Fen Mapping for the Uinta-Wasatch-Cache National Forest

Colorado Natural Heritage Program

September 2023

CNHP's mission is to preserve the natural diversity of life by contributing the essential scientific foundation that leads to lasting conservation of Colorado's biological wealth.

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Report Prepared for:

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Recommended Citation:
Smith, G. 2023. Fen Mapping for the Uinta-Wasatch-Cache National Forest.
Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Front Cover Photo:

P8080063.jpg
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EXECUTIVE SUMMARY

The Uinta-Wasatch-Cache National Forest covers over 2.9 million acres in Utah and Wyoming. Wetlands within the Uinta-Wasatch-Cache National Forest provide important ecological services to both the Forest and lands downstream. Organic soil wetlands known as fens are an irreplaceable resource that the U.S. Forest Service has determined should be managed for conservation and restoration. Fens are defined as groundwater-fed wetlands with organic soils that typically support sedges and low stature shrubs. In the arid west, fen formation requires stable hydrology and plant communities and can take thousands of years to accumulate deep organic soils.

In 2012, the U.S. Forest Service released a new planning rule to guide all National Forests through the process of updating their Land Management Plans (also known as Forest Plans). A component of the new planning rule is that each National Forest must conduct an assessment of important biological resources within its boundaries. To support this effort, U.S. Forest Service contracted Colorado State University and the Colorado Natural Heritage Program (CNHP) to map all potential fens within the Uinta-Wasatch-Cache National Forest.

Potential fens in the Uinta-Wasatch-Cache National Forest were identified from digital aerial photography and topographic maps. Each potential fen polygon was hand-drawn in ArcGIS based on the best estimation of fen boundaries and attributed with a confidence value of 1 (low confidence), 3 (possible fen) or 5 (likely fen). The final map contained 10,462 potential fen locations (all confidence levels), covering 19,965 acres or less than 1% of the total land area of the Forest. This total included 879 ***likely fens***, 2,508 ***possible fens***, and 7,065 ***low confidence fens.*** The average fen polygon was 1.91 acres, but individual fen polygons ranged from 110 acres to less than an acre.

Fen distribution was analyzed by elevation, geology, Ecological Subsection, and watershed. The majority of mapped likely fens occurred between 10,000 to 11,000 feet. This elevation range contained 38% of all potential fen locations and 67% of likely fen locations. Four watersheds in particular have higher numbers of likely fens: East Fork Smiths Fork contains 91 likely fens, East Fork Duchesne River watershed contains 83 likely fens, Dahlgreen Creek-Henrys Fork contains 73 likely fens and Spring Canyon-Provo River contains 64 likely fens.

This report and associated dataset provide the Uinta-Wasatch-Cache National Forest with a critical tool for conservation planning at both a local and Forest-wide scale. These data allow the Uinta-Wasatch-Cache National Forest to conduct the biological assessment required by the 2012 Forest Planning Rule, but also support timber sales, grazing allotments, wilderness stewardship, and other management actions on the Forest. The mapping identifies likely fen locations, other likely wetland resources, and important watersheds where U.S Forest Service efforts to promote conservation and minimize disturbance will protect water sources and key habitats.

ACKNOWLEDGMENTS

The authors at Colorado Natural Heritage Program (CNHP) would like to acknowledge the U.S. Forest Service for their financial support of this project. Special thanks to John Proctor and Tova Spector, Regional Botanists for U.S. Forest Service Region 4, and Jeff Bruggink , Regional Soils and BAER Program Manager for US Forest Service Region 4 for supporting this project.

We also thank colleagues at CNHP who have worked on previous projects mapping and surveying fen wetlands in the field, specifically Denise Culver, Laurie Gilligan, Peggy Lyon, Dee Malone, and Sarah Marshall. Special thanks David Cooper, Rod Chimner, and Brad Johnson, each of whom has shared with us their great knowledge of fens over the years. Thanks to Pete Goodwin from the Utah Geological Survey for editing this report.

Finally, we would like to thank Tracey Trujillo with Colorado State University for logistical support and grant administration.

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1.0 INTRODUCTION

The Uinta-Wasatch-Cache National Forest covers over 2.9 million acres in Utah and Wyoming, and spans a very broad elevation range from 4,232 ft. to 13,451 ft. at the top of Gilbert Peak. Snowfall in the mountains percolates through shallow mountain soils and creates wet meadows, riparian shrublands, and organic soil wetlands known as fens. Fens and other wetland habitats provide important ecological services to both higher-elevation headwaters and lands downstream (Mitsch & Gosselink 2007; Millennium Ecosystem Assessment 2005). Wetlands act as natural filters, helping to protect water quality by retaining sediments and removing excess nutrients. Wetlands help to regulate local and regional hydrology by stabilizing base flow, attenuating floods, and replenishing belowground aquifers. Wetlands provide habitat for numerous plant and animals species that depend on aquatic habitats for some portion of their life cycle (Redelfs 1980 as cited in McKinstry et al. 2004).

Organic soil wetlands known as fens are an irreplaceable resource. Fens are defined as groundwater-fed wetlands with organic soils that typically support sedges and low stature shrubs (Mitch & Gosselink 2007). The strict definition of an organic soil is one with 40 cm (16 in) or more of organic soil material in the upper 80 cm (31 in) of the soil profile (Soil Survey Staff 2014). Development of these deep organic soils requires constant soil saturation and cold temperatures, which create anaerobic conditions that slow the decomposition of organic matter. Undecomposed organic matter accumulates over centuries as peat and eventually forms soils composed entirely of organic material. In the arid west, peat accumulation occurs very slowly; estimates are 20 cm (8 in) per 1,000 years in Colorado (Chimner 2000; Chimner and Cooper 2002). Long-term maintenance of fens requires maintenance of both the hydrology and the plant communities that enable fen formation.

In 2012, the U.S Forest Service released a planning rule that will guide all National Forests through the process of updating their Land Management Plans (also known as Forest Plans).[1] A component of the new planning rule is that each National Forest must conduct an assessment of important biological resources within its boundaries. To support this effort, U.S. Forest Service contracted Colorado State University and the Colorado Natural Heritage Program (CNHP) to map all potential fens within the Uinta-Wasatch-Cache National Forest. This project builds upon CNHP's previous projects mapping fens on the White River National Forest (Malone et al. 2011), Rio Grande National Forest (Smith et al. 2016), Ashley National Forest (Smith & Lemly 2017a), Manti-La Sal National Forest (Smith & Lemly 2017b), Salmon-Challis National Forest (Smith et al. 2017), Bridger-Teton National Forest (Smith & Lemly 2018a), Dixie National Forest (Smith & Lemly 2018b), Humboldt-Toiyabe National Forest (Smith & Lemly 2019a), Fishlake National Forest (Smith and Lemly 2019b), Caribou-Targhee National Forest (Smith & Lemly 2020a), Sawtooth National Forest (Smith & Lemly 2020b), Boise National Forest (Smith & Lemly 2021) and Payette National Forest (Smith & Lemly 2022).

[1] For more information on the 2012 Forest Planning Rule, visit the following website: http://www.fs.usda.gov/main/planningrule/home.

2.0 Study Area

2.1 Geography

The fen mapping study area was the entire Uinta-Wasatch-Cache National Forest, which is administered as four discontinuous units located in north east Utah and a small portion in southern Wyoming (Figure 1). Uinta-Wasatch-Cache National Forest is bounded by the Ashley National Forest to the southeast and the Manti-La Sal National Forest is located nearby to the south. The Uinta-Wasatch-Cache National Forest includes portions of fourteen Utah counties: Box Elder, Cache, Davis, Duchesne, Juab, Morgan, Rich, Salt Lake Panpete, Summit, Tocele, Utah, Wasatch and Weber counties all contain some portion of the Forest. The Forest also crosses into Uinta County, Wyoming. The counties with the largest share of National Forest land are Cache, Summit, Utah and Wasatch counties in Utah. The largest municipalities within 5 miles of the study area are Salt Lake City, Provo and West Jordan, Utah. Elevation in the study area ranges from 4,232 ft. (1,290 m) to 13,451 ft. (4,100 m) and the mean elevation is 7,972 ft. (2,430 m).

Uinta-Wasatch-Cache National Forest spans eight different HUC6 river basins (synonymous with 3rd-field HUs) (Figure 2). The largest portions of the Forest land occur in the Jordan (HUC6:160202), Lower Bear (HUC6: 160102), Weber (HUC6:201) Upper Green (HUC6:140401) and the Lower Green (HUC6: 140600) basins.

2.2 Ecological Subsections

The U.S. Forest Service has developed a National Hierarchy of Ecological Units (Cleland et. al. 1997). Ecological Subsections of the hierarchy were used for this project to describe geologic and geomorphic features associated with fen locations. A Subsection is a unit of land ranging from tens to thousands of square miles with similar surficial geology, lithology, geomorphic process, soil groups, subregional climate, and potential natural communities. Subsection boundaries usually correspond with discrete changes in geomorphology.

There are 25 unique Ecological Subsections in Uinta-Wasatch-Cache National Forest. The most common Ecological Subsection in the Uinta-Wasatch-Cache National Forest is the Southern Bear River-Wasatch Ranges (14% of study area) (Figure 3). The next most common Subsections are the Northern Wasatch Range (10%), Western High Uintas (10%) and Mt. Timpanogos-Southern Wasatch Front (13%) (USFS 2017 Ecological Subregions).

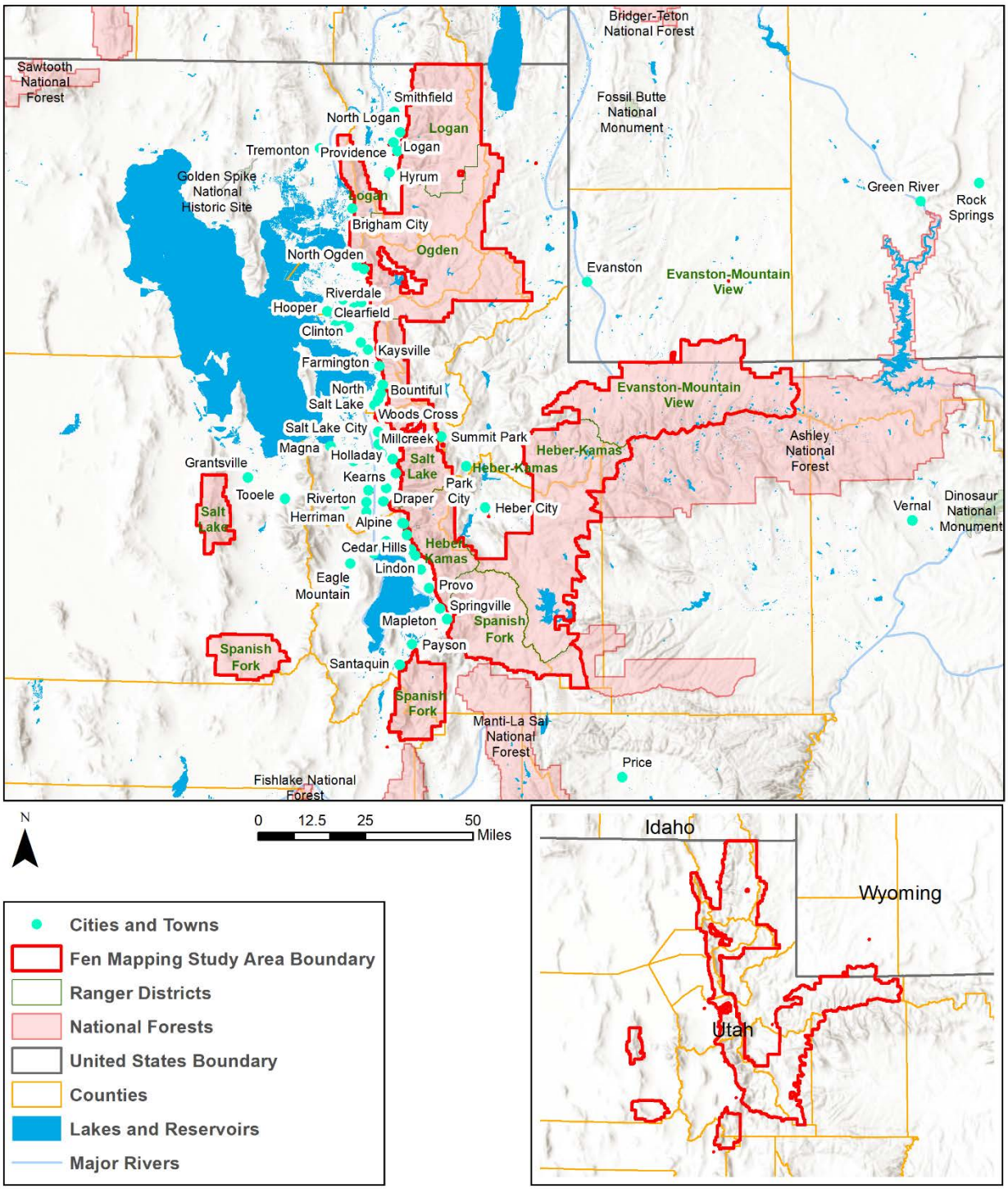

Figure 1. Location of the Uinta-Wasatch-Cache National Forest (fen mapping study area).

