Population Viability Analysis for the clustered lady's slipper (*Cypripedium fasciculatum*)

2010 Progress Report

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PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization dedicated to natural resource conservation, 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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INTRODUCTION

Project Overview

Clustered lady's slipper (*Cypripedium fasciculatum* Kellogg ex S. Watson; synonym includes *Cypripedium knightiae* A. Nelson) is a Bureau Sensitive species, a former Survey and Manage species under the Northwest Forest Plan, and a candidate for listing by the state of Oregon. The orchid is rare throughout its range in the western United States. More than 800 locations for clustered lady's slipper have been identified in the Medford District BLM. Many of these populations had ten or fewer individuals at their last survey date; the current status of most of these populations is unknown. It is difficult to determine if small population sizes are normal and healthy or if they are at an elevated risk of extirpation. In an analysis of clustered lady's slipper and mountain lady's slipper (*Cypripedium montanum*) populations in California, we found that over the period of time follow-up observations were made (1 to 23 years), approximately 66% of populations declined in size and 30% - 45% fell to zero (Kaye and Cramer 2005). Both population size and time since observation were significantly correlated with extinction events. The purpose of this project was to survey populations of clustered lady's slipper in the Medford District BLM in order to better model the probability of extinction (Population Viability Analysis) for this species.

Figure 1. *Cypripedium fasciculatum*.

Species Distribution and Description

Clustered lady's slipper occurs in widely disjunct locations from north central Washington south through Oregon to central California and east to the mountains of Idaho, Montana, Colorado, Wyoming, and Utah. In Oregon, this taxon occurs predominantly in the Klamath Mountains in the southwest corner of the state.

Clustered lady's slipper is small, measuring less than 18 cm from the base to the apex. It has two opposite, elliptical leaves with a total leaf span up to 30 cm. The stem is conspicuously puberulent (see photo on cover). In most cases, there is a single miniature bract between the leaves and the flowers. The flowers are tiny by lady's slipper standards, only 4.5 cm from tip to tip. Flower color ranges from brown markings on a green or golden background to predominately reddish-brown. The flowers are found in clusters of two to ten at the end of the stem, often causing the stem to droop under their weight (Figure 1). The fruits are 2 cm oblong capsules that contain thousands of small, dust-like seeds. Clustered lady's slipper has a small, shallow rhizome with fibrous roots that produces a dormant bud during the current year's growing season (Harrod 1994). This bud remains inactive through the winter, but then bolts in April to produce an aerial stem.

Status

Clustered lady's slipper is currently considered a Sensitive Species in Regions 5 and 6 of the USDA Forest Service. National Forests covered under the Northwest Forest Plan recently treated it as a Survey and Manage Species, but this designation was converted to Sensitive Species (Record of Decision 2004). The USDI Bureau of Land Management lists clustered lady's slipper as a Bureau Sensitive species in California and Oregon. Clustered lady's slipper is on the California Native Plant Society watch list, indicating that it is fairly endangered in California and rare outside the state. The Oregon Natural Heritage Information Center lists clustered lady's slipper as List 2 [threatened with extirpation (ORBIC 2010)]. The species' Heritage rankings are G4 (globally not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences), S3.2 in California, and S3 in Washington and Oregon (ORBIC 2010).

Population Dynamics/Reproduction

The abundance of clustered lady's slipper stems at any one site may range from one to over 1,000. In California, the mean population size is 27 stems (Carothers 2003). Over half of the populations have fewer than 10 stems and over 90% have fewer than 100 stems. Large populations occur occasionally; one clustered lady's slipper population on the Plumas National Forest in the Sierra Nevada has over two thousand stems. This pattern of population size is similar to that observed in the Pacific Northwest. Nearly all sites in Oregon and Washington (96%) have stem counts less than 100, with most ranging between 1 and 20. Most populations on federal land were discovered during pre-disturbance surveys for proposed projects, primarily timber sales. The total number of extant sites is lower than original sighting reports because some populations have declined or dropped to zero.

