

Probability Based Sample Designs for Wetland Condition Assessment:

Lessons Learn from Real World Applications in the Rocky Mountains

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Basics of Probability Based Sample Designs

What is a probability based sample design?

- Sample design in which every unit has a known nonzero chance of being included
- Units that are sampled are randomly selected
- Allow for inference to entire population

What is a spatially balanced probability based design?

- Specially developed for natural resource monitoring across large landscapes
- Accounts for spatial pattern of ecological systems, ensures a spread of the points
- More (statistically) efficient – avoids redundant information

Who uses these designs?

- EPA for National Aquatic Resource Surveys
- Many state water quality monitoring programs, including for wetlands

How do you create one?

- Generalized Random Tessellation Stratified (GRTS) in R ¹
- Reversed Randomized Quadrant-Recursive Raster (RRQRR) approach in ArcGIS²

¹Stevens, D.L. & Olsen, A.R. (2004) *JASA*, **99**: 262-278.

²Theobald, D.M. et al. (2007) *Environmental Management*, **40**: 134-146.

Important Considerations for a Design

Survey Objectives

- Why are you creating the design?

Target Population

- What are you measuring?
- Requires clear, precise definition that field crews can interpret

Sample Frame

- The spatial data used to represent the target population
- Almost always not exact representation of the target population

Subpopulations

- Wetland type (wet meadow vs. riparian area)

Stratification

- Ecoregion (high elevation vs. low elevation)
- Land ownership (public vs. private)

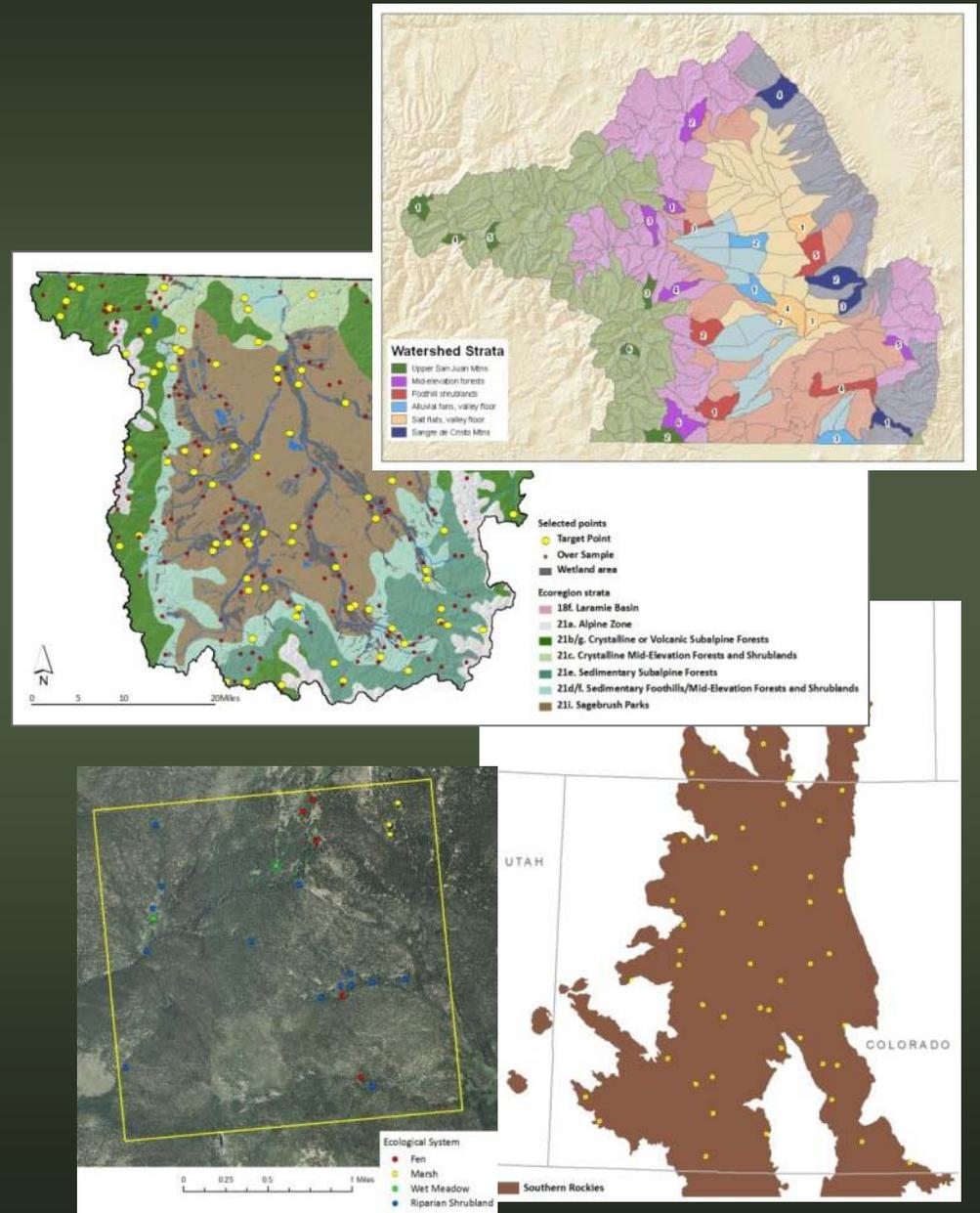
Reporting Unit

- By unit (wetland) or by area



Three Case Studies

- Rio Grande Headwaters Pilot Wetland Condition Assessment
- North Platte Basinwide Wetland Condition Assessment
- Rocky Mountain Regional Wetland Assessment (REMAP)



Rio Grande Headwaters Pilot Project

Project Partners:

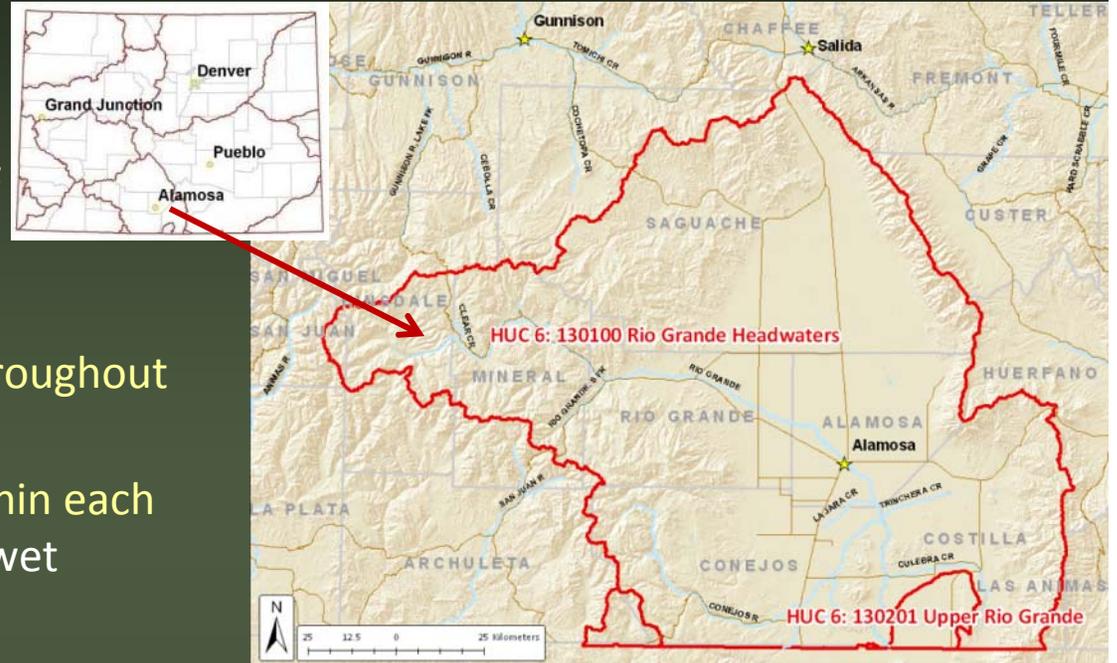
- CNHP, CDOW Wetlands Program
- Funded by EPA Reg 8, Rio Grande NF

Project Objectives:

1. Compile spatial data on wetlands throughout the basin
2. Quantify proportion of wetlands within each major wetland type: riparian areas, wet meadows, fens, playas, marshes
3. Within each wetland type, quantify proportion of wetlands within four major condition classes: excellent, good, fair, poor
4. Use the information to drive protection and conservation action by the Colorado Division of Wildlife.

Project Timeline:

- 2008 to 2011
- Three seasons of field data collection



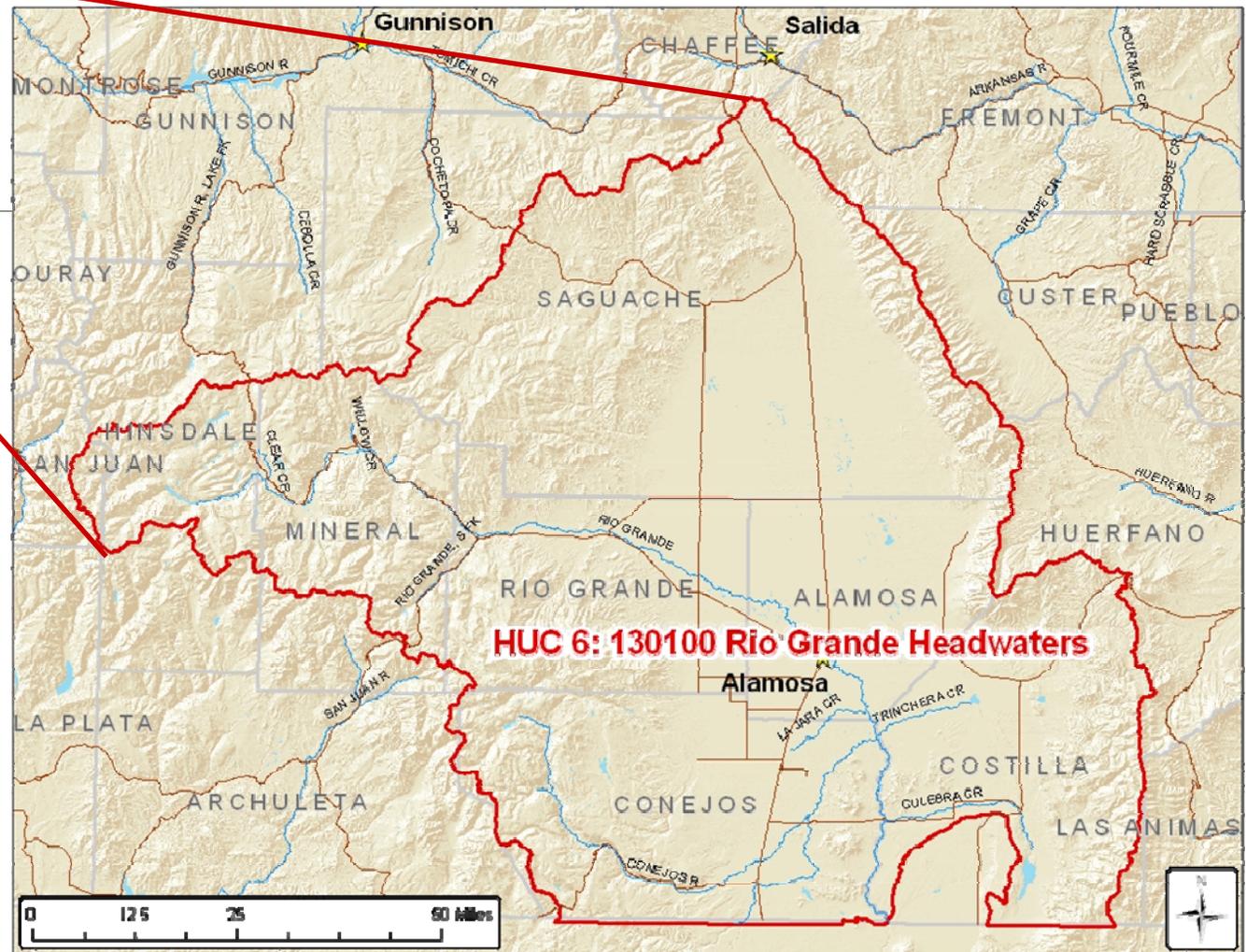


Rio Grande Headwaters Basin

- Area: 19,000 km² (4.7 million acres)
- Elevation Range: 2250–4350 m (7,400–14,275 ft)
- Mean Elevation: 2780 m (9,100 ft)
- 250+ Individual HUC 12 Watersheds

