

Population assessment of arrow-leaf thelypody (*Thelypodium eucosmum*)



2016

Progress Report to the USDI, Bureau of Land
Management, Prineville District

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PREFACE

This report is the result of an agreement between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization whose mission is conservation of native ecosystems through restoration, research and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species.



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Cover photograph: Arrow-leaf thelypody plants under large juniper.

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EXECUTIVE SUMMARY

We monitored 21 sites occurring on Prineville BLM lands in 2016, including 2 previously undocumented sites and 9 sites that had been monitored in 2015. Highlights from 2016 were:

- Identified 2 previously undocumented populations
- Plant counts/estimates revealed 44,024 individuals, and ranged from 12 to 29,249
 - In 2015, plant counts/estimates revealed only 4,821 individuals, and ranged from 33 to 1,690
 - 7 of 9 sites re-monitored from 2015 had higher plant counts in 2016
- Multiple *Thelypodium eucosmum* specimens were collected that show multiple rosettes/plants arising from a single rootstock
- Seed were collected from 11 sites throughout the range of the known populations for deposition and long-term storage in the Rae Selling Berry Seed Bank
- Established transects for measuring plant density at Site 133
 - Will allow more rapid and consistent assessment by BLM in future
 - Density estimate was 29,863
 - 32,403 plants were estimated at the site in 2016, including the 2,540 plants recorded in a separate polygon adjacent to the sampled area at the site
 - Previous high was 11,000 in 2005
 - 20 reproductive plants were tagged to be re-monitored in 2016, to determine if plants die after flowering, in both the ungrazed and grazed (40 total) area of Site 133

Population assessment of arrow-leaf thelypody (*Thelypodium eucosmum*)

PROGRESS REPORT TO THE USDI, BUREAU OF LAND MANAGEMENT

INTRODUCTION

Arrow-leaf thelypody (*Thelypodium eucosmum*; Figure 1) is a member of the Brassicaceae (mustard) family, growing from 7 ½ inches to 3 feet tall (20-100 cm). It is classified as *threatened* by the State of Oregon, and as *sensitive* by the Bureau of Land Management (BLM). It is often characterized as a biennial or short-lived perennial and may die after flowering, although plants grown at the Berry Botanic Garden behave as perennials that can flower for two or more years (Center for Plant Conservation 2010). Hitchcock and Cronquist (1973) refer to it as a perennial arising from spreading rootstock, and note that individual clumps are usually mistaken to be taprooted biennial plants. Flowers are 4-petaled, ½ inch (1.2 cm) long, and lilac-purple in color.

The species inhabits low to intermediate elevations in juniper-sagebrush habitats in the Blue Mountains and along tributaries of the John Day River in Grant and Wheeler counties (NatureServe 2015). Arrow-leaved thelypody is found in mesic microsites in low- to mid-elevation ephemeral stream channels, occurring most commonly in steep canyons, near or under junipers. Occasionally *T. eucosmum* occurs in dry washes, seasonal waterfalls and in flatter terrain near seeps.

There are over 60 documented populations (numbers vary slightly depending on definition of population boundaries), but many have low numbers and seem to be highly influenced by availability of moisture. Potential threats to the species are drought, grazing, exotic plants, juniper encroachment and climate change. *Thelypodium eucosmum* has been historically impacted by grazing, although the current distribution of the species in steep drainages that are often more or less inaccessible to cattle is believed to provide it with some measure of protection. Conversion of grassland-juniper savannah to more overstoried juniper woodlands, influenced by past grazing and



FIGURE 1. *Thelypodium eucosmum* being visited by multiple pollinators. (Photo: C. Whitaker)

possibly fire suppression, may pose a risk to populations (Meinke et al. 2011). Exotic weeds are believed to have a significant effect on recruitment and seed bank maintenance in thelypody populations (Meinke et al. 2011).

The overall conservation status of *T. eucosmum* has not been recently completed and up-to-date information on population size, viability (based on the number of reproductive individuals), and threats is necessary. A current conservation assessment is necessary for (1) reviewing the status of *T. eucosmum* on the state list of threatened and endangered plants (required every 5 years by ORS 564), (2) creating management/research priorities for BLM and USFS, and (3) determining whether or not the species needs to be considered for further protective status at the state and/or federal level.

METHODS

Monitoring

Site locations were obtained from Prineville Bureau of Land Management, Malheur National Forest, and Umatilla National Forest. Various data sources (GeoBOB, ORBIC, past sighting forms, past reports) were used to determine the unique sites to prioritize sampling efforts. Only sites on federal lands were surveyed. Private sites were excluded so that efforts could be focused on updating site information for populations that can potentially be actively managed by the federal agencies. Sites were prioritized by time since previous visit, followed by proximity, to allow us to update lacking records while also maximizing our effort. All sites (Figure 3) were monitored occurred from 5 June to 18 June 2015 and 14 June to 21 June 2016 to coincide with the phenology of the species. We reference the most commonly used site numbers from the individual agencies throughout the report and provide a cross-reference in Appendix A.

Data were collected at each site to meet the following objectives:

- Assess and document abundance, reproduction, population trends, pollinators, soil characteristics and potential threats.
- Update GeoBOB sighting forms. Provide sighting forms to USFS for inclusion into the USFS NRIS database.
- Update GIS layers by re-mapping population and site boundaries.
- Provide updated photographs of each site, as well as, photographs of potential threats at each site.
- Determine the number of extant populations and individuals on BLM land and to assist in developing management guidelines and assessing sites for long-term study potential.

Density Plot Establishment

In 2016, we established transects for measuring density of *Thelypodium eucosmum* at Site 133 (Appendix B). This site has the largest population, nearly half of which has been fenced to eliminate cattle grazing. Transects were established in both the ungrazed and grazed portions of the site to allow a more rapid assessment of population status that can be conducted by BLM staff at regular intervals.

We established a main transect in each area that served as the baseline for perpendicular transects for estimating density. The main transect in the grazed portion runs from northeast to southwest and runs east to west in the ungrazed portion (Appendix B), with 27 (54 total) perpendicular monitoring transects randomly assigned a distance and direction along each main transect (Appendix C, Appendix D). We used belt transects 30 m long by 60 cm wide (Total = 18 m²) and plants were monitored by counting all within 30 cm on either side of the transect(s) and separated into 3 categories: Vegetative Small (<5cm), Vegetative Large (>5cm), and Reproductive (flowering/fruitletting).

In addition to the density transects, we marked 40 individual flowering plants (20 in ungrazed and 20 in grazed) to determine if individuals die after flowering. Numbered metal tags were attached to 8 inch nails and placed at the base of plants (Figure 2). A list of marked individuals was provided in Appendix F. Tagged plants will be monitored in 2017 and beyond to assess the fate of marked individuals.



FIGURE 2. NUMBERED METAL TAG PLACED AT BASE OF *THELYPODIUM EUCOSMUM* PLANTS TO MONITOR FATE OF FLOWERING PLANTS AT SITE 133.

