

RESTORATION OF FIR BUTTE: 2015 ANNUAL REPORT



2016

Report to the Bureau of Land Management
Agreement # L14AC00314-0001

Report prepared by Matt Schultz
Institute for Applied Ecology



PREFACE

This report is the result of agreement number L14AC003014-0001 between the Institute for Applied Ecology (IAE) and the Bureau of Land Management. IAE is a non-profit organization whose mission is the 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.



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Cover photograph: Volunteers plant native species in the nectar islands at Fir Butte. November 2015. *Photo by Matt Schultz.*

SUGGESTED CITATION

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RESTORATION OF FIR BUTTE: 2015 ANNUAL REPORT

REPORT TO THE BUREAU OF LAND MANAGEMENT

INTRODUCTION

Fir Butte is located in Lane County in the West Eugene Wetlands. The primary emphasis of the work of the Institute for Applied Ecology at Fir Butte is to manage and enhance the prairie habitat. The upland prairie at Fir Butte includes populations of several rare species, such as Kincaid's lupine (*Lupinus oregonus*) and Fender's blue butterfly (*Icaricia icarioides fenderi*). Management actions at the site are consistent with those necessary to support populations of these rare species.

SUMMARY OF ACCOMPLISHMENTS IN 2015

In 2015, the Institute for Applied Ecology participated in a variety of activities to support restoration and conservation efforts at Fir Butte (Table 1). Activities included weed control and native species enhancement. For weed control, string-trimmers were used to mow tall oatgrass across the site. Hand weeding of select species of management concern was also conducted. For native species enhancement, four additional nectar islands (each 8 m x 10 m) were planted with plugs, bulbs, and runners and overseeded with native species. Native plant materials were purchased from Heritage seedlings (Dwarf checkermallow (*Sidalcea malviflora* spp. *virgata*) and Roemer's fescue (*Festuca roemerii*) plugs) and the City of Eugene's native plant nursery (all other plant materials) (Tables 2 and 3).

In addition to the restoration work at Fir Butte, 2015 marked the third and final year of data collection on test plots to assess the success of broadcast seeding native forbs and roemer's fescue into three test plots that received the following three treatments: Till + solarization, solarization only, and shade cloth only. Test plot results are summarized in Table 2 and their locations are displayed in Figure 1. The raw data from the test plots are presented in Appendix A.

2015 ACTIVITIES

Table 1: On-the-ground restoration activities completed at Fir Butte in 2015.

Date	Action	Who	Description
3/24	Orientation visit	Matt S., Christine	Visited site for first time, observed nectar islands and got an overview of the site from Christine
4/23	Orientation visit; hand pull & dig weeds	Ian S., Matt S.	Removed meadow knapweed rosettes, Lepidium, thistle, tansy ragwort in northern portion of site
5/6	Remove weeds	Matt S.	Removed meadow knapweed rosettes, Lepidium, thistle, tansy ragwort throughout site
5/12	monitoring	Ian S., Matt S.	Collected data from shadecloth/solarization test plots
5/13	Removed weeds	Matt S.	Removed Lepidium from plot 6, weeded invasive grasses from nectar islands
5/26,5/27	hand mow tall oatgrass	Matt S, 2 people from Walama Restoration	Hand mowed tall oatgrass at 6" throughout site (Figure 2). Where growing concurrently with <i>Lupinus oregonus</i> , mowed above top of raceme. Did not mow Cheryl Schultz's research plots in the SW corner.
6/12	Nectar island weeding	Matt S.	Mowed edges of all nectar islands and Experiments A, B, and C. Weeded velvetgrass out of all nectar islands (except 6, which was excessively weedy).
8/5	Hand weeding	Matt S.	Hand weeded and bagged meadow knapweed, mainly in the NW corner
8/7	Hand weeding	Matt S.	Removed blackberry from edges of nectar islands, weeded nectar islands
11/9	planting	Matt S., Christine, Kathyryn, Looking Glass, volunteer John Koenig	Planted plugs and bulbs in plot 4b (Figure 1)
11/10	planting	Matt S., Christine, Andy Looking Glass, AmeriCorps crew	Planted plugs, bulbs, and runners in plots 4b, 5b and 2b, moved shadecloth to plots 4c, 1c, 2c, and 5c, (Figure 1)
11/13	planting	Matt S., Christine, Andy, 4 volunteers	Planted plugs and bulbs in plots 1b and 2b (cover photo)
11/19	planting	Matt S., Christine	Planted plugs and bulbs in plots 2b and 5b
12/3	Planting, weeding	Matt S., Andy, AmeriCorps crew	Planted strawberry runners in plots 1b, 5b, and 2b weeded <i>agrostis</i> from 1a
12/8	seeding	Matt S.	Overseeded plots 1a, 1b, 2b, 4b, 5a, and 5b (Table 3)



Fir Butte, Shadecloth and Solarization Plots

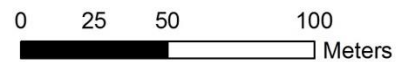


Figure 1: Location of nectar islands and test plots at Fir Butte.



Figure 2. Tall oatgrass mowed adjacent to flagged Kincaid's lupine.

Table 2: Summary of fall 2015 plantings by plot.

