Fen Mapping for the Sawtooth National Forest

March 2021

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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EXECUTIVE SUMMARY

The Sawtooth National Forest covers over 2.1 million acres spread across six units in central and southeast Idaho with a small portion in Utah. Wetlands within the Sawtooth 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, organic soil formation can take thousands of years. 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 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 Sawtooth National Forest.

Potential fens in the Sawtooth 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 3,489 potential fen locations (all confidence levels), covering 5,968 acres or less than 1% of the total land area. This total included 392 ***likely fens***, 824 ***possible fens***, and 2,273 ***low confidence fens.*** The average fen polygon was 1.71 acres, but individual fen polygons ranged from 338 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 8,000 to 9,000 feet. This elevation range contained 37% of all potential fen locations and 56% of likely fen locations. Two watersheds in particular have higher numbers of likely fens: Middle Valley Creek watershed contains 33 likely fens and Bear Creek-South Fork Boise River watershed contains 28 likely fens.

This report and associated dataset provide the Sawtooth National Forest with a critical tool for conservation planning at both a local and Forest-wide scale. These data will be useful for the Sawtooth National Forest biological assessment required by the 2012 Forest Planning Rule, but can also be used for individual management actions, such as planning for timber sales, grazing allotments, wilderness stewardship, and other management actions. Wherever possible, the Forest should avoid direct disturbance to the fens mapped through this project, and should also strive to protect the watersheds surrounding high concentrations of fens, thereby protecting their water sources.

ACKNOWLEDGMENTS

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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.

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

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1.0 INTRODUCTION

The Sawtooth National Forest covers over 2.1 million acres in Idaho, and spans a broad elevation range from 4,514 to 12,009 ft. Several types of wetlands occur within the Sawtooth National Forest. Snowfall in the mountains percolates through shallow mountain soils and creates wet meadows, riparian shrublands, and organic soil wetlands known as fens. These wetland habitats provide important ecological services to both Sawtooth National Forest 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 also support 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 (peat) 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). Accumulation of organic material to this depth requires constant soil saturation and cold temperatures, which create anaerobic conditions that slow the decomposition of organic matter. By storing organic matter deep in their soils, fens act as a carbon sink. 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 new 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 Sawtooth 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) and Caribou-Targhee National Forest (Smith & Lemly 2020).

[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 Sawtooth National Forest, which is administered as six discontinuous units located in central to southeastern Idaho and extending south just into Utah (Figure 1). Sawtooth National Forest borders Salmon-Challis National Forest to the north and east and Boise National Forest to the west. The Craters of the Moon National Preserve, Craters of the Moon National Monument and Hagerman Fossil Beds National Monument are located in between Sawtooth National Forest Units. Sawtooth National Forest includes portions of ten counties in Idaho and one in Utah. The counties with the largest share of National Forest land are Custer, Blaine, Cassia and Camas counties Idaho. The largest municipalities near the study area are Twin Falls, Elmore, and Jerome, Idaho. Elevation in the study area ranges from 4,514 ft. (1,376 m) to 12,009 ft. (3,660 m) and the mean elevation is 7,418 ft. (2,261 m).

Sawtooth National Forest spans four different HUC6 river basins (Figure 2). The majority of the Forest land occurs in either the Salmon (HUC6:170602), Middle Snake-Boise (HUC:170501) or the Upper Snake River (HUC6: 170402) basins. The Snake River originates outside the Forest in Teton National Park, Wyoming, and bisects the Forest as the Snake River flows southwest between the units of Sawtooth National Forest. No portion of the Snake River flows through the Forest, but most of the Forest's watersheds eventually drain into the Snake River across the large open Snake River Plain. Smaller portions of the southernmost units of Sawtooth National Forest occur in the Great Salt Lake (HUC6:160203) basin.

2.2 Ecological Subsections

The U.S. Forest Service has developed Land Type Associations for each National Forest to describe the major geomorphic landforms within the Forest (USDA 2019). EcoMap Ecological Subsections are a component of Land Type Associations.

There are 18 unique Ecological Subsections in Sawtooth National Forest. The most common Ecological Subsection in the Sawtooth National Forest is the South-Central Idaho Ranges (27% of study area), which includes nearly all of the smaller Forest units in the south (Figure 3). The next most common Land Type Association subsections are the Sawtooth Range (17%), Smokey Mountains (16%) and South Fork Boise River Uplands (8%), which occur in the more diverse northern Forest unit (USFS 2017 Ecological Subregions).

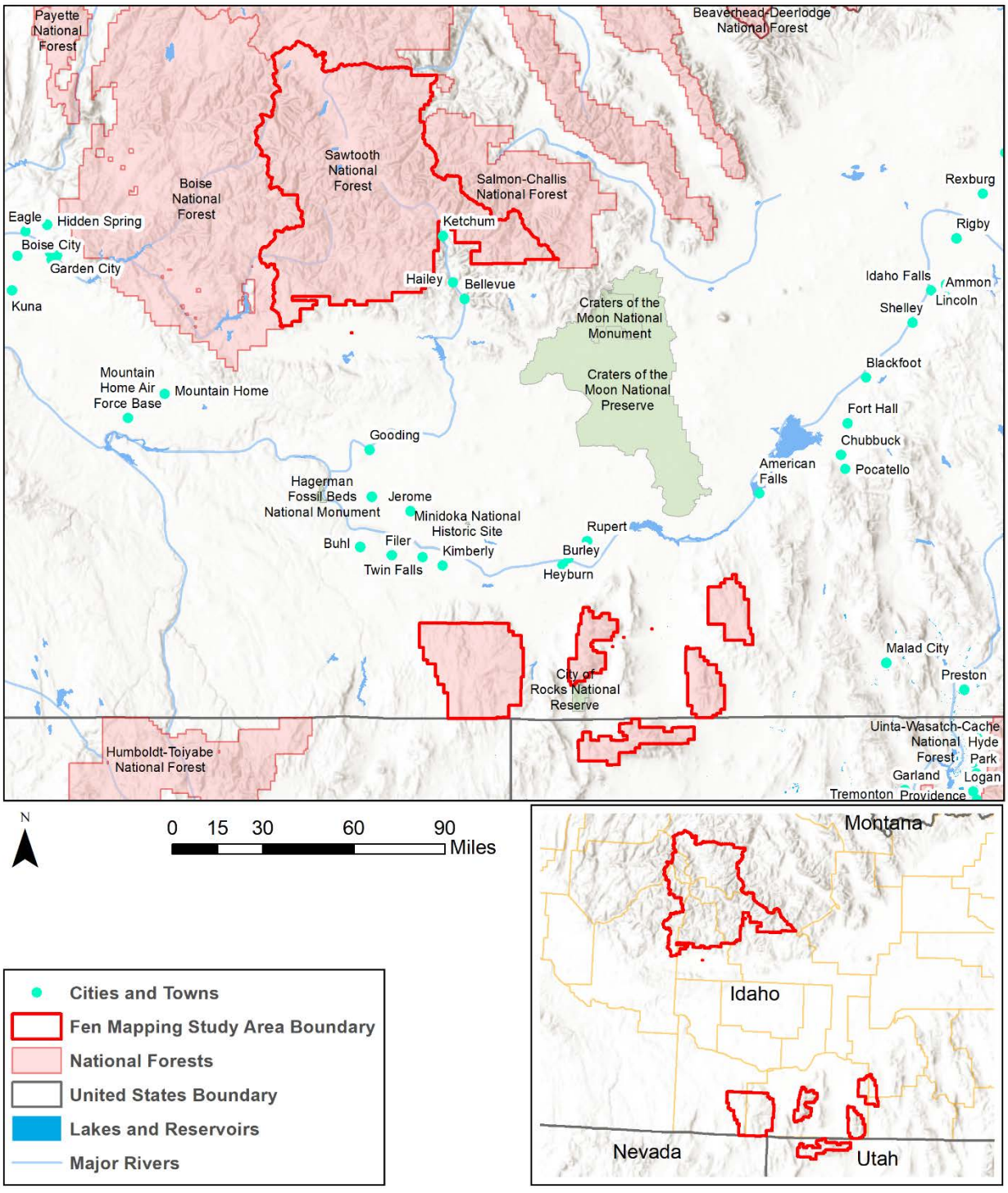

Figure 1. Location of the Sawtooth National Forest (fen mapping study area).