Clustered lady's slipper is a rhizomatous perennial that may propagate sexually and asexually. Clonal propagation from buds on rhizomes often produces tightly-grouped clumps of ramets. Genetic mapping suggests that clonal spread of clustered lady's slipper occurs only over very short distances, on the order of several centimeters. This species appears to rely primarily on sexual reproduction for expanding populations and maintaining genetic diversity (Knecht 1996).

Habitat

Clustered lady's slipper can occur in a wide variety of plant community types. The majority of known clustered lady's slipper sites are in mixed conifer, Douglas-fir, and riparian forests. Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) are the evergreen tree species most frequently associated with *C. fasciculatum*. Hardwood trees and shrubs often associated with this species include mountain dogwood (*Cornus nuttallii*), hazelnut (*Corylus cornuta* var. *californica*), canyon live oak (*Quercus chrysolepis*), and black oak (*Q. kelloggii*). Forbs frequently associated with clustered lady's slippers include trail plant (*Adenocaulon bicolor*), starflower (*Trientalis latifolia*), and false Solomon's seal (*Smilacina racemosa*).

In southwestern Oregon, the vegetation structure around populations of clustered lady's slipper usually consists of high canopy cover of late seral species (e.g. Douglas-fir) often in association with a gap in the overstory filled by mid-level hardwood species such as madrone (*Arbutus menziesii*), black oak, canyon live oak, mountain dogwood, or tanoak [*Lithocarpus densiflorus* (Latham 2001)]. The herbaceous layer is often sparse and composed primarily of a

low abundance of graminoid and forb species. Mid-successional to late-successional forest communities may be optimal habitat for clustered lady's slipper in the Cascade Range of Washington and Oregon, possibly because fungal symbionts are present in these older communities that are not in younger communities (Harrod and Knecht 1994). Knecht (1996) observed that most populations of clustered lady's slipper in that region occurred in forests with >60% canopy cover.

Because of the well-known association between orchids and fungi and the heterotrophic mode of fungal nutrition for orchids, important environmental factors controlling the distribution of clustered lady's slippers may include characteristics of the upper organic layer of the soil profile and how they influence mycorrhizal fungi, rather than the nature of the parent or mineral soil. Some soil factors that may affect mycorrhizal fungi include development of the soil organic layer, soil depth, rate of decomposition of organic matter, moisture content, and pH. The bryophyte communities that cover shallow soils in which clustered lady's slippers rhizomes often grow may also be important for water retention. Coarse woody material may provide microsite moisture, shade, and protect duff and litter layers from disturbance.

METHODS

Data Collection

In May of 2008 – 2010, we visited 78 clustered lady's slipper populations throughout the Medford District BLM that were last surveyed between 1 and 29 years ago (Appendix A). The information available regarding these populations varied, but generally included written physical site descriptions, general directions, habitat descriptions, and clustered lady's slipper population information. Older population descriptions included estimated latitude and longitude coordinates whereas newer sites included latitude/longitude and/or UTMs in the original site description. Newer sites were also generally flagged well and usually included "Plant Site" monument signs in the vicinity of the clustered lady's slipper populations. New populations found over the course of this survey work have "NEW" in their unique-ids (Appendix A), and were not included in the PVA analysis.

Sensitive Plant Sighting Forms (Medford District BLM) were completed for each population, including when the population could not be relocated. In cases where uncertainty existed about the original population's location, the entire area was intensely surveyed using the Intuitive Controlled survey method (Whiteaker et al. 1998). This was especially common for older sites where the original flagging had weathered away and no monuments marked the population. If plants were found, we estimated based on the original written description if the populations were the same, or if the plants were from a new, previously undocumented population. If no plants were found, a survey form was filled out at the particular spot that best matched the original description. All clustered lady's slipper populations that were located were flagged and GPS coordinates were recorded.

