Holy Ghost Ipomopsis Recovery

2010-2011 Progress Report
(Section 6, Segment 25)
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Holy Ghost ipomopsis (*Ipomopsis sancti-spiritus*) is known from only a single location (Holy Ghost Canyon) in the Sangre de Cristo Mountains of north-central New Mexico. It was listed as endangered under the federal Endangered Species Act on 22 April 1994. The draft Recovery Plan prescribes several biological and ecological studies of the species. Yet the core of the recovery effort is several out-plantings to establish new populations in similar habitats within the tributary canyons of the upper Pecos River. Therefore, the initial recovery studies will focus on seed germination, seed production, and ease of establishment at new locations.

Ipomopsis sancti-spiritus is an herbaceous perennial with showy, pink, tubular flowers. It is relatively short-lived (2-5 yrs) and is monocarpic (flowers once - then dies). It inhabits openings in ponderosa pine-Douglas fir forest and prefers disturbed areas with relatively low densities of other perennial species. Five out-planted locations have been proposed in the upper Pecos River watershed to down-list this species to threatened status. To date, we have three experimental plantings in the Indian Creek, Winsor Creek, and Panchuela Creek drainages. Willow Creek (NM Department of Game & Fish land) was planted as seed and rosettes but was subsequently abandoned as a potential site. The Holy Ghost Canyon population usually produces a large amount of seed that has been used as a source for experimental plantings. Establishment of a seed plantation at a cultivated location is also desirable.

Abundance

In addition to annual monitoring efforts of *I. sancti-spiritus* we added an overall census and mapping of Holy Ghost Canyon in the summer of 2008. Conducting a census based primarily on rosettes is difficult in this terrain and further complicated by the lack of morphological differences between rosettes of this species and it's more common congener *I. agreggata*. Aware of this problem we counted any rosettes in the vicinity of flowering plants by the proximal identifiable taxon. Overall this doesn't appear to have been a large problem because colonies were relatively isolated during surveys but it is a potential source of error in the counts obtained.

Habitat occurring at higher elevations (fairly well removed from FS road 122 and Holy Ghost Creek) had not been adequately surveyed and mapped so we GPS'd plants occurring within this

area. In combination with this effort, we obtained a count for the roadside plants occurring within known occupied habitat. We found 1321 roadside plants and an additional 434 plants for a total of 1755 plants. This is considerably less than the population estimate of 2500 that has been offered in the past. We can't assume that the 2008 count reflects a significant reduction in plants since the estimate of 2500 plants may have been unfounded. This new information and the GIS layers developed with it should serve as a good baseline for future monitoring efforts (see map below) and a reference point to understand how monitoring plot numbers relate to overall abundance of this species.

Map of Holy Ghost Ipomopsis occurrences in Holy Ghost Canyon.
Mapping based on July and August Surveys, 2008.

Germination

Approximately 200 Holy Ghost ipomopsis seeds were obtained from wild plants in Holy Ghost Canyon on 18 October 1996. These were stored for two months then cold treated for six weeks in a 40°F refrigerator. The seeds were planted in a commercial starter soil and kept moist at a room temperature of between 70° and 80°F. Seedling emergence times varied from 5 - 25 days. A total of 143 seeds germinated. Subsequent greenhouse rearing of Holy Ghost ipomopsis at UNM has had excellent success in germinating seed and growing rosettes. In 2005 rates of 86% and 89% from samples of 100 and 101 seeds, respectively, were achieved using fresh seed. All seedlings developed into viable rosettes.

Seed Plantation

In late April 1997 each seedling was transferred to a 10 $inch^3$ bullet-tube filled with a mixture of 50% sphagnum peat-moss, 25% vermiculite, and 25% perlite. A small amount of 14-14-14 (N-P-K) osmocoat slow-release fertilizer was added to the mix to sustain a vigorous flush of growth. These seedlings were then maintained in an unheated greenhouse for three months. Transplantation to cultivated ground occurred in early August. The plantation site was a small patch of ground near the NM Forestry lot near the Division's Greenhouse in Santa Fe. This area is an open, fully exposed site receiving all-day sun. A total of 134 plants were planted in five rows between lengths of soaker-hose. These plants were on a once or twice per week irrigation schedule, depending on weather conditions. By the end of the first summer, 128 plants successfully rooted-in and attained rosette diameters of 10-15 cm.

A total of 118 plants survived the winter months at the Forestry lot plantation and most were very vigorous during the 1998 growing season. Aphids were abundant on these plants during July and August, but did not appear to cause any problems (predaceous ladybird beetles were also very abundant). Approximately 90% of these plants bolted and flowered in 1998. Flowering was profuse from late July to mid September. The plantation plants were inspected once a week for mature capsules. Surprisingly, very few flowers produced fruits. This reproductive effort was not quantitatively analyzed, but it appeared that less than 25% of the flowers made any seeds. By visual estimate, this level of reproductive success appeared to be somewhat lower than the natural population in Holy Ghost Canyon.

The reason for this limited seed production on otherwise vigorous plants is unclear. A lack of pollinators may be partially responsible because during the many hours spent with these plants, not a single butterfly, bombilid fly, or hummingbird was observed visiting the flowers. The diurnal vectors that may be abundant in the natural population could be mostly absent in the Santa Fe area. *Ipomopsis sancti-spiritus* is a facultative out-crossing and self-compatible species. Yet even self-pollination may require movement of pollen from anther to stigma by a zootic vector.

This species consists of a single, relatively small population that may be experiencing inbreeding depression. Deleterious alleles can become common in small inbreeding populations and cause high levels of seed abortion or relatively low fertility in offspring. Maschinski (1996) conducted

outcrossing trials with Holy Ghost ipomopsis and found that fertilization and seed production was highly variable depending on which plant was the pollen donor. She also noticed that many anthers failed to produce viable pollen. This meiotic disruption would certainly also occur in the ovules of the ovaries. The results were also obvious in the Santa Fe plantation population. Some whole plants failed to produce more than two or three fruits while other individual plants were relatively successful and produced the majority year's seed crop. While some genetic reproductive barriers may be operating in *Ipomopsis sancti-spiritus* it is more likely that the plant simply does not do well when removed from its natural habitat. It is capable of producing large amounts of viable seed when summer rains are sufficient in its natural habitat.

Willow Creek Seed Planting and Transplants

The first out-planting of *Ipomopsis sancti-spiritus* seed was conducted on May 5 and 6 of 1998. Approximately 1,800 seeds were planted at seven locations along Forest Road 645 in Willow Creek Canyon on land belonging to the State of New Mexico. Seeds were planted by pressing them into bare soil and the areas permanently marked with steel rebar stakes.

The seeded sites at Willow Creek were inspected in August 1999 – two growing seasons after planting. One mature *Ipomopsis sancti-spiritus* was found flowering at only one site. Several rosettes were found at all sites, but could have been either *I. sancti-spiritus* or *I. aggregata*. The Willow Creek seeded sites were visited again in August 2000, August 2001 and August 2002 – three, four and five growing seasons after planting. Surprisingly, only the one mature Holy Ghost ipomopsis was found. This seeding effort was unsuccessful. The Willow Creek habitats are probably too dry and are unsuitable for this species.

Direct seeding may not be a viable option with the limited seed available for such an effort. Therefore, an attempt was made to grow seedlings for a direct planting of a suitable road cut habitat on NM Game & Fish land near Tererro Mine, which is near Holy Ghost Canyon. The seeds that were produced by the plantation plants were greenhouse planted in February 2000 to begin another artificial plantation for seed production. Approximately 1,200 seeds were planted with the same methods previously used in 1996. Approximately 500 seeds germinated, but all damped-off and died. Most died within two weeks of germinating and none lived beyond the 4-leaf stage. Sterile growth medium was purchased for this project, but was apparently infected with a pathogenic microbe.

Approximately 1,000 seeds were harvested from the Holy Ghost Canyon population in September 2001. These seeds were cold stratified and planted in germination trays at the UNM Biology Department greenhouse in February 2002. Approximately 200 seeds germinated, but more than 50% damped off. Only 65 seedlings were produce, but these were healthy and vigorous rosettes when planted near Tererro Mine on 17 July 2002. The first two weeks after planting were very wet, and each transplant became successfully established.

