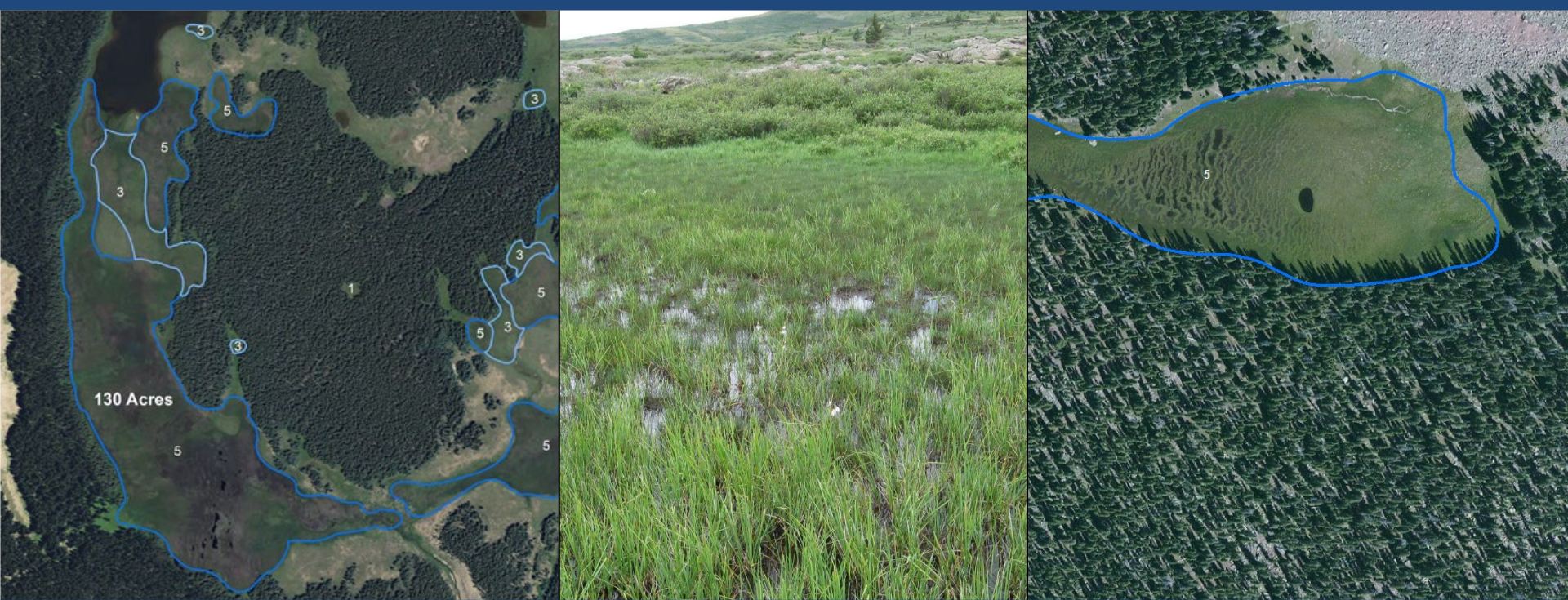


# Mapping Fen Wetlands on National Forests through Aerial Photo Interpretation

Utah Geological Survey, Wetlands Working Group Salt Lake City, UT Nov. 20, 2019



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WARNER COLLEGE  
OF NATURAL RESOURCES  
COLORADO STATE UNIVERSITY

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US Forest Service





# Colorado Natural Heritage Program

- Non-profit organization based at Colorado State University
- Research unit within the Warner College of Natural Resources, funded by grants and contracts.
- Part of an international network of Heritage programs. NatureServe is umbrella over network.
- Mission: *To advance conservation of Colorado's native species and ecosystems through science, planning, and education for the benefit of future generations.*



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# What are Fens?

- Groundwater dependent ecosystems (GDE)
- Due to constant groundwater flows and landscape position, fens maintain saturated conditions year round
- Peat forming ( $\geq 40$  cm peat = fen)
- Typically high elevations (9,000 - 12,000')
- Practically irreplaceable due to extremely slow peat formation
- Fens have high conservation value!
  - They store carbon
  - Maintain stream baseflows
  - Habitat for fen plant species
- USFS includes GDEs in their Land Management Plans (Forest Plans)



# Project Forests & Timeline

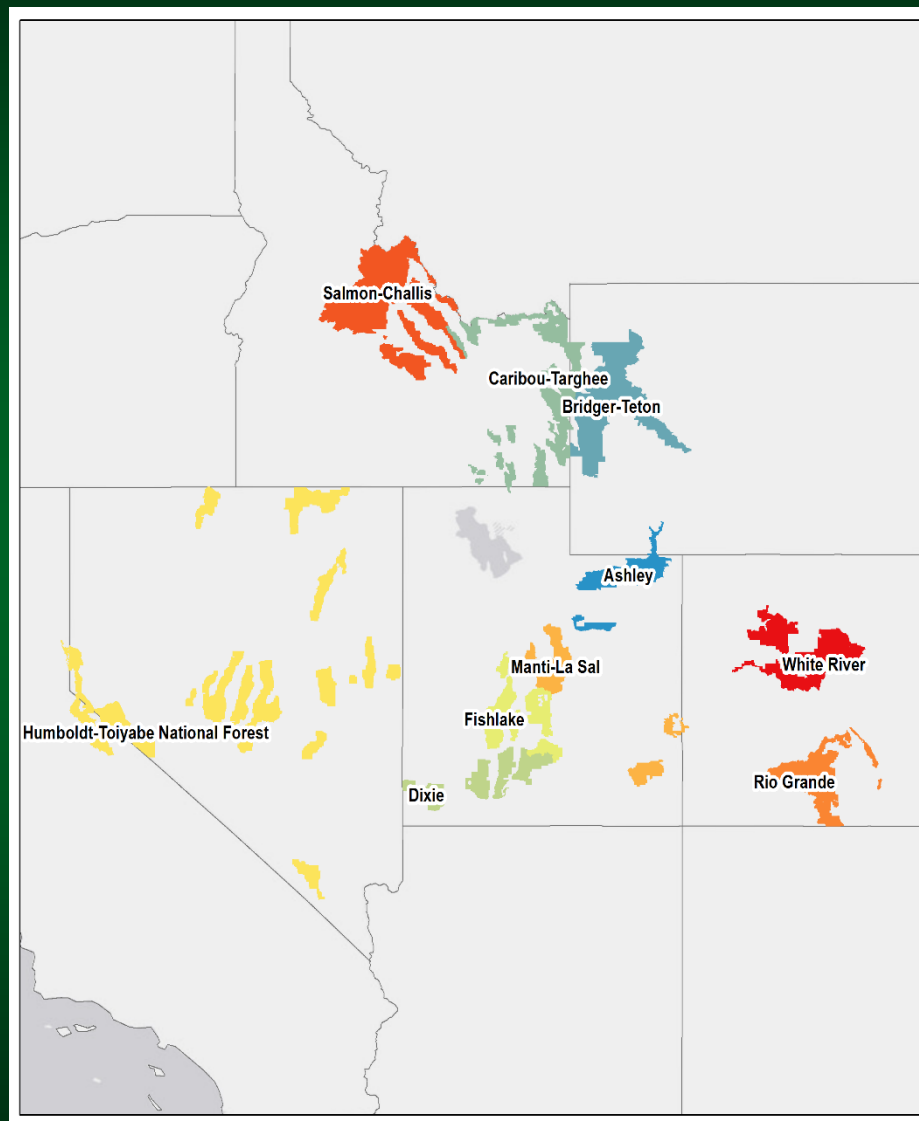
CNHP is mapping fens for the USFS across multiple states.