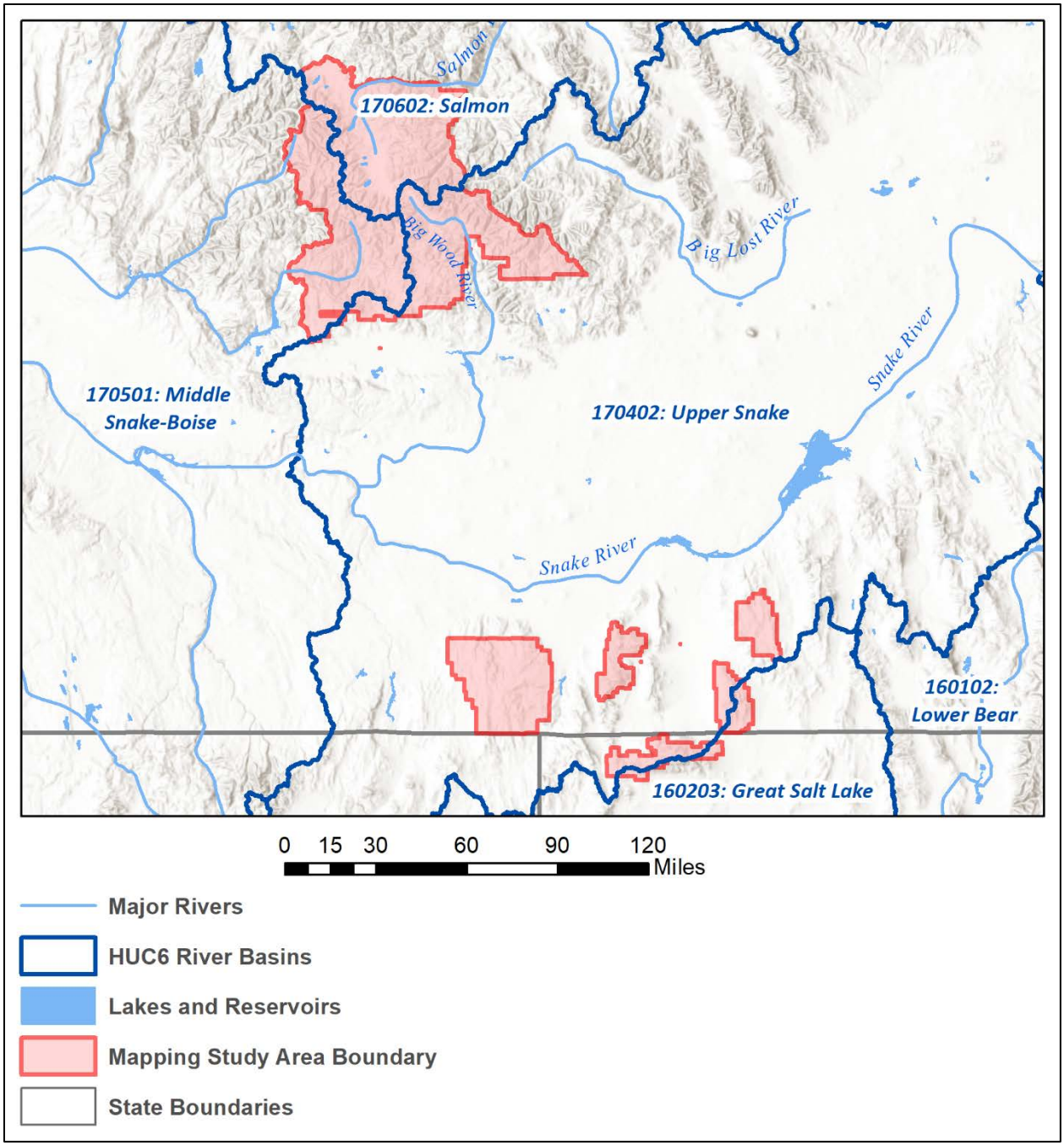

Figure 2. HUC6 river basins and major waterways in the fen mapping study area.

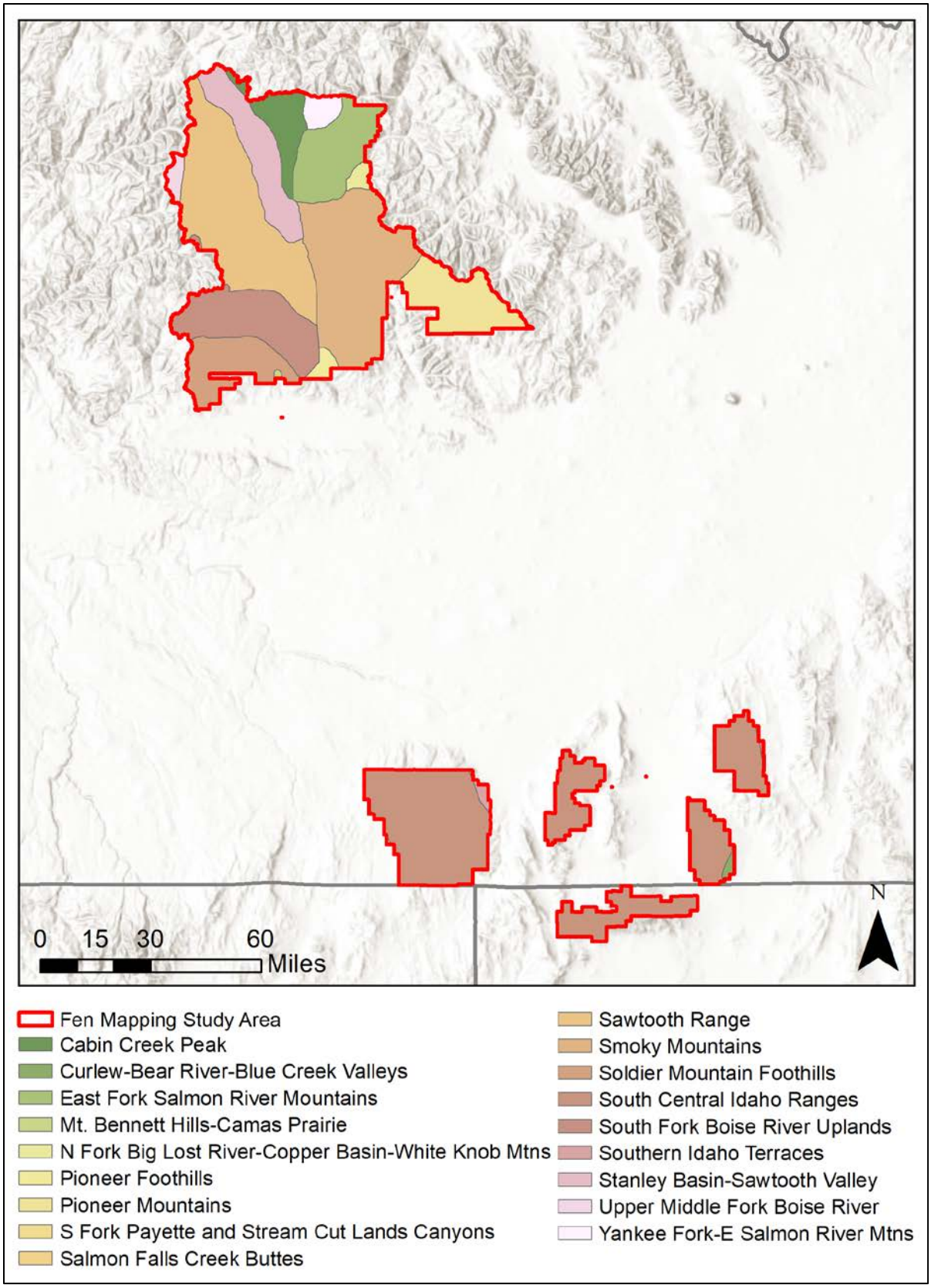

Figure 3. EcoMap Ecological Subsections of the fen mapping study area.

2.3 Geology

The Forest crosses several major geologic provinces in Idaho. Forest units are located on either side of the Snake River Plain or Yellowstone Volcanic Province, a broad depression that arches across the entire width of southern Idaho. The Snake River Plain formed over millions of years as the North American continental plate slowly passes over a stationary magma plume known as the Yellowstone hot spot. The hot spot is currently located beneath Yellowstone National Park and is responsible for the numerous geysers that characterize the National Park. Bedrock geology within the Snake River Plain is primarily basalts, tufts, and other volcanic rocks extruded from various iterations of Yellowstone volcanism.

The northern portion of the Sawtooth National Forest includes the Sawtooth and Smokey Mountain ranges, which formed between 60-110 million years ago from the Idaho batholith. These mountains are primarily granite and granodiorite. East of the Idaho batholith are the Pioneer Mountains and smaller peaks formed later during the Challis volcanic period. These mountains are a more diverse range of extrusive igneous rocks, metamorphic rocks, and some sedimentary layers on the edge of the Basin and Range Province. Forest units to the south are a mix of sedimentary rocks of the Basin and Range and rhyolite from later volcanic explosions.

Across the entire Forest, granodiorite is the most common bedrock geology unit (26% of the land area). Trachyandesite (12%), sandstone (12%) and rhyolite (10%) are also common.

