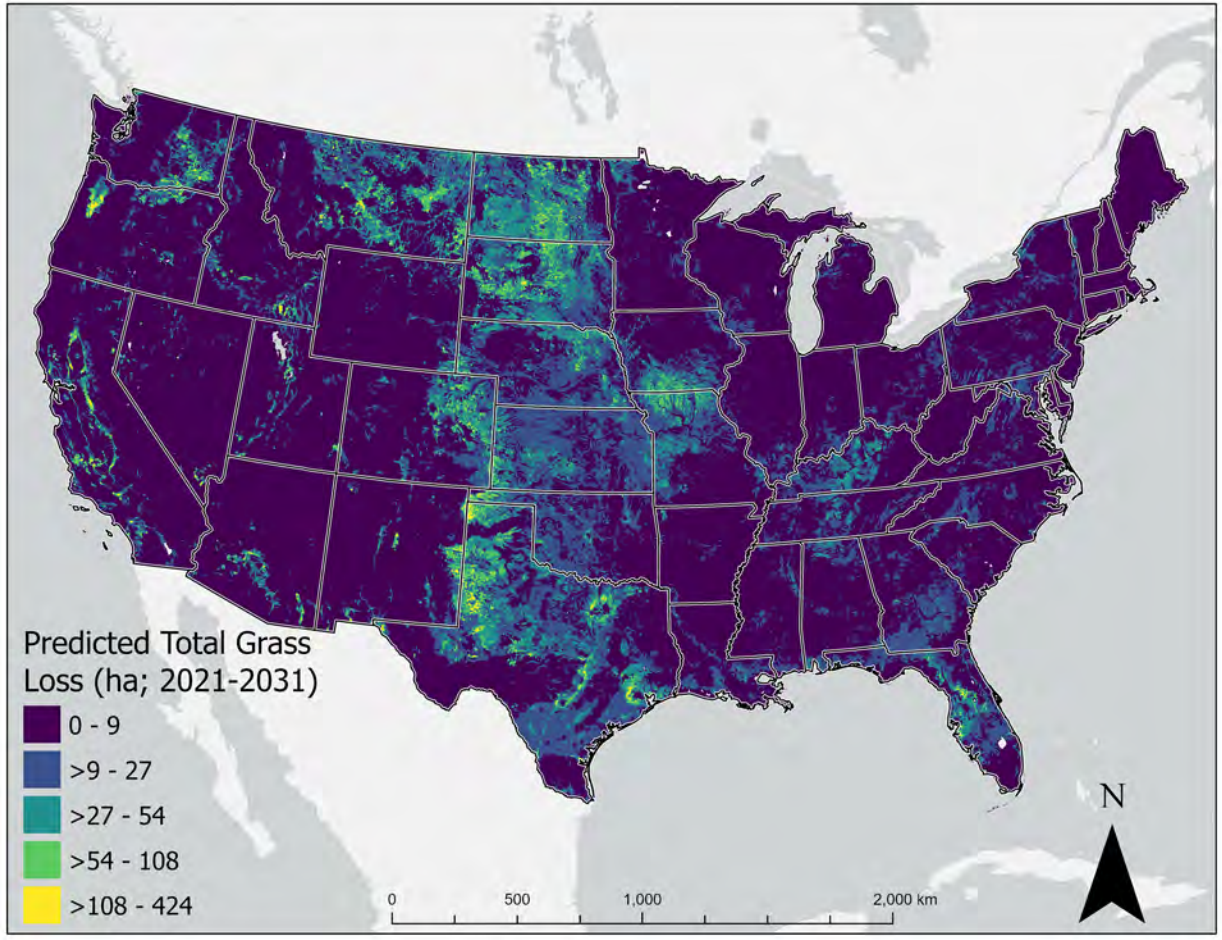


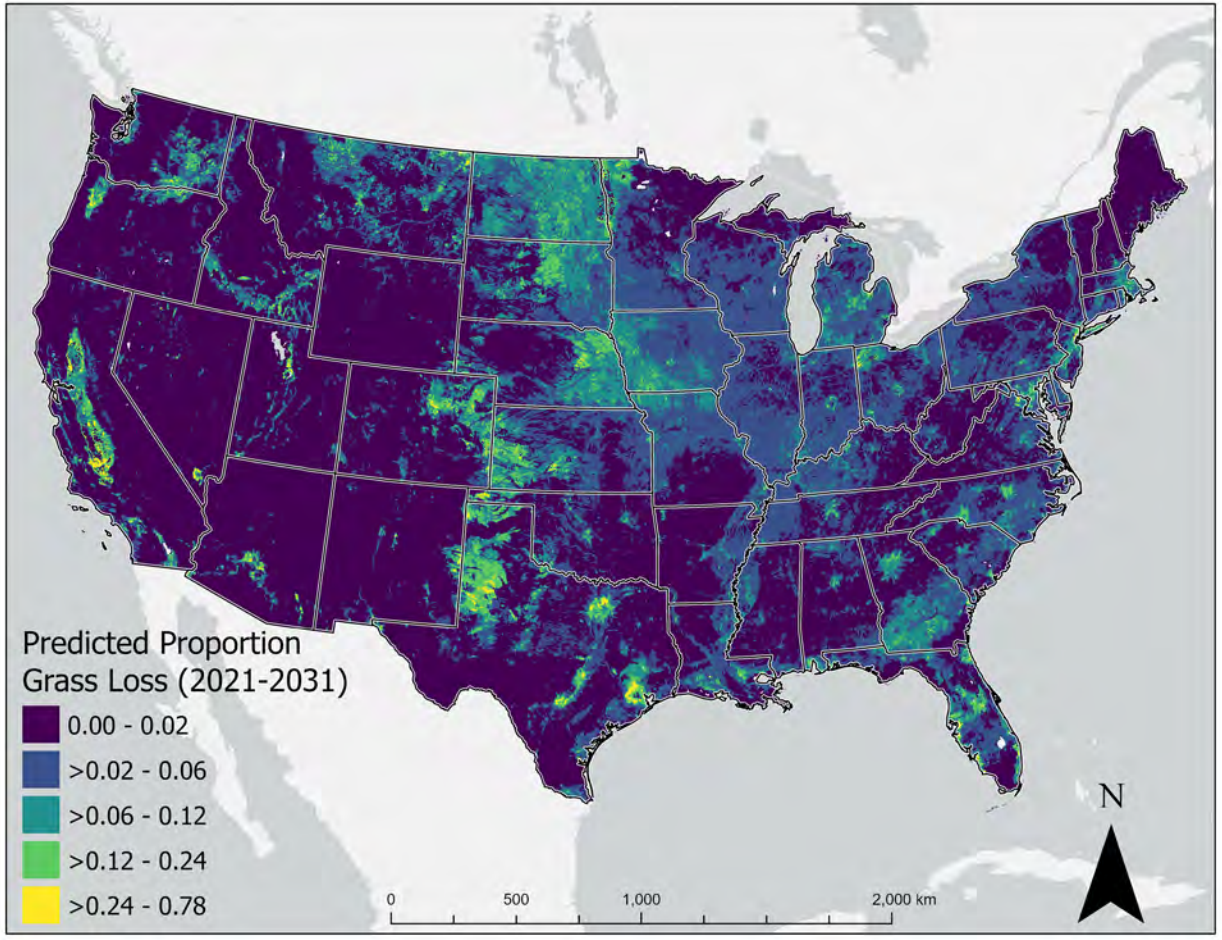
Predicted Grassland Loss 2011-2021