Completed Utah forests:

- Ashley NF, UT (2017)
- Manti-La Sal NF, UT (2017)
- Dixie NF, UT (2018)
- Fishlake NF, UT (2019)

Other States:

- White River NF, CO (2011)
- Rio Grande NF, CO (2016)
- Salmon-Challis NF, ID (2017)
- Bridger-Teton NF, WY (2018)
- Humboldt-Toiyabe NF, NV (2019)
- Caribou-Targhee NF, ID (2020)





# Fen Mapping Methods: Rio Grande NF

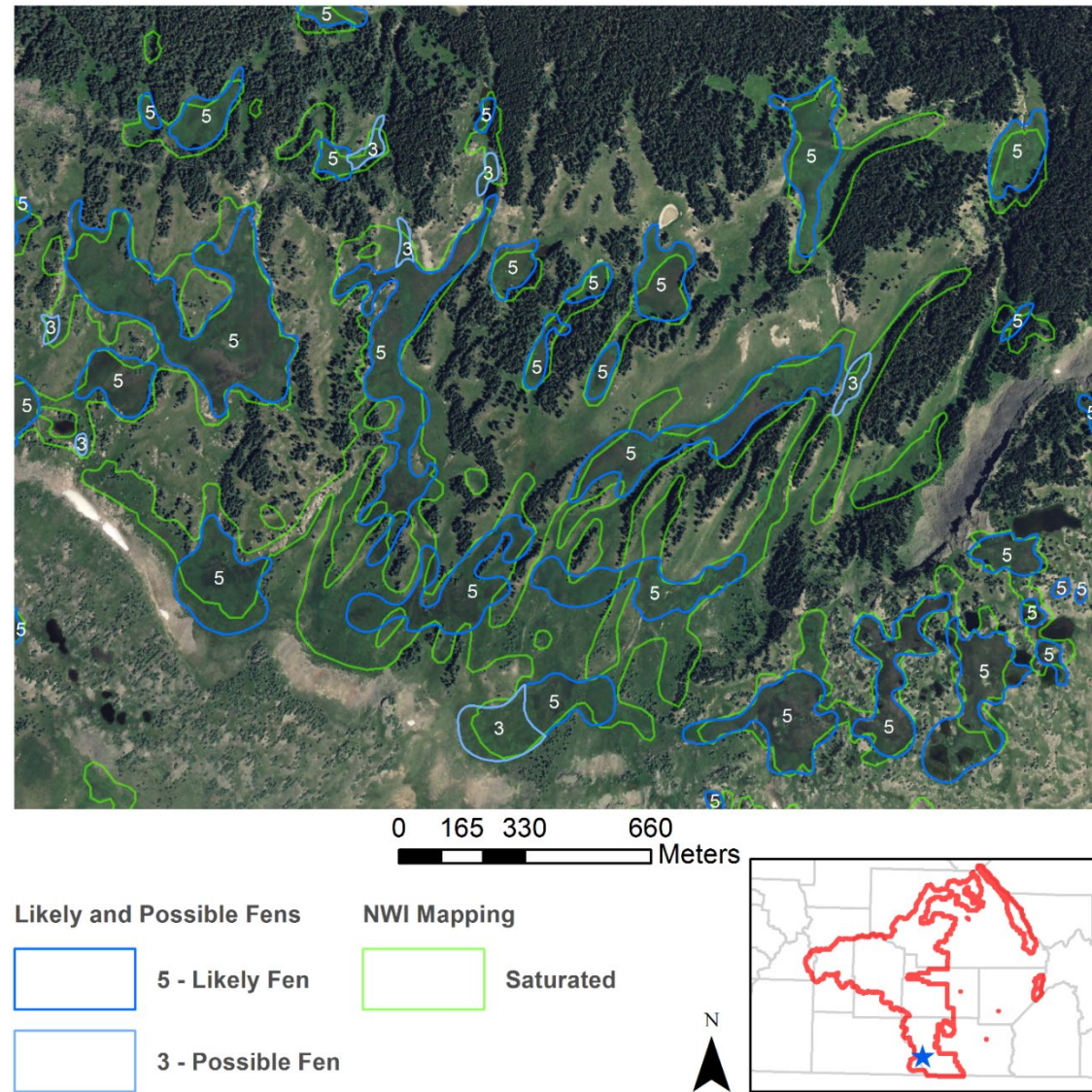
Rio Grande NF – completed in 2016.

Digital NWI mapping already available, no need to digitize.

Hand drawn polygons specific to the fen areas.

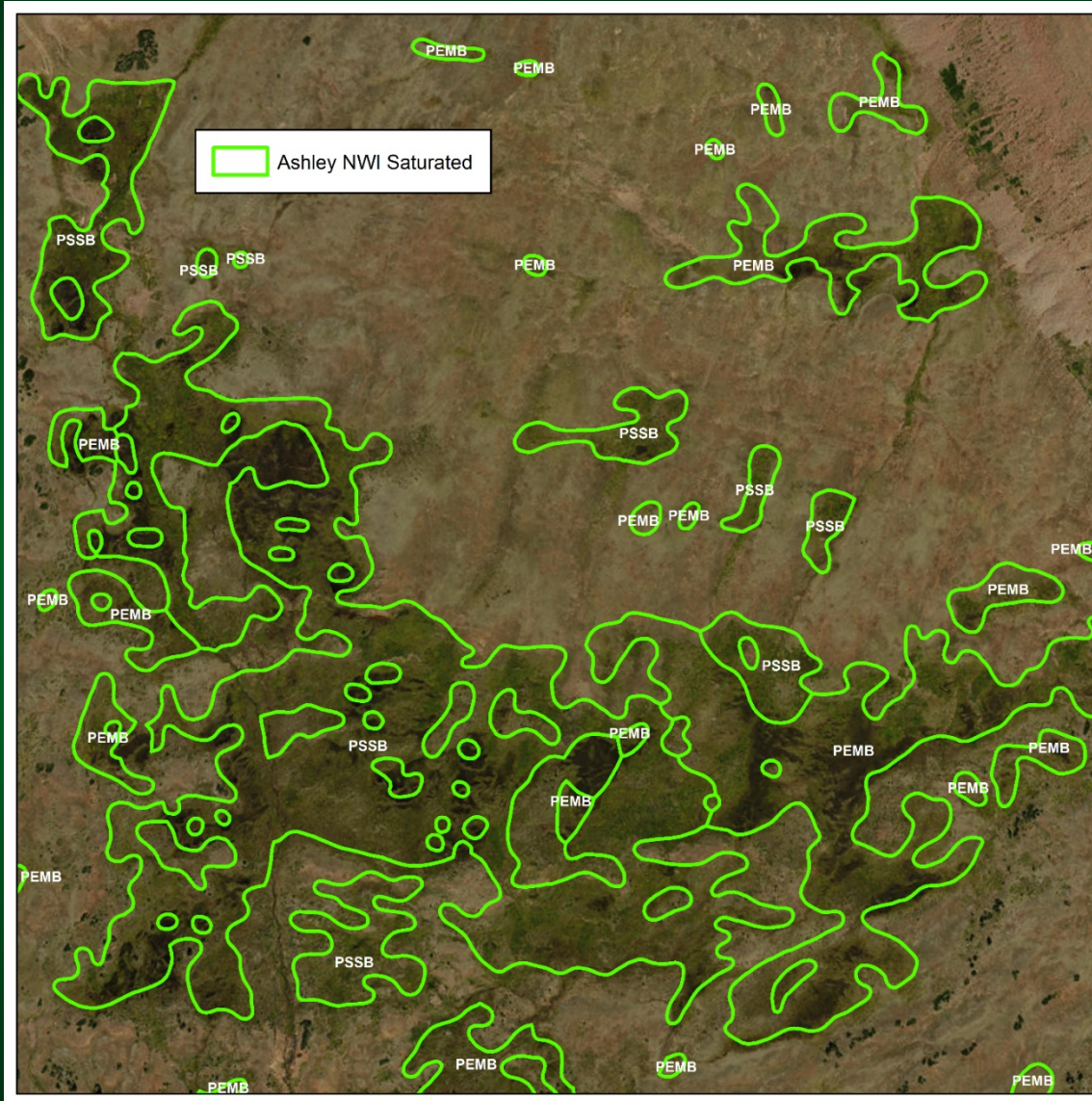
## *Strengths:*

- Image resolution has improved significantly since the NWI was completed.
- Drawn polygons allow for meaningful acreage summaries at various confidence levels.
- Drawn polygons also allow the mapper to capture features that are outside of a saturated polygon.





# Ashley NF Example: Fens vs. NWI



Initial focus:  
Wetlands mapped by  
MWI with Saturated  
Hydrologic Regime (B)

- Palustrine Emergent (PEMB)
- Palustrine Scrub-Shrub (PSSB)