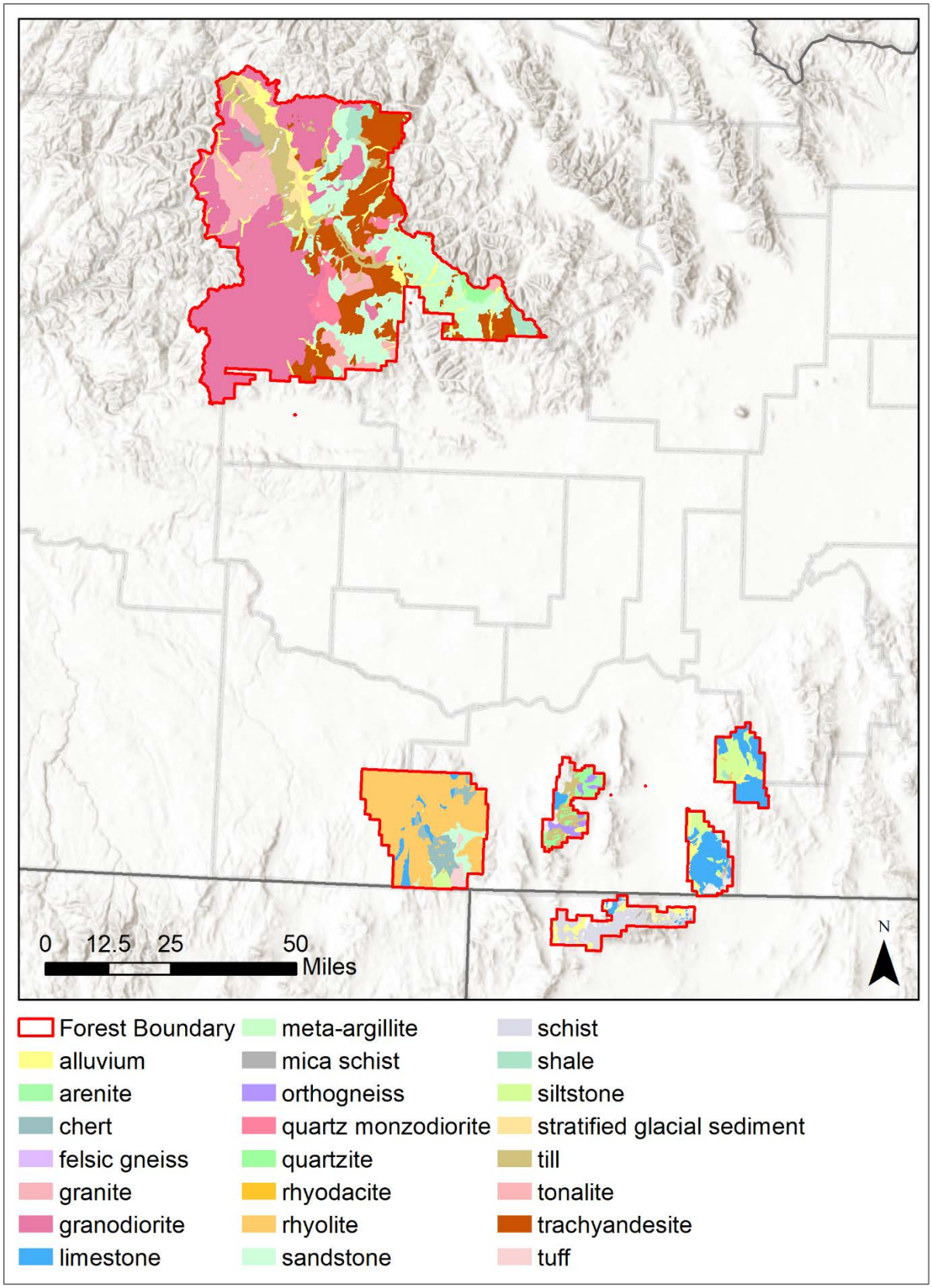

Figure 4. Geology within the fen mapping study area (USGS 2004).

3.0 Fen Mapping Methods

Potential fens in the Sawtooth National Forest were identified by analyzing digital aerial photography and topographic maps. True color aerial photography taken by the National Agricultural Imagery Program (NAIP) in 2004, 2009, 2011, 2013 and 2019 were used in conjunction with color-infrared imagery from 2015 and 2017. High (but variable) resolution World Imagery from Environmental Systems Research Institute (ESRI) was also used. To focus the initial search, where possible, all wetland polygons mapped by the U.S. Fish and Wildlife Service's National Wetland Inventory (NWI) program in the 1970s and early 80s with a "B" (seasonally saturated) hydrologic regime were isolated from the full NWI dataset and examined.[2] Wetlands mapped as Palustrine Emergent Saturated (PEMB) and Palustrine Scrub-Shrub Saturated (PSSB) were specifically targeted, as they can be the best indication of fen formation, and every PEMB and PSSB polygon in the study area was checked. However, photo-interpreters were not limited to the original NWI polygons and also mapped any fens they observed outside of B regime NWI polygons.

Potential fen polygons were hand-drawn in ArcGIS 10.4 based on the best estimation of fen boundaries. 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 Sawtooth 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). In addition to the confidence rating, any justifications of the rating or interesting observations were noted, including beaver influence, floating mats and springs.

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.

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

4.0 RESULTS

4.1 Potential Fen Mapping Acreage

The final map of potential fens contained 3,498 potential fen locations (all confidence levels), covering 5,968 acres or 0.2% of the total land area (Table 2; Figures 5 and 6). This total included 392 likely ***fens*** (confidence level = 5), 824 ***possible fens***, and 2,273 ***low confidence fens.*** On average the likely fens much were larger in size than the possible and low confidence fens (2.21 acres vs. 1.97 or 1.53 acres), resulting in 867 acres of likely fens, 1,624 acres of possible fens, and 3,476 acres of low confidence fens. The size of individual potential fens ranged from over 338 acres to 0.2 acres. The largest mapped likely fen at 99 acres is located above Stanley Lake, near Stanley Lake Creek (Figure 7). The second largest mapped likely fen is Bull Moose Fen (Figure 8) located near the Bull Moose campground and trailhead. The third and fourth largest likely fens are located near Mays Creek and the Salmon River (Figure 9). The Fen above Stanley Lake, Bull Moose Fen and Mays Creek Fen are all located in Custer County, ID and were botanically surveyed by Moseley et al (1994).

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

Confidence	*Count*	*Acres*	*Average size (acres)*
5 – Likely Fen	392	867	2.21
3 – Possible Fen	824	1,624	1.97
1 – Low Confidence Fen	2,273	3,476	1.53
TOTAL	**3,489**	**5,968**	**1.71**

The sections that follow (4.2 through 4.5) break down the fen mapping by elevation range, geology, EcoMap Subsection and HUC12 watershed. The last section summarizes observations made by the fen mappers during the mapping process, including potential floating mat fens.

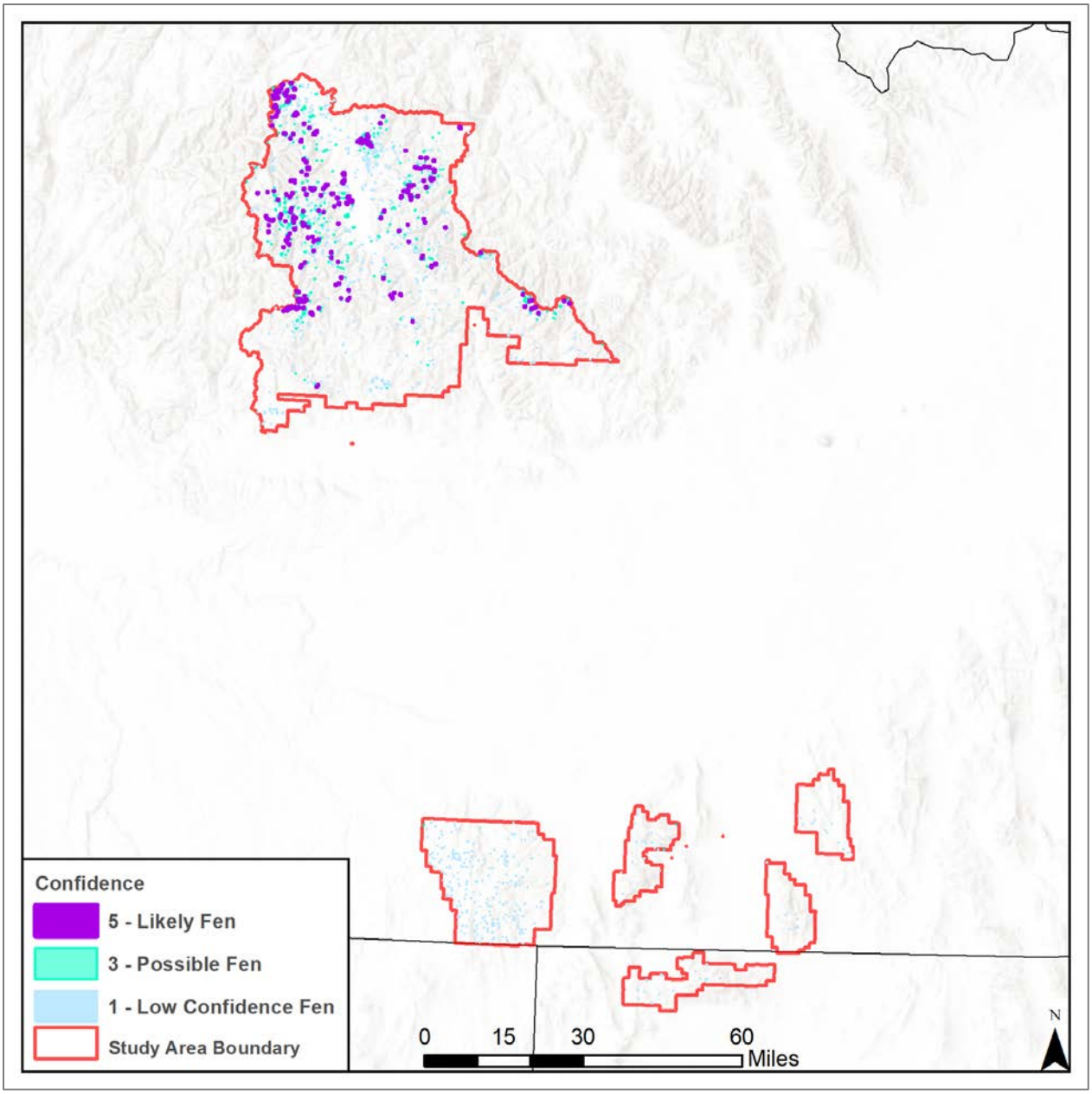

Figure 5. All potential fens within the fen mapping study area.