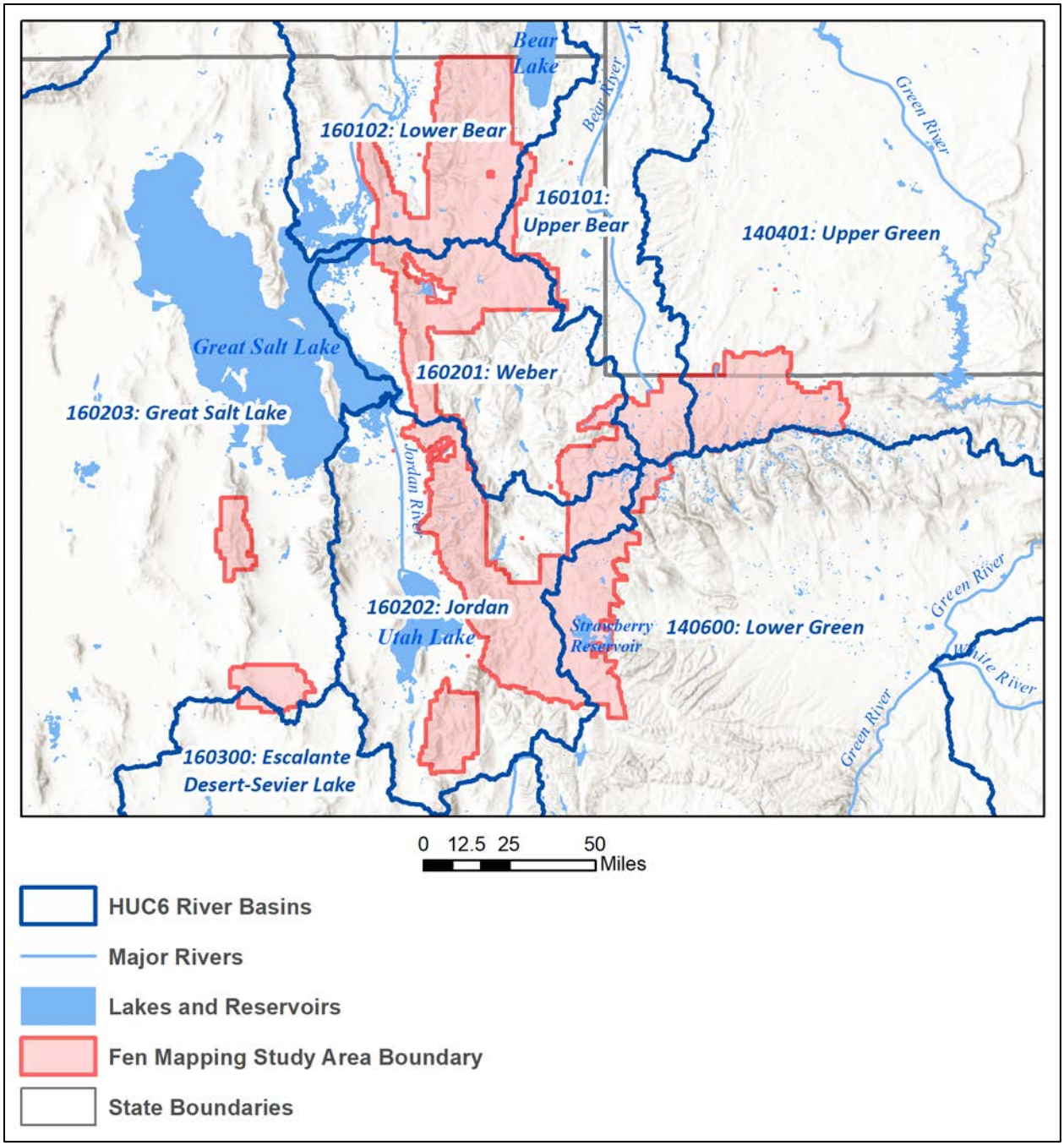

Figure 2. HUC6 river basins and major waterways in the fen mapping study area.

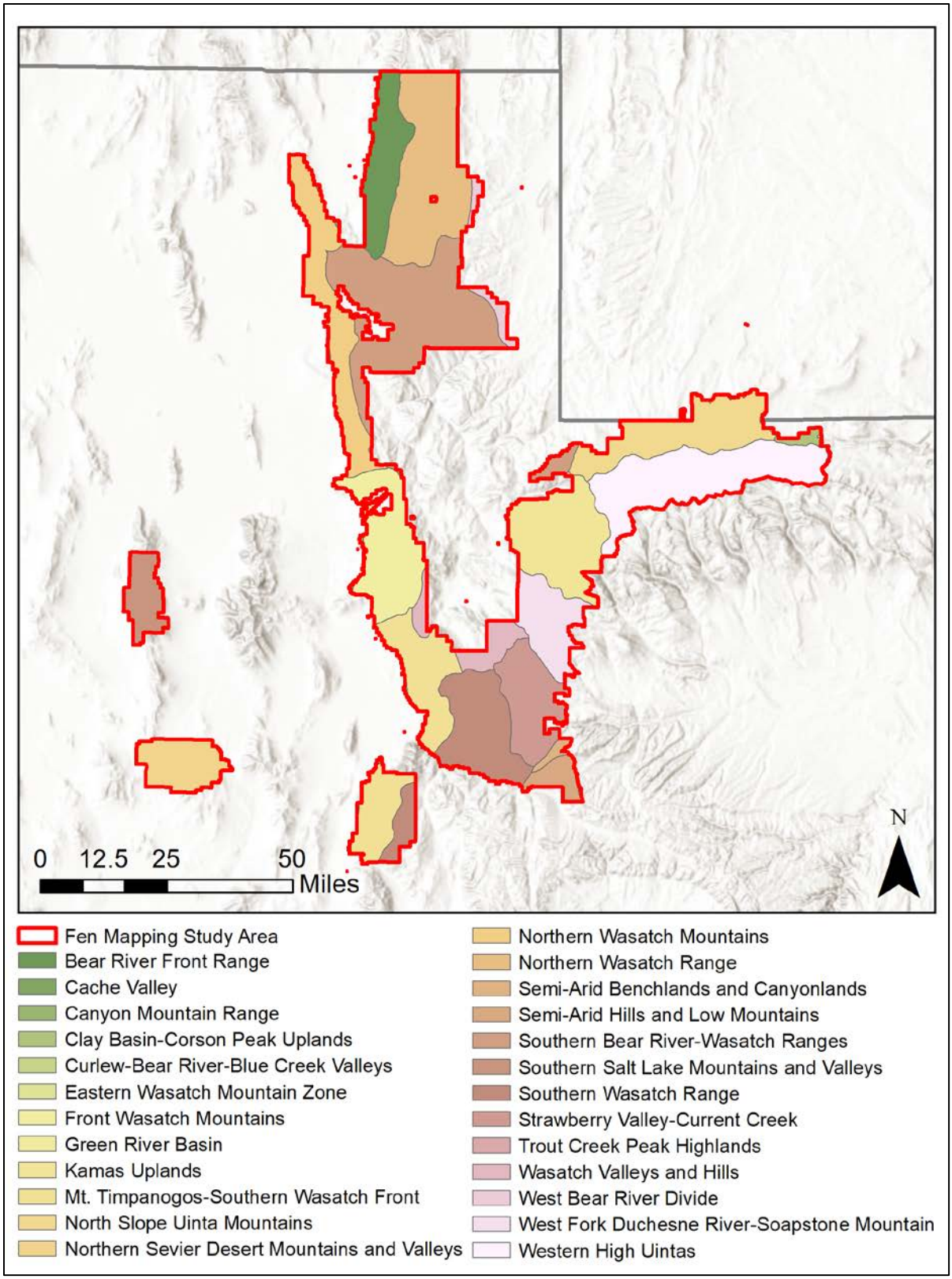

Figure 3. Ecological Subsections of the fen mapping study area.

2.3 Geology

Across the entire Uinta-Wasatch-Cache National Forest, sandstone is the most common bedrock geology unit (17% of the land area). Conglomerate (15%), glacial drift (11%), arenite (11%), dolostone (dolomite) (8%), and limestone (8%) are also common (USGS 2004).

The southern portion of the Forest is dominated by sandstone and the northeastern portions are dominated by conglomerate with dolostone and limestone becoming more common towards the west (figure 4). The High Uintas region of the Forest near the Bear River headwaters is composed primarily of glacial drift and arenite. The southern and southwestern portions of the Forest are more geologically diverse with sandstone, shale, alluvium, limestone, dacite and granodiorite all present.