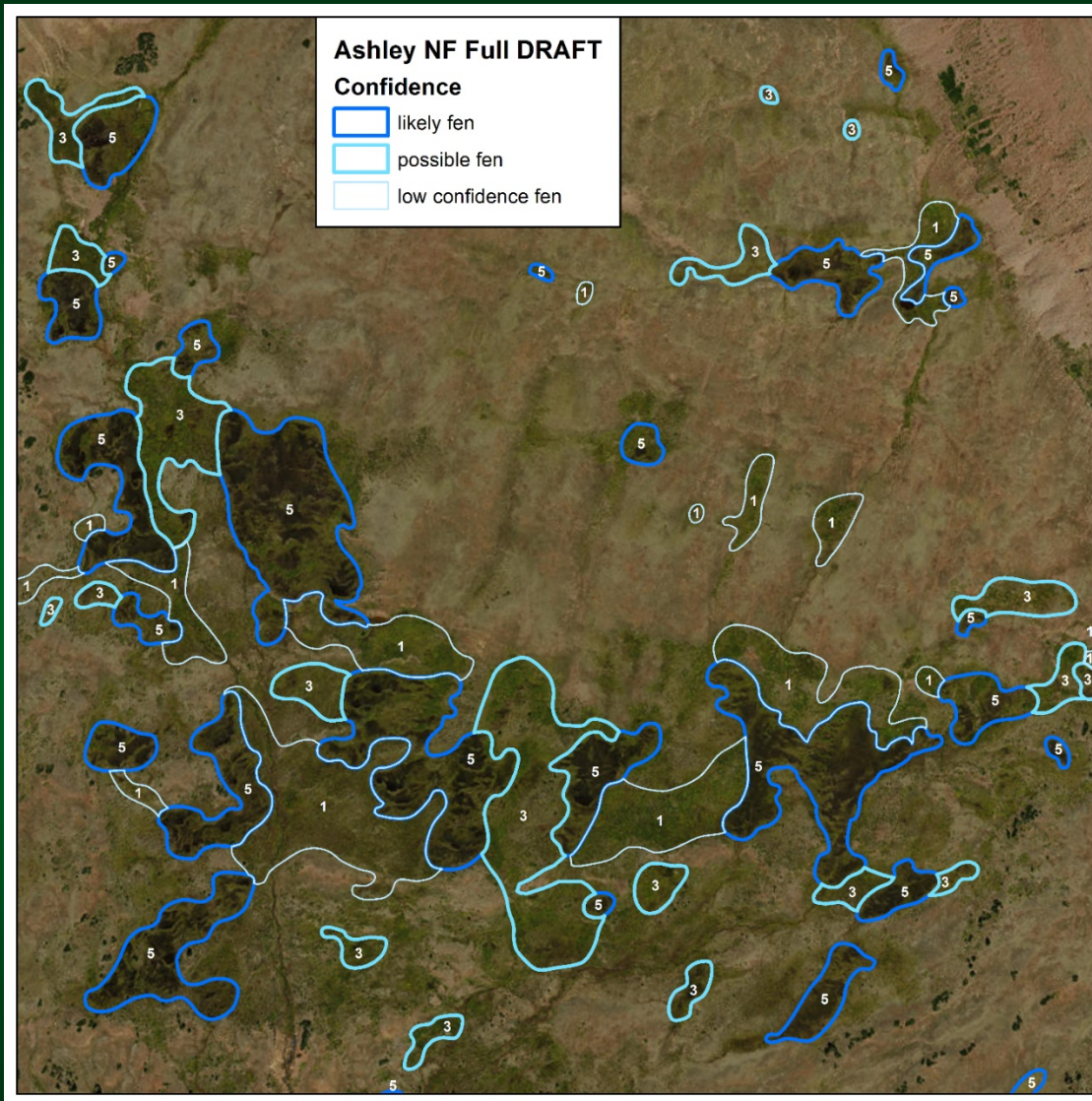








# Ashley NF Example: Fens vs. NWI



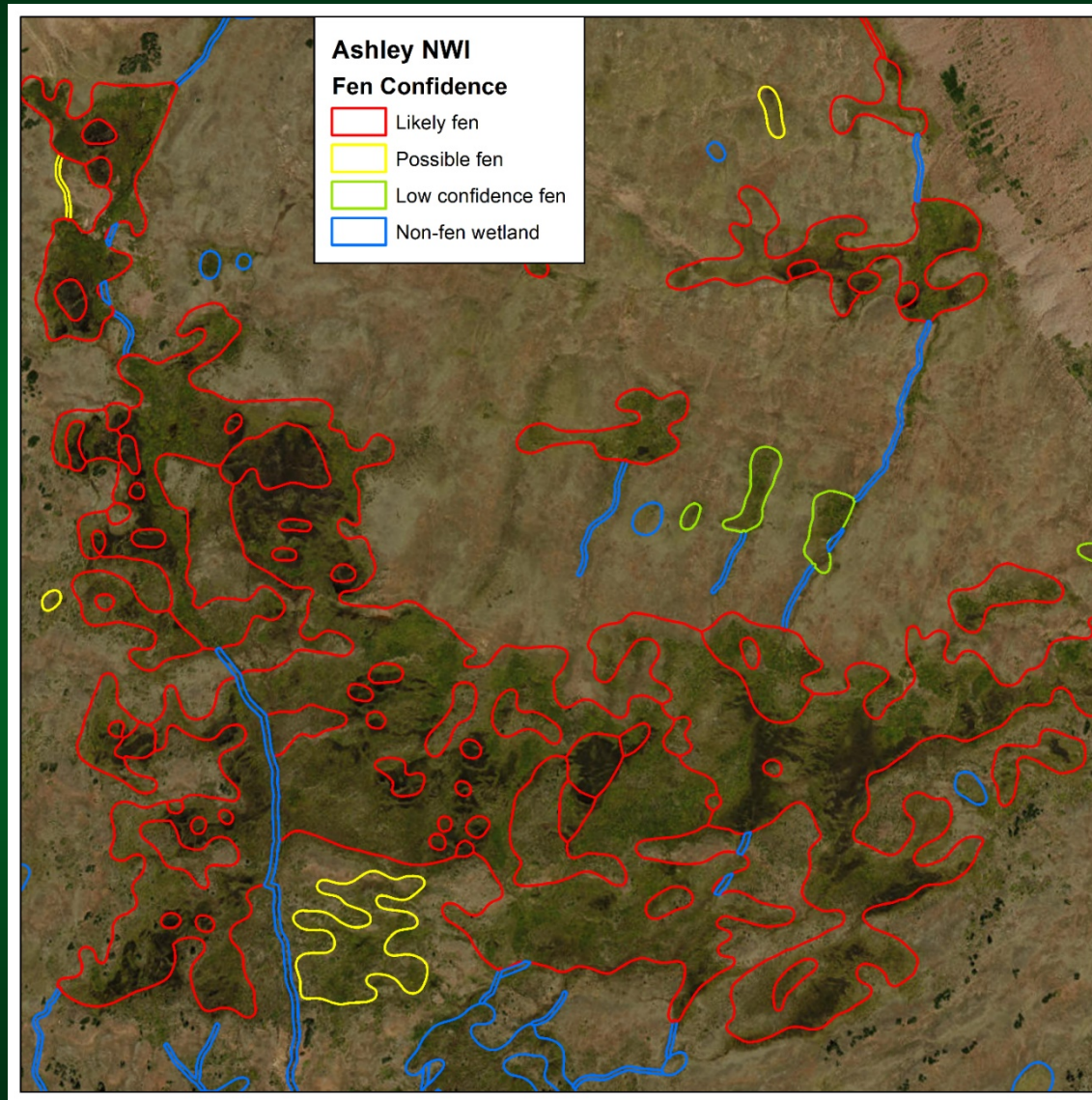
## Potential fen polygons:

- Hand-drawn in ArcGIS 10.3;
- Each potential fen polygon attributed with a confidence value based on presence of 'fen indicators'.