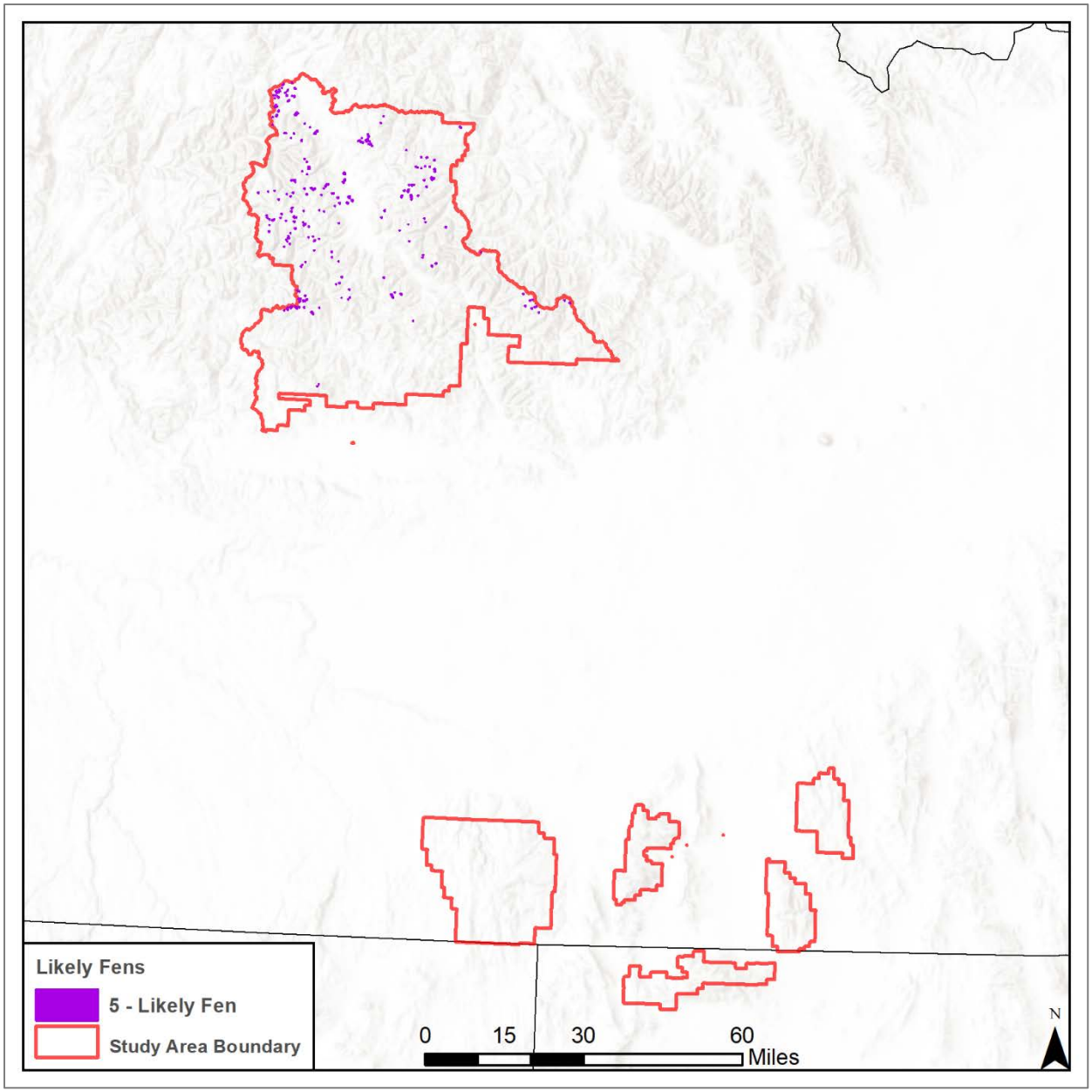

Figure 6. Likely fens (confidence rating = 5) within the fen mapping study area.

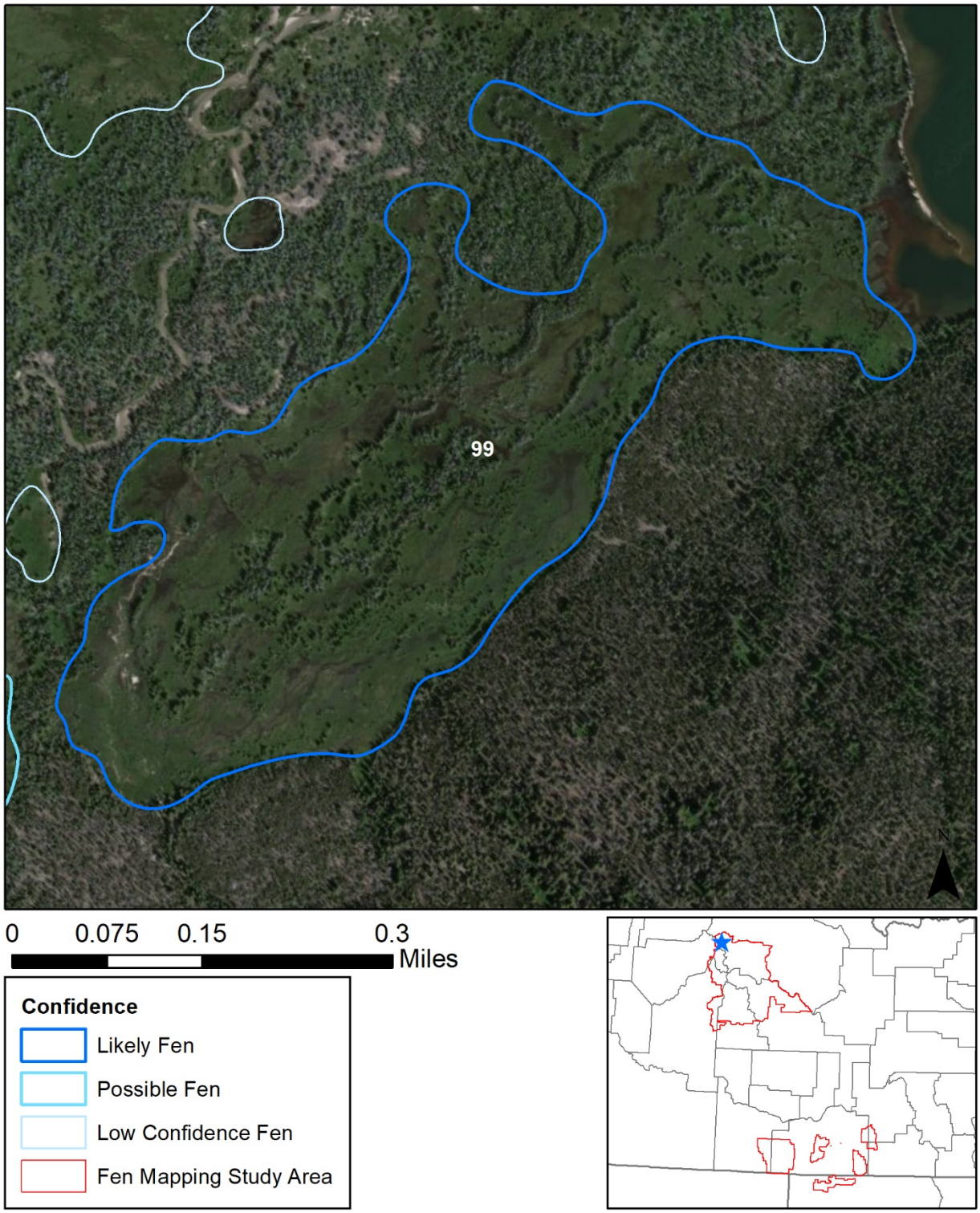

Figure 7. Largest mapped likely fen, 99 acres within one polygon. This fen is located upstream of Stanley Lake, Stanley Lake Creek is visible to the west.

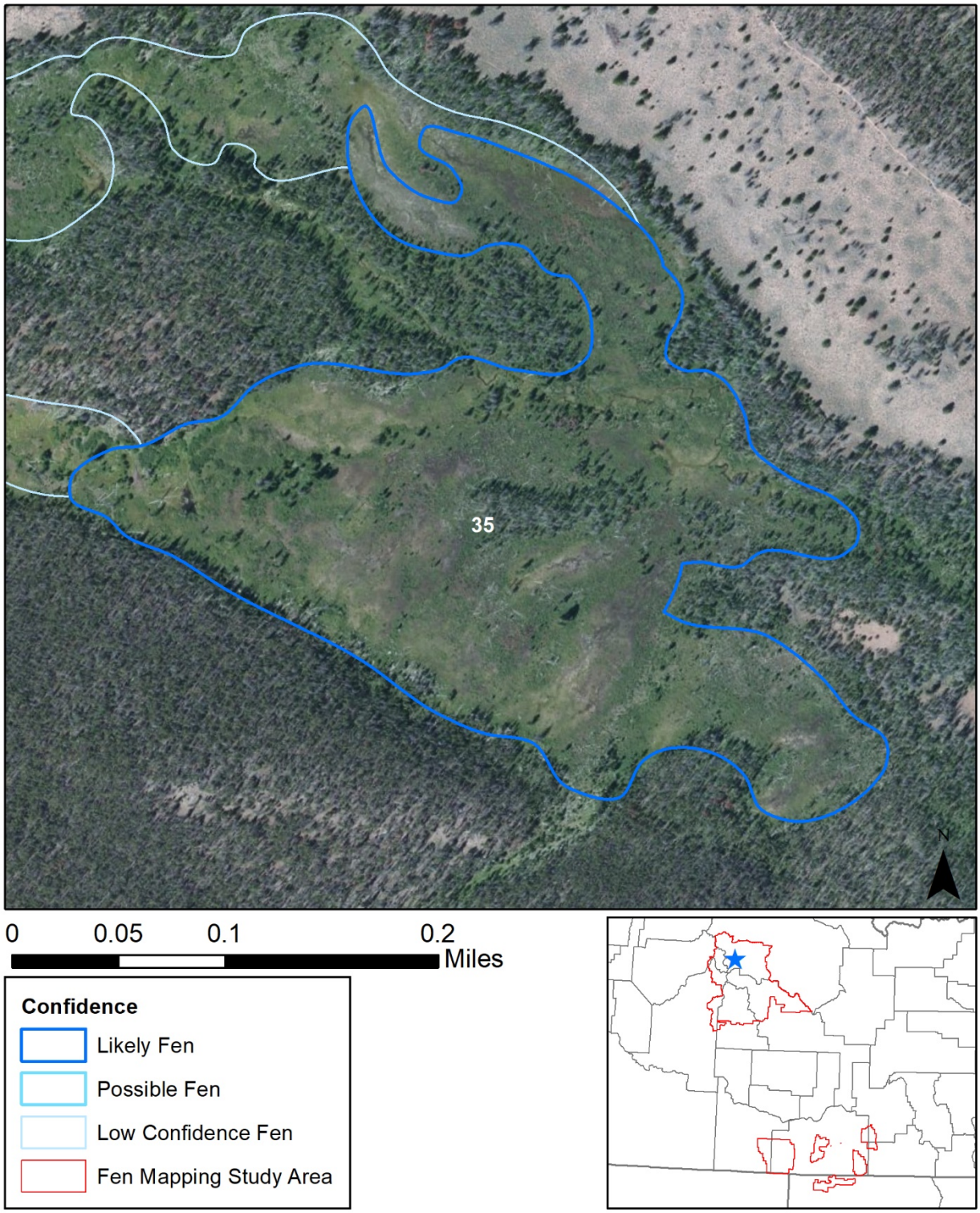

Figure 8. Bull Moose Fen mapped at 35 acres in Custer County, ID. This likely fen is located near the Bull Moose campground which is to the east.