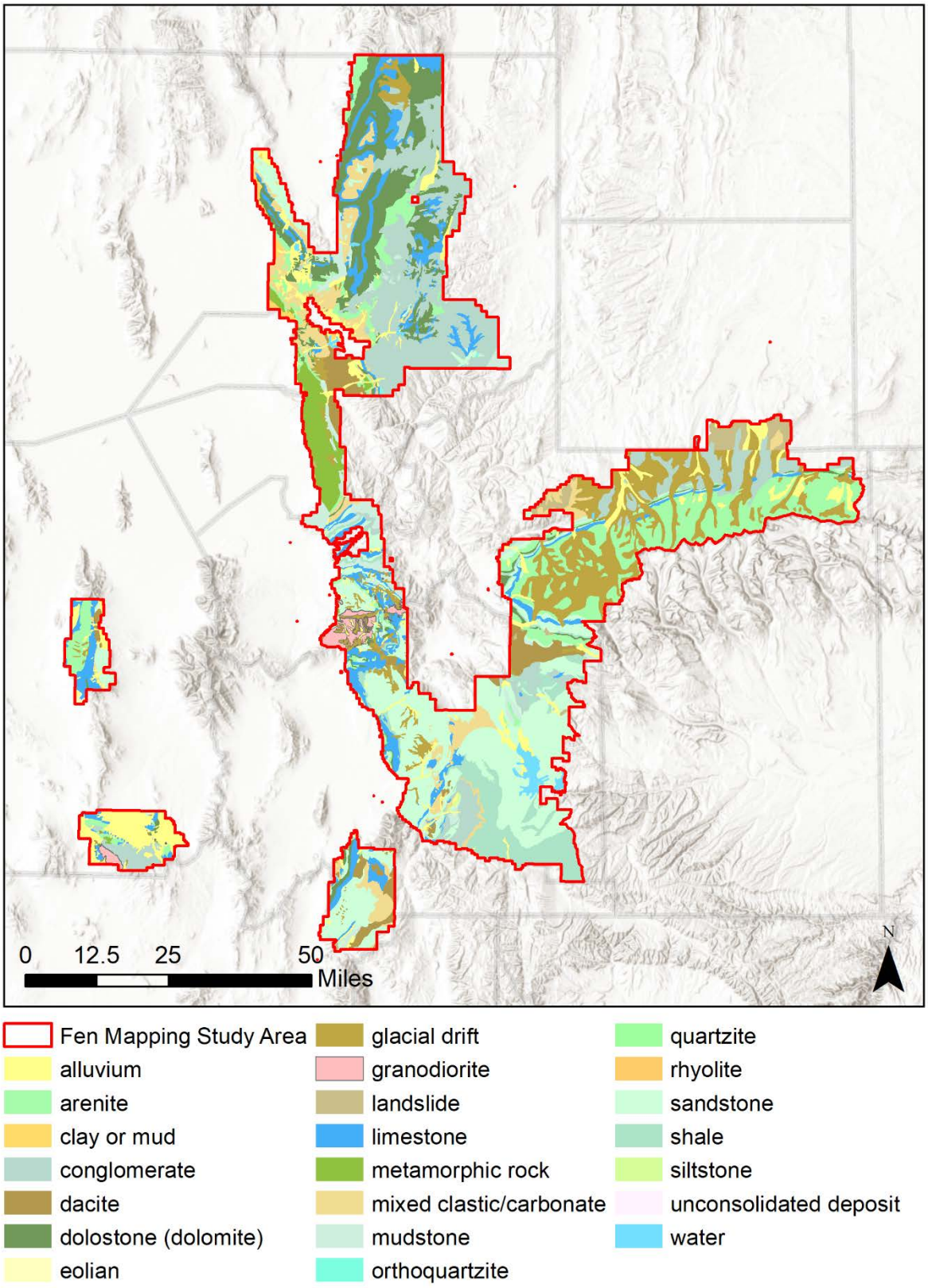

Figure 4. Geology within the fen mapping study area (USGS 2004).

3.0 Fen Mapping Methods

Potential fens in the Uinta-Wasatch-Cache National Forest were identified by analyzing digital aerial photography and USGS topographic maps. True color aerial photography taken by the National Agricultural Imagery Program (NAIP) in 2006, 2011, 2018, and 2021 were used in conjunction with color-infrared (CIR) imagery from 2006, 2018, and 2021. High (but variable) resolution World Imagery from Environmental Systems Research Institute (ESRI) was also used. We used wetland polygons mapped by the U.S. Fish and Wildlife Service's National Wetland Inventory (NWI) program to help identify potential fens. NWI wetland polygons include information about vegetation communities and hydrology and wetlands with a "B" (seasonally saturated) or "D" (continuously saturated) hydrologic regime were isolated from the full NWI dataset and examined.[2] Wetlands mapped as Palustrine Emergent Saturated (PEMB/D) and Palustrine Scrub-Shrub Saturated (PSSB/D) best matched the vegetation and hydrologic conditions necessary for fen formation and every PEMB/D and PSSB/D polygon in the study area was visually checked by trained photo-interpreters. However, photo-interpreters were not limited to the NWI wetland polygons and also mapped any fens they observed outside of B or D regime NWI polygons.

Potential fen polygons were hand-drawn in ArcGIS 10.6 based on the best estimation of fen boundaries visible in the NAIP, World Imagery, or topographic maps. In most cases, this did not match the exact boundaries of the original NWI polygons because the resolution of current imagery is far higher than was available in the 1980s. The fen polygons were often a portion of the NWI polygon or were drawn with different but overlapping boundaries. This will provide Uinta-Wasatch-Cache National Forest the most accurate and precise representation of fens in the Forest, as opposed to estimates based on the NWI polygons themselves. Each potential fen polygon was attributed with a confidence value of 1, 3 or 5 (Table 1). Diagnostic fen characteristics that can be recognized in aerial imagery include: indications of groundwater discharge (stream starts and rivulets), evidence of low energy hydrology (consistent flow paths, lack of seasonal scouring), color (dark green/brown in true color imagery, dark red in CIR imagery), vegetation (lack of tall woody trees, trees if present appear stunted), and surface texture (smooth textures due to graminoid dominance of uniform height, or consistent small ponds/depressions, ridges and striations). In addition to the confidence rating, any justifications of the rating or interesting observations were noted, including beaver influence, floating mats, springs or human stressors.

Each fen location for the purposes of this report is a single potential fen polygon. Potential fen polygons of different confidence levels may be adjacent or nested within each other and together represent a larger fen complex.

[2] For more information about the National Wetland Inventory and the coding system, please visit: http://www.fws.gov/wetlands/

Table 1. Description of potential fen confidence levels.

Confidence	*Description*
5	***Likely fen.*** Strong photo signature of fen vegetation, fen hydrology, and good landscape position. All likely fens should contain peat of 40cm or more throughout the entire area of the mapped feature.
3	***Possible fen.*** Some fen indicators present (vegetation signature, topographic position, ponding or visibly saturated substrate), but not all indicators present. Some may be weak or missing. Possible fens may or may not have the required peat depth of 40cm, but may have patchy or thin peat throughout.
1	***Low confidence fen.*** At least one fen indicator present, but weak. Low confidence fens are consistently saturated areas that do not show peat signatures in the aerial photography, but may contain fen or peat.

4.0 RESULTS

4.1 Potential Fen Mapping Acreage

The final map of potential fens contained 10,452 potential fen locations (all confidence levels), covering 19,965 acres or 0.6% of the total land area (Table 2; Figures 5 and 6). This total included 879 ***likely fens*** (confidence level = 5), 2,508 ***possible fens***, and 7,065 ***low confidence fens.***

On average the likely fens were larger in size to the possible and low confidence fens (3.92 acres vs. 2.11 or 1.59 acres), resulting in 3,447 acres of likely fens, 5,299 acres of possible fens, and 11,219 acres of low confidence fens. The size of individual potential fens ranged from over 110 acres to 0.01 acres. The largest mapped likely fen at 73 acres is located west of South Burro peak in Summit County, Utah near the Summit and Duchesne County border (Figure 7). The second and third largest fens (58 and 41 acres respectively) are located nearby, west and northwest of Beaver Lake (Figure 8 and 9).

Table 2. Potential fen counts and acreage, by confidence levels.

Confidence	*Count*	*Acres*	*Average size (acres)*
5 – Likely Fen	879	3,447	3.92
3 – Possible Fen	2,508	5,299	2.11
1 – Low Confidence Fen	7,065	11,219	1.59
TOTAL	**10,452**	**19,965**	**1.91**

The sections that follow (4.2 through 4.5) break down the fen mapping by elevation range, geology, EcoMap Subsection and HUC12 (synonymous with 6th-field HU's) watershed. The last section

summarizes observations made by the fen mappers during the mapping process, including potential floating mat fens.

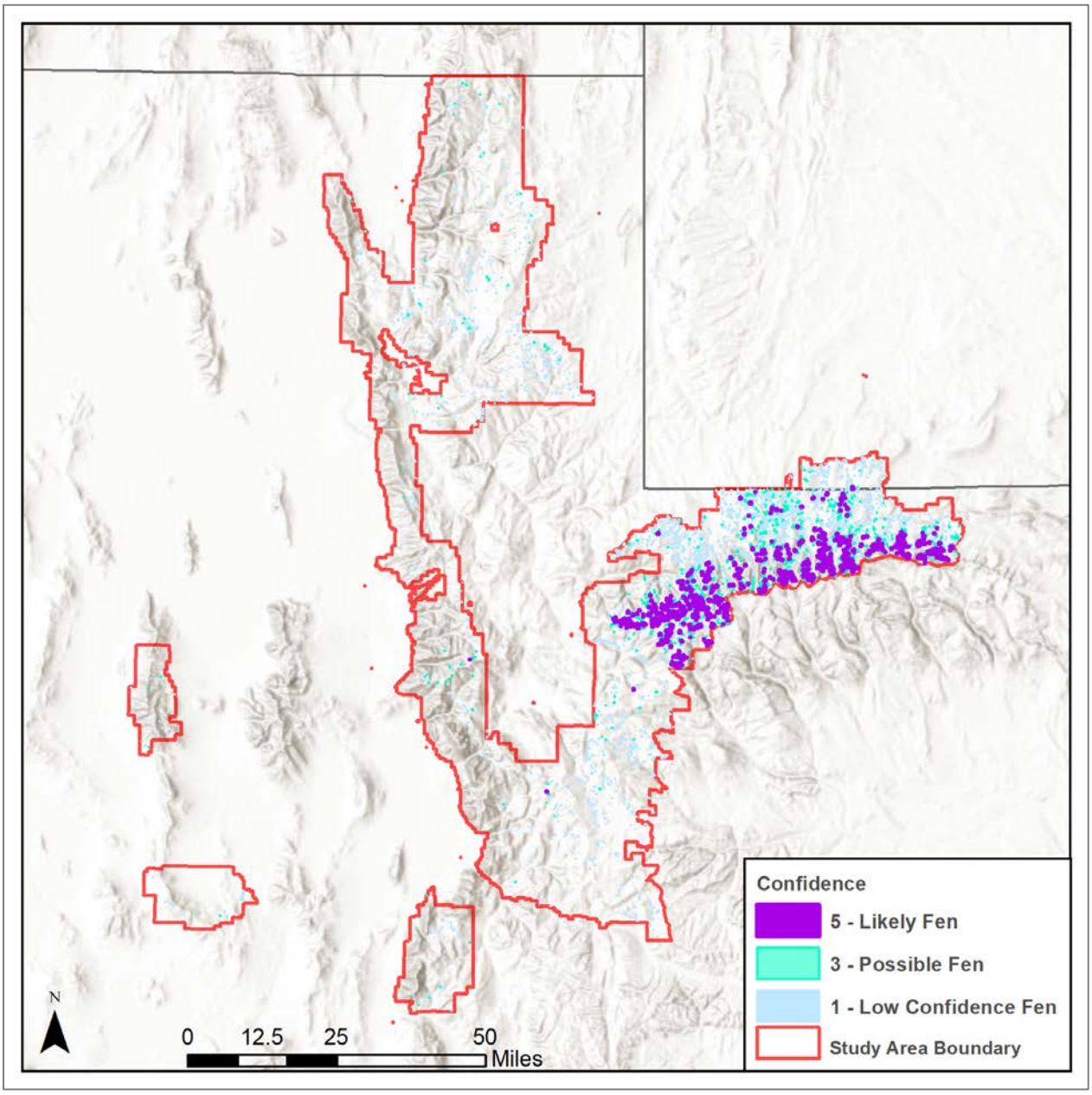

Figure 5. All potential fens within the fen mapping study area.

