Botrychium Monitoring and Information Gaps

Interagency Special Status Species Program
Final Report April 2012

Botrychium ascendens, Guard Station Meadow, photo by Kirk Larson

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Introduction

The objective of the project is to determine population trends of six Sensitive *Botrychium* species (Table 1) (USDA FS 2011) at 12 sites (Appendix 1) on the Colville National Forest. In the summers of 2010 and 2011, 11 permanent monitoring plots and 12 permanent monitoring transects were read at a total of 12 sites.

Table 1. Rarity Rankings of Taxa. The key to rankings is below the table.

Taxa	**Global Rank**	**Federal Status**	**WA State Rank**	**WA State Status**
Ascending moonwort *(Botrychium ascendens)*	G2G33	SC	S2	S
Crenulate moonwort *(Botrychium crenulatum)*	G3	SC	S3	S
Western moonwort *(Botrychium hesperium)*	G3G4		S1	T
Skinny moonwort *(Botrychium lineare)*	G2?		S1	T
Two-spiked moonwort *(Botrychium paradoxum)*	G2	SC	S2	T
Stalked moonwort *(Botrychium pedunculosum)*	G2G3	SC	S2	S

Global Rank
G2 = Imperiled globally (6 to 20 occurrences).
G3 = Either very rare and local throughout its range, or found locally in a restricted range (21 to 100 occurrences).
G4 = Apparently secure globally.

USFWS Federal Status
SC = Species of Concern. An unofficial status, the species appears to be in jeopardy, but insufficient information to support listing.

Washington State Rank
S1 = Critically imperiled (5 or fewer occurrences).
S2 = Imperiled (6 to 20 occurrences), very vulnerable to extirpation.
S3 = Rare or uncommon (21 to 100 occurrences).

Washington State Status
S = Sensitive. Vulnerable or declining and could become Endangered or Threatened in the state.
T = Threatened. Likely to become Endangered in Washington.

Although *Botrychium ascendens* was included in the proposal for this project, there were not enough plants found to include it. On the Colville National Forest *B. ascendens* is documented from Guard Station Meadow, where 48 plants were discovered in 1995 near a cattle trough. Plants were caged with a wire cattle exclosure. In 2002 19 plants were seen and 3 in 2003. None have been seen since. Guard Station Meadow is a large 87-acre meadow that has been treated with herbicides for meadow hawkweed. All other proposed work was completed and is described in Table 2.

Table 2. Proposed *Botrychium* Monitoring Work and Status.

	Proposed Work	**Status**
1	Read 25 permanently marked transects at 12 locations, including six Sensitive species	11 permanent monitoring plots and 12 permanent monitoring transects were read at a total of 12 sites.
2	Analyze data using paired *t*-tests for all sites listed to assess population trends.	See Results #5.
3	Assemble a description of habitat in terms of soil type and when past disturbances (fire, timber harvest, and grazing histories and intensities) occurred	See Results #4.
4	Compare plant counts with the previous year's weather (e.g., dry winter/wet spring) to evaluate possible patterns.	See Results #3.
5	Complete sighting and survey forms for all Sensitive taxa, resulting from FY10 and FY11 monitoring. Record data on the sensitive plant GIS layer and in the NRIS database.	Completed (USDA FS 2012f).
6	Compile all of the above for each site into a report.	Completed.

Figure 1. *Botrychium ascendens*, Guard Station Meadow, photo by Kirk Larson.

Figure 2. *Botrychium crenulatum*
Colville National Forest
Photo by Botany Crew.

Figure 3. *Botrychium hesperium*
Paradise Meadow
Photo by Botany Crew 6/30/2009.

Figure 4. *Botrychium lineare*
Bailey Creek
Photo by Botany Crew 7/3/2007.

Figure 5. *Botrychium paradoxum*
Bestrom Meadow
Photo by Botany Crew 7/12/2010.

Background

In the 2007 Region 6 "Conservation Assessment for 13 Species of Moonworts (*Botrychium* Swartz Subgenus *Botrychium*)," Dr. Cindy Johnson-Groh summarized:

> "…the impact of disturbance on *Botrychium* is poorly understood. Some species of *Botrychium* clearly prefer old disturbance sites, whereas others do not. Sites, which were disturbed approximately ten years ago, seem ideal habitat for many species of *Botrychium*. Roadside ditches, campgrounds, ski hill runs, avalanche chutes, and railroad right-of-ways are common habitat for moonworts. Seemingly suitable sites that have been disturbed more recently or longer ago often do not support moonworts or support smaller populations. …..Historic disturbance appears to be an important factor for moonwort establishment. Nothing is known about the mechanisms of this behavior and little is known about the impact of recent disturbances on extant populations."

This project contributes towards answering several questions concerning the management of moonworts, which were identified in the 2007 Region 6 "Conservation Assessment for 13 Species of Moonworts (*Botrychium* Swartz Subgenus *Botrychium*) (2007):"

- What specific site characteristics are necessary to maintain existing occurrences? What microclimate/microsite conditions favor survival, growth, and reproduction of moonworts?
- How can we identify high likelihood habitats for these species in order to prioritize inventory efforts or to ensure habitat conservation?
- Is there a correlation between the previous year's weather (e.g., dry winter/wet spring) and high or low population counts during the summer?
- What level of disturbance (overstory removal, grazing, fire, etc.) do these species tolerate?
    - Some sites are flat benches associated with old river or stream terraces where soils are alluvial in origin. Are periodic floods part of the natural disturbance regime at these sites and, if so, what effect does this disturbance have on *Botrychium*?
    - How do populations vary in livestock grazed and ungrazed sites? How is this affecting *Botrychium* microsites? How much grazing is too much/enough?
    - What is the fire ecology of *Botrychium*?

Also addressed in this project are several information gaps described in the 2007 R6 *Botrychium* Assessment:

- Population trends.
- Effective management areas (sizes) and habitat characteristics necessary to maintain known occurrences in project areas.
- Short-term and long-term effects of timber harvest, grazing, recreation, fire, fire suppression, and exotic plants on the maintenance of known occurrences.
- Identification of high likelihood habitat, to help prioritize surveys and ensure appropriate habitat conservation.

The monitoring sites on the Colville National Forest were chosen for the presence of Sensitive taxa and ongoing disturbances, i.e., spring stream scouring, cattle grazing, and/or gopher activity.

They are on Three Rivers and Sullivan Lake Ranger Districts on the Colville National Forest and include seven cattle allotments.

Since so little is known about *Botrychiums*, 12 permanent transects at six locations (five in western red-cedar forests and one in a grazed homestead meadow) were established on the Colville National Forest in 1995 by contractor Peter Lesica. His 1995 report, "Monitoring *Botrychium crenulatum* and *B. pedunculosum* on Colville National Forest" described transect designs, locations, and data analysis methods used for monitoring trends in plant density. The proposed data analysis for these transects would test the hypothesis that there is no change occurring in the density of plants over time. The simplest way to test this hypothesis was to compare microplot densities between the first and last recording years using paired t-tests.

Botrychiums, however, often remain alive underground without putting up a visible frond during one or more consecutive growing seasons. A significant difference in plant density between any two years could be the result of either a real trend or differences in the proportion of summer dormant plants perhaps caused by inter-annual climatic fluctuations. Thus, it is necessary to take into account fluctuations in observed density caused by short-term climatic vagaries when testing for long-term trends. Two possible sampling schemes and four possible statistical models for doing this are described in Lescia's 1995 monitoring report.

From 1996 to 1998 five more permanent plots on the Colville NF were established in areas with cattle grazing. Fenced exclosures with permanent plots were built in two meadows (Bestrom and Big Muddy) to compare grazing versus no grazing effects. The forested Bailey Creek and Flat Creek sites were fenced to protect rare *Botrychiums* from cattle grazing. In 2010 permanent plots were established in forest openings at Peltier to monitor disturbance by gophers.

Methods

All work was conducted by Forest Service employees. Locations with general habitats and descriptions of plot designs are shown on Table 3. Transects and macroplots are permanently marked on the ground with red painted rebar locating end or corner locations. An aluminum stake with a numbered tag is placed in the ground two inches north of each plant, so that the tag is even with the ground surface. The number of the tag was recorded on data sheets. For clumps of plants, a corresponding number of tags were placed on one stake. Appendix 2 summarizes plot descriptions. Data was recorded from 11 permanent monitoring plots and 12 permanent monitoring transects at a total of 12 sites from 1995-2011.

Survey and sighting data were entered into the Forest Service NRIS TES Plants database for all monitoring work. The Peltier Homestead Meadow replaced the Guard Station Meadow wire cage exclosure because of the high number of plants at Peltier and the on-going gopher activity. Since not all sites were monitored each year, moving averages were calculated to assess population trends (Jackson 2012), where there was not data for two-tailed paired t-tests. Disturbance histories, soil types, and weather pattern comparisons with plant counts are described for each site.

Table 3. Permanent Sites Monitored with Location Information, Habitat, and Description of Plots.

Site Names, Elevations (feet)	**Species, Abbreviation, Element Occurrence #**	**Quadrangle, Township Range Section, ¼ Section**	**Habitats**	**Population Size in Year Last Monitored, Description of Monitored Areas**
Bailey Creek, 3300	*B. lineare*, BOLI7, EO#001	Jacknife Mtn. T37N R36E S30 SE/SE	Fenced, western red-cedar/ hemlock forest	175m^2 -- Plants are flagged within a fenced area of 1400m^2.
Bestrom Meadow, 3440	*B. hesperium*, BOHE5, EO#004 Subpop. #1; *B. paradoxum*, BOPA9, EO#014 Subpop. #2	Park Rapids T36N R41E S16 NW/NW	Grazed homestead meadow, fenced and unfenced plots	480m^2 -- 2 macroplots, one fenced and one unfenced, each is 12m by 20m with 20 microplots of 3m by 4m.
Big Muddy, 3280	*B. hesperium*, BOHE5, EO#012 Subpop. #1	Ione T37N R42E S10	Grazed home-stead meadow, fenced and unfenced plots	56m^2 – 2 14m transects, 14 1m^2 plots are read on the north side of the transect and 14 along the south for each transect, fenced area is 256m^2.
Deadman Creek, 2475	*B. crenulatum*, BOCR, EO#063	Jacknife Mtn. T37N R36E S28 NE/N	Grazed western red-cedar/ hemlock forest	41m^2 – one macroplot 18m by 20m with 20 circular microplots of 1.5m.
Dominion Meadows, 3250	*B. pedunculosum*, BOPE4, EO#001	Park Rapids T36N R41E S31 NW/NW	Grazed homestead meadow	159 m^2 -- 3 transects. North transect is 50m long with 1m$^{2.}$ Middle transect is 50m long with circular microplots with a radius of 1.5 meters. South transect is 50m long with 25 microplots 1m by 2m.
East Fork Crown Creek, 2500	*B. crenulatum*, BOCR, EO#048 Subpop. #2	Belshazzar Mtn. T40N R38E S26 NW/SE	Old roadbed, trampled, western red-cedar/ hemlock forest	23m^2 – 2 transects. South transect is 30m long with 10 1m^2 micoplots along the transect. North transect is 40m long with 31m^2 microplots along the transect.
Flat Creek Tributary, 3275	*B. crenulatum*, BOCR, EO#012 Subpop. #1	Belshazzar Mtn. T40N R38E S32 NW/NW	Fenced, grazed western red-cedar/hemlock forest	26m^2 -- 2 macroplots. North macroplot is 6m by 2m with 6 1m by 2m microplots. South macroplot is 7m by 2m with 7 microplots 1m by 2m.

Table 3. Continued				
Site Names, Elevations (feet)	**Species, Abbreviation, Element Occurrence #**	**Quadrangle, Township Range Section, ¼ Section**	**Habitats**	**Population Size in Year Last Monitored, Description of Monitored Areas**
Hodgeson Creek, 3990	*B. crenulatum*, BOCR, EO# 032 Subpop. # 1	Boyds T38N R36E S35 NW/NW	Western red-cedar/hemlock forest	$140m^2$ -- 3 transects, each 45m long with 15 circular microplots with 1m radius.
Paradise Meadow, 3320	*B. hesperium*, BOHE5, EO#001, *B. paradoxum*, BOPA9, EO#009 Subpop. #1	Deep Lake T38N R41E S15	Grazed homestead meadow	$104m^2$ – 1 28m transects and one 1 m^2 plot with $1m^2$ microplots.
Peltier Meadow, 3200	*B. hesperium*, BOHE5, FO# 021 Subpop. #1	Ione T37N R42E S14 SW/SW	Small grazed homestead, forest openings	$1000m^2$ -- 2 macroplots. #1 7 circular microplots each with a radius of 1m. # 2 is an area of 35m by 35m.
Road 755, 3640	B. crenulatum, BOCR, EO#046	Boyds T37N R36E S2 SE/SW	Grazed western red-cedar/ hemlock forest	$6m^2$ -- 1 29m transect with 28 1m by 2m microplots along the transect.
Rose Ranch, 2760	*B. hesperium*, BOHE5, EO#009	Belshazzar Mtn. T 40N R38E S22 SE/NW	Grazed homestead meadow	$125m^2$ -- 2 transects. North transect is 24m long with 6 circular microplots plots with a radius of 2m along the transect. South transect is 50m long with 1m by 2m microplots.

Results

Results of this project are organized by questions and information gaps identified in the 2007 Region 6 "Conservation Assessment for 13 Species of Moonworts (*Botrychium* Swartz Subgenus *Botrychium*) (2007)."

<u>1. What specific site characteristics are necessary to maintain existing occurrences? What microclimate/microsite conditions favor survival, growth, and reproduction of moonworts?</u>

We gathered landform and land type information (USDA FS 1998) for each of the locations (Appendices 3 and 4) and evaluated them for similarities. Of the twelve monitoring sites, five are in the Massive Crystalline Landform Group (Big Muddy, Dominion, Hodgeson Creek, Paradise, and Peltier), two are in the Foliated Crystalline (Bailey Creek and Road 755), and two are Pre-Cambrian Bedrock Units of the Belt Super Group (Bestrom and Rose Ranch).

Regarding Land Type Associations, seven occur in Glacial Moraines (Bestrom, Big Muddy, Dominion, Paradise, Peltier, Rose Ranch, and Road 755); two are Glaciated Mountain Slopes (Flat Creek, Hodgeson Creek); two more in Valley Bottoms/Outwash (Deadman Creek and East Fork Crown Creek); and one is Scoured Glaciated Mountain Slope (Bailey Creek).

Soils (USDA NRCS 2012) and climate information is found in Appendix 5. Parent material is generally volcanic ash and loess over glacial till. Soils are mostly well-drained, available water capacity ranges from low (3.3 inches) to high (12 inches), and typical soil profiles are loam (silt, sandy or stony). Frost free days range from 70-120, average annual precipitation spans from 21 to 33 inches, and maximum precipitation ranges from 29 to 41 inches. In addition, aerial photos (Appendix 6) illustrate changes in the general shapes of the meadows over time, as well as canopy cover differences for forest locations.

The *Botrychiums* that occur in the meadows seem to favor sites with old disturbance, old homesteads, and old gopher activity. One year at Big Muddy gophers essentially tilled up the unfenced transect. For several years there were little to no *Botrychiums* present in the transect. Recently there have been a few more *Botrychiums* coming up in the transect, but not in large numbers. This site should continue to be monitored to see if more of the plants return.

At Peltier approximately half of the forest opening with the South macroplot was dug up by gophers in 2009. The bare ground had little to no vegetation of any kind including *Botrychiums*. The edge of the opening had evidence of older gopher disturbance and was teaming with *Botrychiums*. It will be interesting to monitor this site to see if the "newly disturbed" area will fill in with new plants, if the "old disturbed" area will continue to support a large number of plants, if the population will slowly decline due to lack of disturbance, or if the gophers will till up this area.

2. How can we identify high likelihood habitats for these species in order to prioritize inventory efforts or to ensure habitat conservation?

Aerial photos (Appendix 6) (USDA FS 2012a and USDA FS 2012c) are helpful in identifying openings and meadows, such as Bestrom, Dominion, Paradise, and Peltier. Historic aerial photos can be useful to locate old openings, which may be or may have been closed-in by encroaching forests. Although aerial photos are not very helpful in locating forested sites such as Bailey Creek and Road 755, working with other disciplines (i.e., hydrology, soils, and fisheries) is essential for their knowledge of potential habitats.

Associated species are displayed in Appendix 7. For meadow sites 57 associated species have been tallied and 68 in forest locations. The most frequently occurring taxa at the monitoring sites are exhibited in Table 4. The "Frequency" numbers indicate how many sites of the 12 that the associated species was found in.

Table 4. Frequently Occurring Associated Species.

Species	**Frequency**	**Comments**
Meadow Sites		
Fragaria virginianum	5	Long suspected as an indicator species
Trifolium repens	5	Perhaps planted as forage
Achillea millefolium	4	Very common
Botrychium simplex	4	*Botrychiums* occur in clusters of *Botrychium* species
Fragaria vesca	4	Long suspected as an indicator species
Hieracium pratense	4	Non-native invasive
Leucanthemum vulgare	4	Non-native invasive
Prunella vulgaris	4	Very common
Pinus contorta	3	Long suspected as an indicator species
Forested Sites		
Ribes lacustre	6	Not thought of as an indicator species for *Botrychiums*
Thuja plicata	6	Long suspected as an indicator species
Picea engelmannii	5	Not thought of as an indicator species for *Botrychiums*
Alnus sinuata	5	Not thought of as an indicator species for *Botrychiums*
Adenocaulon bicolor	4	Not thought of as an indicator species for *Botrychiums*
Asarum caudatum	4	Not thought of as an indicator species for *Botrychiums*
Betula papyrifera	4	Not thought of as an indicator species for *Botrychiums*
Cornus stolonifera	4	Not thought of as an indicator species for *Botrychiums*
Aralia nudicaulis	2	A component of the THPL Plant Association (THPL/ ARNU2)

3. Is there a correlation between the previous year's weather (e.g., dry winter/wet spring) and high or low population counts during the summer?

Since the precipitation data was for calendar years, we could not separate seasonality of precipitation (e.g., dry winter/wet spring). Graphs of plant totals with annual precipitation (Appendix 8) did not indicate a correlation between precipitation and plant abundance (USDA FS 2012d).

4. What level of disturbance (overstory removal, grazing, fire, etc.) do these species tolerate?

A compilation of the history of grazing (USDA FS 2012e), homesteading (USDI BLM 2012), fire (USDA FS 2012b) and logging for each site is displayed on Table 5.

a. Some sites are flat benches associated with old river or stream terraces where soils are alluvial in origin. Are periodic floods part of the natural disturbance regime at these sites and, if so, what effect this disturbance has on *Botrychium*?

Deadman Creek has a stable population of *Botrychium crenulatum*. The macroplot lies in a floodplain that has not recently (within the time it has been monitored) been catastrophically flooded. There is some evidence that water pools in surface depression, but there has been no recent scouring. Continuation of monitoring at this site would be useful to observe whether the plants here undergo some sort of cycle where there are no vegetative plants vs. vegetative plants produced, perhaps due to the stability of the site. There is also the possibility that a catastrophic flood event may occur, which could dramatically change the site (filling in the depressions or total obliteration). Continued monitoring of this site would provide the opportunity to track short term and long term effects of such an event.

The North Transect of the Flat Creek location of *Botrychium crenulatum* is in a depression on a floodplain. Although the population appears to be stable, bank erosion at the South Transect of this site may provide an opportunity to monitor new subpopulations downstream.

Table 5. History of Grazing, Homesteading, Fire and Logging for Each Site.

Site Name	Allotment, Pasture	Grazing	Current Practices	Homesteading	Year of Fire & Logging
Bailey Creek	CC Mountain, CC	Livestock grazing originally by sheep beginning in early 1920's. Sheep use discontinued in 1944. From 1945 to 1948 area was not grazed. In 1949 Diamond M Ranch issued grazing permit used continuously to 1979. In 1978 rest and rotation grazing management initiated.	Active grazing permit. Exclosure constructed in 1999. Cows in it 2007 & 2008.	None	1929 Fire
Bestrom Meadow	South Fork Mill Creek, Bestrom	Purchased from homesteaders/other landowners by Resettlement Administration in 1938. Earliest grazing record, 1943, shows season-long (5/1-10/31) grazing practiced until mid-1950's. Bestrom Meadow fenced by 1976. A portion of Bestrom Meadow was tilled in 1978 to "break up the sod and stimulate new growth."	Active grazing permit. Exclosure constructed 1998.	Serial Patent, WA State; Issued 2/3/1916 Elmer E. Bestrom, Land Office: Spokane, WA 5/20/1862 Homestead Entry Original (12 Stat. 392) Total acres: 160.	1929 Fire
Big Muddy	Tiger Hill, Tiger Hill	Allotment grazed since early 1930's after it burned; land was privately owned. Purchased by government under Resettlement Act of 1937, placed under Forest Service administration in 1938. Cattle have grazed since 1938. In 1962-1963 rest and rotation grazing management initiated. 1935 aerial photo shows the entire area around the plots devoid of trees. 2009 NAIP image shows most of the area with tree cover.	Active grazing permit. Exclosure constructed 1997.	Serial Patent, WA State Issue Date: 3/1/1911 August George Olson, Land Office: Spokane, WA Authority: 4/24/1820: Sale-Cash Entry (3 Stat. 566) Total Acres: 160.	1929 Fire

Table 5. Continued.					
Site Name	**Allotment, Pasture**	**Grazing**	**Current Practices**	**Homesteading**	**Year of Fire & Logging**
Deadman Creek	CC Mountain, Deadman	Livestock grazing originally by sheep beginning in early 1920's. Sheep use discontinued in 1944. From 1945 to 1948 area was not grazed. In 1949 Diamond M Ranch issued a grazing permit, used continuously to 1979. In 1978 rest and rotation grazing management initiated.	Active grazing permit.		
Dominion Meadow	South Fork Mill, Not in a designated pasture.	South Fork Mill Creek Allotment land purchased from homesteaders/other landowners by Resettlement Administration in 1938. Earliest grazing record, 1943, shows season long (5/1-10/31) grazing practiced until the mid-1950's.	Active grazing permit.		
East Fork Crown Creek	Elbow Lake, Crown Creek	Williams & Guglielmino partnership (E-side allotment: no formalized management system). Actual grazing records date back to 1943. The area was grazed prior to that time.	Active grazing permit,		Crown Timber Sale late 1980s
Flat Creek Tributary	Elbow Lake, Flat Creek	Len McIrvin (W-side of allotment; modified rest-rotation system of management; 3 year, 4 pasture cycle). Actual grazing records date back to 1943. The area was grazed prior to that time.	Active grazing permit. Exclosure constructed 1998. Cows inside it 1998, 1999, 2000.		Flat Timber Sale early 1990s

Table 5. Continued.					
Site Name	**Allotment, Pasture**	**Grazing**	**Current Practices**	**Homesteading**	**Year of Fire & Logging**
Hodgeson Creek	Renner Lake, Renner Lake	Parts of this allotment have been grazed prior to 1935. Grazing probably occurred in the area prior to the establishment of the Colville National Forest in 1907. Before 1945 both cattle and sheep grazed the allotment. After 1945 only cattle grazed. Current boundaries were established in 1959. Season-long grazing system.	Active grazing permit.		
Paradise Meadow	Meadow Creek, Paradise Valley	Paradise Meadow consists of two old homestead meadows cleared prior to purchase by the government. Records show that the area was grazed prior to 1949. 3 homestead claims filed: 2 in 1917 (S 15 & S 22); 1 in 1918 (S22). Past use has been spotty (1963). Proposed in 1963 to make Paradise Meadow permanent grazing.	Active grazing permit, Dawson.	Serial Patent, WA State; Issue Date: 3/10/1922 Peter L. Peterson Patent Details Land Office: Spokane, WA Auth.: 4/24/1820 Sale-Cash entry (3 Stat. 566) Total Acres: 40.	
Peltier Homestead Meadow	Tiger Hill, Tiger Hill	Allotment area grazed since early 1930's after it burned. At that time, the land was privately owned. Private land in the allotment was purchased by the government under the Resettlement Act of 1937 and placed under Forest Service administration in 1938. Cattle have continuously used the area since 1938. In 1962-1963 rest and rotation grazing management initiated. 1935 aerial photo shows the entire area around the plots devoid of trees. 2009 NAIP image shows most of the area with tree cover.	Active grazing permit.	Serial Patent, WA State Issue Date: 10/24/1921 Robert B. Peltier, Land Office: Spokane, WA Authority: 5/20/1862 Homestead Entry Original (12 Stat. 392) Total Acres: 160.	1931 Fire

Table 5. Continued.					
Site Name	**Allotment, Pasture**	**Grazing**	**Current Practices**	**Homesteading**	**Year of Fire & Logging**
Road 755	Boyds, Davis	1922 range resource map indicates grazing has always been by cattle. Current allotment boundaries were established in 1959. Earliest recorded use was in 1943; 43 head from 5/1-10/31. 1945 saw the greatest number of permittees (16) with 153 head grazing the allotment.	Active grazing permit.	Serial Patent, WA State Issued 2/8/1913 Fred C. Machamer Land Office: Spokane, WA Auth.: 5/20/1862: Homestead Entry Original (12 Stat. 392). Total Acres: 159.92. Serial Patent, WA State; Issued 8/14/1946 Harry & Ida A. Beagley Patent Details Land Office: Spokane Auth.: 3/20/1922 Ex-change-FS General Ex Act (42 Stat. 465) Total Acres: 279.92.	1929 Fire. Logged from 1954-1959 & 1961-1967. Roads & logging opened up many acres that were previously unusable for grazing.
Rose Ranch	Elbow Lake, Rose Ranch	Len McIrvin (W-side of allotment; modified rest-rotation system of management; 3 year, 4 pasture cycle). Actual grazing records date back to 1943. The area was grazed prior to that time.	Active grazing permit. Revisits saw grazing to the extent that only bare ground present.	Serial Patent, WA State; Issue Date: 1/8/1951 George T. (G.T.) Rose Patent Details Land Office: Oregon Admin. Auth.: 3/20/1922 Exchange-FS General Ex Act (42 Stat. 465) Total Acres: 265.	Crown Timber Sale late 1980s

b. How do populations vary in livestock grazed and ungrazed sites? How is this affecting *Botrychium* microsites? How much grazing is too much/enough?