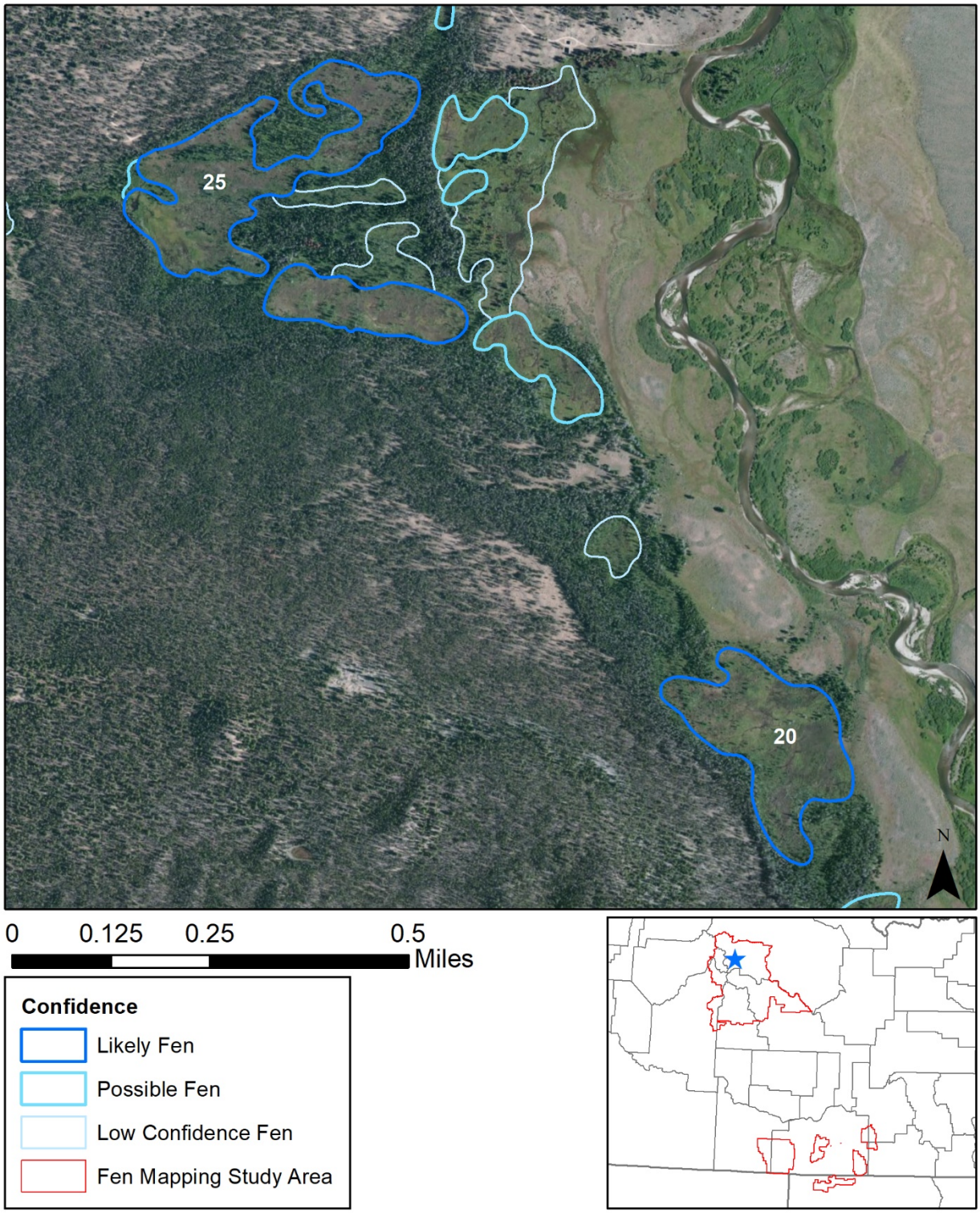

Figure 9: The third and fourth largest likely fens are located near Mays Creek and the Salmon River in Custer County, ID.

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 saturations. This is most often at higher elevations, closer to the zone of 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, 1,299 polygons (1,359 acres) were mapped between 8,000 and 9,000 feet, which represents 37% of potential fen locations and 23% of potential fen acres (Table 3; Figure 10). Of the 392 total likely fens mapped, 218 polygons (56%) and 334 acres (39%) were located between 8,000 and 9,000 feet (Table 3; Figures 11 and 12). This is one zone of maximum fen formation for the Sawtooth National Forest.

In addition, the elevation band of 6,000 to 7,000 feet also contains many potential and likely fens. Between 6,000 to 7,000 feet, there were 851 mapped potential fens (2,498 acres), which represent 24% of potential fen locations and 42% of potential fen acres. In addition, there were 42 likely fens (334 acres), which represent 11% of likely fen locations and 39% of likely fen acres. The fens in this elevation band are much larger in area. While they are fewer in number, they represent a larger total area of all potential fens and a similar area of likely fens.

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*
< 6,000	160	298	-	-
> 6,000 – 7,000	851	2,498	42	334
> 7,000 – 8,000	613	1,283	59	102
> 8,000 – 9,000	1,299	1,359	218	334
> 9,000 – 10,000	545	513	71	94
>10,000	21	16	2	3
Total	**3,489**	**5,968**	**392**	**867**

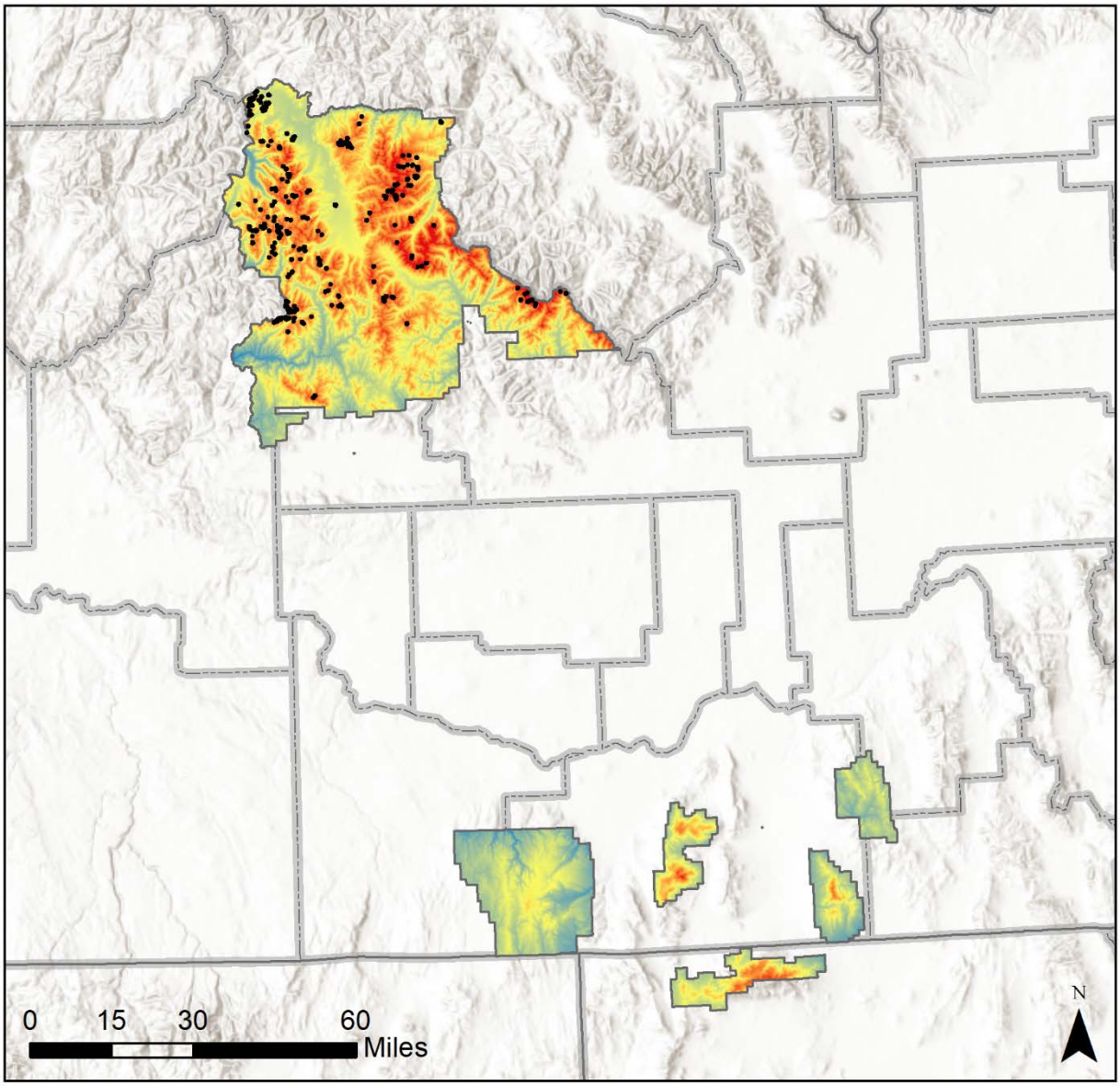

Figure 10: Likely fens (confidence rating = 5) and elevation within the fen mapping study area.