Data Analysis

Data included in the Population Viability Analysis came from two sources beyond what was collected in 2008 - 2010. The first was a selection of populations from the Sierra Nevada bioregion taken from the Carothers (2003) database (N = 78). These data were initially selected and used by Kaye and Cramer (2005) to create a Population Viability Analysis for *C. fasciculatum* and *C. montanum* in California. Data were also included from long term *C. fasciculatum* monitoring plots established in southwestern Oregon forests (land managed primarily by Medford District BLM, but also USFS) and monitored by the BLM and the Institute for Applied Ecology (N = 28). These plots were established between 1996 and 1998 and monitored through 2007.

One set of assumptions made in the creation of the database for the Population Viability Analysis involved populations that were extinct versus those that were not relocated. While some of the information used for the analysis came from well documented monitoring projects, other data came from observations of populations without permanent markers (see above). Uncertainty often existed at older populations that were not relocated because we could not definitively determine that we were at exactly the same location. For the purpose of this analysis it was assumed that populations not relocated were extinct, even though this species is capable of dormancy; some reports of zero plants may have been the result of synchronous dormancy in a small number of plants.

We also made assumptions about the actual population size of previously monitored populations. Some observers censused the entire population, while others estimated population size, potentially complicating the determination of whether a population increased or decreased over time. This problem was uncommon, but when necessary the highest integer reported for a population in a given year was used. For example, if 50-100 plants were reported, we used 100. If the number was somewhat vague, for example 75+, >30, or ca. 50, we used 75, 30, or 50, respectively. At the time of initial visit, populations used in the analysis varied in size from 1 to 1084 (Figure 2).

Extinction risk was estimated from the data using a general linear model with quasibinomial errors. The response variable was population status at the most recent visit (a binomial response, either extinct or extant). The independent variables were the size of the population at the initial visitation and the years between visitations. All analyses were performed in R 2.12 (R Core Development Team, www.cran-r.org).

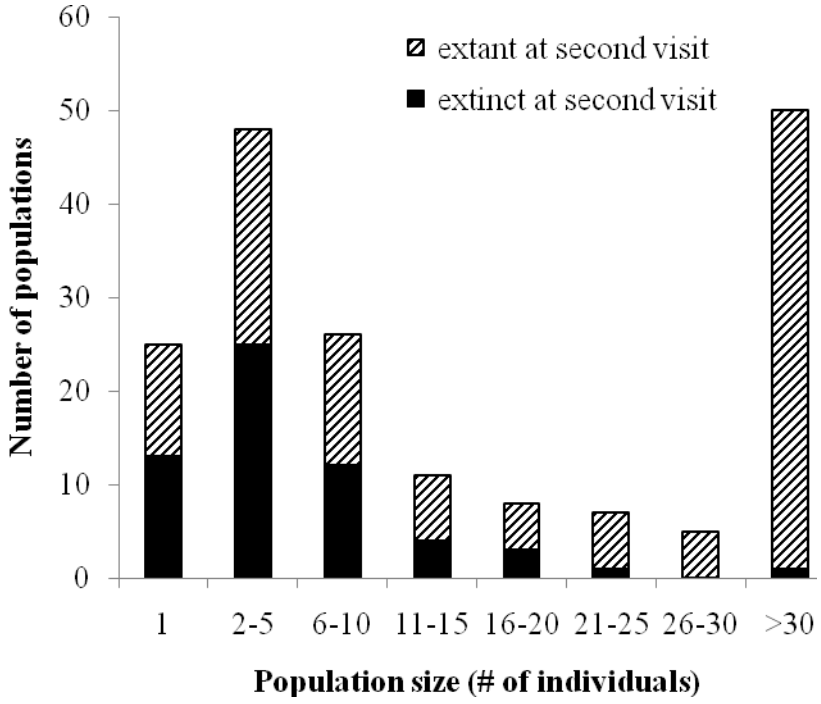

Figure 2. Histogram showing populations used in the population viability analysis grouped by size and status at time of second visit.

RESULTS AND DISCUSSION

Most populations of clustered lady's slippers have very few individuals. The data suggest an ongoing trend of population decline and local extinction. Our data set includes 180 populations of clustered lady's slipper from Oregon and California that were revisited 1 to 29 years after the previous site visit. We found that 59% of these populations declined in size and 33% fell to zero. Small populations (<10 plants) went extinct in 50% of the cases, and mid-sized populations (10-30 plants) went extinct in 30.5% of the cases, while only 2% of large populations (>30 plants) declined to zero.