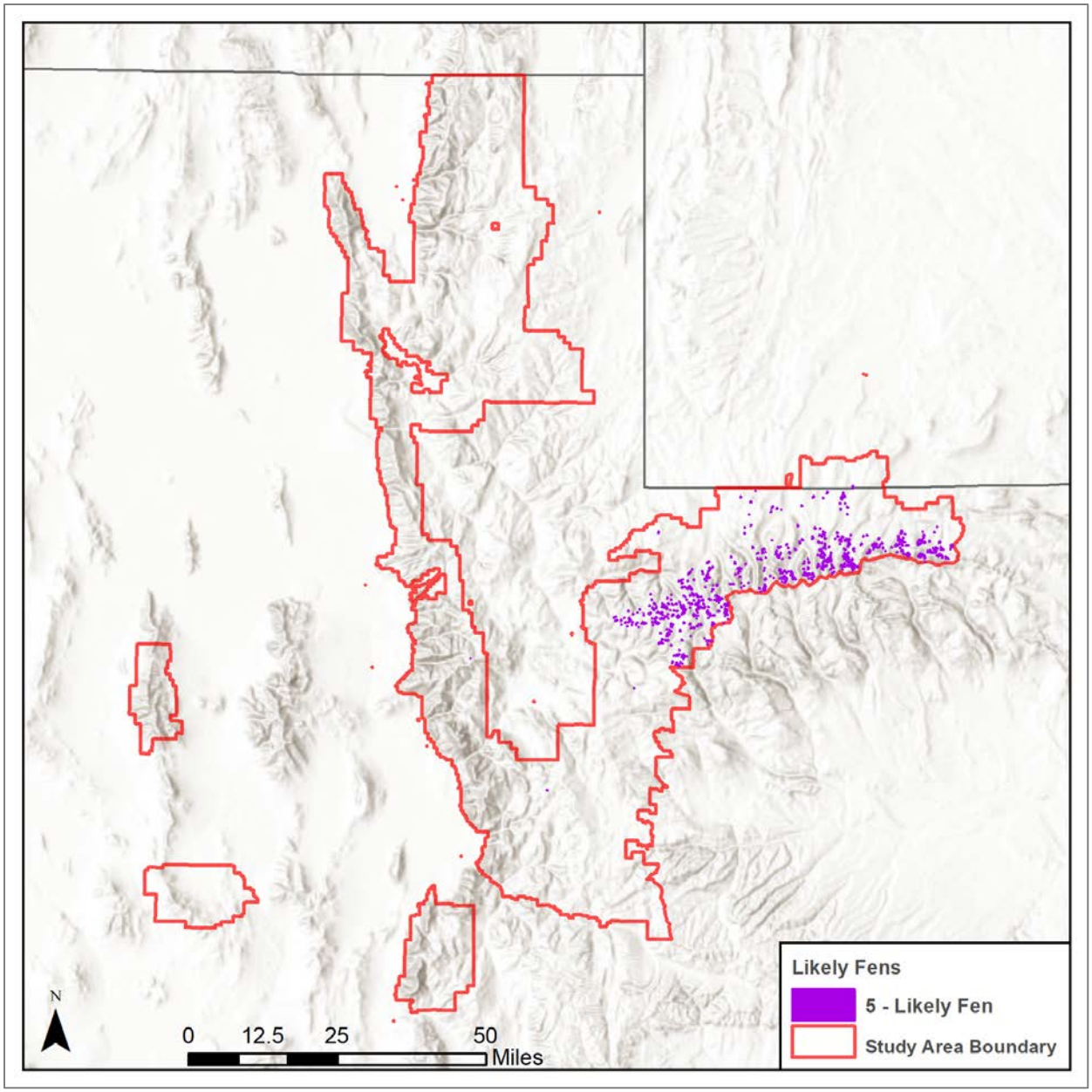

Figure 6. Likely fens (confidence rating = 5) within the fen mapping study area.

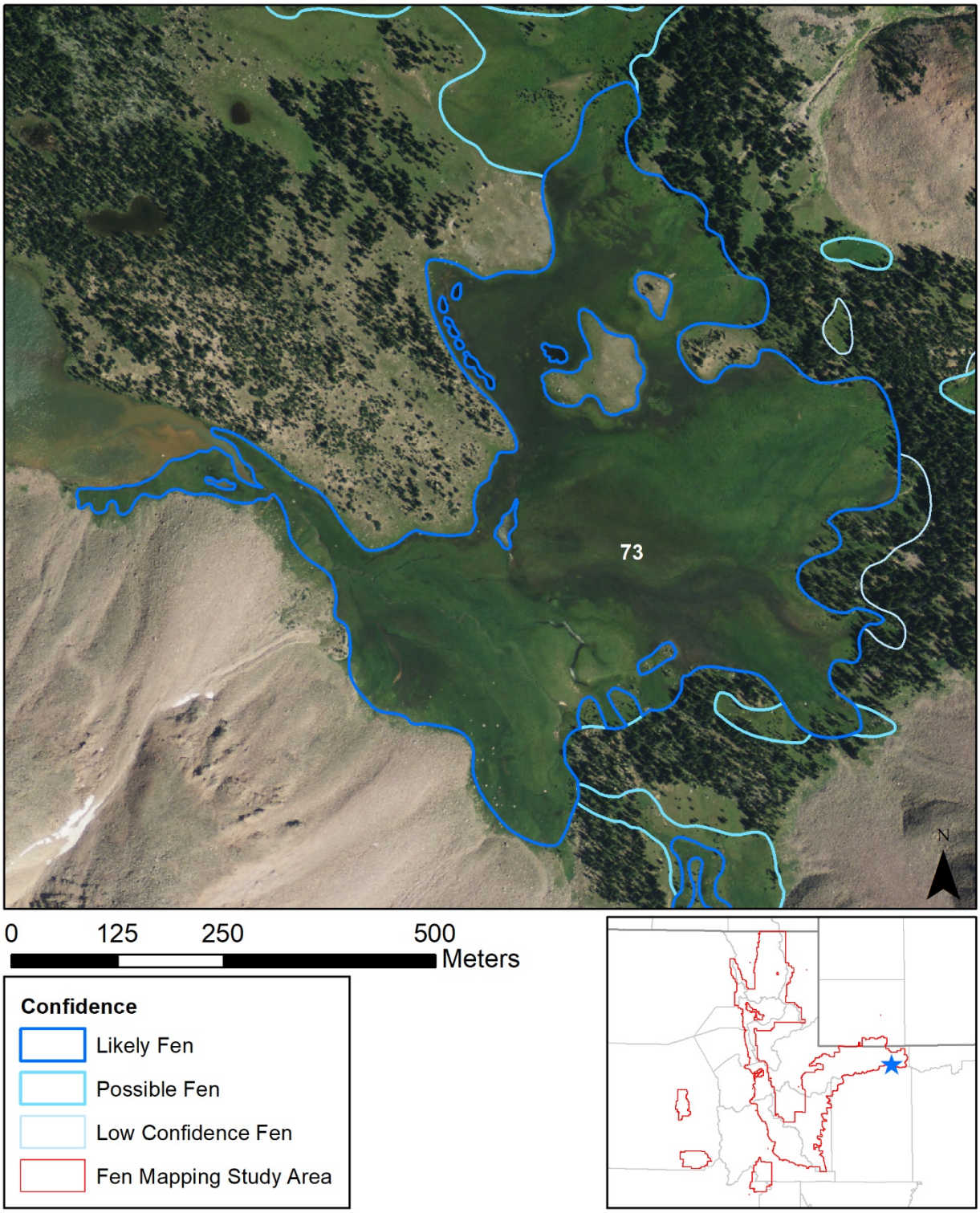

Figure 7. The largest mapped likely fen, 73 acres within one polygon, located west of South Burro peak in Summit County, Utah near the Summit and Duchesne County border.

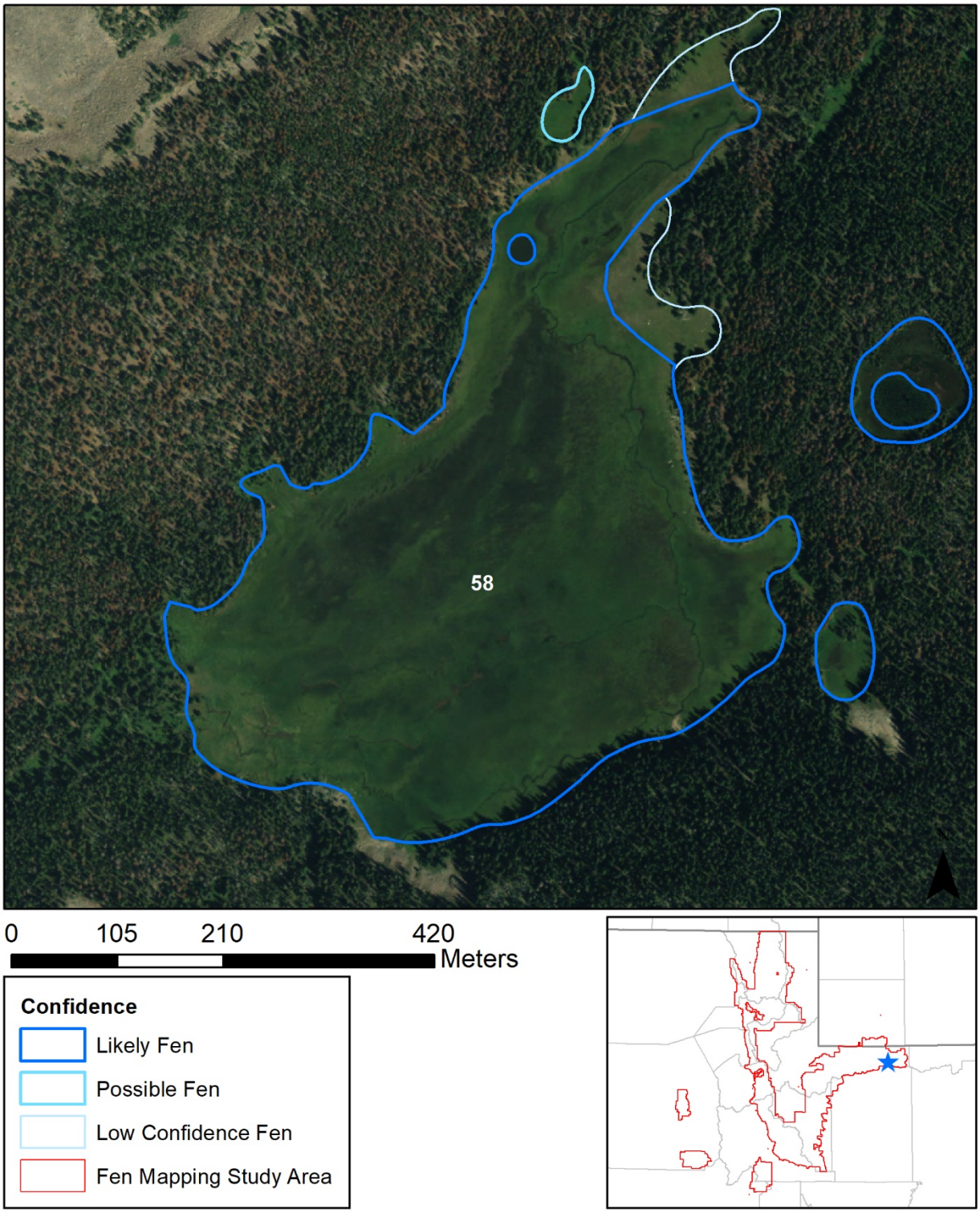

Figure 8. The second largest likely fen at 58 acres, located west of Beaver Lake in Summit County, Utah, about 2 miles northwest of the likely fen shown in Figure 7.