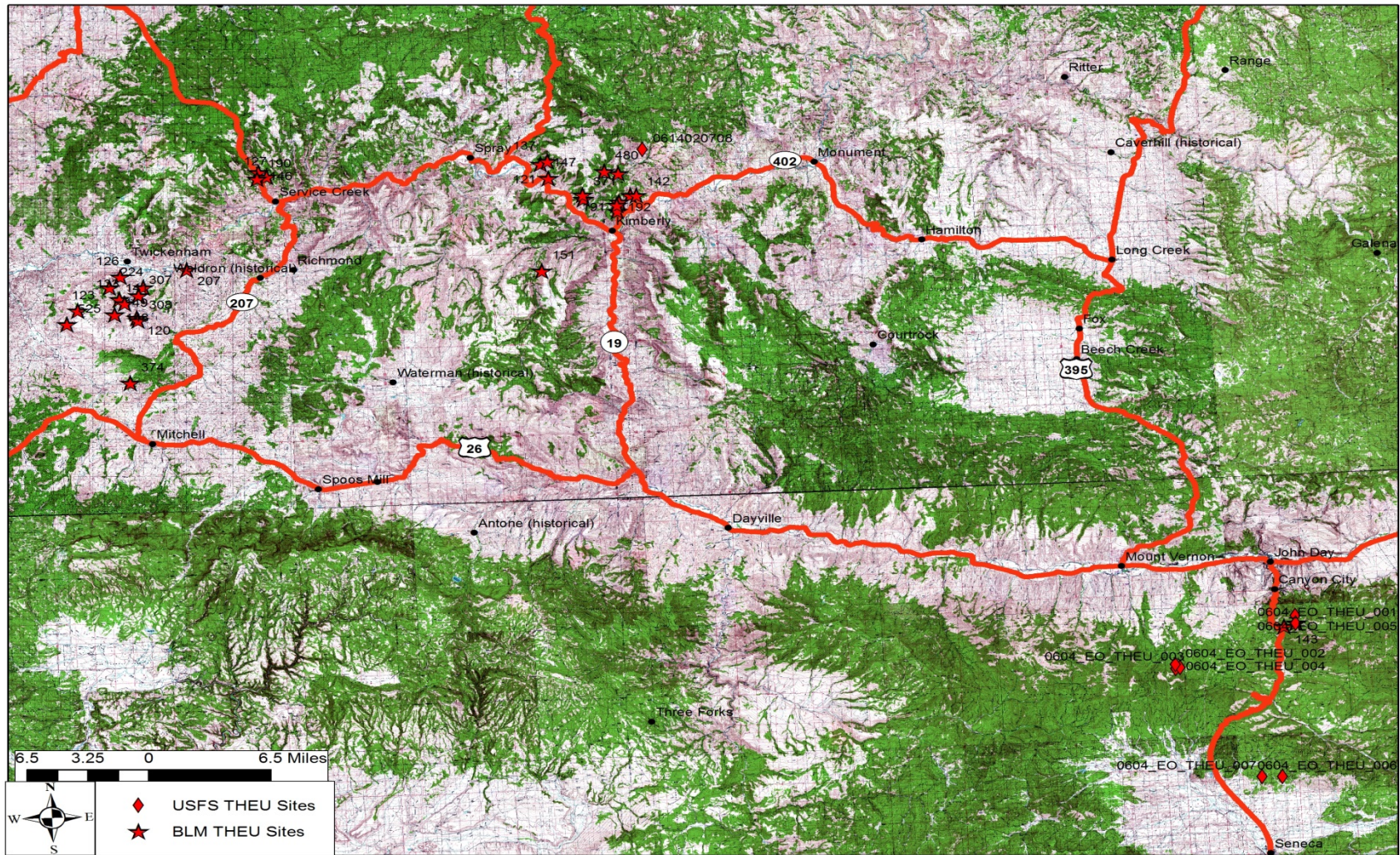


FIGURE 3. OVERVIEW OF *THELYPODIUM EUCOSMUM* SITES MONITORED ON BLM AND USFS LANDS IN EAST-CENTRAL OREGON IN 2015 AND 2016. DETAILED MAPS ARE AVAILABLE IN THE APPENDIX.

RESULTS

Prineville BLM

2016 Monitoring

We monitored 21 sites occurring on Prineville BLM lands in 2016, including 2 previously undocumented sites and 9 sites that had been monitored in 2015 (Table 1, Appendix A). Plant counts/estimates revealed 44,024 individuals, and ranged from 12 to 29,249, with 3 sites found to have no plants in 2016 (Table 1). With the exception of Site 133, we found that most of the plants we encountered were in difficult to reach areas and often in association with large juniper trees (*Juniperus occidentalis*; Figure 4). All sites appear to be quite variable in number of plants between surveys (Appendix A). Even at Site 133, plants tend to be found in close proximity to shrub and tree species.

We divided Site 133 into 2 separate polygons (133 and 133-1) to aid in future sampling (Appendix I).

The main population polygon encompasses the fenced area and a similarly sized area immediately east (Appendix I). The second polygon encompasses a small drainage to the east of the main population. Previous monitoring has focused on the main population and this change will ensure that appropriate monitoring is conducted in future efforts. This smaller polygon at Site 133 had the 3rd highest plant total of all sites for the previous 2 years of monitoring (Table 1, Table 2).

Site 133 had the highest number of plants (29,863) during our survey in 2016 (Table 1), which was a dramatic increase from the 2015 survey (1,690) and the highest number ever recorded (Appendix A). This site has been fenced to eliminate cattle grazing and should be a high priority for repeated annual sampling. Site accessibility and the fact that it is the largest population provide opportunities to provide long-term data on this rare species. We established density transects in 2016, to allow for a more rapid assessment.

Eleven sites had >200 plants, with sites 120, 123, 127, 128, 137, 224, and 525 all having >400 plants during 2016 surveys (Table 1). Site 224 has had at least 500 plants during each survey, while the other sites have shown strong fluctuation in number of individuals (Appendix A). Site 525 did not have any previous count data, but had 704 plants in 2016.



FIGURE 4. *THELYPODIUM EUCOSMUM* GROWING UNDER LARGE *JUNIPERUS OCCIDENTALIS*, A COMMON SITUATION ENCOUNTERED IN OUR SURVEY.

TABLE 1. NUMBER OF INDIVIDUAL *THELYPODIUM EUCOSMUM* PLANTS (FLOWERING, FRUITING, OTHER) AND ASSOCIATED THREATS AT SITES MONITORED ON PRINEVILLE BLM LANDS IN 2016.

Site #	Flowering	Fruit	Other	Total	Threats
120	3	21	745	769	Exotic annual grasses, no grazing noted but evidence of cattle
121	0	0	0	0	Exotic annual grasses, no grazing noted but evidence of cattle
123	3	141	1087	1231	Exotic annual grasses, no grazing noted but evidence of cattle
127	23	576	934	1533	Exotic annual grasses, no grazing noted but evidence of cattle
128	235	15	1155	1405	Exotic annual grasses, no grazing noted but evidence of cattle
129	0	94	105	199	None observed
132	0	5	7	12	None observed
133	0	1100	28763	29863	Exotic annual grasses, no grazing noted but evidence of cattle
133-1	7	2480	53	2540	Exotic annual grasses, no grazing noted but evidence of cattle
137	22	195	1729	1996	Exotic annual grasses, insect herbivory
140	2	20	104	126	Exotic annual grasses
146	0	80	300	380	Exotic annual grasses
148	0	0	0	0	None observed
151	0	0	0	0	Exotic plant species
190	1	39	47	87	Exotic annual grasses, no grazing noted but evidence of cattle
191	6	36	213	255	Exotic annual grasses, no grazing noted but evidence of cattle
207	0	16	186	202	Exotic annual grasses, no grazing noted but evidence of cattle
224	18	1154	1928	3100	Exotic annual grasses, no grazing noted but evidence of cattle
480	1	24	9	34	None observed
525	10	60	634	704	Exotic annual grasses
THEUNEW_1	0	49	118	167	Cattle trail through site, but no grazing recorded
THEUNEW_2	0	4	31	35	None observed

In 2016, we also collected seed from throughout the range of *Thelypodium eucosmum* that will be deposited in the Rae Selling Berry Seed Bank (<https://www.pdx.edu/seed-bank/>; Appendix J). In addition to seed collection, we also collected several specimens that will be deposited at the Oregon State University Herbarium. Several of the specimens collected provide excellent representation of the spreading rootstock described by Hitchcock and Cronquist (1973; Figure 5).