Our analyses of all site revisits show that population size and the time between site visits are very important in predicting extinction probability (Table 1). The interaction between these terms was not significant (p=0.27) and was dropped from the model. Populations with small starting sizes have a greater risk of extinction than those with large starting sizes, and predicted extinction risk is near zero for populations >100 individuals, regardless of the length of time between samples (Figure 3). Further, extinction risk increases as the time between visits increases, most notably for smaller populations. For example, populations of 10 individuals have a 25.7% chance of going extinct after 5 years, but this risk increases to 83.2% after 30 years.

The data provided by multiple years of surveying have not altered the overall predictions of this model, but rather reduced the variability associated with the predictions.

Table 1. Summary statistics for factors affecting extinction risk.

	Estimate	**Standard Error**	**t value**	**Pr(>|t|)**
Starting population size	-0.09	0.02	-4.55	<0.0001
Years between site visits	0.11	0.03	3.57	<0.0001

No coordinated range-wide monitoring program exists for *Cypripedium fasciculatum*. Estimates of the total number of populations of clustered lady's slipper based on historical records may highly overestimate the number of extant populations. While some of the populations that were assumed to be extinct may have been dormant, it is unlikely that all individuals in a population would be dormant, particularly because the probability of dormancy longer than one year is low (Thorpe et al. 2007). Our analysis did not estimate establishment rates; if new sites are frequently colonized, the risk of extirpation from larger areas would be reduced. However, given the relative rarity of undisturbed area in the range of *C. fasciculatum*, it is unlikely that the number of new populations balances the number of extinctions. In light of the likelihood that many documented populations of clustered lady's slipper may be extinct, we recommend the maintenance of protections for this species.