# Ashley NF Example: Fens vs. NWI

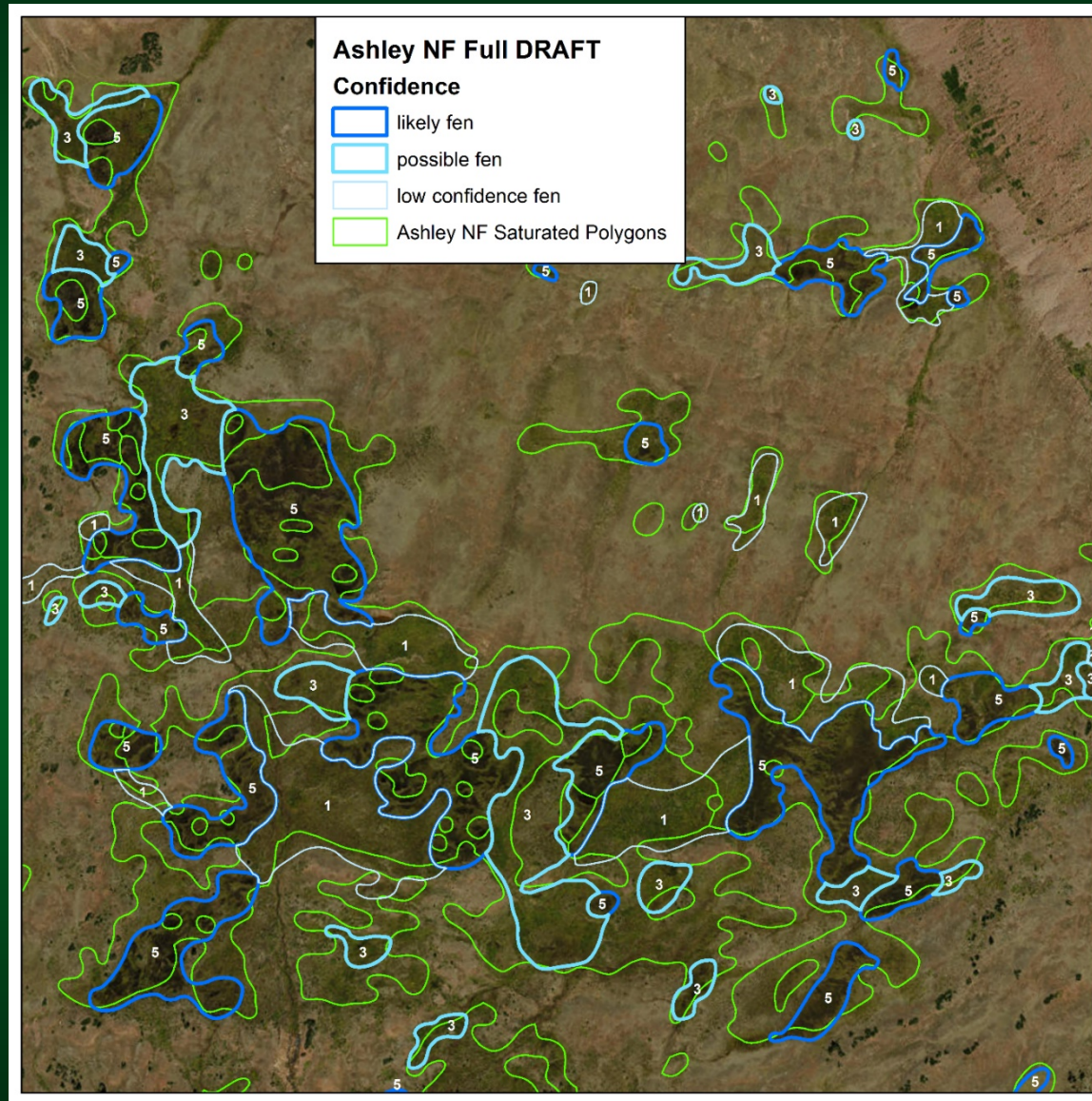


Delineated portions of wetland complexes likely to have peat





# Ashley NF Example: Fens vs. NWI





# Deliverables for all Forests

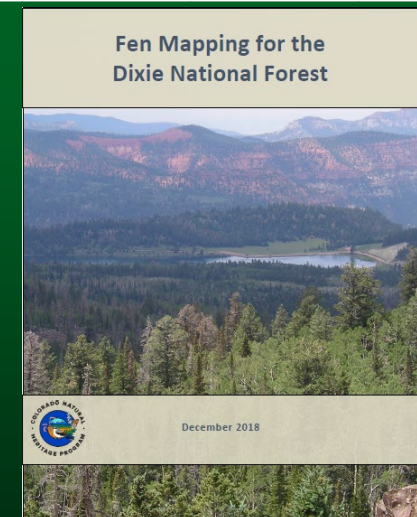
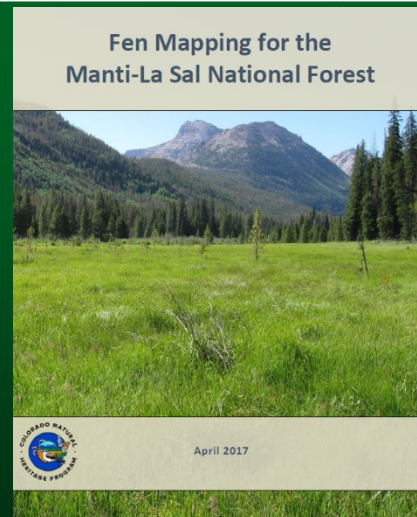
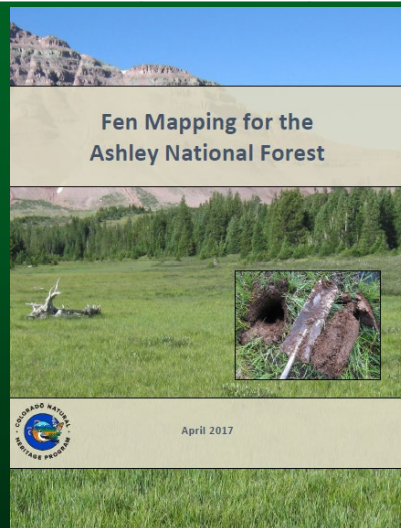
- Geospatial dataset of fen mapping for each Forest, separate from NWI
- One report on fen mapping for each Forest:
  - Summarizing fens by Land Type Associations, elevation, geology, watershed, etc.
  - Highlighting large fen complexes and large individual fens
- Where NWI data exists for a National Forest, that Forest also receives a version of NWI for their forest with fen attribution





# Results: Utah National Forests

Confidence	Ashley NF			Manti-La Sal NF			Dixie NF		
	Count	Acres	Average size (acres)	Count	Acres	Average size (acres)	Count	Acres	Average size (acres)
5 – Likely Fen	4,019	9,007	2.24	30	158	5.26	62	193	3.23
3 – Possible Fen	2,765	2,929	1.06	336	800	2.38	237	538	2.27
1 – Low Confidence	1,830	1,932	1.06	752	586	0.78	585	1,549	2.65
<b>Total</b>	<b>8,614</b>	<b>13,869</b>	<b>1.61</b>	<b>1,118</b>	<b>1,544</b>	<b>1.38</b>	<b>884</b>	<b>2,281</b>	<b>2.58</b>

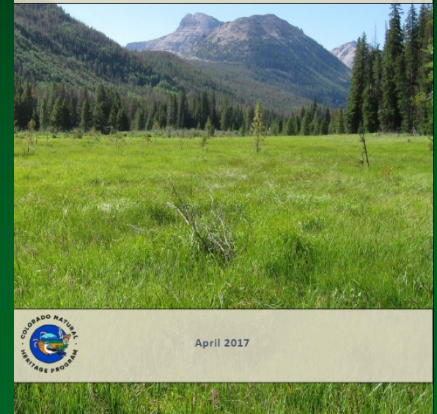




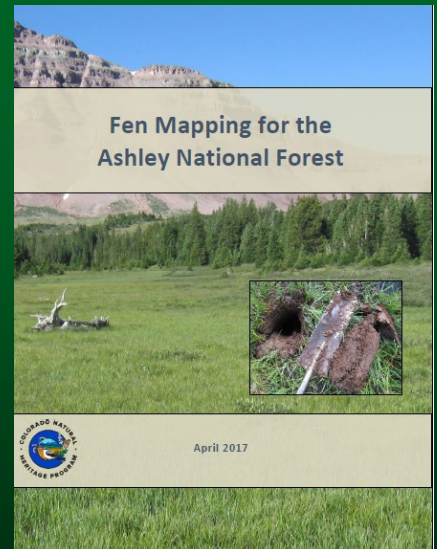
# Results: Utah National Forests

<i>Mapping Characteristic, by area</i>	<i>Ashley NF</i>	<i>Manti-La Sal NF</i>
Percent mapped by NWI	81%	87%
Percent mapped by NWI as 'saturated'	78%	75%
Percent of NWI 'saturated' area NOT mapped as fen	47%	62%
Most common surface geology	Quaternary Alluvium	Shale / Quaternary Alluvium