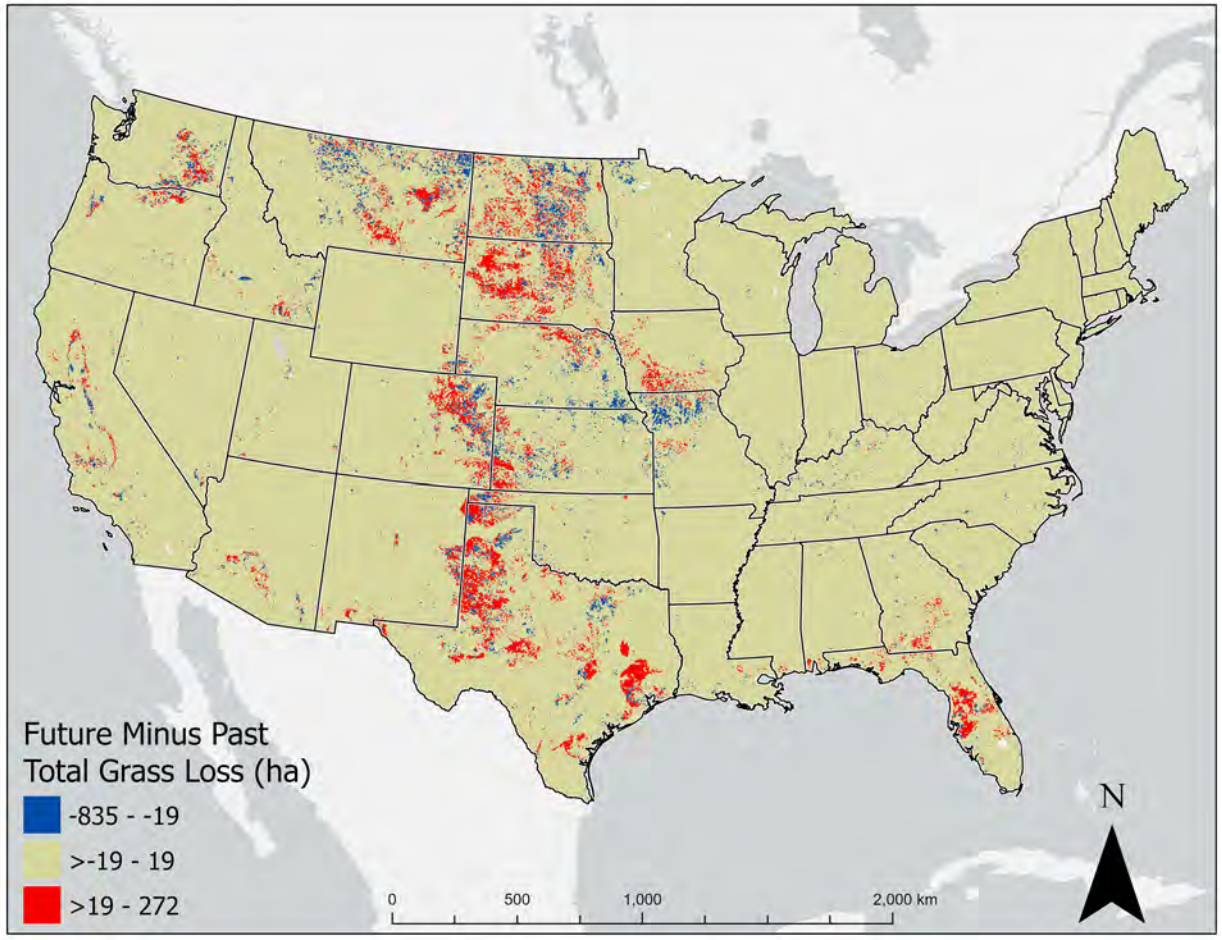


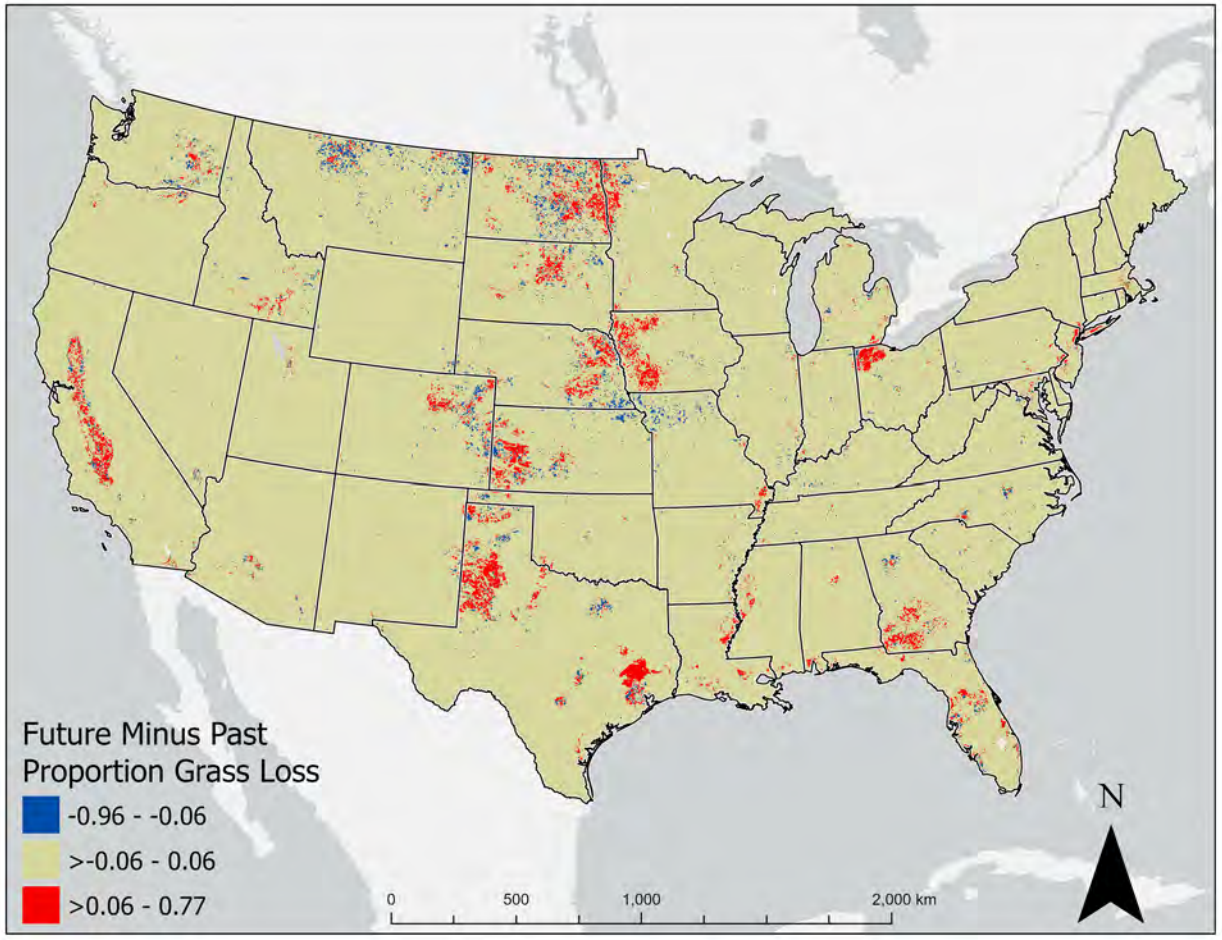
Predicted Future Grassland Loss 2021-2031