For the meadow sites population trends show that overgrazing has occurred. Although the fenced and unfenced macroplots at Bestrom Meadow and Big Muddy appear to show that excluding grazing does not affect population numbers (Table 6), cattle are rotated out of the area on a regular schedule and the sites are not grazed and trampled to dirt. In comparison, the Rose Ranch site has been grazed and trampled to dirt and no *Botrychiums* have been observed. What may be surmised is that some grazing continues the "old" or "some" disturbance factor which is beneficial to the occurrence of *Botrychiums*. However, overgrazing can lead to loss of plant populations whether it's due to the grazing, soil compaction from trampling, or other factors is unknown.

Table 6. Results of Fenced Versus Unfenced Plots.

Site	**Trend**	**Discussion**
Bestrom BOHE5 & BOPA9 Fenced/Unfenced 1998-2001 & 2008-2011	No difference between fenced and unfenced macroplots.	These two sites were fenced to evaluate the effects of grazing on *Botrychiums*, however, our data show that there is no difference between fenced and unfenced macroplots at these two sites.
Big Muddy BOPE4 Fenced/Unfenced Macroplot Totals 2000-2003 & 2008-20011		

c. What is the fire ecology of *Botrychiums*?

None of the 12 locations have been burned since monitoring was initiated. In 2000 a permanent transect to monitor burned and burned plots of *Botrychium simplex* site was established at 12-Mile Meadow on the Three Rivers Ranger District. An herbicide treatment of the meadow in 2001 and 2002 resulted in no plants 2002. In 2010 and 2011 *B. crenulatum* plants were tagged for monitoring at a tributary to Bridge Creek in a fuels reduction project. The prescribed burn is scheduled for the spring of 2012. The site will be checked to determine if the fire actually burned the area of the tagged plants.

5. Population trends.

Care was taken to monitor plots when plants were identifiable, but prior to cattle grazing. The dates are displayed in Appendix 9. To assess population trends, population counts and the results of two-tailed t-tests are shown with trends in Table 7 and discussed in Table 8. To assess trends, moving averages were compared with plant counts (Appendix 10), when there was not enough data for two-tailed paired t-tests (Appendix 11). Table 9 summarizes threats at each location and Table 10 includes recommendations for monitoring.

Table 7. Total Number of Plants and Trends by Site and Years. (Bolded plant counts were used for Two-Tailed t-Tests.)

MEADOW SITES	**Trend**	**t-Tests**	**Year and Plants Counts**																
			1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bestrom BOHE5 Fenced	Stable	0.482 Do not reject				**15**	**8**	**21**	**19**	16	5		5	10		**2**	**4**	**6**	**35**
Bestrom BOHE5 Unfenced	Stable	2.060 Do not reject				**30**	**10**	**45**	**34**	43	6		3	4		**3**	**2**	**0**	**30**
Bestrom BOPA9 Fenced	Declining	3.388 Reject!				**81**	**62**	**72**	**47**	88	35		31	34		**24**	**13**	**10**	**52**
Bestrom BOPA9 Unfenced	Stable	2.146 Do not reject				**61**	**5**	**49**	**35**	48	20		5	2		**4**	**5**	**3**	**25**
Bestrom BOHE5 Fenced/ Unfenced 1998-2001	No difference	0.482 Do not reject				**15/ 30**	**8/ 10**	**21/ 45**	**19/ 34**										
Bestrom BOHE5 Fenced/ Unfenced 2008-2011	No difference	0.284 Do not reject														**2/ 3**	**4/ 2**	**6/ 0**	**35/ 30**
Bestrom BOPA9 Fenced/ Unfenced 1998-2001	No difference	1.987 Do not reject				**81/ 61**	**62/ 5**	**72/ 49**	**47/ 35**										

Table 7. Continued.

MEADOW SITES	**Trend**	**t-Tests**	**Year and Plants Counts**																
			1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bestrom BOPA9 Fenced/ Unfenced 2008-2011	No difference	1.419 Do not reject														**24/ 4**	**13/ 5**	**10 / 3**	**52/ 25**
Big Muddy BOPE4 Fenced North Side Transect						55	62	91	80	101	83	27	25	25		6	1	15	5
Big Muddy BOPE4 Fenced South Side Transect						33	49	95	101	147	121	20	63	51		14	11	5	3
Big Muddy BOPE4 Fenced Macroplot Totals	Declining	12.217 Reject				88	111	**186**	**181**	**248**	**204**	47	88	76		**20**	**12**	**20**	**8**
Big Muddy BOPE4 Unfenced North Side Transect						110		114	55	93	17	2	10	18		3	4	13	47

Table 7. Continued.																			
MEADOW SITES	**Trend**	**t-Tests**	**Year and Plants Counts**																
			1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Big Muddy BOPE4 Unfenced South Side Transect						138		189	66	123	46	3	24	41		4	4	9	11
Big Muddy BOPE4 Unfenced Macroplot Totals	Declining	2.805 Reject				248		**303**	**121**	**216**	**63**	5	34	59		**7**	**8**	**22**	**58**
Big Muddy BOPE4 Fenced / Unfenced Macroplot Totals 2000-2003	No difference	0.527 Do not reject						**186 / 303**	**181 / 121**	**248 / 216**	**204 / 63**								
Big Muddy BOPE4 Fenced / Unfenced Macroplot Totals 2008-20011	No difference	-0.712 Do not reject														**20/ 7**	**12/ 8**	**20/ 22**	**8/ 58**

Table 7. Continued.

MEADOW SITES	**Trend**	**t-Tests**	**Year and Plants Counts**																
			1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Dominion BOPE4 North Transect	Declining		81	138	139	194	144	29					6			0	0	0	0
Dominion BOPE4 Middle Transect	Declining		44	32	57	96	98	94					10			0	0		
Dominion BOPE4 South Transect	Declining		79	59	61	117	69	75					4						
Dominion BOPE4 Macroplot Totals	Declining																		
Paradise BOHE5	Declining	3.476 Reject				**271**	**208**	**60**	**171**		130		100	86		**3**	**31**	**27**	**27**
Parradise BOPA9	Declining					33	37	44	33		3	0	0	0		0	0	0	0
Peltier BOHE5 North Transect																		91	84

Table 7. Continued.																			
MEADOW SITES	**Trend**	**t-Tests**	**Year and Plants Counts**																
			1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Peltier BOHE5 South Transect																		188	193
Peltier BOHE5 Macroplot Totals																		279	277
Rose Ranch BOHE5 North Transect	Declining			24	30	38	61	56					8						
Rose Ranch BOHE5 South Transect	Declining			70	57	76	123	109				0	10						
Rose Ranch BOHE5 Macroplot Totals	Declining			94	87	114	184	165				0	18						

Table 7. Continued.

FOREST SITES	**Trend**	**t-Tests**	**Year and Plants Counts**																
			1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Bailey Creek BOLI7, Fenced	Stable	0.196 Do not reject		**3**	**3**	**8**		8		10	5	9	9	8		5	**4**	**5**	**4**
Deadman Creek BOCR	Increasin g	-4.338 Do not reject	**107**	**100**	**70**	**43**	16	21			76					**202**	**159**	**136**	**173**
East Fork Crown Creek BOCR North Transect	Declining		62	51	50	20	31	9			0					0	0		0
East Fork Crown Creek BOCR South Transect	Declining		85	117	118	117	83	78			1					0	0		0
East Fork Crown Creek BOCR Macroplot	Declining		147	168	168	137	114	87			1					0	0		0

Table 7. Continued.

FOREST SITES	**Trend**	**t-Tests**	**Year and Plants Counts**																
			1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Flat Creek Tributary BOCR North Transect			89	59	22	21	14	6			41					59	95	59	63
Flat Creek Tributary BOCR South Transect			26	17	5	6	2	0			4					2	7	4	1
Flat Creek Tributary BOCR Fenced Macroplot	Stable	0.266 Do not reject	**115**	**176**	**27**	**27**	16	6			45					**61**	**102**	**63**	**64**
Hodgeson Creek BOCR North Transect	Declining		168	241	304	311	290	271											
Hodgeson Creek BOCR Middle Transect	Declining		59	65	94	83	84	77											

Table 7. Continued.

FOREST SITES	**Trend**	**t-Tests**	**Year and Plants Counts**																
			1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hodgeson Creek BOCR South Transect	Increasing		80	51	65	52	60	133											
Hodgeson Creek BOCR Macroplot Total			307	357	463	446	434	481											
Road 755 BOCR	Declining		193	101	103	48	25	77			58					26	17		8

Table 8. Population Trend Discussion for Each Site.

MEADOW SITES	**Trend**	**Discussion**
Bestrom BOHE5 Fenced & Unfenced	Stable	Monitoring indicates that the fence has not made a difference.
Bestrom BOPA9 Fenced	Declining	The decline might be attributed to shading by lodgepoles inside the fence.
Bestrom BOPA9 Unfenced	Stable	
Big Muddy BOPE4 Fenced/Unfenced Macroplot Totals	Declining	Plants may be declining within the fenced plot because of shading by trees. The unfenced plot may be declining from gopher and cattle disturbances.
Dominion BOPE4 North, Middle & South Transects	Declining	Plants may be declining from gopher disturbance, hawkweed and oxeye daisy invasion, and shading.
Paradise BOHE5 & BOPA9	Declining	Plants may be declining from gopher disturbance and hawkweed invasion.
Peltier BOHE5 North & South Transects		Not enough data to determine a trend.
Rose Ranch BOHE5 North & South Transects	Declining	There have been issues of overgrazing at this site.
FOREST SITES		
Bailey Creek BOLI7, Fenced	Stable	
Deadman Creek BOCR	Increasing	Continue to monitor use by cattle.
East Fork Crown Creek BOCR North & South Transects	Declining	Alder is revegetating this old roadbed and the site appears to be drier.
Flat Creek Tributary BOCR Fenced Macroplot	Stable	The creek is eroding the south macroplot.
Hodgeson Creek BOCR North & Middle Transecst	Declining	This site was monitored from 1995-2000. The transect end posts were found in 2007. We recommend revisiting at least once more to see if this relatively undisturbed population still has high plant counts.
Hodgeson Creek BOCR South Transect	Increasing	
Road 755 BOCR	Declining	The decline could be from cottonwood blowdown and deep leaf litter.

Table 9. Summary of Threats and Recommendations.

MEADOW SITES	Trend	Threats						Recommendations and Observations
		Increasing Shade	Hawk weed	Oxeye Daisy	Gophers	Cattle	OHVs	
Bestrom BOHE5 Fenced	Stable	X	X		X			Remove trees from fenced plot.
Bestrom BOPA9 Fenced	Declining							
Bestrom BOHE5 & BOPA9 Unfenced	Stable		X		X	X	X	How to keep OHVs out and monitor gopher disturbance?
Bestrom BOHE5 & BOPA9 Fenced/ Unfenced 1998-2001 & 2008-2011	No difference							Since the fenced and unfenced plots do not have a significance difference, cattle grazing is not significantly impacting the population.
Big Muddy BOPE4 Fenced Macroplot Totals	Declining	X	X		X			Remove trees from fenced plot. How to monitor gopher disturbance?
Big Muddy BOPE4 Unfenced Macroplot Totals	Declining		X		X	X	X	Place boulders along road to keep OHVs out.
Big Muddy BOPE4 Fenced/Unfenced Macroplot Totals 2000-2003 & 2008-20011	No difference							Since the fenced and unfenced plots do not have a significance difference, cattle grazing is not significantly impacting the population.
Dominion BOPE4 Macroplot Totals	Declining		X		X	X	X	Gophers and matted hawkweed have changed site conditions.
Paradise BOHE5 & BOPA9	Declining	X	X	X	X	X		Remove trees from plot.
Peltier BOHE5 Macroplot Totals			X		X			Spray the north plot for hawkweed and compare with South Plot. In 2011 south plot had significant new gopher disturbance on the west side of the plot while the east side did not have any.

Table 9. Continued.

FOREST SITES	Trend	Threats						Recommendations and Observations
		Increasing Shade	Hawk weed	Oxeye Daisy	Gophers	Cattle	OHVs	
Rose Ranch BOHE5 Macroplot Totals	Declining			X		X		The last several years, there have been no plants to monitor. Need better management of cattle.
Bailey Creek BOLI9, Fenced	Stable							
Deadman Creek BOCR	Increasing					X		Cows pass through, but don't linger.
East Fork Crown Creek BOCR Macroplot	Declining	X						
Flat Creek Tributary BOCR Fenced Macroplot	Stable							South transect is being eroded by the creek. Paper birch blowdown on macroplot.
Hodgeson Creek BOCR Macroplot Total	Declining to Stable							This site was monitored from 1995-2000. The transect end posts were found in 2007. We recommend revisiting this site to see if this relatively undisturbed population still has high plant counts.
Road 755 BOCR	Declining					X		Less canopy cover, more cottonwood and cedar blow down and deep leaf litter.

Table 10. Monitoring Comments.

SITES	ACCESS	YEARLY	MONITORING COMMENTS
Recommended to continue monitoring to increase the sample size.			
MEADOW SITES			
Bestrom BOHE5 & BOPA9 Fenced/Unfenced	Can drive to site.	Check fence.	These 2 sites can be monitored in a single day.
Big Muddy BOPE4 Fenced/ Unfenced Macroplot Totals	Can drive to site.	Check fence.	
Paradise BOHE5 & BOPA9	5 minute walk.		
Peltier BOHE5 Macroplot Totals	5 minute walk.		
FOREST SITES			
Bailey Creek BOLI7, Fenced	If gated 15 minutes for walk; if bermed add an hour.	Check fence.	These 2 sites can be monitored in a single day.
Deadman Creek BOCR	Can drive to site.		
Flat Creek Tributary BOCR Fenced Macroplot	30 minute walk.	Check fence.	Long drive, allow 1 day to monitor.
Not recommended to continue monitoring.			
MEADOW SITES			
Dominion BOPE4 Macroplot Totals	Road closed; 15 minute walk.		Few plants are in the transects. Gophers disturbed much of the area several years ago.
Rose Ranch BOHE5 Macroplot Totals	Road closed; 30 minute walk.		Few plants are seen, as cattle grazing is heavy at this location.
FOREST SITES			
East Fork Crown Creek BOCR Macroplot	Road closed; 5 minute walk.		Few plants are left in the transects and road has closed in with alder. There's less bare ground and the road is drier. On road edges *B. pedunculosum* and *B. paradoxum* are more abundant.
Hodgeson Creek BOCR Macroplot Total	Road closed; 90 minute walk.		Access to the site and setting up the 3 transects requires quite a commitment of time.
Road 755 BOCR	Can drive to site.		Few plants are in the transects; blowdown.

6. Effective management areas (sizes) and habitat characteristics necessary to maintain known occurrences in project areas.

Since *Botrychiums* in forested sites on the Colville National Forest generally occur in riparian zones, maintaining the continuity of riparian zones is important to their viability. Complying with riparian buffer requirements (150 foot no harvest buffer on either side of creeks or to the topological break) in Forest projects would be the best way to manage these sites.
Many of the meadow sites where *Botrychiums* grow were forests cleared for homesteads. These openings now are vegetated with noxious weeds and are closing in by encroaching forests (Big Muddy, Peltier). Do we "let nature take its course" or cut the regenerating trees?

Over the years Bestrom Meadow has been sprayed, plowed, and reseeded for grazing. Dominion Meadow and Paradise Meadows are also grazed, but not to the extent of Bestrom. Gophers and hawkweed are the major disturbances, although conifer encroachment is occurring too. Regarding meadows, size does not appear to be as important factor, as range management.

The essential question with the *Botrychiums* that occur in meadows is "which came first--the *Botrychiums* or the meadows? Were they always in the forest in small openings? Did the homestead meadows just create better habitat with less competition? If this is the case, then should we be maintaining the meadows at their current size or create new meadows for more habitat?

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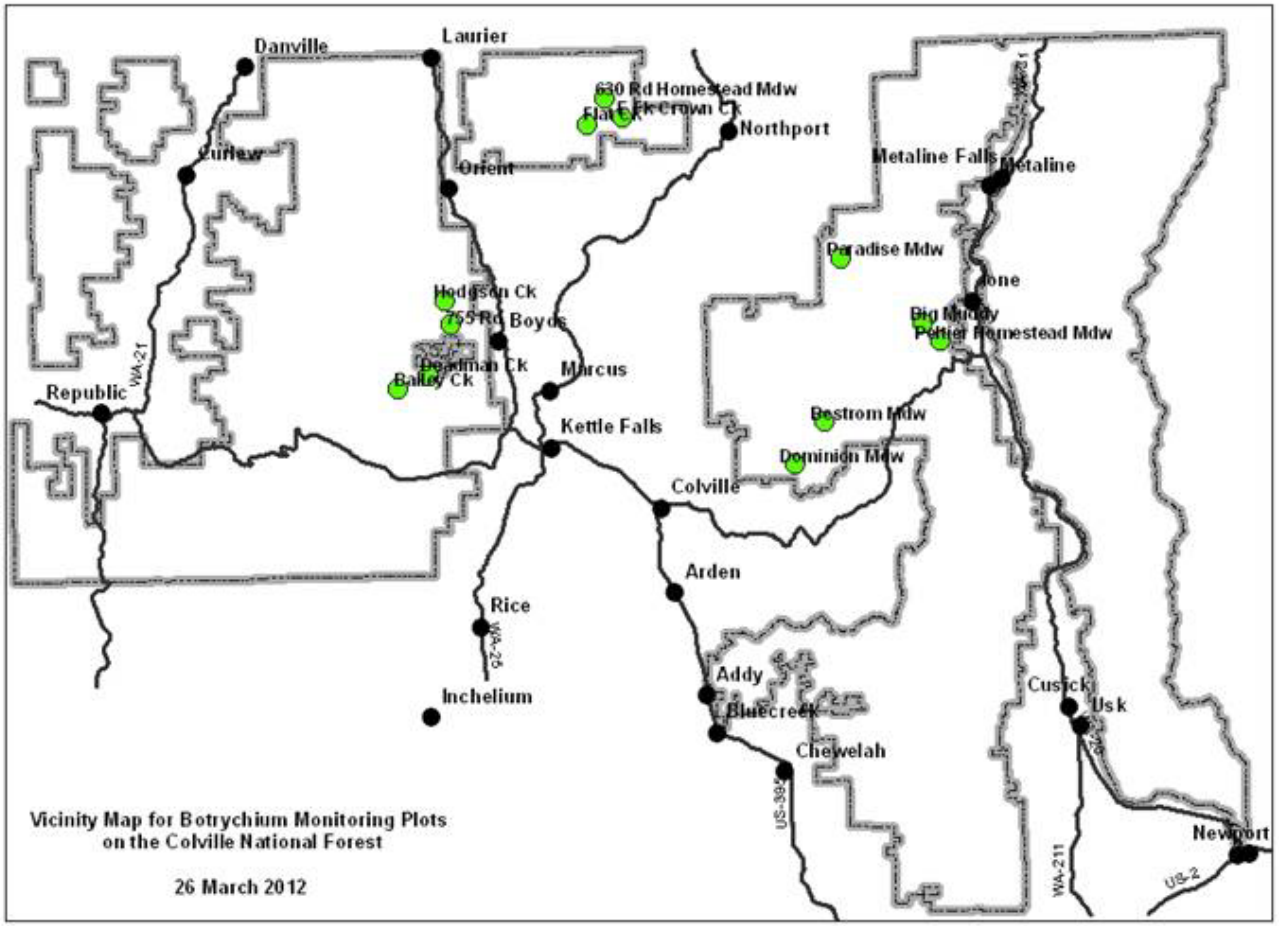
Appendix 1. Locations of 12 Monitoring Sites on the Colville National Forest.



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Appendix 2. *Botrychium* Monitoring Plot Size Summary

Bailey Creek, *Botrychium lineare*, T37N R36E S30 SE/SE.
Bailey Creek has no established transects or formal plots. The fenced area that encloses the plant population has two main areas with plants. The NE section of the exclosure contains the majority of the plants. The SW section of the exclosure contains fewer widely scattered plants.