## Fen Mapping for the Manti-La Sal National Forest

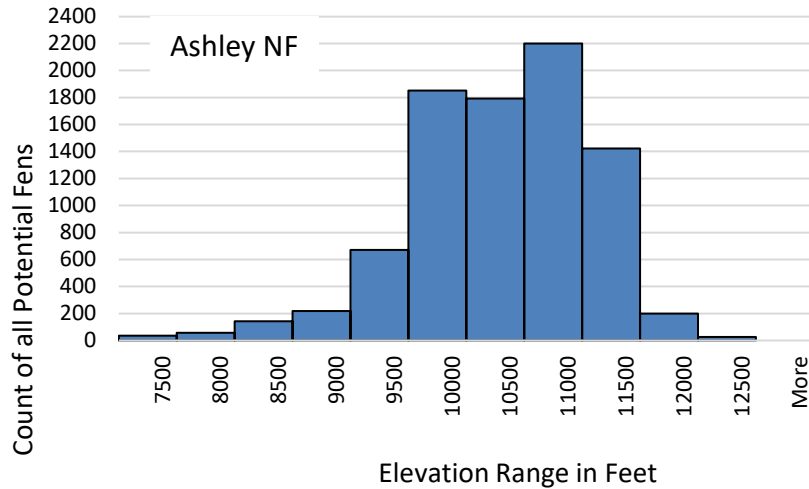


## Fen Mapping for the Ashley National Forest



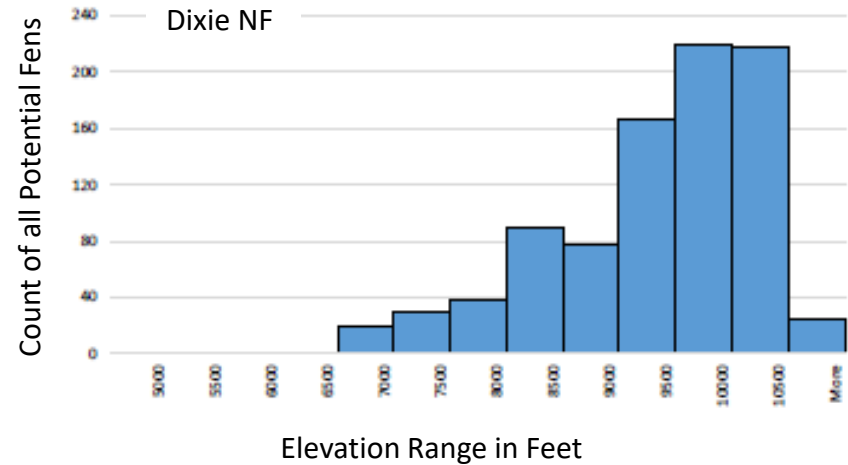
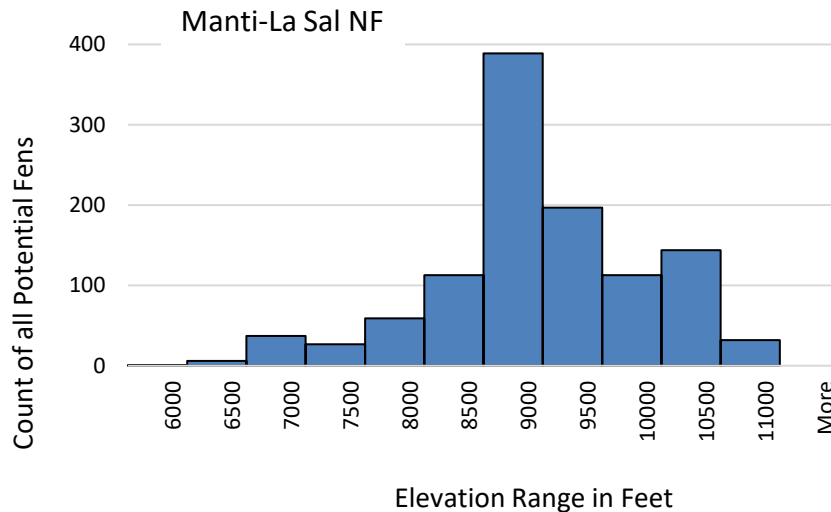


# Results: Utah National Forests



Typically high elevations:

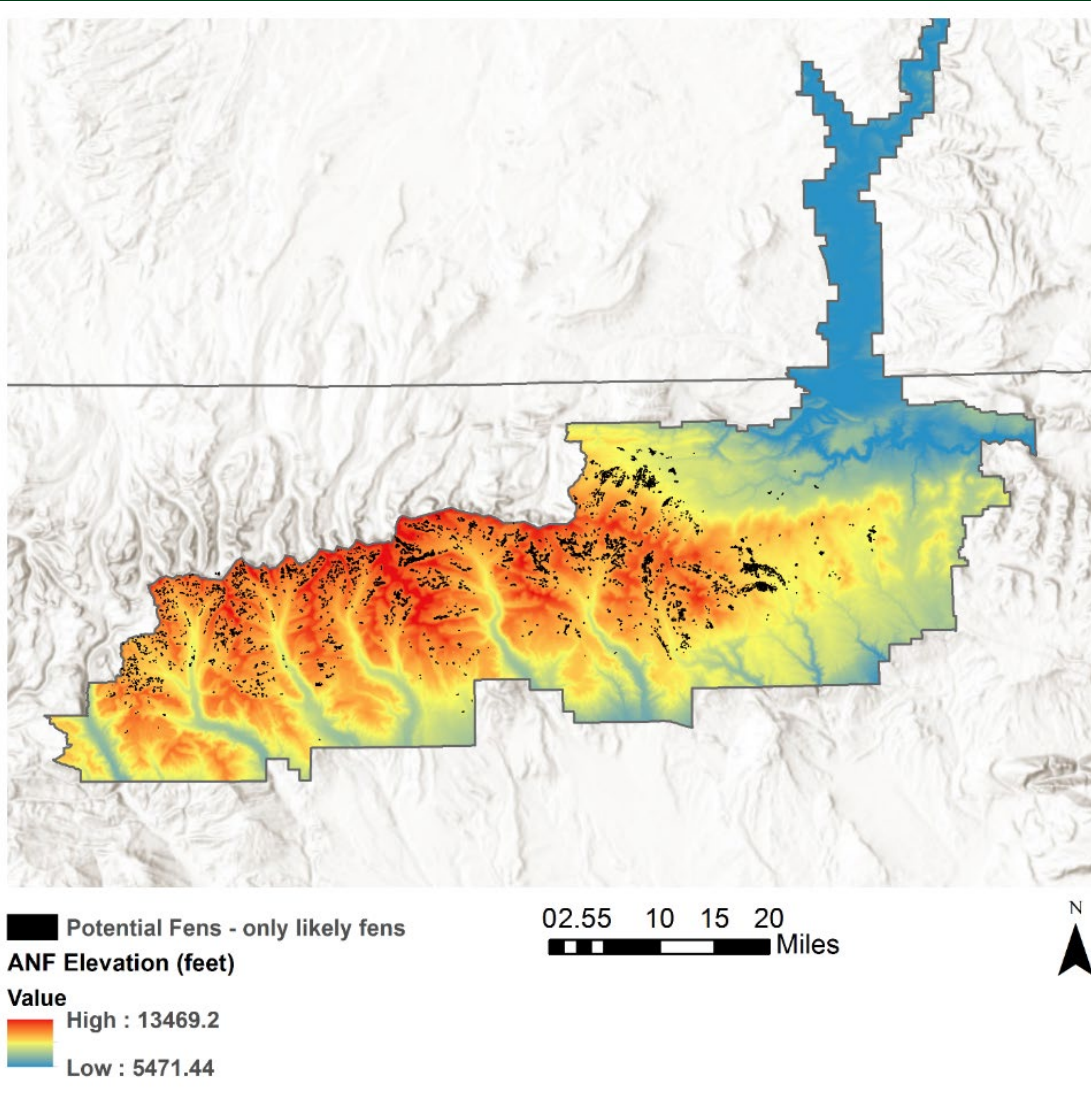
- Range: 6500' to 12000'
- Highest concentrations: 9,000 to 12,000')





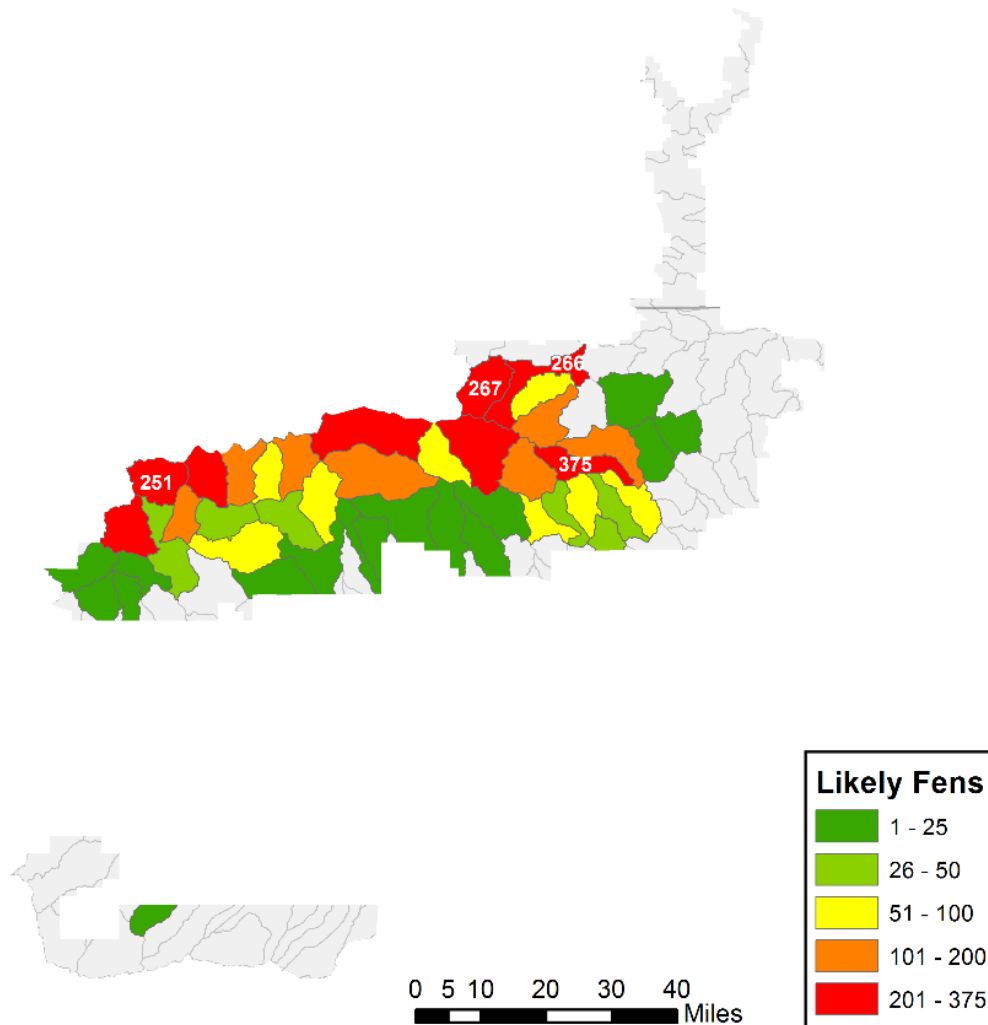
# Ashley National Forest, Utah

Most fens in  
high elevation,  
glaciated terrain.