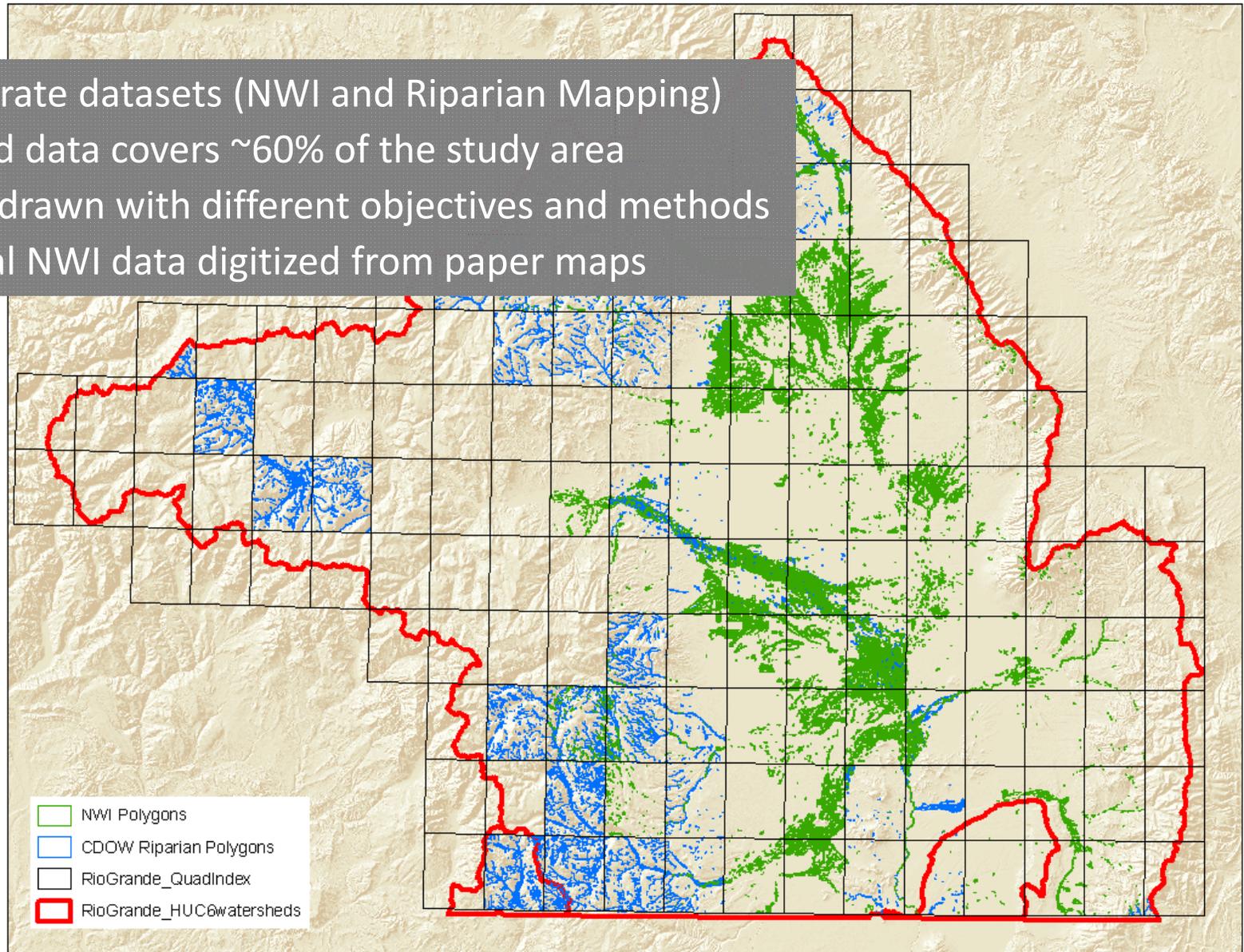
Distinct environmental drivers in different sections of the basin:

- Precipitation
- Geology
- Glacial history
- Elevation gradient
- Land use



Lacking Complete Wetland Spatial Data

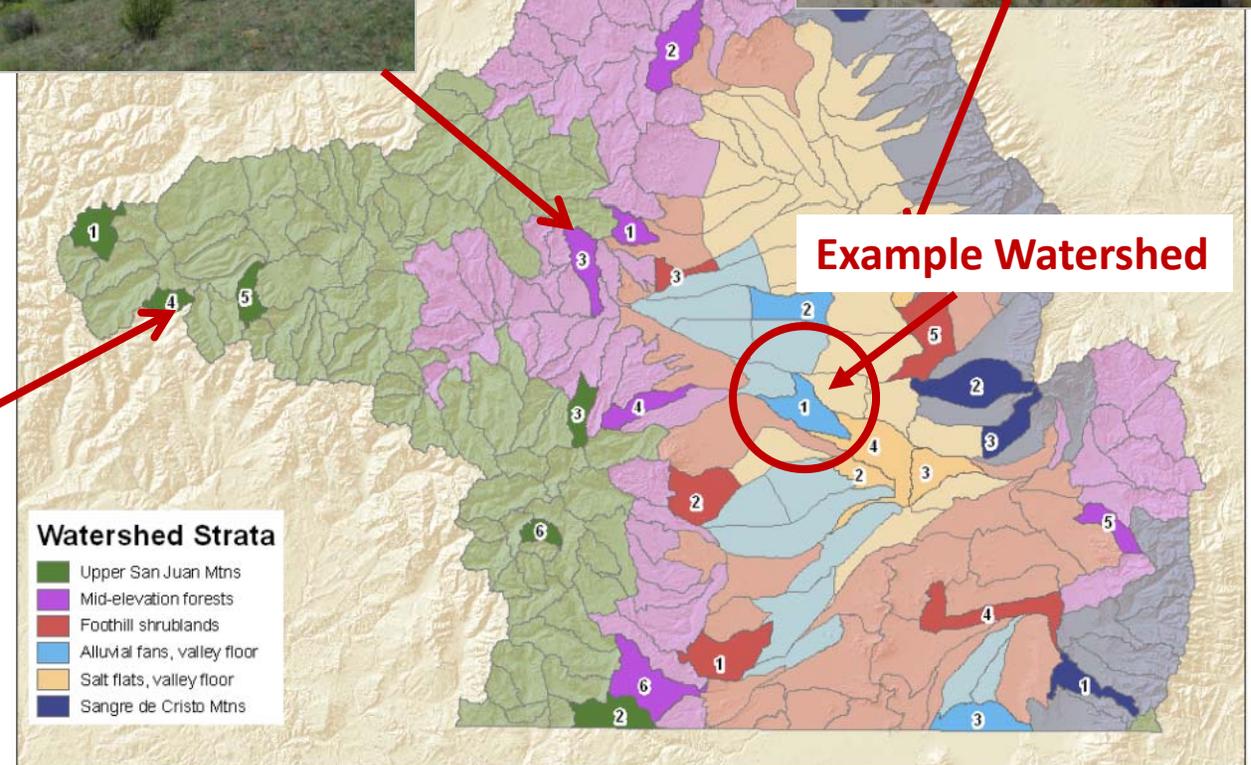
- Two separate datasets (NWI and Riparian Mapping)
- Combined data covers ~60% of the study area
- Datasets drawn with different objectives and methods
- Additional NWI data digitized from paper maps



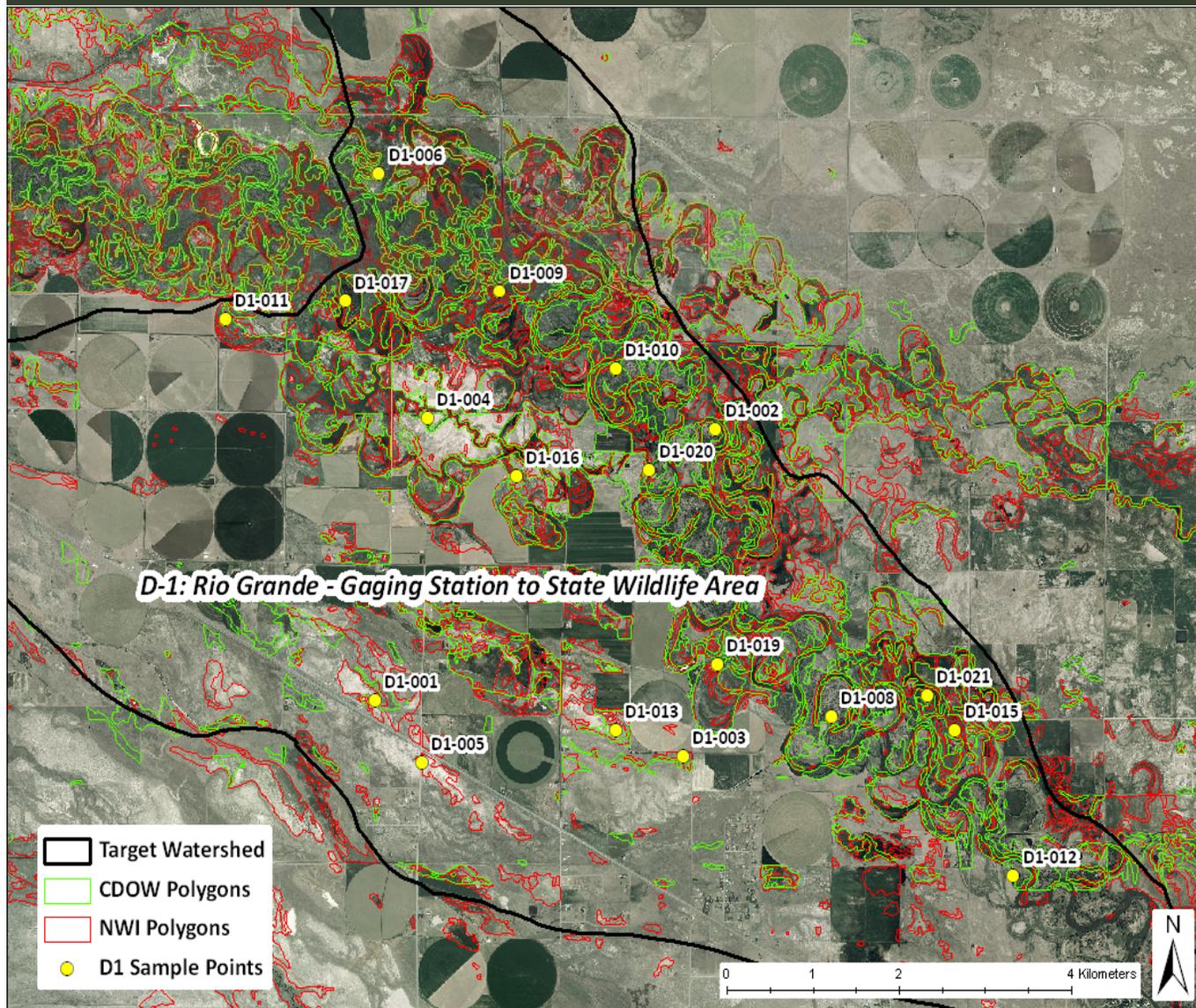
Study Design Stage 1: Watershed Strata and Target Watersheds

Cluster Analysis:

- elevation
- stream gradient
- climate
- geology
- vegetation
- landforms



Study Design Stage 2: Sample Point Selection



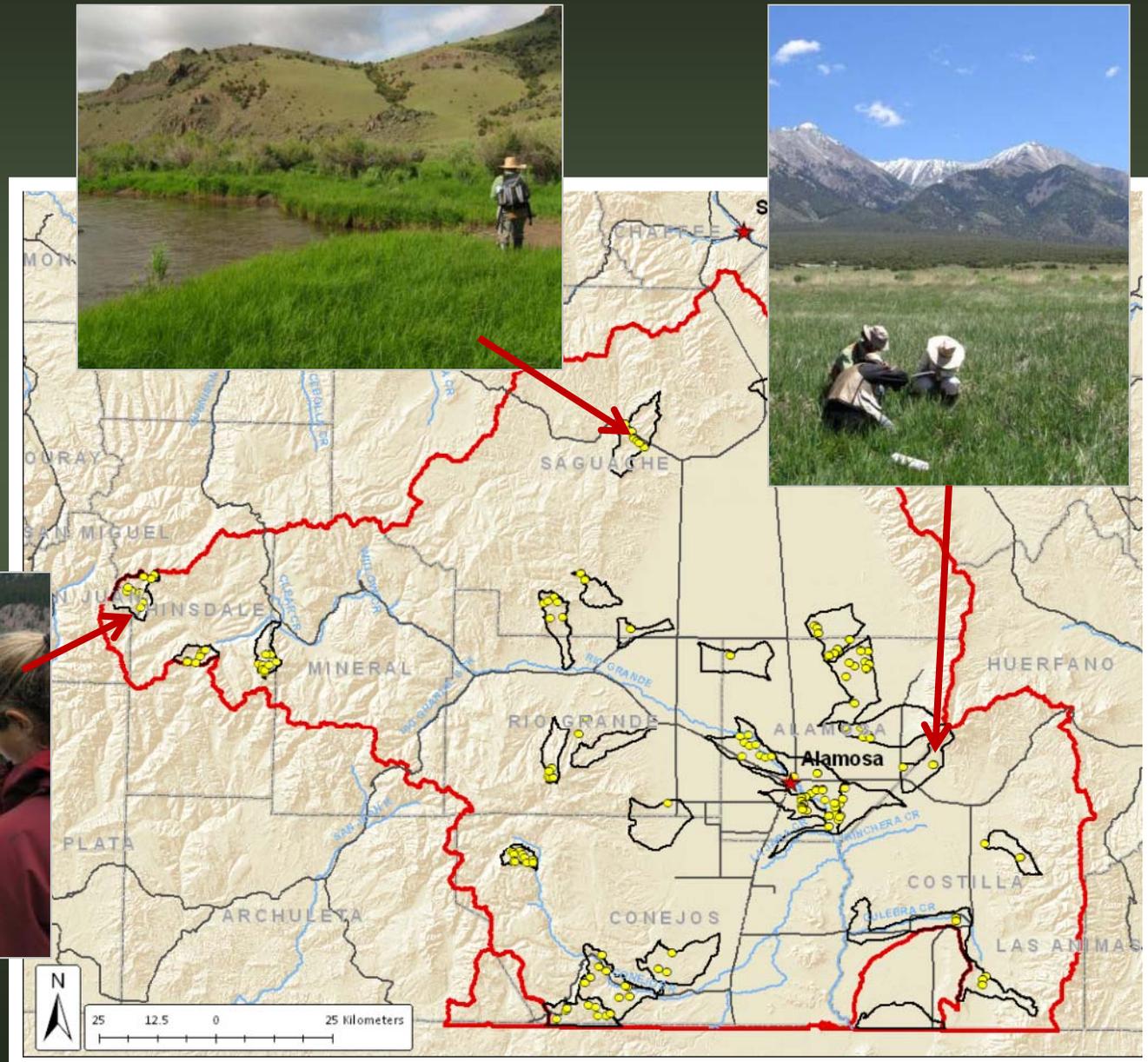
Sample points selected using a spatially balanced random sample survey design.

Number of sample points selected per watershed related to the density of wetland area.

Between 1-12 sample points per watershed.

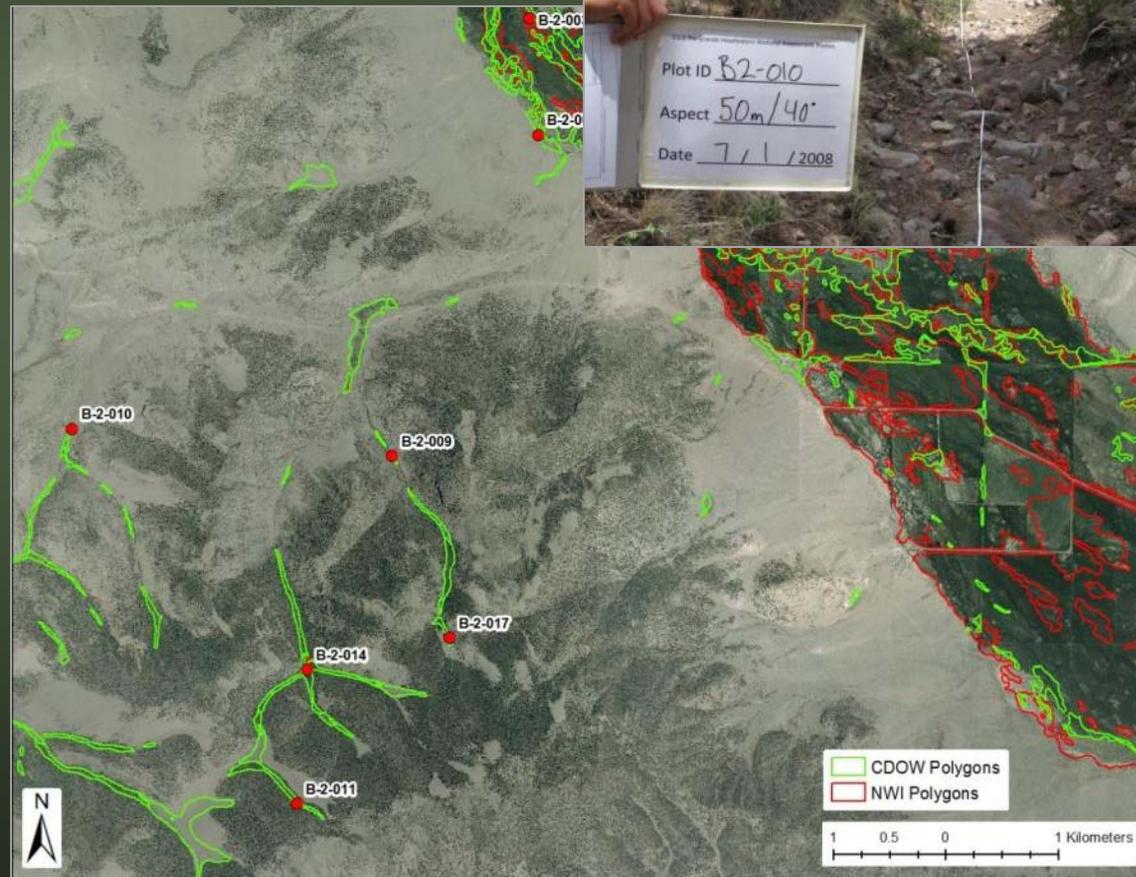
Rio Grande Headwaters Progress to Date

- 150 wetlands sampled between 2008-09
- 30-50 wetlands will be sampled in 2010 (Rio Grande NF)
- Data analysis underway



Lessons Learned from the Rio Grande

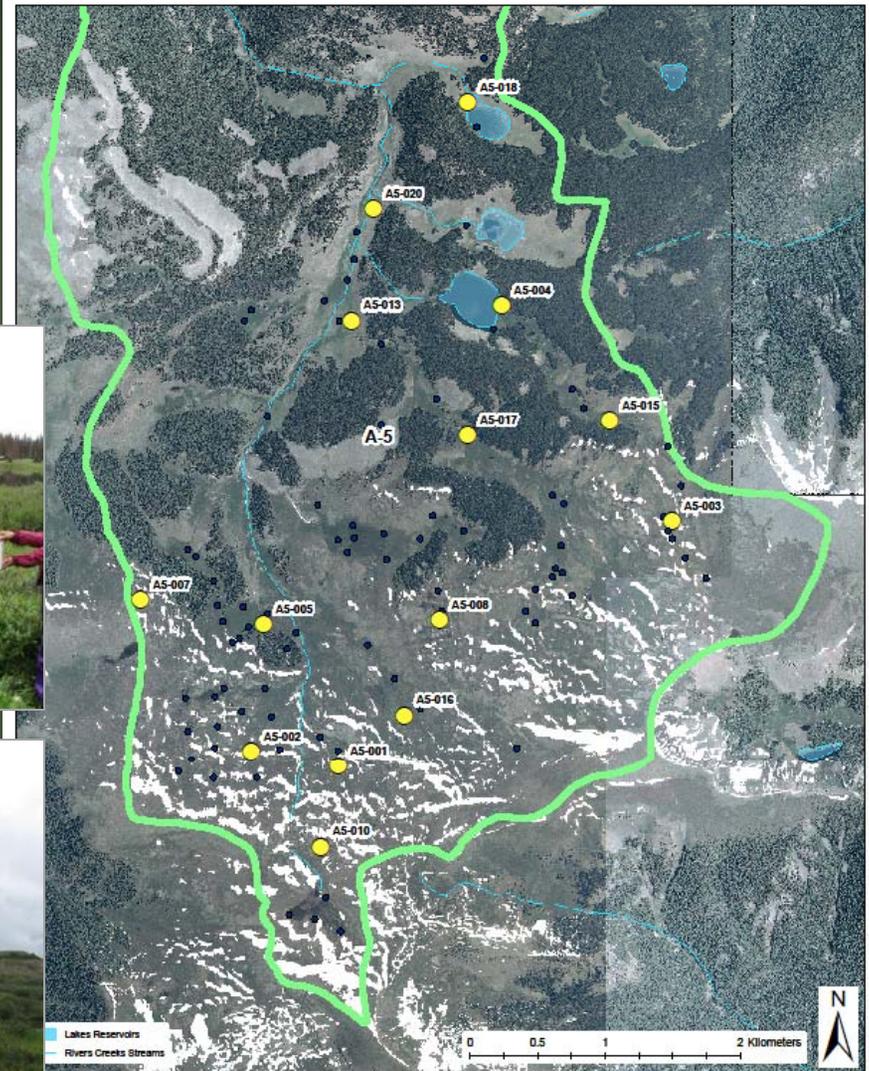
1. Mixing two data layers for the sample frame only works when data layers are very similar



Lessons Learned from the Rio Grande

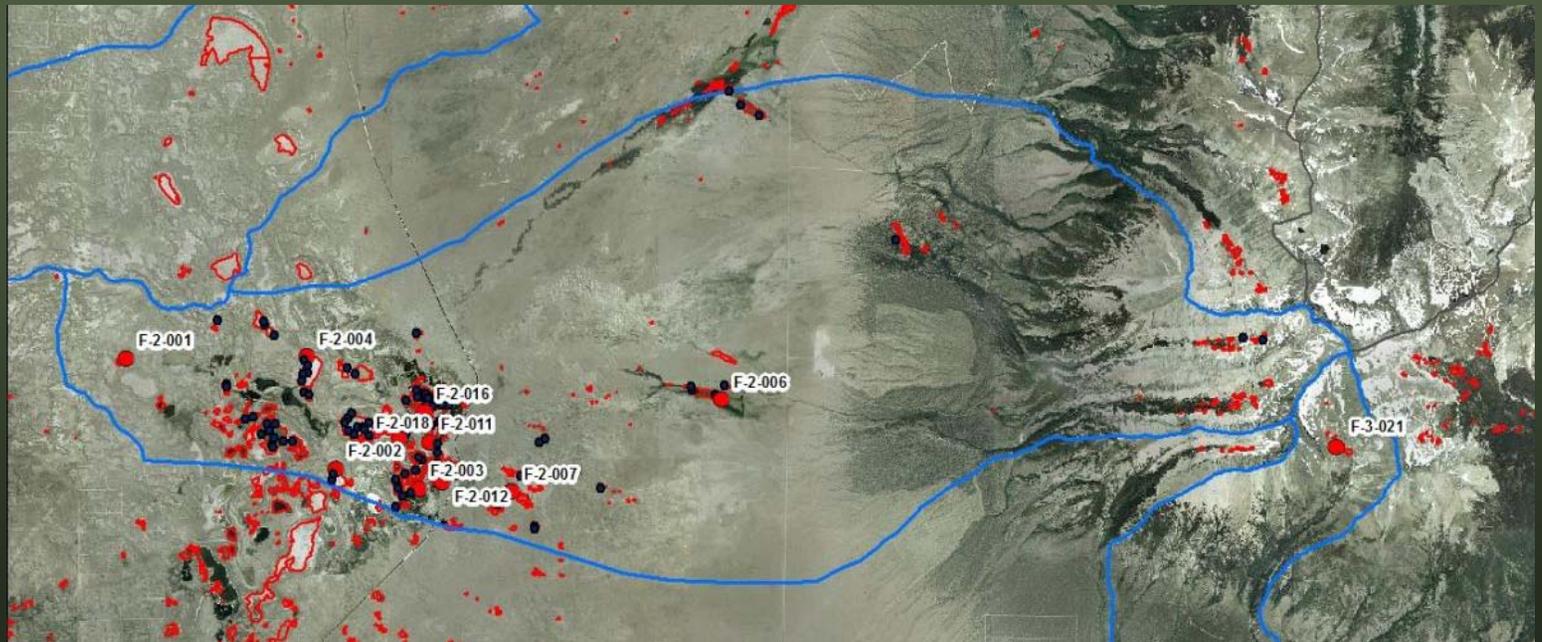
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2. In high mountain areas, target watersheds helped to increase the efficiency in sampling

