Monitoring the Effects of Cattle on Idaho Phlox (*Phlox idahonis*): Second-year Results

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A cooperative project:
Potlatch Corporation
Idaho Department of Fish and Game,
Conservation Data Center
U.S. Fish and Wildlife Service, Region 1

ABSTRACT

Idaho phlox (*Phlox idahonis)* is a narrow endemic known only from the vicinity of Headquarters, Clearwater County, Idaho. It occurs in montane wet meadows surrounded by western redcedar (*Thuja plicata)* and grand-fir (*Abies grandis*) forest. The primary landowner is Potlatch Corporation who, in cooperation with Idaho Department of Fish and Game Conservation Data Center (IDCDC) and the U.S. Fish and Wildlife Service (USFWS), has taken the lead in protecting the species, by funding monitoring and research, and by protecting sites from livestock grazing. This study was initiated to determine how important the removal of livestock grazing is to conservation of Idaho phlox. In 2002, four 14 x 14 m cattle exclosures were constructed in two meadows that have remained part of an active grazing lease. A previous report (Lichthardt and Gray 2003) detailed the selection of paired fenced/unfenced plots, plot locations, plot layouts, and baseline data collection. In June of 2003, the plots were revisited. Cover was not reread at this time, but density measurements of Idaho phlox were repeated and the frequency of shrubs and large forbs was measured using a 1 x 1 m quadrat size. Two other activities took place in 2003 that were relevant to conservation of Idaho phlox. A long term monitoring plan was designed, and a site visit was made by members of the Idaho Phlox Advisory Committee, including representatives of Potlatch, IDCDC, USFWS, and the grazing lease holders.

CONTENTS

LIST OF TABLES

LIST OF APPENDICES

Introduction

Idaho phlox (*Phlox idahonis* Wherry*)* is a narrow endemic known from only four metapopulations located within a four-mile radius of Headquarters, Clearwater County, Idaho. It is a tall, rhizomatous herb with an inflorescence of large, lavender flowers. Once thought to be phylogenetically allied to wild sweetwilliam (*P. maculata*) and thickleaf phlox (*P. carolina*) of eastern North America (Wherry 1955), recent molecular-genetic studies have shown the species to be related most closely to our common western species long-leaf phlox (*Phlox longifolia*; Schultz 2000). Idaho phlox occurs in montane meadows surrounded by western redcedar (*Thuja plicata)* and grand-fir (*Abies grandis*) forest. Its historical habitat has been reduced and altered by road and railroad construction, livestock grazing, and land development. Ninety-eight percent of its known, occupied habitat is owned by Potlatch Corporation. Detailed descriptions of the plant and its habitat can be found in Moseley and Crawford (1993). Idaho phlox is currently ranked G1 by the Idaho Department of Fish and Game Conservation Data Center (IDCDC) which means it is considered critically imperiled globally. It has no official conservation status with the U.S. Fish and Wildlife Service (USFWS).

In 1978, seven permanent plots containing Idaho phlox were established in four different meadows (Crawford 1980). These plots were resampled in 1993, to determine 15-year changes in vegetation, and in abundance of Idaho phlox (Moseley and Crawford 1993). Analysis of the 1993 data indicated that livestock grazing intensity explained a majority of the floristic variation among plots, but that moderate levels of grazing were not detrimental to Idaho phlox. Populations exhibited different trends among the meadows, disappearing completely from one plot, apparently as a result of heavy livestock grazing (Moseley and Crawford 1993, 1995). Shrub and tree invasion of the meadow habitat did not appear to be a threat during the initial 15-year monitoring period. Recommendations in the 1993 report included protection for all populations, exclusion of grazing from heavily grazed meadows (Casey Meadow and Casey Meadow North), and monitoring at 5-yr intervals.

In response to these findings Potlatch phased out livestock grazing in most Idaho phlox habitat by 1995. The only exceptions are Casey Meadow (EOR# 4) and the meadow just upstream which is referred to as Casey Meadow North (EOR# 3). These meadows are part of an active, long-standing grazing lease where the permittee has been cooperating in keeping cattle out of Idaho phlox habitat. Cattle are unloaded in Casey Meadow at the beginning of June and immediately dispersed into the uplands. Cattle are removed by October 31, and are immediately corralled upon returning to the meadow. As a result of this management, very little cattle grazing is thought to be occurring in the meadows.

In 2001, an Idaho phlox advisory panel was assembled by Brian Moser, Potlatch Biologist, to revise the Conservation Agreement between Potlatch and the USFWS. Part of this process was a discussion of the need for excluding grazing in Idaho phlox habitat where it had occurred historically. Monitoring the effects of grazing was identified as a priority of Idaho phlox management (Potlatch Corporation and USFWS 2002). As a result, Potlatch and the USFWS entered into a cooperative agreement to establish grazing exclosures at sites with the greatest potential for cattle use, Casey Meadow and Casey Meadow North, and to monitor these exclosures over four years.

Four sets of paired plots, two in each meadow, were established in 2002. Baseline data were recorded on Idaho phlox density and frequency, and on the frequency and cover of many species associates. This report contains the second consecutive year of data on Idaho phlox density and frequency, with additional data on the frequency of tall forbs and shrubs that we thought may

have been inadequately quantified in 2002. Following 2003 sampling, the monitoring plan was reevaluated, revised, and expanded to include the Crawford plots established in 1978 as well as monitoring of populations at the landscape level. The revised plan is included as Appendix 1.

Monitoring objectives

The objective of monitoring is to detect changes in 1) the condition of wet meadow communities and 2) the abundance of Idaho phlox, in paired plots, one of which is protected from cattle grazing. Lesica and Hanna (2002) found that the frequency of indicator species was a useful measurement for monitoring the effects of grazing on grassland condition. In the present study, increased frequency of non-native weeds or of native species that increase in abundance under grazing pressure will be considered indicative of a downward trend in condition. The abundance of Idaho phlox will be evaluated based on a combination of density and frequency of stems, and the total number of flowering stems. Changes in stem frequency and number of flowering stems will be the primary indicators of a treatment response.