# Ashley National Forest, Utah

Likely fens  
by HUC12  
watershed.





# Ashley National Forest, Utah





# Ashley National Forest, Utah





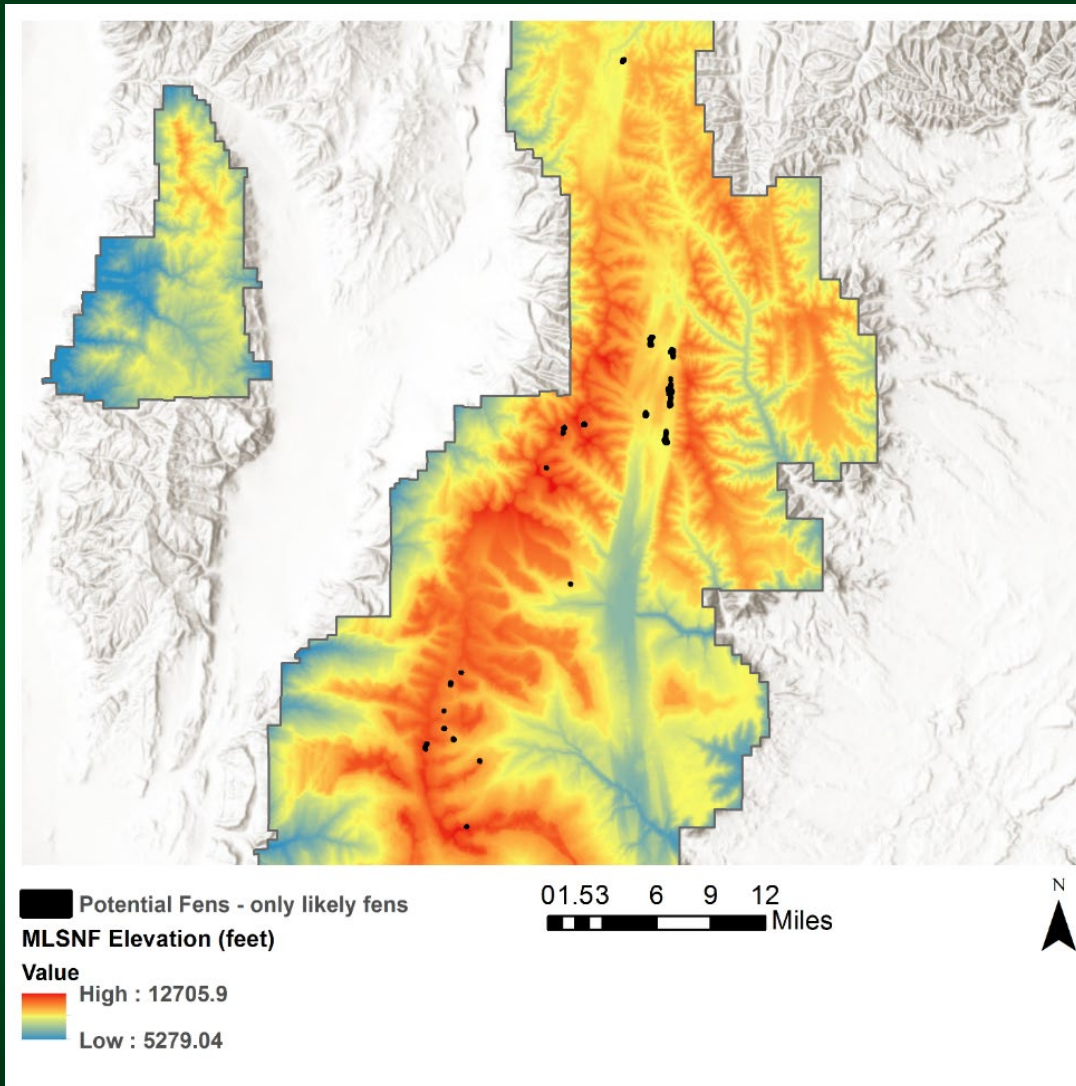
# Ashley National Forest, Utah





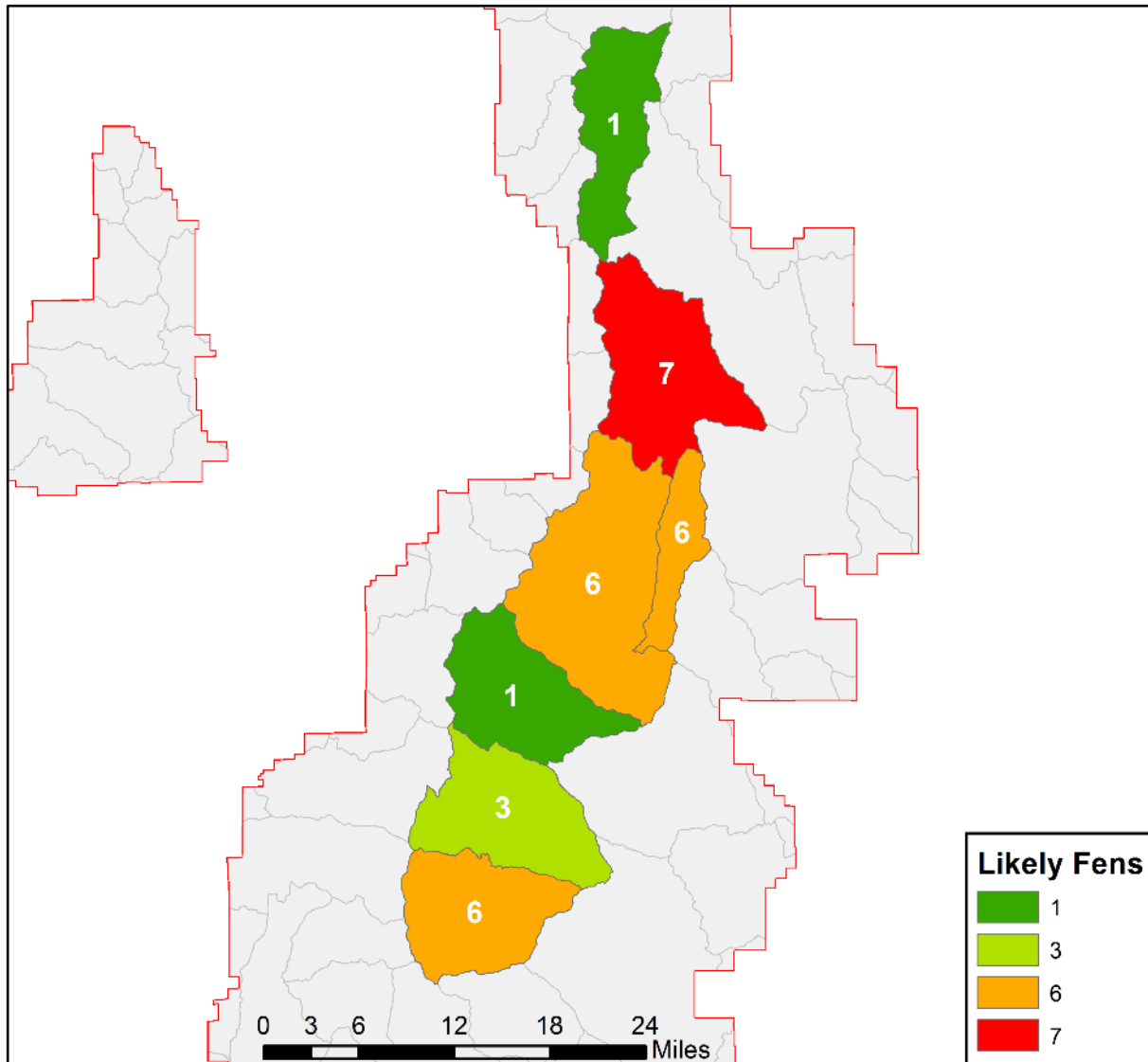
# Manti-La Sal National Forest, Utah

Most fens in high elevation, glaciated terrain of the Wasatch Plateau.