Bailey Creek, *Botrychium lineare* plant (lavender flag) on south side of creek.

Bestrom Meadow, *Botrychium hesperium*, and *B. paradoxum*, T36N R41E S16 NW/NW.
Bestrom Meadow has two adjacent macroplots, one fenced and one unfenced. Each is 12 meters by 20 meters. There are 20 microplots within each of the two macroplots. Microplots are 3 meters by 4 meters each. The macroplots are oriented with the 20 meter length on a N/S line and the 12 meter width on an E/W line. Each macroplot has an area of 240 square meters. The two macroplots have a total area of 480 meters squared.

Bestrom fenced plots looking north.

Bestrom unfenced plots looking northwest.

Big Muddy, *Botrychium pedunculosum*, T37N R42E S10.
Big Muddy has two 14-meter transects: one fenced and one unfenced. Total area for all Big Muddy plots is 56 square meters. In 1997 Mike Borysewicz constructed the fenced exclosure measuring 20 meters by 20 meters. On July 1, 1998 the 14-meter transect was installed within the exclosure. Both ends of the transect were marked by a half-meter piece of rebar driven into the ground, so that about 6 centimeters protrudes from the ground. Plot one is at the western end of the transect. Fourteen one- meter squared plots are read on the north side of the transect and 14 along the south. Total area for the fenced plots is 28 square meters.

The unfenced transect runs west to east and is 14 meters long by 2 meters wide. Plots are read on both sides of the transect line. Plant locations are recorded on a 1 meter by 1 meter grid. Total area for the unfenced plots is 28 square meters.

Big Muddy, unfenced transect, west to east.

Big Muddy, fenced transect, west to east.

Deadman Creek, *Botrychium crenulatum*, T37N R36E S28 NE/NE.
The Deadman Creek site has one macroplot 18 meters on the east and west sides and is 20 meters on the north and south sides with an area of 400 square meters. There are 20 microplots within the macroplot, each with an area of 7.07 square meters. Total microplot area is 141.4 square meters.

The east baseline bearing is 20 degrees , the west baseline bearing is 17 degrees. The transect bearing (north and south sides) is 87 degrees. The four corners of the macroplot are permanently marked with iron rods driven into the ground. Baseline tapes are laid out between the corner pins on the east and west sides of the macroplot. A third (transect) tape is laid out between the two baseline tapes at the following intervals: 1m, 6m, 9m, 16m. Microplot positions on the transect tape are: 2m, 6m, 10m, 14m, 18m and have a radius of 1.5 meters.

Appendix 2. Continued.

Deadman transect east to west.

Dominion Meadow, *Botrychium pedunculosum*, T36N R41E S31 NW/NW.
Dominion Meadow has three transects: North, Middle and South. The North transect is 50 meters in length on a bearing of 203 degrees with 25 microplots of 1meter by 1 meter (1 m squared). Microplots are read at the every other meter mark starting at 1 meter on the east (uphill) side of the transect line(1m, 3m, 5m, etc). Total transect area is 50 square meters. Total microplot area is 25 square meters.

The Middle transect is 50 meters in length with a transect bearing of 188 degrees. The 12 micrpoplots are circular with a radius of 1.5 meters (7.07 square meters). Microplot locations are 4 meters apart starting at the 2-meter mark (2m, 6m, 10m, etc.). Total transect area is 150 square meters. Total microplot area is 84.84 meters squared. The South transect is 50 meters in length on a bearing of 197 degrees with 25 microplots 1 meter by 2 meters (2 meters squared). Microplot location is every other meter mark starting at 1 meter on the east (uphill) side of the transect line (1m, 3m, 5m, etc.). Total transect area is 100 square meters. Total microplot area is 50 square meters.

Appendix 2. Continued.

Dominion Meadow, looking south to north.

East Fork Crown Creek, *Botrychium crenulatum*, T40N R38E S26 NW/SE.
East Fork Crown Creek has two transects, North and South. Total area of the transects is 70 square meters. Total area of the microplots is 23 square meters. The North transect is 40 meters in length on a bearing of 326 degrees with a microplot size of 1-meter squared (1m x 1m). There are 13 microplots along the transect. Total area of the microplots is 13 meters squared. Microplots are read every 3 meters starting at the one meter mark (1m, 4m, 7m, etc.) on the west side of the transect.

The South transect is 30 meters in length on a bearing of 326 degrees with a microplot size of 1-meter squared (1m x 1m). There are 10 mircoplots along the transect. Total area of the microplots is 10 square meters. Microplots are read every 3 meters starting at the one meter mark (1m, 4m, 7m, etc.) on the west side of the transect.

East Fork of Crown Creek, north transect looking north.

East Fork of Crown Creek, south transect looking north.

Appendix 2. Continued.

Flat Creek Tributary, *Botrychium crenulatum*, T40N R38E S32 NW/NW.
Flat Creek has 2 fenced macroplots, North and South. Total area of both transects is 26 meters squared. The North macroplot is 6 meters by 2 meters (12 meters squared) which is divided into 6 adjacent microplots 1-meter by 2-meters along a transect with a bearing of 274 degrees. The South macroplot is 7 meters by 2 meters (14 meters squared) which is divided into 7 adjacent microplots 1-meter by 2-meters along a transect with a bearing of 90 degrees.

Flat Creek, north transect looking west to east.

Hodgeson Creek, *Botrychium crenulatum*, T38N R36E S35 NW/NW.
The Hodgeson Creek monitoring site has three transects: South, Middle and North. Total area for all microplots is 139.5 square meters. The North transect is 45 meters in length with a bearing of 27 degrees. There are 15 circular microplots with a 1-meter radius (3.1 square meters) along the transect. Total North transect area is 46.5 square meters. Microplot locations are every 3 meters starting at the 1 meter mark (1m, 4m, 7m, etc.).

The Middle transect is 44 meters in length with a bearing of 23 degrees. There are 15 circular microplots with a 1-meter radius (3.1 square meters) along the transect starting at the 1 meter mark (1m, 4m, 7m, etc.). Total North transect area is 43.4 square meters.

The South transect is 45 meters in length with a transect bearing of 42 degrees. There are 15 circular microplots with a 1-meter radius (3.1 square meters) along the transect. Total South transect area is 46.5 square meters. Microplot locations are every 3 meters starting at the 1 meter mark (1m, 4m, 7m etc.).

Appendix 2. Continued.

Hodgeson transect.

Paradise Meadow, *Botrychium hesperium* and *B. paradoxum*, T38N R41E S15.
There are two transects and one 1-meter squared plot in the area. Total area is 104 square meters. The BOHE5 transect is 28 meters in length along a transect bearing of 212 degrees. The 28 plots are 1 meter-squared and are read on alternate sides of the transect line starting on the east side at the 0 meter mark and then going to the west side at the 1 meter mark. Total transect area is 28 square meters.

The BOPA9 transect is approximately 37.5 meters in length. Plants were found within a 1-meter area on either side of the transect line. Total area is 75 square meters. The total area for the meter squared BOPA9 plot is, of course, 1 square meter.

Appendix 2. Continued.

Paradise, southeast *B.hesperium* transect.

Paradise, southeast *B. hesperium* transect looking northeast.

Peltier Homestead Meadow, *Botrychium hesperium*, T37N R42E S14 SW/SW
Peltier Homestead Meadow has two areas being monitored. Total area for both is 2867 square meters. The North plot covers an area of approximately 53.34 meters by 53.34 meters (175 feet by 175 feet) with no subplots. Total area is approximately 2,845 square meters. The South macroplot includes 7 circular plots each with a radius of 1 meter. Plot centers are marked with rebar. The total area of the plots is 21.98 square meters.

Peltier Homestead, north opening.

Peltier Homestead, south opening.

Appendix 2. Continued.

Road 755, *Botrychium crenulatum*, T37N R36E S2 SE/SW.
The 755 road monitoring site has one 29-meter long transect of 28 1-meter by 2-meter plots along the transect with a bearing of 160 degrees. Total transect area is 116 square meters. Total plot area is 56 square meters.

Road 755, south end of transect.

Road 755, *Botrychium crenulatum* marked with blue flags.

Rose Ranch, *Botrychium hesperium*, T 40N R38E S22 SE/NW.
The Rose Ranch monitoring site has two transects, North and South. Total transect area is 196 square meters. The North transect is 24 meters in length with a bearing of 234 degrees. There are 6 plots with a radius of 2-meters along the transect line. The centers of the plots are at the 2m, 6m, 10m, 14m, 18m, 22m marks. The total area for the North transect is 96 square meters. The total area for the plots is 75.36 square meters. The South transect is 50 meters in length with a bearing of 176 degrees. There are 25 1-meter by 2-meter plots. Total transect/plot area is 50 square meters.

Appendix 2 Continued.

Rose Ranch; eastern portion of meadow.

Appendix 3. Landform Groups and Land Type Associations.

Site Name	Landform Group	Land Type Associations
Bailey Creek BOLI9	*a* Foliated Crystalline	G Scoured Glaciated Mountain Slopes
Bestrom BOHE5 & BOPA9	h Pre-Cambrian Bedrock Units of the Belt Super Group	L Glacial Morianes
Deadman Creek BOCR	u Not defined	O Valley Bottoms/Outwash
Big Muddy BOPE4	b Massive Crystalline	L Glacial Morianes
Dominion BOPE4	b Massive Crystalline	L Glacial Morianes
East Fork Crown Creek BOCR	u Not defined	O Valley Bottoms/Outwash
Flat Creek Tributary BOCR	g Bedrock of the Kootenay Arc	I Glaciated Mountain Slopes
Hodgeson Creek BOCR	b Massive Crystalline	I Glaciated Mountain Slopes
Paradise BOHE & BOPA9	b Massive Crystalline	L Glacial Morianes
Peltier BOHE5	b Massive Crystalline	L Glacial Morianes
Road 755 BOCR	*a* Foliated Crystalline	L Glacial Morianes
Rose Ranch BOHE5	h Pre-Cambrian Bedrock Units of the Belt Super Group	L Glacial Morianes

Appendix 4. Key to Landforms and Land Types (Davis 1998) on Appendix 2.

Landform Groups

a Foliated Crystalline, highly foliated metamorphic rock units which display gneissic or schistic fabric created by alignment of mineral grains into sheets or layers. These are most typically physically tough and chemically resistant. Chemistry ranges from felsic to mafic, with mafic lithologies often seen as amphibolites. A rectangular joint pattern is common. Typical units include pre-Tertiary banded gneiss (pTbg) as the Tonasket and Swakane Biotite Gneiss (Ksg).

b Massive Crystalline, igneous plutonic rock units of Cretaceous and Tertiary age. Composition massive, but earlier plutons may display gneissic or migmatic fabric due to regional metamorphism or partial re-melting during intrusion of younger magmas. Resistant to weathering and commonly forms ridges in areas of alpine glaciation. Rhyolite and/or granitic dikes are locally present. Typical units include Mount Stuart and Entiat Plutons, and mixed metamorphic and igneous rocks ((KJmi) of Tiffany Mountain.

g Bedrock of the Kootenay Arc, a sequence of tightly folded metamorphosed strata consisting of interbedded metacarbonates, metaargilites, metasiltites, and quartzites. The depositional environment produced alternating layers of massive and thin bedded rock 1,000 and more meters thick derived from marine and near shore sediments deposited from 630 to 420 million years ago. Typical units are Meta-argillite (Oar), the Ledbetter Slate and Meta-quartzite (C-Zq) and the Gypsy-Addy Quartzite.

h Pre-Cambrian Bedrock, units of the Belt Super Group in Northeast Washington are a 7,500M thick sequence of thinly bedded, quartz and mica argillite, and quartzite. Beds are moderately dipping with multiple sets of large scale joints in an orthogonal pattern. The dominant outcrop trend of this widespread unit follows the regional northeast orientation. Ravalli Group (Yms2) is typical of the unit.

Land Type Associations

I Glaciated Mountain Slopes, moderate relief mountain slopes and smooth, moderately broad convex ridges mantled with glacial till. Shaped by continental or lower elevation alpine ice sheets. Till typically deeper in draws and north facing slopes and shallower or absent along ridges. Slope commonly less than 45%. Bedrock and geologic structure control topographic expression with vegetation influenced by depth of glacial deposits and elevation. Valleys mildly V- to U-shaped. Slopes dissected by well defined, moderate to high gradient, intermittent and perennial streams in a sub-parallel to dendritic pattern. Streams moderately to deeply incised. Seeps and springs common along concave lower slopes and occur on upper slopes near the boundary with the unit, Scoured Glaciated Mountain Slopes.

G Scoured Glaciated Mountain Slopes, moderate relief mountain slopes and smooth mildly convex ridges. Scoured by continental or alpine *g*laciation. Bedrock close to the surface and controls topographic expression and vegetative patterns. Slope ranges from 30-60% with steeper gradients along break lands bordering higher order streams. Residual soils shallow and poorly developed but pockets of glacial till may occur along lower slopes and draws. Veneer of loess

and ash not uncommon. Dissected by moderate gradient, lower order, intermittent streams. Geologic bedrock and structure strongly influence stream pattern and density. Drainage pattern varies from weak rectangular to dendritic, and sub-parallel along steeper side slopes. Seeps are uncommon and limited to swales and draws.

Appendix 4. Continued.

L Glacial Morianes, low to moderate relief, undulating or hummocky surface underlain by very deep glacial deposits. Deposited mainly by down wasting of glaciers but includes marginal and pro-glacial deposits such as outwash and eskers. Till depth typically greater than 20 feet but rocky knobs may protrude. Slope gradients less than 40%. Relief rarely exceeds 1,000 feet. Mostly occurs in wide upland valleys but may extend up lower side slopes and/or down valleys of higher order streams. Occasionally mantles ridges and mountain passes. Slopes dissected by well defined, low to moderate gradient perennial streams in a weak dendritic to random drainage pattern. Streams usually deeply incised. Seeps, springs and ponding common. May include glacial flood or lacustrine deposits and potholes. Vegetation influenced by depth and high available water capacity of glacial deposits.

O Valley Bottoms/Outwash, nearly level terraces and floodplains in broad valley bottoms. Leveled by river flooding induced by the melting of glaciers. Slope generally less than 10%. Dissected by high energy low gradient perennial streams. Channels most commonly meandering but may be braided in upper reaches. Substrate usually comprised of stratified sand to cobble size material but very large boulders not uncommon. Ponds, marshes and overflow channels may occur. Subject to frequent flooding. High subsurface water storage. Subsurface and in stream flow may be in continuity. May include alluvial fan and colluvial deposits along the valley sides.

Appendix 5. Weather, Aerial Photo Comparisons, Soils and Drainage by Site.

Meadow Sites	**Weather Station, Date, Elevation (feet), Precipitation (inches)**	**Aerial Photos Comparisons**	**Soil Information**					
Site Name, Species			**Soil Type**	**Frost-free period (days)**	**Parent Material**	**Drainage class**	**Available Water Capacity (inches)**	**Typical Profile (inches)**
Bestrom BOHE5, BOPA9	Mill Creek 1977-2011 Elev: 3040 Ave: 26.48 Max 36.4	Photos for 1943, 1960 & 2009 show meadow about the same size with no trees.	Bonner silt loam	90-120	Volcanic ash and loess over glacial outwash	Well-drained	Low 4.6	0-17: Silt loam
Big Muddy BOHE5	Seldom Seen 1980-2011 Elev: 4390 Ave: 25.34 Max: 34.25	The 1935 & 2009 photos show a huge difference in the area: in 1935 the area was devoid of trees & 2009 area is mostly treed-in except for small openings with *Botrychiums*.	Aits stony loam	90-110	Volcanic ash and loess over glacial till from mixed minerology	Well-drained	Moderate 7.4	0-12: Stony loam
Dominion BOPE4	Mill Ck 1977-2011 Elev: 3040 Ave: 26.48 Max: 36.4	Photos for 1943, 1960 & 2009 show meadow to have changed dramatically on the W-side.	Newbell silt loam	90-120	Volcanic ash and loess over glacial till derived from granite	Well-drained	Very high 14.4	0-10: Silt loam
Paradise BOHE5, BOPA9	Abercrombie 1980-2002 Elev: 4450 Ave: 33.76 Max: 41.3	1960, 2000 & 2009 photos are very similar; the 2009 photo shows more vegetation in the mid-NW portion of the meadow.	Kegel loam	80-100	Mixed alluvium	Somewhat poorly drained	Moderate 7.5	0-14: Loam

Appendix 5. Continued.

Meadow Sites	**Weather Station, Date, Elevation (feet), Precipitation (inches)**	**Aerial Photos Comparisons**	**Soil Information**					
Site Name, Species			**Soil Type**	**Frost-free period (days)**	**Parent Material**	**Drainage class**	**Available Water Capacity (inches)**	**Typical Profile (inches)**
Peltier BOHE5	Seldom Seen 1980-2011 Elev: 4390 Ave: 25.34 Max: 34.25	The 1935 & 2009 photos show a huge difference in the area: in 1935 the area was devoid of trees & 2009 area is mostly treed-in except for small openings with *Botrychiums*.	Newbell stony silt loam	90-120	Volcanic ash and loess over glacial till from mixed minerology	Well-drained	Moderate 6.1	0-12: Stony silt loam
			Kegel loam	80-100	Alluvium	Somewhat poorly drained	Moderate 7.0	0-16: Loam
Rose Ranch BOHE5	Fischer Creek 1979-2011 Elev: 3200 Ave: 23.27 Max: 31.75	1943 & 1960 photos show some small difference with the 1960 photo showing a few more trees. The 2009 photo appears to be about the same as the 1960 photo.	Aits stony loam	90-110	Volcanic ash and loess over calcareous glacial till	Well-drained	Moderate 7.7	0-12: Stony loam
Forest Sites								
Bailey Creek BOLI7	Growden 1979-2008 Elev: 2600 Ave: 21.25 Max: 29.4	Comparison of 1943 & 2009 photos show little or no change in area.	MkE—Merkel sandy loam	90-120	Volcanic ash over glacial till derived from granite	Well-drained	Low 3.2	0-17: Sandy loam

Appendix 5. Continued.

Forest Sites	**Weather Station, Date, Elevation (feet), Precipitation (inches)**	**Aerial Photos Comparisons**	**Soil Information**					
Site Name, Species			**Soil Type**	**Frost-free period (days)**	**Parent Material**	**Drainage class**	**Available Water Capacity (inches)**	**Typical Profile (inches)**
Deadman Creek BOCR	Growden 1979-2008 Elev: 2600 Ave: 21.25 Max: 29.4	Comparison of 1943 & 2009 photos show little or no change in area.	Sh—Shaskit-Tonata complex	70-100	Shaskit & Tonata: Alluvium and glacial outwash	Shaskit & Tonata: poorly drained	Shaskit: Moderate 8.2, Tonata: High 12.0	Shaskit: 0-7: Silt loam, 7-17: Sandy loam, To-nata: 0-9: Silt loam
East Fork Crown Creek BOCR	Fischer Creek 1979-2011 Elev: 3200 Ave: 22.69 Max: 31.75	Comparison of 1943 & 2009 photos show little or no change in area.	Aits stony loam	90-110	Volcanic ash and loess over calcareous glacial till	Well-drained	Moderate 7.7	0-12: Stony loam
Flat Creek BOCR	Fischer Creek 1979-2011 Elev: 3200 Ave: 22.69 Max: 31.75	No prior photos to compare.	Aits stony loam	90-110	Volcanic ash and loess over calcareous glacial till	Well-drained	Moderate 7.7	0-12: Stony loam
Hodgeson Creek BOCR	Growden 1979-2008 Elev: 2600 Ave: 21.25 Max: 29.4	No prior photos to compare.	NlD—Nevine loam	90-120	Volcanic ash over dense till	Well-drained	Low 4.5	0-17: Loam
Road 755 BOCR	Growden 1979-2008 Elev: 2600 Ave: 21.25 Max: 29.4	No prior photos to compare.	NlD—Nevine loam	90-120	Volcanic ash over dense till	Well-drained	Low 4.5	0-17: Loam

Appendix 6. Comparison of Aerial Photos.

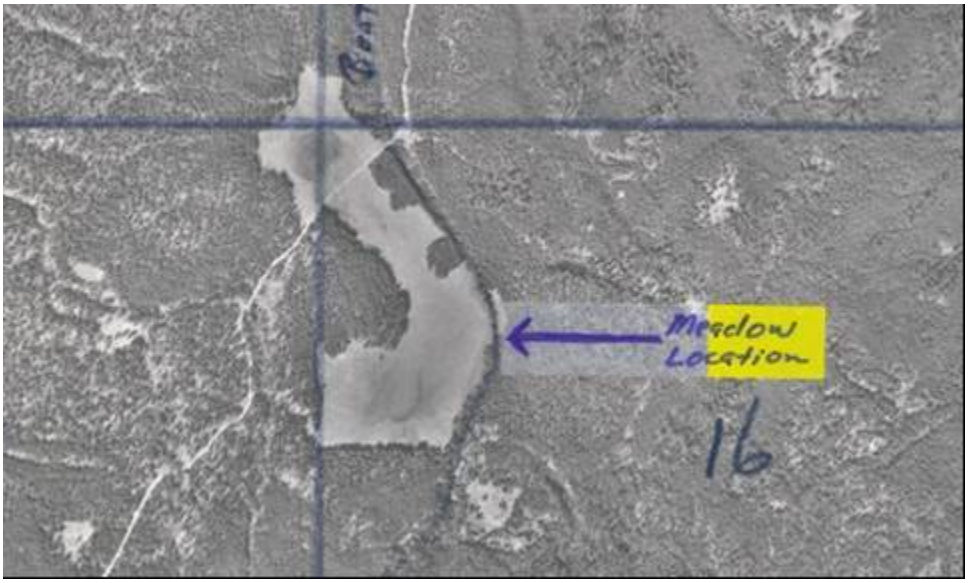
Bailey Creek, 2009 NAIP Image.

Bailey Creek, Aerial Photo 1943 Photo # 521.

Appendix 6. Continued.

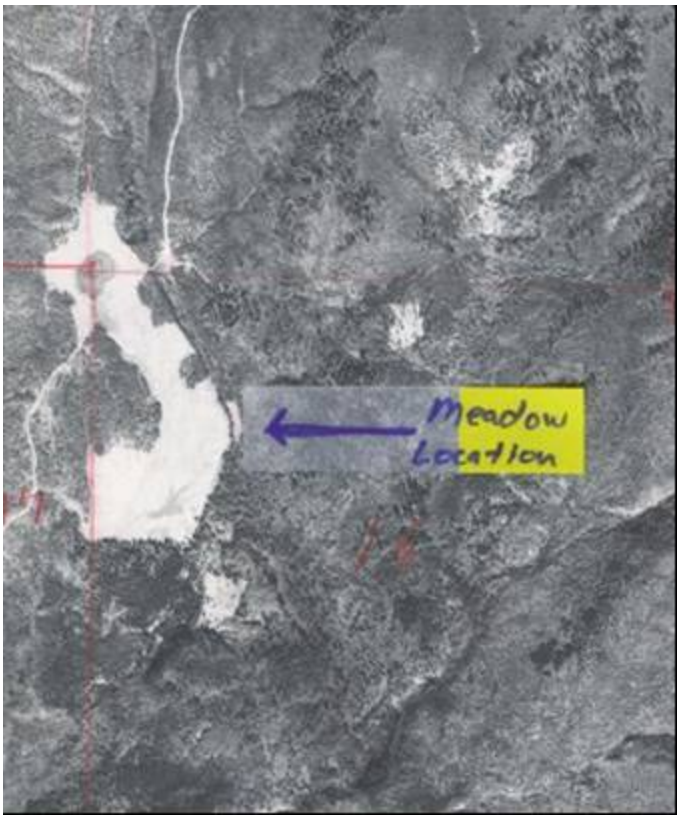
Bestrom Meadow, 2009 NAIP Image.