Methods

Siting of plots, sampling design, techniques, and other aspects of methodology are described in Lichthardt and Gray (2003). Because the methods used in 2003 fieldwork were an extension of that sampling, we have included all methods as Appendix 2, so that they are contained in a single report.

Four sets of paired plots were selected in 2002, two in Casey Meadow and two in Casey Meadow North (Appendix 3). All plots have one side along Casey Creek, with transects running parallel to this side. Idaho phlox was usually most abundant at the stream edge, or even restricted to that side of the plot. Exclosures may show whether this is related to the water table, or to the disturbance by cattle.

Plots were numbered 8-15 to differentiate them from the seven permanent plots previously established for monitoring Idaho phlox. Paired plots are numbered consecutively (8 and 9, 10 and 11, etc.) with the even-numbered plots in exclosures.

Exclosures are 14 x 14 m in size and constructed of standard four-strand barbed wire. A 2-m buffer was allowed between the transects and the fence, except for transect 1, which is sometimes much closer to the fenceline in order to keep it close to the stream in all cases (Appendix 4). Exclosures were constructed in June, 2002, shortly following baseline sampling.

The sampling design is compatible with that used at the Crawford plots, in which 2 x 5 dm sampling frames are placed at 1-m intervals along five transects. To cut down on sampling time, we used three such transects, resulting in 30 microplots per plot. Most transects are marked with steel fenceposts at one or both ends. Others are marked with a length of rebar. Plot layout and orientation of transects are shown in Appendix 4. Photos were taken of all plots and are filed at the IDCDC.

The number of microplots in which Idaho phlox occurred was used as a measure of frequency, and the number of ramets per microplot as a measure of density. These parameters were measured in both 2002 and 2003 monitoring.

Community composition within macroplots is described in Lichthardt and Gray (2003). To compare composition over time, we used rooted frequency as a measure of the relative abundance

of indicator species. Indicator species include 1) non-natives; 2) species known to increase under grazing, such as yarrow (*Achillea millefolium*) and goldenrod (*Solidago missouriensis*); and 3) indicators of the natural meadow communities such as panicle bluebells (*Mertensia paniculata*), cow parsnip (*Heracleum lanatum*), and bluejoint reedgrass (*Calamagrostis canadensis*; Table 1).

Table 1. Indicator species and their frequencies as measured in 2002 (percent of 30 microplots). M = in macroplot, but not rooted in microplots.

		Plot							
		8	9	10	11	12	13	14	15
		% of 30 microplots							
Shrubs	O[1]								
Rhamnus alnifolia				20	27				M
Symphoricarpos albus			M	M	60	M		M	
Graminoids									
Agrostis capillaris	X	70	60		43	37	33	3	3
Calamagrostis canadensis		17	23		3		17	13	33
Carex aquatilis		57	43	3	3	13	4	17	13
Phleum pratense	X	70	43	27	47	87	100	37	13
Poa pratensis	X	100	100	80	97	100	100	90	97
Other native sedges[2]		43	43	10	27	37	30	20	13
Forbs									
Achillea millefolium		83	73	37	50	97	97	83	17
Heracleum lanatum					M				M
Leucanthemum vulgare	X		M						
Mertensia paniculata			M	M	M			M	M
Phlox idahonis		20	30	43	67	10	3	67	47
Plantago lanceolata	X	70	10	10	10		0		
Potentilla recta	X	17	70	7		3	7	3	
Senecio hydrophilus					M			M	M
Solidago canadensis		M	M	M	M		M	M	M
Veratrum californicum		M			M	M	M	M	M

[1] Origin, "X" indicates non-native.
[2] Other than *Carex aquatilis*.

In 2003, we sampled large forbs and shrubs using a larger, 1 x 1 m quadrat. We felt that these two groups had not been adequately characterized in 2002 because of the small quadrat size. A quadrat size that results in a frequency of 30 to 80% maximizes the potential for detecting a response (Elzinga et al. 1998) and the size needed will vary depending on the size and distribution of the particular species. Snowberry was an exception among shrubs in that it was common enough to be sampled with the 2 x 5 dm quadrat. The larger quadrats were placed in the same way, with one side at zero on the tape. Allowing a meter between quadrats meant that only 5 quadrats could be placed along each of the three transects.

Results

Species diversity is high in the two meadows, but only a few species provide substantial herbaceous cover. These are yarrow (*Achillea millefolium*), Kentucky bluegrass (*Poa pratensis*),

false hellebore (*Veratrum californicum*; in certain places), and alkali-marsh butterweed (*Senecio hydrophilus*). The most constant species across macroplots (present in six or more) were:

Achillea millefolium	western yarrow
**Agrostis capillaris*	colonial bentgrass
Aster occidentalis	western aster
Calamagrostis canadensis	bluejoint reedgrass
Carex aquatilis	water sedge
Fragaria spp.	wild strawberry
Galium spp.	bedstraw/goosegrass
Geum macrophyllum	large-leaf geum
Microsteris gracilis	pink microsteris, an annual
**Phleum pratense*	timothy
**Poa pratensis*	Kentucky bluegrass
**Potentilla recta*	sulfur cinquefoil
Ranunculus uncinatus	little buttercup
Rudbeckia occidentalis	western coneflower
**Rumex acetosella*	sheep sorrel
Senecio hydrophilus	alkali-marsh butterweed
Solidago canadensis	Canada goldenrod
**Taraxacum officinale*	dandelion
**Trifolium* sp.	clover
Veratrum californicum	California false hellebore

Seven of these species (*) are non-natives and among these sulfur cinquefoil and Kentucky bluegrass are particularly aggressive. Timothy and Kentucky bluegrass occur in all macroplots, the latter generally with high cover. Another non-native grass, colonial bentgrass, is also common, but generally low in cover. Western yarrow, an increaser under grazing, occurs with high frequency and accounts for most of the forb cover in the plots. Community composition and condition (abundance of non-native species) in the macroplots are described in detail in Lichthardt and Gray (2003).