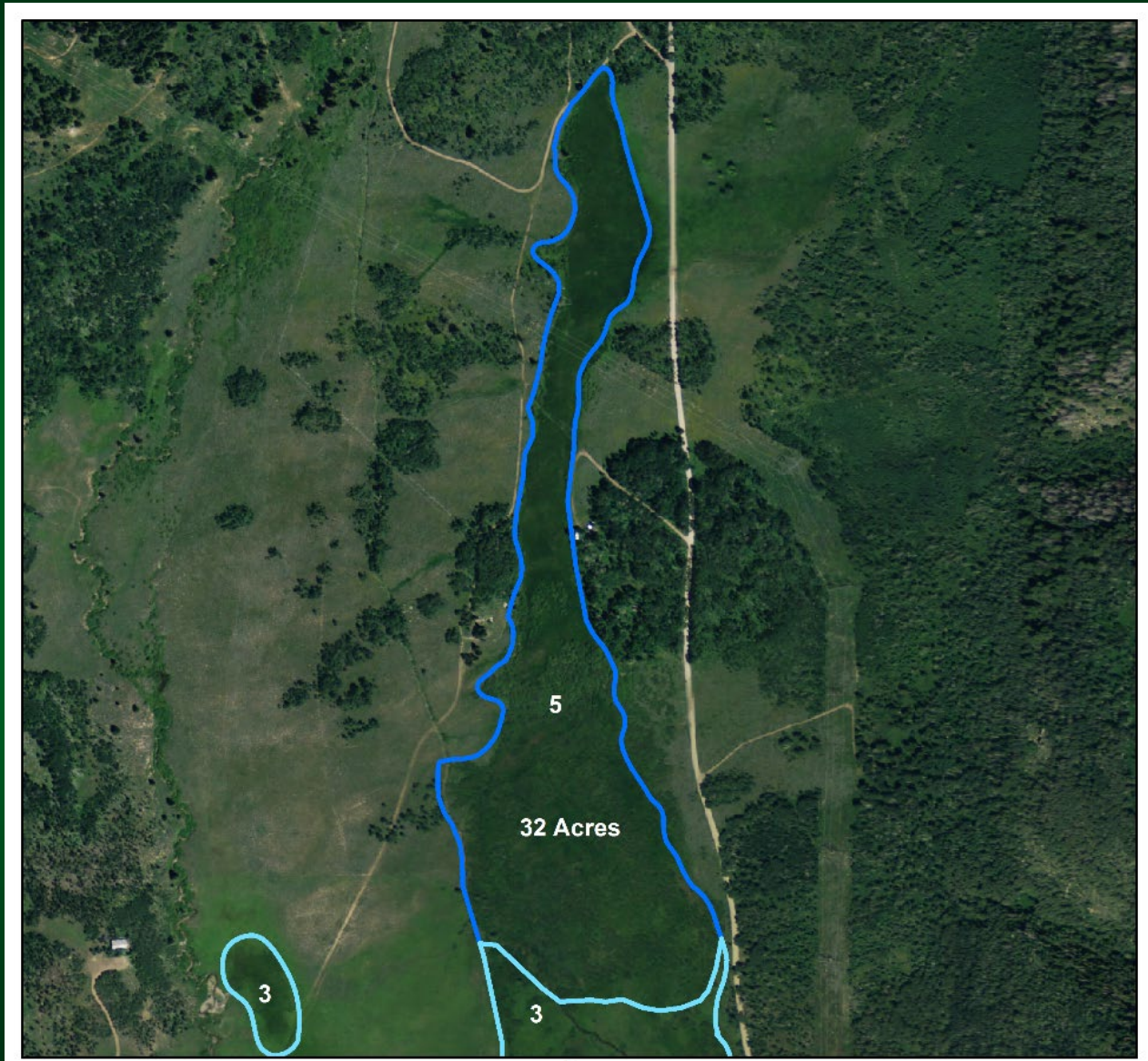
# Manti-La Sal National Forest, Utah



Likely fens  
by HUC12  
watershed.