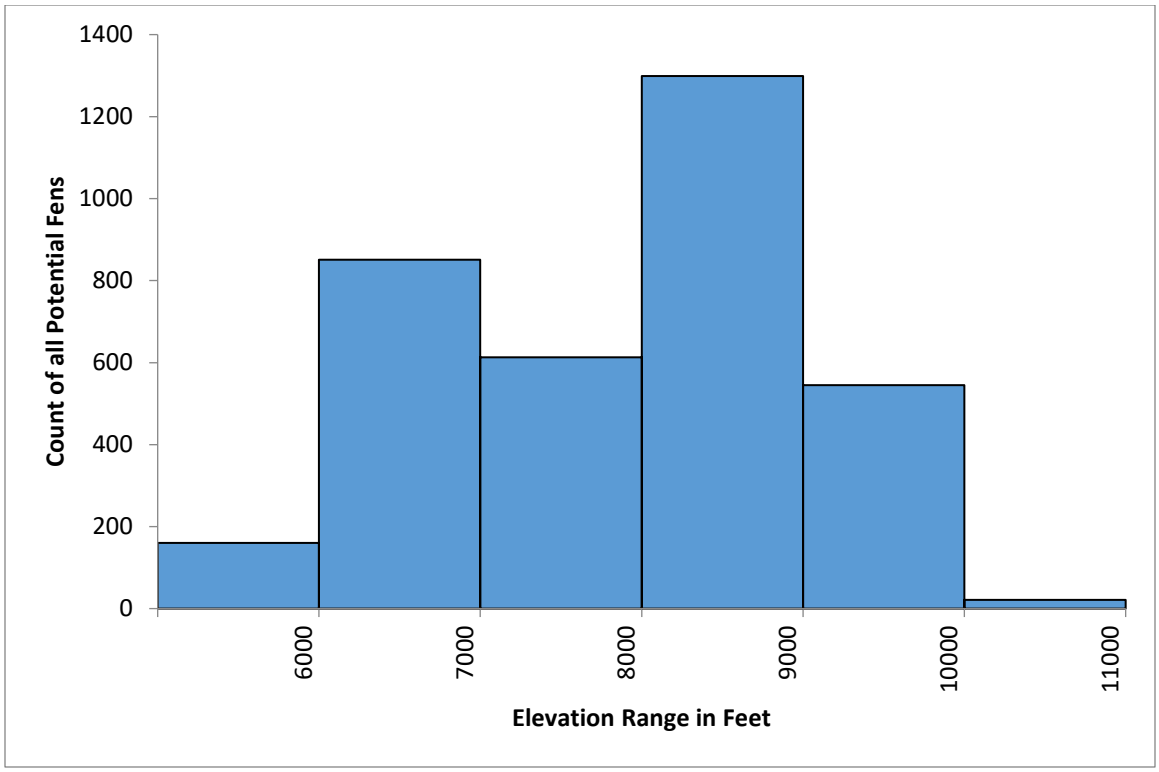

Figure 11. Histogram of all potential fens by elevation within the fen mapping study area.

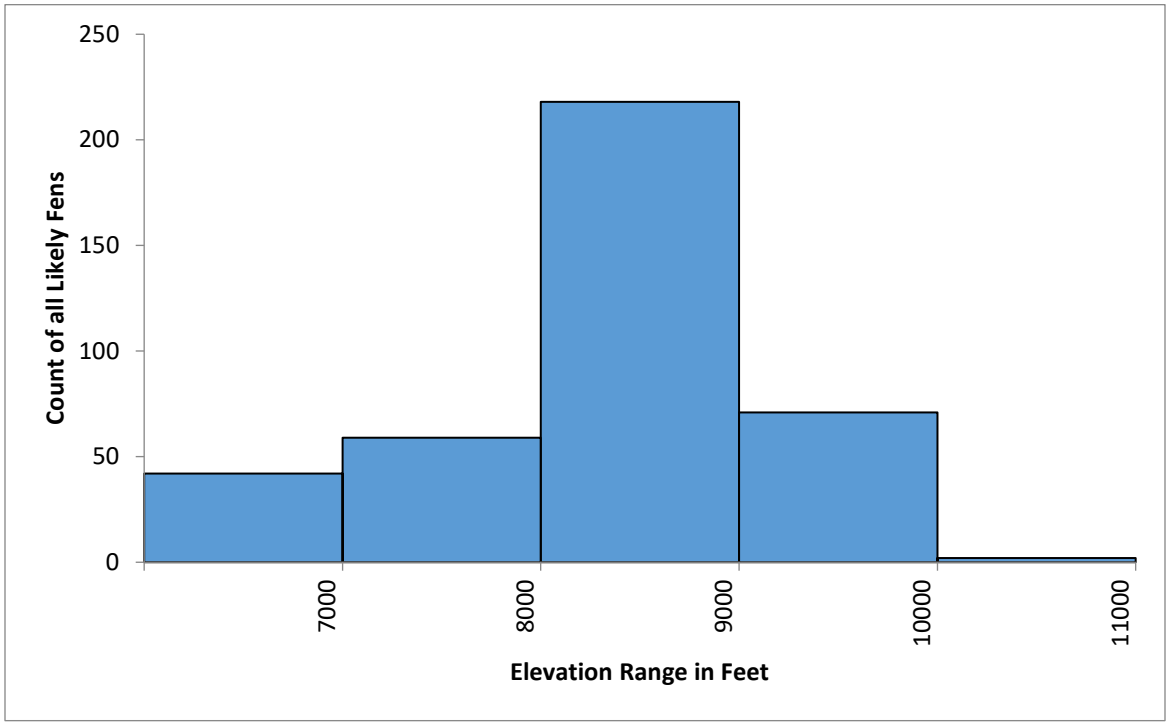

Figure 12. Histogram of the most likely fens by elevation within the fen mapping study area.

4.3 Mapped Potential Fens by Geology

The most common geologic substrate under potential fens in Sawtooth National Forest was the volcanic formation granodiorite, which underlies 1,112 mapped potential fens (1,252 acres). The most common geologic substrates under likely fens was also granodiorite, which underlies 159 mapped likely fens (204 acres) (Table 4). While granodiorite underlies 27% of the Forest, 32% of all potential fens and 41% of likely fens occurred in these areas. Granodiorite is a volcanic rock formation that along with granite composes most of the Idaho batholith.

Till underlies the highest number of likely fen acres, 71 likely fens and 344 likely fen acres (40% of likely acres). Till typically occurs at the toe of slopes as alluvial fans or within the floodplains of rivers and other low-lying areas that can accumulate alluvial material over time. Similarly, fens often form at the toe of slopes or the edges of floodplain valleys where there is a distinct break in slope, locations that are likely to contain alluvium.

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

Geology	*Acres of Geologic Substrate Within HTNF[1]*	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
granodiorite	576,304	1,112	1,252	159	204
granite	115,028	491	634	80	119
rhyolite	229,067	422	177	-	-
till	118,321	354	1,954	71	344
trachyandesite	267,573	308	406	18	54
sandstone	254,651	258	317	28	56
alluvium	108,431	130	486	6	38
quartzite	32,206	66	96	7	13
chert	30,960	56	8	-	-
limestone	105,277	50	21	-	-
quartz monzodiorite	40,473	40	34	9	8
shale	36,027	32	40	6	6
stratified glacial sediment	19,723	31	359	2	16
siltstone	47,816	31	13	-	-
schist	46,798	25	12	-	-
meta-argillite	56,282	17	23	2	2
water	4,832	14	41	1	0
mica schist	6,405	13	37	3	9
dolostone (dolomite)	13,989	10	2	-	-
tonalite	24,588	9	26	-	-
tuff	9,108	9	28	-	-
orthogneiss	12,018	6	1	-	-

felsic gneiss	313	2	1	0	-
metamorphic rock	4,569	2	0	0	-
mudstone	4,700	1	0	0	-
		3,489	**5,968**	**392**	**867**

[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 Sawtooth National Forest.

4.4 Mapped Potential Fens by Ecological Subsection

Land Type Associations (LTA) combine location, geology, and dominant vegetation and are defined by each Forest. Ecological Subsections are a component of LTAs. The Falls River Ecological Subsection covers 17% of the Sawtooth National Forest, but this Subsection contains 34% of potential fens (1,173) and 56% likely fen locations (218). The South-Central Idaho Ranges Subsection covers 27% of the Forest and contains 20% of potential fens (698), but no likely fens. The Smokey Mountains Subsection covers 16% of the Forest, yet it contains 358 mapped potential fens (313 acres) and 22 likely fens (31 acres) (Table 5).

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

EcoMap Ecological Subsection Name	*Acres within Sawtooth National Forest*[1]	*# of All Potential Fens*	*All Potential Fen Acres*	*# of Likely Fens*	*Likely Fen Acres*
Sawtooth Range	710,465	1,173	1,868	218	294
South Central Idaho Ranges	1,121,079	698	300	0	-
Smoky Mountains	644,744	358	313	22	31
East Fork Salmon River Mountains	269,990	320	492	56	125
Stanley Basin-Sawtooth Valley	255,382	271	1,954	33	304
Cabin Creek Peak	144,219	244	375	21	41
South Fork Boise River Uplands	338,938	169	264	27	36
Pioneer Mountains	271,084	142	258	11	27
Soldier Mountain Foothills	223,764	77	88	2	4
Upper Middle Fork Boise River	30,618	15	26	2	5
N Fork Big Lost River-Copper Basin-White Knob Mtns	25,403	12	16	-	-
Yankee Fork-E Salmon River Mtns	51,110	4	10	-	-
Salmon Falls Creek Buttes	2,566	4	3	-	-
Pioneer Foothills	26,672	1	<1	-	-
Southern Idaho Terraces	17,478	1	<1	-	-
		3,489	**5,968**	**392**	**867**

[1] Acres of Land Type Associations 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 Sawtooth National Forest.