Orange hawkweed (*Hieracium aurantiacum*), a noxious weed of meadows, was discovered near plot 10 and should be killed as soon as possible. The coordinates of its locations (in UTMs) are: 502248 x 5386182 and 501714 x 5384833 (zone 11, NAD 27). The approximate location is shown in Appendix 3.

The distribution of Idaho phlox is patchy, genets (genetic individuals) apparently producing a large number of small, tightly clustered ramets (individual stems from a rhizome) and occasionally one or more tall, stout ramets, which are the ones that flower. Fewer than 1% of ramets flower (Lichthardt and Gray 2001), and flowering seems to be restricted to plants in tall meadow vegetation and shrub patches, where the stems are much taller. Vegetative ramets are small and inconspicuous in the meadow vegetation.

Paired plots are very comparable with regard to abundance of Idaho phlox. The lowest frequencies and densities were found in pair 12-13, and the highest frequencies and densities in 14-15 (Table 2). Plots 14 and 15 are examples of "tall meadow" communities.

Frequencies of Idaho phlox in 2002 and 2003 is shown in Table 2. Frequency (percentage of microplots in which Idaho phlox occurred) is indicative of how well stems are distributed across the macroplot. For six of the eight plots, the number of microplots occupied in 2003 differed by

only 1 or 2 plots from 2002. In plot 11 the number decreased by six plots and in plot 15 it increased by four.

Table 2. Frequency of Idaho phlox in monitoring plots, 2002 and 2003. Shaded columns are plots within grazing exclosures.

	Plot							
	8	**9**	**10**	**11**	**12**	**13**	**14**	**15**
	# plots/30							
2002	6	9	13	20	3	1	20	14
2003	7	8	14	14	5	3	21	18

Stem density estimates are shown in Table 3. Small increases are indicated for four plots (10, 11, 12, and 14), but no significance tests were done. Plot 8 showed a decreased density (one stem/0.1 m^2), and plot 15 an increased density of nearly two stems/0.1 m^2. There is a large variation in stem density among microplots due to the clumped distribution of stems. For this reason, changes in frequency may be easier to detect.

Table 3. Density of Idaho phlox stems, 2002 and 2003. Shaded plots are within grazing exclosures.

	Plot							
	8	**9**	**10**	**11**	**12**	**13**	**14**	**15**
	Mean stem density (/0.1 m^2) [1]							
2002	2.6	1.9	2.6	3.4	0.3	0.6	11.7	6.3
2003	1.6	1.8	3.0	3.8	0.4	0.6	11.8	8.2

Most plots exhibit a gradient in vegetation related to distance from the stream (the only exception is plot 14). In these plots Idaho phlox is restricted to the side of the plot nearest the stream. In 2002, it was only found in transect 1 of plots 8 and 9. In 2003 the situation was similar, with the exception of a single stem in transect 2 (both plots). Only one flowering stem was found in microplots in 2002.

Frequencies of shrubs and large forbs

The 1 x 1 m sampling frames worked well for sampling alder buckthorn (*Rhamnus alnifolia*), western coneflower, and false hellebore, because frequencies between 30 and 80% were obtained in the majority of cases (Table 4). This plot size worked less well, but better than the 2 x 5 dm quadrats, for cow parsnip and panicle bluebells. For these species rooted frequency was detected in many cases where it had previously not been (compare with Table 1).

Table 4. Frequency of shrubs and large forbs, 2003. Shaded plots are in grazing exclosures.

	Plot size	Plot #							
		8	9	10	11	12	13	14	15
		Frequency (%)[1]							
Shrubs									
Rhamnus alnifolia	1x1 m	-	7	47	40	7	-	-	27
Symphoricarpos albus	2x5 dm	-	3	63	60	23	-	10	-
Large forbs									
Heracleum lanatum	1x1 m	-	-	7	13	-	-	-	60
Mertensia paniculata	1x1 m	-	7	40	20	-	-	20	7
Rudbeckia occidentalis	1x1 m	7	-	53	27	-	-	47	60
Veratrum californicum	1x1 m	13	-	-	7	33	67	73	73

[1] Based on 30, 2 x 5 dm plots or 15, 1 x 1 m plots.

Discussion

The recommendation that domestic grazers be removed from Idaho phlox habitat was based on the findings of Moseley and Crawford (1993, 1995). Their analysis indicated that grazing intensity had a relatively strong influence on the composition of meadow communities, including the loss of Idaho phlox from within and near one, 10 x 10 m plot. The mechanism by which cattle may have affected these meadows was not addressed. Casey Meadow and Casey Meadow north have had a long history of livestock use, which has been intensive at certain times. Historically, the effects of intensive livestock use on Idaho phlox habitat might be related to soil compaction and trampling, direct utilization of the plant, and/or alteration of the plant community.

Soil compaction would primarily be a problem in the spring when the soil is near saturation. During the summer the surface soil is dry. In places where cattle congregate and linger the vegetation is certain to be trampled—conditions under which weedy species have an advantage and can establish a satellite from which they can spread. Cattle favor grasses over forbs and shrubs, so as long as cattle are not confined to a small area, direct utilization of Idaho phlox is probably not a problem.

Cattle may alter the plant community in a variety of ways including 1) the introduction of weed seeds, 2) soil disturbance that allows weeds a foothold, and 3) by the increase of species that are either stimulated by grazing or avoided by grazers (increaser species). The effect of cattle on weed dispersal might be similar to that of elk (*Cervis canadensis*), which are also grazers, provided the cattle are not fed hay containing seeds of weedy forbs. The potential for soil disturbance would be related again to the stocking level and extent to which they are allowed to congregate within sensitive areas.