Bestrom Meadow, Aerial Photo 1960 Photo # EIL-4-134.



Appendix 6. Continued.

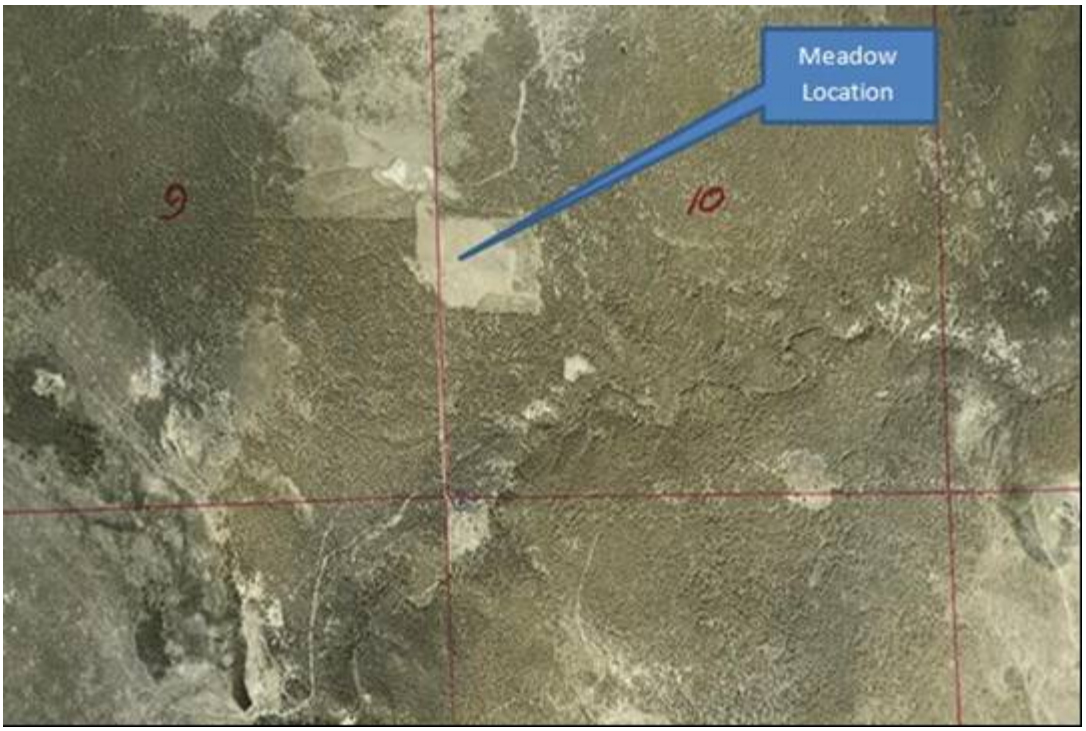
Bestrom Meadow, Aerial Photo 1943 Photo # 1056.



Big Muddy, 2009 NAIP Image.

Appendix 6. Continued.

Big Muddy, Aerial Photo 1935 Photo # X-812-35.



Deadman Creek, 2009 NAIP Image.

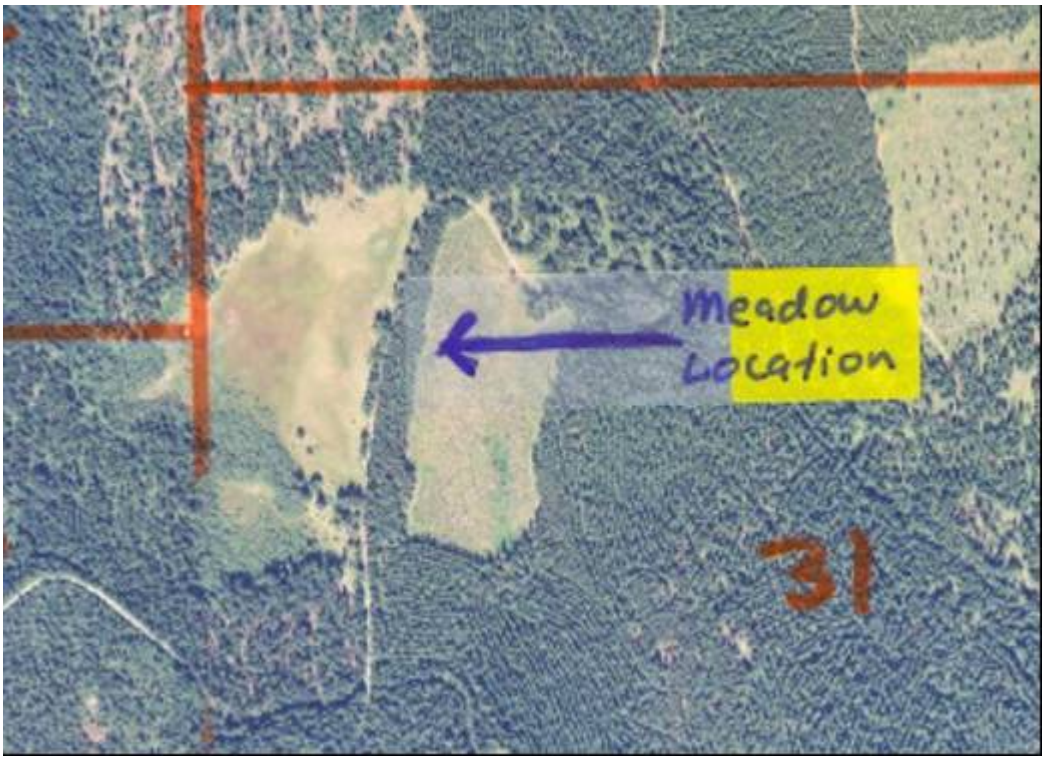
Appendix 6. Continued.

Deadman Creek, Aerial Photo 1943 Photo# 555.

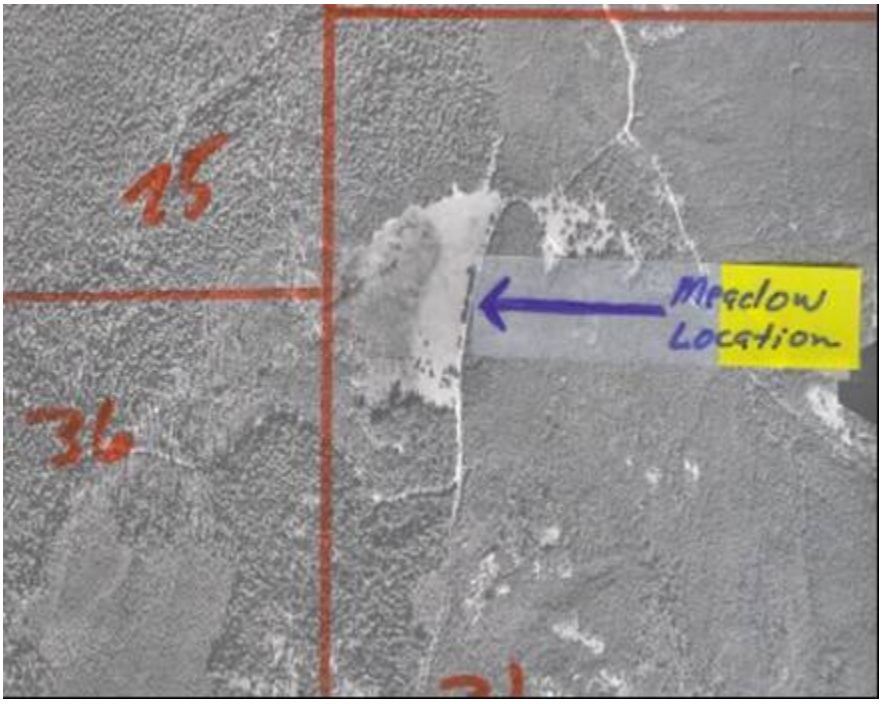
Dominion Meadow, 2009 NAIP Image.

Appendix 6. Continued.

Dominion Meadow, Aerial Photo 2000 60-131-184.

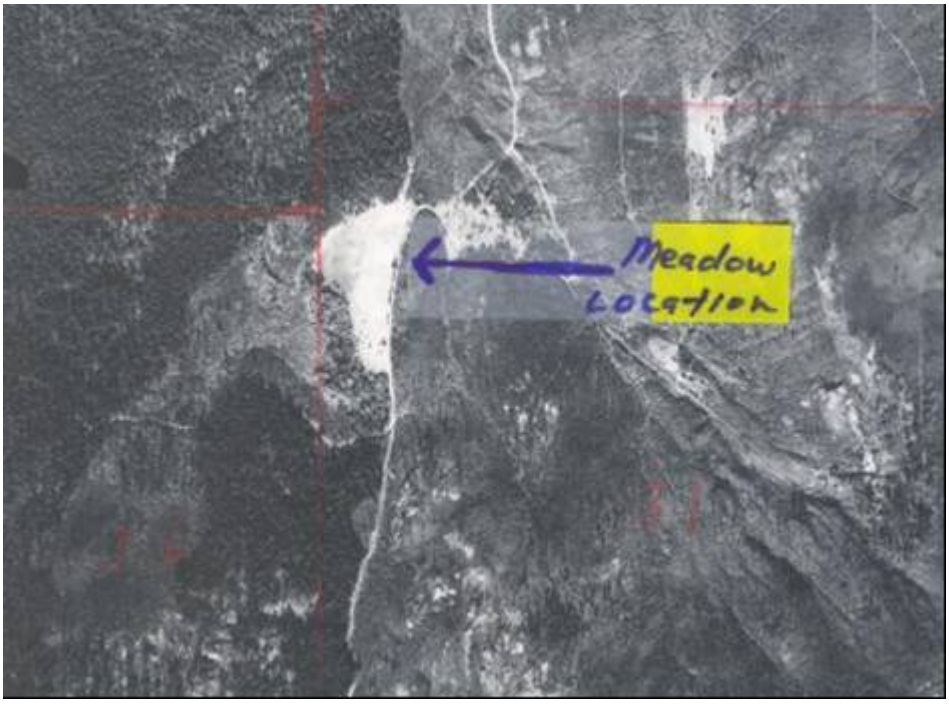


Dominion Meadow, Aerial Photo 1960 EIL-2-140.



Appendix 6. Continued.

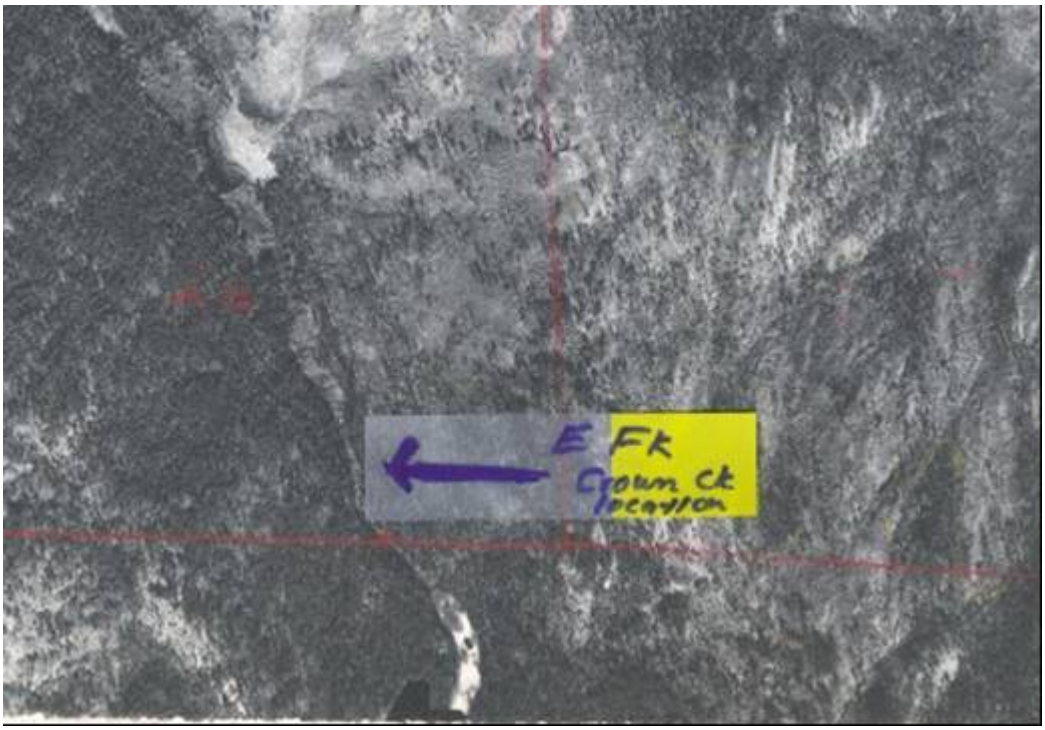
Dominion Meadow, Aerial Photo 1943 Photo # 1008.



East Fork Crown Creek, 2009 NAIP Image.

Appendix 6. Continued.

East Fork Crown Creek, Aerial Photo 1943 Photo # 752.



Flat Creek Tributary, 2009 NAIP Image.

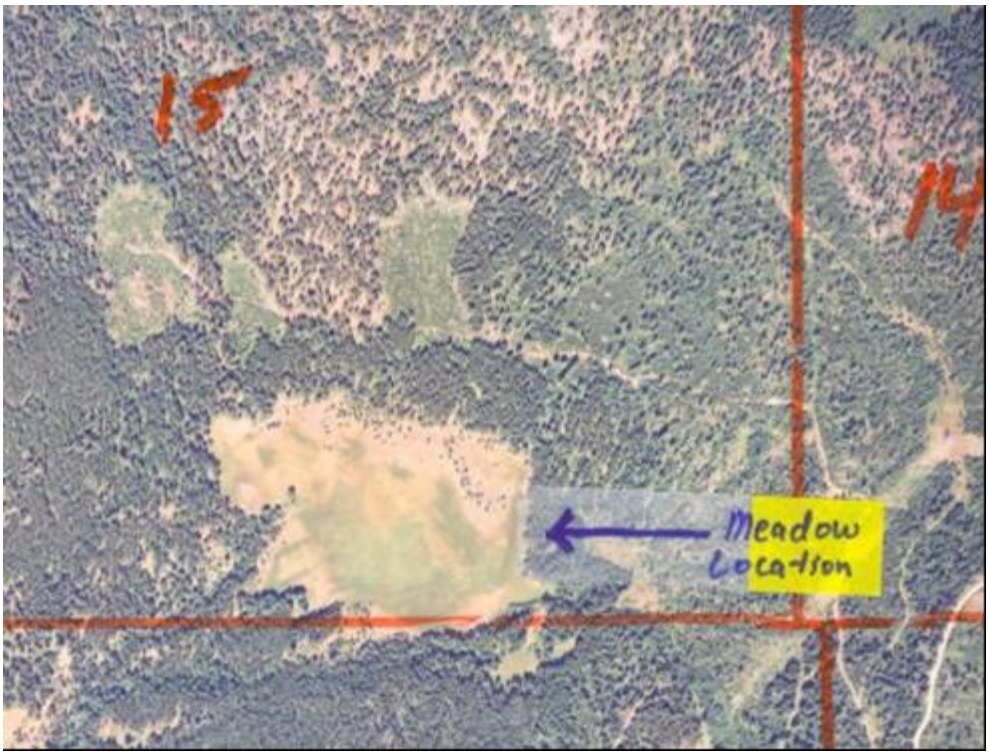
Appendix 6. Continued.

Hodgeson Creek, 2009 NAIP Image.

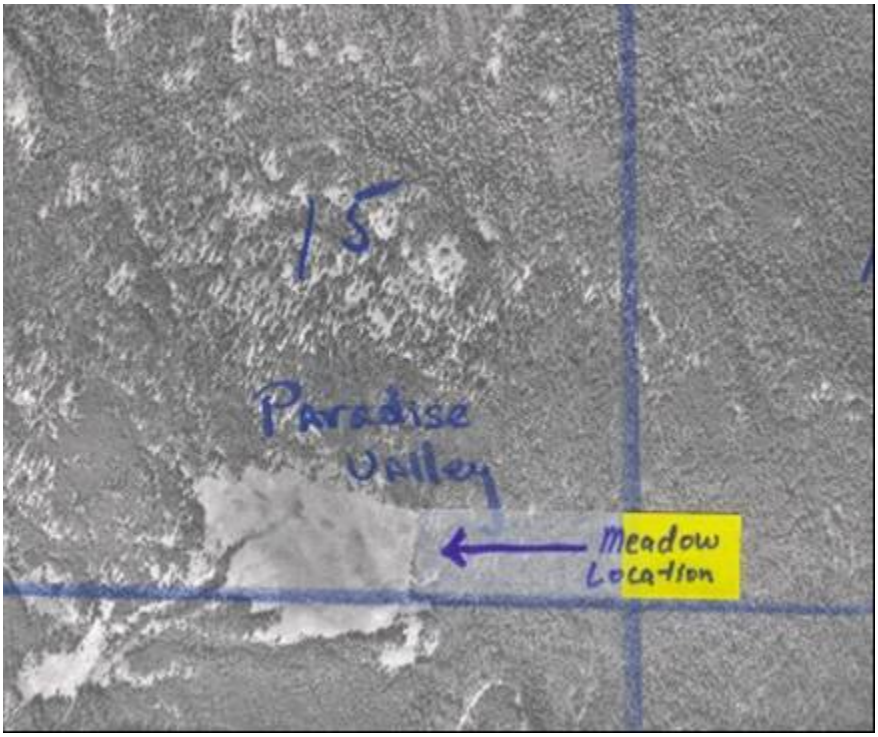
Paradise Meadow, 2009 NAIP Image.

Appendix 6. Continued.

Paradise Meadow, Aerial Photo 2000 67-134-148.

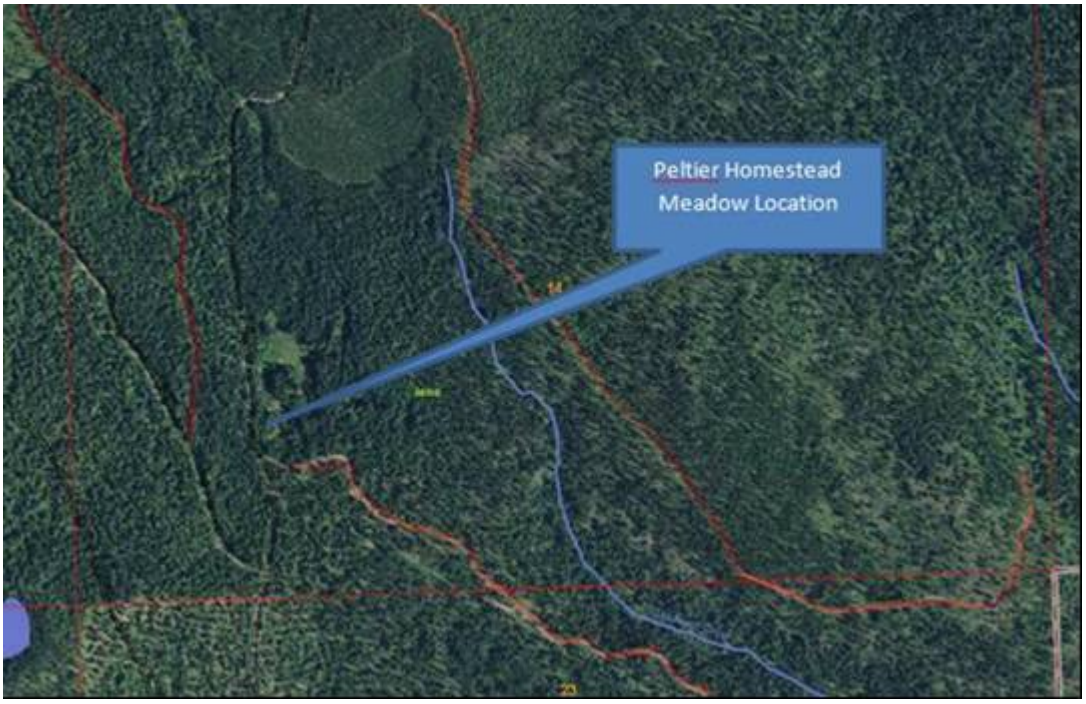


Paradise Meadow, Aerial Photo 1960 EIL-4-108.

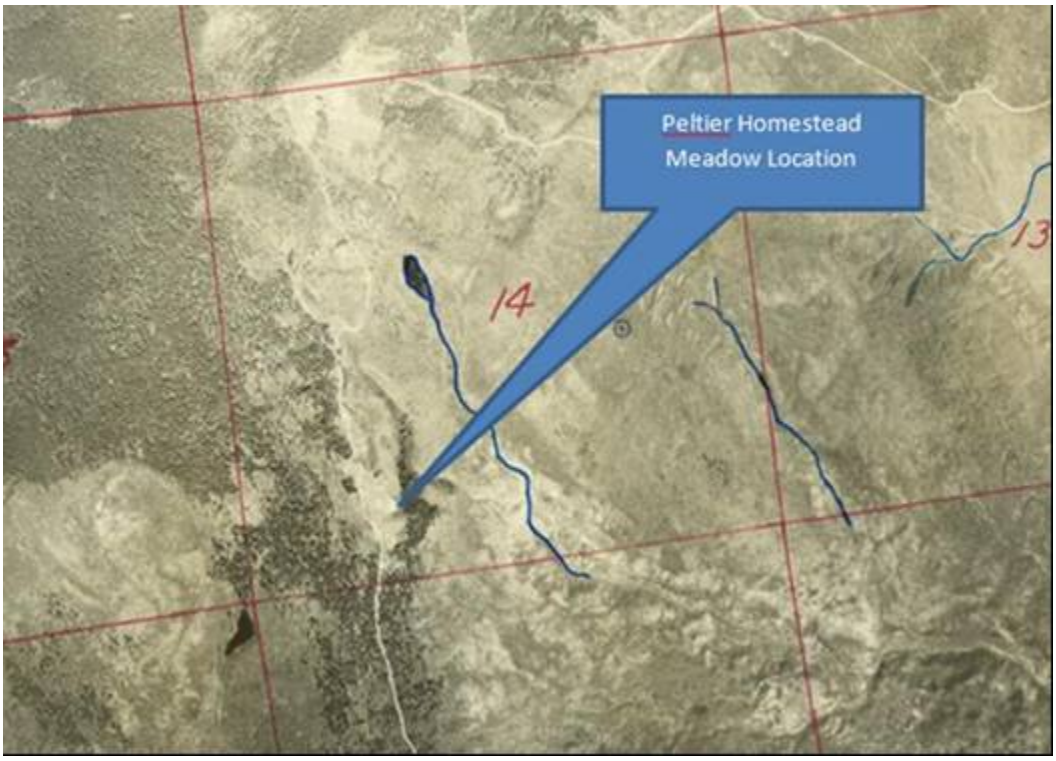


Appendix 6. Continued.

