POPULATION MONITORING AND MANAGEMENT PLAN FOR IDAHO PHLOX (*PHLOX IDAHONIS*)

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Abstract

Idaho phlox (*Phlox idahonis*) is a narrow endemic known from four metapopulations within a 6 km radius of Headquarters, Clearwater County. *Phlox idahonis* is without close relatives in western North America, being related instead to *P. maculata* and *P. carolina* of eastern North America and separated from them by at least 2000 km. *Phlox idahonis* is a tall rhizomatous herb with an inflorescence of large, lavender flowers. *Phlox idahonis* is one of six plants endemic or near-endemic to the Clearwater River basin that were recommended by the Smithsonian Institution in 1975 and 1976, for Threatened or Endangered status under the Endangered Species Act. Rex Crawford investigated the conservation status of the Clearwater endemics in 1977 and 1978, and concluded that only the *Phlox* warranted further consideration for federal listing. *Phlox idahonis* is currently a category 1 candidate for listing under the Endangered Species Act. Ninety-eight percent of *Phlox* habitat is owned by Potlatch Corporation. As part of Crawford's investigations, he established seven permanent plots containing *Phlox idahonis* in four meadows throughout its range in 1978. We reread these plots in 1993, to determine the 15-year trend of the species.

Direct gradient analysis of plant cover data indicate that livestock grazing intensity explained a majority of the floristic variation in the plots. Secondarily, meadow type and soil water content, explained the remaining variation. Summary of stem density for all plots indicates that *Phlox idahonis* remained stable over the 15 year monitoring period. There was, however, significant differences between meadows. *Phlox* density increased in one plot in Eureka Meadows, the cause of which is unexplainable to us. It decreased in Plot 7, however, probably as a result of post-fire succession at this site in CPTPA Meadow. *Phlox* disappeared completely from Plot 4 in North Casey Meadow. Stem density and vegetation composition and structure data indicate that heavy livestock grazing caused the disappearance. Our data indicate that no grazing and moderate levels of grazing are not detrimental to population viability. We also found that shrub and tree invasion of the prime meadow habitat does not appear to be a threat, at least during the 15-year monitoring period. The current conservation status of *Phlox idahonis*, as a category 1 candidate, is appropriate. Our recommendations include protection for all populations, grazing be excluded from heavily grazed meadows, permanent plots be read every five years, and management remain adaptive to new information, among others.

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Introduction and Status Review of Idaho Phlox (*Phlox idahonis*).

INTRODUCTION

Since its discovery and description by Edgar Wherry in the early 1940's, Idaho phlox (*Phlox idahonis*) has captured the attention of botanists due to its beauty, its rarity, and its unique biogeographic position of being without close relatives in western North America (Wherry 1941; 1955; Davis 1952; Cronquist 1959; Johnson 1976; 1977; 1981; Crawford 1980). For many years, this tall, showy phlox was only known from the meadow south of the Clearwater-Potlatch Timber Protective Association (CPTPA) office on Reeds Creek. Inventories in the 1970's revealed the presence of populations in only a few other areas around Headquarters, despite thorough surveys of the Headquarters, Elk River and Elk City areas. A majority of the species is on Potlatch Corporation land. Its rarity and vulnerability to extinction has been recognized for over 20 years and has been recommended for listing as Endangered and later Threatened by the Rare and Endangered Plants Technical Committee of the Idaho Natural Areas Council (Johnson 1977; 1981). Idaho phlox remains the rarest member of Idaho's flora and is currently a category 1 candidate for listing under the Endangered Species Act. The category 1 status indicates that the U.S. Fish and Wildlife Service has enough biological information on hand to make a decision to list it as Threatened or Endangered (U.S. Fish and Wildlife Service 1993). The Service has not acted on this matter largely because the species occurs almost entirely on private land, where virtually no legal protection for plants exists.

During 1977 and 1978, Idaho phlox was the research subject of Rex Crawford, while a graduate student in the Department of Forest Resources, University of Idaho. He studied the species' range, habitat, seral role, reaction to management practices, and certain autecological attributes. He also established seven permanent plots throughout the species range. Along with Potlatch's recent interest in assuring maintenance of viable population levels, we are presented with a unique opportunity to use Crawford's 1977-78 data as a baseline from which to measure 15 years of change in the habitat and populations of Idaho phlox. This will allow us to develop a management plan with supporting biological data. This type of opportunity rarely presents itself when studying plant populations, let alone rare plants.

Initially, we recommended that the following five areas of investigation be pursued in 1993:

Inventory Crawford prepared detailed maps of the distribution of Idaho phlox, along with a comprehensive vascular plant species list, with abundance ratings for each species (Crawford 1980). During June 1993, we remapped the distribution and estimated population sizes for Idaho phlox. We were not able to make direct comparisons between 1977-78 and 1993 data, however, because no population estimates were made in the earlier study and map accuracy was coarse.

Permanent Plots Seven permanent macroplots were established in four meadows containing Idaho phlox in June 1978. Cover and frequency data for all vascular species, as well as density data for Idaho phlox were collected in 40 microplots within each macroplot. With considerable trouble and the help of a metal detector we found all the plots in June 1993, and reread frequency data for all species and density of Idaho phlox. Analysis of these data form the core of this report, both in the Status Review of Section 1, and especially in Section 2.

Burning Treatment Because phlox was observed to decrease as shrub canopy increases, Crawford designed a burning study to evaluate the effects of fire in opening the shrub canopy. A late-season, low-intensity controlled burn was conducted in October 1977, with pre- and post-burn data collected to study the response of the phlox population and certain community attributes. Unfortunately, the small quadrats used in this study were randomly located and not permanently marked. We were unable to relocate these

and the two line intercept transects used to collect shrub cover data.