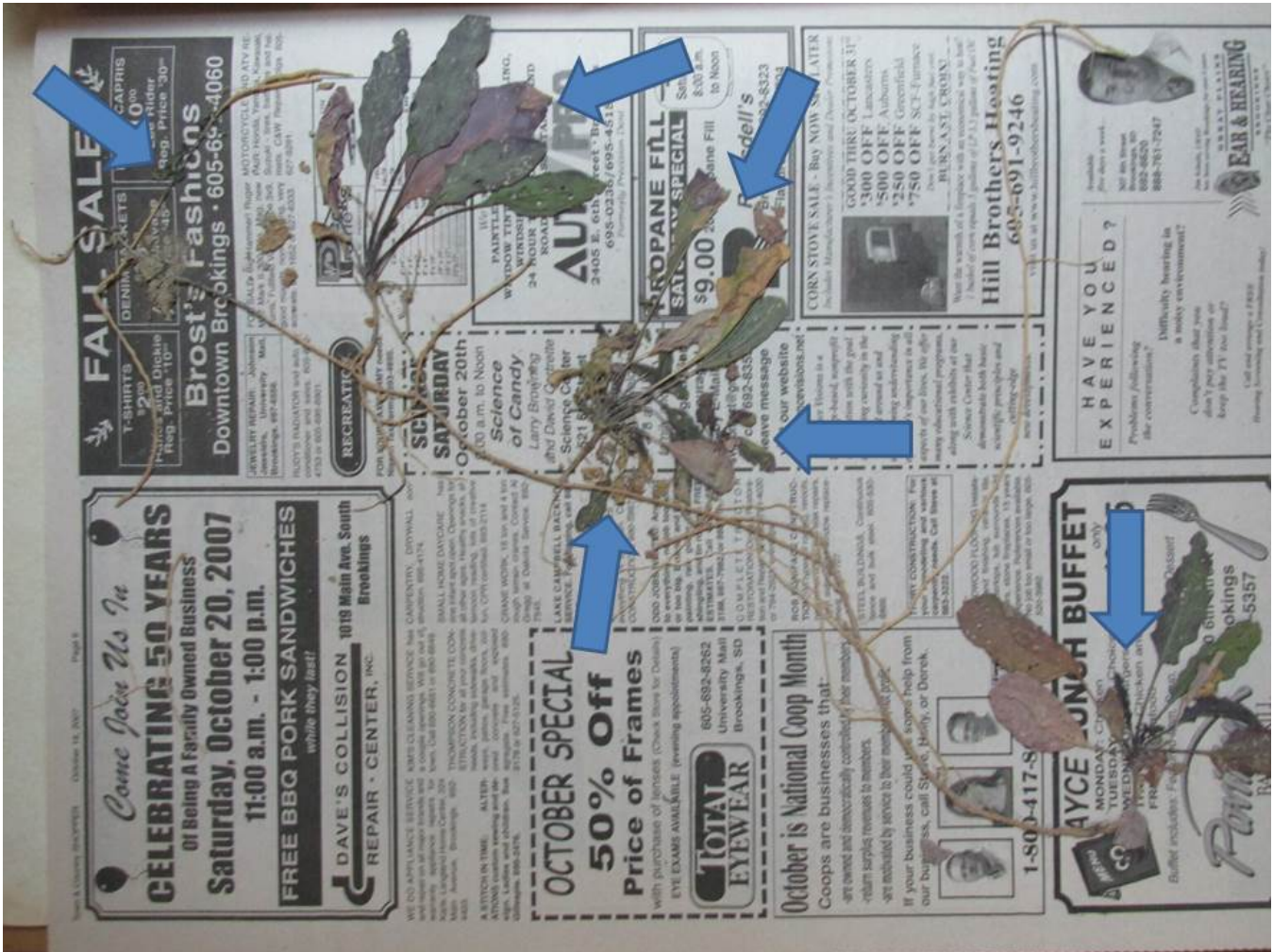


FIGURE 5. MULTIPLE *THELYPODIUM EUCOSMUM* ROSETTES ARISING FROM A SINGLE ROOT SYSTEM (6 ROSETTES ARE INDICATED BY BLUE ARROWS).

Density Plots

In 2016, we established 27 transects in the ungrazed and 27 in the grazed areas for measuring density of *Thelypodium eucosmum* at Site 133 (Appendix C and Appendix D). Small vegetative individuals (<5 cm) made up the majority of plants counted in both the ungrazed and grazed transects (Table 2). There

were fewer vegetative plants (small and large) per transect in the ungrazed compared to the grazed area. Reproductive plants densities were similar in the ungrazed and grazed areas and no seedlings were recorded in either area in 2016 (Table 2).

The density of 11,091 ($\pm 4,164$) plants estimated for the ungrazed area was similar to the highest count recorded for the site, prior to 2016 (Appendix A). This also represents a nearly 10-fold increase from the 1,609 plants counted in 2015 (Table 3), and the contrast is even more stark when adding in the 29,864 ($\pm 7,806$) plants estimated in the adjacent ungrazed area (Table 2, Appendix I). Even if we used the lower 95% confidence interval estimates (17,839; Table 2), the total would still be over 8,000 more plants than the previous high count in 2005 (Appendix A).

TABLE 2. NUMBER OF VEGETATIVE AND REPRODUCTIVE *THELYPODIUM EUCOSMUM* RECORDED IN DENSITY TRANSECTS AT SITE 133 IN 2016.

	Seedling	Vegetative Small (<5cm)	Vegetative Large (>5cm)	Reproductive
Ungrazed				
Average/per transect (18 m ²)	0	32	7	2
Density/m ²	0	2	0	0
Density Estimate for Entire area*	0	8583	1936	573
Lower 95% Confidence Interval (Entire Area)	0	5533	1107	285
Upper 95% Confidence Interval (Entire Area)	0	11632	2765	861
		(+/- 3050)	(+/- 829)	(+/- 288)
Grazed				
Average/per transect (18 m ²)	0	47	12	2
Density/m ²	0	3	1	0
Density Estimate for Entire area*	0	14421	3823	528
Lower 95% Confidence Interval (Entire Area)	0	8835	1813	266
Upper 95% Confidence Interval (Entire Area)	0	20006	5834	790
		(+/- 5555)	(+/- 1991)	(+/- 260)
Density Estimate Total	0	23004	5759	1101
Lower 95% Confidence Interval (Total)	0	14368	2920	551
Upper 95% Confidence Interval (Total)	0	31638	8598	1651

*Area for Ungrazed is 4800 m² and Grazed area is 5580 m²

2015 Monitoring

We monitored 22 sites occurring on Prineville BLM lands in 2015 (Figure 3), and found plants at 14 of the sites. Plant counts/estimates revealed only 4,821 individuals, and ranged from 33 to 1,690 (Table 2). Similar to previous sampling efforts (Meinke et al. 2011), we found that most of the plants we encountered were in difficult to reach areas and often in association with large juniper trees (*Juniperus occidentalis*; Figure 4). All sites appear to be quite variable in number of plants between surveys (Appendix A.).



FIGURE 6. *THELYPODIUM EUCOSMUM* GROWING AMONG MUCH TALLER *MELILOTUS* AT SITE 133.

Site 133 had the highest number of plants during our survey in 2015, and although this was an increase from the previous survey (330 in 2014), it was still much lower than the 11,000 recorded in 2005 (Appendix A). Site accessibility and the fact that it is the largest population provide opportunities to provide long-term data on this rare species. The site still faces significant threats from the heavy erosion from past grazing, as well as heavy cover of exotic, invasive species. Sweetclover (*Melilotus* sp.) are particularly dense in suitable habitat for arrow-leaf thelypody (Figure 6).

Eight sites had >200 plants, with sites 146, 191, and 371 all >400 plants during 2015 surveys (Table 2). Site 146 has historically been consistently higher than many other populations, while 191 and 371 have shown strong fluctuation in number of individuals (Appendix A). Although 371 did not have any previous count data, previous BLM written reports have listed it as a potentially ephemeral population.

Seven sites with multiple records had fewer plants in 2015 than the previous survey, while 9 had higher plant counts (excluding records with a single count; Appendix A.). Two of the sites with higher counts in 2015 (120, 132), recorded the highest documented totals. Of the sites with multiple records, 7 of the 14 with plants in 2015 have had plants during every survey (123, 132, 133, 137, 146, 190).

TABLE 3. NUMBER OF INDIVIDUAL *THELYPODIUM EUCOSMUM* PLANTS (FLOWERING, FRUITING, OTHER) AND ASSOCIATED THREATS AT SITES MONITORED ON PRINEVILLE BLM AND MALHUR NF LANDS IN 2015.

Site #	Flower	Fruit	Other*	Total	Threats
Prineville BLM					
120	3	12	213	228	Exotic annual grasses
123	13	46	223	282	Exotic annual grasses
124	0	0	0	0	Exotic annual grasses
126	3	22	242	267	Exotic annual grasses
132	2	3	118	123	None observed
133	6	161	1523	1690	Exotic grass and forb species, specifically <i>Melilotus</i> sp.
137	3	0	300	303	Exotic annual grasses
140	1	0	32	33	None recorded
141	0	0	0	0	None recorded
142	0	0	0	0	None recorded, but very dry
143	0	0	0	0	Exotic annual grasses
146	0	23	409	432	Exotic grass and forb species, but currently low cover
147	12	29	101	142	None observed
149	0	0	0	0	Exotic forbs (<i>Melilotus</i> , <i>Dipsacus</i> , etc.)
154	0	0	0	0	Exotic grass and forb species, but currently low cover
190	2	15	37	54	Exotic annual grasses
191	19	23	451	493	None observed
192	2	10	45	57	Exotic annual grasses
307	0	0	0	0	Heavily degraded due to cattle grazing
308	0	0	0	0	Heavily degraded due to cattle grazing
371	7	58	424	489	Exotic grass and forb species, but currently low cover
374	0	59	169	228	Exotic grass and forb species, but currently low cover
Malheur NF					
THEU_001	62	7	800	869	Trail erosion; drainage appears to be travel corridor
THEU_002	6	7	60	73	None observed
THEU_003	14	10	90	114	Minor ungulate herbivory
THEU_004	0	0	0	0	None observed
THEU_005	0	0	0	0	Road(s) bisect population and are eroding
THEU_006	0	0	350	350	No grazing noted, but cattle in area
THEU_007	49	166	224	439	None observed

*Includes all non-reproductive individuals (rosettes and seedlings).