Future Minus Past Grass Loss





Model Benefits for Conservation Planning

- Landscape-scale product
  - Matches scale of conservation delivery and species ecology
  - Covers entire lower 48
- More intuitive and useful than probability of conversion at the pixel level
  - Can better understand payoffs of conservation actions (save this much grass from being lost)
- Near-future predictions have less uncertainty than long-term predictions
  - Useful for conservation in the short-term
- Can be used to define landscape vulnerability
  - Intensity, exposure, and impact = vulnerability
  - Can be used with land values to optimize conservation

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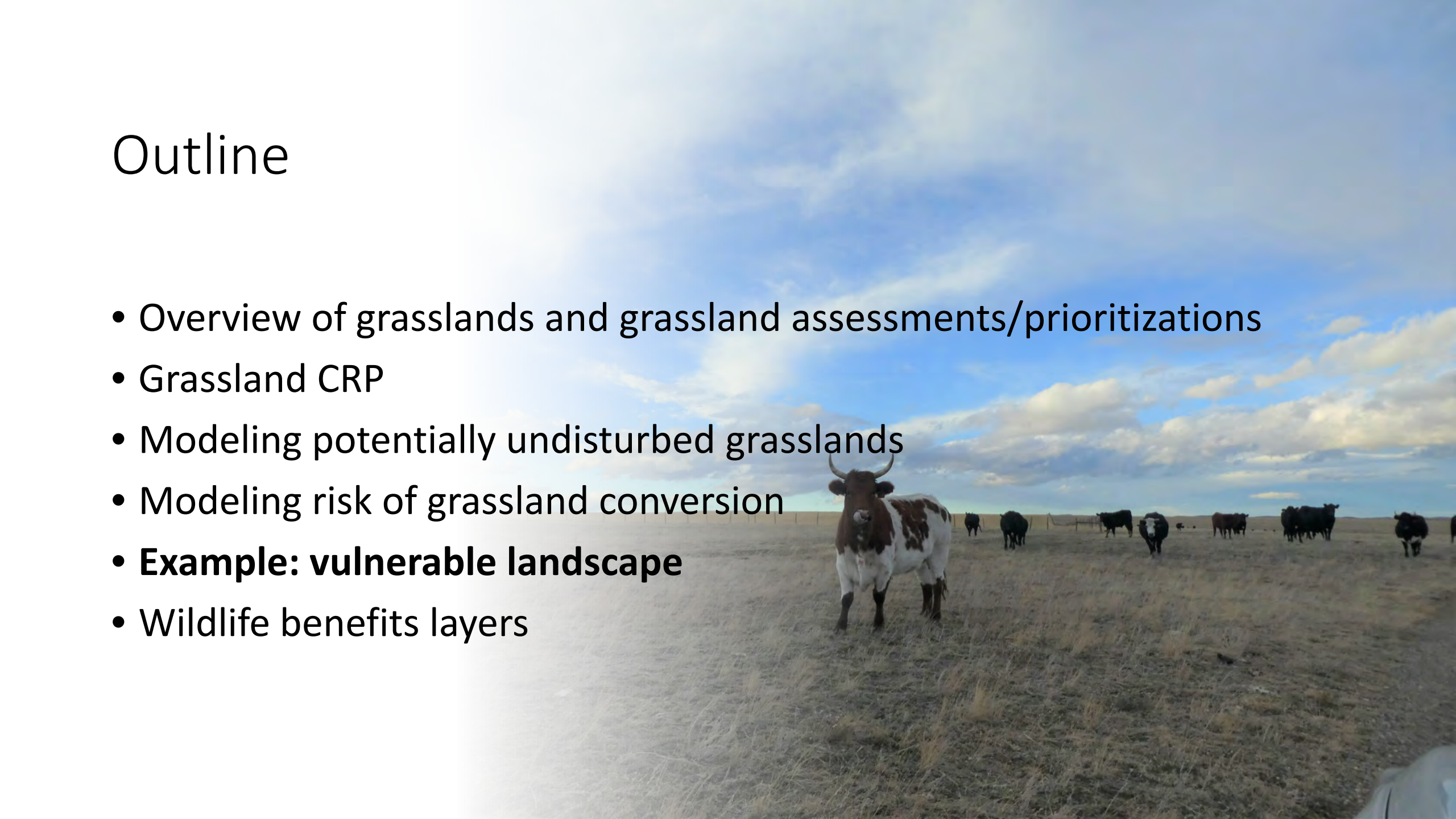
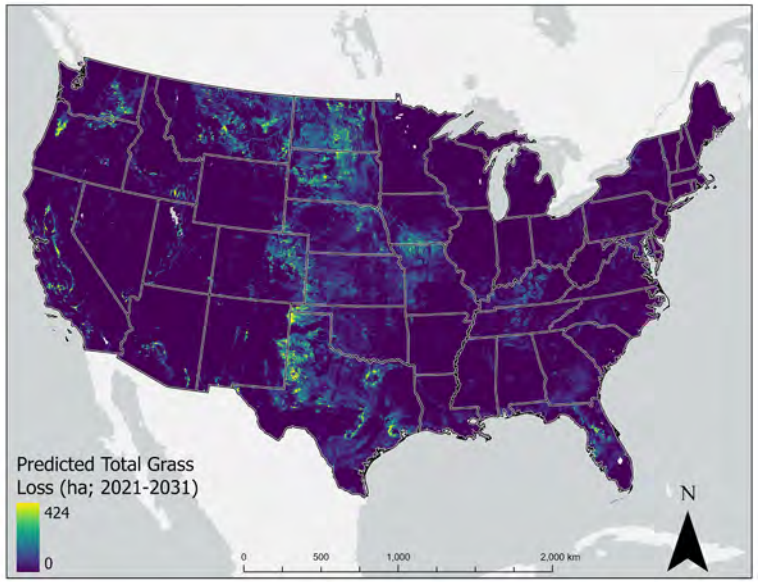
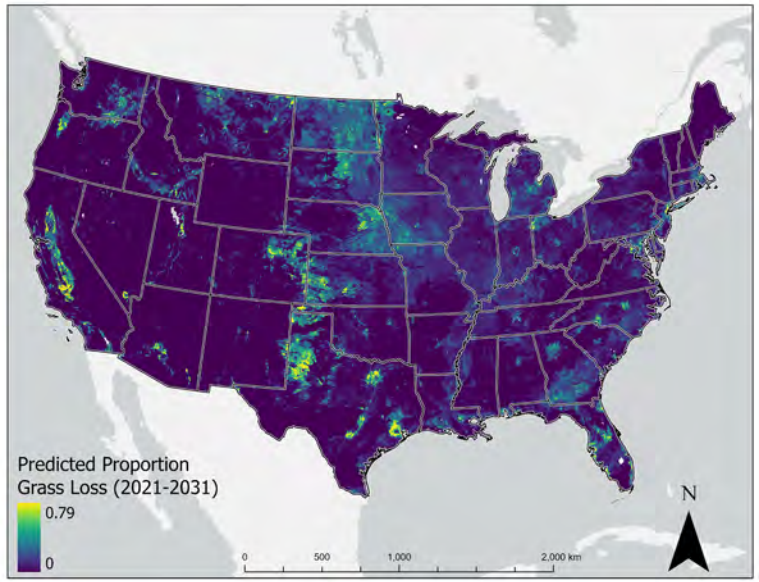
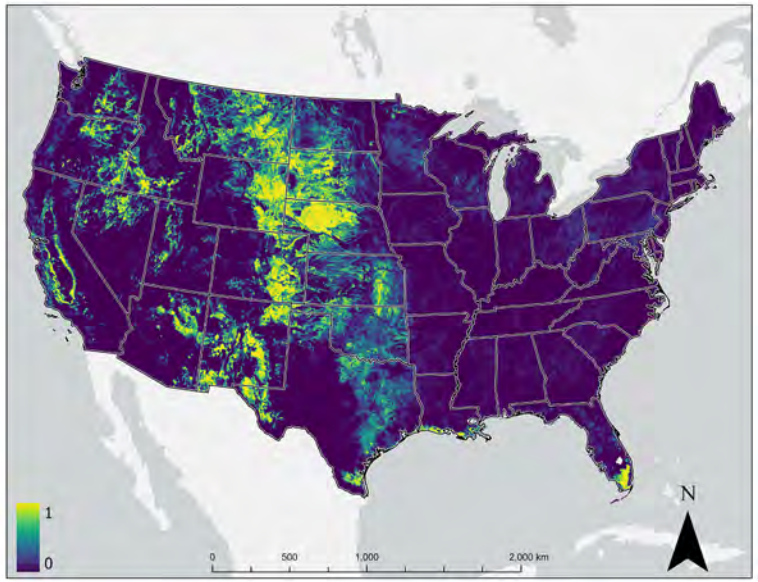