The factor with potentially the greatest effect on the plant community is the advantage gained by increaser species. Kentucky bluegrass (*Poa pratensis*) is a prime example. It increases under grazing pressure (Daubenmire 1970) and can form a solid sod, making it difficult for other species to germinate. Sulfur cinquefoil (*Potentilla recta*), a perennial forb, is avoided by grazers,

probably due to a high concentration of tannins in the leaves and stems (Sheley and Petroff 1999) and is therefore able to increase rapidly at the expense of other species. Ox-eye daisy (*Leucanthemum vulgare*) displaces other herbaceous vegetation by its dense growth (Bossard et al. 2000). Other aggressive non-natives observed in the monitoring plots include Canada thistle (*Cirsium arvense*), common St. John's wort (*Hypericum perforatum*), timothy (*Phleum pretense*), and creeping buttercup (*Ranunculus repens*).

Orange hawkweed was observed in Casey Meadow near plots 10 and 11. This is a new introduction in the area that has the ability to rapidly invade and dominate meadow sites and should be treated as soon as possible.

None of the meadow communities sampled are in a pristine condition. All have significant amounts of Kentucky bluegrass and six have the noxious weed sulfur cinquefoil. In contrast, sulfur cinquefoil was found in only two of the seven previously established monitoring plots (Lichthardt and Gray 2001). One of our concerns is that the prevalence of aggressive non-native plants in these plots could outweigh the effects of current grazing levels. Although exclusion from grazing should benefit native grasses and decreaser forbs, we fear that certain non-natives may continue to increase due to their intrinsic competitiveness.

Another factor that must be considered is the intensity of grazing. If the unprotected plots are not being used by cattle, then changes in the vegetation, or lack thereof, cannot be attributed to cattle grazing. Cattle are unloaded in Casey Meadow, and then dispersed into surrounding uplands. The cattle are immediately dispersed into the uplands and the permittee keeps them out of meadows containing Idaho phlox as best as possible. At the time our sampling was done we observed little evidence of cattle use. In future years it will be necessary to visit the plots in late summer to look for cattle sign and to assess vegetation utilization. Disturbance within the exclosures, such as by elk and deer, could also be checked. In order to answer our question about the effects of grazing, management may have to change to allow cattle use of unprotected plots ("grazed" treatment).

Recommendations

At a meeting in 2004 between IDCDC biologists, Brian Moser of Potlatch, and the USFWS, it was decided that a monitoring plan should be outlined that coordinated the long-term permanent plots, grazing exclosures, and landscape-level monitoring (Appendix 1). That meeting was followed up with a site visit.

The updated monitoring plan recognizes that grazing effects will only be detected over the long term and that the previously established plots (1-7) are valuable as controls and in assessing long-term trends. To detect changes in total extent of Idaho phlox, element occurrences (EO) will be updated at 5-yr intervals using GPS as a mapping tool and the IDCDC's element database to store disturbance and habitat-condition data. It was decided that a limited amount of cattle grazing would be allowed in the two meadows with grazing exclosures. Brian Moser will coordinate with the permittee to determine how this will be done. Juanita Lichthardt will submit budgets and proposals for monitoring, which will be conducted by IDCDC botanists.

In non-monitoring years, site visits will be made by Potlatch staff to make a subjective assessment of cattle presence and impact in the meadows, and to check for soil and vegetation disturbance, such as by game animals or rodents, within the exclosures. The permittee will be consulted about presence and duration of cattle in the two meadows.

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Appendix 1

Idaho phlox 10-year Monitoring Action Plan

Idaho phlox 10-year Monitoring Action Plan

2005 – Site visit, no monitoring.
2006 – Conduct long-term monitoring–funding to be provided by Potlatch
2007 – Conduct monitoring at grazing study sites–funding to be provided by Potlatch
2008 – Conduct site visits to all the existing EOs, update the habitat and threats information, and ensure the perimeters of the sites have been accurately mapped using a GPS--funding to be determined.
2009 – Quick visit to at least three sites by Potlatch staff.
2010 – Quick visit to at least three sites by Potlatch staff.
2011 – Conduct long-term monitoring–funding to be determined
2012 – Conduct monitoring at grazing study sites–funding to be determined
2013 – Conduct site visits to all the existing EOs, update the habitat and threats information--funding to be determined.
2014 – Quick visit to at least three sites by Potlatch staff.
2015 – Quick visit to at least three sites by Potlatch staff.

Each year will have a report generated and submitted to the U.S. Fish and Wildlife Service summarizing the results of the monitoring. If small invasive non-native plant populations are located during monitoring efforts, their locations will be reported to Potlatch so they may be carefully treated.

Appendix 2

Methods used in 2002 and 2003

Methods used in 2002 and 2003

In July of 2002, we conducted a reconnaissance of Casey Meadow and North Casey Meadow to identify sites for monitoring plots. Four sets of paired sites were ultimately identified. Sites were selected to contain a number of patches of Idaho phlox, to be as similar as possible within pairs (open/fenced), and to be equally accessible to cattle. It was soon apparent that the amount of Idaho phlox encompassed in a plot would be maximized by placing one edge of the plot along the stream, in taller meadow vegetation. All plots have one side along the stream (Casey Creek) with transects running parallel to this side (Appendix 4). Idaho phlox was usually most abundant at the stream edge, or even restricted to that side of the plot. Exclosures may show whether this is related to disturbance and grazing by cattle.

Once paired plots had been located, a coin toss was used to determine which would be enclosed (protected from cattle by four-strand barbed-wire fencing). Plots were numbered 8-15 to differentiate them from the seven permanent plots previously established for monitoring Idaho phlox. Even-numbered plots are within exclosures, with the pair being the next consecutive number (8 and 9, 10 and 11 etc.).