FIGURE 7. TYPICAL *THELYPODIUM EUCOSMUM* HABITAT AT THEU_001 (NOTE THEU PLANTS UNDER DEAD JUNIPER AT BOTTOM LEFT).

site. The plants are patchily distributed down the drainage, mostly in association with junipers and rock outcrops.

Site THEU_006 showed the largest decrease in population size since the previous survey, having only 372 plants in 2015 compared to 5,000 in 2003 (Appendix A). In 2015, we found only 6% of the population to be reproductive (Table 1). The population consisted of many very small rosettes, concentrated in an area that had recently been grazed by cattle (Figure 8).

Although we attempted to locate Umatilla NF site (EO 60) and found no plants in 2015, after discussion with USFS staff we feel that we did not locate the correct area. We have removed the site from our 2015 records and USFS staff will revisit the site in future years.

USFS

2016 Monitoring

USFS Sites were not monitored in 2016.

2015 Monitoring

Of the 9 sites on USFS lands (8 on Malheur NF and 1 on Umatilla NF; Figure 2), we were able to visit 7 in 2015. Of the 7 visited, 5 had plants and ranged from 73 to 869 individuals (Table 1). All 5 sites with plants occurred on Malheur NF lands and contained all the arrow-leaf thelypody plants we encountered in 2015 (1,845; Table 1). Of the 5 sites with historic count data available, 4 showed a decline in plant numbers from the previous survey.

Site THEU_001 had the largest number of individuals in 2015 and was the only USFS population to have more plants than the previous survey. THEU_001 had scattered large juniper trees, with mostly native bunchgrass understory, with much bare ground/exposed rock (Figure 7). The only recorded threat at the site was light trail erosion along a worn path at the northeast corner of the



FIGURE 8. SITE THEU_006 ON MALHEUR NF. NOTE THE MANY SMALL *THELYPODIUM* ROSETTES AMONG THE GRAZED NATIVE *FESTUCA* SP. AND UNGRAZED NATIVE *LEYMUS* SP., AS WELL AS THE COW PIES IN THE PHOTO.

DISCUSSION

Monitoring

Our sampling in 2015 and 2016 shows highly variable population fluctuations, similar to those seen in previous sampling efforts (Appendix A). Fifteen sites had plants during every previous survey (123, 127, 128, 129, 132, 133, 137, 140, 146, 190, 207, 224, 480, THEU_001, THEU_006). Of these sites, 6 had >100 plants during all previous surveys and would be strong candidates for protection and future research efforts (127, 137, 146, 224, THEU_001, THEU_006). Several others had >50 plants during all previous surveys and also should be given priority for protection/management actions (128, 129, 190).

Eight sites had no plants recorded during our surveys. Of these sites, 151 is likely extirpated and should be low priority for future monitoring. This population had 25 plants during initial surveys in 1988, but the 4 subsequent surveys (1992, 1994, 2007, 2016) have all reported no plants and there is minimal suitable habitat. Site 307 had no plants recorded during the 3 most recent monitoring efforts with habitat degradation noted, and should also be low priority for future monitoring. The remaining 6 sites (121, 124, 142, 143, 154, 308, THEU_004, THEU_005) should be resurveyed because more data is needed to determine status, especially since several sites have rebounded after having no plants recorded during previous survey efforts (e.g. 120; Appendix A).

We were able to confirm that *Thelypodium eucosmum* is a perennial with multiple rosettes arising from the same rootstock (Hitchcock and Cronquist 1973). We found rosettes of multiple sizes arising from the same roots, including very small plants that could be confused for seedlings (Figure 5). This is important because rosette/plant counts don't necessarily give an accurate picture of population size. These counts will have to continue to serve as a surrogate, because it would require much more intensive study to be able to quantify the amount of asexual versus sexual reproduction.

FUTURE RESEARCH AND CONSERVATION NEEDS

Previous survey efforts, including our project, have revealed several important research needs to address to provide the best available information to prevent further decline of the species. The following list is meant to be a starting point for setting research priorities and should not be considered exhaustive, as other questions are sure to arise.

An area for potential research would be a more thorough investigation of population demography. Knowing how much recruitment is attributable to sexual versus asexual reproduction would help to more accurately estimate functional population sizes and potentially elucidate genetic relationships.

Germination trials at Lewis and Clark College and The Berry Botanic Garden have demonstrated that cold stratification is necessary for germination, with no germination of seeds not subjected to cold stratification (Center for Plant Conservation 2010). This information provides a starting point for producing the species from seed and development of propagation methods. Further refinement of propagation and reintroduction protocols should be a high priority, due to the seemingly rapid decline of these populations. Reintroduction efforts should monitor the establishment and survival of outplanted individual and/or seed(s).

Controlling exotic, invasive species and monitoring arrow-leaf thelypody response(s) is an area in need of study. Many previous surveys, including ours, have noted the prevalence of invasive species growing in areas suitable for thelypody. The research should focus on both exotic grasses and exotic forbs. In many areas invasive annual grasses have come to dominate areas in and around thelypody and have likely impacted the fire-return intervals, as well as potentially altered soil characteristics that could be limiting. At Site 133 where grazing has been removed, exotic, invasive forbs (predominately *Melilotus*) are growing very dense in potential thelypody habitats (Figure 6).

Studying the effects of disturbances on *Thelypodium* populations would aid in land management decisions. There are anecdotal reports of increased numbers following fire, but better data are necessary. Although ungulate grazing was very minor during our survey, grazing impacts need to be better understood. There were areas where cattle were obviously present, yet no grazing of *Thelypodium eucosmum* was recorded. This is different from previous monitoring that noted grazing at every sampled site, including being “very intense” in some areas (Meinke et al. 2011). It is possible that the long-term changes to the plant community (e.g. increased exotic, invasive species) brought on by grazing could be as or more important than the direct grazing of plants and would be important information for not only area botanists, but also area range managers.

Another area of research would be to elucidate soil relationships to *Thelypodium* populations. This would include not only looking at specific soil characteristics (beyond anecdotal reports), but also studying soil moisture relationships that encourage germination, survival and reproduction. While grazing likely caused the species to decline in more accessible habitats, the relationship of *Thelypodium* to *Juniperus* in the remote canyon populations could also be explored further. While juniper removal in areas where it has encroached could increase available moisture, the large, old junipers found in remote canyons appear to be providing some of the most suitable habitat.

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APPENDIX A. HISTORICAL SURVEY INFORMATION FOR *THELYPODIUM EUCOSMUM* POPULATIONS OCCURRING ON PRINEVILLE BLM AND MALHEUR NF LANDS SAMPLED IN 2015 AND 2016.