4.5 Mapped Potential Fens by Watershed

An analysis of likely fens in HUC12 watersheds revealed interesting patterns. Three watersheds in particular had significant numbers of likely fens (Figure 13). Middle Valley Creek (HUC12: 170602010103) had 33 likely fens, which covered 0.33% of the landscape in this watershed. Elk Creek (HUC12: 170602010101) had 28 likely fens, covering 0.30% of the landscape. Bear Creek-South Fork Boise River (HUC12: 170501130303) also had 21 likely fens, representing 0.11% of the landscape. Stanley Lake Creek (HUC12: 170602010105) which is adjacent to Middle Valley and Elk Creek watersheds has the highest fen density (0.59%) with 104 likely fens, including the largest mapped likely fen located above Stanley Lake. No likely fens were found in the southern units of the Forest.

See Appendix A for the full HUC12 watershed and likely fens table.

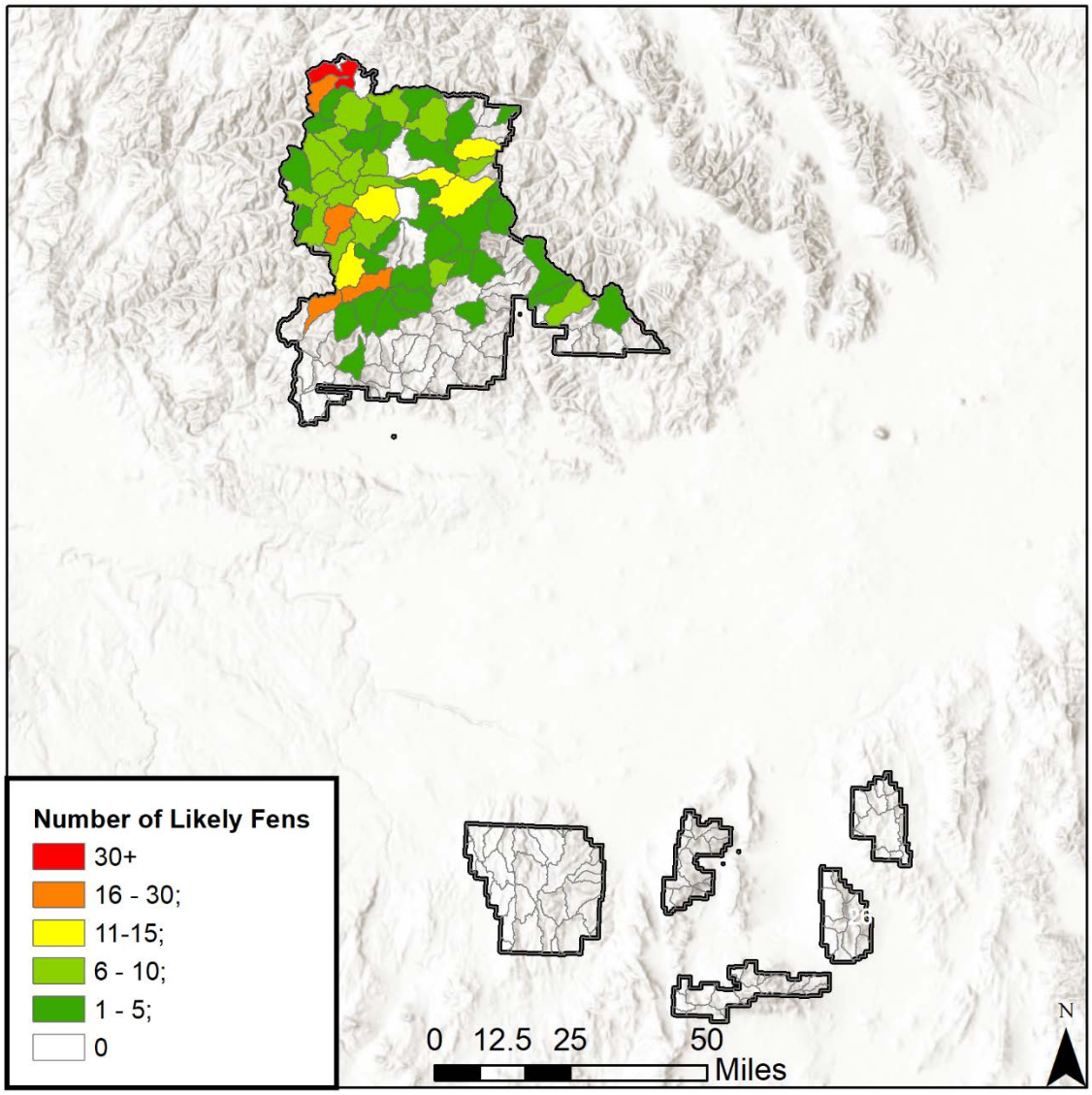

Figure 13. Likely fens by HUC12 watershed within the fen mapping study area.

4.6 Mapped Potential Fens with Distinctive Characteristics

Several characteristics related to fens were noted by photo-interpreters when observed throughout the fen mapping process (Table 6), though this was not an original objective of the project and was not consistently applied.

Of particular interest was identifying markers for potential floating mat fens, a rare type of fen that may occur in Sawtooth National Forest (Kate Dwire, *personal communications*). Eight potential fens (42 acres) and one likely fen (14 acres) were identified as potential floating mat fens. See Figure 14 for a likely fen that shows floating mat characteristics located south of Sullivan Lake in Blaine County, Idaho.

Springs and fens are both important components of groundwater-dependent ecosystems (GDEs) and are of particular interest to the U.S. Forest Service (USDA 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. Eight hundred and thirty potential fens and three likely fens were observed in proximity to springs.

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. One hundred and five potential fens (801 acres) and two likely fens (2 acres) showed some evidence of beaver influence. Figure 15 shows the 125 acre possible fen mapped at Vat Creek that shows indications of beaver activity.

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	830	319	3	7
Possible Floating Mat	8	42	1	14
Beaver Influence	105	801	2	2
Total	**943**	**1,162**	**6**	**23**

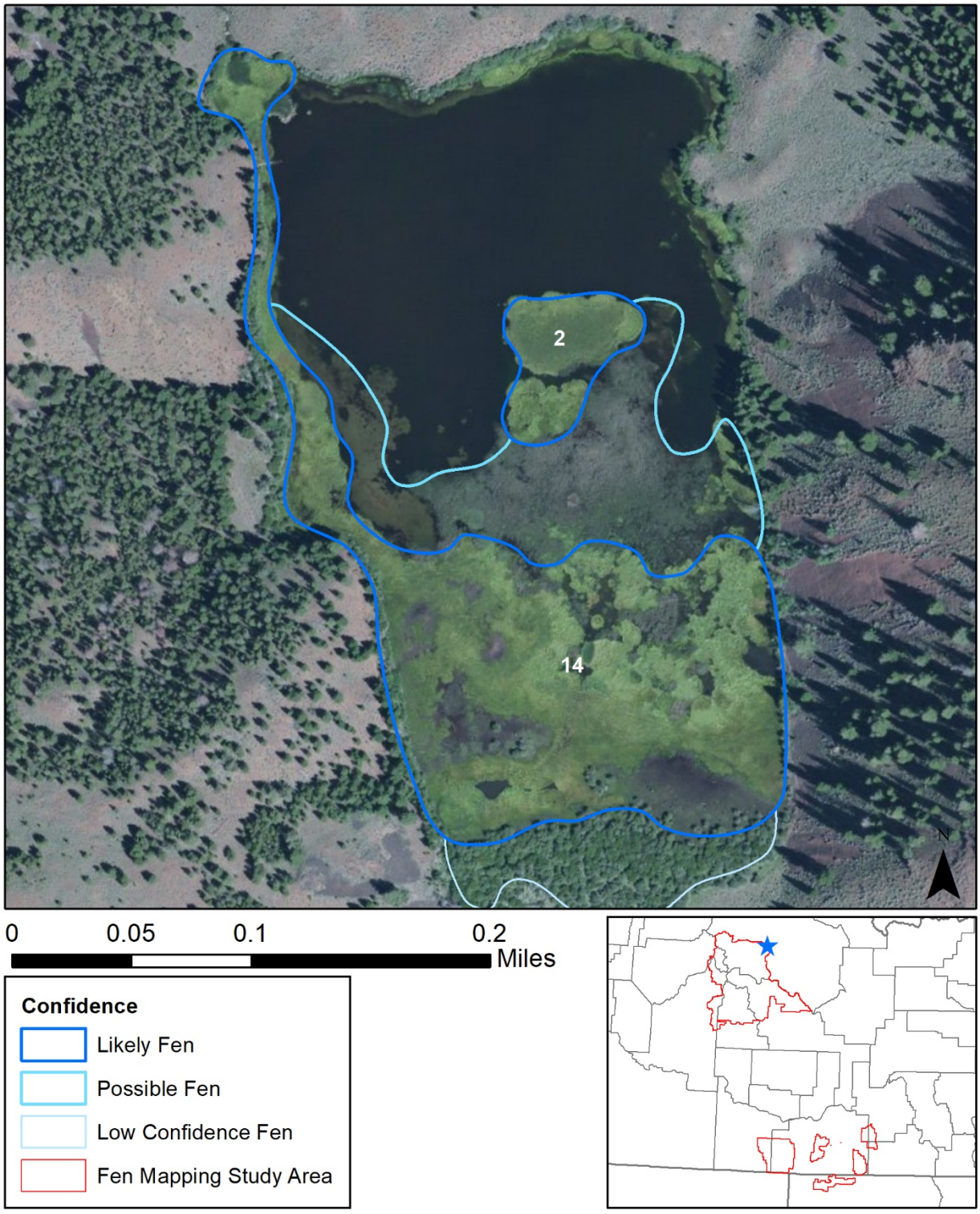

Figure 14: Possible floating mat fen located on the south edge of Sullivan Lake in Custer County, Idaho very close to the northern Forest boundary.