Species	Form	Plot 1b	Plot 2b	Plot 4b	Plot 5b
<i>Iris tenax</i>	4" pots	10	10	10	10
<i>Sisyrinchium idahoense</i>	4" pots	20	20	20	20
<i>Eriophyllum lanatum</i>	Small band pots	15	15	15	15
<i>Sidalcea malviflora</i> spp. <i>virgata</i>	Heritage medium plug trays	640	640	640	640
<i>Allium amplexans</i>	Bulbs in 1' x 2' flats (100 bulbs per flat)	1.75 trays	1.75 trays	1.75 trays	1.75 trays
<i>Festuca roemerii</i>	Heritage medium plug trays	612	612	612	612
<i>Zigadenus venenosus</i>	Bulbs in 1'x2' flats (100 bulbs per flat)	1.25 trays	1.25 trays	1.25 trays	1.25 trays
<i>Fragaria virginiana</i>	Ramets	250	250	250	250

Table 3: Seed mixture broadcast seeded on to plots 1a, 1b, 2b, 4b, 5a, and 5b in fall 2015

Species	Total seed (lbs) plots 1b, 2b, 4b and 5b combined
<i>Achillea millefolium</i>	0.09
<i>Camassia leichtlinii</i>	1.61
<i>Clarkia purpurea</i> ssp. <i>quadrivulnera</i>	0.02
<i>Epilobium densiflorum</i>	0.07
<i>Eriophyllum lanatum</i>	0.23
<i>Festuca roemerii</i>	0.52
<i>Linanthus bicolor</i>	0.02
<i>Lomatium nudicaule</i>	0.22
<i>Microseris laciniata</i>	0.12
<i>Nemophila menziesii</i> var. <i>atomaria</i>	0.06
<i>Plectritis congesta</i>	0.51
<i>Potentilla gracilis</i>	0.40
<i>Prunella vulgaris</i> var. <i>lanceolata</i>	0.18
<i>Sidalcea virgata</i>	0.83
<i>Wyethia angustifolia</i>	0.75
Total seed (lbs)	5.22
Total Forb seed (lbs)	4.7
Total Graminoid seed (lbs)	0.52

SITE PREPARATION TECHNIQUES AND THE ESTABLISHMENT OF NATIVE SPECIES

Methods

In 2012, three test plots were established to evaluate the effects of three site preparation techniques on native species establishment. The three techniques were:

- Till + solarize – Experiment A-
- Solarize – Experiment B
- Shadecloth – Experiment C

After preparing each test plot, the test plots were seeded with belly seeders in fall 2012. No weed control was performed, except for annual mowing in the fall. Percent cover of native species, non-native species, and bare soil was recorded for a sample of each of the three test plots from 2013-2015 and summarized in Table 4.

Results

Cover of native species was generally highest in the first year before dropping off in the second and third years following treatment. Each treatment had less than 30% native cover by 2015 (Table 4). The till + solarize treatment had the highest cover of native species after three years, but natives were still less than 30% of the total cover. Much of the native cover in the till + solarization treatment was provided by a species not included in the seeding mix, deervetch (*Lotus micranthus*) (Appendix A).

The solarization and shadecloth treatments resulted in much higher amounts of bare soil than the till + solarization treatment in the first two years after establishment of the test plots.

By the third year, bentgrasses (*Agrostis stolonifera* and *A. capillaris*) were the dominant nonnative species across all treatments, with absolute cover exceeding 50%.

Conclusions and lessons learned

The results of the experiment show that, regardless of the establishment method chosen, ongoing weed control is necessary to maintain a significant native component to a seeded area. Currently, hand weeding is the only option, but this is difficult and time-consuming over even the small scale of the currently established nectar islands. Herbicide, particularly a grass-specific herbicide, would be a useful tool to maintain the nectar islands, especially from the second year after establishment. Invasive grasses do not appear to be a big problem the first growing season after seeding.

All three establishment treatments were effective in the establishment of native species. However, much of the native cover on the plot receiving the till + solarization treatment was deervetch (*Lotus micranthus*), which was apparently abundant in the seedbank. The other establishment techniques had much lower cover of deervetch and better establishment of seeded species such as

yarrow (*Achillea millefolium*), Oregon sunshine (*Eriophyllum lanatum*), and self-heal (*Prunella vulgaris*). Plot level data is included in Appendix B.

Table 4. Summary of site preparation test plots

	% Cover (rel. mean)		
Experiment A	2013	2014	2015
Native cover	47.1	50.2	28.1
Nonnative cover	52.9	49.8	71.9
Bare ground	62.3	8.8	8.3
# seeded native species present	9	8	8
Experiment B			
Native cover	46.9	27.2	11.9
Nonnative cover	52.7	72.8	88.1
Bare ground	70.5	33.9	26.3
# seeded native species present	4	4	4
Experiment C			
Native cover	66.0	30.1	15.2
Nonnative cover	34.0	69.9	84.8
Bare ground	73.7	29.5	12.8
# seeded native species present	4	3	5

2016 ACTIVITIES

In 2016, IAE will continue several of the 2015 activities. Primary activities will include hand weeding, weed whacking of tall oatgrass, and planting and seeding additional nectar islands. Pending BLM approval, IAE expects to begin herbicide applications at Fir Butte, including fusilade at the research plots managed by Dr. Cheryl Schultz, glyphosate on tall oatgrass and bracken fern across the site, triclopyr on patches of Himalayan blackberry, and clopyralid on patches of meadow knapweed. IAE will continue to collaborate with the BLM to support the process leading up to herbicide implementation.

APPENDIX A SHADECLOTH AND SOLARIZATION PLOTS

Table 5: Management in shadecloth and solarization plots at Fir Butte.