We wanted the sampling design to be compatible with that used at previously established monitoring plots for Idaho phlox, which utilize a 10 x 10 m macroplot, with 2 x 5 dm microplots placed at 1-m intervals along five transects. To cut down on sampling time, we used three such transects, resulting in 30 microplots per plot. Most transects are marked with steel fenceposts at one or both ends. Others are marked with a length of rebar. Sketches were made of plot layout and orientation of transects. Photos were taken of all except plot 13 and are filed at the IDCDC.

The number of microplots in which Idaho phlox occurred was used as a measure of frequency, and the number of ramets per microplot as a measure of density. Community composition was described by estimating canopy cover, in each microplot, by life form group and species (where practical) using cover classes (1 = <5% and 10, 20 … 90 each represent the midpoints of 10% classes). There are a number of small, caespitose native sedges that were lumped as "other native sedges." Water sedge (*Carex aquatilis*) was recorded separately because it is a large species with high cover.

In tall meadow vegetation, where the sampling frame could not be worked down to the ground without significant disturbance of the cover, the observer would hold the sampling frame up at the upper canopy level and estimate cover of that level before lowering it to the ground to look at the ground layer.

Because frequency is generally measured as rooted frequency, we noted with an asterisk any cover values that were due to plants not rooted within the microplot, and these were not used in calculating frequency. In this way frequency can be calculated for any of the species recorded.

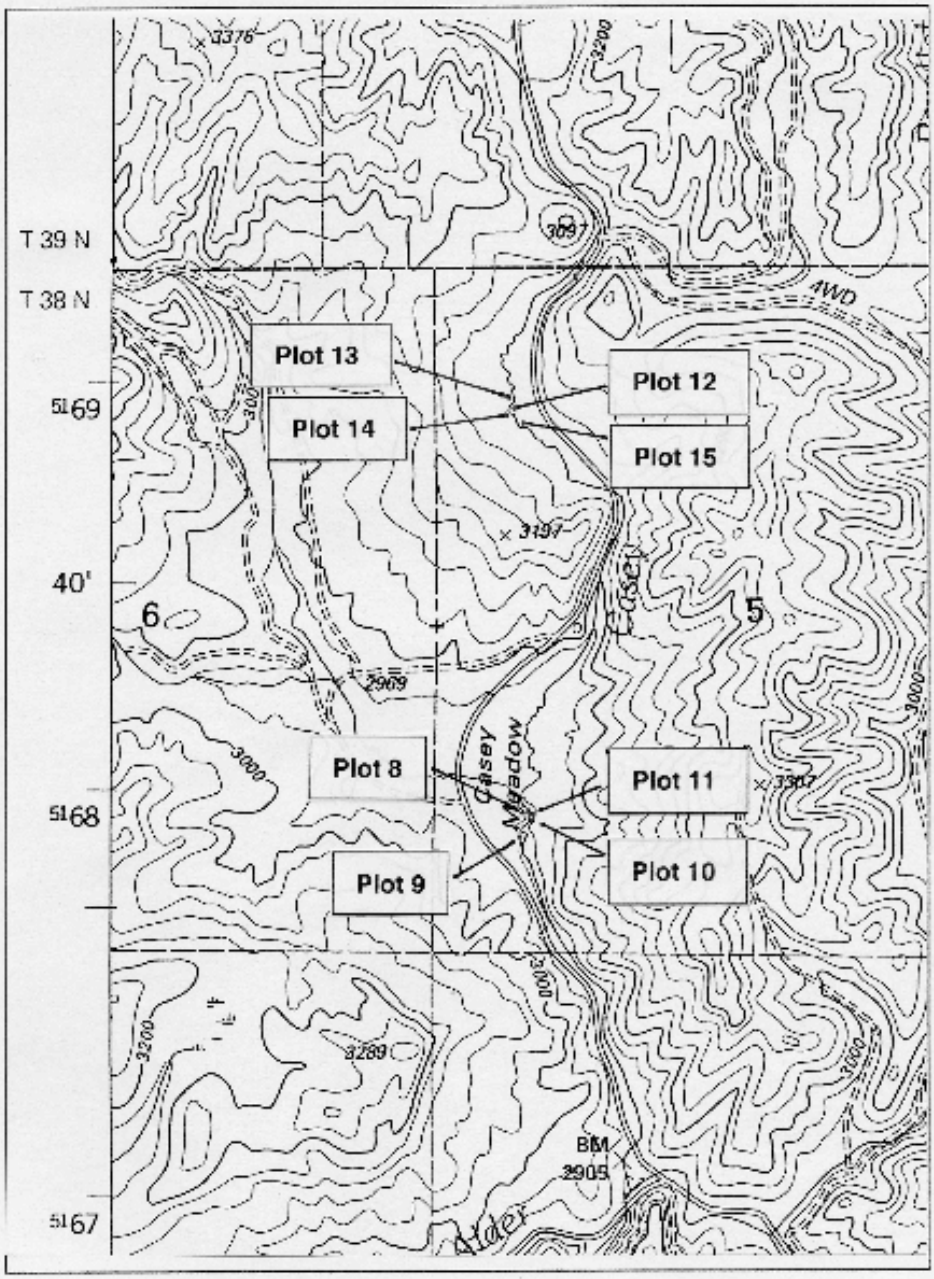
Exclosures are 14 x 14 m in size to allow room for a 2-m buffer around a 10 x 10 m macroplot. Plot 10 is an exception. It is 12 x 14 m due to space constraints. However, a much smaller buffer was sometimes allowed in order to keep transect 1 close to the stream in all cases. Exclosures were constructed in June, shortly following sampling.

In 2003, we sampled large forbs and shrubs using a larger, 1 x 1 m quadrat that was better at quantifying large, widely spaced plants. Snowberry was an exception among shrubs in that it was common enough to be sampled with the 2 x 5 dm quadrat. The larger quadrats were placed in the

same way, with one side at zero on the tape. Allowing a meter between quadrats meant that only 5 quadrats could be place along each of the three transects.