Peltier Homestead Meadow, 2009 NAIP Image.



Peltier Homestead Meadow, Aerial Photo 1935 Photo # X-678.



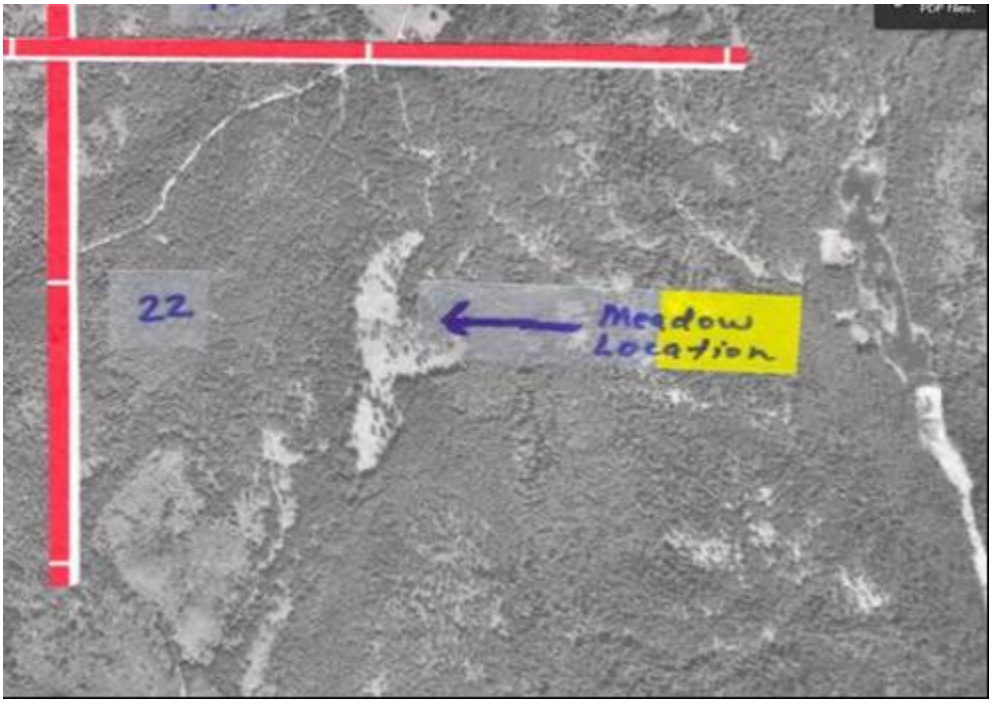
Appendix 6. Continued.

Road 755, 2009 NAIP Image.

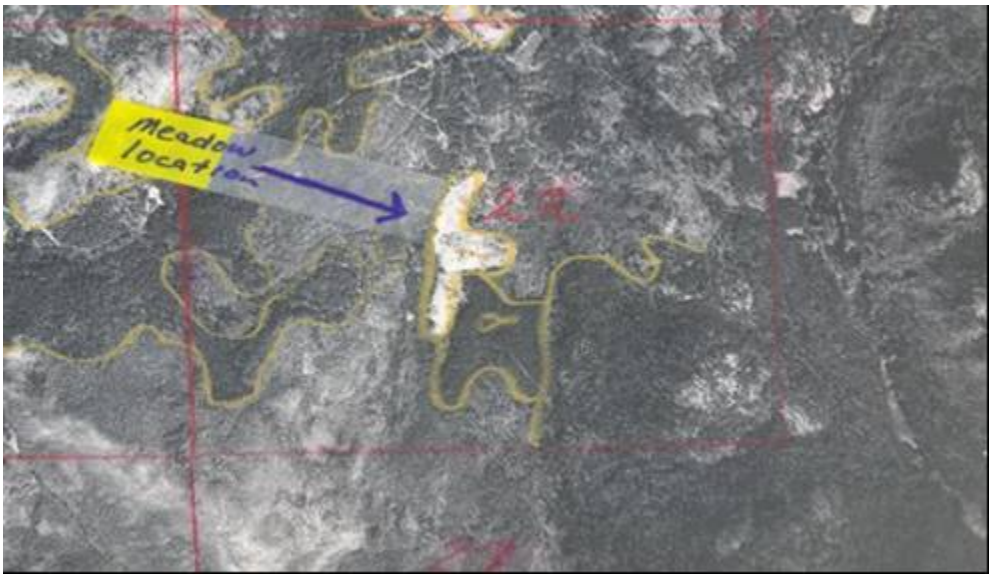
Rose Ranch, 2009 NAIP Image.

Appendix 6. Continued.

Rose Ranch, Aerial Photo 1960 Photo # EIL-6-144.



Rose Ranch, Aerial Photo 1943 Photo # 731.



Appendix 7. Associated Species.

Site Name / Plant Name	Meadow Sites							Forest Sites						
	Be-strom	**Big Muddy**	**Do-min-ion**	**Para-dise**	**Pel-tier**	**Rose Ranch**	**Meadow Total**	**Bailey Creek**	**Dead-man Creek**	**East Fork Crown Creek**	**Flat Creek**	**Hodge-son Creek**	**Road 755**	**Forest Total**
Abies grandis					x	x	2			x	x			2
Abies lasiocarpa							0		x			x		2
Acer glabrum var. douglasii							0		x		x		x	3
Achillea millefolium	x	x		x	x		4							0
Actaea rubra							0	x			x		x	3
Adenocaulon bicolor							0	x			x	x	x	4
Agrostis sp.							0			x				1
Alnus incana							0			x				1
Alnus sinuata							0		x	x	x	x	x	5
Antennaria microphylla	x					x	2							0
Antennaria neglecta	x						0							0
Antennaria sp.				x	x		2							0
Aralia nudicaulis							0		x		x			2
Arctostaphylus uva-ursi					x		1							0
Arnica cordifolia							0	x						1
Asarum caudatum							0	x	x	x	x			4
Athyrium felix-femina							0				x	x		2
Betula papyrifera						x	1		x	x	x		x	4
Botrychium crenulatum							0	x						1
Botrychium hesperium	x		x				2							0

Appendix 7. Continued.

Site Name / Plant Name	Meadow Sites							Forest Sites						
	Be-strom	**Big Muddy**	**Do-min-ion**	**Para-dise**	**Pel-tier**	**Rose Ranch**	**Meadow Total**	**Bailey Creek**	**Dead-man Creek**	**East Fork Crown Creek**	**Flat Creek**	**Hodge-son Creek**	**Road 755**	**Forest Total**
Botrychium lanceolata			x				1							0
Botrychium lunaria							0					x		1
Botrychium minganense		x	x				2	x	x			x		3
Botrychium montanum							2	x	x					2
Botrychium paradoxum	x			x			2	x						1
Botrychium pendunculosum	x	x	x				3							0
Botrychium simplex	x	x	x	x			4							0
Botrychium virginianum							0	x				x	x	3
Bromus inermis	x						1							0
Chimaphila umbellata var. occidentalis							0		x					1
Clintonia uniflora							0		x		x	x		3
Collinsia sp.				x			1							0
Cornus canadensis							0	x	x					2
Cornus stolonifera							0	x	x	x			x	4
Dactylis glomerata	x			x			2							0
Equisetum sp.							0		x					1
Fragaria sp.						x	1		x					1
Fragaria vesca		x	x	x	x		4			x				1

Appendix 7. Continued.

Site Name / Plant Name		Meadow Sites							Forest Sites					
	Be-strom	**Big Muddy**	**Do-min-ion**	**Para-dise**	**Pel-tier**	**Rose Ranch**	**Meadow Total**	**Bailey Creek**	**Dead-man Creek**	**East Fork Crown Creek**	**Flat Creek**	**Hodge-son Creek**	**Road 755**	**Forest Total**
Fragaria virginianum	x	x	x	x	x		5							0
Galium sp.							0	x	x			x		3
Gentiana amarella	x	x					2							0
Geum spp.							0		x					1
Grass spp.					x	x	2		x					1
Gymnocarpium dryopteris							0		x					1
Habenaria sp.							0					x		1
Hieracium caespitosum	x				x		2							0
Hieracium pratense	x	x	x	x			4							0
Hieracium sp.							0			x				1
Hypericum perfoliatum			x	x	x		3			x				1
Juncus sp.				x			1							0
Larix occidentalis		x					1	x			x	x		3
Leucanthemum vulgare	x			x	x	x	4							0
Linnaea borealis							0		x	x	x			3
Listera convallaroides							0						x	1
Listera sp.							0					x		1
Lupinus sp.					x		1							0
Medicago lupulina		x					1							0

Appendix 7. Continued.

Site Name / Plant Name	Meadow Sites							Forest Sites						
	Be-strom	**Big Muddy**	**Do-min-ion**	**Para-dise**	**Pel-tier**	**Rose Ranch**	**Meadow Total**	**Bailey Creek**	**Dead-man Creek**	**East Fork Crown Creek**	**Flat Creek**	**Hodge-son Creek**	**Road 755**	**Forest Total**
Mitella sp.							0		x					1
Moss sp.		x					1					x		1
Oplopanax horridus							0					x		1
Osmorhiza chilensis							0	x				x	x	3
Paschistima myrsinites							0				x			1
Phleum pratense	x		x				2							0
Picea engelmannii						x	1		x	x	x	x	x	5
Pinus contorta	x	x			x		3							0
Pinus monticola		x			x		2							0
Pinus ponderosa				x			1	x						1
Plantago lanceolata	x	x		x			3							0
Plantago major				x			1							0
Poa pratensis			x				1							0
Poa sp.				x			1							0
Polytrichum juniperum	x						1							0
Populus tremuloides						x	1	x					x	2
Populus trichocarpa						x	1					x	x	2
Potentilla argentea		x					1							0
Potentilla rectus							0			x				1
Potentilla sp.				x			1							0
Prunella vulgaris		x	x	x		x	4			x				1
Pseudotsuga menziesii	x				x	x	3	x			x			2

Appendix 7. Continued.

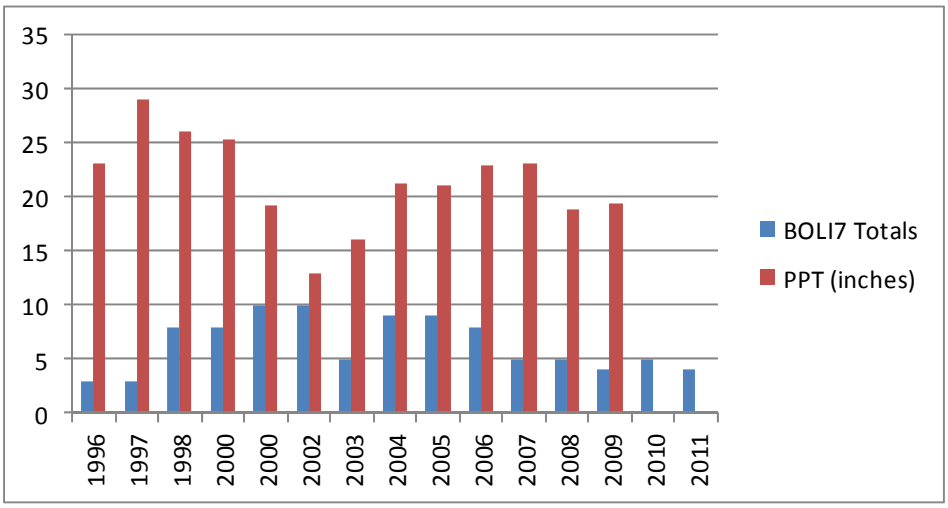
Site Name / Plant Name	Meadow Sites							Forest Sites						
	Be-strom	**Big Muddy**	**Do-min-ion**	**Para-dise**	**Pel-tier**	**Rose Ranch**	**Meadow Total**	**Bailey Creek**	**Dead-man Creek**	**East Fork Crown Creek**	**Flat Creek**	**Hodge-son Creek**	**Road 755**	**Forest Total**
Pteridium aquilinum		x			x		2							0
Pyrola sp.							0					x		1
Ribes lacustre							0	x	x	x	x	x	x	6
Rosa sp.							0		x					1
Rubus parviflorus							0				x	x	x	3
Rumex acetosella			x				1			x				1
Rumex sp.					x		1							
Salix sp.							0					x		1
Sisyrinchium septentrionale	x						1							0
Smilacina sp.							0	x	x			x		3
Streptopus amplexifolius							0	x				x		2
Symphoriocarpus albus				x			1		x				x	1
Taraxacum officinale			x	x		x	3							0
Thalictrum occidentalis							0					x		1
Thuja plicata							0	x	x	x	x	x	x	6
Tiarella unifoliata							0		x		x	x		3
Tortula sp.					x		1							0
Trifolium agrarium	x						1			x				1
Trifolium repens	x	x	x	x		x	5			x				1

Appendix 7. Continued.

	Meadow Sites							Forest Sites						
Site Name **Plant Name**	**Be-strom**	**Big Muddy**	**Do-min-ion**	**Para-dise**	**Pel-tier**	**Rose Ranch**	**Meadow Total**	**Bailey Creek**	**Dead-man Creek**	**East Fork Crown Creek**	**Flat Creek**	**Hodge-son Creek**	**Road 755**	**Forest Total**
Trifolium sp.				x			1							1
Tsuga heterophylla							0			x				0
Vaccinium sp.							0		x					1
Viola canadensis							0	x						1
Viola glabrella							0	x	x					2
Viola spp.				x			1				x	x		2

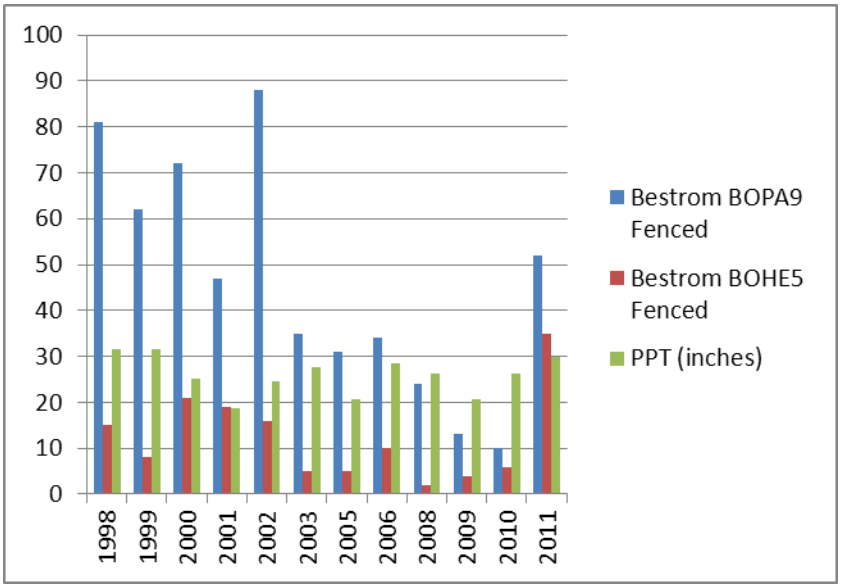
Appendix 8. Population Counts with Annual Precipitation.

Bailey Creek, Population Counts with Annual Precipitation.



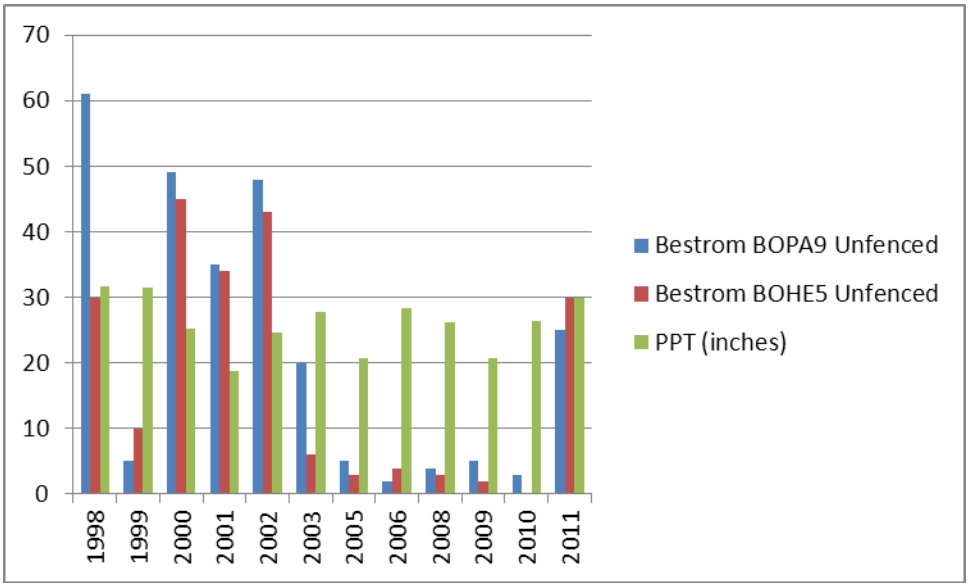
Note: The Growden precipitation gauge was decommissioned in 2009 due to the removal of the Growden Dam.

Bestrom, Population Counts in Fenced Macroplot with Annual Precipitation.

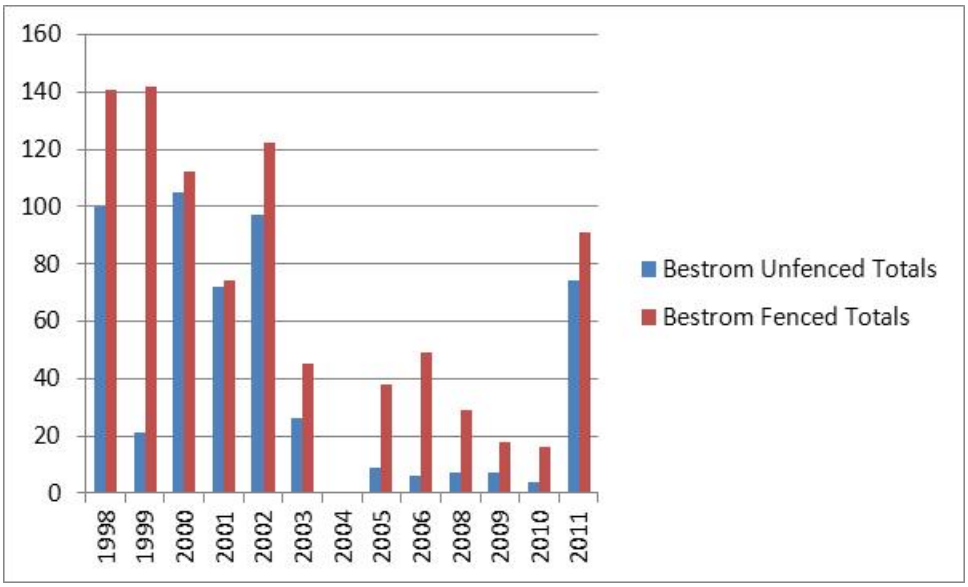


Appendix 8. Continued.

Bestrom, Population Counts in Unfenced Macroplot with Annual Precipitation.

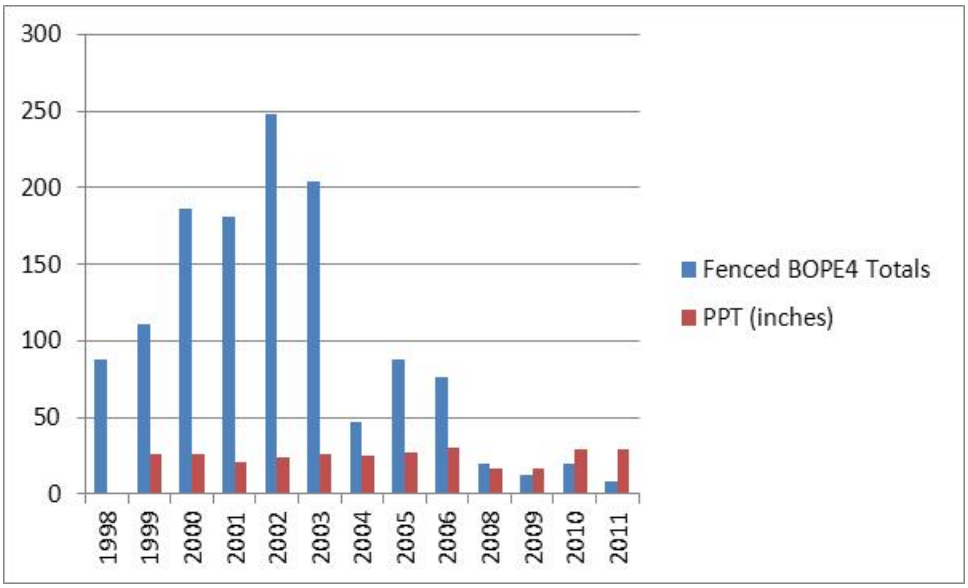


Bestrom, Population Counts in Fenced and Unfenced Macroplots.

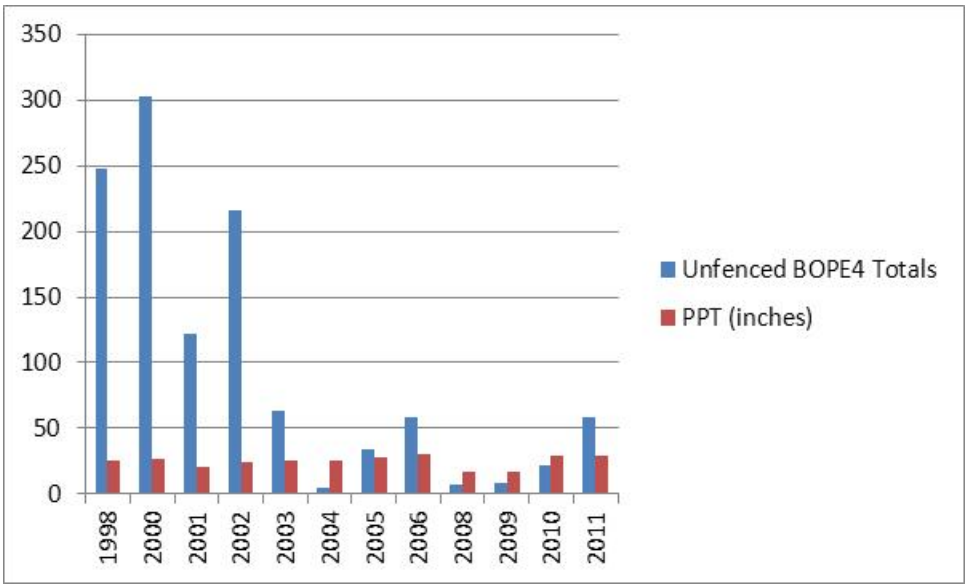


Appendix 8. Continued.

Big Muddy, Population Counts in Fenced Macroplot with Annual Precipitation.