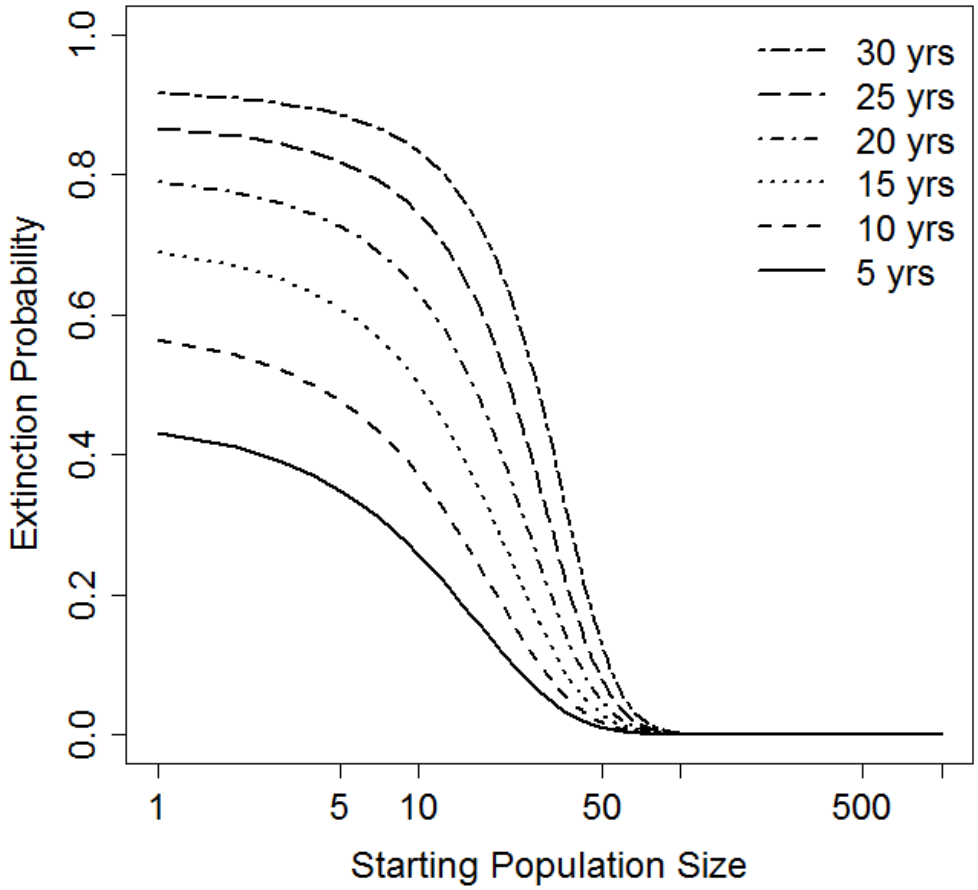

Figure 3. Extinction probability as a function of starting population size and years between visits. Each line represents a specific time interval between population site visits. As the time between site visits increases, the extinction probability also increases. Populations of larger size have a reduced risk of extinction. Note the logarithmic scale of the x-axis.

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APPENDIX A. CLUSTERED LADY'S SLIPPER SITES SURVEYED IN 2008.

Unique-id	years since obs	County	BLM Resource Area/USFS	Quad	Township	Range	Section	1/4 of 1/4	UTM E (zone 10)	UTM N (zone 10)	Datum
8480	9	Josephine	Grants Pass RA	Takilma	40S	7W	9	SW of SE	456402	4660700	Nad27
650	17	Josephine	Grants Pass RA	Takilma	40S	7W	9	SW of SE	456307	4660714	Nad27
2253	10	Josephine	Grants Pass RA	Sexton Mt.	35S	5W	29	SW 1/16 of NE 1/4	474204	4705244	Nad27
7255	9	Josephine	Grants Pass RA	Takilma	40S	7W	17	SW of SW	453980	4659008	Nad27
643	16	Josephine	Grants Pass RA		39S	8W	17	NW of NW	444083	4670299	Nad27
8532	11	Josephine	Grants Pass RA	Holland	39S	7W	5	SW 1/16 of NW 1/4	453803	4672747	Nad27
2266	10	Josephine	Grants Pass RA	Onion Mt.	36S	7W	27	NE 1/16 of NW 1/4	457726	4695780	Nad27
12721	1	Josephine	Grants Pass RA	Wilderville	36S	7W	27	NE 1/4	458140	4695800	Nad27
11658	2	Josephine	Grants Pass RA	Onion Mt.	37S	7W	3	NW of NE	457894	4692807	Nad27
1405	12	Jackson?	Grants Pass RA	Onion Mt.	37S	7W	3	NW of NW	458034	4692657	Nad27
7529	8	Josephine	Grants Pass RA	Murphy	38S	5W	5	SE of NW	473897	4682221	Nad27
8968	3	Jackson	Butte Falls RA	Skeleton Mt.	33S	3W	20	SE of SW	493253	4725208	Nad27
*NEW-1	NA	Jackson	Butte Falls RA	Skeleton Mt.	33S	3W	20	SE of SW	493268	4725317	Nad27
*NEW-2	NA	Jackson	Butte Falls RA	Skeleton Mt.	33S	3W	20	SE of SW	493276	4725201	Nad27
11552	2	Jackson	Butte Falls RA	McConville Pk	34S	3W	21	NW of NW	494337	4717015	WGS84
10563	3	Jackson	Butte Falls RA	McConville Pk	35S	3W	17	SE of SW	493226	4707771	Nad27
*NEW-3	NA	Jackson	Butte Falls RA	Wimer	35S	4W	7	NW 1/16 of SW 1/4	481503	4709717	Nad27
4782	5	Josephine	Glendale RA	Golden	34S	5W	11	SW of NW	478153	4719874	Nad27
9283-1	4	Josephine	Glendale RA	Sexton Mt.	34S	5W	17	NE of SE	474270	4717780	WGS84
9283-2	4	Josephine	Glendale RA	Sexton Mt.	34S	5W	17	NE of SE	474573	4717811	WGS84
9283-3	4	Josephine	Glendale RA	Sexton Mt.	34S	5W	17	NE of SE	474602	4717727	WGS84
7554	8	Josephine	Glendale RA	Golden	33S	5W	28	NW of SW	474972	4724429	Nad27
2355	10	Josephine	Glendale RA	Glendale	33S	7W	26	NE 1/16 of NE 1/4	460088	4725130	Nad27
4790	5	Josephine	Glendale RA	Merlin	34S	6W	15	NE 1/16 of SE 1/4	468334	4717811	Nad27
4789	5	Josephine	Glendale RA	Merlin	34S	6W	15	SE 1/16 of NE 1/4	468373	4718155	Nad27
9779	3	Jackson	Ashland RA	Applegate	37S	4W	14	SE of SW	488050	4688601	WGS84