Appendix 3

Map of plot locations



Locations of Idaho phlox monitoring plots 8 – 15. Even-numbered plots are within grazing exclosures. A portion of Headquarters 7.5' quad.

Appendix 4

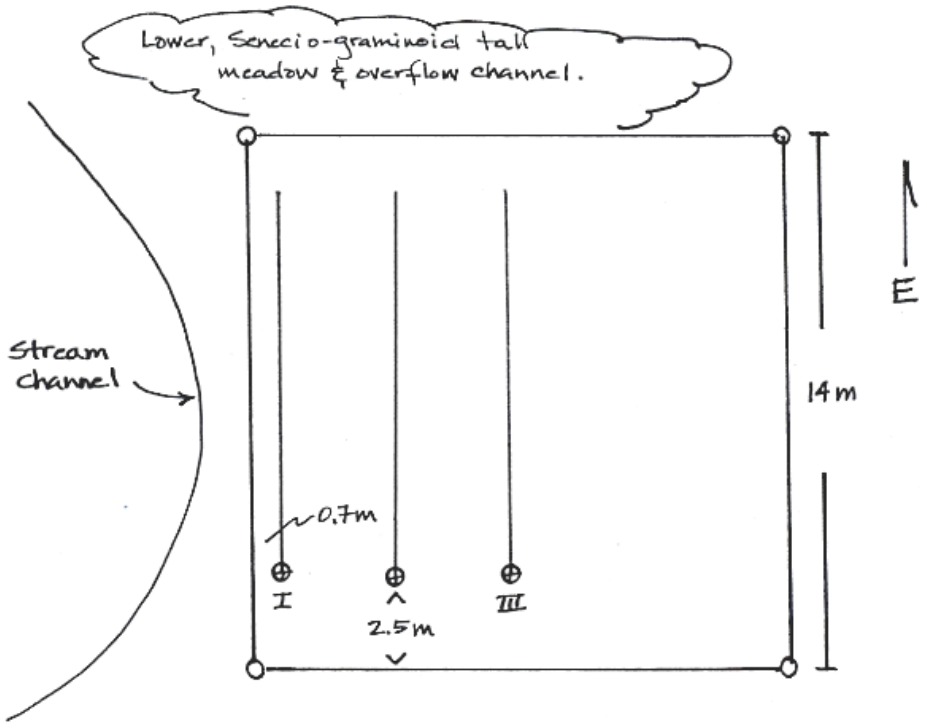
Layout of plots

General–Exclosures are 14 m x 14 m. Transects are 10 m long and 3 m apart. Compass declination was set to 0. Even numbered plots are within exclosures.

As you look from the beginning of transect, microplots are placed on the right side of tape with 0.2 dm end flush with tape, starting at 0.

All diagrams are oriented with the transect starting points at the bottom. Direction of the transects is different in each case.

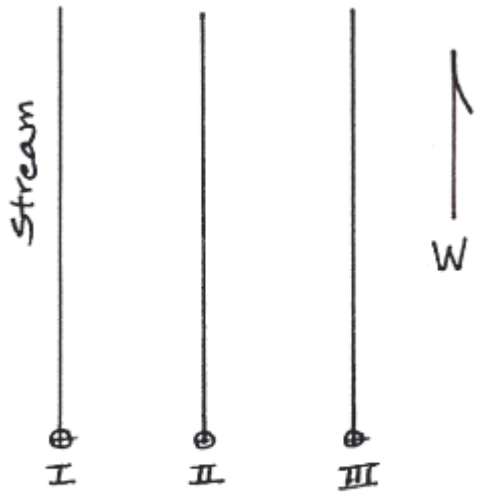
Plot 8–Casey Meadow, west side of Casey Creek (exclosure). Baseline randomly located 0.2 m in from the west edge of the macroplot. Transects run from west to east, with transect 1 nearest the stream, approx. 0.7 m from the north fenceline which was not yet constructed at time of sampling. The start of each line is marked with a steel fencepost, the ends with rebar. Vegetation grades from tall-meadow vegetation near stream, to short meadow dominated by California brome (*Bromus carinatus*), colonial bentgrass, and timothy, further out. False hellebore occurs in east 1/3 of exclosure. Sampled June 24, 2002.



Plot 8

Plot 9–Casey Meadow, west side of Casey Creek (open). Transects run from east to west with transect 1 nearest the stream in water sedge--alkali-marsh butterweed.