Example

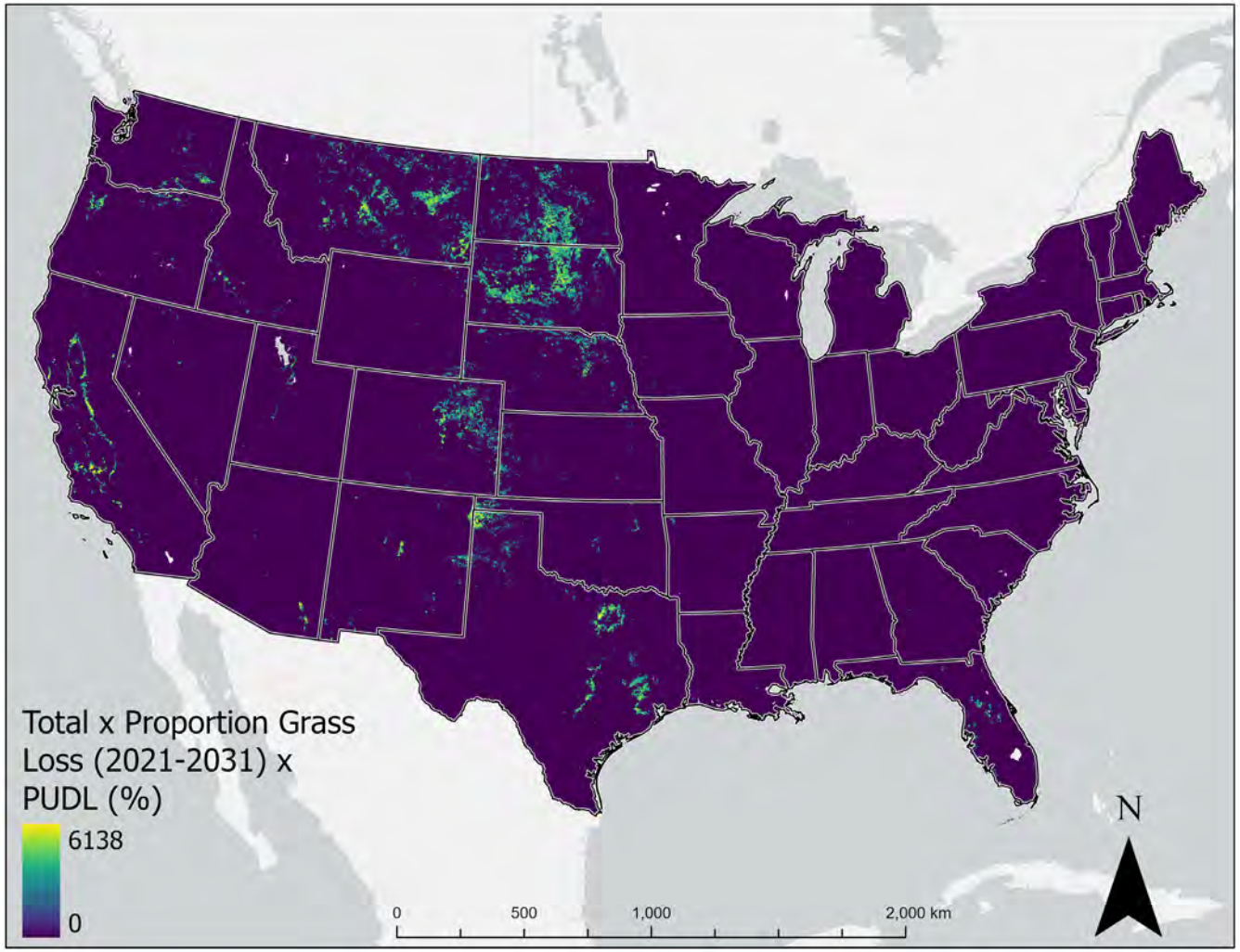
- Total Loss x Proportion Loss x Impact = vulnerable landscapes



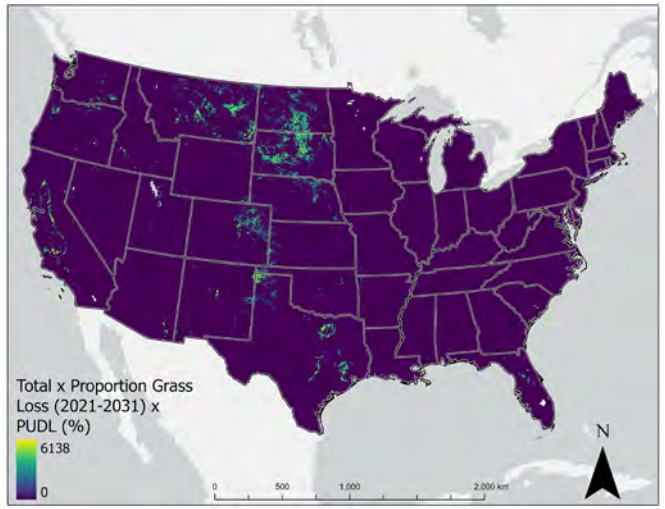




Vulnerable grasslands



Vulnerable grasslands/cost



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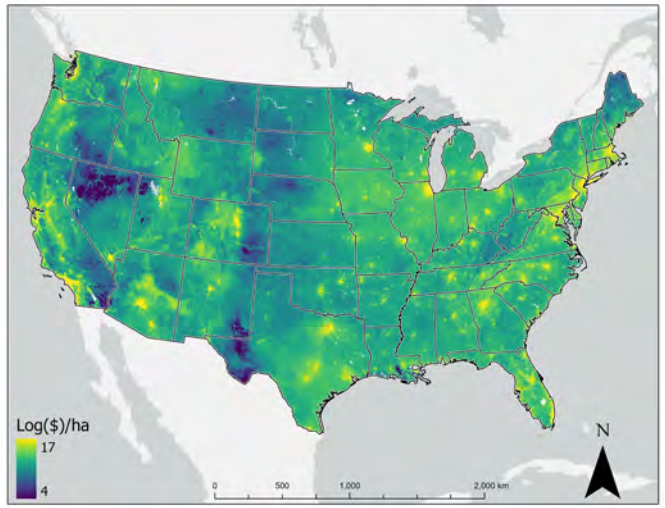