*Denotes new population found over the course of the survey work not included in the PVA analysis.

APPENDIX A. (CONT.) CLUSTERED LADY'S SLIPPER SITES SURVEYED IN 2009.

Unique-id	years since obs	County	BLM Resource Area/USFS	Quad	Township	Range	Section	1/4 of 1/4	UTM E (zone 10)	UTM N (zone 10)	Datum
7569	8	Jackson	Ashland RA		39S	3W	29	NW of NW	492501	4666887	WGS84
590	23	Jackson	Ashland RA		39S	4W	27	SE of NE	487456	4666534	Nad27
10277	4	Jackson	Ashland RA		39S	4W	21	NE of SE	485901	4667492	Nad27
*NEW-4	NA	Jackson	Ashland RA		39S	4W	31	NE of SE	482671	4664433	Nad27
609	23	Jackson	Ashland RA		39S	4W	31	NE of SE	482683	4664330	Nad27
2365	10	Jackson	Ashland RA	Tallowbox Mt.	39S	4W	26	SE of SW	488157	4665711	WGS84
9724-a	3	Jackson	Ashland RA	Applegate	37S	4W	21	NE of SW	484988	4687303	WGS84
9724-b	3	Jackson	Ashland RA	Applegate	37S	4W	21	NE of SW	485029	4687318	WGS84
9724-c	3	Jackson	Ashland RA	Applegate	37S	4W	21	NE of SW	485005	4687258	WGS84
*NEW-5	NA	Jackson	Ashland RA	Applegate	37S	4W	21	NE of SW	485025	4687316	WGS84
559	21	Jackson	Ashland RA		37S	4W	27	SW of NW	485982	4686063	WGS84
Round Prairie C	2	Josephine	Grants Pass RA	Onion Mt.	37S	7W	3	NE of NE	458392	4693114	Nad83
11665	3	Josephine	Grants Pass RA	Onion Mt.	37S	7W	3	NE of SE	458509	4692192	Nad83
1026	14	Josephine	Grants Pass RA	Williams	39S	5W	14	NW of SW	478635	4669123	Nad83
1033	14	Josephine	Grants Pass RA		40S	7W	12	SW of NW	460223	4661466	Nad83
4600	6	Jackson	Ashland RA	Talent	39S	2W	5	NW of NW	502166	4673535	Nad83
674	18	Jackson	Ashland RA		39S	4W	31	NW of NW	481482	4665259	Nad83
2338	11	Jackson	Ashland RA		38S	4W	12	SW 1/16 of SE 1/4	490222	4680397	Nad83
12687	2	Jackson	Ashland RA		38S	4W	13	NE of SE	490444	4679001	Nad83
7517	5	Jackson	Ashland RA		39S	1W	19	NE of NW	511007	4668503	Nad27
2738	11	Josephine	Grants Pass RA		35S	5W	33	SW of NW	476395	4711800	Nad83

*Denotes new population found over the course of the survey work not included in the PVA analysis.

APPENDIX A. (CONT.) CLUSTERED LADY'S SLIPPER SITES SURVEYED IN 2010.