Plot	Size	Pre treatment species cover	Shade-cloth application	Solarization plastic application	Till before solarization	Date of solarization/shadecloth removal	Flame weeding	Date planted/seeded after site preparation	Comments
1a	8m x 10m	8/2/12: AGRSTO 60%, ARRELA 25%, RUBARM 7%, HOLLAN 1%, VICTET 1%, <1%: PLALAN, DAUCAR, RUMALI, AIRCAR, GALTRI, HYPPER, VICSAT, PARVIS, VULOCT, BROHOR	8/2/12	N/A	N/A	N/A	10/31/13, 3/20/14, 5/20/14, 10/30/14	planted 11/3-11/5/14, overseeded on 1/14/15	
2a	8m x 10m	8/2/12: RUBARM 50%, ARRELA 25%, AGRSTO 20%, DAUCAR 4%, HOLLAN 2%, ANTODO 1%, VULOCT 1%, <1%: AVEFAT, RUMALI, GALTRI, AIRCAR, BROHOR, HYPPER, DACGLO	8/2/12	05/14/13	yes	9/16/2013 -- plastic in shreds; unclear how long it remained intact	10/31/13	planted 11/4-11/6/13, overseeded on 11/7/13	hand weeded 6/17-6/18/14
3a	8m x 10m	8/2/12: AGRSTO 50%, PTEAQU 20%, RUBARM 10%, ARRELA 5%, ANTODO 4%, DACGLO 3%, GALTRI 3%, HOLLAN 2%, PARVIS 1%, <1%: POTGRA, RUMALI, HYPPER, CYTSCO, CIRVUL, SIDVIR	8/2/12	05/15/13	no	9/18/2013 -- plastic in shreds	10/31/13	planted 11/4-11/6/13, overseeded on 11/7/13	hand weeded 6/17-6/18/14; prescribed burn 10/6/14
4a	8m x 10m	8/2/12: RUBARM 55%, ANTODO 40%, ARRELA 10%, HOLLAN 4%, VICTET 2%, AGRSTO 1%, <1%: DAUCAR, GALTRI, HYPPER, PARVIS, RUMALI, SIDVIR	8/2/12	05/14/13	yes	9/16/2013 -- plastic in shreds	10/31/13	planted 11/4-11/6/13, overseeded on 11/7/13	hand weeded 6/17-6/18/14

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Plot	Size	Pre treatment species cover	Shade-cloth application	Solarization plastic application	Till before solarization	Date of solarization/shade cloth removal	Flame weeding	Date planted/seeded after site preparation	Comments
5a	8m x 10m	8/2/12: ARRELA 45%, RUBARM 40%, AGRSTO 20%, GALTRI 1%, <1%: CIRVUL, HYPPER, HOLLAN, DAUCAR, RUMALI, CYNECH, PARVIS, VULOCT, VICTET, AMEALN	8/2/12	05/22/13	yes	9/18/2013 -- plastic in shreds	10/31/13, 3/20/14, 5/20/14, 10/30/14	planted 11/3-11/5/14, overseeded on 1/14/15	
1b	8m x 10m	5/10/13: AGRSTO 40%, VICSAT 35%, ANTODO 10%, VICTET 5%, SHEARV 3%, RUMACE 1%, <1%: RUMARM, DAUCAR, ARRELA, PLANLAN, FESARU, HOLLAN, CAMQUA, PLECON, PARVIS, DICCON, CERGLO, ERILAN	Fall 2014	N/A	N/A				
2b	8m x 10m	5/10/13: AGRSTO 45%, ARRELA 15%, ANTODO 12%, VICSAT 8%, VICTET 6%, <i>Brodiaea</i> sp. 2%, RUBARM 1%, DAUCAR 1%, <1%: SHEARV, PLALAN, FESARU, HOLLAN, RUMACE, POTGRA, PLECON, PARVIS, TAROFF, FESROE, DICCON, LOTDEN, HYPRAD, CRESET, DANCAL, DACGLO, NEMARE, LINBIC	05/14/13	N/A	N/A				
3b	8m x 10m	5/10/13: AGRSTO 75%, ANTODO 4%, PTEAQU 3%, HOLLAN 2%, 1%: VICSAT, VICTET, DAUCAR, RUMACE, DACGLO; <1%: RUMARM, CIRVUL, LATSYL, SHEARV, ARRELA, FESARU, CAMQUA, SIDVIR, HYPPER, POTGRA, PARVIS, LOTDEN, HYPRAD, CERGLO, SENJAC, RANOCC, ERILAN	05/15/13	N/A	N/A	8/22/14 shade cloth removed	10/30/14	planted 11/3-11/5/14, overseeded on 1/14/15	prescribed burn 10/6/14

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Plot	Size	Pre treatment species cover	Shade-cloth application	Solarization plastic application	Till before solarization	Date of solarization/shadecloth removal	Flame weeding	Date planted/seeded after site preparation	Comments
4b	8m x 10m	5/10/13: AGRSTO 40%, ANTODO 40%, VICTET 3%, VICSAT 2%, RUMARM 2%, LATSYL 2%, 1%: DAUCAR, SHEARV, HOLLAN, SIDVIR, RUMACE, <i>Brodiaea</i> sp.; <1%: CIRVUL, LOMNUD, ARRELA, ALOPRA, PLALAN, FESARU, <i>Madia</i> sp., EPIDEN, CAMQUA, HYPPER, GALAPA, LATSPH	05/14/13	N/A	N/A				
5b	8m x 10m	5/10/13: AGRSTO 50%, BROCOM/HOR 15%, VICTET 14%, ARRELA 10%, <i>Vulpia</i> sp. 3%, <1%: VICSAT, RUMARM, DAUCAR, ANTODO, FESARU, HOLLAN, CAMQUA, SIDVIR, RUMACE, <i>Brodiaea</i> sp., LATSPH, DICCON, PTEAQU	Fall 2014	N/A	N/A				
Experiment A	15m x 25m	No data	N/A	6/1/12	yes	Oct-12	N/A	planted and overseeded on 11/6/2012, second seeding on 11/7/13	Area covered with shadecloth from 2007-Sept 2011; post-treatment plant community data taken on 5/1/13; some hand weeding June 2013; prescribed burn 10/6/14