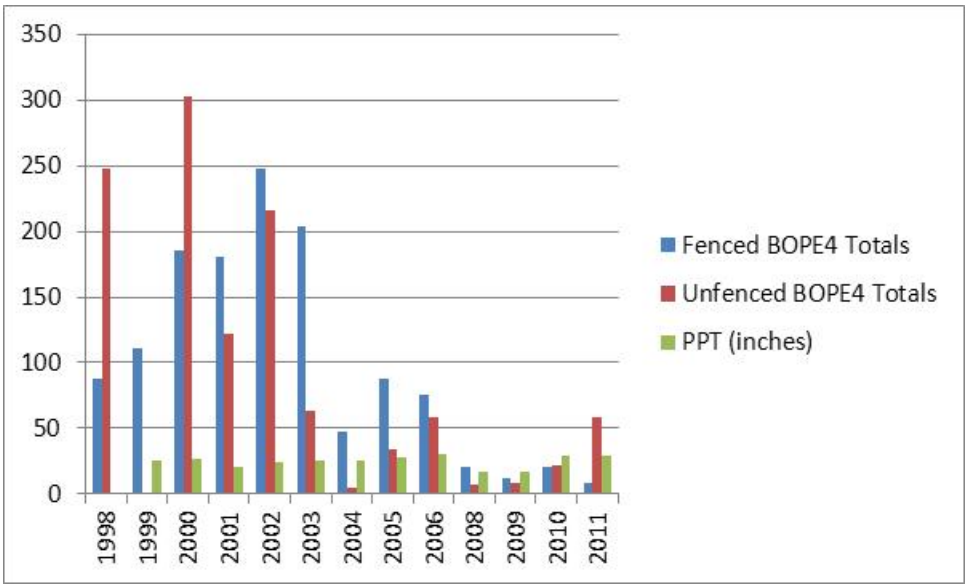


Big Muddy, Population Counts in Unfenced Macroplot with Annual Precipitation.

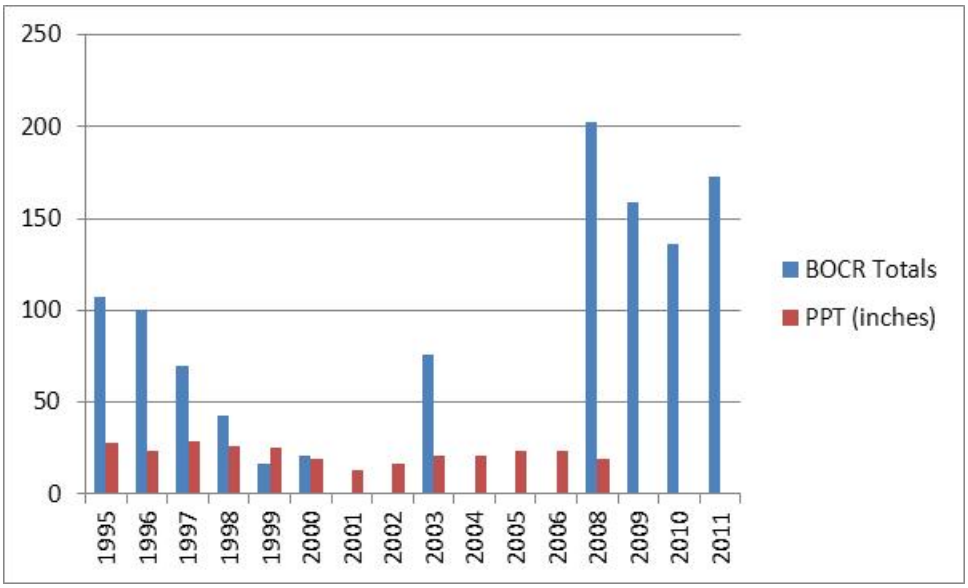


Appendix 8. Continued.

Big Muddy, Population Counts in Fenced and Unfenced Macroplots with Annual Precipitation. .

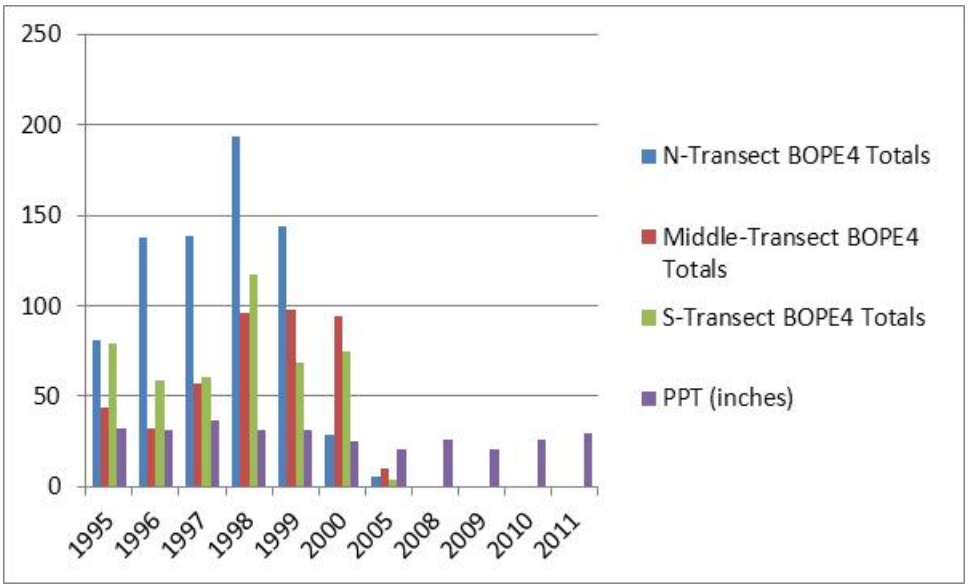


Deadman, Population Counts with Annual Precipitation.

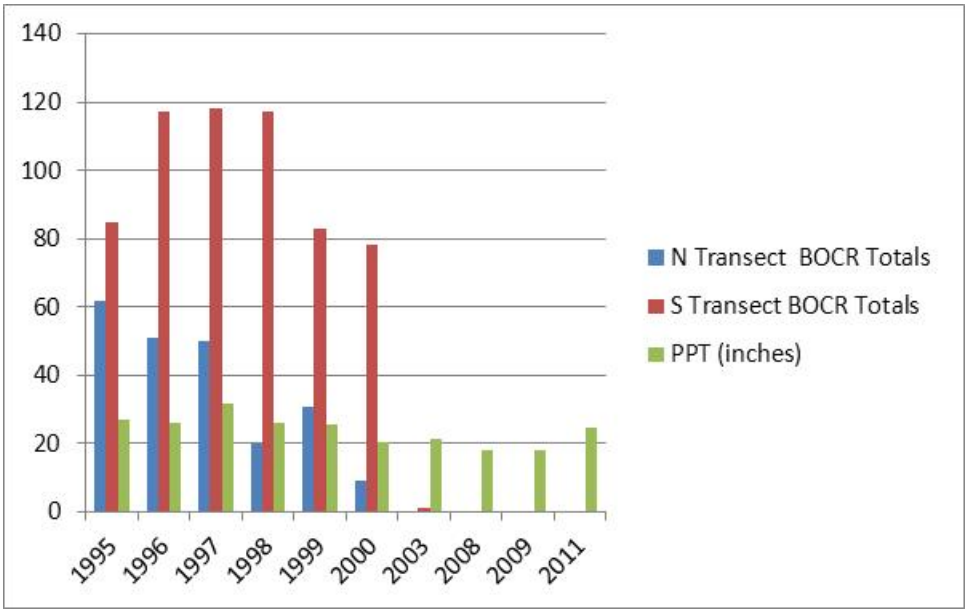


Appendix 8. Continued.

Dominion, Population Counts with Annual Precipitation.

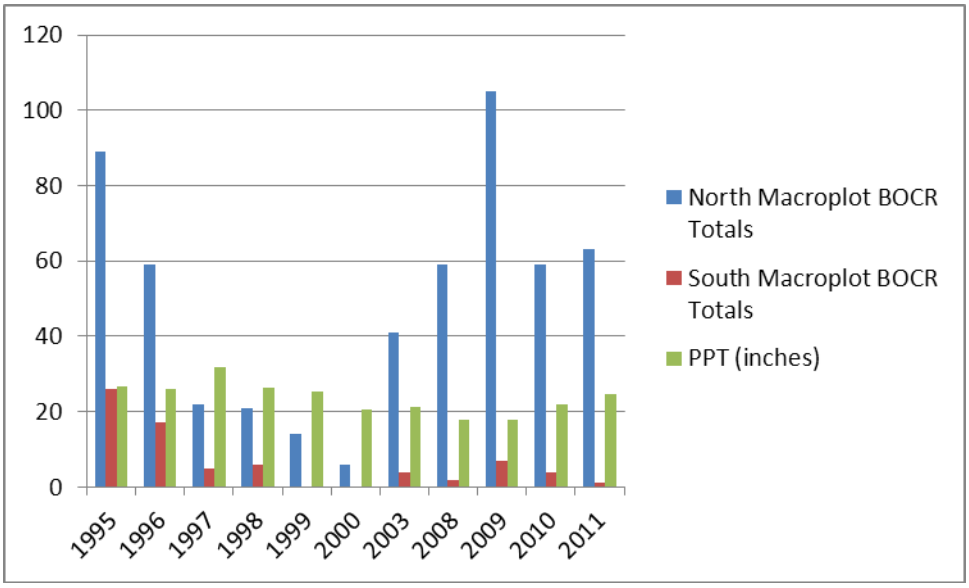


East Fork Crown Creek, Population Counts with Annual Precipitation.

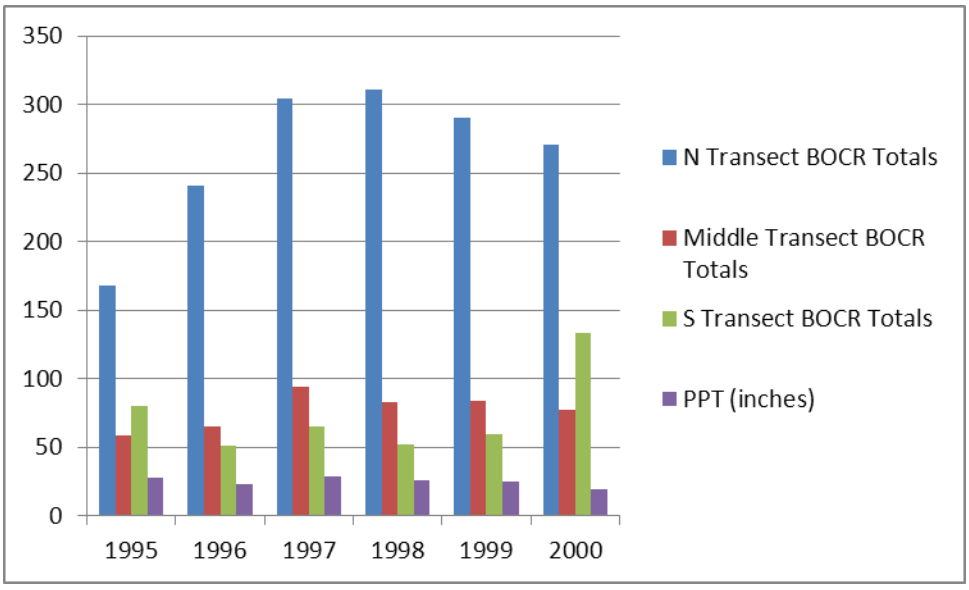


Appendix 8. Continued.

Flat Creek, Population Counts with Annual Precipitation.

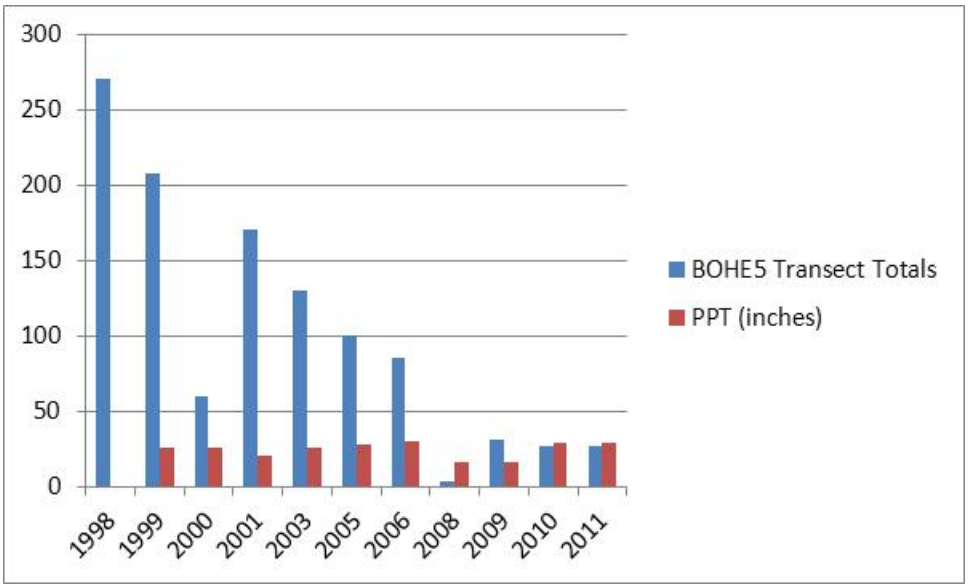


Hodgeson Creek, Population Counts with Annual Precipitation.

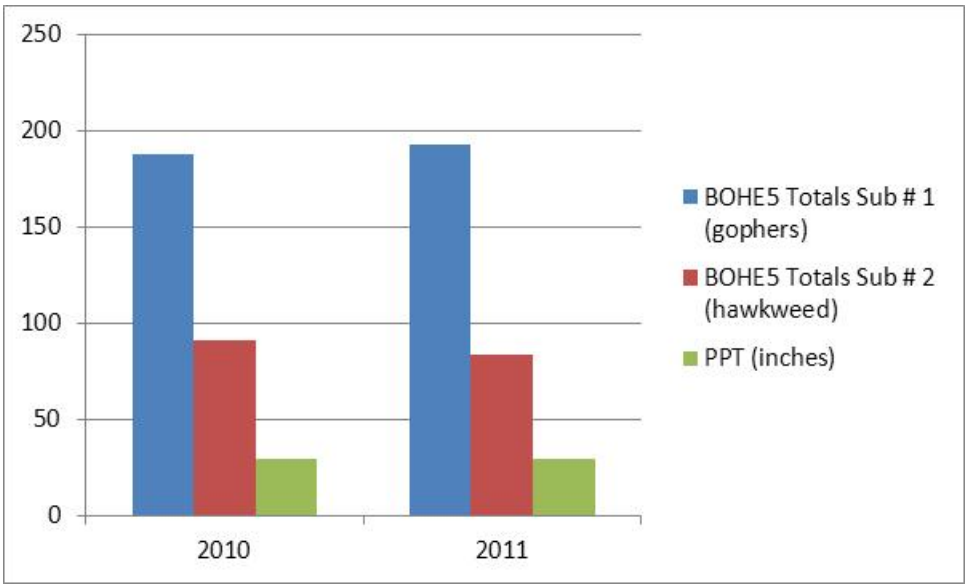


Appendix 8. Continued.

Paradise Meadow, Population Counts with Annual Precipitation.

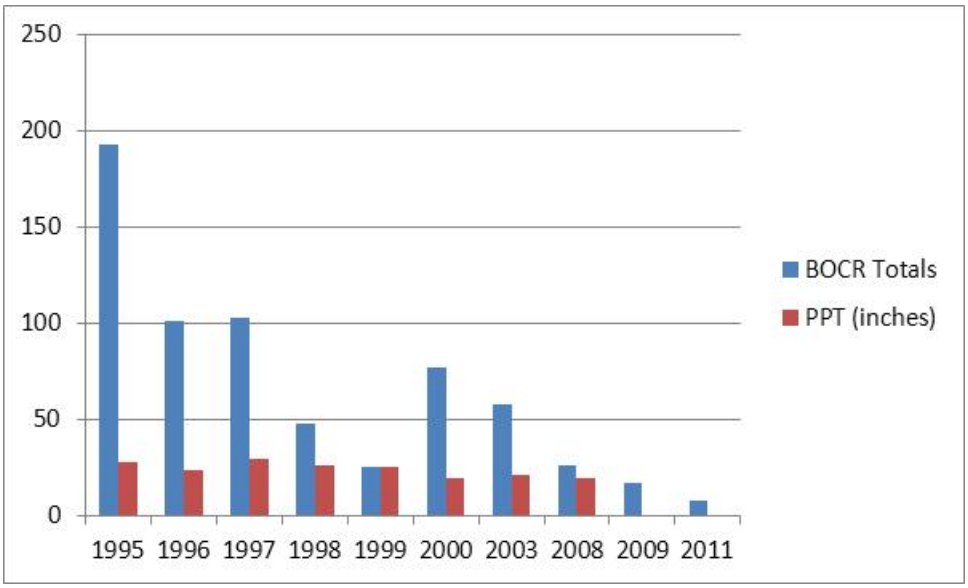


Peltier Homestead, Population Counts with Annual Precipitation.

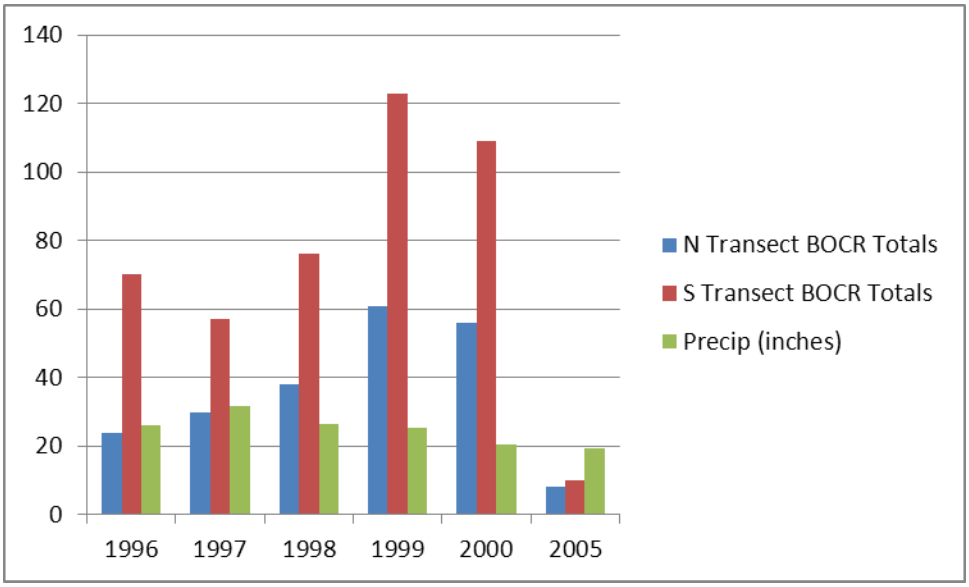


Appendix 8. Continued.

Road 755, Population Counts with Annual Precipitation.



Rose Ranch, Population Counts with Annual Precipitation.

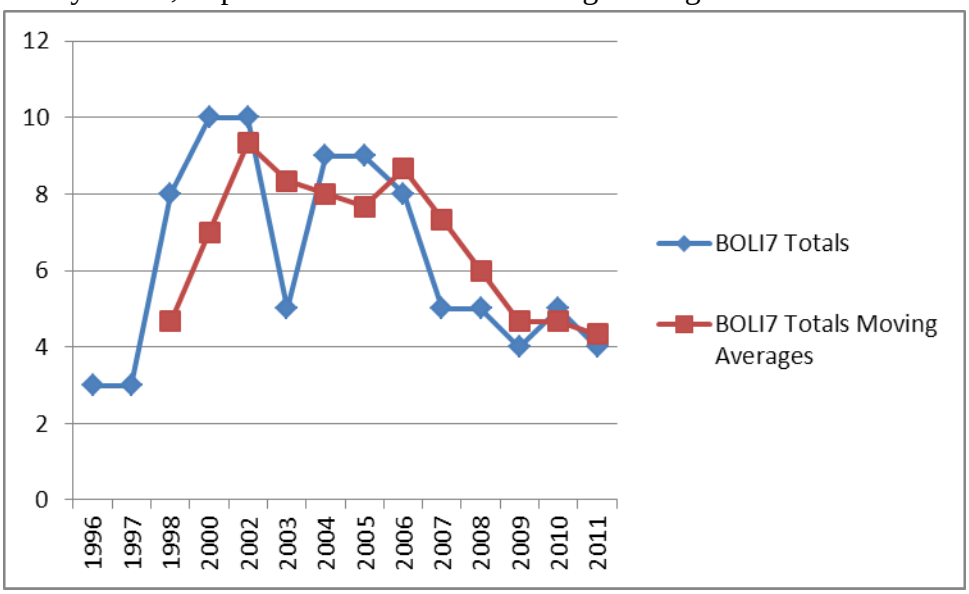


Appendix 9. Dates Plots Read.

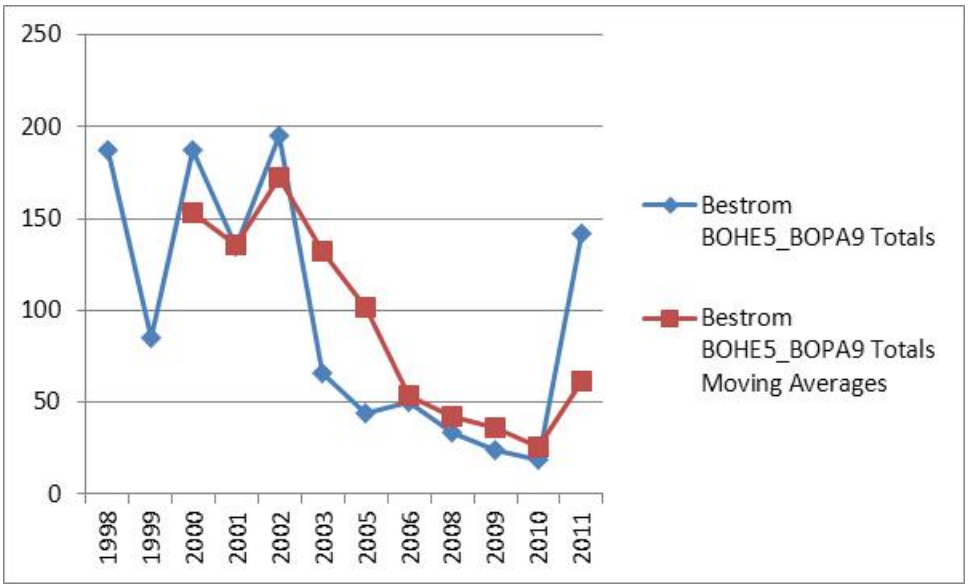
MEADOW SITES	Year and Dates Plots Read																
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Bestrom				6/24&7/2	6/8	6/28	6/26	6/12	6/19	6/29	6/21	6/28		7/2	7/1	7/12	7/6
Big Muddy				7/1	7/8	6/28	6/27	6/6	6/24	7/1	6/27	6/20		7/8	7/7	7/13	7/11
Dominion	7/26	7/22	7/28	7/20-21	7/27&29	7/24		7/26	6/23	7/7	6/30			7/1	6/30	7/12	7/12
Paradise				6/18	6/17	6/8	6/13		6/19	6/30	6/27	6/28		7/10	6/30	7/13	7/12
Peltier																6/22, 7/15	7/5
Rose Ranch			6/23	7/1	6/29	6/27				8/8	7/6						
FOREST SITES																	
Bailey Creek		7/23	6/5	6/15		6/14		7/2	7/7	7/6	7/5	7/6		7/9	7/6	7/6	7/7
Deadman Creek	7/25	7/25	7/31	7/23	7/20	7/25			7/7					7/15	7/15	7/6	7/14
East Fork Crown Creek	7/24	7/23	7/29	7/22	7/22	7/26			7/14					7/14	7/16		7/13
Flat Creek Tributary	7/24	7/23	7/29	7/22	7/26	7/26			7/14					7/14	7/16	7/14	7/13
Hodgeson Creek	7/27	7/24	7/1	7/27	8/3-4	7/27											
Road 755	7/25	7/25	7/31	7/23	7/20	7/25			7/7					7/15	7/15		7/7

Appendix 10. Population Counts with Moving Averages.