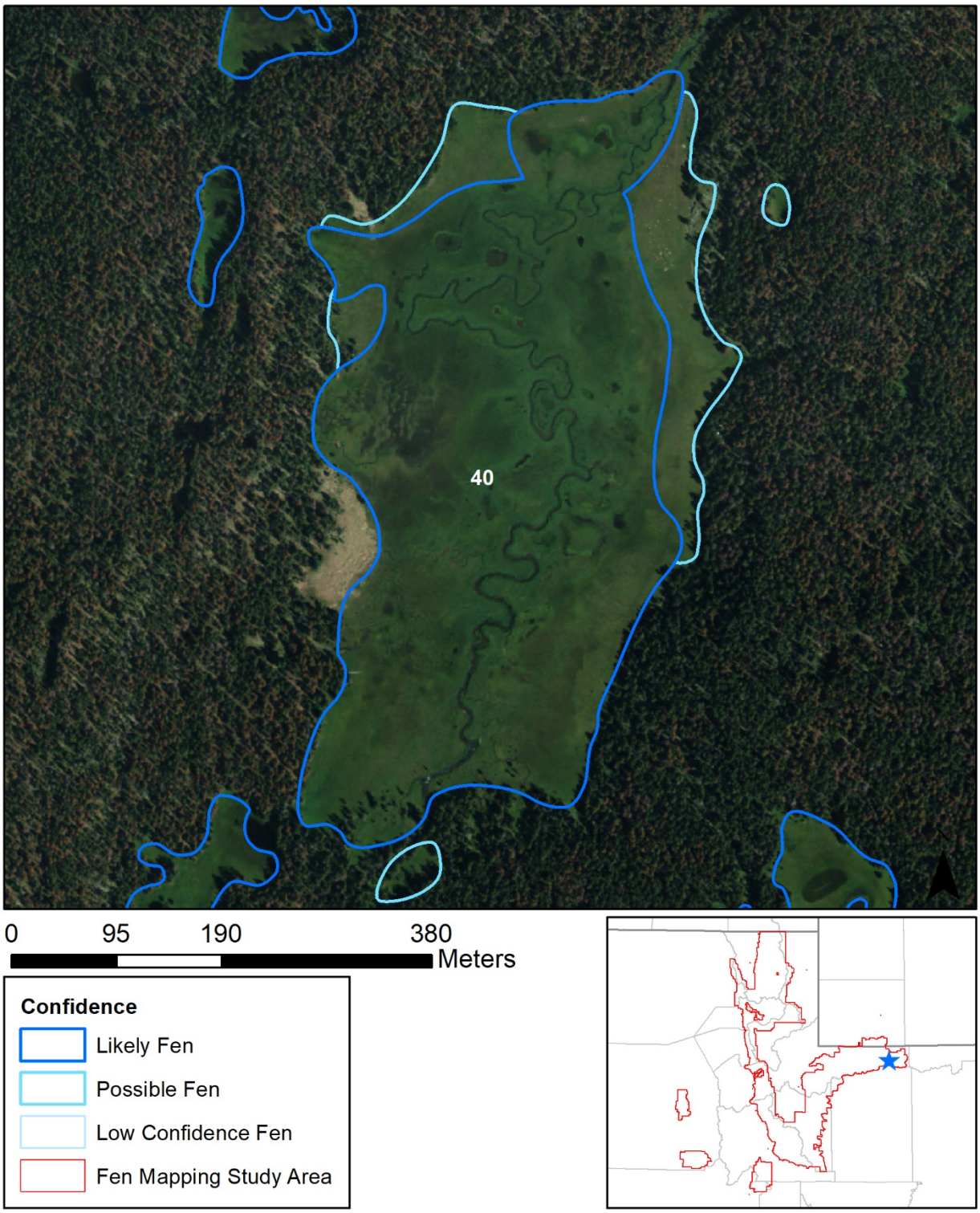

Figure 9: The third largest likely fen (40 acres) located south of Hidden Lake, along the Middle Fork of Beaver Creek, in Summit County, Utah.

4.2 Mapped Potential Fens by Elevation

Elevation is an important factor in the location of fens. Fen formation occurs where there is sufficient groundwater discharge to maintain permanent saturation. This is most often at higher elevations, where slow melting snowpack can percolate into subsurface groundwater. Springs are also an important water source for fens in more arid regions and can occur across a wider elevation range.

Of all potential fens, 3,949 polygons (7,673 acres) were mapped between 10,000 and 11,000 feet, which represents 38% of potential fen locations and potential fen acres (Table 3; Figure 10). Of the 879 total likely fens mapped, 585 polygons (67%) and 2,320 acres (67%) were located between 10,000 and 11,000 feet (Table 3; Figures 11 through 14). This is one zone of maximum fen formation for the Uinta-Wasatch-Cache National Forest.

In addition, the elevation band of 9,000 to 10,000 feet also contains many potential and likely fens. Between 9,000 to 10,000 feet, there were 3,409 mapped potential fens (2,876 acres), which represent 33% of potential fen locations and 34% of potential fen acres. In addition, there were 200 likely fens (797 acres), which represent 23% of likely fen locations and 23% of likely fen acres. The elevation band of 11,000 to 12,000 feet contains 89 likely fens (326 acres) which represent 10% of likely fen locations and 9% of likely fen acres.

Table 3. Potential and likely fens by elevation within the fen mapping study area.

Elevation Range (ft)	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
> 5,000	10	58	--	--
> 5,000 – 6,000	199	233	--	--
> 6,000 – 7,000	390	434	--	--
> 7,000 – 8,000	776	1,065	--	--
> 8,000 – 9,000	911	2,286	5	4
>9,000 – 10,000	3,409	6,709	200	797
>10,000 – 11,000	3,949	7,673	585	2,320
>11,000 – 12,000	799	1,495	89	326
>12,000	9	11	--	--
Total	**10,452**	**19,965**	**879**	**3,447**

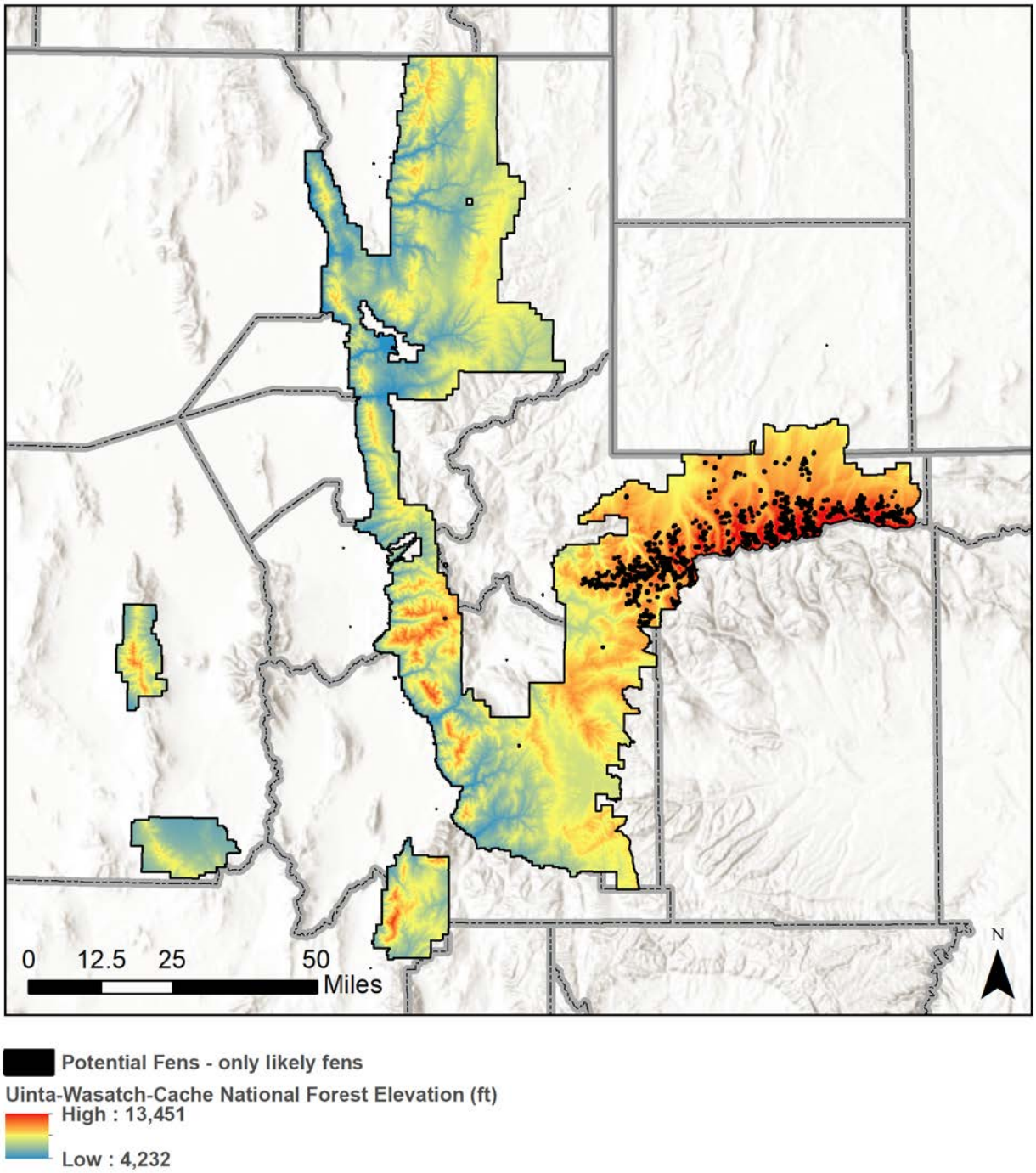

Figure 10: Likely fens (confidence rating = 5) and elevation within the fen mapping study area.

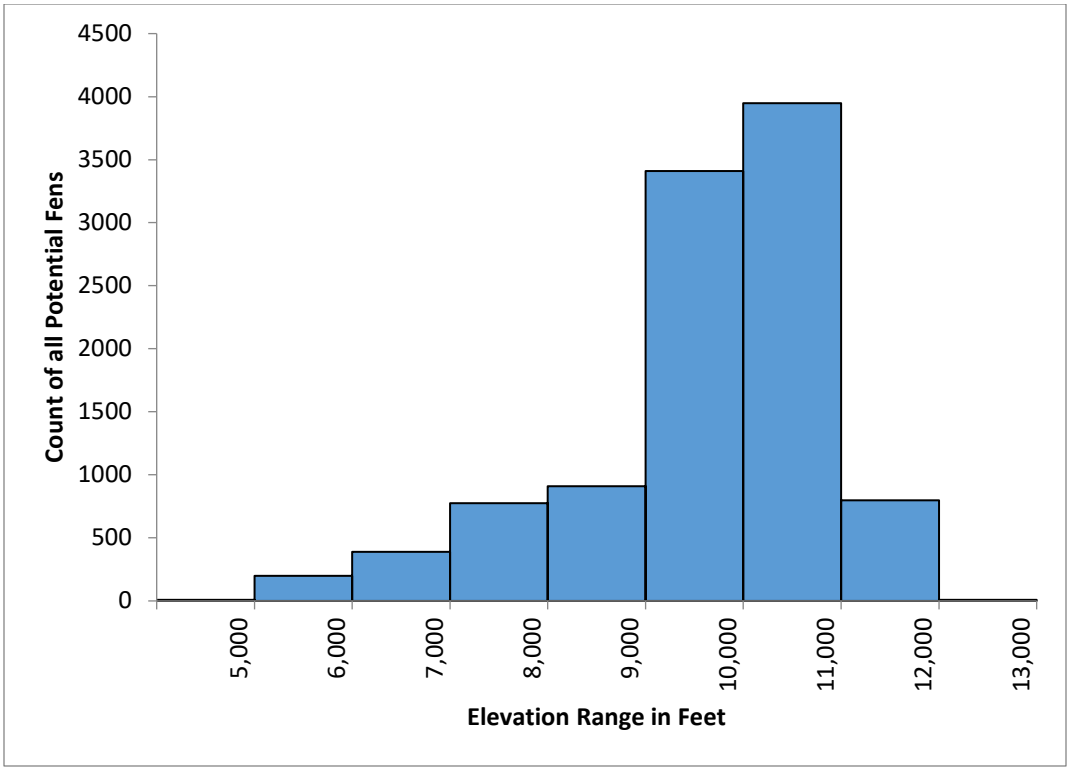

Figure 11. Histogram of all potential fens by elevation within the fen mapping study area.