Latitude/longitude coordinates (NAD27): 46º39.659'N, 115º51.704'W

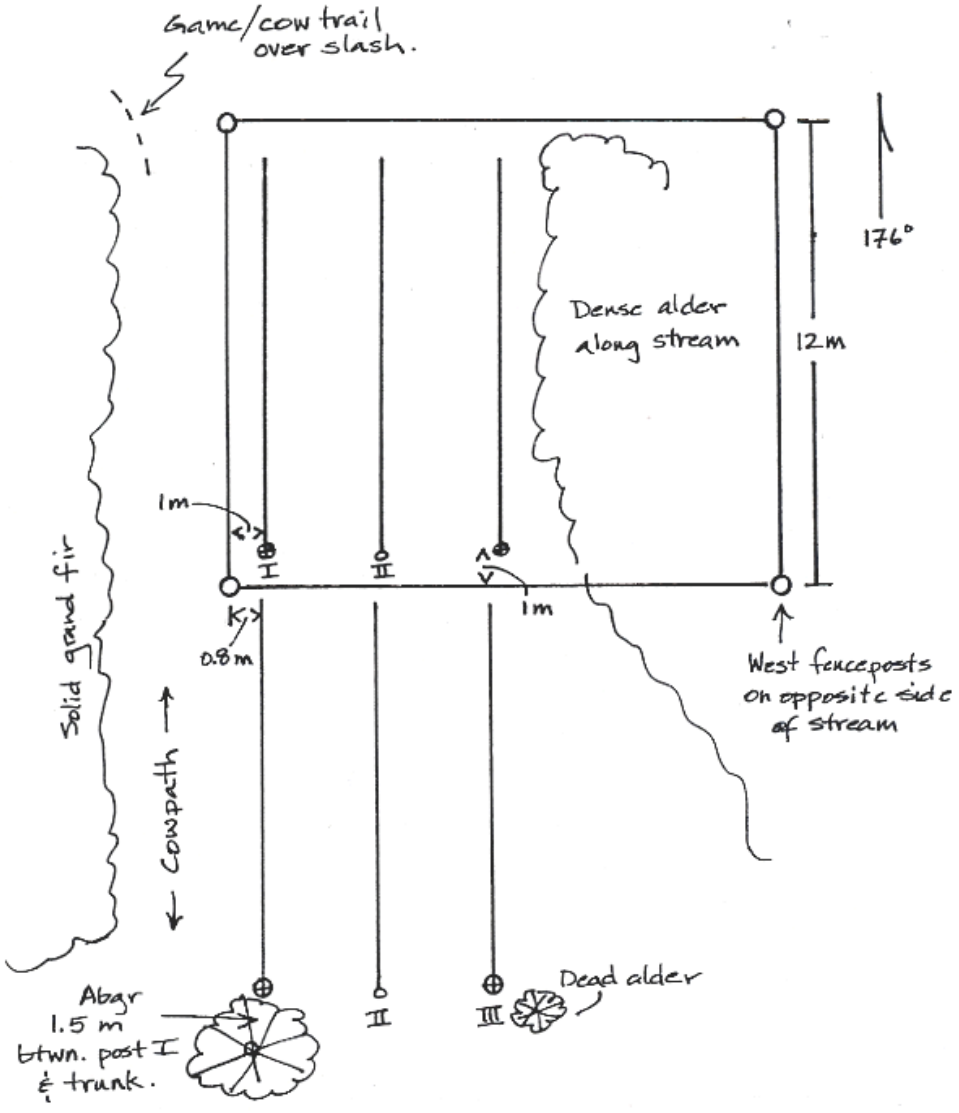


Plot 9

Plot 10–Casey Meadow (exclosure). Transects run from north to south (176º) with line 1 *furthest* from the stream (unusual in this respect). Fenceposts mark start of lines 1 and 3. Transects start approximately 1 m south of fenceline (fence not yet constructed at time of sampling). Due to space constraints, the N/S fencelines are only 12 m.

Plot 11–Casey Meadow (open). Immediately north of plot 10 exclosure. Transects run from north to south (176º) with line 1 *furthest* from the stream. Fence posts mark start of lines 1 and 3, and rebar line 2.

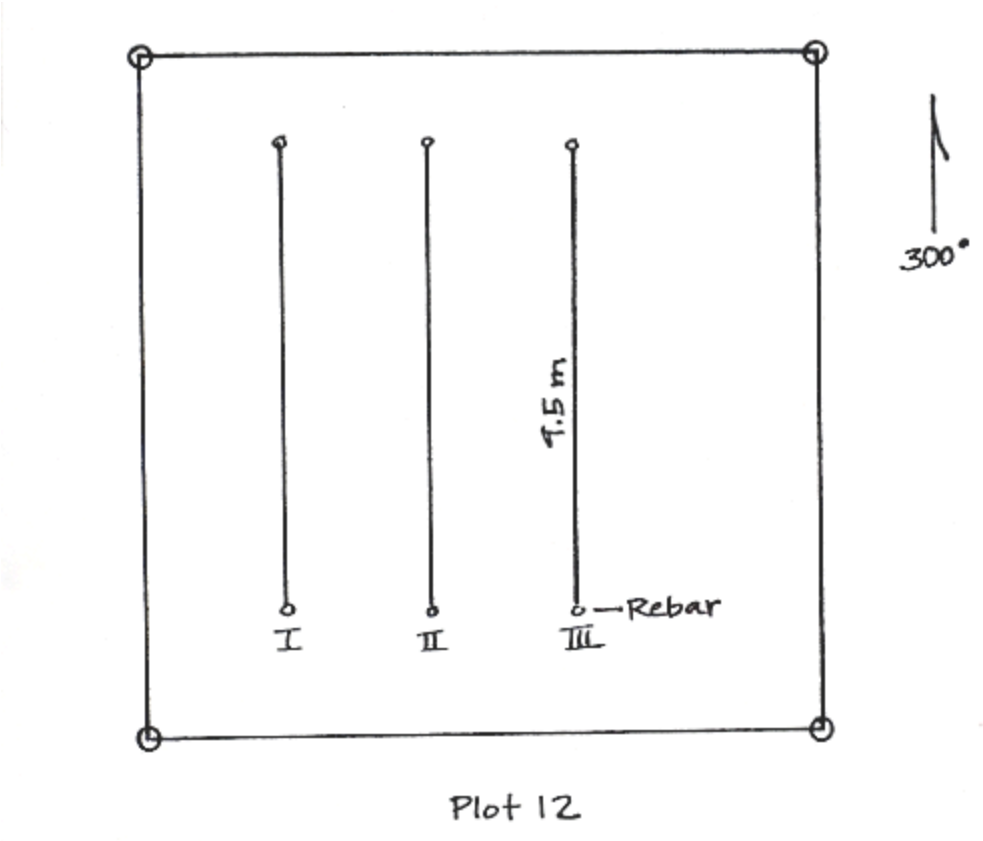
Latitude/longitude coordinates (NAD27): 46º39.680'N, 115º51.679'W



Plots 10 (exclosure) & 11 (open)

Plot 12–Casey Meadow North (exclosure). Transects (marked with short rebar) run south to north (300º) with line 1 closest to the stream.