Watershed A5 Sample Points



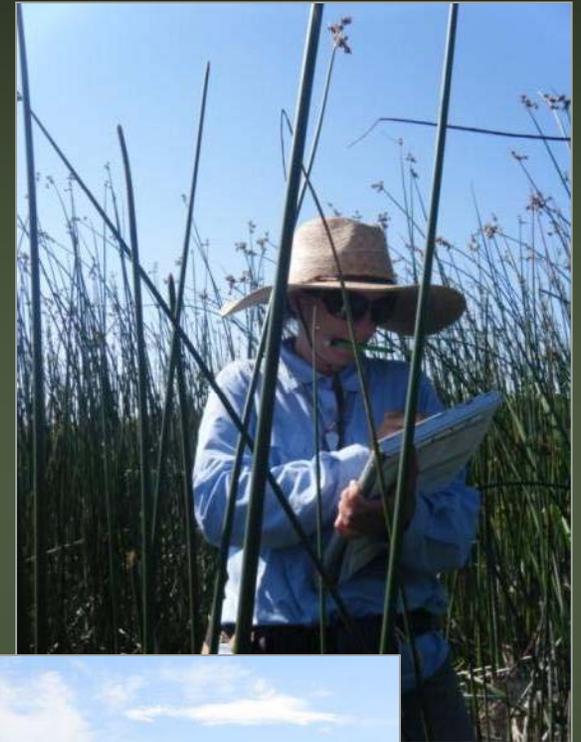
Lessons Learned from the Rio Grande

1. Mixing two data layers for the sample frame only works when data layers are very similar
2. In high mountain areas, target watersheds helped to increase the efficiency in sampling
3. Watershed cluster analysis did not control for the range of variation found with one watershed

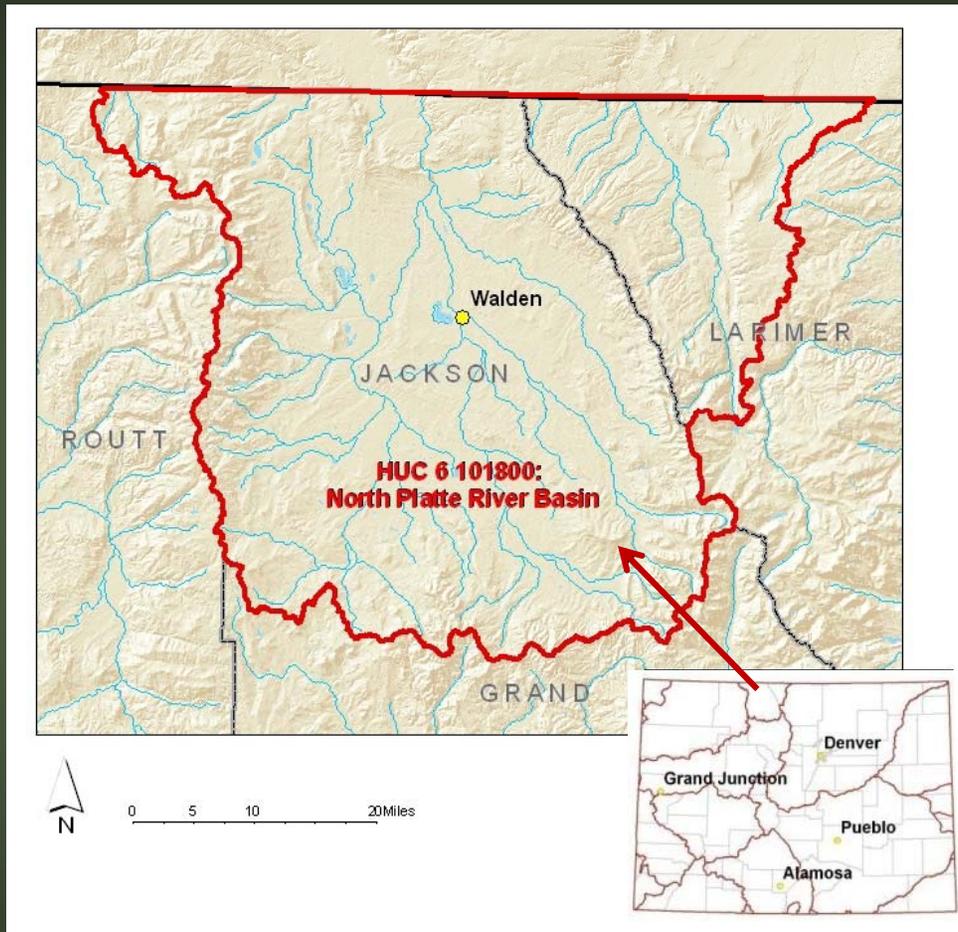


Lessons Learned from the Rio Grande

1. Mixing two data layers for the sample frame only works when data layers are very similar
2. In high mountain areas, target watersheds helped to increase the efficiency in sampling
3. Watershed cluster analysis did not control for the range of variation found with one watershed
4. In rural areas with extensive private land holdings, target watersheds often end up with only a few land owners
5. Pilot project / pilot season always helpful to uncover unknown issues!



North Platte Wetland Condition Assessment



Project Partners:

- CNHP, CDOW, CSU Statistics Dept
- Funded by EPA Region 8

Project Objectives:

1. Compile existing spatial data for wetlands
2. Conduct a statistically valid survey of wetland condition
3. Model the distribution of wetland condition throughout the basin
4. Determine optimal metrics for measuring key habitat features for wildlife