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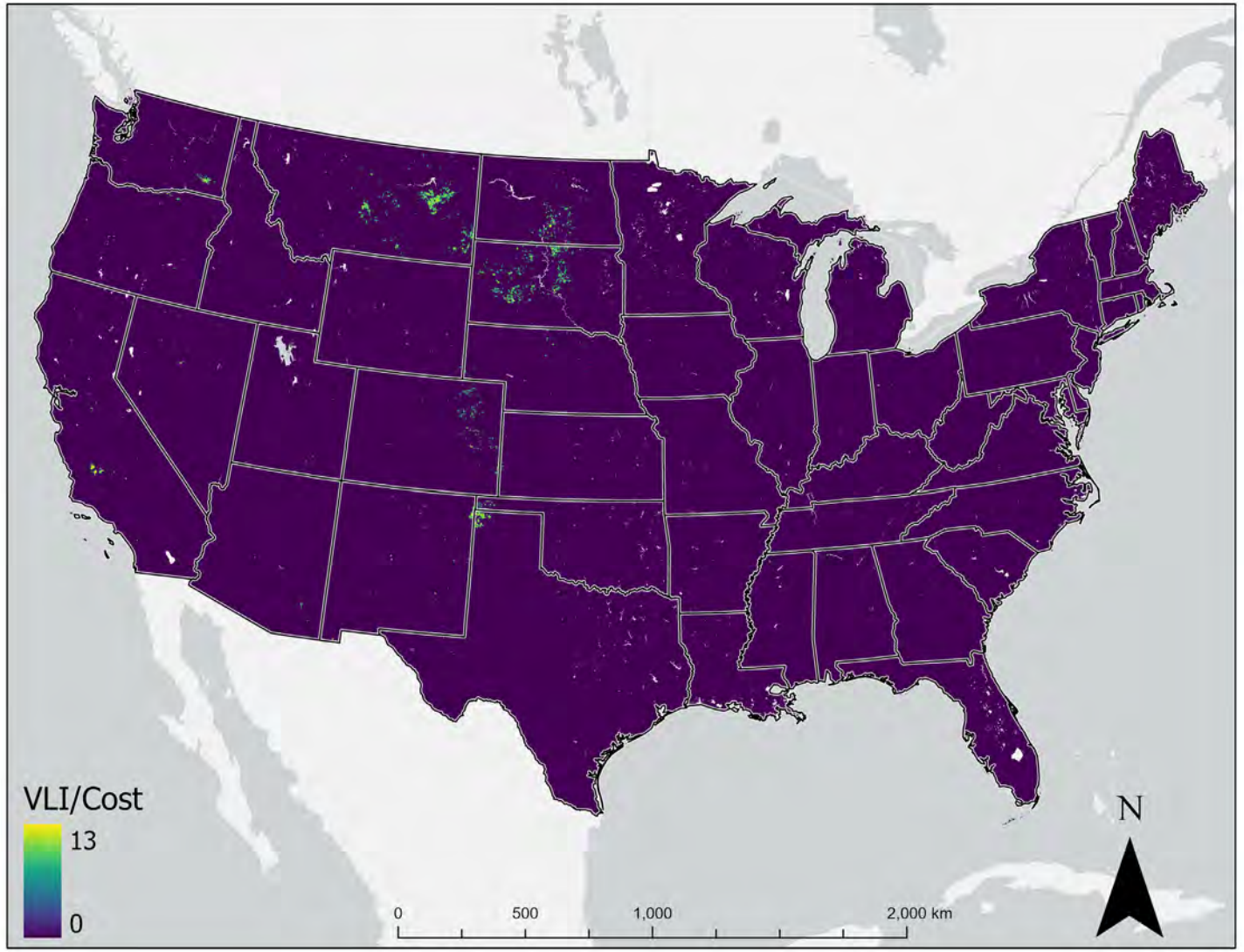
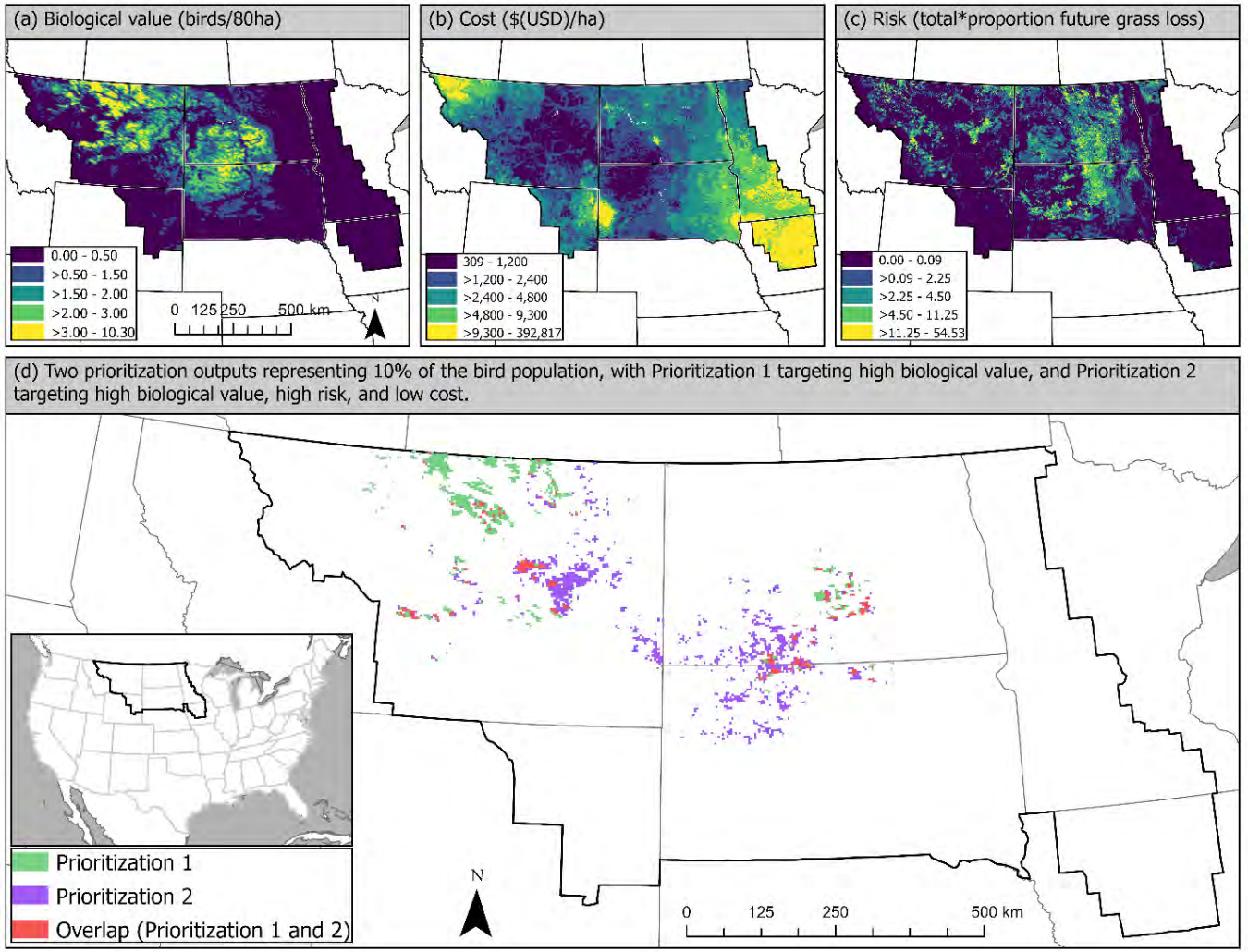