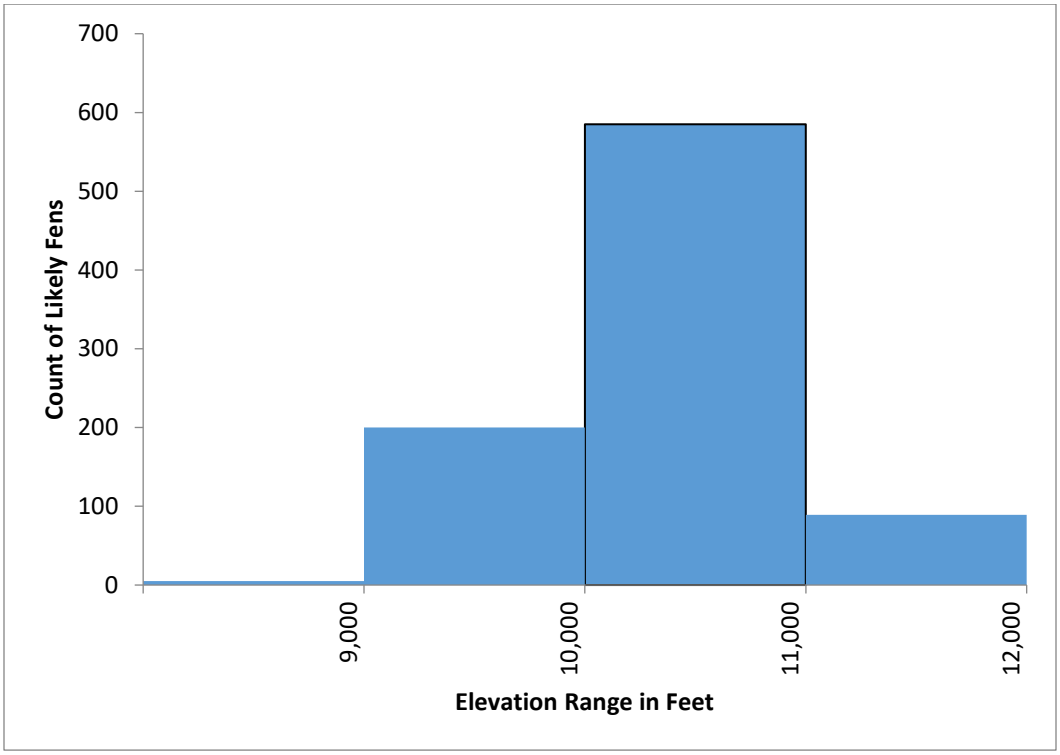

Figure 12. Histogram of the most likely fens by elevation within the fen mapping study area.

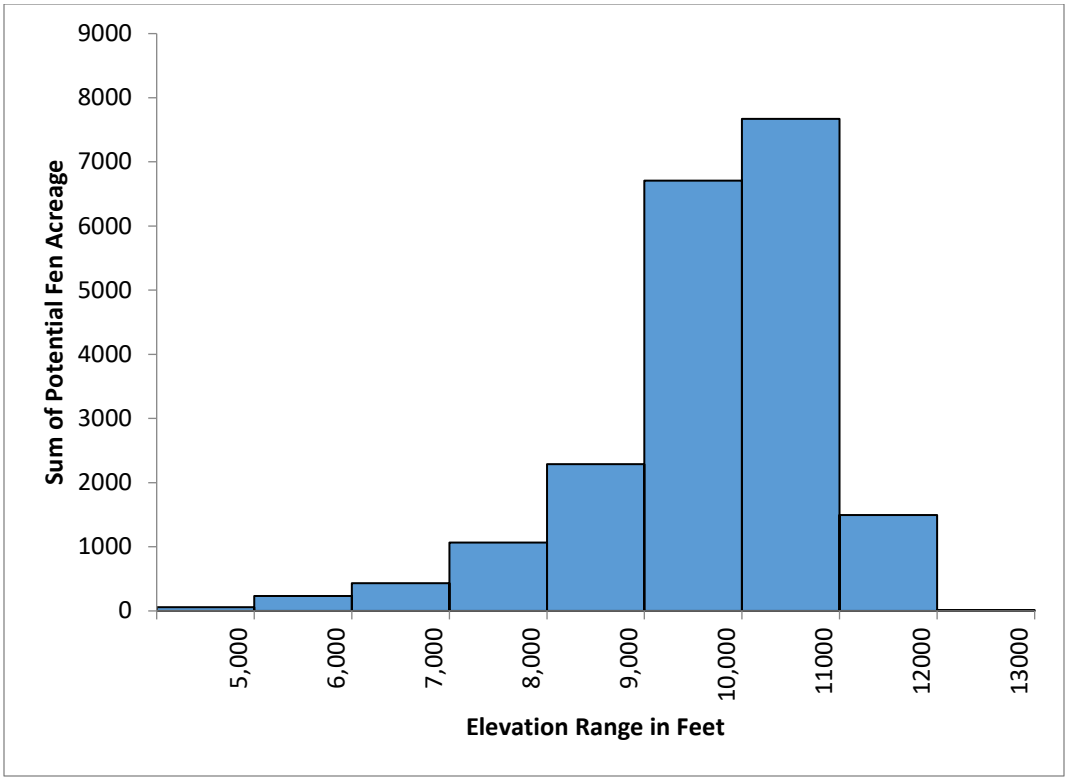

Figure 13. Graph of the sums of potential fen acreage by elevation within the study area.

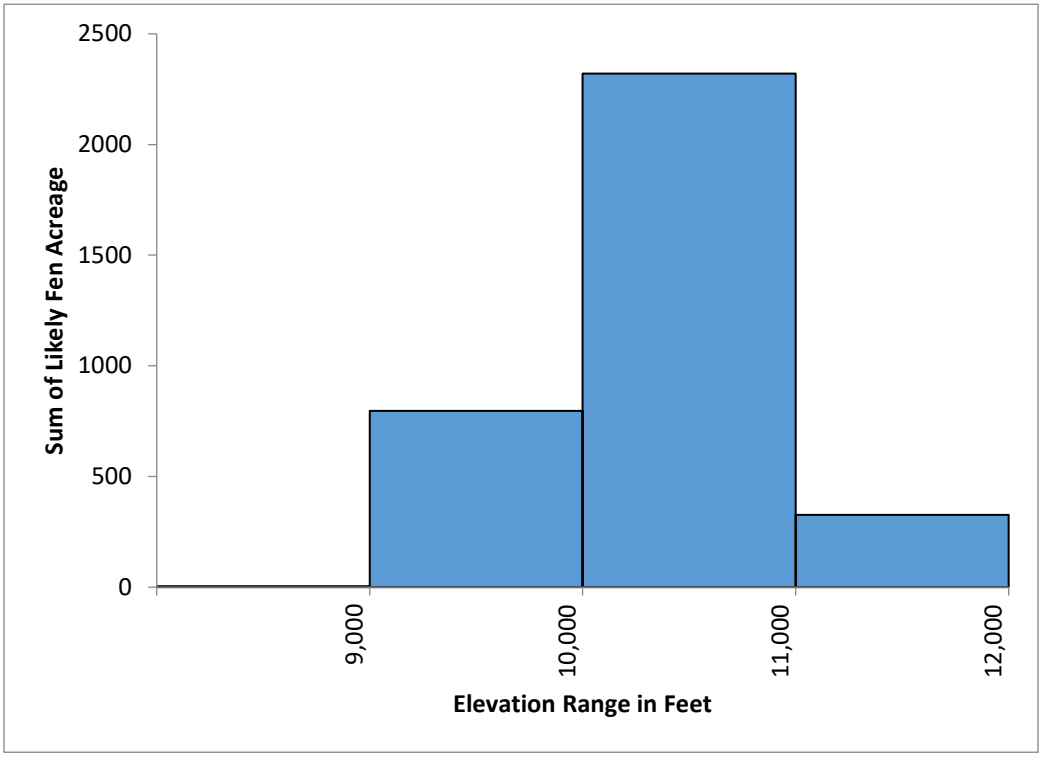

Figure 14. Graph of the sums of likely fen acreage by elevation within the study area.

4.3 Mapped Potential Fens by Geology

The most common geologic substrate under potential fens in Uinta-Wasatch-Cache National Forest was glacial drift, which underlies 4,775 mapped potential fens (9,452 acres) (Table 4). The most common geologic substrate under likely fens was also glacial drift, which underlies 519 mapped likely fens (2,044 acres). Arenite, conglomerate, and alluvium underlies most of the remaining likely fen acres, with 329 likely fens and 1,217 likely fen acres on granite (37% of likely acres), 15 likely fens and 103 likely fen acres on conglomerate (3% of likely acres) and 12 likely fens and 61 likely acres on alluvium (2% of likely acres). While sandstone is the most common geologic substrate in the Forest, underlying 17% of the Forest, these areas contain only 4% of all potential fens and only 1 likely fen.

Table 4. Potential and likely fens by geologic substrate within the fen mapping study area

Geology	*Acres of Geologic Substrate Within UWCNF*[1]	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
glacial drift	319,311	4,775	9,452	519	2,044
arenite	318,438	2,751	5,149	329	1,217
conglomerate	449,115	972	1,631	15	103
alluvium	208,197	546	1,599	12	61
sandstone	487,768	386	609	1	1
landslide	40,821	202	621	1	8
limestone	225,063	145	150	1	10
dolostone (dolomite)	244,847	135	117		
shale	138,590	122	172		
dacite	89,206	121	128		
mixed clastic/carbonate	158,932	113	137		
mudstone	83,877	98	76		
granodiorite	28,885	37	41	1	1
metamorphic rock	68,076	16	14		
water	22,239	16	32		
unconsolidated deposit	982	8	19		
clay or mud	20,955	3	12		
orthoquartzite	801	3	0		
siltstone	1,209	2	0		
eolian	1,285	1	6		
quartzite	2,155	0	-		
rhyolite	24	0	-		
		10,462	**19,965**	**879**	**3,445**

[1] Acres of geologic substrate shown are only for those substrates where fens were mapped. The total acreage is not shown because it does not equal the total acreage of the Uinta-Wasatch-Cache National Forest.

4.4 Mapped Potential Fens by Ecological Subsection

The Western High Uintas Ecological Subsection covers 10% of the Uinta-Wasatch-Cache National Forest, but this Subsection contains 46% of potential fens (4,771) and 53% likely fen locations (582) (Figure 15). The North Slope Uinta Mountains Subsection covers 7% of the Forest and contains 18% of potential fens (1,909), and 4% of likely fens (34). The Kamas Uplands Subsection covers 7% of the Forest, and it contains 1,735 mapped potential fens (2,485 acres) and 239 likely fens (757 acres) which represents 29% of likely fen locations and 22% of likely fen acres (Table 5).

Table 5. Potential and likely fens by ecological subsection within the fen mapping study area.

EcoMap Ecological Subsection Name	*Acres within Uinta-Wasatch-Cache National Forest*[1]	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
Western High Uintas	283,221	4,771	10,678	582	2,519
North Slope Uinta Mountains	190,134	1,909	4,112	34	160
Kamas Uplands	209,503	1,735	2,485	259	757
Southern Bear River-Wasatch Ranges	394,551	638	725	1	8
Northern Wasatch Range	297,243	255	289		
West Fork Duchesne River-Soapstone Mountain	118,122	203	530	1	1
Strawberry Valley-Current Creek	137,862	181	255		
Mt. Timpanogos-Southern Wasatch Front	219,985	142	55		
Southern Wasatch Range	210,162	134	63	1	1
Front Wasatch Mountains	187,462	122	130	1	2
Northern Wasatch Mountains	194,579	65	187		
Wasatch Valleys and Hills	61,616	65	100		
Bear River Front Range	135,208	60	23		
Southern Salt Lake Mountains and Valleys	69,229	50	19		
Semi-Arid Hills and Low Mountains	37,353	32	100		
Northern Sevier Desert Mountains and Valleys	98,281	30	41		
West Bear River Divide	27,865	21	9		
Clay Basin-Corson Peak Uplands	11,682	18	17		
Green River Basin	2,162	6	134		
Trout Creek Peak Highlands	1,005	5	6		
Cache Valley	1,628	4	1		
Semi-Arid Benchlands and Canyonlands	11,506	4	4		
Canyon Mountain Range	10,051	2	2		
Curlew-Bear River-Blue Creek Valleys	207	-	-		
Eastern Wasatch Mountain Zone	237	-	-		
		10,452	**19,965**	**879**	**3,448**

[1] Acres of Ecological Subsections shown are only for those ecoregions where fens were mapped. The total acreage is not shown because it does not equal the total acreage of the Uinta-Wasatch-Cache National Forest.