The transplant site was a southwest-facing road cut in Willow Creek. It occurs on a reclaimed road in forest of *Psuedotsuga menzesii, Pinus ponderosa, Populus tremuloides* and *Quercus gambelii*. The soils are derived from Tererro limestone and very similar to the Holy Ghost

Canyon habitat, which is only 1.5 miles to the southeast and at a similar elevation.

All transplanted rosettes survived the winter of 2002/2003 and 58 initiated flowering stalks in early summer 2003. These plants were in full flower by early July, which was nearly two weeks earlier than the natural population in Holy Ghost Canyon. Flowering transplants ceased flowering by July 20th. Holy Ghost ipomopsis in Holy Ghost Canyon was still in full flower in late July and continued to flower and set fruit through August and early September. Flowering periods and reproductive effort were significantly different between these two sites (Table 1). The Willow Creek site is apparently less suitable habitat than Holy Ghost Canyon because the plants transplanted there flowered earlier and for a much shorter period than those in native habitat.

Reproductive effort of Holy Ghost ipomopsis at Willow Creek transplant site was five times less than Holy Ghost Canyon plants and was not be sufficient to establish a self-sustaining population. The transplant site was in a similar vegetation community, but was apparently a drier micro-habitat (exposure, soil) than the native habitat or was limited by another characteristic that is not readily evident. Therefore, potential future transplant sites must be reassessed and situated at higher elevations, more westerly exposures, or soils with better water holding capacities.

Table 1. Reproductive efforts of Ipomopsis sancti-spiritus at Willow Creek transplant site and a sample from Holy Ghost Canyon in 2003. Holy Ghost n=56; Willow Creek N=56

	Total Capsules	Mean Capsules per plant	Median Capsules per plant	Range Capsules per plant
Holy Ghost	3,218	57.5	53	2-350
Willow Creek	621	11.1	7	0-47

The Willow Creek transplant site had no flowering Holy Ghost ipomopsis individuals during the summers of 2004 and 2005 and was abandoned as a site for a new recovery population.

Santa Fe National Forest Transplants

Most of the previously identified transplant sites were discarded as unsuitable after the failures of the transplant and seeding experiments at Willow Creek. USDA-Forest Service and NM Forestry Division jointly conducted Field surveys for new transplant sites during the summer of 2004. The goal was to find more mesic sites with wetter soil conditions than existed at the failed Willow Creek site. Three potential transplant locations were identified:

Indian Creek. Steep SW-facing slope with mesic soils that are, in part, subirrigated by spring seeps.

Winsor Creek. Steep S-facing slope with mesic soils that are, in part, subirrigated by spring seeps.

Panchuela Creek. Steep SW-facing slope in mixed conifer at higher elevation than Holy Ghost Canyon.

An additional 230 Holy Ghost ipomopsis seedlings were raised at the UNM greenhouse in autumn of 2003 in preparation for out-planting to Indian Creek in the spring of 2004. Santa Fe National Forest postponed the 2004 spring planting because USDA-Forest Service wanted to conduct a forest-wide consultation with USF&WS before transplanting to any new locations on the Santa Fe National Forest. These plants began to bolt in the greenhouse and an August planting was scheduled. However, the Forest Service again failed to conduct the necessary consultation and no transplanting was allowed. All these plants flowered and died in the greenhouse during the summer of 2004 because of bureaucratic delay.

Permission to transplant Holy Ghost ipomopsis on the Santa Fe National Forest was finally received in 2005. A total of 381 seedlings were produced at the UNM greenhouse and transplanted to two recovery sites on the forest. Panchuela Canyon received 169 seedlings and Winsor Canyon received 212 seedlings (Table 2a-b). These seedlings were planted on July 5 and 6, 2005 to coincide with normal rainy season of late summer. Unfortunately, late summer rains did not begin until the end of July. During this hot, dry period, all seedlings were watered by hand two times each week until soil moisture conditions became suitable for growth in mid-August. This effort to keep these seedlings alive resulted in a good rate of survival. Average survival of all transplants was 89.4% up to dormancy in early autumn (Table 2a-b). Seven of the plants transplanted to Winsor Canyon were already bolting when planted and successfully flowered and set seed in late summer of 2005.

One year later, 280 (73.5%) of the transplants at Panchuela and Winsor canyons were remaining after surviving an exceedingly dry winter and spring. A total of 258 bolted and flowered in late summer of 2006 (Table 2a-b). Seed production was not assessed, but most flowering plants in Winsor Canyon had mature capsules in September. Panchuela Canyon plants also had mature capsules, but a greater number of flowering stems had been severely browsed by deer and these had few flowers. The ground immediately around the place where seven Winsor Canyon plants flowered in 2005 had 29 new seedlings in September 2006.

A total of 957 new greenhouse-reared Holy Ghost ipomopsis rosettes were transplanted to the National Forest on July 5 and 6, 2006. The Panchuela Canyon and Winsor Canyon transplant sites were augmented with 308 and 299 new rosettes respectively. A new transplant site at the Indian Creek location was initiated and received 350 plants (Table 2c). A very wet late-summer season in 2006 provided excellent conditions for establishment and about 98% of these transplants were alive and healthy in late September.

A total of 842 of the original plants still remained as rosettes in the spring of 2007. In addition 135 seedlings were located. It must be reiterated that we could not find a reliable way of distinguishing *Ipomopsis sancti-spiritus* rosettes from the more common *I. aggregata*. All of our monitoring data is based on best estimates of what would be expected based on the known locations of *I. aggregata* growing within or near our transplant sites, and the proximity of plants to where we placed *I. sancti-spiritus.* The survival and germination of seed will hopefully lead to

the spread of this plant within these experimental populations. After a few years of attempting to count seedlings and rosettes at the transplant sites, it seemed prudent to monitor mainly flowering adults in coming years.

Only flowering adults were counted in 2011. All three transplant sites have shown a gradually increasing number of flowering adults (tables 2a, 2b and 2c), which are establishing a soil seed bank at the transplant sites. Drought conditions during the summer of 2011 however, likely suppressed the germination of new seedlings that could have become flowering adults in subsequent years.

Table 2a. Monitoring of the Panchuela Creek experimental population. It should be noted that numbers are best estimates for *Ipomopsis sancti-spiritus*, but may include some *I. aggregata* rosettes.

Location	Row letter	2005 Planting	9/21/05 Count	2006 count	07 Seedling	07 Adults	08 Seedlings	08 Rosettes	08 Flowering	09 Seedlings	09 Rosettes	09 Flowering	10 Rosettes	10 Flowering	11 Flowering	Planted
Panchuela Creek	A	54	54	52	1	3	2	3	0	0	7	0	3	4	1	7/6/2005
Panchuela Creek	B	44	41	41	6	6	5	5	0	16	4	0	15	6	4	7/6/2005
Panchuela Creek	C	71	69	63	31	6	23	7	0	0	27	1	39	5	8	7/6/2005
Panchuela Creek	D	N/A	N/A	31	0	20	0	0	0	0	0	0	4	3	0	7/6/2006
Panchuela Creek	E	N/A	N/A	20	0	17	0	0	0	0	2	0	11	5	2	7/6/2006
Panchuela Creek	F	N/A	N/A	20	17	68	5	2	0	0	23	0	12	5	4	7/6/2006
Panchuela Creek	G	N/A	N/A	25	0	21	11	14	0	0	12	0	12	0	3	7/6/2006
Panchuela Creek	H	N/A	N/A	77	0	67	9	7	0	0	10	1	6	0	0	7/6/2006
Panchuela Creek	I	N/A	N/A	44	0	41	1	0	0	0	17	0	53	2	18	7/6/2006
Panchuela Creek	J	N/A	N/A	30	0	24	0	0	0	0	1	0	5	1	1	7/6/2006
Totals		169	164	403	55	273	56	38	0	16	103	2	160	31	41	

Table 2b. Monitoring of the Winsor Creek experimental population. It should be noted that numbers are best estimates for *Ipomopsis sancti-spiritus*, but may include some *I. aggregata* rosettes.