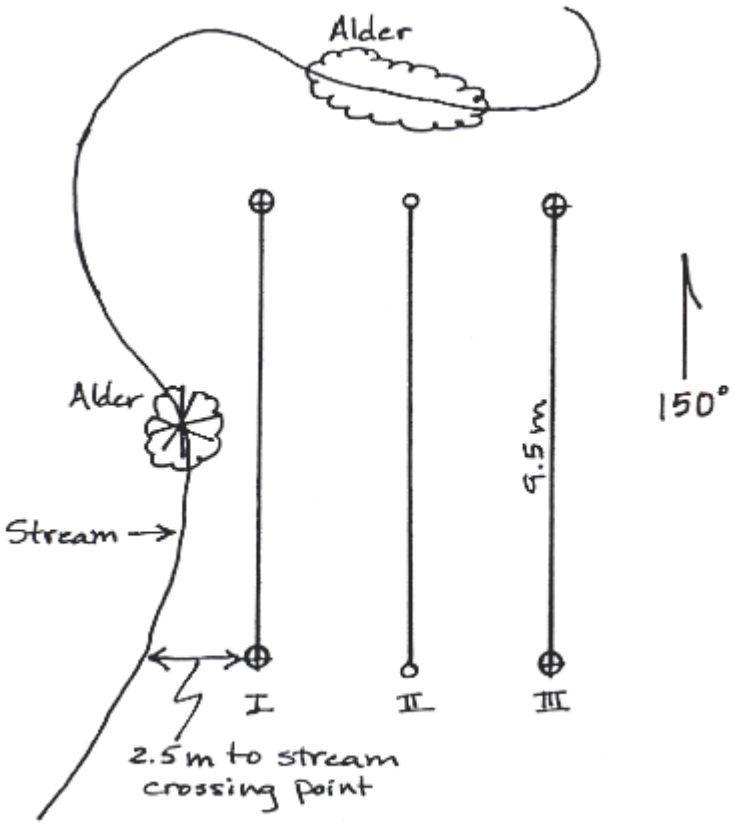
Latitude/longitude coordinates (NAD27): 46º40.219'N, 115º51.704'W



Plot 12

Plot 13–Casey Meadow North (open). Transects 1 and 3 marked at both ends with fenceposts, and transect 2 with rebar. Transects run from north to south at 150º with transect 1 nearest the stream (all transect end points are also near stream).

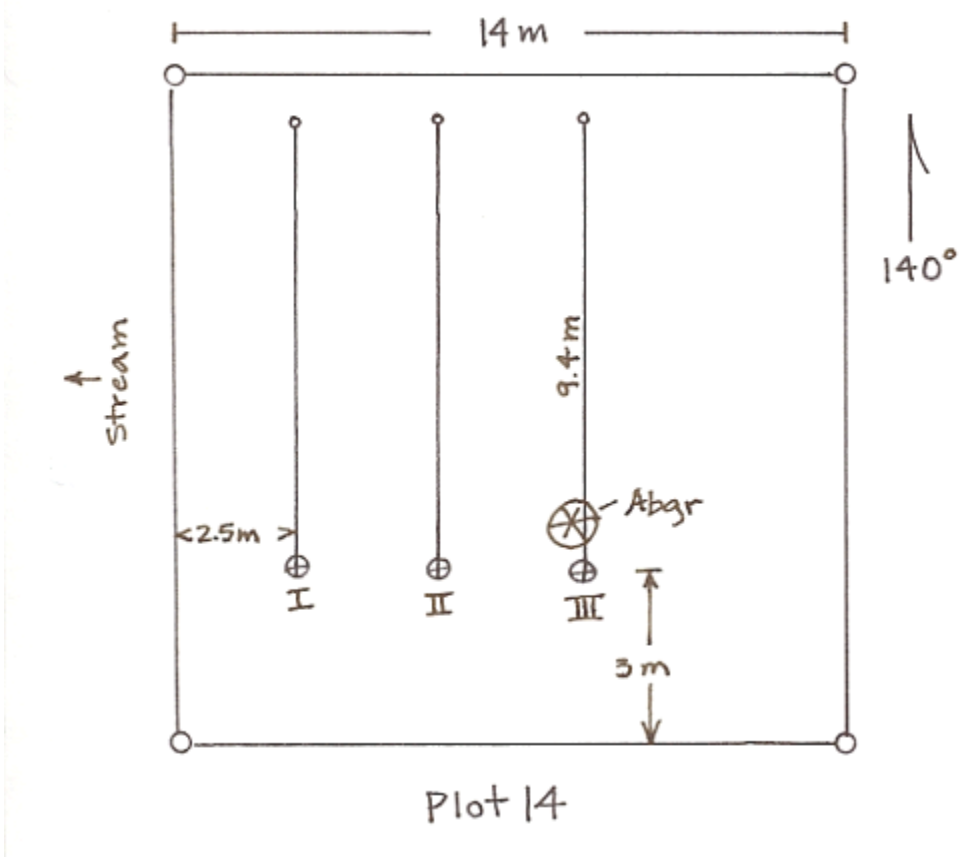
Latitude/longitude coordinates (NAD27): 46º40.242'N, 115º51.726'W



Plot 13

Plot 14–Casey Meadow North (exclosure). East side of Casey Creek. Baseline randomly located 3 m inside the north fenceline (fence not yet constructed at time of sampling). Transects run from north to south (140º).

Latitude/longitude coordinates (NAD27): 46º40.220'N, 115º51.723'W



Plot 15–Casey Meadow North, east side of stream (open). Transects run from south to north at 300º with transect 1 nearest the stream. Transects 1 and 3 marked at both ends with fenceposts, transect 2 at beginning only (rebar at end). From the railroad bed (parking) it is about 35 m at 200º to the end of line 3.

Latitude/longitude coordinates (NAD27): 46º40.205'N, 115º51.703'W