Bailey Creek, Population Counts with Moving Averages.

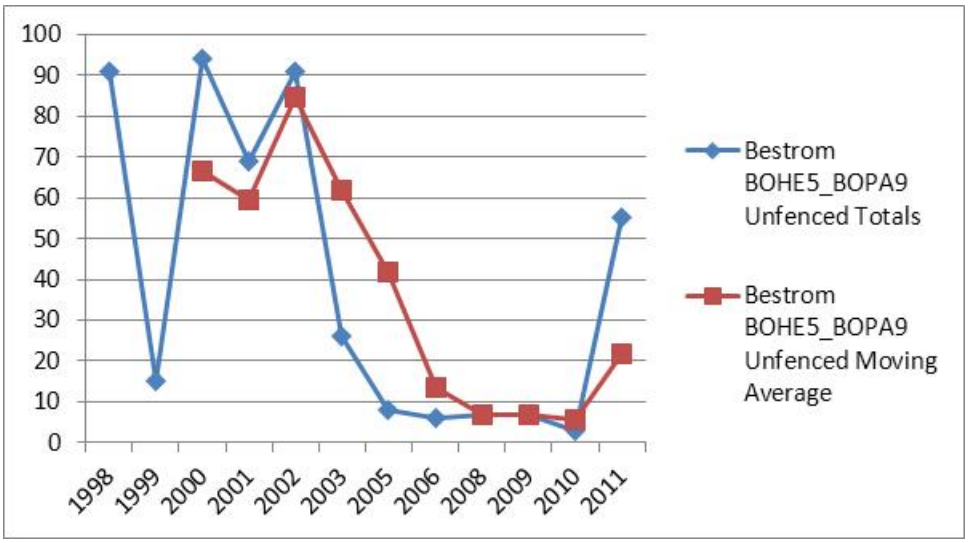


Bestrom, Population Counts with Moving Averages.

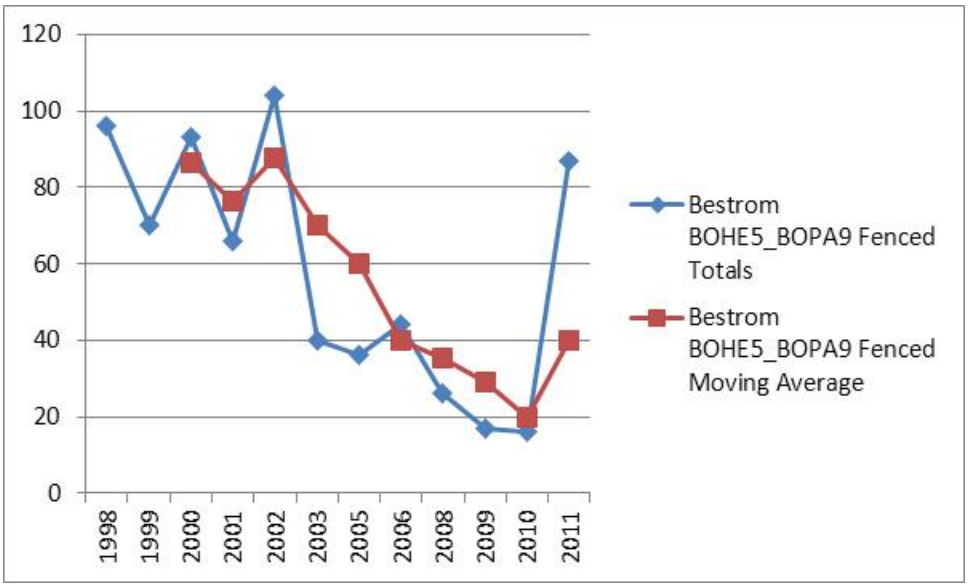


Appendix 10. Continued.

Bestrom, Population Counts in Unfenced Macroplot with Moving Averages.

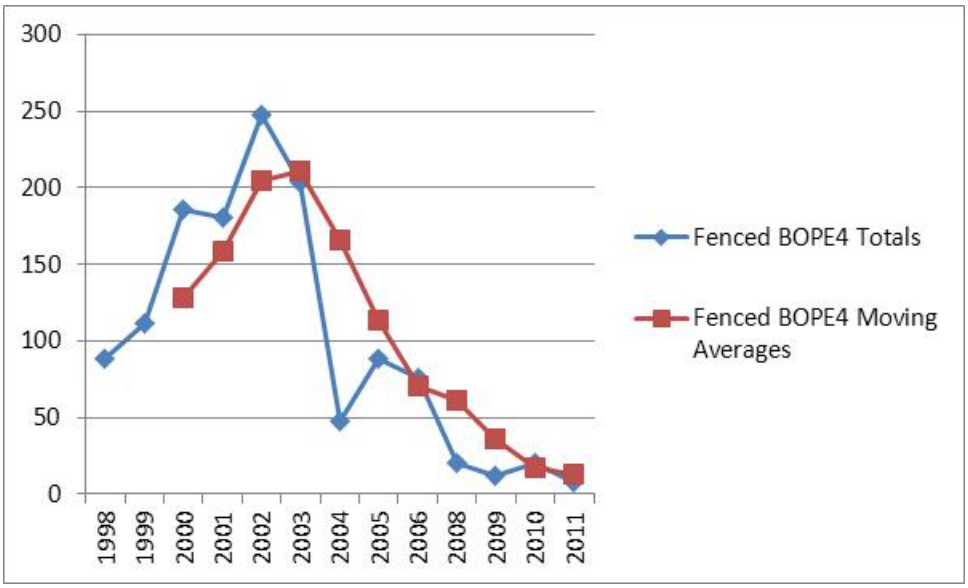


Bestrom, Population Counts in Fenced Macroplot with Moving Averages.

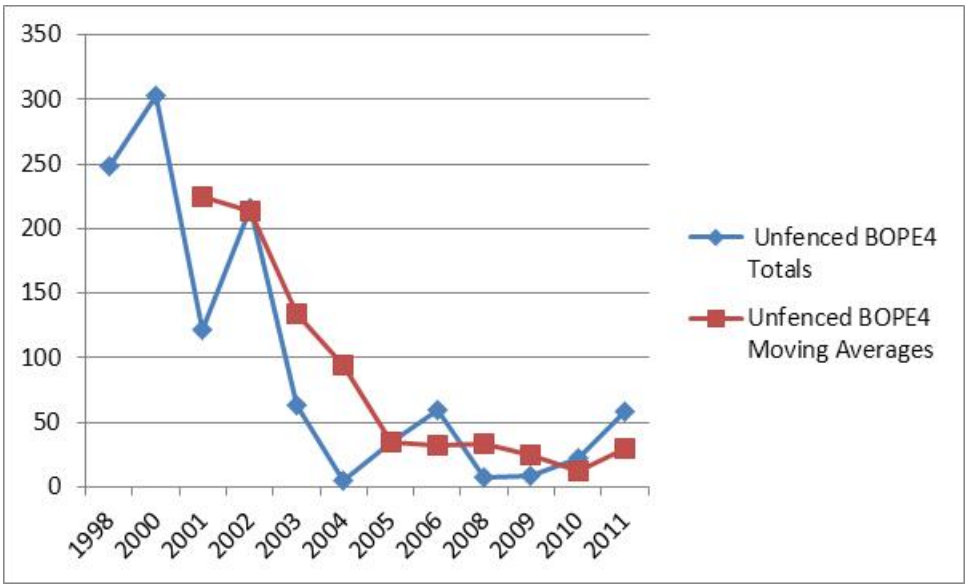


Appendix 10. Continued.

Big Muddy, Population Counts in Fenced Macroplot with Moving Averages.

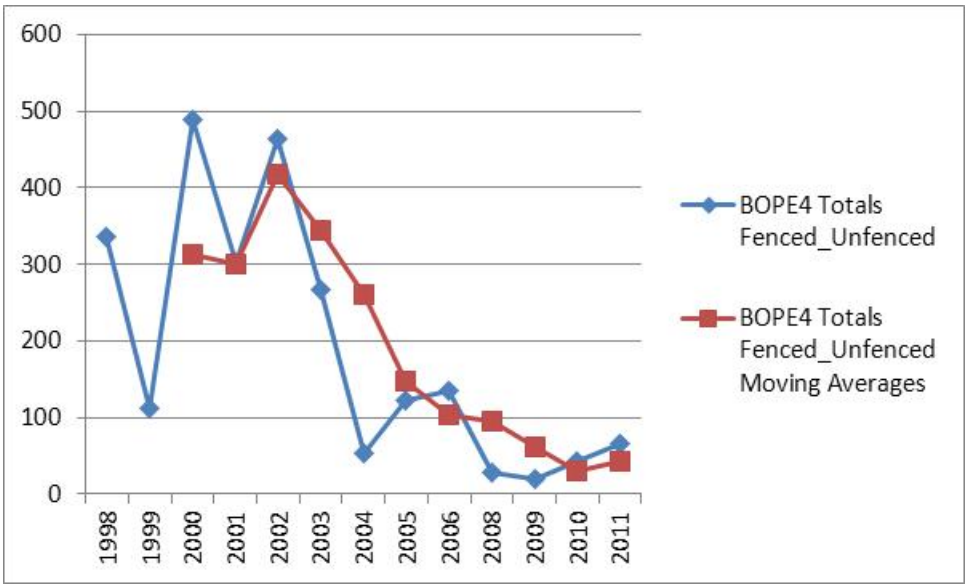


Big Muddy, Population Counts in Unfenced Macroplot with Moving Averages.

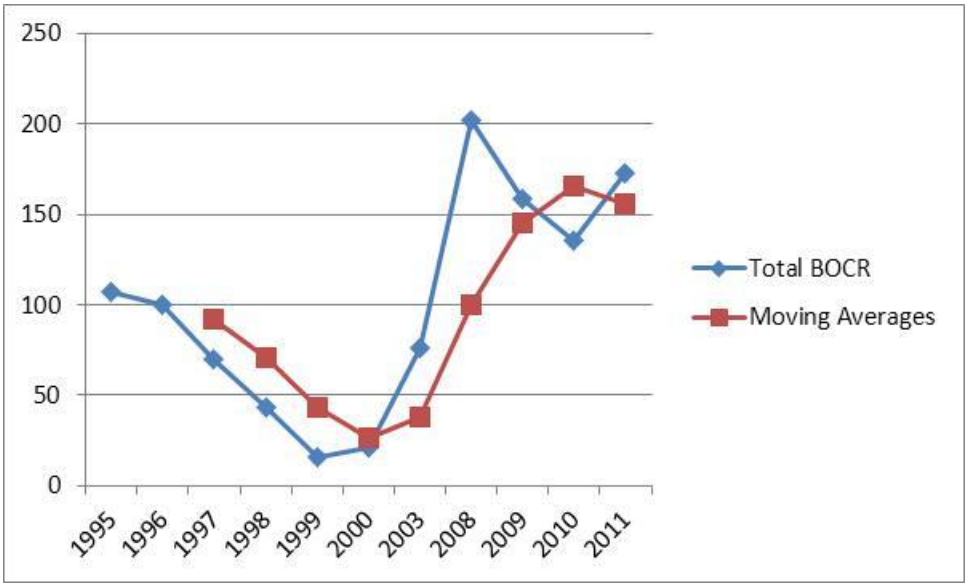


Appendix 10. Continued.

Big Muddy, Population Counts in Fenced and Unfenced Macroplots with Moving Averages.

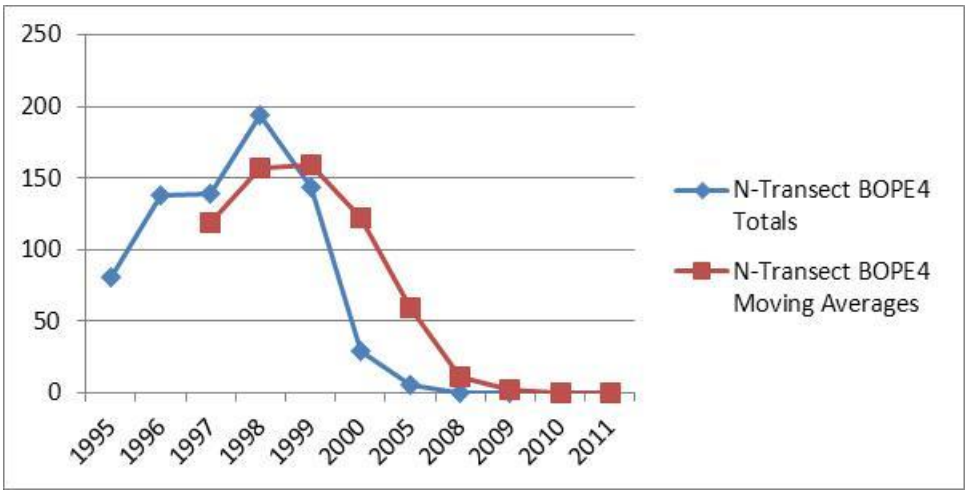


Deadman, Population Counts with Moving Averages.

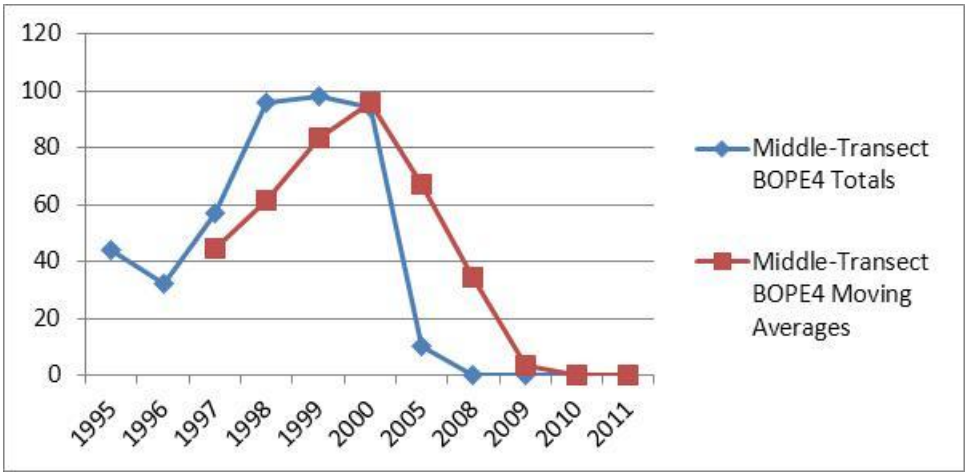


Appendix 10. Continued.

Dominion, North Transect, Population Counts with Moving Averages.

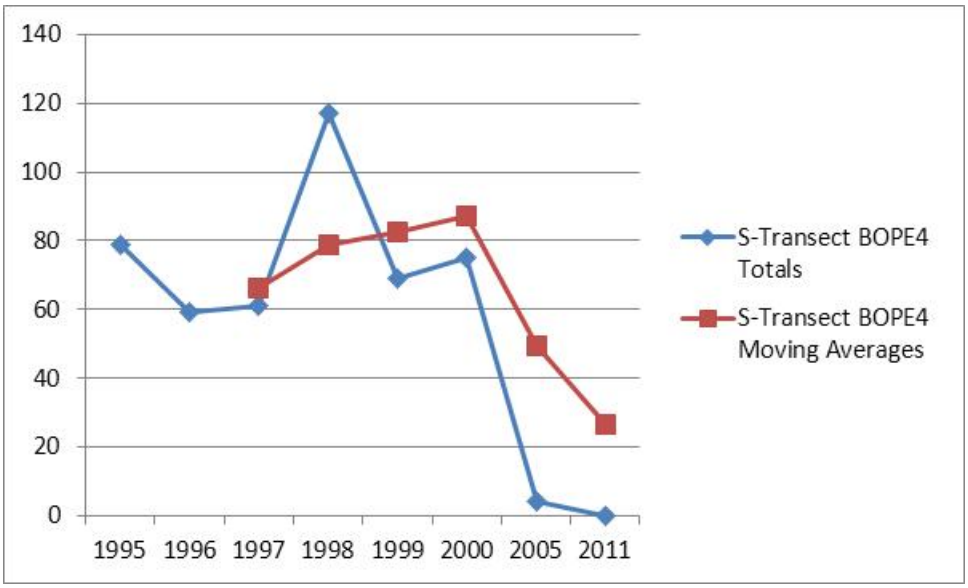


Dominion, Middle Transect, Population Counts with Moving Averages.

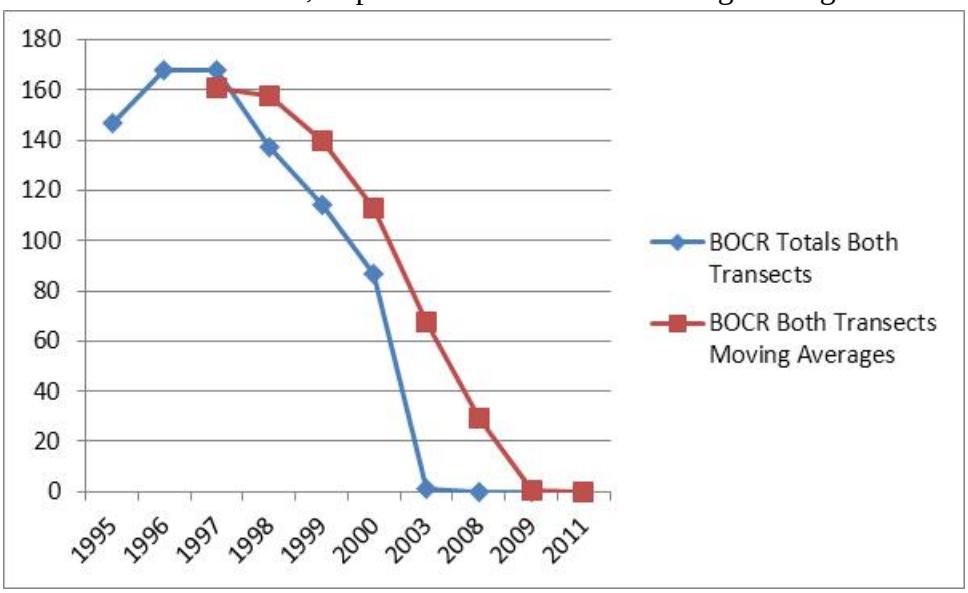


Appendix 10. Continued.

Dominion, South Transect, Population Counts with Moving Averages.

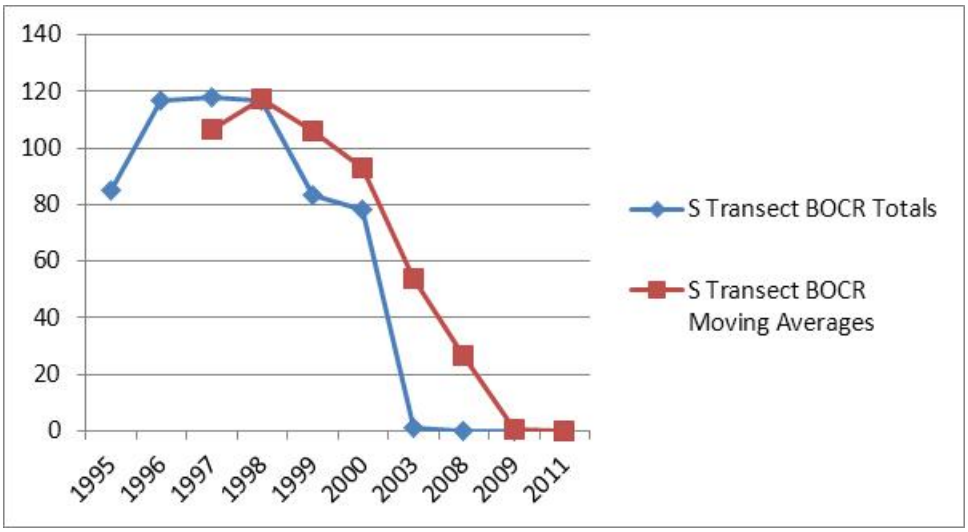


East Fork Crown Creek, Population Counts with Moving Averages.

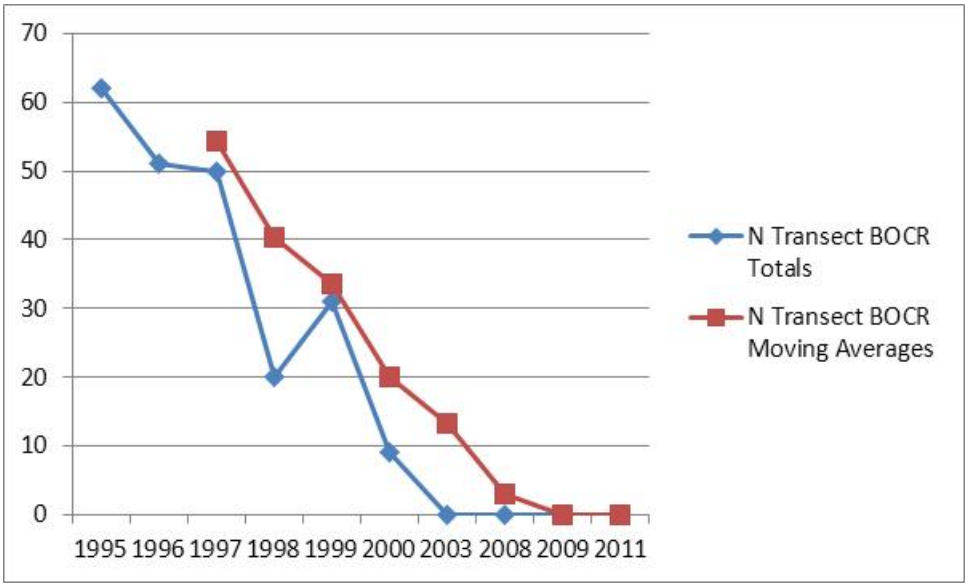


Appendix 10. Continued.

East Fork Crown Creek, South Transect, Population Counts with Moving Averages.