Location	Row letter	2005 Planting	9/21/05 Count	2006 count	07 Seed-ling	07 Adults	08 Seed-lings	08 Rosettes	08 Flowering	09 Seedlings	09 Rosettes	09 Flowering	10 Rosettes	10 Flowering	11 Flowering	Planted	Replanted
Winsor Creek	A	38	29	49	0	27	4	2	0	0	4	1	3	0	0	7/5/2005	7/5/2006
Winsor Creek	B	54	38	29	13	24	6	8	1	0	8	2	10	6	2	7/5/2005	7/5/2006
Winsor Creek	C	45	40	18	10	13	3	2	1	0	3	1	3	1	1	7/5/2005	7/5/2006
Winsor Creek	D	38	35	27	34	39	18	6	3	0	28	0	29	8	7	7/5/2005	7/5/2006
Winsor Creek	E	37	36	56	9	60	28	6	2	0	23	1	55	5	16	7/5/2005	7/5/2006
Winsor Creek	F		N/A	85	4	65	19	3	1	0	23	0	84	10	21	7/5/2006	
Winsor Creek	G		N/A	35	10	27	7	6	0	0	44	0	39		12	7/5/2006	
Totals		212	178	299	80	255	85	33	8	0	133	5	223	30	59		

Table 2c. Monitoring of the Indian Creek experimental population. It should be noted that numbers are best estimates for *Ipomopsis sancti-spiritus*, but may include some *I. aggregata* rosettes. E1 totals are included in E.

Location	Row letter	2005 Planting	9/21/05	2006 count	07 Seedling	07 Adults	08 Seedlings	08 Rosettes	08 Flowering	09 Seedlings	09 Rosettes	09 Flowering	10 Rosettes	10 Flowering	11 Flowering	Planted
Indian Creek	A	N/A	N/A	12	0	11	0	0	0	0	20	0	26	1	5	7/6/2006
Indian Creek	B	N/A	N/A	143	0	1	7	7	3	0	30	1	47	4	23	7/6/2006
Indian Creek	C	N/A	N/A	128	0	114	6	13	0	0	30	0	38	2	8	7/6/2006
Indian Creek	D	N/A	N/A	18	0	16	0	0	0	0	6	0	10	1	2	7/6/2006
Indian Creek	E	N/A	N/A	20	0	18	3	2	0	0	25	1	66	15	22	7/6/2006
Indian Creek	E1	N/A	N/A	29		26	0	0	0	0	0	0	0	0	0	7/6/2006
Totals				350	0	314	16	22	3	0	111	2	187	23	60	

Holy Ghost Canyon Monitoring Plots

NM Forestry Division established permanent *Ipomopsis sancti-spiritus* monitoring plots in Holy Ghost Canyon to monitor population trends and generate control-group data to compare with the recovery transplant sites. Seven monitoring locations were established in the summer of 2003 and assessed again in subsequent years (Table 3). Each location is on road cut inhabited by *Ipomopsis sancti-spiritus* and has one to three 10x4 meter belt transects for a total of 13 equal plots. The center line of each plot is parallel to Holy Ghost Canyon Road and is marked at each end by a ½-inch steel rebar stake. Population density is obtained by counting individual Holy Ghost ipomopsis within a belt transect that is four meters wide (2 m on either side of center line) and ten meters long.

Associated vegetation in each plot is determined by foliar intercept along the center line. This data can be used to monitor changes in foliar cover and species composition that may influence the population density of Holy Ghost Ipomopsis within the plots. Results of the first year's assessment of these plots indicate a variety of native plant associates and cover values in the Holy Ghost ipomopsis population. Only Plot No. 3 has a significant encroachment of the exotic pasture grasses, smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*) (Table 4).

Table 3. Holy Ghost Canyon monitoring plot data for *Ipomopsis sancti-spiritus*.

Plot Number	1A	1B	1C	2A	2B	3	4A	4B	4C	5A	5B	6	7	
Year 2003														Total
No. flowering plants	8	30	9	3	4	11	8	7	11	11	8	2	5	117
No. rosettes	46	127	64	15	9	61	20	55	13	12	11	35	33	501
Year 2004														
No. flowering plants	49	103	38	1	6	15	15	44	20	3	16	12	6	328
No. rosettes	35	43	28	3	15	84	24	14	30	2	7	22	25	332
Year 2005														
No. flowering plants	19	21	11	3	10	49	10	8	19	1	13	12	8	184
No. rosettes	18	17	8	5	17	70	59	126	80	4	40	15	24	483
Year 2006														
No. flowering plants	4	4	3	1	3	25	19	22	31	4	13	6	5	130
No. rosettes	13	36	47	11	16	68	92	234	94	14	57	20	20	722
Year 2007														
No. flowering plants	9	18	11	3	11	12	36	39	29	6	38	6	4	222
No. rosettes	43	38	42	9	17	47	65	152	67	9	54	22	14	579
Year 2008														
No. flowering plants	15	6	6	0	5	0	15	37	15	7	4	5	2	117
No. rosettes	70	39	43	4	12	42	39	139	50	9	27	8	23	505
Year 2009														
No. flowering plants	10	19	13	0	2	15	10	22	5	4	7	1	1	109
No. rosettes	42	45	48	2	43	61	21	102	73	15	50	4	24	530
Year 2010														
No. flowering plants	3	14	4	0	17	16	8	21	10	0	11	2	4	110
No. rosettes	20	15	14	6	41	30	14	66	40	14	36	7	16	319
Year 2011														
No. flowering plants	5	5	5	3	35	15	6	36	22	12	27	2	0	173
No. rosettes	4	1	2	3	21	25	17	56	39	4	22	2	11	208

Table 4. Line intercept data showing linear centimeters of foliar cover by all taxa within the Holy Ghost Canyon monitoring plots. This original data can be compared to cover measurements in the future to note changes within occupied habitat.

Plot Number	1A	1B	1C	2A	2B	3	4A	4B	4C	5A	5B	6	7
Year 2003													
Achillea millefolium					6		11						
Allium cernuum				2									
Ambrosia psilostachya												3	
Androsace septentrionalis													
Apocynum androsaemifolia	79	12	33		3	3	81	60	53	49	200	27	133
Artemisia ludoviciana	31											36	16
Artemisia sp.				110	2								
Bahia dissecta			6										
Blepharoneuron tricholepis						89	33			85	29		
Brickellia grandiflora									54				
Bromus ciliatus	23	55	31	1	1		35	110	227	154	115	65	7
Bromus inermis						195							
Campanula rotundifolia						4							
Carex sp.					81	9					3		
Cercocarpus montanus	20								110				
Chenopodium sp.										7			
Cymopteris lemmonii				2	16								5
Elymus longifolius	18	30	19										
Elymus trachycaulis					6			32		124			
Erigeron subtrinervis	82	23	30		11	13	8	21	26				
Eriogonum alatum				6					3				
Eriogonum jamesii							18			33	111		5
Fragaria vesca				50	19								
Galium boreale											1	40	
Galium triflorum												68	