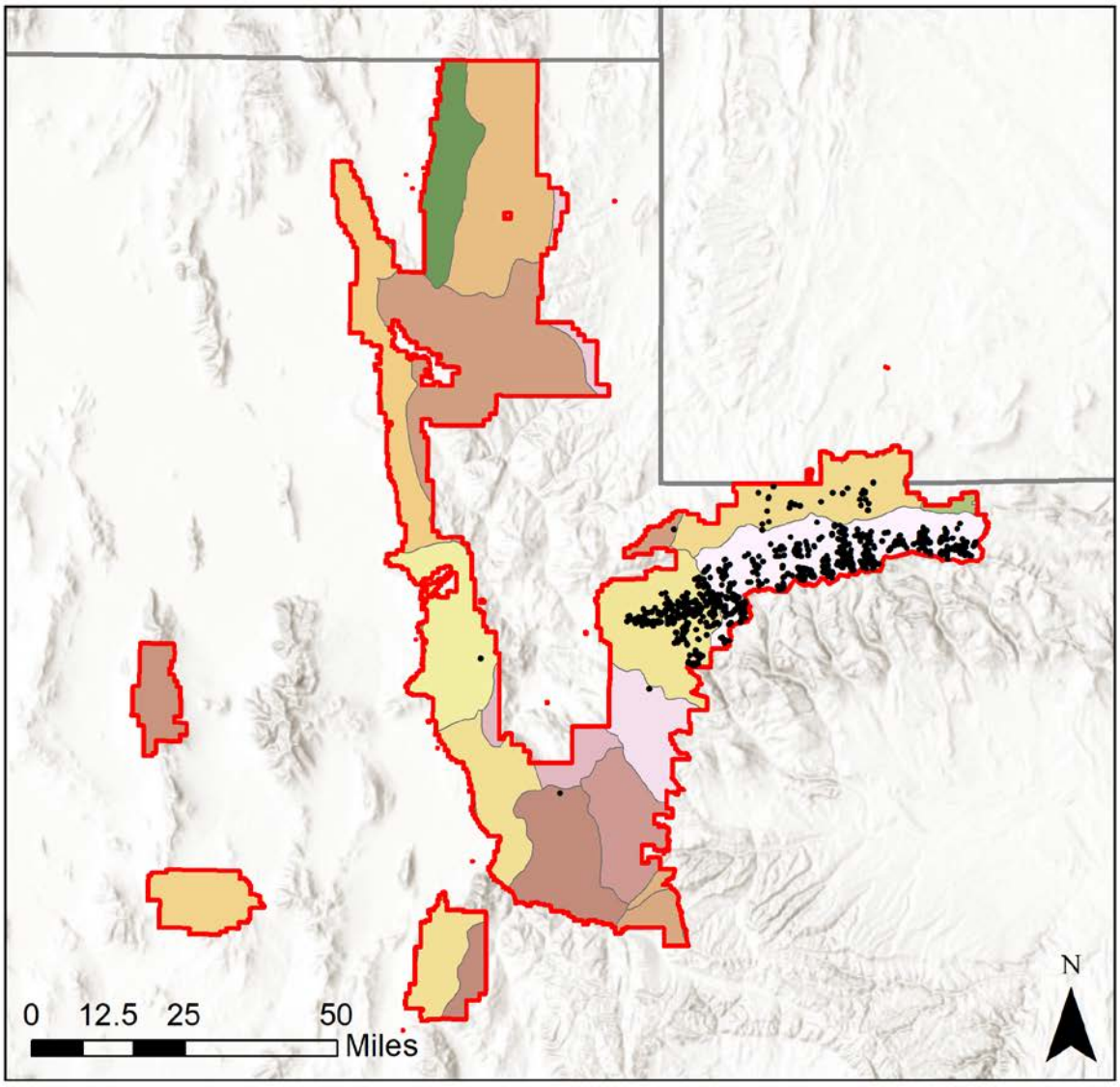

Figure 15: Likely Fens on Ecological Subsections. Note Western High Uintas (pale pink) has the highest number of likely fens and likely fen acres.

4.5 Mapped Potential Fens by Watershed

An analysis of likely fens in HUC12 (6th-field HU) watersheds revealed interesting patterns. Four watersheds in particular had substantially more likely fens (Figure 16). East Fork Smiths Fork (HUC12: 140401070201) had 91 likely fens, which covered 1.23% of the landscape in this watershed. East Fork Duchesne River (HUC12: 140600030104) had 83 likely fens, covering 1.40% of the landscape. East Fork Blacks Fork (HUC12: 140401070102) had 74 likely fens, representing 0.80% of the landscape. Spring Canyon-Provo River (HUC12: 160202030102) watershed is also notable in that it has the third highest fen density (1.17%) with 64 likely fens at 293 acres. See Appendix A for the full HUC12 watershed and likely fens table.

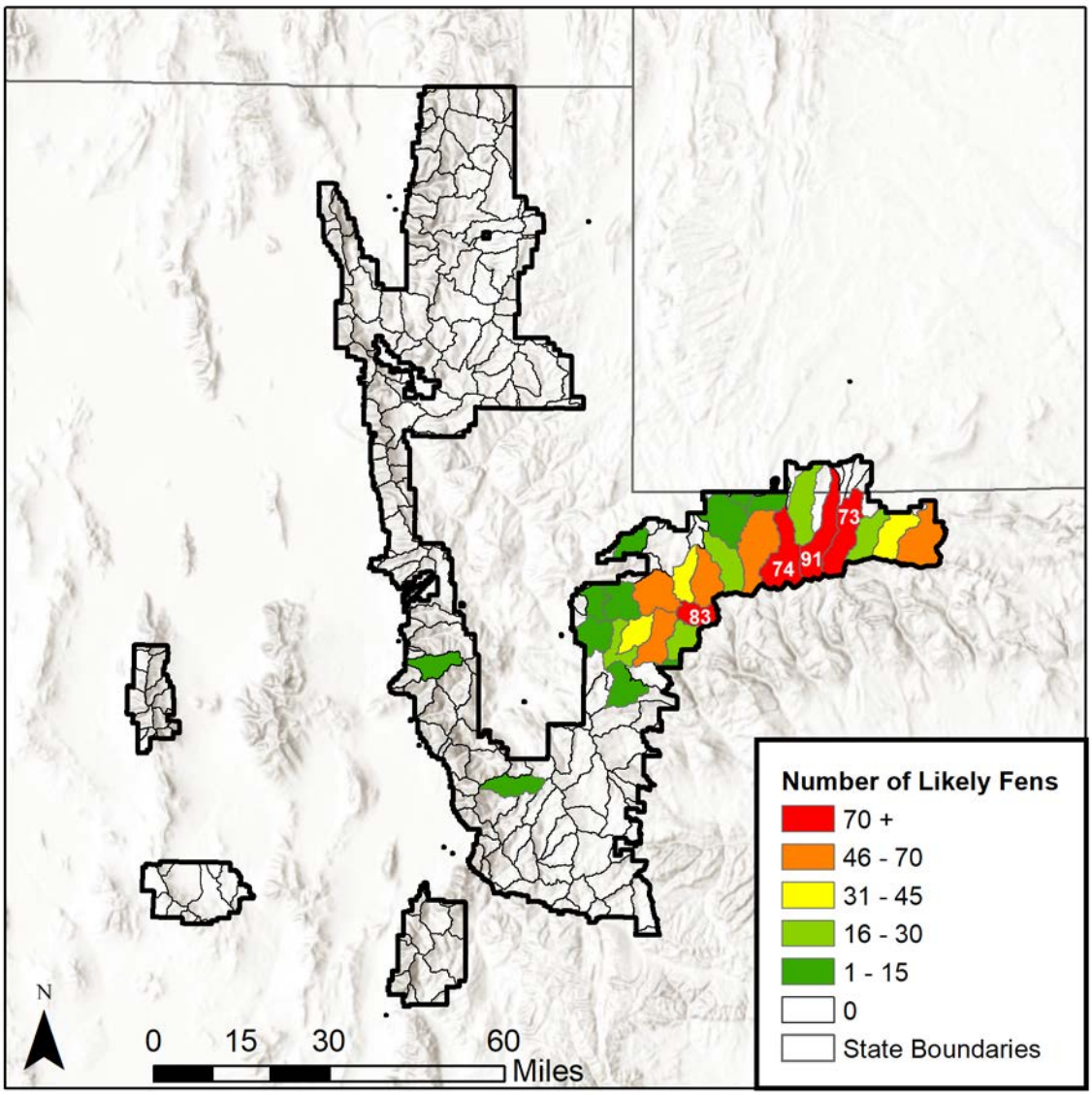

Figure 16. Likely fens by HUC12 watershed within the fen mapping study area.

4.6 Mapped Potential Fens with Distinctive Characteristics

Photo-interpreters observed several types of unique fens such as floating mats, beaver influence and nearby springs throughout the project (Table 6). We flagged these unique fen types in the dataset for potential management interest. This flagging was opportunistic and driven by visibility of the unique features.

Of particular interest was identifying markers for potential floating mat fens, a rare type of fen that may occur in National Forests throughout the intermountain region (Kate Dwire, Research Ecologist at the US Forest Service Rocky Mountain Research Station, *personal communications in 2016*). Sixty-two potential fens (112 acres) and four likely fens (1 acre) were identified as potential floating mat fens. Figure 17 shows a likely fen that shows floating mat characteristics located in Utah County, Utah west of Wardsworth Peak.

Springs and fens are both important components of groundwater-dependent ecosystems (GDEs) and are of particular interest to the U.S. Forest Service (USFS 2012). Springs were noted when observed on either the topographic map or aerial imagery. However, this was not a comprehensive investigation of springs or even springs within fens. Nine hundred and 81 potential fens and one likely fen were observed in proximity to springs. Springs were identified either by NHD spring points or spring annotation on USGS topographic maps. Figure 18 shows a 2-acre likely fen mapped in Salt Lake County, Utah that is located on a NHD spring point.

Beaver influence is a potentially confounding variable in fen mapping because longstanding beaver complexes can cause persistent saturation that looks very similar to fen vegetation signatures. Beavers also build dams in fens, so areas influenced by beavers cannot be excluded from the mapping. Eight hundred and thirty-two potential fens (3,419 acres) showed some evidence of beaver influence. Table 7 shows a comparison of beaver-influenced potential fen acreages in all of the US Forest Service Region 4 National Forests. Half of all beaver influenced potential fens in Region 4 National Forests occur in the Uinta-Wasatch-Cache National Forest as well as 37% of beaver influenced potential fen acres in the region.

Table 6. Potential and likely fens with distinctive characteristics within the fen mapping study area.