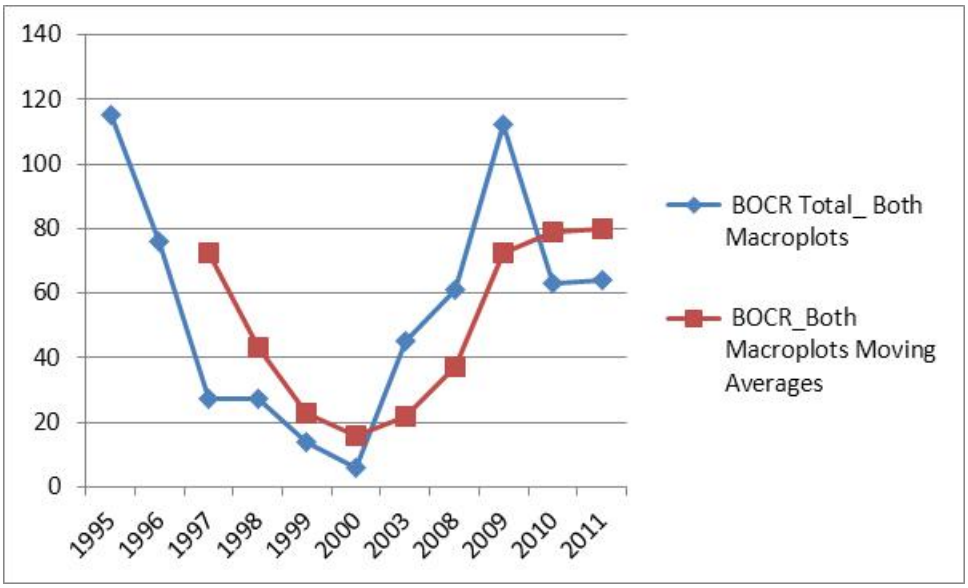


East Fork Crown Creek, North Transect, Population Counts with Moving Averages.

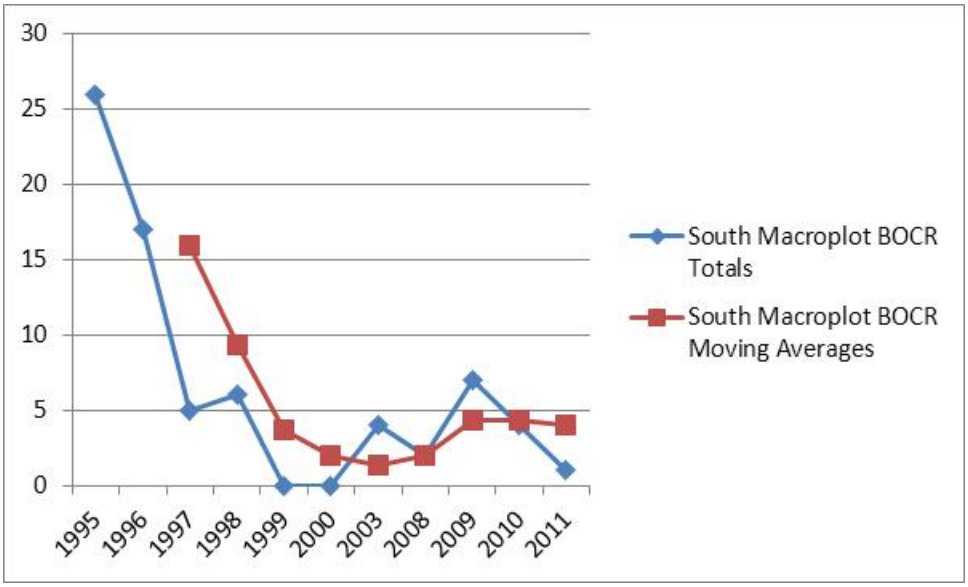


Appendix 10. Continued.

Flat Creek, Population Counts with Moving Averages.

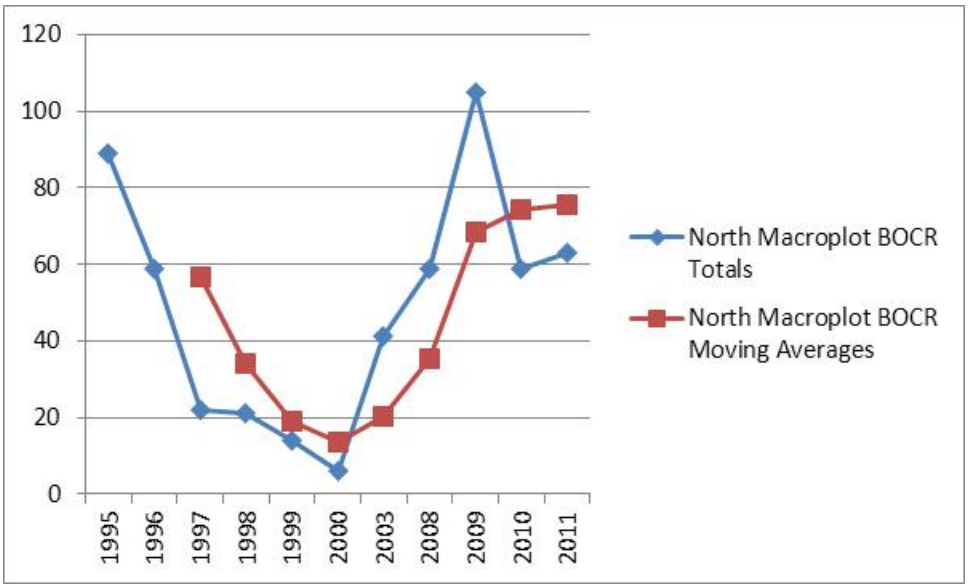


Flat Creek, South Transect, Population Counts with Moving Averages.

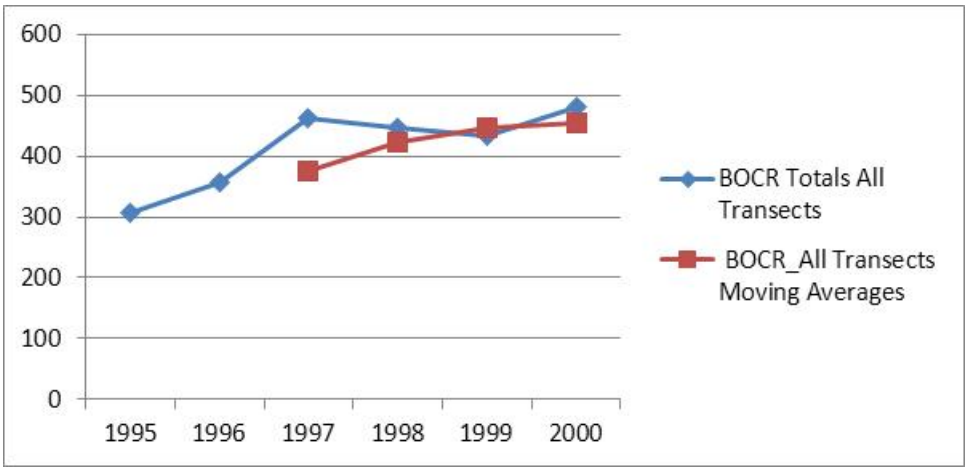


Appendix 10. Continued.

Flat Creek, North Transect, Population Counts with Moving Averages.

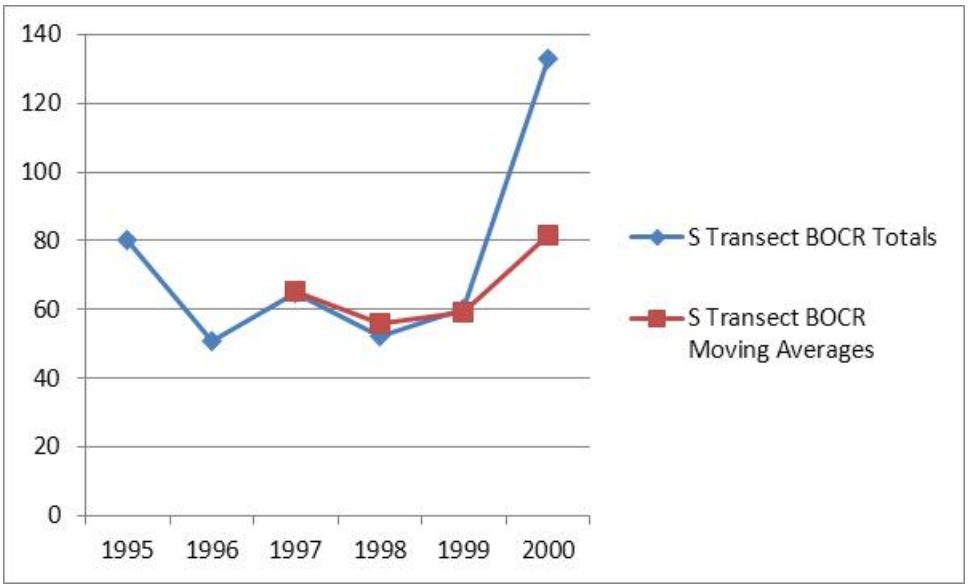


Hodgeson Creek, Population Counts with Moving Averages.

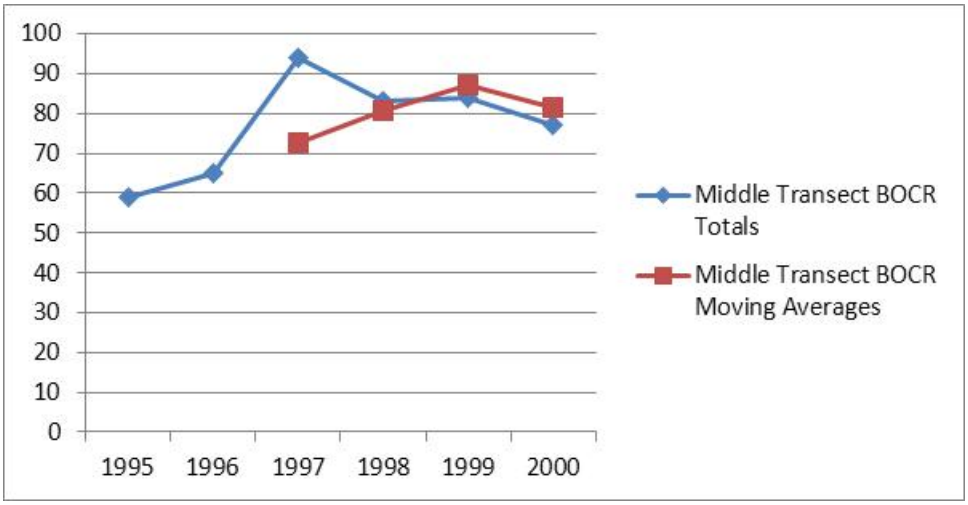


Appendix 10. Continued.

Hodgeson Creek, South Transect, Population Counts with Moving Averages.

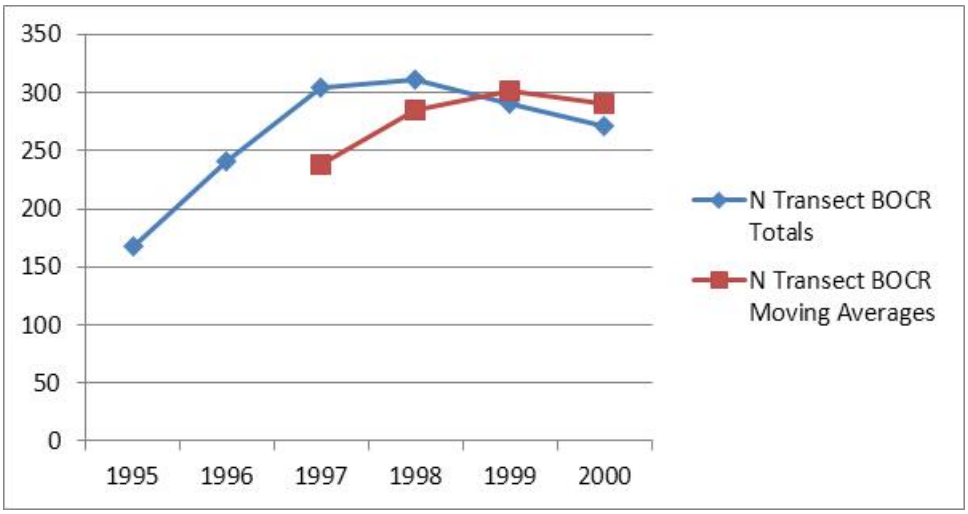


Hodgeson Creek, Middle Transect, Population Counts with Moving Averages.

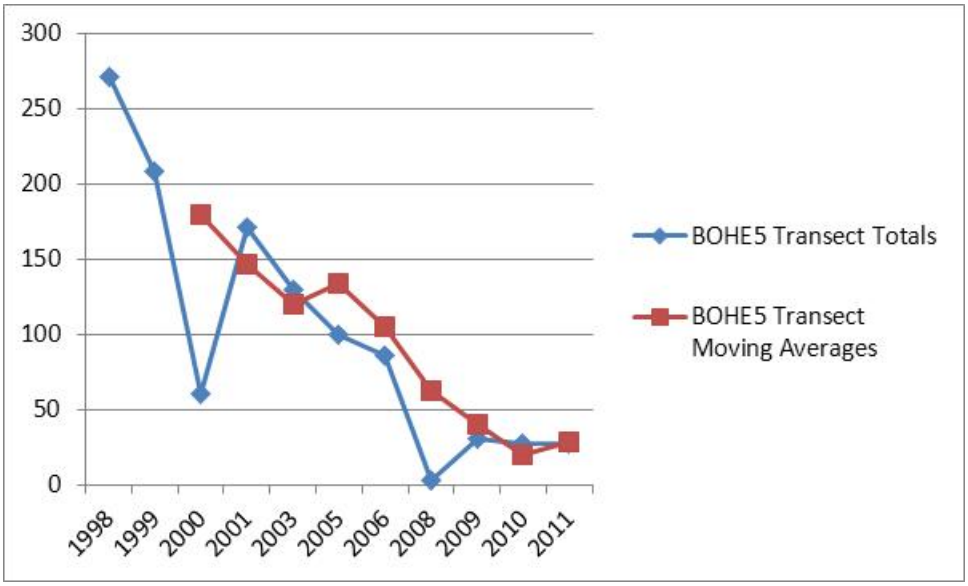


Appendix 10. Continued.

Hodgeson Creek, North Transect, Population Counts with Moving Averages.



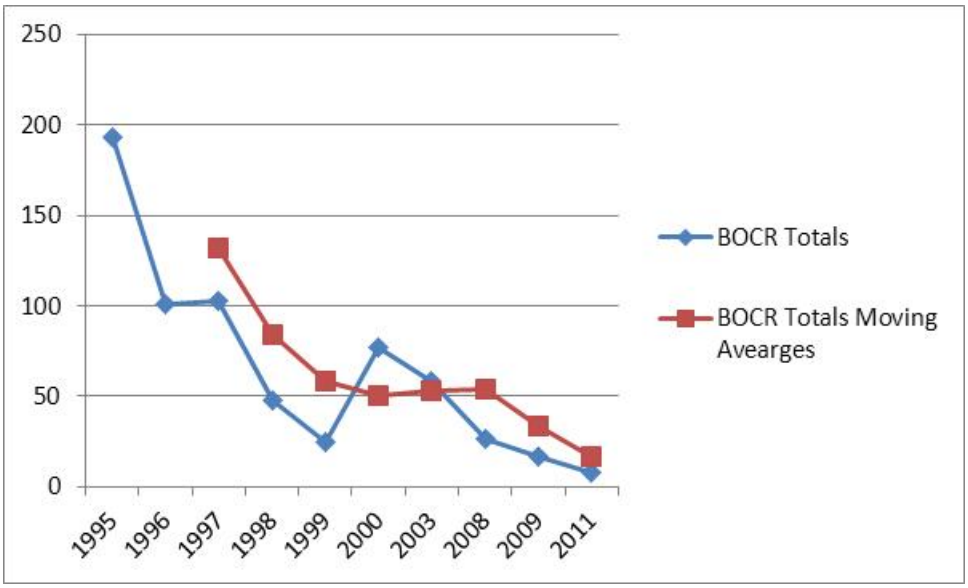
Paradise Meadow, Population Counts with Moving Averages.



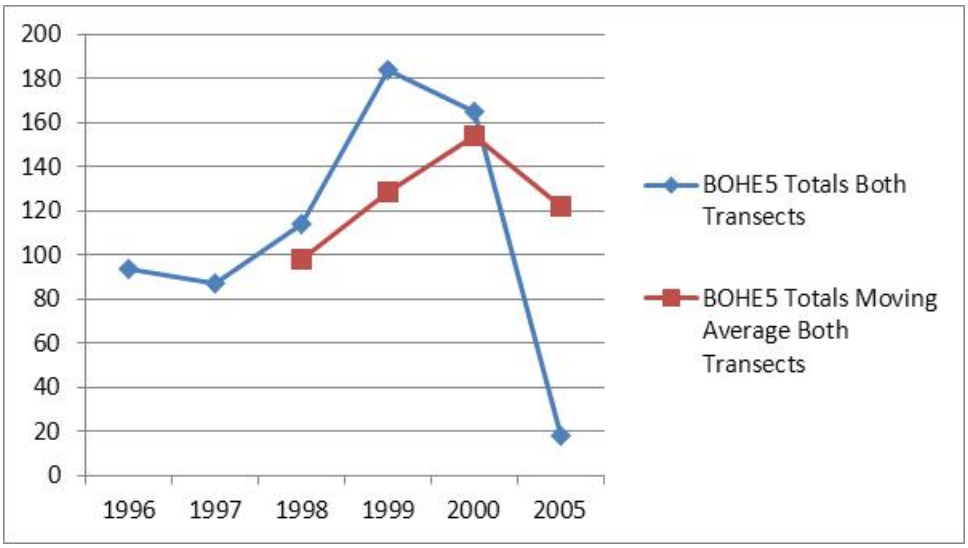
Peltier Homestead, Population Counts with Moving Averages.
Not enough data to track

Appendix 10. Continued.

Road 755, Population Counts with Moving Averages.

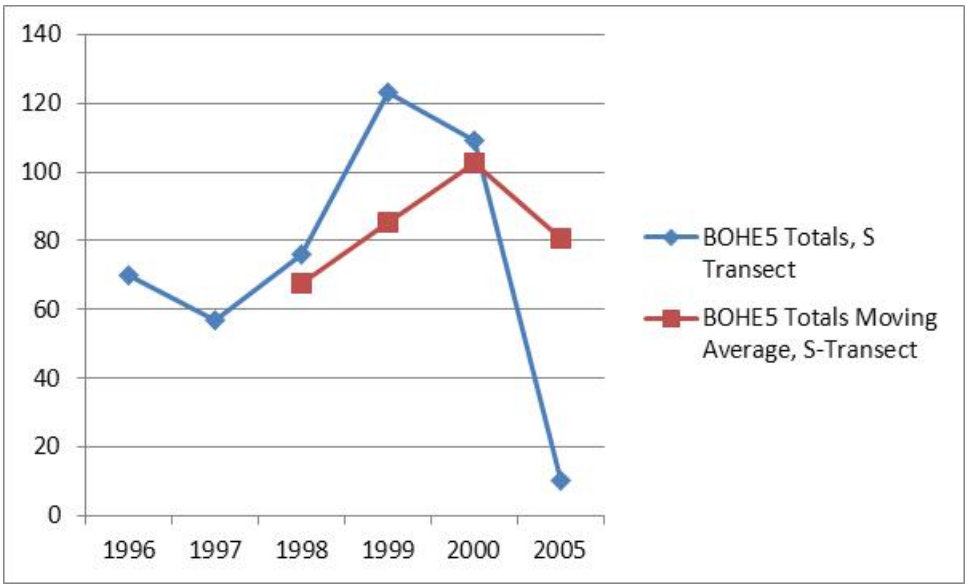


Rose Ranch, Population Counts with Moving Averages.

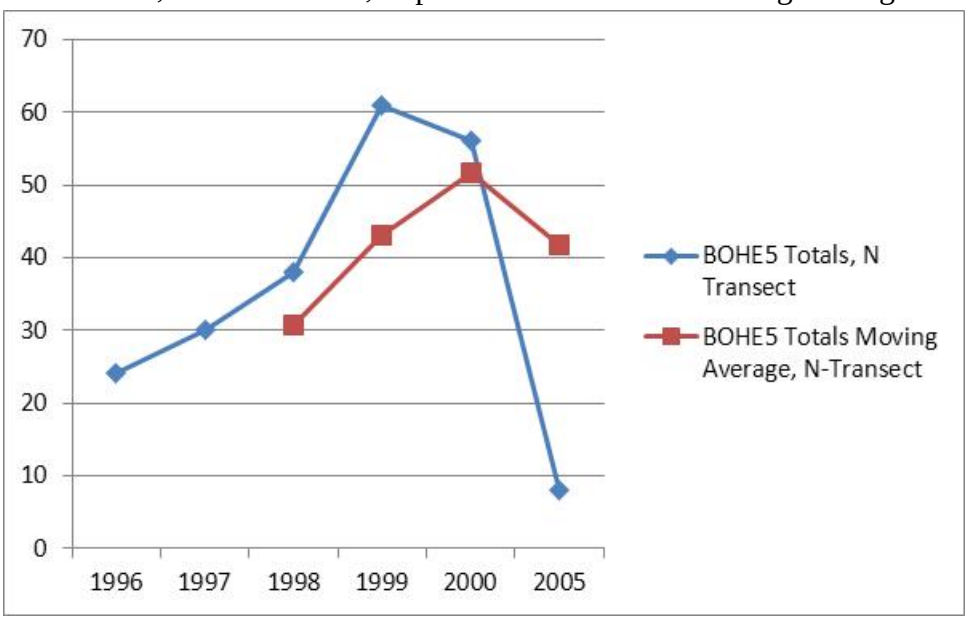


Appendix 10. Continued.

Rose Ranch, South Transect, Population Counts with Moving Averages.



Rose Ranch, North Transect, Population Counts with Moving Averages.



Appendix 11. Two-tailed Paired t-Tests.

Null=No difference between population means		
Alternate=Difference between population means		
Reject null if computed value of t exceeds 2.447		
Macroplots are italicized.		
MEADOW SITES	**Computed *t***	**Results**
Bestrom BOHE Fenced	0.481688872	Do not reject
Bestrom BOHE Unfenced	2.059632047	Do not reject
Bestrom BOPA Fenced	3.388243775	Reject
Bestrom BOPA Unfenced	2.145870496	Do not reject
Bestrom BOHE Fenced / Unfenced 1998-2001	-1.783403315	Do not reject
Bestrom BOHE Fenced / Unfenced 2008-2011	0.284374029	Do not reject
Bestrom BOPA Fenced / Unfenced 1998-2001	1.986531833	Do not reject
Bestrom BOPA Fenced / Unfenced 2008-2011	1.419144587	Do not reject
Big Muddy BOPE Fenced Macroplot Totals	12.21706477	Reject
Big Muddy BOPE Unfenced Macroplot Totals	2.805390353	Rejec
Big Muddy BOPE Fenced / Unfenced Macroplot Totals 2000-2003	0.527203745	Do not reject
Big Muddy BOPE Fenced / Unfenced Macroplot Totals 2008-2011	-0.71191758	Do not reject
Paradise BOHE	3.476144377	Reject
FOREST SITES		
Bailey Creek BOLI, Fenced	0.196116135	Do not reject
Deadman Creek BOCR	-4.337658066	Reject
Flat Creek Tributary BOCR Fenced Macroplot	0.26573764	Do not reject