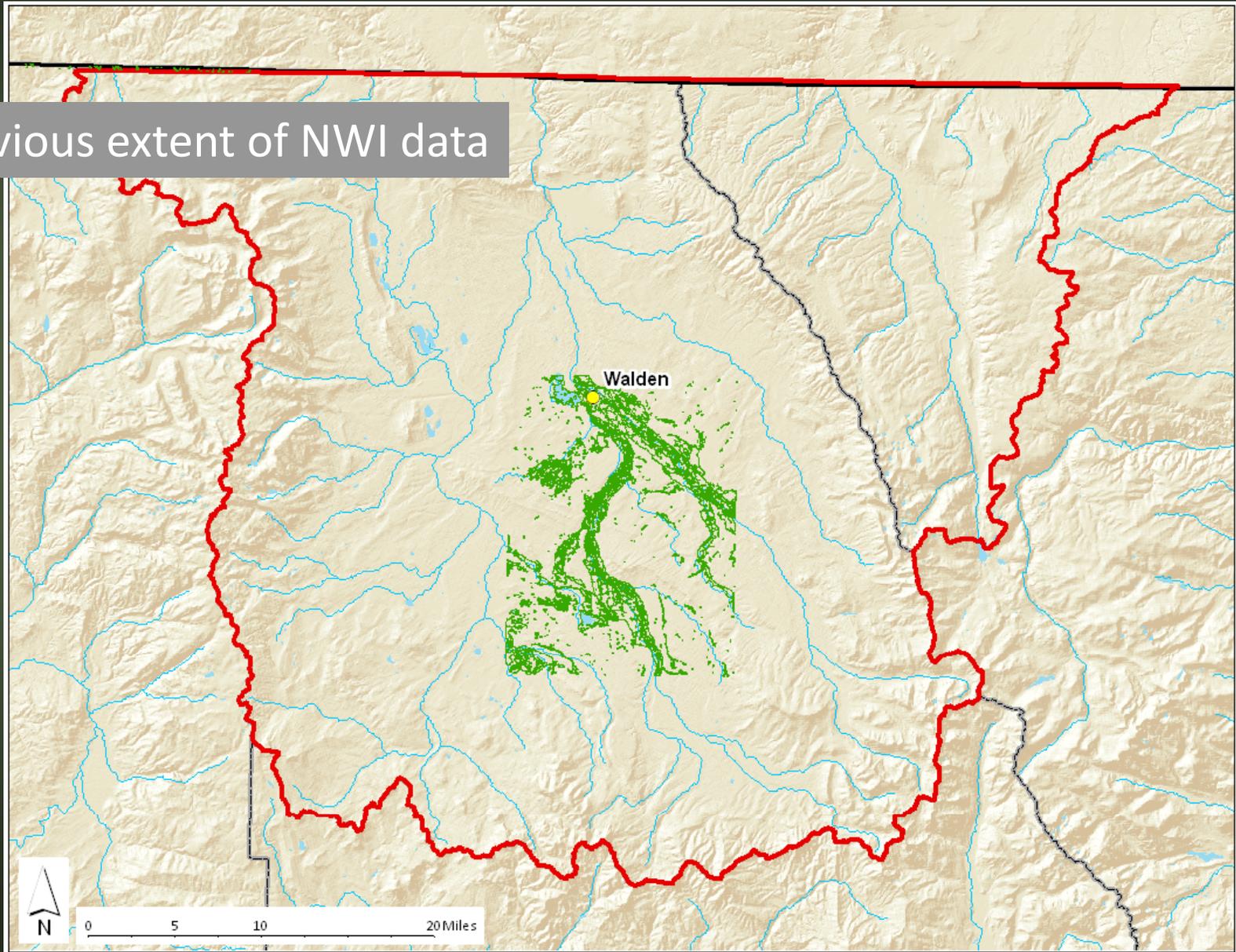
Project Timeline

- 2009 to 2011
- Two seasons on field data collection



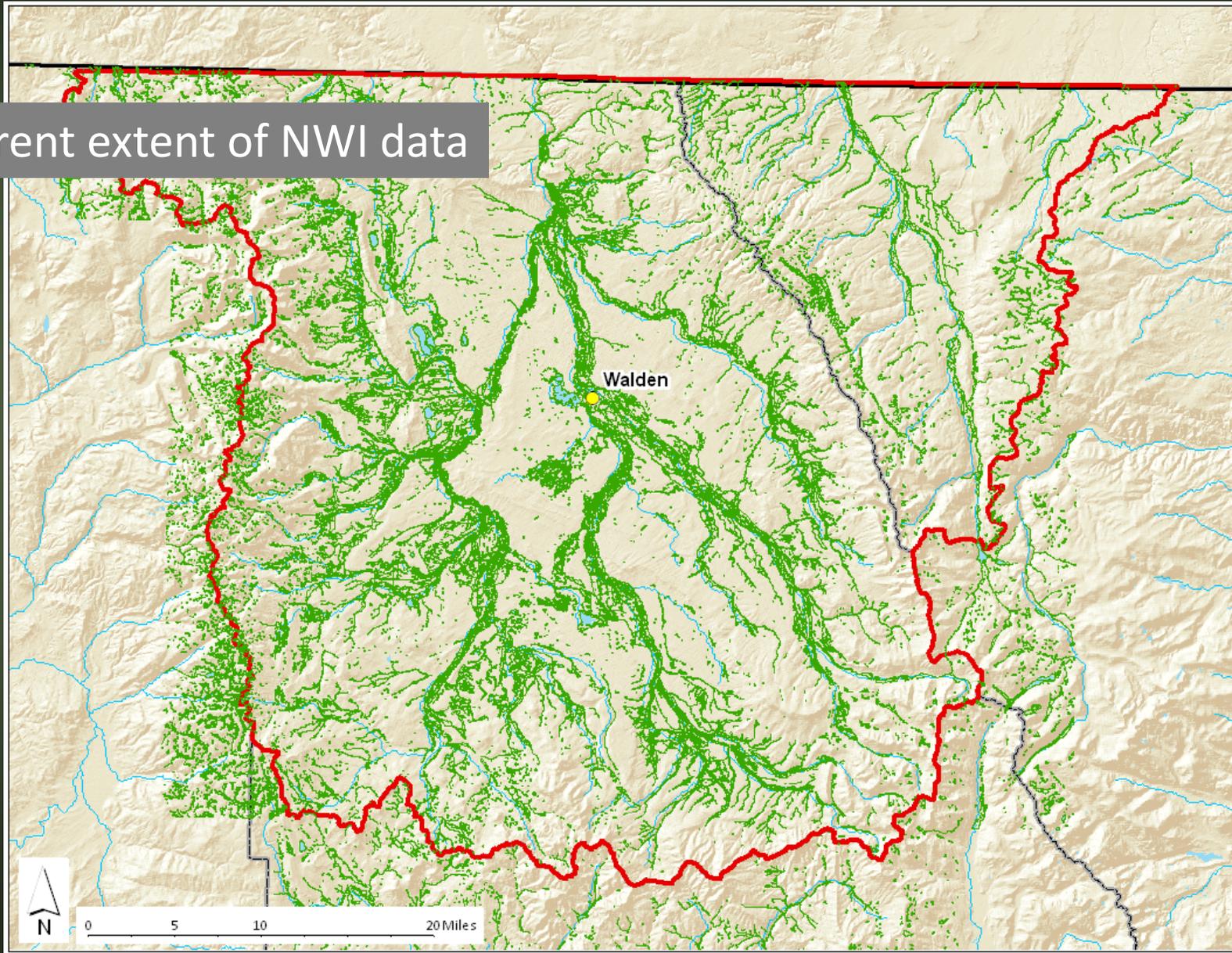
Complete the Sample Frame First

Previous extent of NWI data



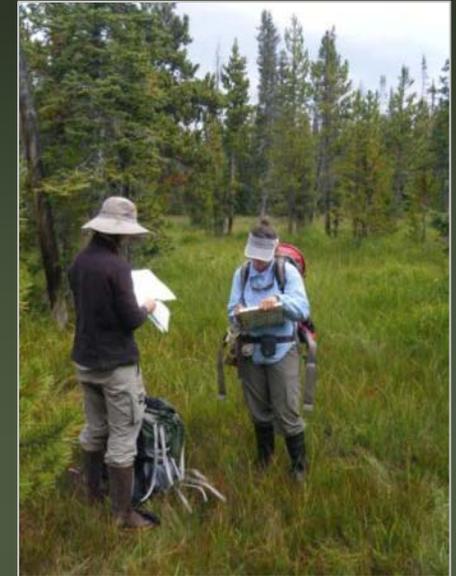
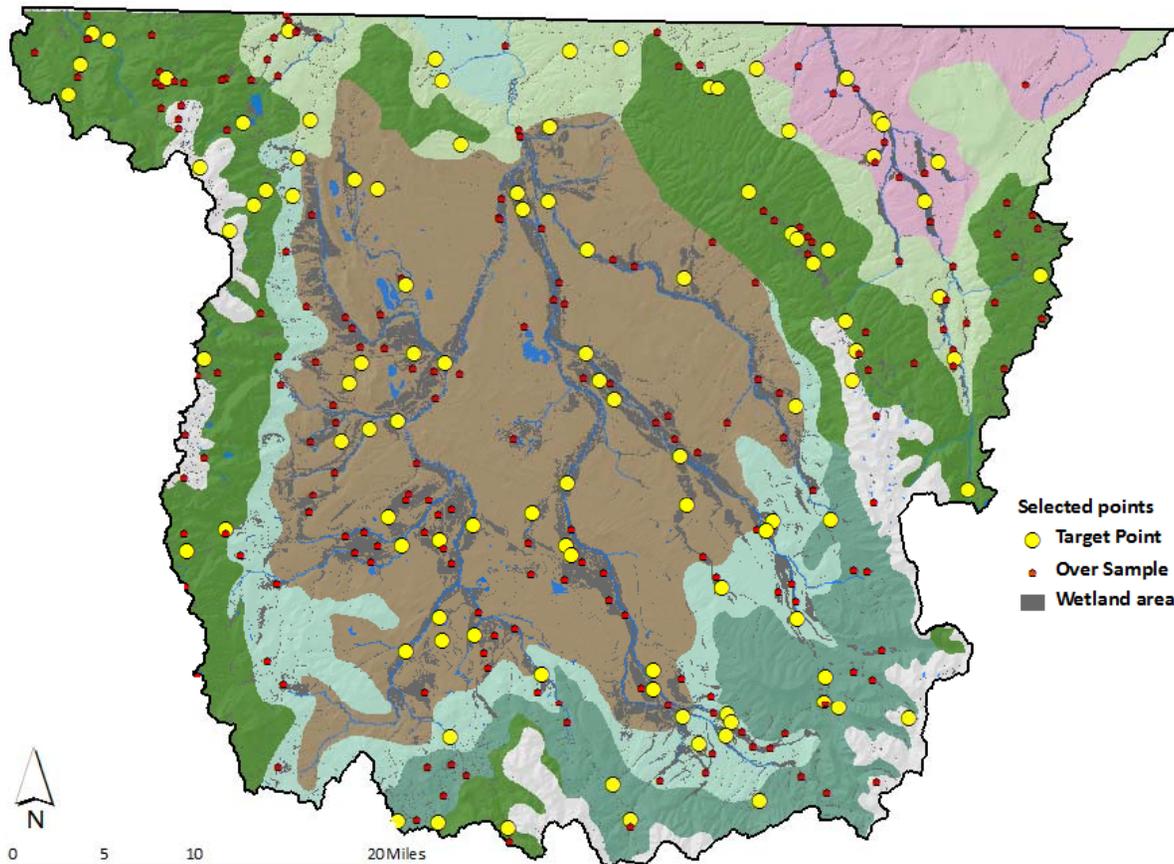
Complete the Sample Frame First

Current extent of NWI data



Initial North Platte Sample Design

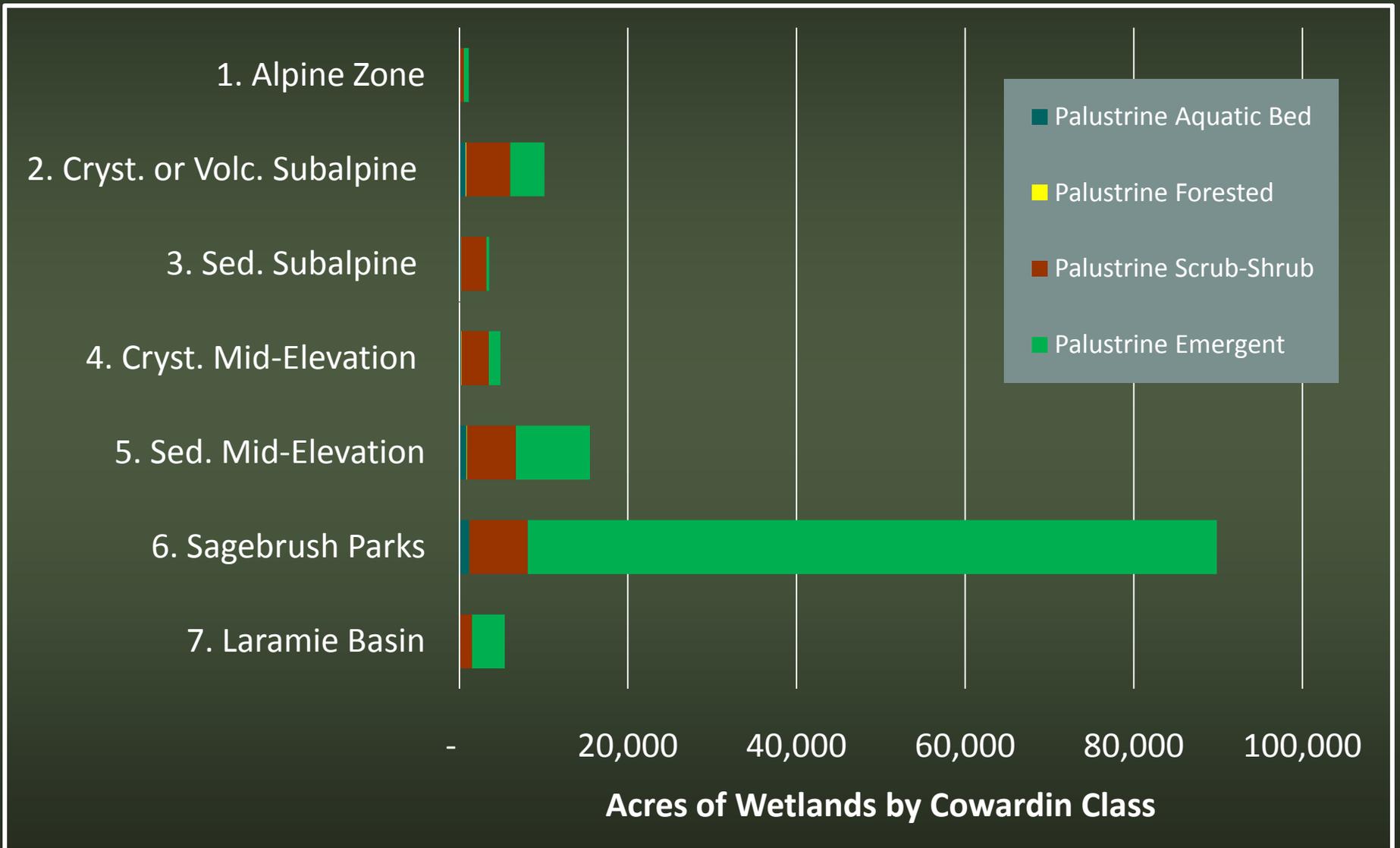
- Area: 5,260 km² (1.3 million acres): <1/3 Rio Grande
- One-stage sample design
- No target watersheds
- Stratified by EPA Level 4 Ecoregion