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Plot	Size	Pre treatment species cover	Shade-cloth application	Solarization plastic application	Till before solarization	Date of solarization/shade cloth removal	Flame weeding	Date planted/seeded after site preparation	Comments
Experiment B	15m x 25m	No data	N/A	6/1/12	no	Oct-12	N/A	planted and overseeded on 11/6/2012, second seeding on 11/7/13	Area covered with shade cloth from 2007-Sept 2011; post-treatment plant community data taken on 5/1/13; prescribed burn 10/6/14
Experiment C	15m x 25m	No data	06/01/12	N/A	N/A	Oct-12	N/A	planted and overseeded on 11/6/2012, second seeding on 11/7/13	Area covered with shade cloth from 2007-Sept 2011; post-treatment plant community data taken on 5/1/13; prescribed burn 10/6/14
6	15m x 25m	No data	11/06/12	N/A	N/A	11/20/2013 (shade cloth)	10/31/13, 3/20/14, 5/20/14		Plot excessively weedy in Fall 2014; decided to abandon plot.
7	15m x 25m	No data	Fall 2014	N/A	N/A				Area covered with shade cloth from 2007-Sept 2011
"Lepidium"		No data; assuming shade cloth placed by Joe Simons; assuming <i>Lepidium heterophyllum</i> was here previously because there is a location of it on a map in the management plan.	?	N/A	N/A	9/16/2013	11/01/13	planted 11/4-11/6/13, overseeded on 11/7/13	

APPENDIX B DATA TABLES FROM ESTABLISHMENT EXPERIMENT

Table 6. Experiment A, 2013 Monitored 5/1/2013. Raw data is absolute cover

Plot #	Experiment A: Till, Solarize (% cover)									
	1	2	3	4	5	6	7	8	9	10
<i>Achillea millefolium</i> *	2	1	3	0.5	0.5	1	1	0.5	3	3
<i>Agrostis stolonifera/capillaris</i>	5	5	3	6	20	8	2	7	7	2
<i>Anthoxanthum odoratum</i>	1	0	0	0	0	0	0	0	0	0
<i>Calindrinia ciliata</i>	0	5	0	0	0	2	0	0	8	0
<i>Cardamine sp.</i>	0	0	0	0	0	0	0	0	0	0
<i>Cerastium glomeratum</i>	0	0	0	0	0	0	0	0	0	0
<i>Daucus carota</i>	0	0	0	0	0	0	0	0	0	0
<i>Dichelostemma/Brodiaea/Triteleia</i>	0	0	0	0	0	0	0	0	0	0
<i>Epilobium densiflorum</i> *	0	0	0.5	0	0	0.5	0	0	0	0
<i>Eriophyllum lanatum</i> *	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0	0
<i>Holcus lanatus</i>	0	20	0	0	0	0	2	0	0	0
<i>Hypericum perforatum</i>	0	0	0	0	0	0	0	0	0	0
<i>Hyphochaeris radicata</i>	0	5	0	0	0	0	0	0	0	0
<i>Juncus bufonius</i>	0	2	0	0	0	0	0	0	0.5	0
<i>Juncus tenuis</i>	0	0	0	0	0	0	0	0	0	0
<i>Lathyrus sphaericus/sylvestris</i>	0.5	0.5	0.5	0.5	0.5	1	0.5	0	1	0.5
<i>Lepidium heterophyllum</i>	0	0	0	0	0	0	0	0	0	0
<i>Lilium sp.?</i>	0	0	0	0	0	0	0	0	0	0
<i>Linanthus bicolor</i> *	0.5	1	1	0	0.5	1	0	0	1	1
<i>Lotus micranthus</i>	25	2	6	7	6	15	6	5	20	25
<i>Microseris laciniata</i> *	0.5	1	0.5	0.5	0.5	3	1	0.5	1	2
<i>Myosotis discolor</i>	0	0.5	0	0	0	0	0.5	0	0	0
<i>Nemophila menziesii var. atromaria</i> *	0	0.5	0	0	0	0	0	0	0	0.5

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<i>Plectritis congesta</i> *	0.5	1	0.5	0.5	0.5	0.5	0.5	0	1	1
<i>Poa annua</i>	0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i> *	0	0.5	0	0.5	0	1	0	1	0	0
<i>Rumex acetosella</i>	0.5	1	20	25	3	0.5	8	3	7	2
<i>Sherardia arvensis</i>	0	0	0	0	0	0	0	0	0	0
<i>Sidalcea virgata</i> *	0	0	0	0	0	0.5	0	0	0	0.5
<i>Taraxicum officinale</i>	0	1	0	0	0	0	0	0	0	0
<i>Vicia sativa</i>	0	1	0	3	0.5	7	1	0	1	0
<i>Vicia tetrasperma</i>	5	0	1	0.5	0.5	1	0.5	0.5	1	1
Total	41	48.5	36.5	44.5	33	42.5	23	18	51.5	38.5
Bare ground (100-Total)	59	51.5	63.5	55.5	67	57.5	77	82	48.5	61.5
Relative Cover Native	70.7	29.9	32.9	21.3	25.8	58.8	37.0	41.7	67.0	85.7
Relative Cover Non-native	29.3	70.1	67.1	78.7	74.2	41.2	63.0	58.3	33.0	14.3

Table 7. Experiment B, 2013. Monitored 5/1/2013. Raw data is absolute cover

	Experiment B: No till, Solarize (% cover)									
Plot #	1	2	3	4	5	6	7	8	9	10
<i>Achillea millefolium</i> *	0	0	7	10	1	4	6	15	5	0
<i>Aira caryophylla</i>	0	0	0.5	0	0.5	0.5	0.5	0	0	0
<i>Agrostis stolonifera/capillaris</i>	60	40	35	25	50	40	25	45	20	85
<i>Anthoxanthum odoratum</i>	0	0	0	0	0	0	0	0	0	0
<i>Arrhenatherum elatius</i>	0	0	0	0	0	0	0	0	0	0
<i>Cerastium viscosum</i>	0	0.5	0	0	0	0	0	0	0	0
<i>Bromus</i> sp.	0	0	0	0	0	0	0	0	0	0
<i>Bromus carinatus</i>	0	0	0	0	0	0	0	0	0	0
<i>Daucus carota</i>	0	0	0	0	0	0	0	0	0	0
<i>Eriophyllum lanatum</i> *	0	1	1	0.5	0.5	0	0.5	1	3	0.5