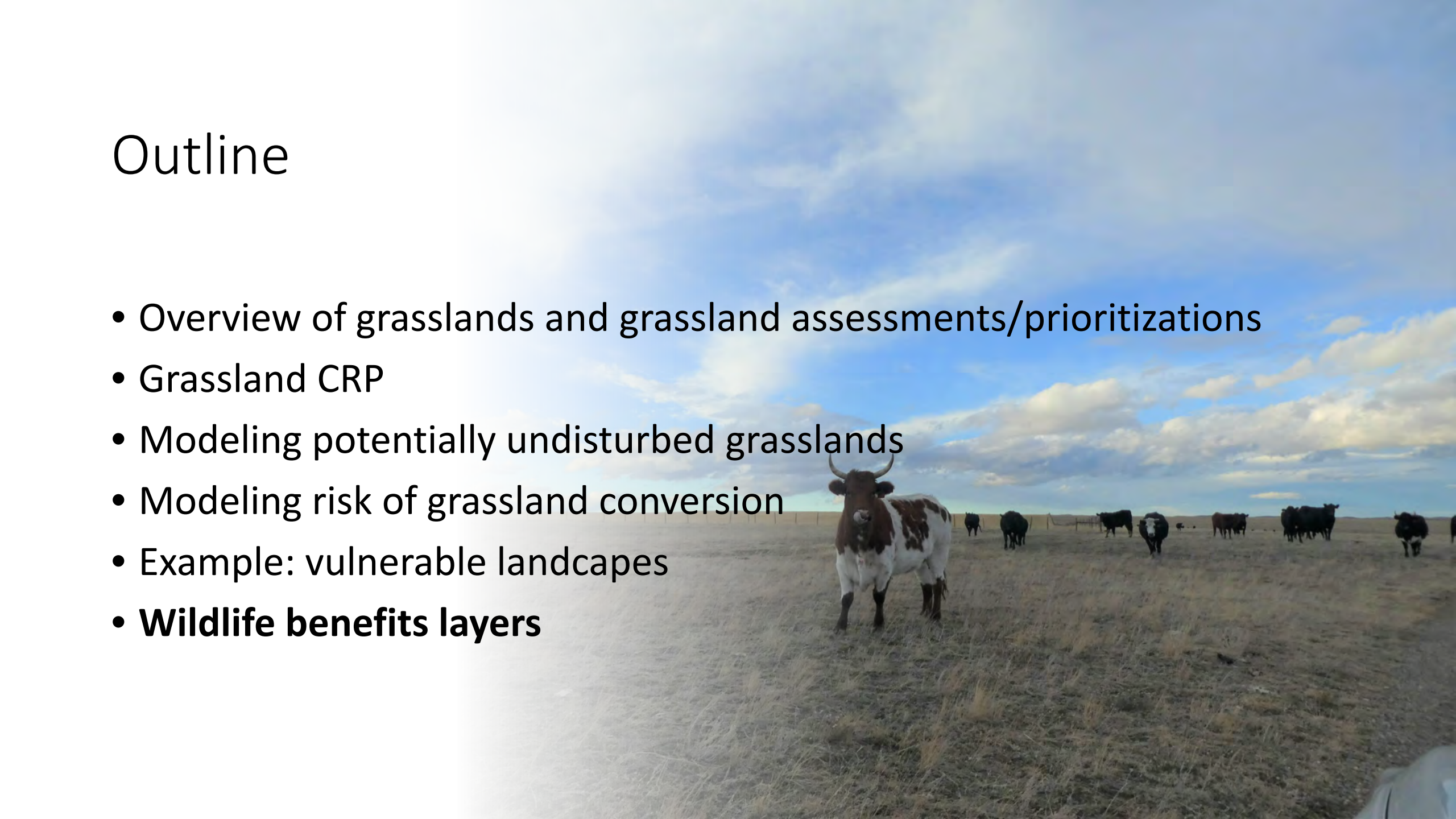
Wildlife Prioritizations

- Prioritization 1
  - Bird density
  - Top 10% of population
- Prioritization 2
  - High bird density & risk
  - Low cost
  - 10% of population



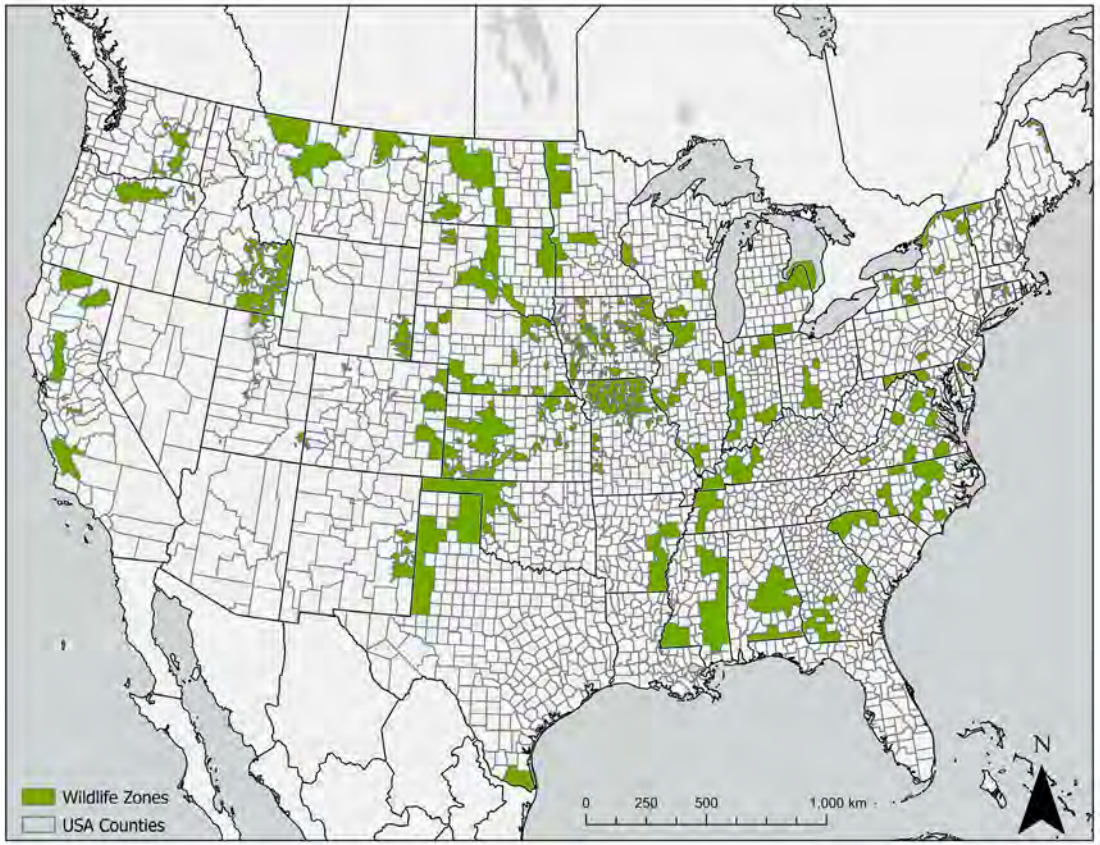
Outline

- Overview of grasslands and grassland assessments/prioritizations
- Grassland CRP
- Modeling potentially undisturbed grasslands
- Modeling risk of grassland conversion
- Example: vulnerable landcapes
- **Wildlife benefits layers**