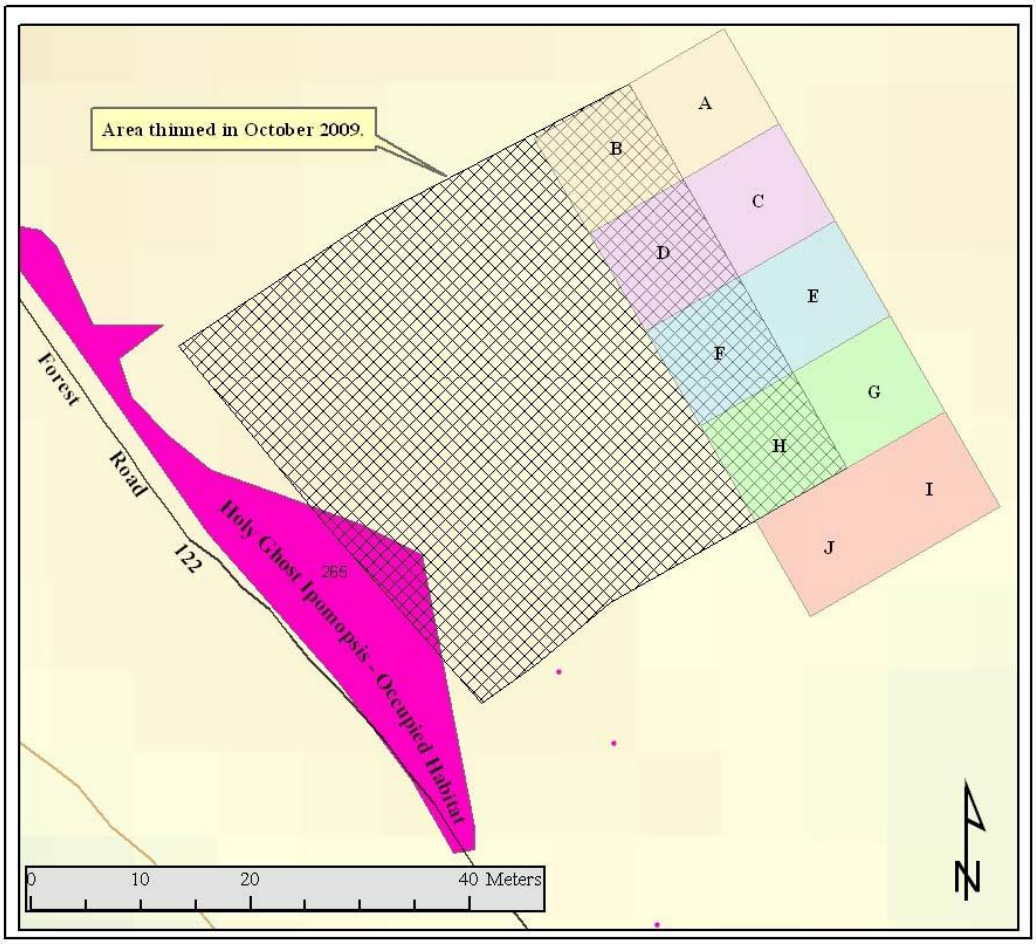
Plot Number	1A	1B	1C	2A	2B	3	4A	4B	4C	5A	5B	6	7
Geranium caespitosum			3	8	11							4	10
Helianthus rigidus		11	27					4	6	13	14		19
Heliomeris multiflora									27	11			
Heliopsis parviflora										21			5
Hymenopappus newberryi				94	202	16						35	
Ipomopsis sancti-spiritus				16		30	19	14	66	4		12	25
Lathrus leucanthus				70	27					6	10	9	90
Lathyrus sp.							3	28	12				
Linum lewisii										22			
Medicago lupulina		4											

Holy Ghost Canyon Treatments

256 greenhouse-grown *I. sancti-spiritus* rosettes were planted back into Holy Ghost Canyon on July 26 2007. The intention was to move back up the slope because it appeared that most of the *Ipomopsis* was growing near the road. We wanted to avoid a downslope progression of the Ipomopsis colonies towards the road, since gravity and water would move most of the loose seed onto the road where it could easily be swept out of the habitat or run over by vehicle traffic. When we went to plant the greenhouse transplants there were many new rosettes occurring well above the road as well. This is the first time in several years that rosettes had been observed higher up on the road cuts.

Most of these planted rosettes survived and many of them flowered and fruited in abundance in 2008. These plants had been in the greenhouse for at least two years and were healthy and vigorous. Their head start in the greenhouse combined with good precipitation in 2007-2008 lead to a high flower density and fruit set.

In October 2009 we carried out forest thinning within two designated sites within Holy Ghost Canyon. Prior to thinning the area we gathered baseline ecological data within and beyond the thinned area (ca. 1 acre at two Holy Ghost Canyon sites). With well-established baseline composition and cover estimates we can monitor vegetation shifts within and just beyond the thinned areas over time. Ecological data was entered into a Microsoft Access database that is currently stored at Natural Heritage New Mexico (copies of this stand-alone database are available for distribution to collaborators on this project – summary information provided within this report is of limited use and should not be used for before and after analysis). The database contains cover and diversity estimates for 80 1x1 meter quadrangles. Vegetative cover, litter, soil, rock and moss estimates are included by quad. This information is included as averaged cover in Table 6. Additional 10-meter line intercept transects were established (10 per site) within the plots as illustrate below. Plots were established on either side of the thinned area, so that disturbance, seeding and transplant studies can be conducted within and adjacent to the thinned area. The results of the pre-treatment transect data are also summarized in Table 5.



Holy Ghost Canyon – sample plot design relative to thinning project and occupied habitat.


Photo of forest thinning Plot 1 in October 2009 in Holy Ghost Canyon.

The two thinned sites in Holy Ghost Canyon were planted with Holy Ghost ipomopsis in late July 2011. The established plots are divided into thinned and unthinned areas with four 10 x 10 m grids in the thinned forest (B, D, F, H) and four adjoining grids in unthinned forest (A, C, E, G). Each 10 x 10 m grid received 40 greenhouse-grown rosettes for a total of 320 transplants in the study plots in each of the two thinned areas. There is also a control (non-treatment) area (I and J) at each site. An additional 471 greenhouse-grown rosettes were planted in the lower (larger) thinned area just below Plot 1 for a total of 1,111 rosettes planted in 2011.

Table 5. 2009 Plant cover data for plots within and adjacent to thinned forest in Holy Ghost Canyon

Plot	Species Name	Transect Intersected in meters
1A	*Lithospermum multiflorum*	1.12
1A	*Heliopsis parvifolia*	0.89
1A	*Muhlenbergia montana*	0.88
1A	*Erigeron subtrinervis*	0.46
1A	*Bromus ciliatus*	0.27
1A	*Picea pungens*	0.24
1A	*Thalictrum fendleri*	0.22
1A	*Berberis fendleri*	0.19
1A	*Galium boreale*	0.19
1A	*Vicia spp.*	0.13
1A	*Galium trifidum*	0.11
1A	*Achillea millefolium*	0.05
1A	*Heliomeris multiflora*	0.05
1A	*Artemisia ludoviciana*	0.04
1A	*Rosa spp.*	0.04
1B	*Quercus gambelii*	3.28
1B	*Pinus ponderosa*	2.3
1B	*Picea pungens*	2.14
1B	*Erigeron subtrinervis*	1.48
1B	*Thalictrum fendleri*	0.99
1B	*Poa pratensis*	0.47
1B	*Muhlenbergia montana*	0.34
1B	*Pseudocymopterus montanus*	0.34
1B	*Pseudostellaria jamesiana*	0.33
1B	*Iris missouriensis*	0.28
1B	*Geranium caespitosum*	0.26
1B	*Achillea millefolium*	0.17
1B	*Bromus ciliatus*	0.17
1B	*Artemisia ludoviciana*	0.15
1B	*Rosa spp.*	0.12
1B	*Heliopsis parvifolia*	0.1
1B	*Lithospermum multiflorum*	0.09
1B	*Apocynum androsaemifolium*	0.02
1C	*Pinus ponderosa*	10
1C	*Erigeron subtrinervis*	1.33
1C	*Lithospermum multiflorum*	1.12
1C	*Picea pungens*	0.61
1C	*Berberis fendleri*	0.47
1C	*Rosa spp.*	0.37
1C	*Galium boreale*	0.33
1C	*Mahonia repens*	0.22
1C	*Cercocarpus montanus*	0.12
1C	*Geranium caespitosum*	0.09
1C	*Carex spp.*	0.05
1C	*Cirsium spp.*	0.04
1D	*Pinus ponderosa*	3.98