Observation	*# of Potential Fens*	*Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
Spring	981	504	1	2
Possible Floating Mat	62	112	4	1
Beaver Influence	832	3,419	--	--
Total	**1,766**	**3,910**	**5**	**3**

Note: some potential fens are influenced by both beaver and springs

Table 7. Beaver influenced potential fens in USFS Region 4 Forests

Region 4 National Forest	*# of Potential Fens*	*Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
Ashley	63	471	3	81
Boise	62	451	--	--
Bridger-Teton	160	1,259	--	--
Caribou-Targhee	239	1,550	1	5
Dixie	7	136	--	--
Fishlake	34	230	--	--
Humboldt-Toiyabe	41	200	1	<1
Manti-La Sal	54	162	--	--
Payette	26	352	--	--
Salmon-Challis	27	288	1	6
Sawtooth	105	801	2	2
Uinta-Wasatch-Cache	832	3,419	--	--
Total	**1,650**	**9,319**	**8**	**94**

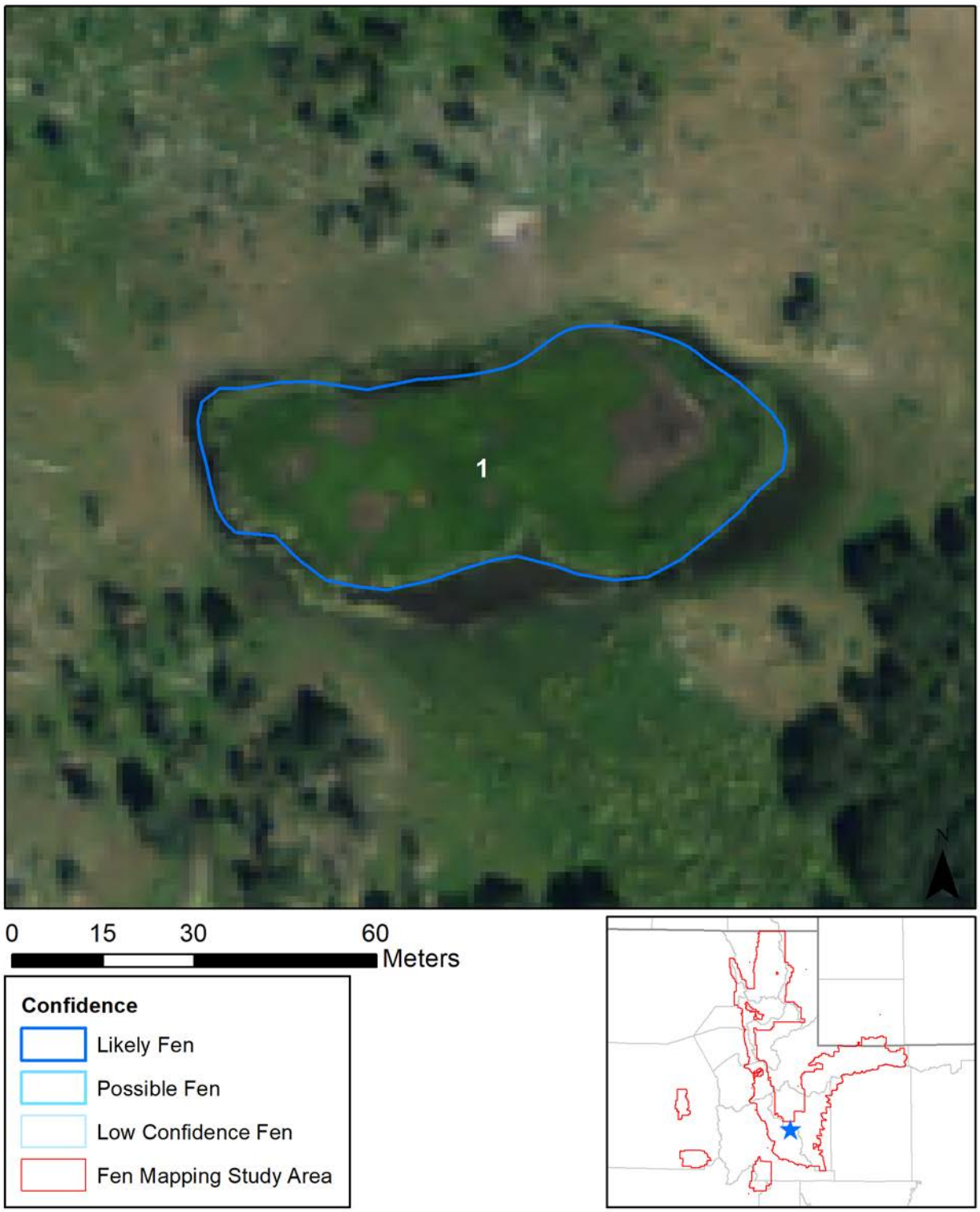

Figure 17: A likely fens with possible floating mat components located in Utah County, Utah west of Wardsworth Peak.

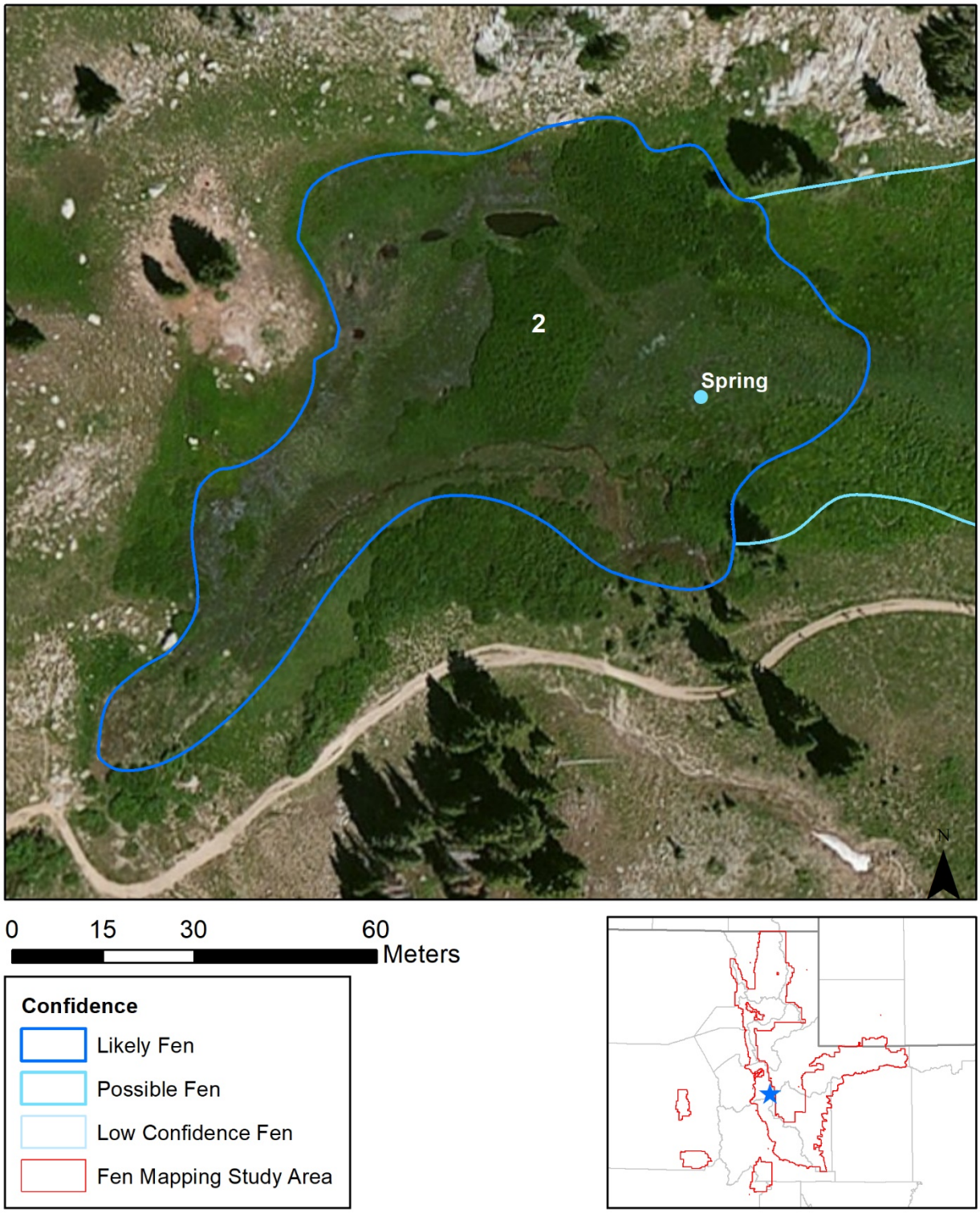

Figure 18: Largest spring influenced likely fen located in Salt Lake County, Utah east of the Alta Ski Area.

5.0 Discussion

The Uinta-Wasatch-Cache National Forest contains a relatively small number of potential fen wetlands, covering up to 19,965 acres across its jurisdiction. While the potential fens represent a very small portion of the entire landscape, they are an irreplaceable resource for the Forest and the citizens of Utah and Wyoming. Fens throughout the West support numerous rare plant species that are often disjunct from their main populations (Cooper 1996; Cooper et al. 2002; Johnson & Stiengraeber 2003; Lemly et al. 2007). Along with habitat for rare plant species, fens also play a pivotal role in regional hydrologic processes. By slowly releasing groundwater, they help maintain stream flows throughout the growing season. With a predicted warmer future climate, in which snow pack may be less and spring melt may occur sooner, maintaining groundwater storage high in the mountains is imperative. Intact fens also sequester carbon in their deep organic soils, however, disturbing fen hydrology can lead to rapid decomposition of peat and associated carbon emissions (Chimner 2000).

In total, 10,452 potential fens were mapped throughout the Uinta-Wasatch-Cache National Forest, of which 879 were most likely to be fens. While uncommon across the Forest, analysis of the potential fen data showed clear hotspots in the Uinta-Wasatch-Cache National Forest. There is a strong elevation pattern found within the mapping, with 67% of likely fens falling between 10,000 and 11,000 feet and nearly all likely fen acres occurring above 9,000 ft. Specific watersheds also stood out for fen abundance. In particular, the East Fork Smiths Fork and East Fork Duchesne River watersheds had either high numbers of fens or a high density of fen acres. Lastly, specific fens identified though this study appear to have notable characteristics, such as floating mats or direct association with springs.

Previous studies of wetland condition in other high elevation forests have found that high elevation wetlands were generally in excellent to good condition (Lemly 2012). Human stressors were observed in some fen wetlands while mapping fens on the Uinta-Wasatch-Cache National Forest, such as impoundments or excavated ponds, and those observations were captured in the “Notes” field of the GIS dataset accompanying this report. However most potential fens in Uinta-Wasatch-Cache National Forest showed little sign of human disturbance, particularly at higher elevations.

This report and associated dataset provide the Uinta-Wasatch-Cache National Forest with a critical tool for conservation planning at both a local and Forest-wide scale. These data will be useful for the Uinta-Wasatch-Cache National Forest assessment required by the 2012 Forest Planning Rule, by being used to prioritize sites for future field surveys on fens.

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APPENDIX A: LIKELY FENS BY HUC12 WATERSHED, SORTED BY LIKELY FEN COUNT

HUC12 Code	HUC12 Name	Watershed Acres	Likely Fen Count	Likely Acres	Fen Density (Fen Acres/HUC12 Acres)
140401070201	East Fork Smiths Fork	37,112	91	458	1.23%
140600030104	East Fork Duchesne River	15,476	83	217	1.40%
140401070102	East Fork Blacks Fork	37,218	74	297	0.80%
140401060301	Dahlgreen Creek-Henrys Fork	34,934	73	342	0.98%
160201010201	Dry Fork-Weber River	28,093	68	152	0.54%
140401060308	Burnt Fork	42,742	67	379	0.89%
160202030102	Spring Canyon-Provo River	25,118	64	293	1.17%
140401070101	West Fork Blacks Fork	42,281	60	137	0.33%
160101010102	Stillwater Fork	24,790	47	148	0.60%
140401060304	Beaver Creek-Henrys Fork	36,957	34	309	0.83%
160101010101	Hayden Fork	16,408	33	100	0.61%
160202030103	North Fork Provo River	15,762	32	69	0.44%
140600030105	Little Deer Creek-Duchesne River	17,324	30	80	0.46%
160101010104	East Fork Bear River	25,871	23	53	0.20%
140401070203	West Fork Smiths Fork	34,051	20	123	0.36%
140401060305	West Fork Beaver Creek	22,937	19	142	0.62%
160202030105	Shingle Creek-Provo River	15,070	17	32	0.22%
160201010202	Smith and Morehouse Creek	24,534	15	26	0.11%
140600030106	Hades Creek-Duchesne River	18,293	7	28	0.15%
160201010101	Left Fork Beaver Creek-Beaver Creek	21,930	7	17	0.08%
160101010106	Cottonwood Creek-Mill Creek	42,735	7	29	0.07%
160201010204	South Fork Weber River	12,337	2	4	0.03%
140401070103	Meeks Cabin Reservoir-Blacks Forks	29,248	1	2	0.01%
140401080101	West Muddy Creek	26,604	1	2	0.01%
160202040202	Headwaters Little Cottonwood Canyon	17,495	1	2	0.01%
160202020401	Headwaters Left Fork Hobble Creek	18,863	1	1	0.00%
160202030104	Mill Hollow-South Fork Provo River	22,032	1	0	0.00%
160201010301	East Fork Chalk Creek	21,745	1	8	0.04%