Site #	EO #	Year	Total
Prineville BLM			
120	47	2016	769
		2015	228
		2009	0
		2003	0
		2000	93
		1998	0
		1997	182
		1992	9
121	12	2016	0
		2014	0
		1990	18
		1989	126
		1988	171
		1987	149
123	12	2016	1231
		2015	282
		2014	60
		2011	144
		2010	30
		2009	240
		2000	704
		1994	957
124	19	2015	0
		2009	0
		2005	100
		2002	64
		2000	16
		1994	206
126	17	2015	267
		2009	13
		2007	0
		2005	125
		2000	175
		1994	770
		1992	67

Site #	EO #	Year	Total
127	23	2016	1520
		2005	140
		2001	398
		1996	850
		1994	600
		1991	256
128	33	2016	1405
		2005	100
		1994	609
		1991	50
129	23	2016	199
		2005	470
		1996	200
		1994	70
		1991	300
132	n/a	2016	12
		2015	123
		1998	20
133	25	2016	32403
		2015	1690
		2014	330
		2009	8600
		2005	11000
		1994	5052
137	5, 24	2016	1996
		2015	303
		2009	105
		2008	1293
		1998	528
		1993	1300
		1991	400
140	5, 20	2016	126
		2015	33
		2009	135
		2008	38
		1998	56
		1994	250
		1992	36
	1988	20	

Site #	EO #	Year	Total
141	5	2015	0
		2008	108
		1998	100
		1992	26
		1988	20
142	5,36	2015	0
143	28,49,68	2015	0
146	30	2016	380
		2015	432
		1996	1475
		1994	200
		1991	2000
147	27	2015	142
148	45	2016	0
		2008	299
		2002	723
		1994	343
		1983	150
149	46	2015	0
		2008	924
		2002	31
		1994	3600
		1992	23
151	n/a	1988	100
		2016	0
		2007	0
		1994	0
		1992	0
154	15	2015	0
190	40	2016	87
		2015	54
		2009	18
		1998	100
		1992	12
191	18	2016	255
		2015	493
		2009	0
		1993	560
		1992	14

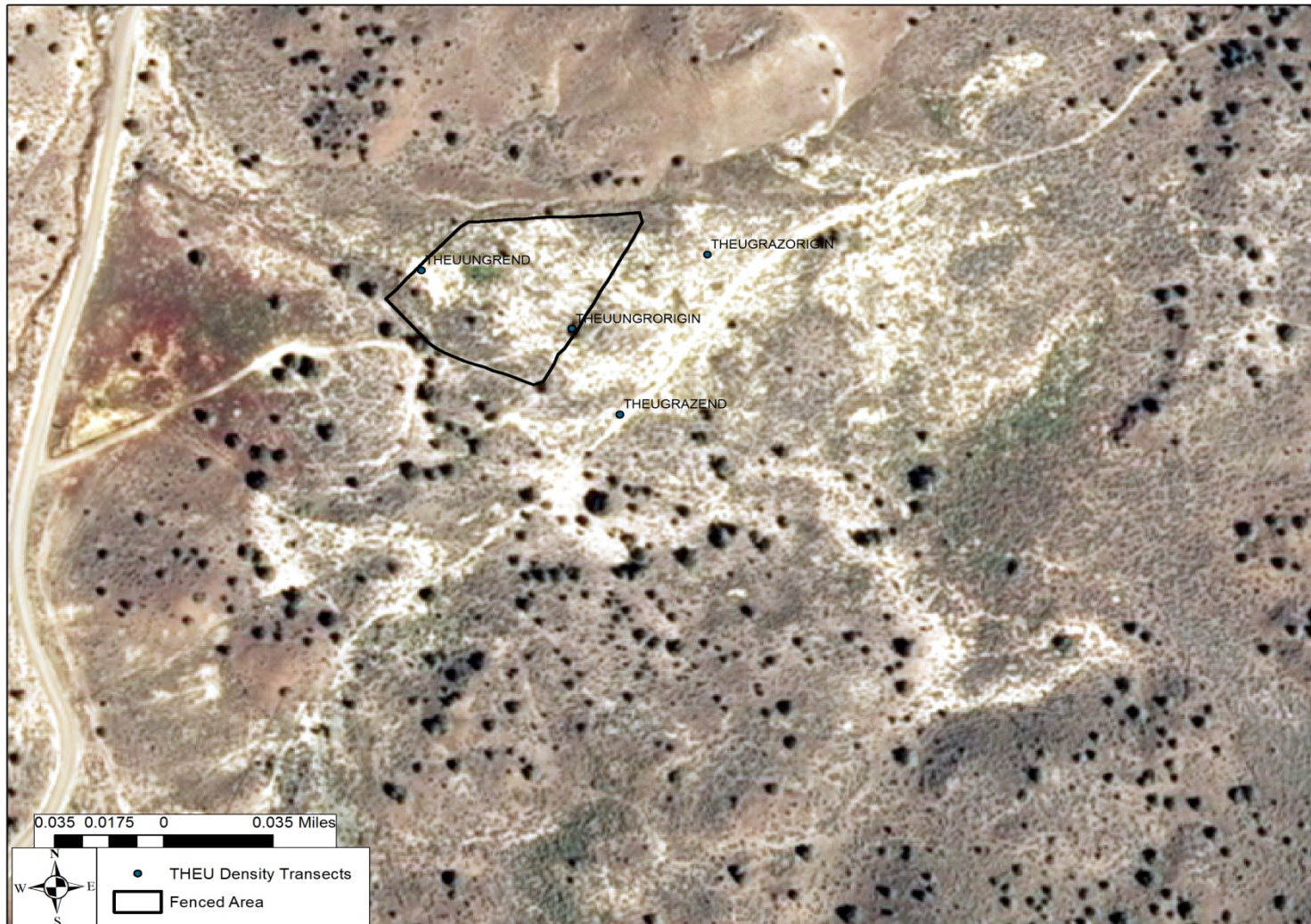
Site #	EO #	Year	Total
192	39	2015	57
		2014	0
		1993	58
207	12	2016	202
		2014	75
		2003	1
		2000	50
		1992	235
224	41	2016	3100
		2000	1854
		1993	500
307	57	2015	0
		2013	0
		2009	0
		2000	92
		1994	167
308	n/a	2015	0
		2013	0
		2007	29
		2006	32
		1994	21
371	5, 36	2015	489
374	5,67	2015	228
480	23	2016	34
		2005	630
		2001	37
525	n/a	2016	704

Malheur NF

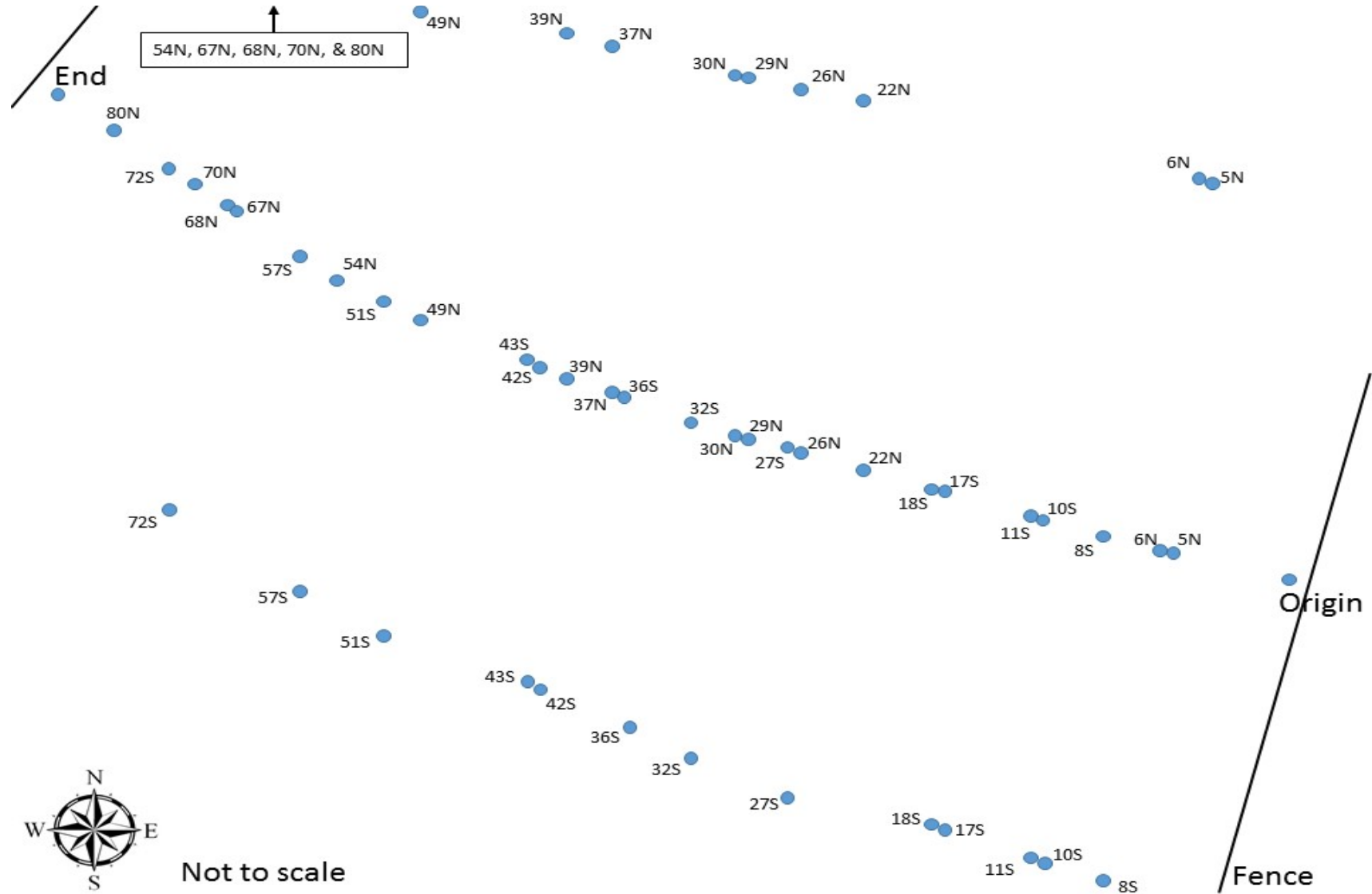
THEU_001	2015	869
	1990	500
THEU_002	2015	73
THEU_003	2015	114
THEU_004	2015	0
	1995	100
THEU_005	2015	0
	1999	26
THEU_006	2015	372
	2003	5000
THEU_007	2015	439