Plot	Species Name	Transect Intersected in meters
1D	*Erigeron subtrinervis*	1.13
1D	*Carex spp.*	1.11
1D	*Lithospermum multiflorum*	1.04
1D	*Picea pungens*	0.63
1D	*Poa pratensis*	0.51
1D	*Artemisia ludoviciana*	0.48
1D	*Mahonia repens*	0.39
1D	*Geranium caespitosum*	0.37
1D	*Bromus ciliatus*	0.36
1D	*Achillea millefolium*	0.28
1D	Moss	0.21
1D	*Pseudocymopterus montanus*	0.21
1D	*Lathyrus lanszwertii var. leucanthus*	0.2
1D	*Rosa spp.*	0.15
1D	*Allium cernuum*	0.11
1D	*Iris missouriensis*	0.11
1D	*Helianthus pauciflorus ssp. subrhomboideus*	0.08
1D	*Heliopsis parvifolia*	0.04
1E	*Pinus ponderosa*	7.7
1E	*Carex spp.*	2.25
1E	*Quercus gambelii*	2.09
1E	*Cercocarpus montanus*	2.06
1E	*Erigeron subtrinervis*	1.61
1E	*Geranium caespitosum*	1.39
1E	*Berberis fendleri*	0.89
1E	*Pseudotsuga menziesii - adv regen*	0.56
1E	*Lithospermum multiflorum*	0.42
1E	*Mahonia repens*	0.4
1E	*Bromus ciliatus*	0.23
1E	*Lathyrus lanszwertii var. leucanthus*	0.14
1E	*Artemisia ludoviciana*	0.1
1E	*Heliomeris multiflora*	0.1
1E	*unidentified forb*	0.09
1E	*Achillea millefolium*	0.08
1E	*Pseudocymopterus montanus*	0.08
1E	*Rosa spp.*	0.07
1E	*Cirsium spp.*	0.05
1E	*Poa pratensis*	0.01
1F	*Pinus ponderosa*	3.6
1F	*Carex spp.*	1.65
1F	*Erigeron subtrinervis*	1.65
1F	*Lithospermum multiflorum*	0.9
1F	*Mahonia repens*	0.83
1F	*Cercocarpus montanus*	0.34
1F	*Heliopsis parvifolia*	0.27
1F	*Quercus gambelii*	0.27
1F	*Geranium caespitosum*	0.24

Plot	Species Name	Transect Intersected in meters
1F	*Iris missouriensis*	0.22
1F	*Bromus ciliatus*	0.17
1F	*Lithospermum spp.*	0.15
1F	*Achillea millefolium*	0.12
1F	*Cirsium spp.*	0.11
1F	*Rosa spp.*	0.11
1F	*Galium boreale*	0.06
1F	*Lathyrus lanszwertii var. leucanthus*	0.04
1F	*Pseudocymopterus montanus*	0.04
1G	*Quercus gambelii*	5.3
1G	*Carex spp.*	1.68
1G	*Erigeron subtrinervis*	0.72
1G	*Achillea millefolium*	0.54
1G	*Cercocarpus montanus*	0.5
1G	*Erigeron spp.*	0.45
1G	*Galium boreale*	0.43
1G	*Mahonia repens*	0.41
1G	*Helianthus pauciflorus ssp. subrhomboideus*	0.21
1G	*Heliomeris multiflora*	0.19
1G	*Galium trifidum*	0.14
1G	*Lithospermum multiflorum*	0.14
1G	*Symphoricarpos oreophilus*	0.08
1G	*Pseudocymopterus montanus*	0.04
1G	*Apocynum androsaemifolium*	0.01
1G	*Iris missouriensis*	0.01
1H	*Quercus gambelii*	3.76
1H	*Cercocarpus montanus*	1.76
1H	*Carex spp.*	1.25
1H	*Lithospermum multiflorum*	0.61
1H	*Erigeron subtrinervis*	0.29
1H	*Heliopsis parvifolia*	0.27
1H	*Mahonia repens*	0.21
1H	*Achillea millefolium*	0.15
1H	*Iris missouriensis*	0.11
1H	*Poa pratensis*	0.1
1H	*Pseudocymopterus montanus*	0.07
1H	*Fragaria vesca*	0.04
1H	*Galium boreale*	0.04
1I	*Pinus ponderosa*	4.6
1I	*Carex spp.*	2.39
1I	*Quercus gambelii*	1.52
1I	*Erigeron subtrinervis*	1.37
1I	*Ceanothus fendleri*	1.27
1I	*Poa pratensis*	0.66
1I	*Lithospermum multiflorum*	0.48
1I	*Mahonia repens*	0.48
1I	*Achillea millefolium*	0.29

Plot	Species Name	Transect Intersected in meters
1I	*Heliopsis parvifolia*	0.21
1I	*Galium boreale*	0.18
1I	*Iris missouriensis*	0.18
1I	*Rosa spp.*	0.17
1I	*Galium trifidum*	0.15
1I	*Pseudocymopterus montanus*	0.12
1I	*Cirsium spp.*	0.08
1I	*Artemisia ludoviciana*	0.07
1I	*Bromus ciliatus*	0.06
1I	*Thalictrum fendleri*	0.06
1I	*Vicia spp.*	0.05
1I	*Geranium caespitosum*	0.04
1I	*Heliomeris multiflora*	0.02
2A	*Pseudotsuga menziesii*	4.01
2A	*Carex spp.*	1.14
2A	*Erigeron subtrinervis*	0.46
2A	*Poa pratensis*	0.42
2A	*Quercus gambelii*	0.37
2A	*Mahonia repens*	0.26
2A	*Lathyrus lanszwertii var. leucanthus*	0.23
2A	*Heliopsis parvifolia*	0.2
2A	*Geranium caespitosum*	0.14
2A	*Pseudocymopterus montanus*	0.09
2A	*Bromus ciliatus*	0.07
2A	*Vicia spp.*	0.05
2A	*Elymus trachycaulus*	0.04
2A	*Galium boreale*	0.03
2A	*Penstemon spp.*	0.02
2A	*Elymus elymoides*	0.01
2B	*Pseudotsuga menziesii*	3.44
2B	*Quercus gambelii*	1.78
2B	*Populus tremuloides*	0.94
2B	*Mahonia repens*	0.41
2B	Moss	0.34
2B	*Poa pratensis*	0.24
2B	*Galium boreale*	0.21
2B	*Carex spp.*	0.2
2B	*Bromus ciliatus*	0.17
2B	*Allium cernuum*	0.16
2B	*Geranium caespitosum*	0.12
2B	*Rosa spp.*	0.1
2B	*Achillea millefolium*	0.09
2B	*Berberis fendleri*	0.07
2B	*Vicia spp.*	0.05
2B	*Erigeron subtrinervis*	0.03
2C	*Carex spp.*	1.81
2C	*Poa pratensis*	0.83

Plot	Species Name	Transect Intersected in meters
2C	*Mahonia repens*	0.79
2C	*Lathyrus lanszwertii var. leucanthus*	0.53
2C	*Erigeron subtrinervis*	0.51
2C	*Bromus ciliatus*	0.5
2C	*Elymus trachycaulus*	0.32
2C	*Galium trifidum*	0.31
2C	*Heliopsis parvifolia*	0.29
2C	*Galium boreale*	0.27
2C	*Artemisia ludoviciana*	0.13
2C	*Quercus gambelii*	0.11
2C	*Penstemon spp.*	0.06
2C	*unidentified forb*	0.05
2C	*Rosa spp.*	0.04
2C	*Geranium caespitosum*	0.02
2D	*Pseudotsuga menziesii*	4.51
2D	*Populus tremuloides*	1.7
2D	*Erigeron subtrinervis*	0.91
2D	*Picea pungens*	0.9
2D	*Pinus ponderosa*	0.6
2D	*Mahonia repens*	0.53
2D	*Carex spp.*	0.48
2D	*Lathyrus lanszwertii var. leucanthus*	0.41
2D	*Geranium caespitosum*	0.37
2D	*Bromus ciliatus*	0.26
2D	*Quercus gambelii*	0.25
2D	*Artemisia ludoviciana*	0.18
2D	*Heliopsis parvifolia*	0.17
2D	*Elymus trachycaulus*	0.14
2D	*Galium trifidum*	0.05
2D	*Poa pratensis*	0.05
2D	*Pseudocymopterus montanus*	0.04
2E	*Quercus gambelii*	7.22
2E	*Carex spp.*	3.27
2E	*Populus tremuloides*	1.9
2E	*Thalictrum fendleri*	0.36
2E	*Erigeron subtrinervis*	0.33
2E	*Achillea millefolium*	0.17
2E	*Bromus ciliatus*	0.14
2E	*Galium boreale*	0.14
2E	*Mahonia repens*	0.12
2E	*Brickellia grandiflora*	0.11
2E	*Lathyrus lanszwertii var. leucanthus*	0.11
2E	*Geranium caespitosum*	0.1
2E	*Pseudocymopterus montanus*	0.02
2F	*Quercus gambelii*	5.4
2F	*Populus tremuloides*	3
2F	*Erigeron subtrinervis*	1.27