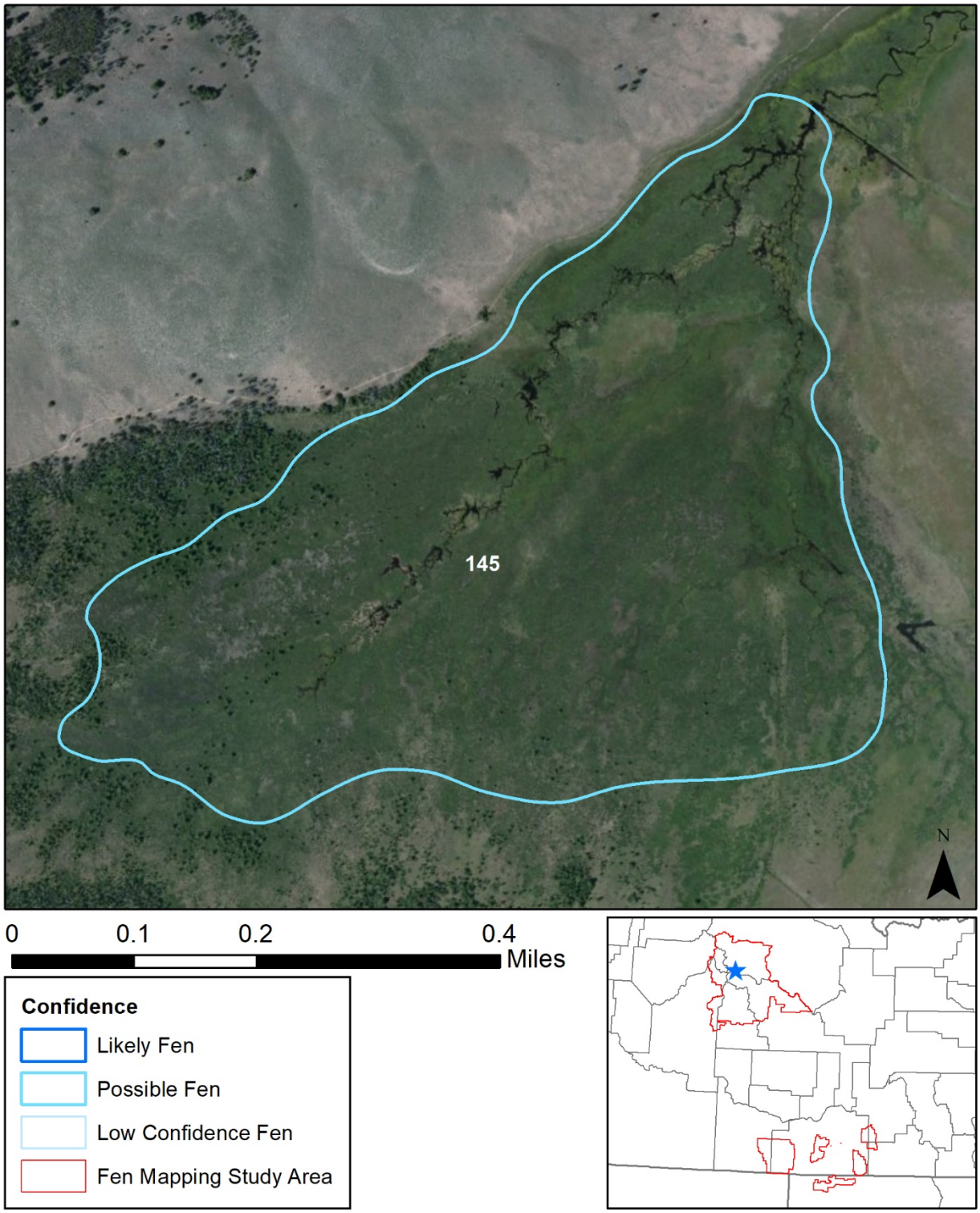

Figure 15: Vat Creek potential fen shows evidence of small beaver ponds in Blaine county, ID.

5.0 DISCUSSION

The Sawtooth National Forest contains a relatively small number of potential fen wetlands, covering up to 5,968 acres across its jurisdiction. While the potential fen resource represents a very small portion of the entire landscape, these fen wetlands are an irreplaceable resource for the Forest and the citizens of Idaho. 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, 3,489 potential fens were mapped throughout the Sawtooth National Forest, of which only 392 were most likely to be fens. Analysis of the potential fen data showed clear hotspots for fens in the Sawtooth National Forest, particularly the Middle Valley and Bear Creek-South Fork Boise River watersheds. A 1994 survey of peatlands in Custer and Blaine Counties, Idaho documented the following rare and uncommon plant species in Sawtooth National Forest: *Carex buxbaumii, Carex livida, Drosera intermidea*, *Epilobium palustre* and *Scirpus caespitosus* (Moseley et al, 1994). There is a strong elevation pattern found within the mapping, with 56% of likely fens falling between 8,000 and 9,000 feet and all likely fen acres occurring above 6,000 ft.

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 Sawtooth 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 Sawtooth National Forest showed little sign of human disturbance, particularly at higher elevations.

This report and associated dataset provide the Sawtooth National Forest with a critical tool for conservation planning at both a local and Forest-wide scale. These data will be useful for the Sawtooth National Forest biological assessment required by the 2012 Forest Planning Rule, but can also be used to establish buffers around potential fens for individual management actions, such as timber sales, grazing allotments, and other management actions. Wherever possible, the Forest should avoid direct disturbance to the fens mapped through this project, and should also strive to protect the watersheds surrounding high concentrations of fens, thereby protecting their water sources.

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

HUC12 Code	HUC12 Name	Watershed Acres	Likely Fen Count	Likely Acres	Fen Density (Fen Acres/Watershed Acres
170602010103	Middle Valley Creek	17,581	33	59	0.33%
170602010101	Elk Creek	12,915	28	52	0.30%
170501130303	Bear Creek-South Fork Boise River	17,730	21	19	0.11%
170501130406	Willow Creek	14,069	18	31	0.18%
170501110101	Rock Creek-Middle Fork Boise River	17,875	17	23	0.13%
170602011003	Germania Creek	32,029	13	14	0.08%
170602010302	Lower Alturas Lake Creek	26,448	12	31	0.18%
170602010402	Fourth of July Creek	11,510	12	17	0.10%
170501130301	Ross Fork	19,142	11	15	0.08%
170602011102	Big Boulder Creek	17,710	11	30	0.17%
170402190102	Prairie Creek	11,041	10	11	0.06%
170501200101	Benedict Creek-South Fork Payette River	11,935	10	19	0.11%
170602010106	Lower Valley Creek	23,973	10	39	0.22%
170602010301	Upper Alturas Lake Creek	18,560	10	8	0.05%
170602010702	Lower Warm Springs Creek	25,674	10	24	0.13%
170602011101	Little Boulder Creek	11,753	10	40	0.23%
170501200103	Baron Creek	14,487	9	5	0.03%
170501110202	Queens River	20,804	9	7	0.04%
170602010406	Upper Redfish Lake Creek	12,135	9	18	0.10%
170402190402	Hyndman Creek	21,381	8	18	0.10%
170602010403	Hell Roaring Creek-Salmon River	11,891	8	64	0.36%
170602010404	Huckleberry Creek	11,695	8	67	0.38%
170501200104	Goat Creek-South Fork Payette River	20,565	7	12	0.07%
170501110102	Mattingly Creek-North Fork Boise River	12,079	7	7	0.04%
170501110302	Johnson Creek	16,990	7	10	0.06%
170501200102	Pinchot Creek-South Fork Payette River	12,581	6	14	0.08%
170602010601	Big Casino Creek-Salmon River	22,680	6	8	0.04%

170501130304	Skunk Creek-South Fork Boise River	18,854	5	3	0.02%
170602010701	Upper Warm Springs Creek	26,098	5	5	0.03%
170602011004	Ibex Creek-East Fork Salmon River	34,230	5	5	0.03%
170402190107	Boulder Creek-Big Wood River	17,105	4	5	0.03%
170501110301	Ballentyne Creek-North Fork Boise River	18,751	4	6	0.03%
170501130302	Johnson Creek	11,887	4	2	0.01%
170602010105	Stanley Lake Creek	11,456	4	104	0.59%
170602010202	Beaver Creek	9,698	4	4	0.02%
170602010401	Champion Creek	12,301	4	4	0.02%
170602010603	Rough Creek-Salmon River	23,329	4	9	0.05%
170501110201	Little Queens River	11,363	3	5	0.03%
170501130101	Upper Big Smoky Creek	20,231	3	3	0.02%
170501130104	Lower Big Smoky Creek	19,510	3	2	0.01%
170402210101	Mandolin Creek-Little Wood River	22,951	2	6	0.04%
170501130402	Boardman Creek	12,563	2	4	0.02%
170602010407	Lower Redfish Lake Creek	16,054	2	3	0.02%
170602010906	Sullivan Creek-Salmon River	21,799	2	16	0.09%
170402190101	Headwaters Big Wood River	21,019	1	1	0.00%
170402190103	Anderson Creek-Big Wood River	13,092	1	0	0.00%
170402190203	Rooks Creek-Warm Springs Creek	12,886	1	4	0.02%
170402190303	Corral Creek	10,656	1	3	0.02%
170402190304	Trail Creek	30,793	1	1	0.00%
170501200201	Wapiti Creek-South Fork Payette River	24,125	1	1	0.01%
170501130102	Middle Big Smoky Creek	18,089	1	0	0.00%
170501130403	Skeleton Creek	15,534	1	1	0.01%
170602010204	Pole Creek	13,022	1	0	0.00%
170602010408	Cleveland Creek-Salmon River	16,677	1	0	0.00%
170602010901	Slate Creek	20,421	1	1	0.01%
170602011001	West Pass Creek	16,760	1	7	0.04%