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<i>Holcus lanatus</i>	0.5	3	6	4	3	1	3	0.5	0.5	0.5
<i>Hypericum perforatum</i>	0	0	0	0	0	0	0	0	0	0
<i>Hyphochaeris radicata</i>	10	30	25	35	40	12	12	3	0	4
<i>Lepidium heterophyllum</i>	0	0	0	0	0	0	0	0	0	0
<i>Lotus micranthus</i>	10	1	0.5	0.5	0.5	0.5	0	2	0.5	0.5
<i>Microseris laciniata*</i>	0	0	0	0	0	0	0	0	0	0
<i>Myosotis discolor</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Parentucellia viscosa</i>	0.5	0.5	5	2	0.5	0	0	0	0.5	0.5
<i>Potentilla gracilis*</i>	0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris*</i>	0	1	0	0	0	0	0	0	0	0
<i>Rubus armeniacus</i>	0	0	0	0	0	0	0	0	0	0
<i>Rumex acetosella</i>	0.5	15	0	0	1	5	0.5	6	1	1
<i>Sherardia arvensis</i>	0	0	0	0	0	0	0	0	0	0
<i>Sidalcea maliviflora ssp. virgata</i>	0.5	0	0	0	0.5	0.5	0	0	0	0
<i>Vicia sativa</i>	0.5	0	0	0.5	0.5	0	0	0	0	0.5
<i>Vicia hirsuta</i>	0	0	0	0	0	0	0	0	0	0
<i>Wyethia angustifolia</i>	0	0	0	0	0	0	0	0	0	0
Total	83	92	80	77.5	98	63.5	47.5	72.5	30.5	92.5
Bare ground (100-Total)	17	8	20	22.5	2	36.5	52.5	27.5	69.5	7.5
Relative Cover Native	12.7	3.3	10.6	14.2	2.6	7.9	13.7	24.8	27.9	1.1
Relative Cover Non-native	87.3	96.7	89.4	85.8	97.4	92.1	86.3	75.2	72.1	98.9

Table 8. Experiment C, 2013. Monitored 5/1/2013 Raw data is absolute cover

Plot #	Experiment C: Shadecloth (% cover)									
	1	2	3	4	5	6	7	8	9	10
<i>Achillea millefolium*</i>	2	4	1	20	4	4	30	0	0.5	15
<i>Aira caryophyllea</i>	0	0.5	6	0.5	2	0.5	0	0.5	0	0

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<i>Agrostis stolonifera/capillaris</i>	75	80	60	60	65	85	55	65	55	10
<i>Anthoxanthum odoratum</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Arrhenatherum elatius</i>	0	0	0	0	0	0	0	0	0	2
<i>Cerastium viscosum</i>	0	0.5	0	0.5	0.5	0	0	0.5	0	0.5
<i>Bromus sp.</i>	0	0	0	0	0.5	0	0	0	0	0
<i>Bromus carinatus</i>	0	0	0	0	0	0	0	0	0	2
<i>Daucus carota</i>	0	0	0	0	0	0	0	0	0	0.5
<i>Eriophyllum lanatum*</i>	2	1	1	3	1	2	2	1	3	0.5
<i>Holcus lanatus</i>	0.5	0	0.5	0.5	0	0.5	0.5	0	0.5	0.5
<i>Hypericum perforatum</i>	0.5	0	0	0	0.5	0	0.5	0	0	0
<i>Hyphochaeris radicata</i>	20	7	30	10	15	15	5	5	4	0.5
<i>Lepidium heterophyllum</i>	0	0	0	0	0	0.5	0	0.5	2	0
<i>Lotus micranthus</i>	0	0	0.5	0.5	0	0.5	0	0.5	0	1
<i>Microseris laciniata*</i>	0	0	0	0.5	0	0.5	0	0	0	0
<i>Myosotis discolor</i>	1	0	0	0.5	0	0	0	0	0	0
<i>Parentucellia viscosa</i>	0.5	0.5	0.5	0.5	0.5	3	0.5	0.5	1	0.5
<i>Potentilla gracilis*</i>	0	0	0	0	0	0	0	0	0	0.5
<i>Prunella vulgaris*</i>	0	0.5	0	0	1	0.5	0.5	0.5	2	0.5
<i>Rubus armeniacus</i>	0	0	0	0	0	0	0	0	0	0
<i>Rumex acetosella</i>	0	0.5	10	5	0.5	0	1	0	10	0
<i>Sherardia arvensis</i>	0	0.5	0	1	0	0	0	0.5	0	0.5
<i>Sidalcea maliviflora ssp. virgata</i>	0	0	0	0.5	0	0	0	0	2	0.5
<i>Vicia sativa</i>	0.5	0.5	0.5	0	0	0	0.5	0.5	0	0.5
<i>Vicia hirsuta</i>	0.5	0	0	0	0	0	0.5	0	0	0
<i>Wyethia angustifolia</i>	0	0	0	0.5	0	0	0	0	0	0
Total	103	95.5	110	103.5	90.5	112	96	75	80	35.5
Bare ground (100-Total)	0	4.5	0	0	9.5	0	4	25	20	64.5
Relative Cover Native	3.9	5.8	2.3	24.2	6.6	6.7	33.9	2.7	9.4	56.3
Relative Cover Non-native	96.1	94.2	97.7	75.8	93.4	93.3	66.1	97.3	90.6	43.7

Table 9. Experiment A, 2014. Montioered June 6, 2014 Raw data is absolute cover.