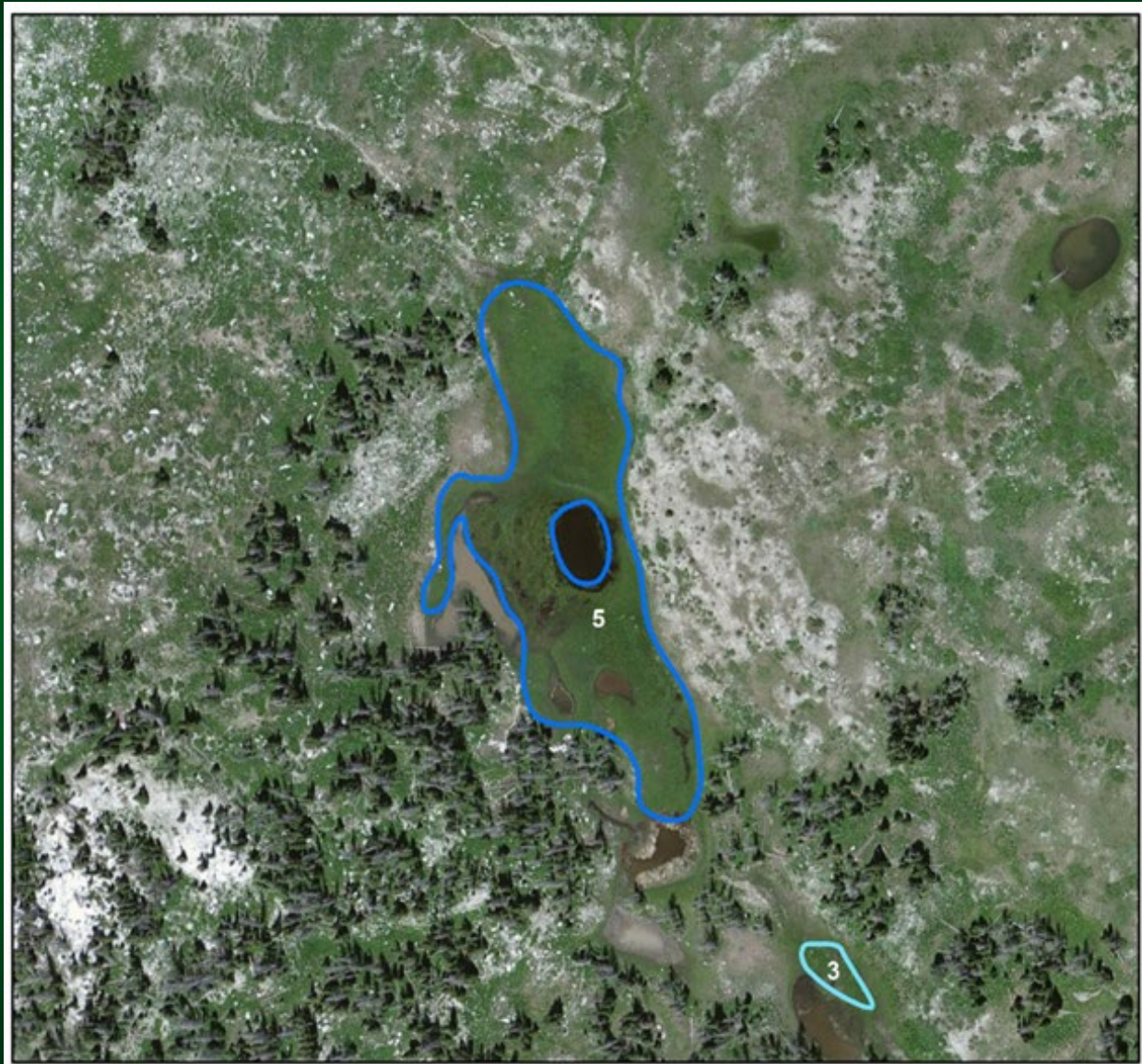


# Manti-La Sal National Forest, Utah





# Manti-La Sal National Forest, Utah



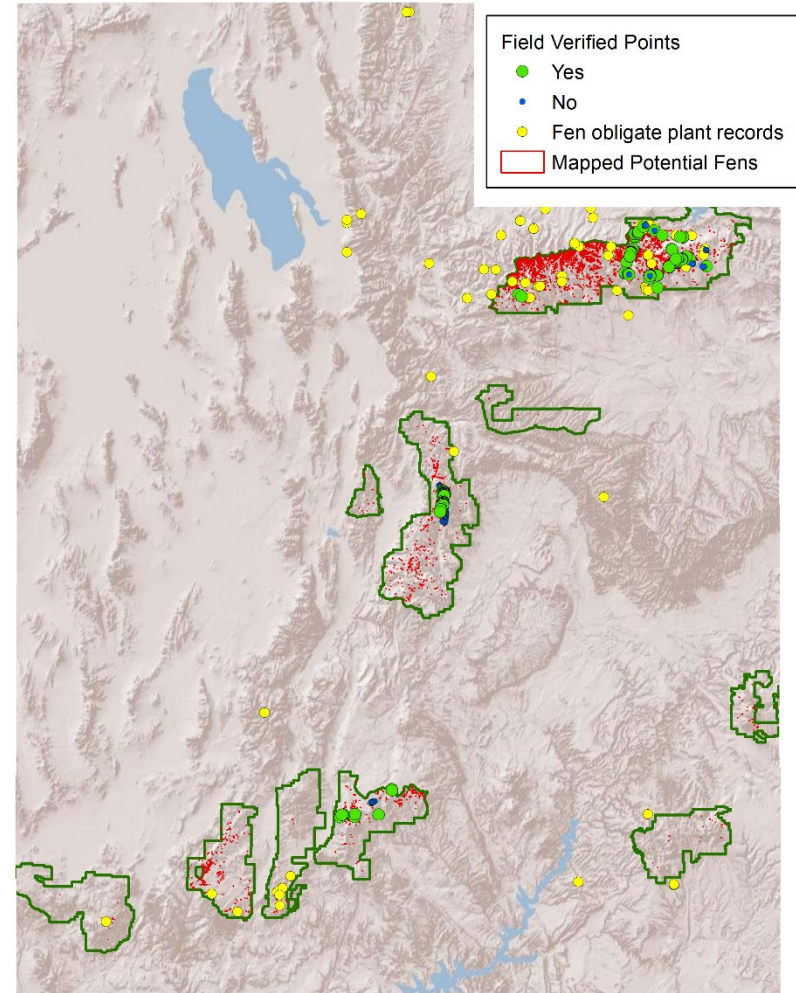
# USFS Level 1- GDE inventory methods



United States Department of Agriculture  
Forest Service  
Gen. Tech. Report WO-86a  
March 2012

## Groundwater-Dependent Ecosystems: Level I Inventory Field Guide

Inventory Methods for  
Assessment and Planning





# USFS Level 1- GDE inventory methods

	Attributes/ resources	Variables recorded/ References Used
<b>Pre-field</b>	Map Information	USGS maps; Soil Map Unit; Polygon delineation (aerial photo or other remote sensing image)
	Site Identification	Forest Service Site General; unique identifier
	Geographic & Administrative Units	Ownership; Grazing allotments; water rights; management activities; ecological unit; preliminary GDE type; archaeological, cultural, historic sites or use
<b>Field</b>	Site Visit Information	Date, time, weather; driving/hiking route
	Locations and Description	GPS reference points; elevation; GDE type; area; photos; sketch map
	Geologic Setting	Surficial material; primary & secondary lithology; geologic structure type
	<b>Soil</b>	Location of core; organic layer depth; redoximorphic features
	<b>Hydrology</b>	Location & time of water measurement; hydroperiod; water table depth; flow patterns; presence of channels, open water.
	<b>Vegetation</b>	Surrounding vegetation; polygon; dominant life forms; dominant species; species of interest; bryophytes
	Aquatic & Terrestrial Fauna	Aquatic invertebrates & vertebrates; terrestrial invertebrates & vertebrates;
	Disturbance – Natural & Anthropogenic	Hydrologic & soil alteration; structures; recreation; animals; soil erosion category; archaeological, cultural, historic sites or use

# Validation & Error Estimation of Fen Rankings

## Steps:

- 1) Compile all existing data on wetland GDEs that was not used to inform mapping;
- 2) Ground-truth to determine which mapped wetlands are true fens (peat depth  $\geq 40$  cm) ?
- 3) Construct a 'validation data set';
- 4) Compare rankings of mapped wetland polygons with site-specific data (from 'validation data set) to estimate 'error' in fen rankings.





# Validation & Error Estimation of Fen Rankings

## Ashley NF

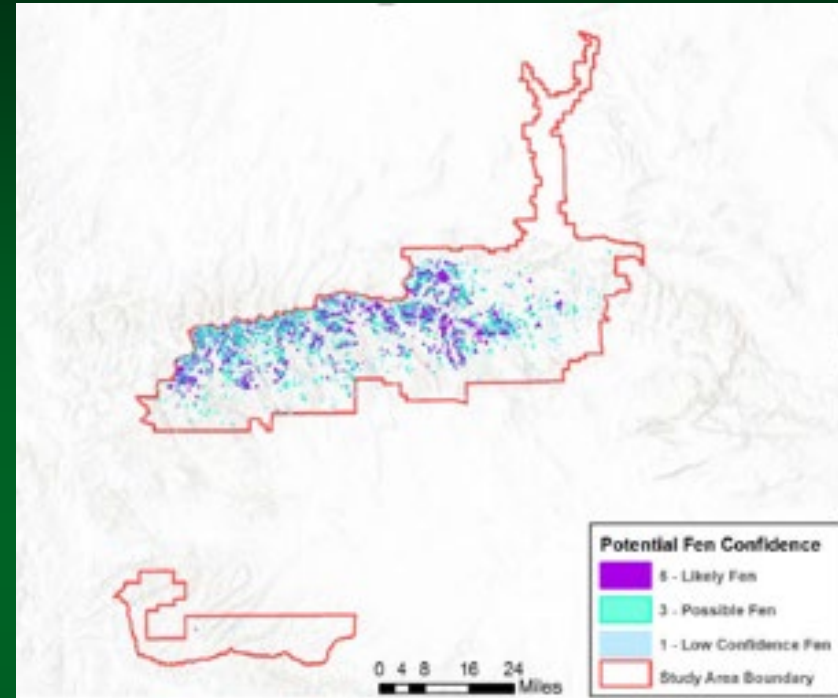
- District –level GDE Level 1 inventories
- Plant specimen records of fen obligate Species in USFS Herbarium, Vernal

*Carex livida*

*Carex lasiocarpa*

*Carex diandra*

*Carex limosa*





# Dixie NF: Validation/Error Estimation





# Combining GDE Level 1 with Rare Plant Surveys

Fens are common;  
fens supporting  
rare plants are rare.



*Eriophorum gracile*  
B. Heidel



*Drosera anglica*  
J. Proctor



*Epilobium oregonense*  
B. Heidel



*Eriophorum chamissonis*  
J. Proctor



J. Proctor



# Utility of Wetland Maps & GDE Inventories

## Forest and district-level scale:

### 1) Identification of the need/ options for improved resource management:

- Grazing; mining authorizations; *timber harvest & fuels treatments*; water diversions;
- Actions specified in forest plan revisions.

### 2) Improved capability to assess and predict threats to groundwater resources (project planning).





# Utility of Wetland Maps & GDE Inventories

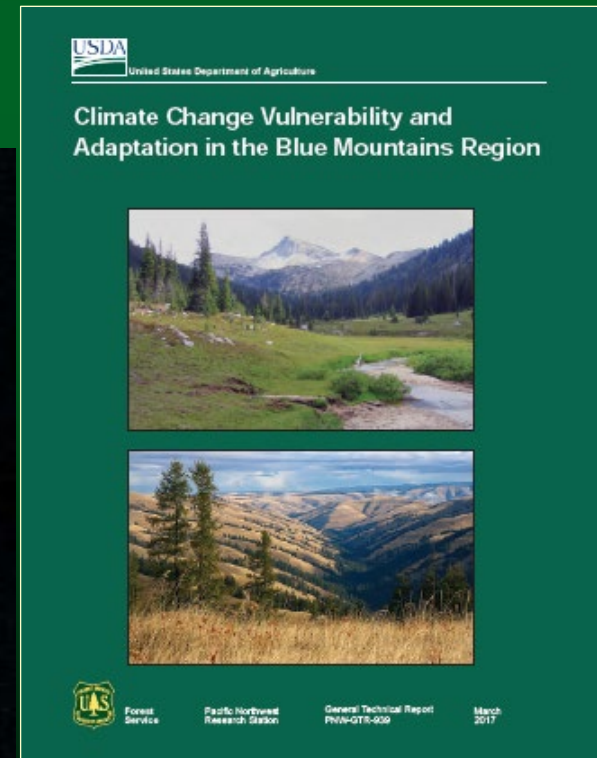
## Regional and National scales:

### 3) Locating populations of rare biota:

Rare plants, vertebrates, invertebrates wholly or partially dependent on groundwater-supported habitats.

### 4) Regional and forest-level assessments of climate change vulnerability.

### 5) Multiscale assessments of carbon storage, instream flow support, & other ecosystem services.



# For More Information

- Reports available by forest online:
  - Ashley National Forest (2017)
  - Manti-La Sal National Forest (2017)
  - Dixie National Forest (2019)
- Visit <http://www.cnhp.colostate.edu/download/reports.aspx> and filter by Forest name
- For any methods questions or comments:  
email Gabrielle Smith, Wetland Mapping Specialist  
[Gabrielle.Ann.Smith@colostate.edu](mailto:Gabrielle.Ann.Smith@colostate.edu)



Thank You!  
Questions?