*Only records with specific counts/estimates were included.

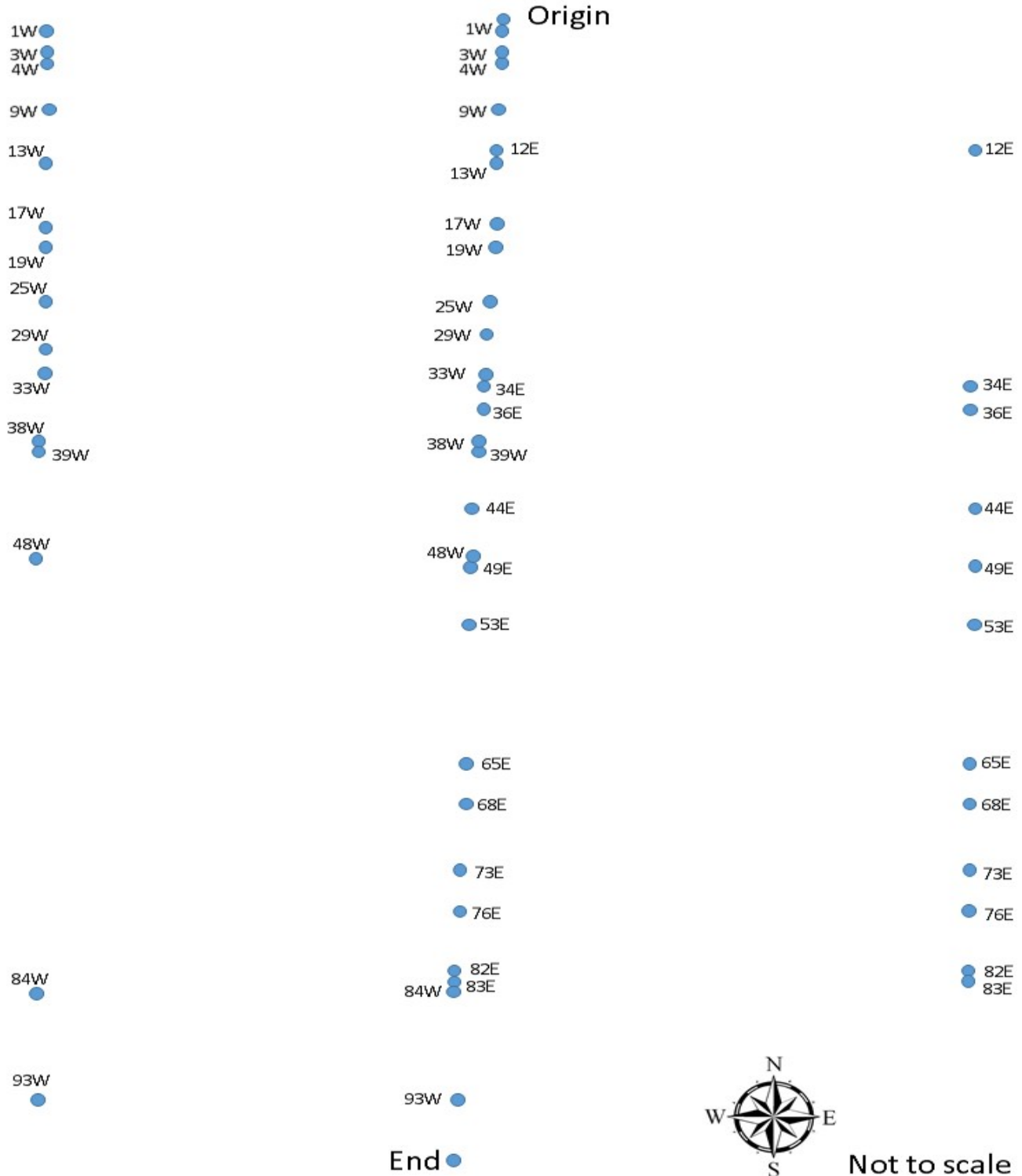
APPENDIX B. LAYOUT OF DENSITY MONITORING TRANSECTS AT SITE 133.



APPENDIX C. DIAGRAM OF DENSITY TRANSECTS IN FENCED PORTION AT SITE 133. NUMBERS ARE METERS FROM ORIGIN AND LETTERS REPRESENT DIRECTION OF TRANSECT.



APPENDIX D. DIAGRAM OF DENSITY TRANSECTS IN GRAZED (UNFENCED) PORTION AT SITE 133. NUMBERS ARE METERS FROM ORIGIN AND LETTERS REPRESENT DIRECTION OF TRANSECT.



APPENDIX E. LOCATION, DIRECTION, AND NUMBER OF THELYPODIUM EUCOSMUM PLANTS FOR DENSITY TRANSECTS MONITORED AT SITE 133 IN 2016.

Meters from Origin	Direction	Tag #	Seedling	Vegetative Small (<5cm)	Vegetative Large (>5cm)	Reproductive
Ungrazed						
5	North	284	0	82	12	7
6	North		0	39	7	3
8	South	525	0	6	0	0
10	South		0	5	0	0
11	South		0	5	0	1
17	South		0	4	0	0
18	South		0	2	0	0
22	North	286	0	73	5	2
26	North		0	33	10	3
27	South		0	22	2	2
29	North		0	74	12	13
30	North	287	0	56	3	4
32	South	521	0	22	0	1
36	South	520	0	47	4	2
37	North	762	0	64	11	2
39	North		0	27	13	0
42	South		0	93	12	3
43	South		0	26	7	7
49	North	895	0	96	31	1
51	South		0	35	1	1
54	North		0	4	29	1
57	South		0	0	0	0
67	North		0	19	3	1
68	North		0	13	16	0
70	North	1887	0	7	4	1
72	South	1927	0	10	3	2
80	North		0	5	11	1
Grazed						
1	West	288	0	15	3	0
3	West		0	13	0	0
4	West		0	33	3	0
9	West	290	0	19	0	1
12	East	294	0	26	0	0
13	West		0	5	0	0

17	West	289	0	5	0	0
19	West		0	8	3	1
25	West		0	71	12	5
29	West	519	0	10	3	0
33	West		0	64	7	4
34	East		0	53	9	4
36	East		0	63	18	0
38	West		0	58	8	1
39	West	291	0	14	2	0
44	East	292	0	161	12	3
48	West		0	33	4	4
49	East		0	192	38	9
53	East		0	132	67	5
65	East		0	58	11	3
68	East		0	71	16	0
73	East		0	81	63	3
76	East		0	25	22	0
82	East		0	21	9	0
83	East	293	0	20	19	2
84	West		0	3	1	0
93	West		0	2	3	1

APPENDIX F. TAG NUMBER AND DESCRIPTION OF FLOWERING *THELYPODIUM EUCOSMUM* INDIVIDUALS AT SITE 133.