Unique-id	years since obs	County	BLM Resource Area/USFS	Quad	Township	Range	Section	1/4 of 1/4	UTM E (zone 10)	UTM N (zone 10)	Datum
2256	11	Josephine	Grants Pass RA	Grant's Pass	35S	5W	33	SW of SE	475621	4702941	Nad83
820	12	Josephine	Grants Pass RA	Mt. Peavine	34S	8W	34	NE of SE	448614	4713007	Nad27
1439	15	Jackson	Ashland RA	Tallowbox Mt.	38S	4W	28	SE 1/16 of SE 1/4	485682	4675359	Nad83
2043	6	Jackson	Ashland RA	Tallowbox Mt.	39S	4W	23	NW 1/16 of NW 1/4	487538	4668566	Nad83
2311	12	Jackson	Ashland RA	Ruch	38S	3W	7	SW 1/16 of SW 1/4	490877	4680193	Nad83
2327	12	Jackson	Ashland RA	Ruch	38S	3W	18	SE 1/16 of NW 1/4	491211	4679361	Nad27
2329	12	Jackson	Ashland RA	Mount Isabelle	38S	3W	18	SE of NW	491520	4679118	Nad27
2598	12	Jackson	Grants Pass RA	Rogue River	37S	4W	5	SE1/16 of NW 1/4	483352	4692554	Nad83
4781	7	Josephine	Glendale RA	Golden	34S	5W	9	SE of NE	476316	4719869	Nad27
7259	11	Josephine	Grants Pass RA	Takilma	40S	7W	18	SE of SW	452514	4659028	Nad83
7536	10	Jackson	Butte Falls RA	Trail	33S	1W	1	SW 1/16 of SE 1/4	519373	4730273	Nad83
7574	10	Jackson	Ashland RA	Tallowbox Mt.	39S	4W	32	SE of SE	484025	4664098	Nad83
8531	10	Josephine	Grants Pass RA	Holland	39S	7W	3	NW of NE	457959	4673600	Nad83
8542	9	Jackson	Butte Falls RA	Trail	33S	1W	10	SE 1/16 of NW 1/4	515667	4729685	Nad83
8778	11	Josephine	Glendale RA	Sexton Mt.	34S	5W	18	NE of SE	472791	4717812	Nad27
10541	5	Douglas	Glendale RA	Glendale	33S	6W	3	SW of SE	467760	4730544	Nad27
10596	5	Jackson	Butte Falls RA	Wimer	35S	4W	7	NW of NW	481445	4710325	Nad27
11608	4	Josephine	Grants Pass RA	Murphy	37S	5W	18	SE 1/16 of SW 1/4	471385	4688647	Nad83
12947	3	Josephine	Glendale RA	Glendale	33S	6W	29	SW of SW	463855	4723928	Nad27
13161	2	Jackson	Ashland RA	Tallowbox Mt.	39S	4W	31	NE of SE	482548	4664595	Nad27
577	29	Jackson	Butte Falls RA	McConville Pk	35S	3W	17	NW of SW	492600	4707985	Nad83
609	2	Jackson	Ashland RA	Tallowbox Mt.	39S	4W	31	NE of SE	482676	4664422	Nad27
3833	19	Josephine	RRSNF	Takilma	40S	7W	22	SW of NE	457655	4658629	Nad83
3827	19	Josephine	RRSNF	Takilma	40S	7W	21	NE of NE	4658590	456720	Nad27
3846	19	Josephine	RRSNF	Takilma	40S	7W	19	NE of NE	453449	4658781	Nad83
EOR 81	20	Jackson	RRSNF	Talent NE	39S	1W	33	SE of NE	515133	4664898	Nad83
EOR 82-1	13	Jackson	RRSNF	Siskiyou Peak	40S	1W	5	SE of SE	513531	4662647	Nad83
EOR 82-2	20	Jackson	RRSNF	Siskiyou Peak	40S	1W	5	SE of SE	513459	4662566	Nad83
EOR 830-12	12	Josephine	RRSNF	Carberry Creek	40S	5W	13	NW of NW	479524	4660391	Nad83
EOR 830-13	12	Josephine	RRSNF	Carberry Creek	40S	5W	13	NW of NW	479352	4660523	Nad83
EOR 830-14	12	Josephine	RRSNF	Carberry Creek	40S	5W	11	SE of SE	479141	4660672	Nad83