Plot	Species Name	Transect Intersected in meters
2F	*Bromus ciliatus*	1.1
2F	*Thalictrum fendleri*	0.85
2F	*Carex spp.*	0.81
2F	*Berberis fendleri*	0.47
2F	*Apocynum androsaemifolium*	0.45
2F	*Pseudotsuga menziesii*	0.36
2F	*Lathyrus lanszwertii var. leucanthus*	0.35
2F	*Mahonia repens*	0.3
2F	*Geranium caespitosum*	0.23
2F	*Artemisia ludoviciana*	0.18
2F	*Allium cernuum*	0.14
2F	*Achillea millefolium*	0.13
2F	*Hymenopappus newberryi*	0.11
2F	*Pseudocymopterus montanus*	0.1
2F	*Iris missouriensis*	0.09
2F	*Taraxacum officinale*	0.08
2F	*Poa pratensis*	0.07
2F	*Packera fendleri*	0.05
2F	*Helianthus pauciflorus ssp. subrhomboideus*	0.04
2F	*Galium trifidum*	0.01
2G	*Quercus gambelii*	4.64
2G	*Pseudotsuga menziesii*	3.46
2G	*Populus tremuloides*	2.65
2G	*Thalictrum fendleri*	1.39
2G	*Poa pratensis*	0.98
2G	*Carex spp.*	0.81
2G	*Iris missouriensis*	0.44
2G	*Mahonia repens*	0.44
2G	*Apocynum androsaemifolium*	0.41
2G	*Erigeron subtrinervis*	0.32
2G	*Lathyrus lanszwertii var. leucanthus*	0.27
2G	*Bromus ciliatus*	0.23
2G	*Symphoricarpos oreophilus*	0.2
2G	*Geranium caespitosum*	0.16
2G	*Galium trifidum*	0.15
2G	*Pseudocymopterus montanus*	0.15
2G	*Ceanothus fendleri*	0.12
2G	*Rosa spp.*	0.05
2G	*Galium boreale*	0.04
2G	*Taraxacum officinale*	0.04
2H	*Pseudotsuga menziesii*	6.68
2H	Moss	1.5
2H	*Bromus ciliatus*	0.72
2H	*Quercus gambelii*	0.49
2H	*Erigeron subtrinervis*	0.24
2H	*Mahonia repens*	0.19
2H	*Carex spp.*	0.17

Plot	Species Name	Transect Intersected in meters
2H	*Galium trifidum*	0.12
2H	*Iris missouriensis*	0.1
2H	*Symphoricarpos oreophilus*	0.1
2H	*Lathyrus lanszwertii var. leucanthus*	0.08
2H	*Galium boreale*	0.06
2H	*Geranium caespitosum*	0.06
2H	*Elymus trachycaulus*	0.03
2H	*Poa pratensis*	0.01
2I	*Pseudotsuga menziesii*	7.2
2I	*Quercus gambelii*	2.13
2I	*Bromus ciliatus*	0.56
2I	*Mahonia repens*	0.41
2I	*Erigeron subtrinervis*	0.36
2I	*Rosa spp.*	0.25
2I	*Carex spp.*	0.21
2I	*Pseudocymopterus montanus*	0.18
2I	*Achillea millefolium*	0.16
2I	*Apocynum androsaemifolium*	0.08
2I	*Poa pratensis*	0.06
2I	*Galium trifidum*	0.05
2J	*Pseudotsuga menziesii*	7.1
2J	*Quercus gambelii*	6.97
2J	*Pinus ponderosa*	4.14
2J	*Carex spp.*	4.01
2J	*Poa pratensis*	1.55
2J	*Erigeron subtrinervis*	1.53
2J	*Ceanothus fendleri*	0.93
2J	*Apocynum androsaemifolium*	0.83
2J	*Mahonia repens*	0.47
2J	*Thalictrum fendleri*	0.47
2J	*Bromus ciliatus*	0.12
2J	*Lithospermum multiflorum*	0.12
2J	*Pseudostellaria jamesiana*	0.1
2J	*Toxicodendron radicans*	0.08
2J	*Pseudocymopterus montanus*	0.07
2J	*Rosa spp.*	0.06
2J	*Geranium caespitosum*	0.05
2J	*Fragaria vesca*	0.04
2J	*Symphoricarpos oreophilus*	0.04
2J	*Taraxacum officinale*	0.04
2J	*Achillea millefolium*	0.03

Biotic/ Abiotic Name	Average % Cover (4 quads)	Plot
Achillea millefolium	1.05	1A
Allium cernuum	0.1	1A

Artemisia ludoviciana	0.5	1A
Berberis fendleri	1.5	1A
Bromus ciliatus	0.75	1A
Carex spp.	0.75	1A
Erigeron subtrinervis	3	1A
Galium boreale	1	1A
Galium trifidum	3	1A
Geranium caespitosum	1	1A
Heliomeris multiflora	0.5	1A
Heliopsis parvifolia	1.5	1A
Lithospermum multiflorum	5.33	1A
Muhlenbergia montana	1.5	1A
Packera fendleri	0.5	1A
Pseudocymopterus montanus	1.75	1A
Pseudotsuga menziesii	71.66	1A
Quercus gambelii	16.5	1A
Rosa spp.	1	1A
Thalictrum fendleri	5.25	1A
unidentified spp. - (Asteraceae, Lactuceae)	0.5	1A
unidentified spp. (Onagraceae)	1	1A
Rock	4.62	1A
Litter	86.5	1A
Soil	11.83	1A
Achillea millefolium	1.02	1B
Artemisia ludoviciana	0.4	1B
Berberis fendleri	1.16	1B
Bromus ciliatus	0.1	1B
Carex spp.	1.4	1B
Erigeron subtrinervis	7.75	1B
Galium boreale	0.5	1B
Geranium caespitosum	1	1B
Heliomeris multiflora	2	1B
Lithospermum multiflorum	5.75	1B
Mahonia repens	1	1B
Pinus ponderosa	75	1B
Poa pratensis	0.36	1B
Pseudocymopterus montanus	1.5	1B
Pseudostellaria jamesiana	1	1B
Quercus gambelii	26.5	1B
Rosa spp.	1	1B
Taraxacum officinale	1.5	1B
Thalictrum fendleri	2.33	1B
unidentified spp.	0.5	1B
unidentified spp.	0.1	1B
Vicia spp.	0.1	1B

Litter	80.5	1B
Rock	7.56	1B
Soil	4.83	1B
Artemisia ludoviciana	0.75	1C
Berberis fendleri	0.87	1C
Carex spp.	0.23	1C
Cercocarpus montanus	7	1C
Cirsium spp.	2.5	1C
Erigeron subtrinervis	7.62	1C
Galium boreale	3.5	1C
Galium trifidum	4.5	1C
Geranium caespitosum	1	1C
Iris missouriensis	1	1C
Lathyrus lanszwertii var. leucanthus	2	1C
Lithospermum multiflorum	9.25	1C
Mahonia repens	3	1C
Pinus ponderosa	90	1C
Pseudoclappia arenaria	0.5	1C
Pseudocymopterus montanus	1	1C
Pseudotsuga menziesii - adv regen	6	1C
Pseudotsuga menziesii - yng regen	0.5	1C
Quercus gambelii	8.5	1C
Rosa spp.	1.5	1C
Symphoricarpos oreophilus	3.5	1C
Litter	92.72	1C
Rock	6.75	1C
Soil	0.52	1C
Achillea millefolium	1.25	1D
Allium cernuum	0.1	1D
Artemisia ludoviciana	0.75	1D
Bromus ciliatus	0.36	1D
Carex spp.	0.52	1D
Cercocarpus montanus	8.75	1D
Erigeron subtrinervis	1.9	1D
Galium boreale	0.5	1D
Galium trifidum	1	1D
Geranium caespitosum	0.55	1D
Helianthus pauciflorus ssp. subrhomboideus	0.5	1D
Heliopsis parvifolia	1	1D
Iris missouriensis	0.1	1D
Lithospermum multiflorum	3.1	1D
Mahonia repens	1.9	1D