Ungrazed	
Tag #	Description (meant to be used in conjunction with GPS coordinates in Appendix G)
305	Approx. 2 meters North of main transect and 2 meters East of 682 in yellow rabbitbrush; single stalk with 2 small rosettes near base
655	In open near greasewood with 684 approx. 12-15 inches NE; single flowering stalk with no close rosettes
657	Within 3 inches of 683 in small greasewood, approx. 1-2 meters East of 655 and 684 near large clump of biological soil crust island with cheatgrass and greasewood; single flowering stalk with no close rosettes
660	At base of same <i>Leymus</i> as 675 approx. 2 meters North of 673; single flowering stalk with no close rosettes
669	Approx. 2-3 meters West of 673 near large greasewood with <i>Leymus</i> ; 3 flowering stalks with no close rosettes
672	In open ground 1 meter North of greasewood and 3 meters NW of large <i>Leymus</i> , 2 meters SW of 677; 2 flowering stalks, no close rosettes
673	In open between 2 greasewood and approx. 2 meters SW of <i>Leymus</i> , approx. 2-3 meters East of 669
675	At base of same <i>Leymus</i> as 660 near small greasewood; single flowering stalk with no close rosettes
677	In open ground 2 meters NE of 672; single flowering stalk, 2 branches, no rosettes near
678	In open, 1 meter NE of 677, approx. 3-4 meters North of <i>Leymus</i> ; 2 flowering stalks, no close rosettes
679	Single stalk near old dead shrub in yellow rabbitbrush; 2 other flowering rosettes
680	Just South of main transect in greasewood; 1 flowering stalk 3-4 rosettes within 6 inches
682	Approx. 2 meters North of main transect in yellow rabbitbrush; 4-5 small rosettes within 6 inches
683	Within 3 inches of 657 in small greasewood, approx. 1-2 meters East of 655 and 684 near large clump of biological soil crust island with cheatgrass and greasewood; single flowering stalk with no close rosettes
684	In greasewood next to biological soil crust island containing 657 and 683; single stalk with multiple small rosettes within 3-4 inches
685	0.5 meters East of transect rebar near large greasewood; 4 flowering stalks; multiple small and 1 large (8cm diameter) rosette within 6 inches
687	Under <i>Juniperus</i> SE of 679; 2 flower stalks w/ no other rosettes
688	1-2 meters North of 678 and 4-6 meters North of <i>Leymus</i> ; single stalk, no close rosettes
690	On opposite side of <i>Juniperus</i> from 687 on bare soil; single flowering stalk w/ 1 rosette within 2 inches
694	In wash near end of density transect at 72meters; 4 flowering stalks, multiple rosettes and flowering plants within 6 inches
Grazed	
654	Approx. 30 cm E. of 676; single flowering stalk with large rosette within 2 inches
656	1 meter West of 664; 3 flowering stalks with no close rosettes
658	South side of wash approx. 4 meters West of 663; 3 flowering stalks and large rosette within 3 inches
659	In middle of wash approx. 3-4 meters from 663; single flowering stalk with large and small rosette within 6 inches
661	South side of wash approx. 10 meters East of 663 near base of greasewood with large <i>Juniperus</i> approx. 3-4 meters; multiple rosettes within 6 inches
662	On North side of wash opposite <i>Juniperus</i> ; approx. 0.5 meters East of 686; single flowering stalk with 1 small rosette at base
663	On South side of wash in open on side slope; approx. 15-20 meters from 662, 686, 691 grouping; single flowering stalk with 2 small rosettes within 6 inches
664	Approx. 30 cm West of 674; single flowering stalk with multiple rosettes with 6 inches
665	North side of wash approx. 3-4 m West of 661 in dead portion of greasewood; no close rosettes
666	South side of wash approx. 30 cm SE of 658; 2 flowering stalks with 1 rosette within 2 inches

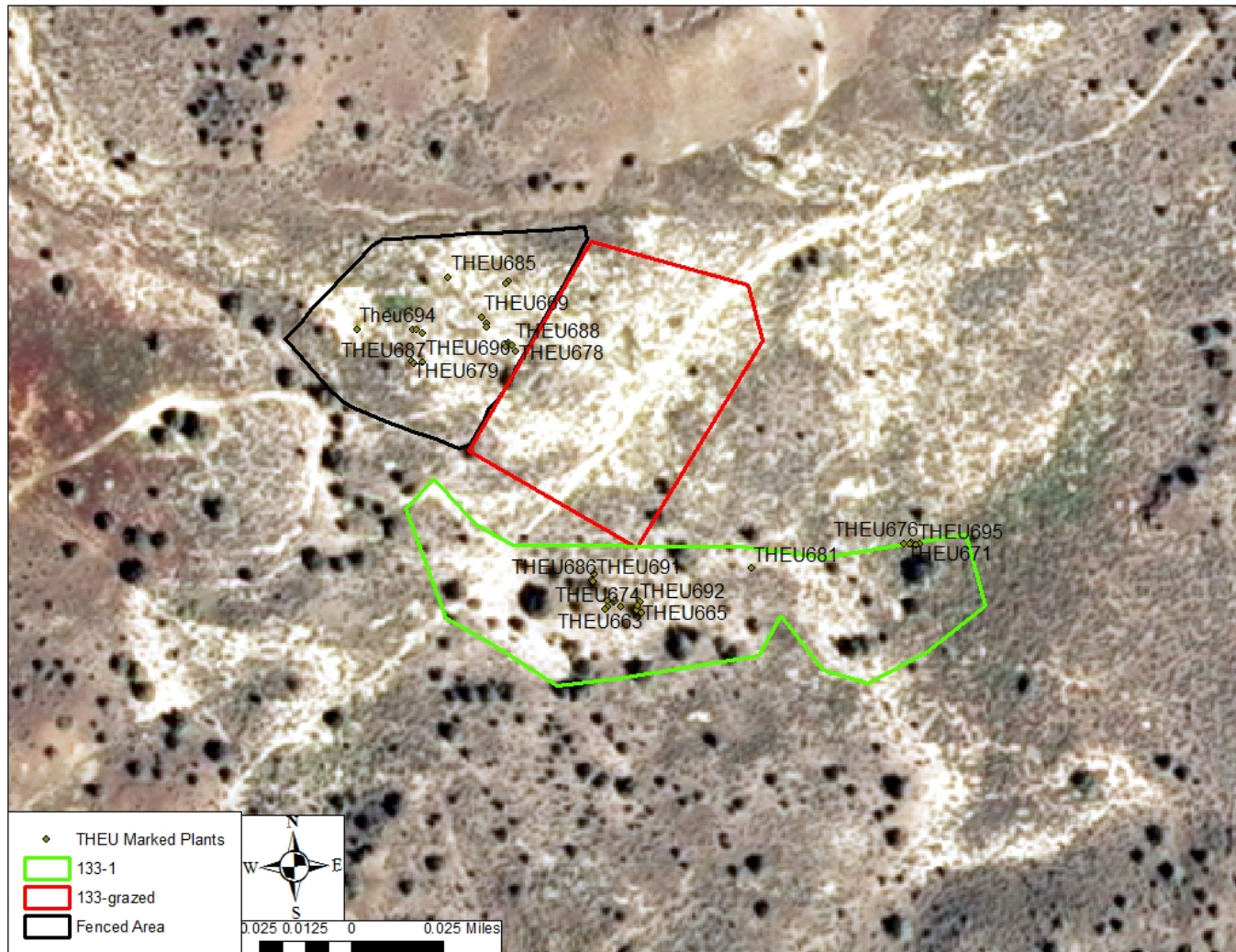
667	At base of greasewood with 670 approx. 3-4 meters North of 695; single flowering stalk with multiple rosettes within 2 inches
670	At base of greasewood with 667 approx. 3-4 meters North of 695; single flowering stalk with multiple rosettes within 2 inches
671	In side drainage to NW of main drainage in greasewood near mid-size Juniperus; large rosettes within 2 inches
674	Approx. 0.75 meters West of 658 on South side of wash in small greasewood; 2 flowering stalks with 2 rosettes within 6 inches
676	Approx. 2 meters North of mid-size Juniperus within 30 cm of 654 and approx. 4 meters East of 671 in middle of cowpie; 2 flowering stalks with no close rosettes
681	South side of main wash under old greasewood; no close rosettes
686	On North side of wash opposite Juniperus; approx. 0.5 meters East of 691; single flowering stalk with 10 small rosettes within 6 inches
691	On North side of wash opposite Juniperus; approx. 0.5 meters East of 686; single flowering stalk with 1 small rosette within 3 inches
692	In middle of wash near dead sagebrush stump approx. 2-3 meters East of 659 with multiple rosettes within 6 inches
695	Near large sagebrush approx. 3 meters East from mid-size Juniperus and approx. 3 meters SE of 654 and 676; 4 rosettes within 2 inches

APPENDIX G. GPS COORDINATES OF FLOWERING *THELYPODIUM EUCOSMUM* INDIVIDUALS AT SITE 133 (GCS NORTH AMERICAN 1983).