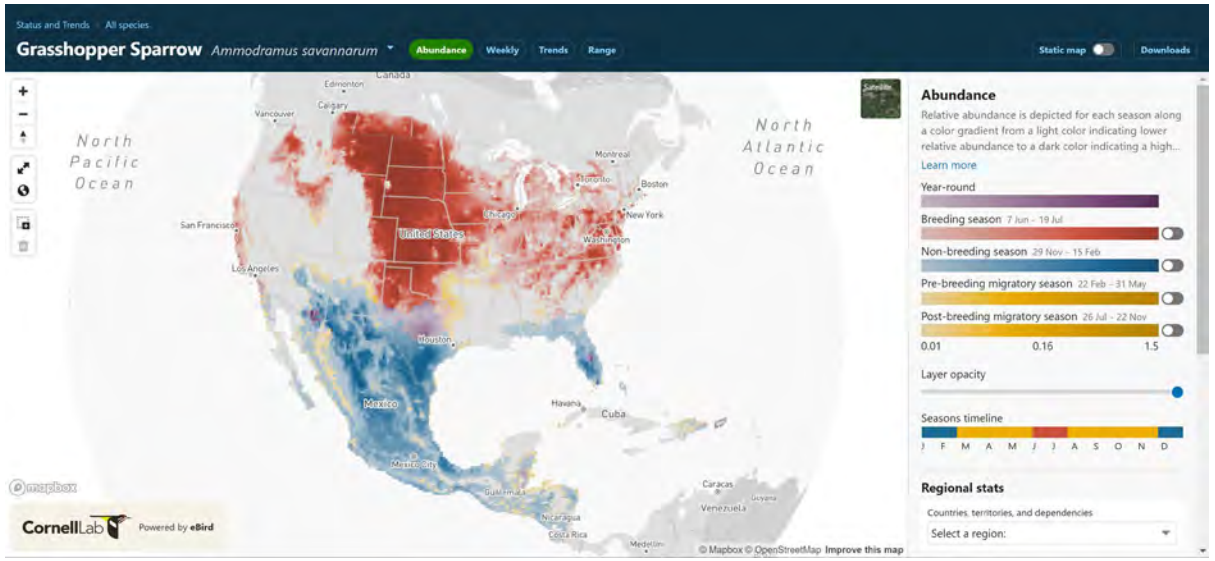
Wildlife Benefits Layer

- Spatial layer to inform general CRP sign up EBI and grassland CRP ranking.
  - Wildlife benefits index (subfactor N1c)
    - What wildlife?
      - Will wildlife benefit no matter the conservation practice?
    - Are criteria for designating areas consistent across states?
      - Are designations objective, defensible, and transparent?



Birds as Bioindicators

- Ecology is well understood
  - Range and vegetal associations
    - responsive to environmental condition/change
  - Cover different levels of the ecological pyramid in every environment
- Measurable and easily detected



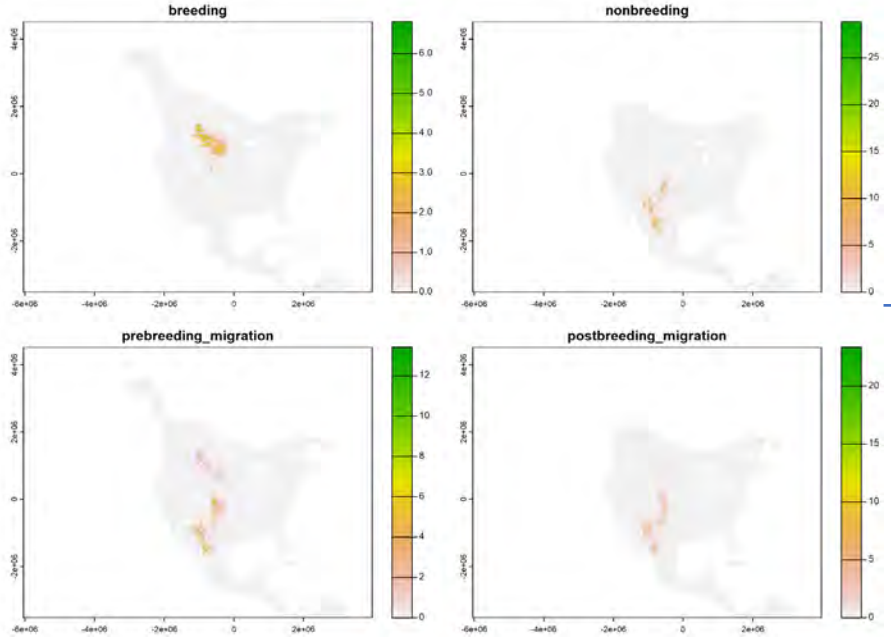
eBird

- Database of bird observations
  - Citizen science
  - Standardized surveys (e.g. BBS)
- Weekly relative abundance models
  - Aggregated to seasons
  - Relative abundance = individual species counts expected for 1-hour 1-km traveling survey by an expert eBirder under optimal weather
  - 2.54 km resolution

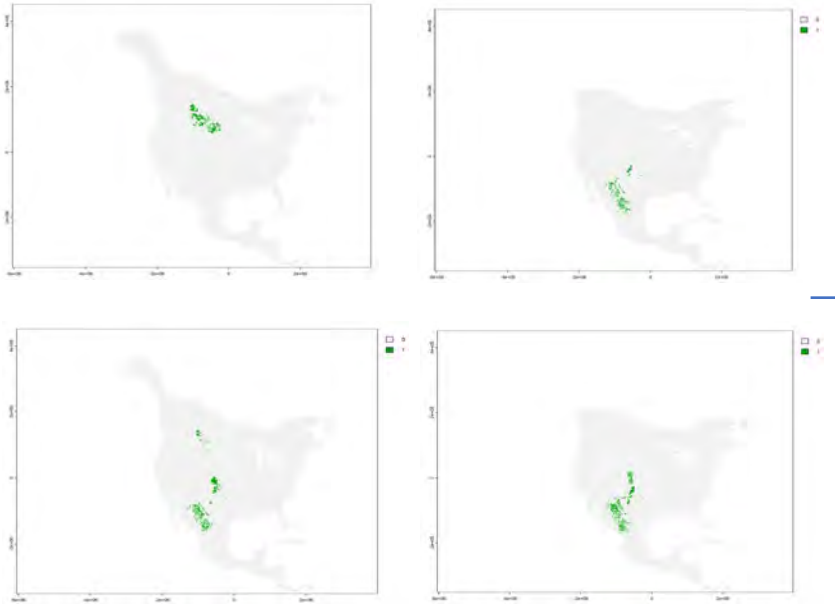
Bioindicator Metric

- Extract North American Migratory Bird Joint Venture priority species (n=361).
  - Higher conservation need
  - Grass/shrub (=261) vs. Forest (n=192)
- Extracted their seasonal relative abundance models from eBird.
  - For each species we extracted the top 50% of population, converted to binary indicator
  - Summed all species models together
    - Lands of higher importance across species