Packera fendleri	0.5	1D
Pinus ponderosa	38.33	1D
Poa pratensis	0.23	1D
Pseudocymopterus montanus	0.75	1D
Quercus gambelii	5	1D
Rosa spp.	0.87	1D
Thalictrum fendleri	0.5	1D
unidentified spp.	1	1D
Vicia spp.	0.4	1D
Litter	93.7	1D
Rock	2.3	1D
Soil	6.66	1D
Achillea millefolium	0.55	1E
Apocynum androsaemifolium	0.5	1E
Artemisia ludoviciana	1.5	1E
Berberis fendleri	4.5	1E
Bromus ciliatus	2.5	1E
Carex spp.	1	1E
Ceanothus fendleri	0.5	1E
Cercocarpus montanus	1.25	1E
Cirsium spp.	1.25	1E
Erigeron subtrinervis	6	1E
Galium boreale	1	1E
Geranium caespitosum	1.02	1E
Ipomopsis spp.	0.5	1E
Iris missouriensis	2.5	1E
Lathyrus lanszwertii var. leucanthus	0.5	1E
Lithospermum multiflorum	4.83	1E
Mahonia repens	1	1E
Pinus ponderosa	76.25	1E
Poa pratensis	2.5	1E
Pseudocymopterus montanus	1	1E
Pseudostellaria jamesiana	0.3	1E
Quercus gambelii	18.62	1E
Rosa spp.	2.25	1E
Taraxacum officinale	0.5	1E
Litter	97.5	1E
Rock	1.83	1E
Soil	1.12	1E
Allium cernuum	0.1	1F
Apocynum androsaemifolium	0.5	1F
Bromus ciliatus	0.5	1F

Carex spp.	0.4	1F
Cercocarpus montanus	3	1F
Erigeron subtrinervis	6.87	1F
Galium boreale	1	1F
Geranium caespitosum	0.36	1F
Heliopsis parvifolia	0.5	1F
Iris missouriensis	5	1F
Lithospermum multiflorum	3.5	1F
Mahonia repens	1	1F
Pinus ponderosa	50	1F
Pseudocymopterus montanus	0.5	1F
Quercus gambelii	6.75	1F
Rosa spp.	1	1F
Litter	99	1F
Rock	4	1F
Soil	0	1F
Achillea millefolium	4.12	1G
Achnatherum spp.	4.33	1G
Allium cernuum	0.5	1G
Bromus ciliatus	0.3	1G
Carex spp.	3.62	1G
Ceanothus fendleri	5.5	1G
Erigeron subtrinervis	7.5	1G
Eriogonum alatum	1	1G
Galium boreale	2	1G
Galium trifidum	3.33	1G
Geranium caespitosum	1.66	1G
Helianthus pauciflorus ssp. subrhomboideus	1.5	1G
Heliopsis parvifolia	10	1G
Iris missouriensis	2.33	1G
Lathyrus lanszwertii var. leucanthus	0.75	1G
Lithospermum multiflorum	3.16	1G
Mahonia repens	5.75	1G
Poa pratensis	1	1G
Pseudocymopterus montanus	1	1G
Quercus gambelii	33	1G
Rosa spp.	2	1G
Thalictrum fendleri	5.25	1G
unidentified spp.	0.5	1G
Litter	97.47	1G
Rock	1.83	1G
Soil	1.15	1G
Achillea millefolium	2.33	1H

Artemisia ludoviciana	0.55	1H
Carex spp.	2	1H
Ceanothus fendleri	0.5	1H
Erigeron subglaber	11	1H
Erigeron subtrinervis	1.5	1H
Fragaria vesca	0.5	1H
Galium boreale	1.25	1H
Geranium caespitosum	0.66	1H
Lathyrus lanszwertii var. leucanthus	0.5	1H
Lithospermum multiflorum	2	1H
Mahonia repens	3.62	1H
Pinus ponderosa	46.66	1H
Poa pratensis	4	1H
Pseudocymopterus montanus	0.53	1H
Pseudotsuga menziesii	52.5	1H
Quercus gambelii	1.5	1H
Rosa spp.	0.83	1H
Symphoricarpos oreophilus	9	1H
Litter	96.75	1H
Rock	5	1H
Soil	2	1H
Achillea millefolium	1	1I
Berberis fendleri	1.5	1I
Bromus ciliatus	1.5	1I
Ceanothus fendleri	3.5	1I
Cercocarpus montanus	1	1I
Elymus trachycaulus	15	1I
Erigeron subtrinervis	7	1I
Galium boreale	1.75	1I
Geranium caespitosum	2.83	1I
Heliomeris multiflora	3	1I
Heliopsis parvifolia	0.5	1I
Iris missouriensis	4	1I
Lathyrus lanszwertii var. leucanthus	0.5	1I
Lithospermum multiflorum	2.33	1I
Mahonia repens	2	1I
Pinus ponderosa	25	1I
Poa pratensis	4	1I
Pseudocymopterus montanus	0.53	1I
Pseudotsuga menziesii	0.5	1I
Quercus gambelii	29.5	1I
Rosa spp.	3.25	1I
Vicia spp.	0.5	1I
Litter	86.5	1I
Rock	11.75	1I
Soil	1.75	1I

Artemisia ludoviciana	1	1J
Berberis fendleri	7	1J
Bromus ciliatus	0.5	1J
Carex spp.	1.25	1J
Cercocarpus montanus	1	1J
Cirsium spp.	0.5	1J
Erigeron subtrinervis	3.83	1J
Geranium caespitosum	0.75	1J
Helianthus pauciflorus ssp. subrhomboideus	0.3	1J
Heliomeris multiflora	1	1J
Lithospermum multiflorum	3.25	1J
Mahonia repens	3.75	1J
Packera fendleri	0.5	1J
Pinus ponderosa	25	1J
Pseudocymopterus montanus	0.5	1J
Quercus gambelii	16	1J
Rosa spp.	0.5	1J
Litter	100	1J
Apocynum androsaemifolium	0.5	2A
Artemisia ludoviciana	1.25	2A
Bromus ciliatus	0.1	2A
Carex spp.	3	2A
Erigeron subtrinervis	1.16	2A
Galium boreale	1.33	2A
Geranium caespitosum	0.3	2A
Heliopsis parvifolia	4.25	2A
Iris missouriensis	0.5	2A
Mahonia repens	1.87	2A
Muhlenbergia montana	2.25	2A
Populus tremuloides - mature	80	2A
Pseudocymopterus montanus	0.75	2A
Pseudostellaria jamesiana	2.25	2A
Pseudotsuga menziesii	82.5	2A
Pseudotsuga menziesii - yng regen	1.5	2A
Quercus gambelii	10	2A
Rosa spp.	0.5	2A
Thalictrum fendleri	1.5	2A
Vicia spp.	0.3	2A
Litter	63.12	2A
Rock	2.62	2A
Soil	34.25	2A
Abies concolor	1	2B
Achillea millefolium	0.5	2B