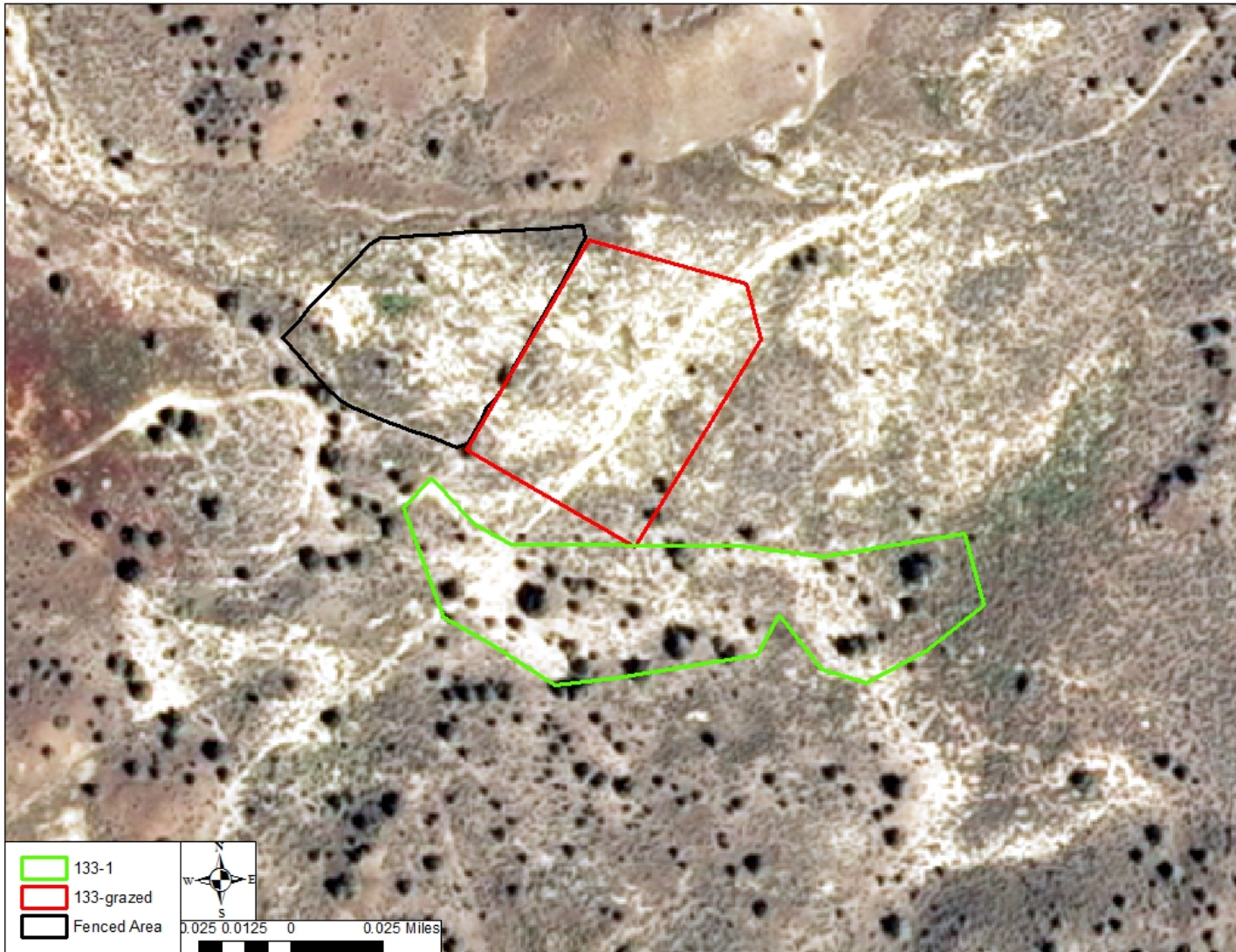
Tag #*	Latitude	Longitude
305	44.71957437	-120.26586032
654	44.71868739	-120.26320703
655 & 684	44.71976447	-120.26537702
656	44.71849754	-120.26489347
657 & 683	44.71975885	-120.26539471
658	44.71847148	-120.26489004
659	44.71845547	-120.26473246
660	44.71960245	-120.26550577
661	44.71844323	-120.26470563
662	44.71860240	-120.26496271
663	44.71847131	-120.26482030
664	44.71849285	-120.26485567
665	44.71848967	-120.26471519
666	44.71849712	-120.26485257
667 & 670	44.71867851	-120.26315942
669	44.71962935	-120.26553695
671	44.71868035	-120.26324375
672	44.71951142	-120.26540686
673	44.71958996	-120.26551155
674	44.71846368	-120.26490906
676	44.71867977	-120.26321265
677	44.71952466	-120.26539370
678	44.71948837	-120.26535347
679	44.71946523	-120.26593124
680	44.71958987	-120.26591657
681	44.71860508	-120.26409417
682	44.71958744	-120.26589838
685	44.71978978	-120.26571222
686	44.71857835	-120.26497402
687	44.71945392	-120.26591405
688	44.71951318	-120.26536898
690	44.71946054	-120.26586686
691	44.71857474	-120.26496606
692	44.71847433	-120.26472885
694	44.71959532	-120.26622661
695	44.71867281	-120.26318206

*Plants in close proximity, within the error of the GPS unit, were marked with a single point.

APPENDIX H. MAP OF TAGGED PLANTS AT SITE 133. REFER TO APPENDIX F FOR DESCRIPTIONS OF LOCATIONS OF CLUMPED INDIVIDUAL PLANTS NOT LABELED ON MAP.



APPENDIX I. LOCATION OF NEW POLYGON (133-1) IN RELATION TO FENCED AREA AT SITE 133.



APPENDIX J. SEED ACCESSION NUMBERS FOR *THELYPODIUM EUCOSMUM* DEPOSITED AT THE RAE SELLING BERRY SEED BANK.

TAXON	ACCESSION #	STATE	COUNTY	LOCATION	ACC DATE	COLLECTION DATE(S)	IAE number(s)
<i>Thelypodium eucosmum</i>	SB2016-1000 to -1003	OR	Wheeler	Pop #120	11/10/2016	6/15/2016	154071-073
<i>Thelypodium eucosmum</i>	SB2016-1004 to -1006	OR	Wheeler	Pop #137	11/10/2016	6/15/2016	154082, 151003-004
<i>Thelypodium eucosmum</i>	SB2016-1007 to -1008	OR	Wheeler	Pop #123	11/10/2016	6/16/2016, 6/19/2016	154095, 154074
<i>Thelypodium eucosmum</i>	SB2016-1009 to -1010	OR	Wheeler	Pop #133	11/10/2016	6/16/2016, 6/17/2016	154075-076
<i>Thelypodium eucosmum</i>	SB2016-1011	OR	Grant	Pop #190	11/10/2016	6/16/2016	154096
<i>Thelypodium eucosmum</i>	SB2016-1012 to -1016	OR	Grant	Pop #224	11/10/2016	6/17/2016	151007-011
<i>Thelypodium eucosmum</i>	SB2016-1017 to -1019	OR	Wheeler	Pop #127	11/15/2016	6/18/2016	154099-097
<i>Thelypodium eucosmum</i>	SB2016-1020 to -1021	OR	Wheeler	Pop #128	11/15/2016	6/19/2016	151006-005
<i>Thelypodium eucosmum</i>	SB2016-1022 to -1023	OR	Wheeler	Pop #129	11/15/2016	6/20/2016	151002, 154100
<i>Thelypodium eucosmum</i>	SB2016-1024 to -1028	OR	Wheeler	Pop #140	11/15/2016	6/19/2016	154083-087
<i>Thelypodium eucosmum</i>	SB2016-1029 to -1033	OR	Wheeler	Pop #525	11/15/2016	6/18/2016	154078-081, 154077

APPENDIX K. DETAILED MAPS OF THELYPODIUM EUCOSMUM SITES MONITORED IN 2015 AND 2016.