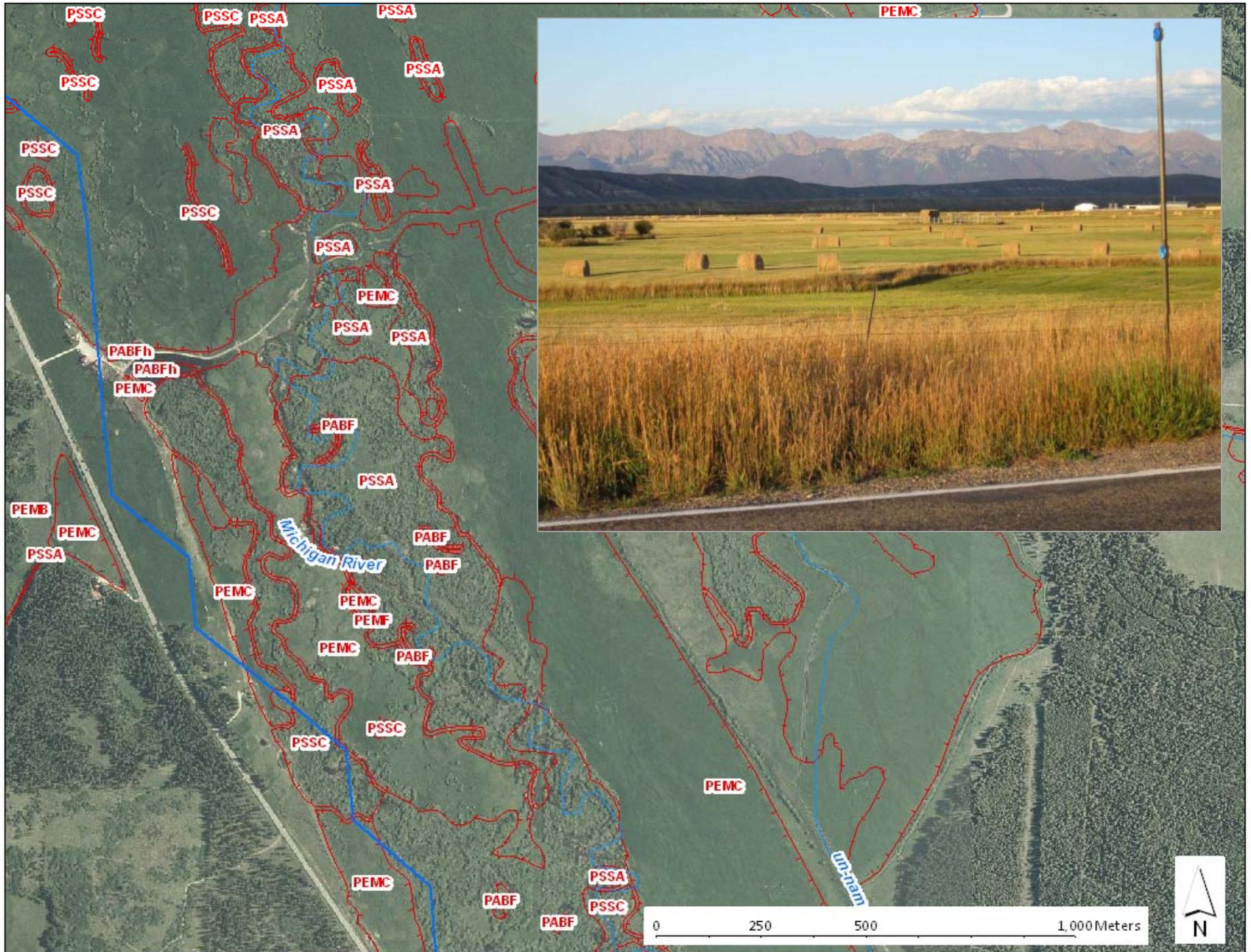


Wetland Acres by Level 4 Ecoregion

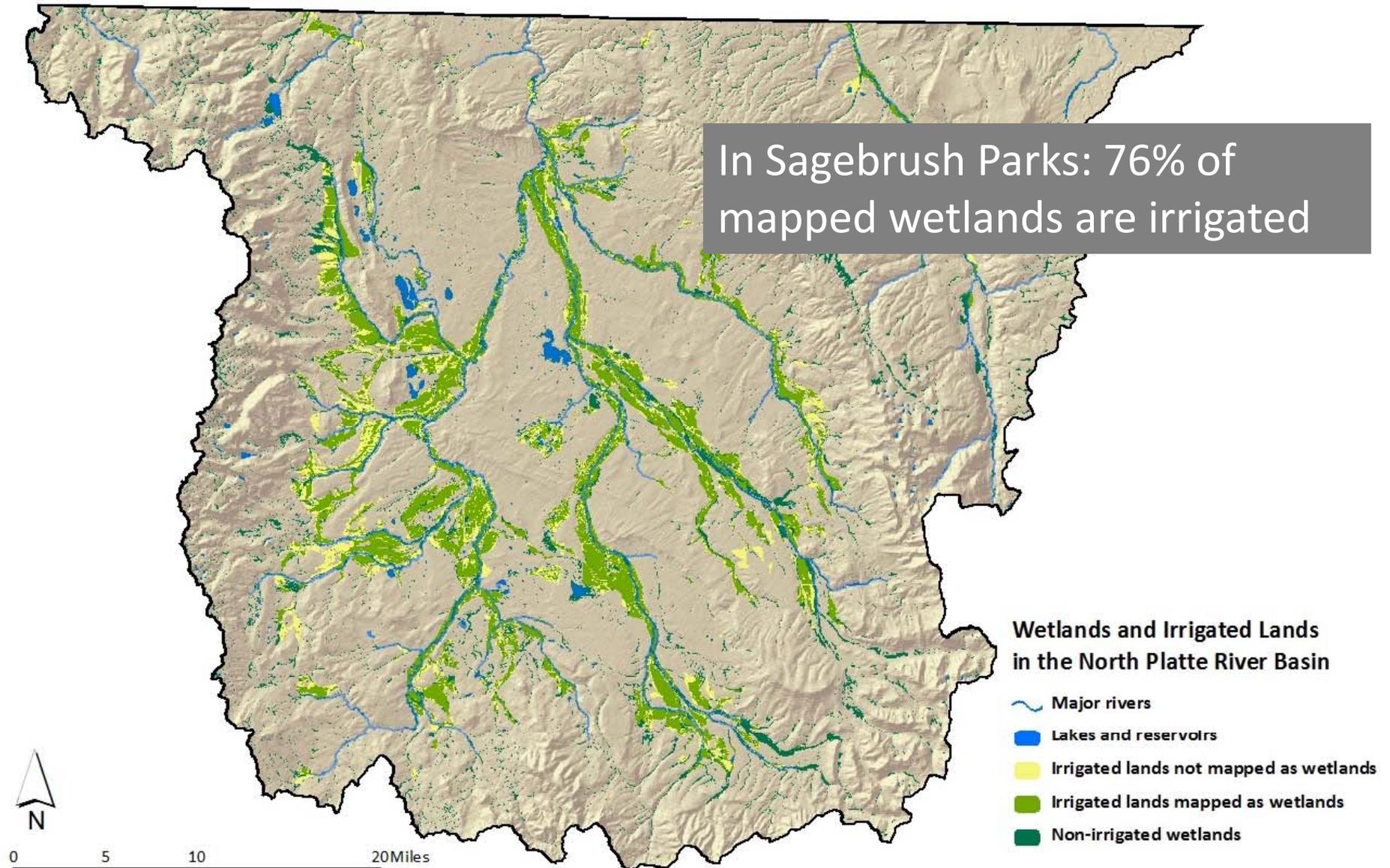
	Percent of Total Study Area	Percent of Total Wetland Area
1. Alpine Zone	5%	1%
2. Crystalline or Volcanic Subalpine Forests	22%	8%
3. Sedimentary Subalpine Forests	9%	3%
4. Crystalline Mid-Elevation Forests and Shrublands	10%	4%
5. Sedimentary Mid-Elev Forests and Shrublands	12%	12%
6. Sagebrush Parks	37%	69%
7. Laramie Basin	6%	4%

Wetland Acres by Level 4 Ecoregion



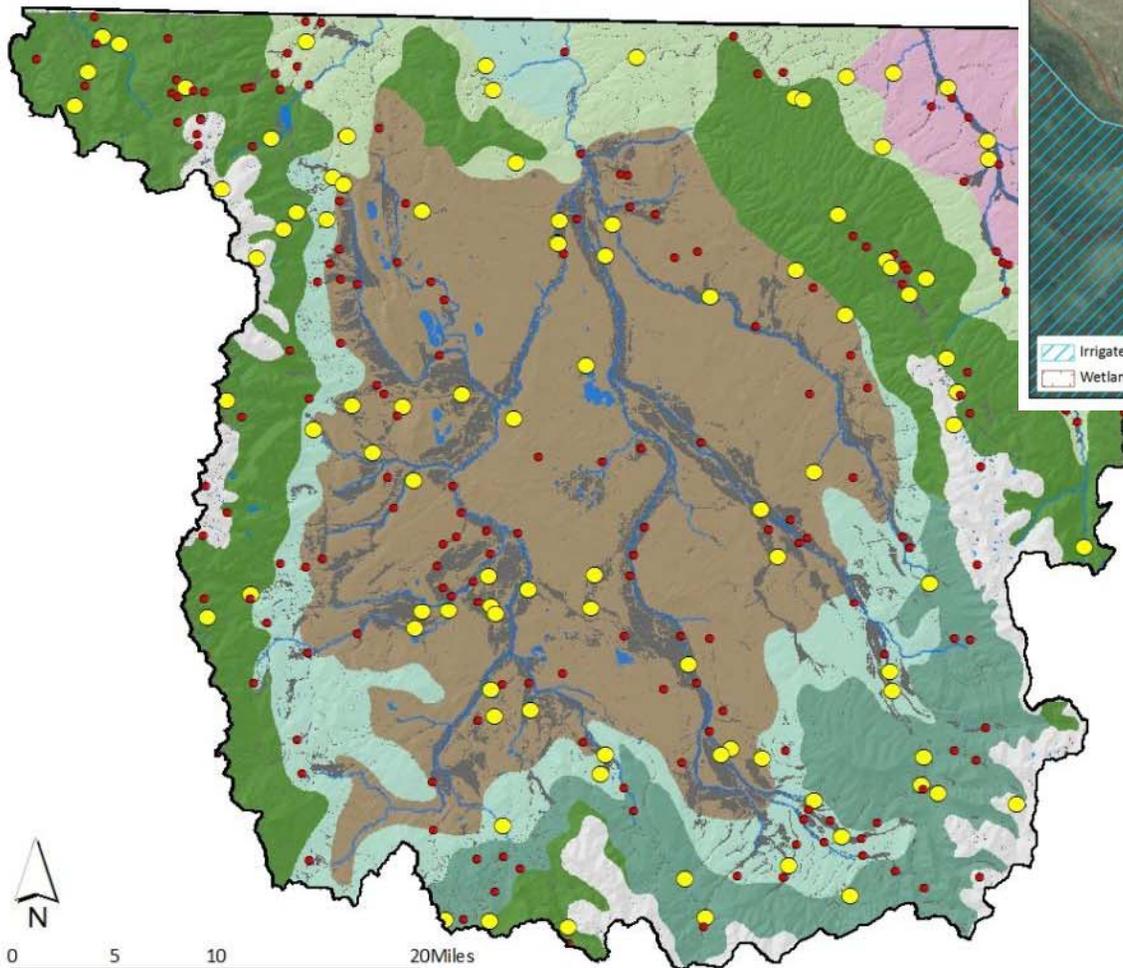


Irrigated Lands Mapped as Wetlands



Final North Platte Design

- Irrigated lands removed based on GIS layer
- Manual desktop screen before field sampling



Selected points

- Target Point
- Over Sample
- Wetland area

Ecoregion strata

- 18f. Laramie Basin
- 21a. Alpine Zone
- 21b/g. Crystalline or Volcanic Subalpine Forests
- 21c. Crystalline Mid-Elevation Forests and Shrublands
- 21e. Sedimentary Subalpine Forests
- 21d/f. Sedimentary Foothills/Mid-Elevation Forests and Shrublands
- 21i. Sagebrush Parks

Lessons Learned from the North Platte

1. Preliminary field season very important to uncover problems!
2. Many areas mapped in NWI are not within our target population
3. No GIS layer is perfect match for target, manual examination of points is necessary
4. Having spatial data allows for simpler one-stage design, better for smaller river basins



Rocky Mountain Regional Wetland Assessment

Project Partners:

- Colorado
- Montana
- Wyoming
- Funded through EPA REMAP

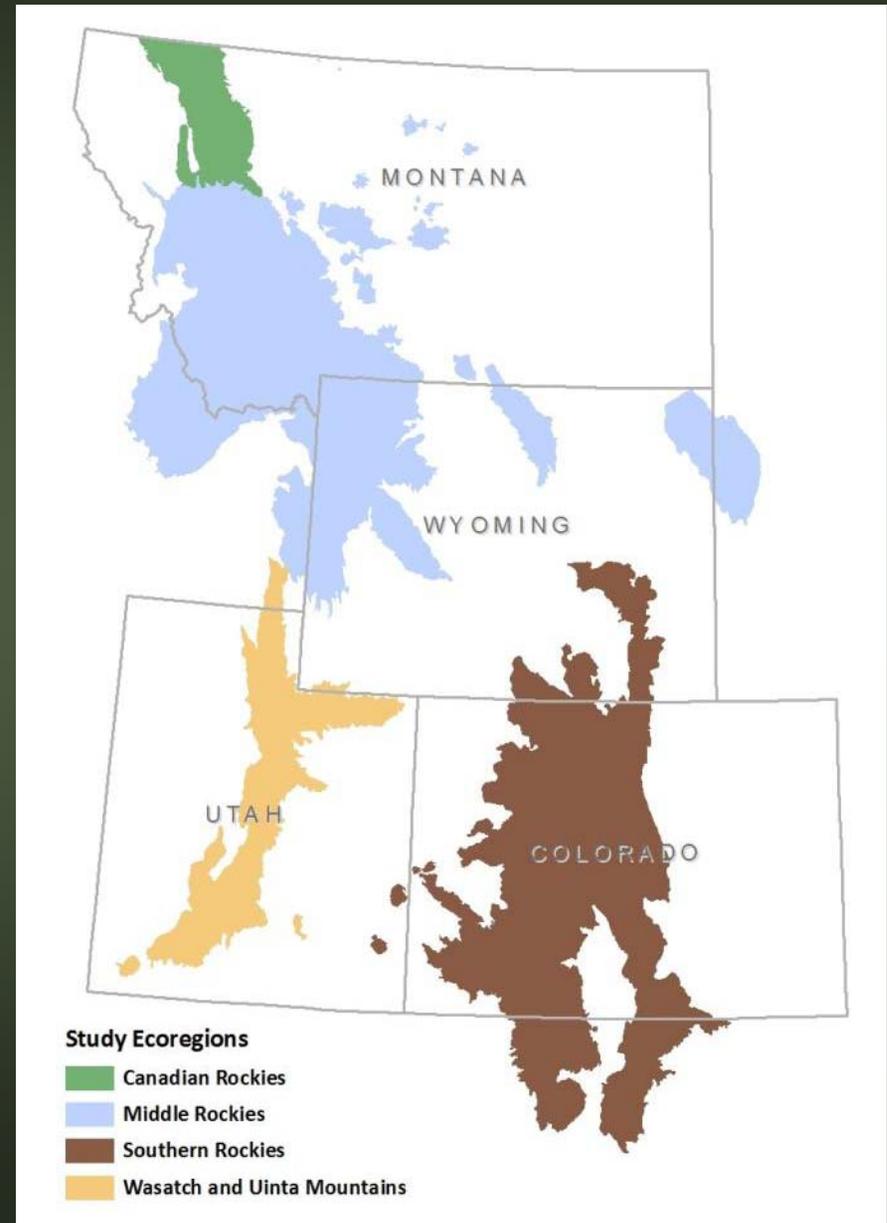


Project Objectives:

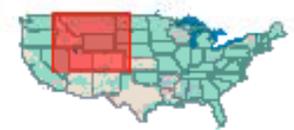
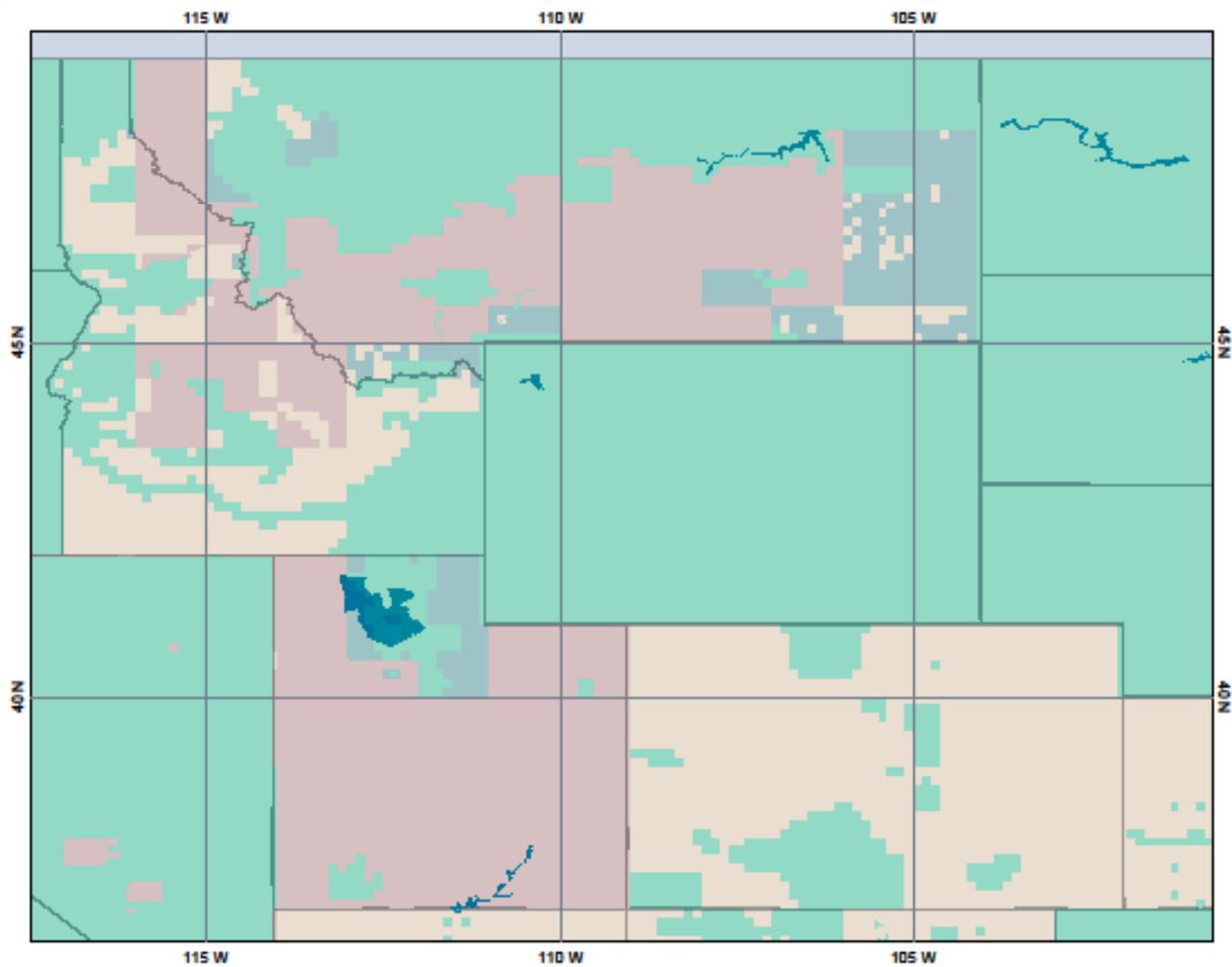
1. Develop a regional network of reference condition wetlands: fens, wet meadows, marshes, riparian shrublands
2. Quantify the range of variability within reference condition wetlands
3. Select regionally applicable indicators and methods
4. Support the 2011 NWCA

Project Timeline

- 2009 to 2011
- Two seasons on field data collection



NWI Coverage in the Rocky Mountains



Legend

- Lower 48 Available Wetland Data
- Non-Digital
 - Digital
 - No Data
 - Scan
 - Major Waterbodies
 - 25M
 - South America
 - North America

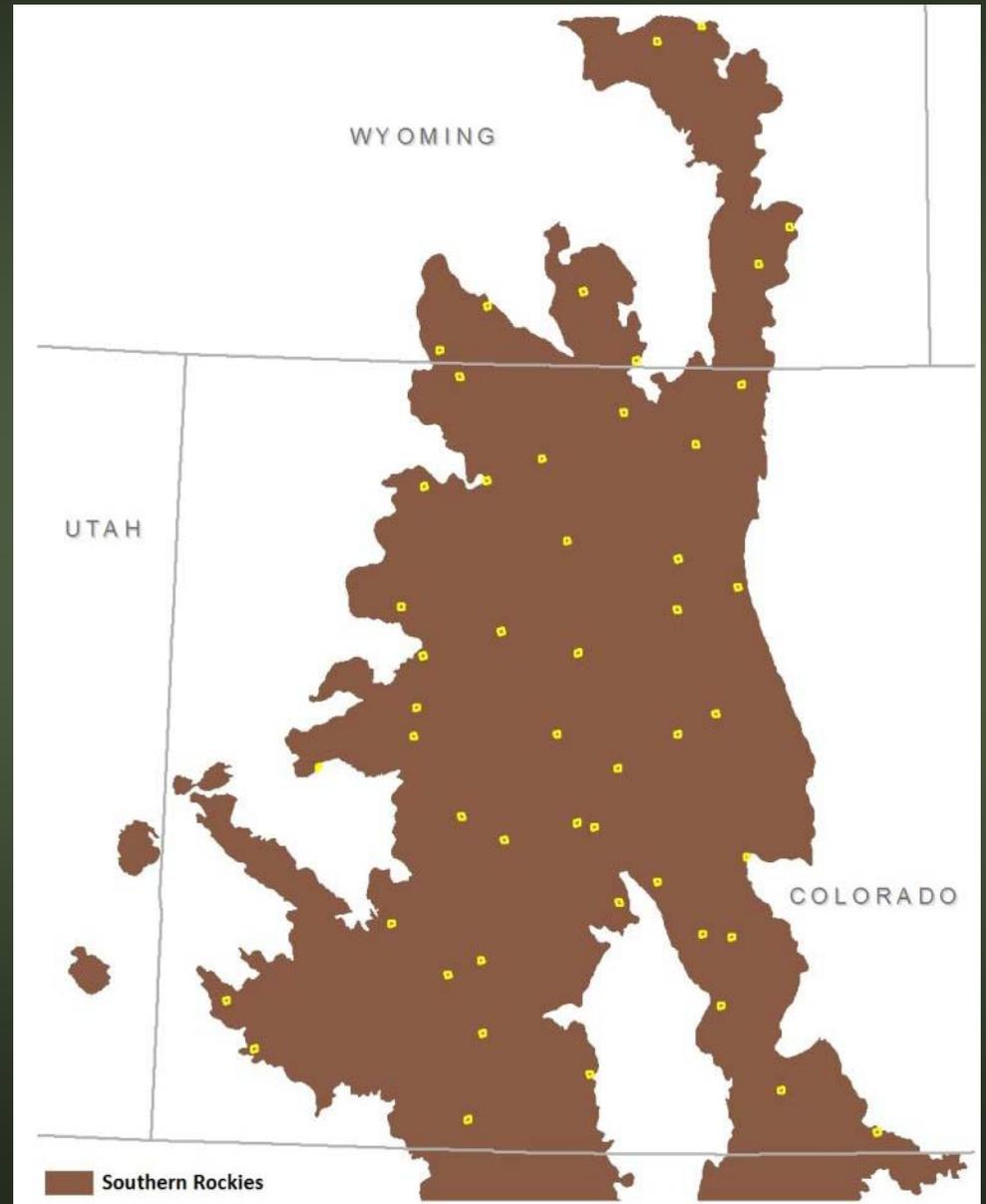
Map center: 42°58' N, 109°8' W

Scale: 1:10,000,000

This map is a user generated static output from an internet mapping site and is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. THIS MAP IS NOT TO BE USED FOR NAVIGATION.

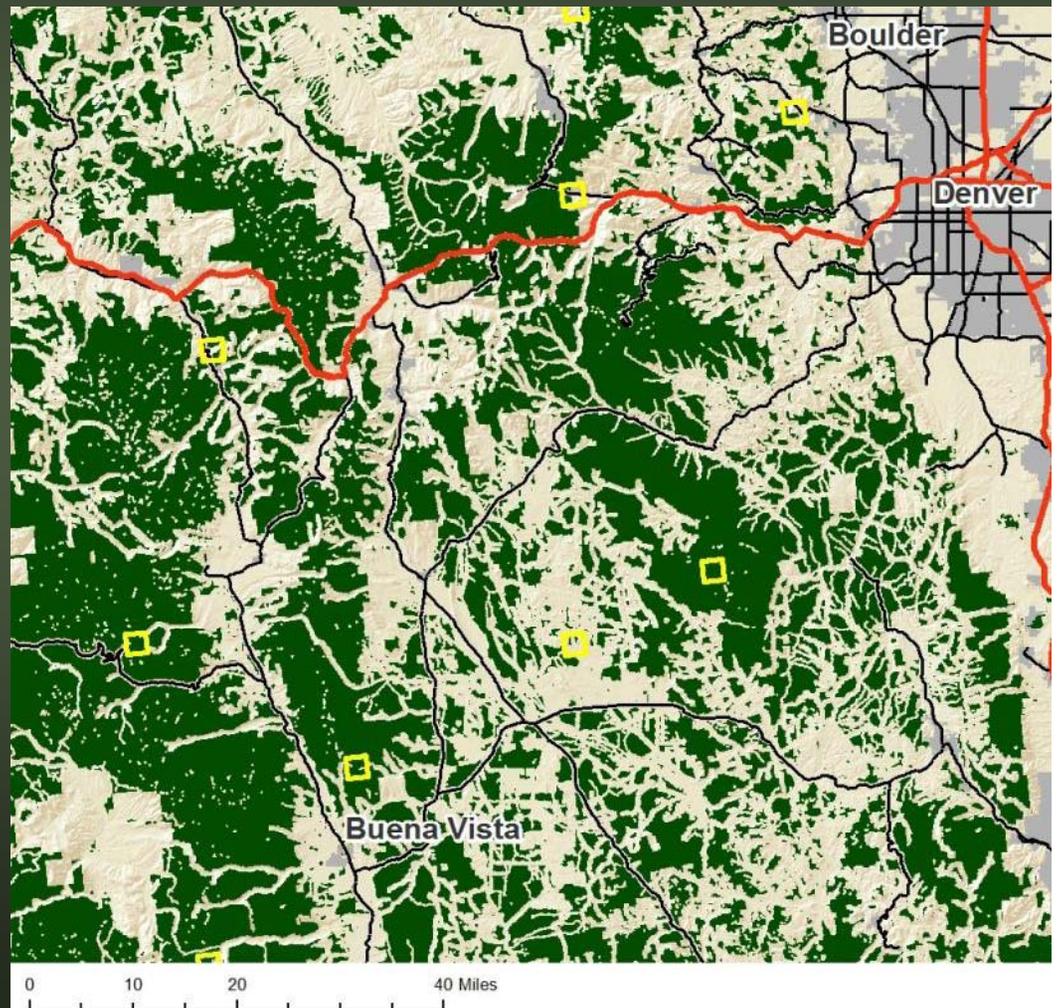
Stage One: Target Cells

- Selected 2x2 mile cells across each Level 3 Ecoregion
- 50 bases cells and 100 oversample