Seasonal Abundance

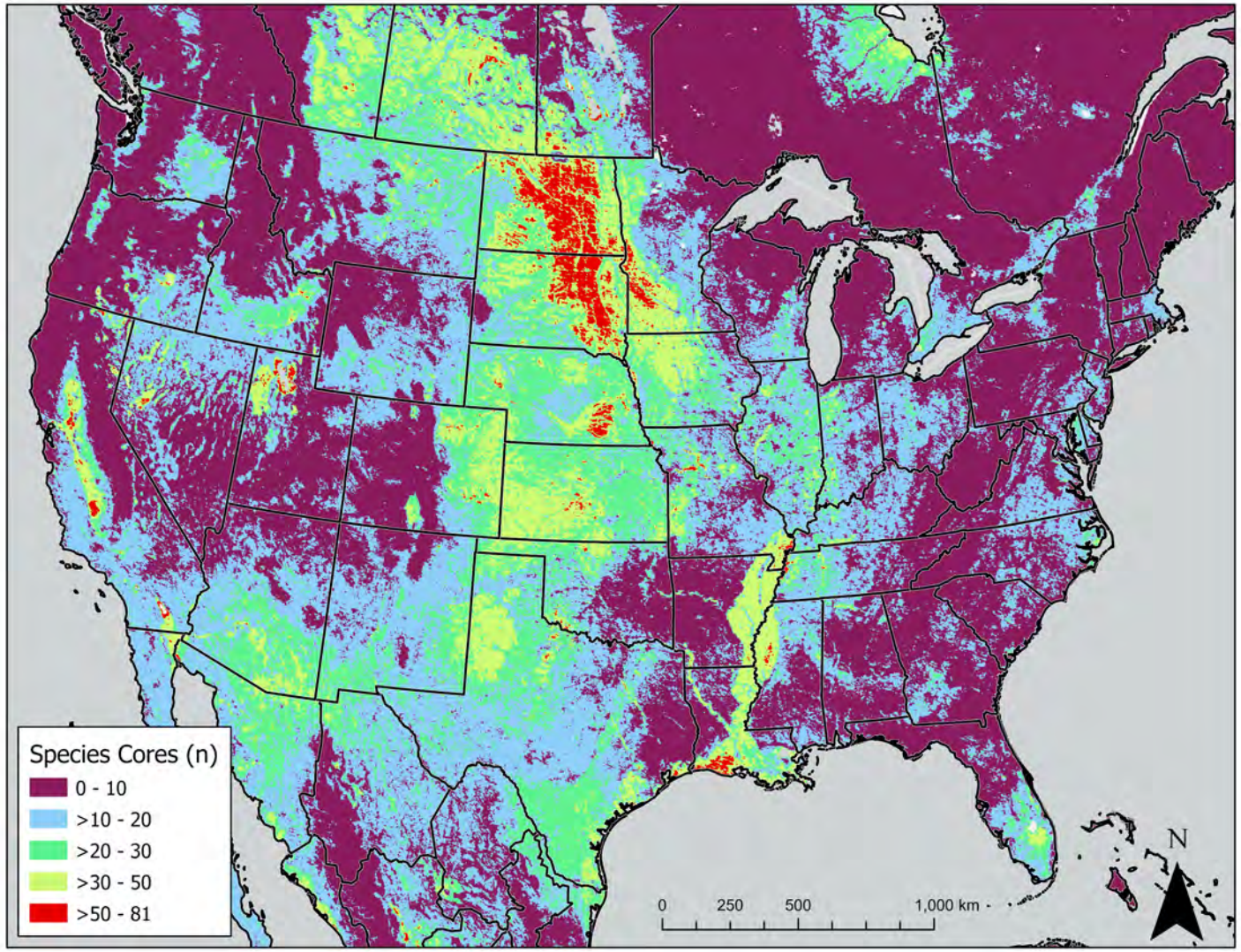


Seasonal Top 50%

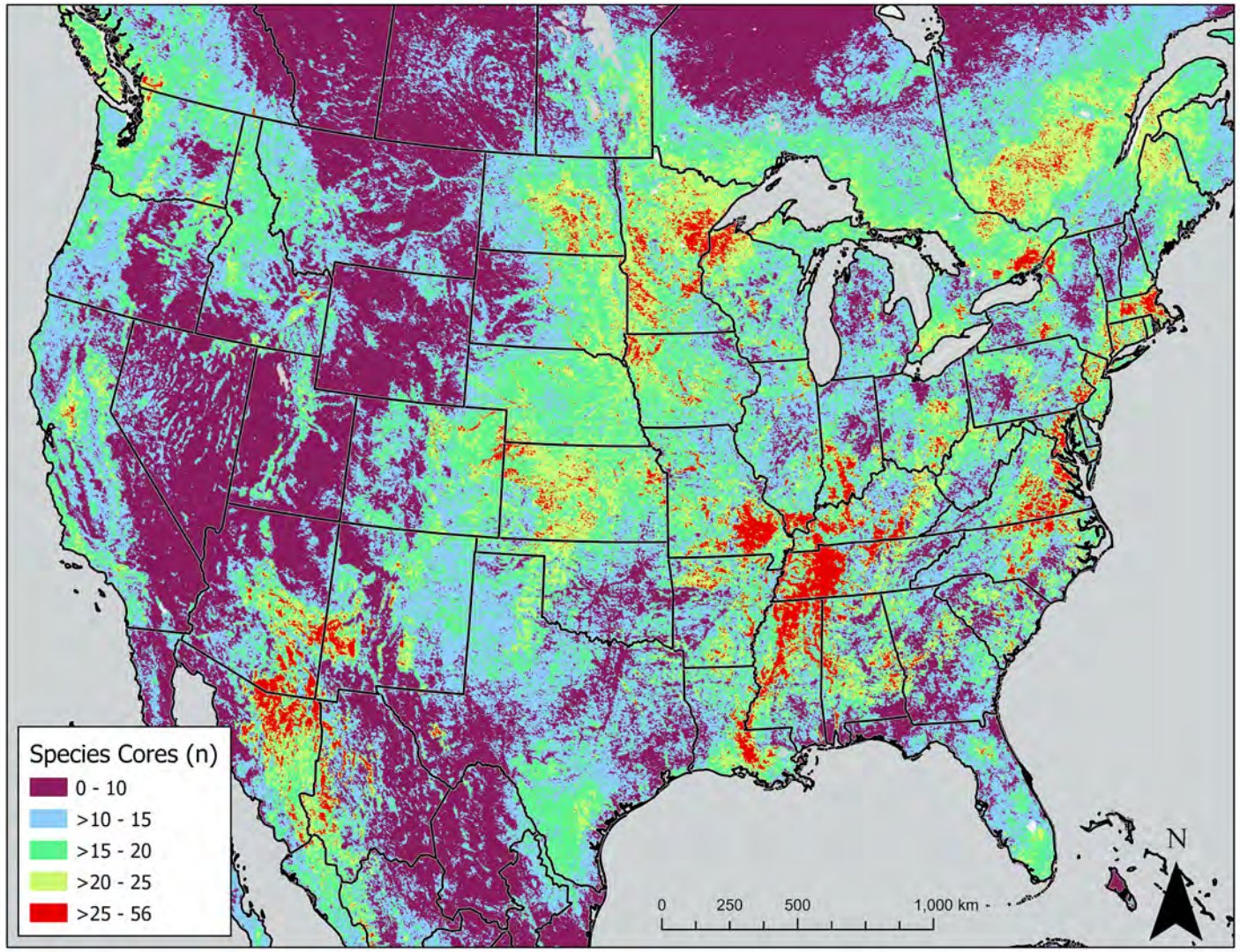


Seasonal Top 50% Combined

Grass, Shrub & Wetland Species



Forest & Wetland Species



Summary

- Models can be used stand alone or integrated with other information to inform and define programmatic priority areas
- Models were developed to specifically meet programmatic goals at the scale of delivery but could have broader interest/application
- Models were developed in a strategic, consistent, flexible, transparent, well defined, and defensible manner.
- Look forward to opportunities to work with USDA and other potential partners to develop applications of the models for conservation planning.

Questions…

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Link to recording of presentation
https://www.fsa.usda.gov/programs-and-services/economic-and-policy-analysis/natural-resources-analysis/webinars/index

Photo Credit: Krista Lundgren/USFWS