	Experiment A: Till, Solarize									
Plot #	1	2	3	4	5	6	7	8	9	10
<i>Achillea millefolium*</i>	10	7	6	8	4	10	0.5	0.5	3	1
<i>Agrostis stolonifera/capillaris</i>	2	25	25	20	15	7	70	75	70	50
<i>Aira caryophyllea</i>	0	0	0	0	0	0	0	0	0	0
<i>Anthoxanthum odoratum</i>	0	0	0	0	0	0	0	0	0	0
<i>Bromus hordeaceus</i>	0	0	0	0	0	0	0	0	0	0
<i>Calindrinia ciliata</i>	0	0	0	0	0	0	0	0	0	0
<i>Cerastium viscosum</i>	0	0	0	0	0	0	0	0	0	0
<i>Clarkia amoena</i>	0	0	0	0	0	0	0	0	0	0
<i>Collomia grandiflora</i>	0	0	0	0	0	0	0	0	0	0
<i>Daucus carota</i>	0	0	0	0	0	0	0	0	0	0
<i>Eriophyllum lanatum*</i>	0	1	0	1	2	5	0	0	0.5	0
<i>Holcus lanatus</i>	0.5	1	1	0.5	4	2	2	1	1	1
<i>Hyphochaeris radicata</i>	0	1	0	0	0	1	5	2	3	0
<i>Juncus bufonius</i>	0	0	0	0	0	0	0	0	0	0
<i>Juncus tenuis</i>	0	0	0	0	0	1	0	0	0	0
<i>Lepidium heterophyllum</i>	0	0	0	0	0	0	0	0	0	0
<i>Linanthus bicolor*</i>	0	0	0	0	0	0	0	0	0	0
<i>Lotus micranthus</i>	80	60	60	60	45	70	0.5	10	15	10
<i>Lotus unifoliolatus</i>	0	0	0	0	0	0	0	0	0	0
<i>Microseris laciniata*</i>	0	0	0	0.5	0	0	1	0	0	0
<i>Parentucellia viscosa</i>	2	1	1	1	0.5	0	1	0.5	2	2
<i>Potentilla gracilis</i>	0	0	0	0	0	0.5	0	0	0	0
<i>Prunella vulgaris*</i>	1	1	0.5	0.5	1	3	0	0	0	1

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<i>Rumex acetosella</i>	4	3	6	5	5	4	1	0	10	4
<i>Vicia sativa</i>	0	0	0	0	0	0	0	0	0	0
<i>Vulpia myuros</i>	0	0	0	0	1	1	0	0.5	0	0
Total	99.5	100	99.5	96.5	77.5	104.5	81	89.5	104.5	69
Bare ground (100-Total)	0.5	0	0.5	3.5	22.5	0	19	10.5	0	31
Relative Cover Native	91.5	69.0	66.8	72.5	67.1	85.6	2.5	11.7	17.7	17.4
Relative Cover Non-native	8.5	31.0	33.2	27.5	32.9	14.4	97.5	88.3	82.3	82.6

Table 10. Experiment B, 2014 Monitored June 6, 2014 Raw data is absolute cover.

	Experiment B: No till, Solarize									
Plot #	1	2	3	4	5	6	7	8	9	10
<i>Achillea millefolium</i> *	20	20	20	30	2	1	4	3	8	1
<i>Agrostis stolonifera/capillaris</i>	35	6	25	12	25	30	35	30	20	65
<i>Aira caryophylla</i>	0	0	0	0	0	3	0	1	0	0
<i>Anthoxanthum odoratum</i>	0	0	0	0	0	0	0	0	0	0
<i>Bromus hordeaceus</i>	0	0	0.5	0	0	0	0	0	0.5	0
<i>Calindrinia ciliata</i>	0	0	0	0	0	0	0	0	0	0
<i>Cerastium viscosum</i>	0	0	0	0	0	0	0.5	0.5	0	0
<i>Clarkia amoena</i>	0	0	0	1	2	1	0	0.5	1	0.5
<i>Collomia grandiflora</i>	0	0	0	0	0	0	0	0	0	0
<i>Daucus carota</i>	0	0	0	0	0	0	0	0.5	0	0
<i>Eriophyllum lanatum</i> *	3	6	2	1	3	0	0	0	1	0
<i>Holcus lanatus</i>	4	20	3	10	15	8	5	4	3	0.5
<i>Hyphochaeris radicata</i>	1	3	8	1	4	10	1	2	0	0.5
<i>Juncus bufonius</i>	1	0	2	2	1	0	0	0	0.5	1

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<i>Juncus tenuis</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Lepidium heterophyllum</i>	0	0	0	0	0	0	0	0.5	0	0
<i>Linanthus bicolor*</i>	0.5	0	1	0.5	0.5	0	1	0	0.5	0
<i>Lotus micranthus</i>	20	2	10	1	1	2	0	0.5	0.5	0
<i>Lotus unifoliolatus</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Microseris laciniata*</i>	0	0	0	0	0	0	0	0	0	0
<i>Parentucellia viscosa</i>	1	1	3	6	20	5	3	3	0.5	0.5
<i>Potentilla gracilis</i>	0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris*</i>	1	0	3	0	3	0	1	0	1	0
<i>Rumex acetosella</i>	0	2	2	0	0	0.5	4	0.5	15	4
<i>Vicia sativa</i>	0.5	0	0	0	0	0.5	0	0	0	0
<i>Vulpia myuros</i>	0	0	0	0	0.5	6	0	0	0	0
Total	88	60	79.5	64.5	77	67	54.5	46	51.5	73
Bare ground (100-Total)	12	40	20.5	35.5	23	33	45.5	54	48.5	27
Relative Cover Native	52.8	46.7	47.8	55.0	16.2	6.0	11.0	8.7	24.3	3.4
Relative Cover Non-native	47.2	53.3	52.2	45.0	83.8	94.0	89.0	91.3	75.7	96.6

Table 11. Experiment C, 2014. Monitored June 6, 2014 Raw data is absolute cover.