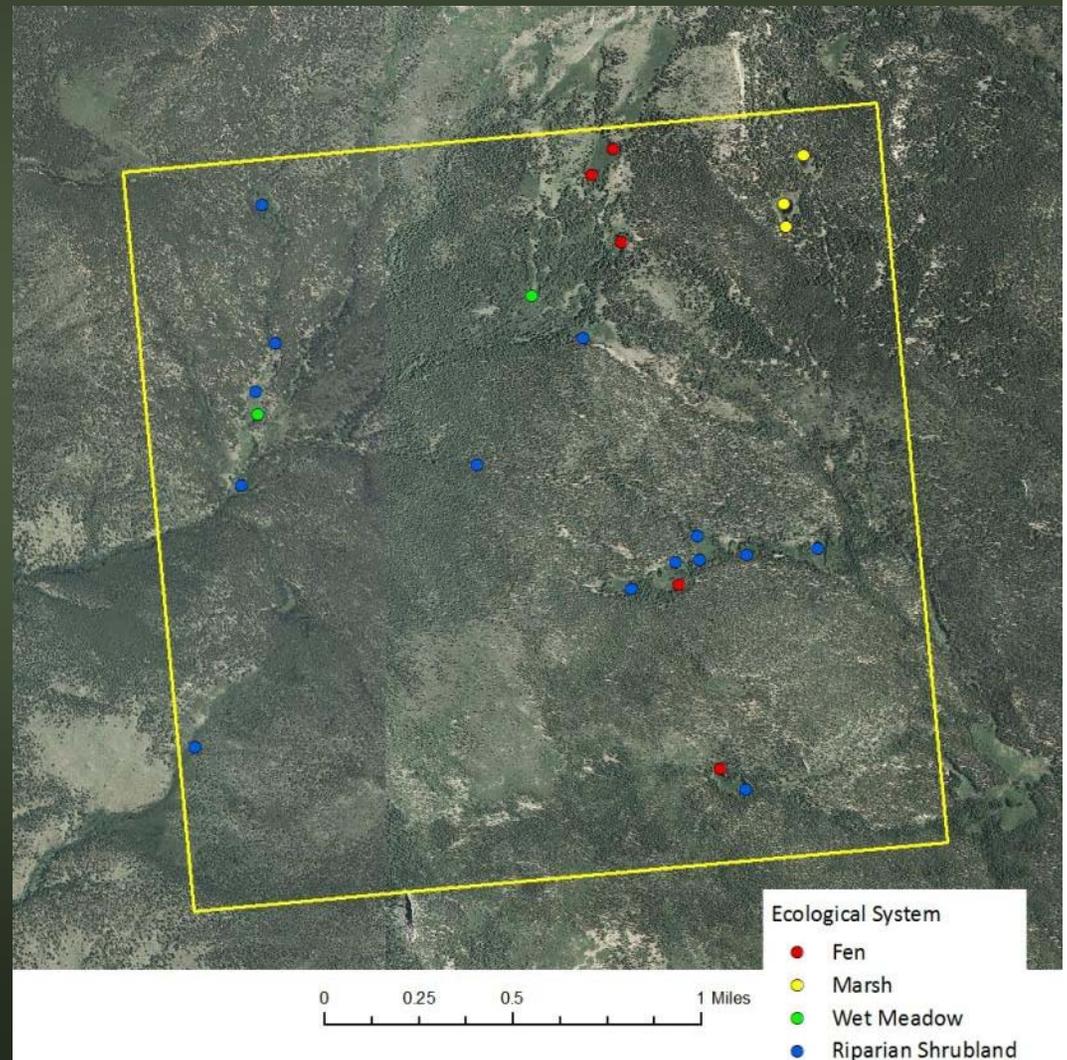
Landscape Integrity Model

- Used Level 1 Landscape Integrity Model to guide us towards reference condition
- Developed by MTNHP
- Incorporates numerous landscape-based stressors
- Weighted algorithm based on a distance-decay function for each stressor
- Low integrity landscape excluded from the sample frame



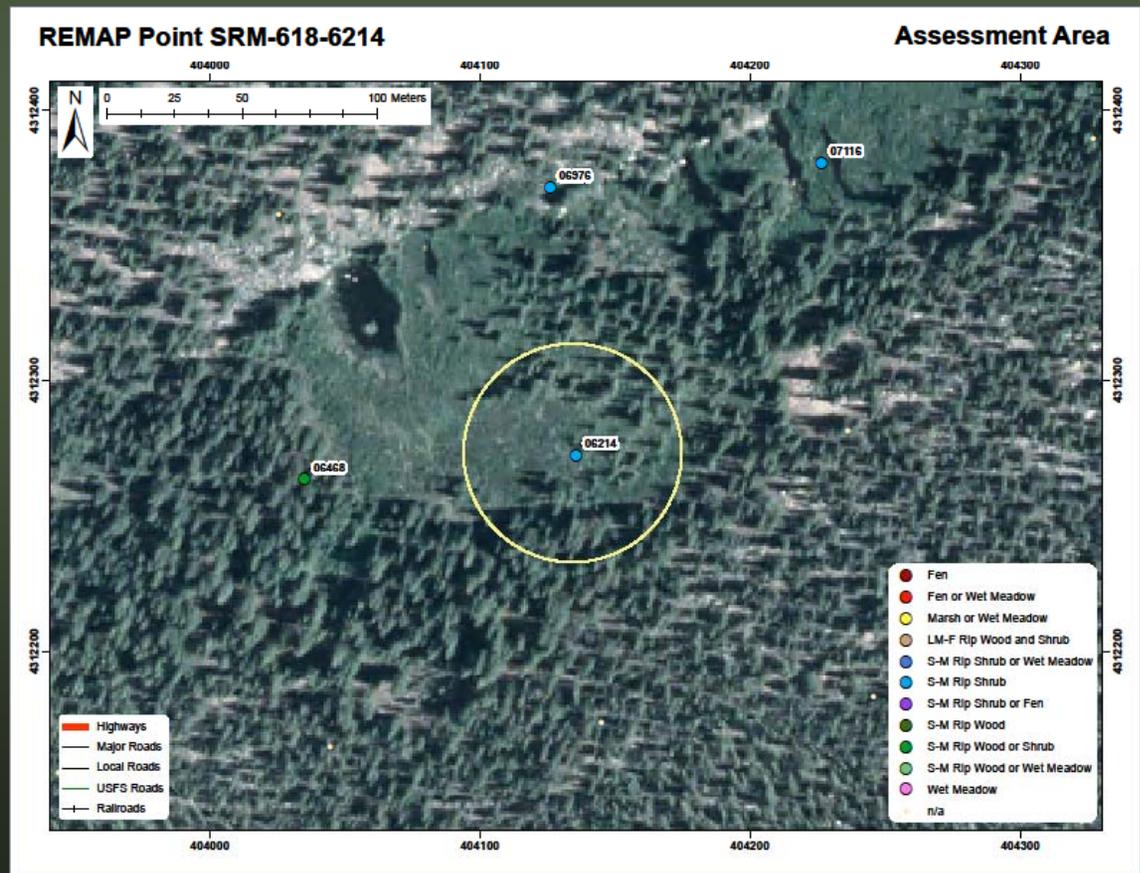
Stage Two: Point Screening and Selection

- Within the high integrity landscape of each target cell, laid down a grid of points
- Points ordered by GRTS in a spatially balance random sequence
- Identified all potential wetlands within the cells through photo-interpretation, classified by wetland type
- Selected the first ordered point from each different wetland type for sampling



Stage Two: Point Screening and Selection

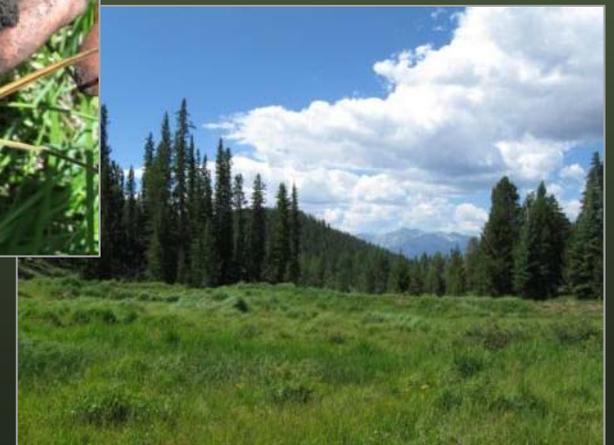
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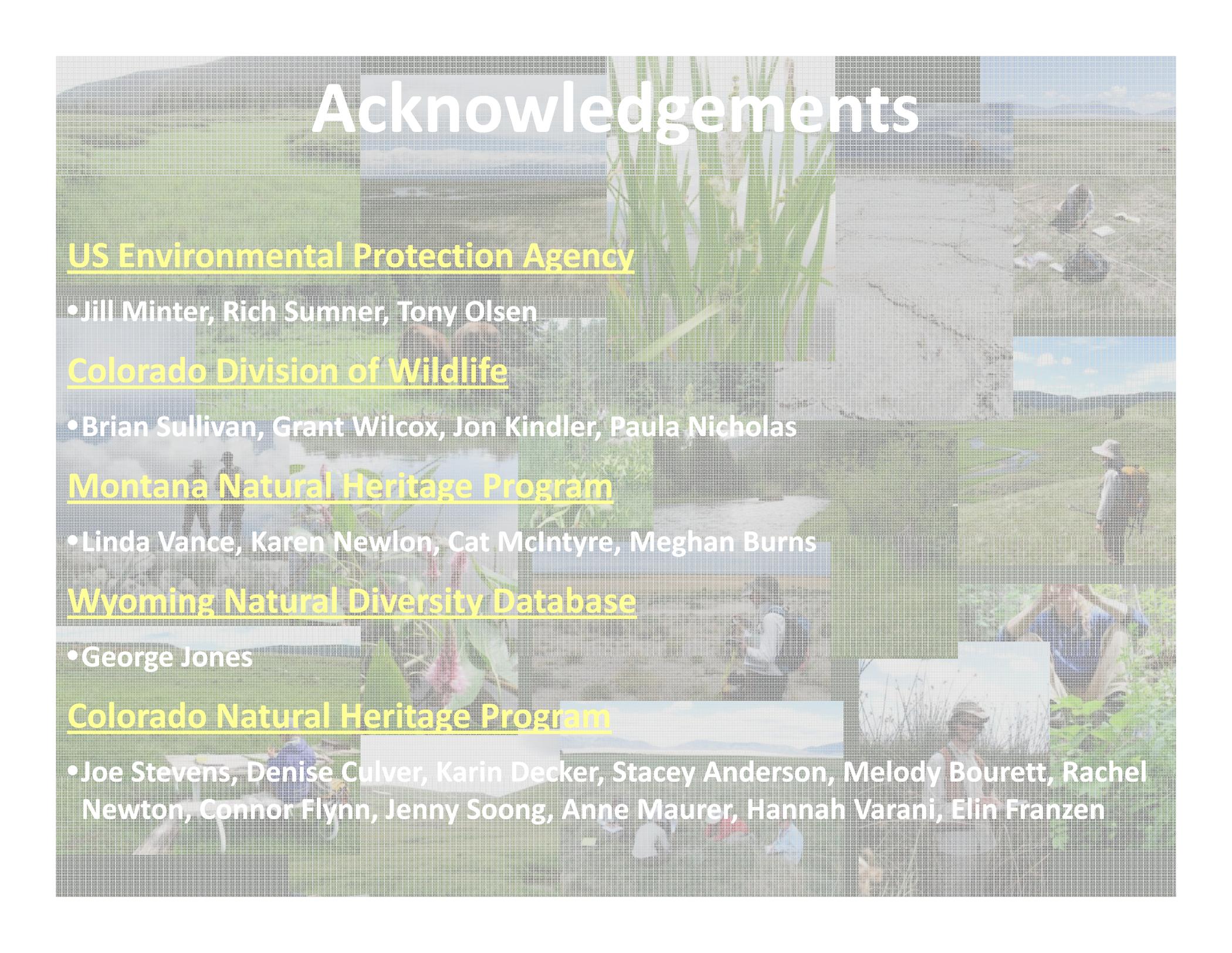
Lessons Learn from Rocky Mtn REMAP

1. Preliminary field season very important to uncover problems!
2. Random sample designs are difficult without spatial data
3. Important to have a *very clear* definition of your target populations, particularly when lacking spatial data or lacking proper attributes in your spatial data.
4. Will it be more robust than targeted sites?

Ask us next year when the data are analyzed!



Acknowledgements



US Environmental Protection Agency

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Wyoming Natural Diversity Database

- George Jones

Colorado Natural Heritage Program

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Questions?