Apocynum androsaemifolium	0.5	2B
Berberis fendleri	3.5	2B
Bromus ciliatus	0.75	2B
Carex spp.	2	2B
Erigeron subglaber	2	2B
Erigeron subtrinervis	1.83	2B
Fragaria vesca	0.5	2B
Galium boreale	0.5	2B
Galium trifidum	0.5	2B
Geranium caespitosum	1.25	2B
Hymenopappus newberryi	0.1	2B
Mahonia repens	1.87	2B
Poa pratensis	1	2B
Pseudocymopterus montanus	1	2B
Pseudotsuga menziesii	67	2B
Quercus gambelii	4.83	2B
Rosa spp.	0.5	2B
Vicia spp.	0.1	2B
Litter	73	2B
Moss	11	2B
Rock	4	2B
Soil	22.25	2B
Achillea millefolium	3	2C
Apocynum androsaemifolium	3	2C
Artemisia ludoviciana	1	2C
Bromus ciliatus	1.87	2C
Carex spp.	2.62	2C
Elymus trachycaulus	1	2C
Erigeron subtrinervis	1.87	2C
Galium boreale	0.75	2C
Galium trifidum	1.5	2C
Geranium caespitosum	1.25	2C
Lathyrus lanszwertii var. leucanthus	1.25	2C
Mahonia repens	4.25	2C
Penstemon barbatus	2	2C
Pinus ponderosa	100	2C
Poa pratensis	0.55	2C
Populus tremuloides - adv regen	3	2C
Populus tremuloides - mature	100	2C
Pseudocymopterus montanus	1.05	2C
Pseudotsuga menziesii - yng regen	0.5	2C
Quercus gambelii	2.75	2C
Rosa spp.	0.75	2C
Thalictrum fendleri	2.25	2C
Litter	93.35	2C
Rock	2.52	2C

Soil	4.125	2C
Allium cernuum	0.1	2D
Apocynum androsaemifolium	1	2D
Artemisia ludoviciana	0.5	2D
Bromus ciliatus	0.56	2D
Carex spp.	0.65	2D
Clematis columbiana	0.5	2D
Erigeron subtrinervis	3.62	2D
Galium boreale	0.66	2D
Galium trifidum	0.5	2D
Geranium caespitosum	0.52	2D
Heliopsis parvifolia	1.5	2D
Lathyrus lanszwertii var. leucanthus	0.5	2D
Mahonia repens	5	2D
Poa pratensis	0.1	2D
Populus tremuloides	10	2D
Pseudocymopterus montanus	0.66	2D
Pseudotsuga menziesii	68	2D
Quercus gambelii	5.5	2D
Rosa spp.	0.5	2D
Symphoricarpos oreophilus	0.5	2D
Litter	95	2D
Rock	4.875	2D
Soil	6	2D
Achillea millefolium	1	2E
Allium cernuum	0.1	2E
Apocynum androsaemifolium	0.5	2E
Artemisia ludoviciana	1.83	2E
Bromus ciliatus	0.86	2E
Carex spp.	2.25	2E
Erigeron subtrinervis	2.16	2E
Galium boreale	1.2	2E
Galium trifidum	1	2E
Geranium caespitosum	1.16	2E
Mahonia repens	1.02	2E
Muhlenbergia montana	1	2E
Populus tremuloides	75	2E
Pseudocymopterus montanus	0.55	2E
Pseudostellaria jamesiana	0.5	2E
Pseudotsuga menziesii	100	2E
Pseudotsuga menziesii - yng regen	0.1	2E
Quercus gambelii	41.5	2E
Rosa spp.	1	2E
Taraxacum officinale	0.5	2E
Thalictrum fendleri	1.5	2E

Vicia spp.	1	2E
Litter	78.5	2E
Rock	0.83	2E
Soil	20.87	2E
Achillea millefolium	0.75	2F
Allium cernuum	0.1	2F
Apocynum androsaemifolium	4	2F
Berberis fendleri	2.75	2F
Bromus ciliatus	0.65	2F
Carex spp.	0.75	2F
Erigeron subtrinervis	2.83	2F
Fragaria vesca	0.1	2F
Galium boreale	0.5	2F
Galium trifidum	0.5	2F
Geranium caespitosum	0.87	2F
Heliomeris multiflora	4.5	2F
Hymenopappus newberryi	2	2F
Mahonia repens	2.75	2F
Poa pratensis	0.1	2F
Populus tremuloides	1	2F
Pseudocymopterus montanus	0.36	2F
Pseudotsuga menziesii	2	2F
Quercus gambelii	33	2F
Vicia spp.	0.5	2F
Litter	89	2F
Rock	5.5	2F
Soil	16.5	2F
Achillea millefolium	1	2G
Apocynum androsaemifolium	1.15	2G
Brickellia grandiflora	2.5	2G
Bromus ciliatus	1.12	2G
Carex spp.	1.62	2G
Ceanothus fendleri	1.5	2G
Erigeron subglaber	3	2G
Erigeron subtrinervis	3.5	2G
Fragaria vesca	1	2G
Geranium caespitosum	0.66	2G
Iris missouriensis	3	2G
Lathyrus lanszwertii var. leucanthus	1.53	2G
Mahonia repens	2.25	2G
Poa pratensis	0.1	2G
Populus tremuloides - mature	12	2G
Pseudocymopterus montanus	2	2G
Pseudotsuga menziesii	100	2G
Pseudotsuga menziesii - yng regen	0.5	2G

Quercus gambelii	50.5	2G
Rosa spp.	0.66	2G
Taraxacum officinale	0.5	2G
Thalictrum fendleri	2	2G
Vicia spp.	0.53	2G
Litter	97.57	2G
Moss	0.5	2G
Rock	2.36	2G
Soil	0.52	2G
Achillea millefolium	0.3	2H
Androsace septentrionalis	0.1	2H
Brickellia grandiflora	0.5	2H
Bromus ciliatus	0.3	2H
Carex spp.	0.36	2H
Erigeron subglaber	3.5	2H
Erigeron subtrinervis	1.36	2H
Fragaria vesca	0.5	2H
Galium boreale	1	2H
Iris missouriensis	0.5	2H
Mahonia repens	0.87	2H
Packera fendleri	16.86	2H
Poa pratensis	2	2H
Pseudocymopterus montanus	0.1	2H
Pseudotsuga menziesii	34.16	2H
Quercus gambelii	29.7	2H
Taraxacum officinale	0.5	2H
unidentified spp.	0.3	2H
unidentified spp.	0.5	2H
unidentified spp.	0.1	2H
Vicia spp.	0.5	2H
Litter	97.66	2H
Moss	3	2H
Rock	1	2H
Abies concolor - yng regen	0.5	2I
Achillea millefolium	0.1	2I
Apocynum androsaemifolium	1	2I
Bromus ciliatus	1.12	2I
Carex spp.	0.77	2I
Erigeron subglaber	1	2I
Fragaria vesca	0.1	2I
Galium boreale	0.55	2I
Galium trifidum	1.05	2I
Geranium caespitosum	1	2I
Lathyrus lanszwertii var. leucanthus	2	2I

Mahonia repens	2.33	2I
Poa pratensis	0.3	2I
Pseudocymopterus montanus	0.66	2I
Pseudotsuga menziesii	80	2I
Pseudotsuga menziesii - mature	90	2I
Pseudotsuga menziesii - yng regen	1	2I
Quercus gambelii	53.66	2I
Quercus gambelii - yng regen	0.1	2I
Rosa spp.	2.5	2I
Litter	98.33	2I
Moss	2.5	2I
Rock	2.75	2I
Soil	0.5	2I
Achillea millefolium	1	2J
Apocynum androsaemifolium	2.25	2J
Bromus ciliatus	0.5	2J
Carex spp.	0.83	2J
Erigeron subtrinervis	3.66	2J
Eriogonum alatum	0.5	2J
Galium boreale	0.5	2J
Geranium caespitosum	0.5	2J
Helianthus paradoxus	1.5	2J
Lathyrus lanszwertii var. leucanthus	1.25	2J
Mahonia repens	1.12	2J
Packera fendleri	0.5	2J
Poa pratensis	0.5	2J
Pseudocymopterus montanus	0.8	2J
Pseudotsuga menziesii	68.75	2J
Quercus gambelii	35	2J
Rosa spp.	1	2J
Thalictrum fendleri	10.33	2J
Litter	99.12	2J
Moss	1.5	2J
Rock	2	2J

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