Plot #	Experiment C: Shadecloth									
	1	2	3	4	5	6	7	8	9	10
<i>Achillea millefolium*</i>	4	10	4	35	3	30	5	12	3	10
<i>Agrostis stolonifera/capillaris</i>	25	25	25	30	15	15	35	40	50	30
<i>Aira caryophyllea</i>	1	0	1	0	0	0	0	0	0	0
<i>Anthoxanthum odoratum</i>	2	0	0	0	0	0	0	0	0	0
<i>Bromus hordeaceus</i>	0	0	0	0	0	0	0	0	0	0
<i>Calindrinia ciliata</i>	0	0	0	0	0	8	0	0	0	0
<i>Cerastium viscosum</i>	0	0	0	0	0	0	0	0	0	0

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<i>Clarkia amoena</i>	2	0.5	0	0	0	0	0	0	0	0.5
<i>Collomia grandiflora</i>	0	0	0	0	0	0	0	0	1	0
<i>Daucus carota</i>	1	0	0.5	0	0	0	1	0	0	2
<i>Eriophyllum lanatum*</i>	2	7	3	2	2	4	2	2	4	4
<i>Holcus lanatus</i>	0	1	3	3	0.5	3	10	0.5	5	2
<i>Hyphochaeris radicata</i>	10	15	20	2	0.5	1	4	0.5	4	5
<i>Juncus bufonius</i>	0	0	0	0	0	0	0	0	0	0
<i>Juncus tenuis</i>	0	0	0	0	0	0	0	0	0	0
<i>Lepidium heterophyllum</i>	0	0	0	0	0	0	0	0	0	0
<i>Linanthus bicolor*</i>	0	0	0	0	0	0	0	0	0.5	0
<i>Lotus micranthus</i>	2	0.5	4	2	2	3	3	1	4	2
<i>Lotus unifoliolatus</i>	0	0	0	0.5	0	0	5	0	0	0
<i>Microseris laciniata*</i>	0	0	0	0	0	0	0	0	0	0
<i>Parentucellia viscosa</i>	2	4	2	1	0	0	2	0	2	4
<i>Potentilla gracilis</i>	0	0.5	0	0	0	0	0	0	0	0
<i>Prunella vulgaris*</i>	2	3	2	1	0	3	3	2	2	3
<i>Rumex acetosella</i>	5	0.5	3	0	60	2	3	15	0	0.5
<i>Vicia sativa</i>	0	0	0	0	0	0	0	0	0	0
<i>Vulpia myuros</i>	0	0	0	0	0	0	0	0	0	0
Total	58	67	67.5	76.5	83	69	73	73	75.5	63
Bare ground (100-Total)	42	33	32.5	23.5	17	31	27	27	24.5	37
Relative Cover Native	20.7	32.1	19.3	52.9	8.4	69.6	24.7	23.3	19.2	31.0
Relative Cover Non-native	79.3	67.9	80.7	47.1	91.6	30.4	75.3	76.7	80.8	69.0

Table 12. Experiment A, 2015. Monitored May 12, 2015 Raw data is absolute cover.

	Experiment A: Till, Solarize									
Plot #	1	2	3	4	5	6	7	8	9	10

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<i>Achillea millefolium*</i>	0.5	13	8	2	5	15	7	8	1	5
<i>Aira caryophylla</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Agrostis stolonifera/capillaris</i>	40	15	40	60	90	50	40	80	75	70
<i>Anthoxanthum odoratum</i>	1	0	0	0	0	0	0	0.5	0	0
<i>Arrhenatherum elatius</i>	0	0	0	0	0	0	0	0	0	0
<i>Cerastium viscosum</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Bromus sp.</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Bromus carinatus</i>	0	0	0	0	0	0	0	0	0	0
<i>Daucus carota</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Eriophyllum lanatum*</i>	0.5	0	2	0.5	0.5	5	2	0.5	0	0.5
<i>Holcus lanatus</i>	1	0.5	0.5	0.5	1	4	5	3	0.5	1
<i>Hypericum perforatum</i>	0	0.5	0	0	0	0	0	0	0	0
<i>Hyphochaeris radicata</i>	4	5	5	0	0	3	5	6	2	5
<i>Lepidium heterophyllum</i>	0	0	0	0	0	0	0	0	0	0
<i>Lotus micranthus</i>	15	50	35	25	4	9	25	3	2	10
<i>Microseris laciniata*</i>	0	0	0.5	0.5	0	0.5	0	0	0	0
<i>Myosotis discolor</i>	0.5	0	0	0	0	0.5	0	0	0	0
<i>Parentucellia viscosa</i>	1	4	2	3	0.5	0	6	0.5	0.5	0.5
<i>Potentilla gracilis*</i>	0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris*</i>	0.5	0.5	0	0.5	0	0.5	0	0	0	0
<i>Rubus armeniacus</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Rumex acetosella</i>	1	2	3	1	5	0.5	6	2	2	5
<i>Sherardia arvensis</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Sidalcea maliviflora ssp. virgata</i>	0.5	0	0	0	0	0	0	0	0.5	0
<i>Vicia sativa</i>	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0	1
<i>Vicia hirsuta</i>	1	0	0	0	0	0	0	0	0	0
<i>Wyethia angustifolia</i>	0	0	0	0	0	0	0	0	0	0
Total	70	91	96.5	93.5	106.5	88.5	96	104	83.5	98
Bare ground (100-Total)	30	9	3.5	6.5	0	11.5	4	0	16.5	2

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Relative Cover Native	24.3	69.8	47.2	30.5	8.9	33.9	35.4	11.1	4.2	15.8
Relative Cover Non-native	75.7	30.2	52.8	69.5	91.1	66.1	64.6	88.9	95.8	84.2

Table 13. Experiment B, 2015 Monitored May 12, 2015 Raw data is absolute cover.

Plot #	Experiment B: No till, Solarize									
	1	2	3	4	5	6	7	8	9	10
<i>Achillea millefolium</i> *	0	0	7	10	1	4	6	15	5	0
<i>Aira caryophylla</i>	0	0	0.5	0	0.5	0.5	0.5	0	0	0
<i>Agrostis stolonifera/capillaris</i>	60	40	35	25	50	40	25	45	20	85
<i>Anthoxanthum odoratum</i>	0	0	0	0	0	0	0	0	0	0
<i>Arrhenatherum elatius</i>	0	0	0	0	0	0	0	0	0	0
<i>Cerastium viscosum</i>	0	0.5	0	0	0	0	0	0	0	0
<i>Bromus sp.</i>	0	0	0	0	0	0	0	0	0	0
<i>Bromus carinatus</i>	0	0	0	0	0	0	0	0	0	0
<i>Daucus carota</i>	0	0	0	0	0	0	0	0	0	0
<i>Eriophyllum lanatum</i> *	0	1	1	0.5	0.5	0	0.5	1	3	0.5
<i>Holcus lanatus</i>	0.5	3	6	4	3	1	3	0.5	0.5	0.5
<i>Hypericum perforatum</i>	0	0	0	0	0	0	0	0	0	0
<i>Hyphochaeris radicata</i>	10	30	25	35	40	12	12	3	0	4
<i>Lepidium heterophyllum</i>	0	0	0	0	0	0	0	0	0	0
<i>Lotus micranthus</i>	10	1	0.5	0.5	0.5	0.5	0	2	0.5	0.5
<i>Microseris laciniata</i> *	0	0	0	0	0	0	0	0	0	0
<i>Myosotis discolor</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Parentucellia viscosa</i>	0.5	0.5	5	2	0.5	0	0	0	0.5	0.5
<i>Potentilla gracilis</i> *	0	0	0	0	0	0	0	0	0	0
<i>Prunella vulgaris</i> *	0	1	0	0	0	0	0	0	0	0
<i>Rubus armeniacus</i>	0	0	0	0	0	0	0	0	0	0

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<i>Rumex acetosella</i>	0.5	15	0	0	1	5	0.5	6	1	1
<i>Sherardia arvensis</i>	0	0	0	0	0	0	0	0	0	0
<i>Sidalcea maliviflora</i> ssp. <i>virgata</i>	0.5	0	0	0	0.5	0.5	0	0	0	0
<i>Vicia sativa</i>	0.5	0	0	0.5	0.5	0	0	0	0	0.5
<i>Vicia hirsuta</i>	0	0	0	0	0	0	0	0	0	0
<i>Wyethia angustifolia</i>	0	0	0	0	0	0	0	0	0	0
Total	83	92	80	77.5	98	63.5	47.5	72.5	30.5	92.5
Bare ground (100-Total)	17	8	20	22.5	2	36.5	52.5	27.5	69.5	7.5
Relative Cover Native	12.7	3.3	10.6	14.2	2.6	7.9	13.7	24.8	27.9	1.1
Relative Cover Non-native	87.3	96.7	89.4	85.8	97.4	92.1	86.3	75.2	72.1	98.9

Table 14. Experiment C, 2015. Monitored May 12, 2015. Raw data is absolute cover.

	Experiment C: Shadecloth									
Plot #	1	2	3	4	5	6	7	8	9	10
<i>Achillea millefolium</i> *	2	4	1	20	4	4	30	0	0.5	15
<i>Aira caryophylla</i>	0	0.5	6	0.5	2	0.5	0	0.5	0	0
<i>Agrostis stolonifera/capillaris</i>	75	80	60	60	65	85	55	65	55	10
<i>Anthoxanthum odoratum</i>	0.5	0	0	0	0	0	0	0	0	0
<i>Arrhenatherum elatius</i>	0	0	0	0	0	0	0	0	0	2
<i>Cerastium viscosum</i>	0	0.5	0	0.5	0.5	0	0	0.5	0	0.5
<i>Bromus</i> sp.	0	0	0	0	0.5	0	0	0	0	0
<i>Bromus carinatus</i>	0	0	0	0	0	0	0	0	0	2
<i>Daucus carota</i>	0	0	0	0	0	0	0	0	0	0.5
<i>Eriophyllum lanatum</i> *	2	1	1	3	1	2	2	1	3	0.5
<i>Holcus lanatus</i>	0.5	0	0.5	0.5	0	0.5	0.5	0	0.5	0.5
<i>Hypericum perforatum</i>	0.5	0	0	0	0.5	0	0.5	0	0	0
<i>Hyphochaeris radicata</i>	20	7	30	10	15	15	5	5	4	0.5

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<i>Lepidium heterophyllum</i>	0	0	0	0	0	0.5	0	0.5	2	0
<i>Lotus micranthus</i>	0	0	0.5	0.5	0	0.5	0	0.5	0	1
<i>Microseris laciniata*</i>	0	0	0	0.5	0	0.5	0	0	0	0
<i>Myosotis discolor</i>	1	0	0	0.5	0	0	0	0	0	0
<i>Parentucellia viscosa</i>	0.5	0.5	0.5	0.5	0.5	3	0.5	0.5	1	0.5
<i>Potentilla gracilis*</i>	0	0	0	0	0	0	0	0	0	0.5
<i>Prunella vulgaris*</i>	0	0.5	0	0	1	0.5	0.5	0.5	2	0.5
<i>Rubus armeniacus</i>	0	0	0	0	0	0	0	0	0	0
<i>Rumex acetosella</i>	0	0.5	10	5	0.5	0	1	0	10	0
<i>Sherardia arvensis</i>	0	0.5	0	1	0	0	0	0.5	0	0.5
<i>Sidalcea maliviflora ssp. virgata</i>	0	0	0	0.5	0	0	0	0	2	0.5
<i>Vicia sativa</i>	0.5	0.5	0.5	0	0	0	0.5	0.5	0	0.5
<i>Vicia hirsuta</i>	0.5	0	0	0	0	0	0.5	0	0	0
<i>Wyethia angustifolia</i>	0	0	0	0.5	0	0	0	0	0	0
Total	103	95.5	110	103.5	90.5	112	96	75	80	35.5
Bare ground (100-Total)	0	4.5	0	0	9.5	0	4	25	20	64.5
Relative Cover Native	3.9	5.8	2.3	24.2	6.6	6.7	33.9	2.7	9.4	56.3
Relative Cover Non-native	96.1	94.2	97.7	75.8	93.4	93.3	66.1	97.3	90.6	43.7