Repeat Photography Numerous historical photographs exist in the files of the CPTPA and the University of Idaho showing the general landscape of meadows inhabited by Idaho phlox. These can be used to visually monitor changes in vegetation structure over the last 50+/- years, changes that may not be detected in quantitative plot data. Because it took more time than expected to relocate the plots, the repeat photography was put off until 1994. We made copies of all pertinent slides from the University of Idaho collection and they are now part of the Idaho phlox file at the Conservation Data Center.

Management Plan Synthesize the results of Crawford's (1980) thesis work, in addition to our 15-year reassessment of geographic and permanent plot data into a management plan containing recommendations for short-term and long-term management strategies necessary to maintain Idaho phlox and its habitat. Section 3 of this report contains the management plan.

STATUS REVIEW

Phlox idahonis Wherry

TAXONOMY

Full bibliographic citation: Wherry, E.T. 1941. The phloxes of Idaho. No. 87. Notulae Naturae of the Academy of Natural Sciences of Philadelphia. 15 p.

Type specimen: Wherry s.n., July 17, 1940, 1.5 miles south-southeast of Headquarters, Clearwater County, Idaho (PH).

Pertinent synonym(s): None.

Common name: Idaho phlox.

Size of genus: About 50 or 60 species, native to North America and northern Asia, best developed in western North America (Cronquist 1959).

Family name: Polemoniaceae

Common name for family: Phlox

History of knowledge of taxon in Idaho: Idaho phlox was first collected by Carl Epling at Headquarters sometime prior to 1940, and the collection remained unnamed in the herbarium of the University of California at Los Angeles for some years (Wherry 1941). Wherry searched for the plant at Headquarters in 1940 but was unable to find it there, although he did eventually locate a population in the meadows around the office of the CPTPA, 1.5 miles south-southeast of Headquarters (Wherry 1941). Collections of Idaho phlox were made by Blaisdell and Davis in the 1940's from the CPTPA Meadow. Searches by Bob Steele, Fred Johnson, and others in the late 1960's and early 1970's did not locate any new populations (Johnson 1976, Crawford 1980). During his graduate work on the ecology of this and other Clearwater basin endemics, Rex Crawford (1980) expanded the known range of Idaho phlox nearly to its

present configuration in 1977 and 1978. Bob Moseley expanded the known size of the Headquarters population in 1993.

Alternative taxonomic treatments: None, however, it should be noted that several people have made the suggestion that Idaho phlox may be an introduced species, an escaped cultivar of one of it's near relatives, *Phlox carolina* or *P. maculata* of eastern North America (Crawford 1980). Edgar Wherry, from the University of Pennsylvania, was a taxonomic expert in the genus *Phlox*, and knew the eastern species well. He was unequivocal in both his treatment of the genus in Idaho (Wherry 1941) and as a whole (Wherry 1955) that *Phlox idahonis* was distinct, although he included it in subsection *Ovatae* along with *P. carolina* and *P. maculata*. After extensive field observation and study, it is our opinion that Idaho phlox is native.

LEGAL OR OTHER FORMAL STATUS

National:

U.S. Fish and Wildlife Service: Idaho phlox is currently a category 1 candidate for listing under the Endangered Species Act, meaning the U.S. Fish and Wildlife Service has substantial information on hand to support the biological appropriateness of proposing to list it as endangered or threatened (U.S. Fish and Wildlife Service 1993).

Other current formal status recommendations: It is given a global rank of 1 by the Biodiversity Information Network - the International Association of Natural Heritage Programs and Conservation Data Centers (Moseley and Groves 1992). The G1 rank (on a scale of 1-5) indicates that Idaho phlox is critically imperiled because of extreme rarity or because of some factor of its biology making it especially vulnerable to extinction.

State:

Idaho

Idaho Native Plant Society: Because Idaho phlox is a federal candidate, the Idaho Native Plant Society does not assign a state rank (Idaho Native Plant Society 1993).

Conservation Data Center: Because it is an Idaho endemic, The Biodiversity Information Network state ranking for Idaho phlox is the same as the global rank above (Moseley and Groves 1992).

Review of past status: In his 1977 review of this taxon for the Rare and Endangered Plants Technical Committee of the Idaho Natural Areas Council, Johnson recommended a federal status of Endangered (Johnson 1977). He changed his recommendation in the 1981 review to Threatened (Johnson 1981), due largely to the discovery of new populations by Crawford (1980).

DESCRIPTION

General nontechnical description: This member of the phlox family generally has one stem growing up from a slender, shallow rhizome to one meter tall. Both the stem and foliage are covered by short, soft hairs. In addition, the hairs of the inflorescence are glandular. The leaves are opposite and widely spaced on the stem about 9 cm long and 3 cm wide. The flowers occur in a tightly branched inflorescence at the top of the stem. Up to 50, large, lavender flowers occur in this aggregate, although only 10-20 flowers are open at any one time.

Technical description: Perennial, 5-10 dm tall, the stem solitary from the upturned end of a slender rhizome, evidently glandular in the inflorescence, otherwise loosely spreading-hairy or partly glabrate; leaves glabrous or subglabrous above, loosely spreading-hairy beneath, lanceolate or lance-ovate, acuminate, the lower several pairs more or less reduced and soon withering, the others up to 9 cm long and 3 cm wide, the broadest ones not far below the openly branched inflorescence; intercostal membranes of the calyx tending to be carinate at anthesis, but distended by the growing capsule; corolla pink, the tube 17-20 mm long, about twice as long as the calyx, the obovate lobes 8-9 mm long; style elongate, nearly or quite reaching the orifice of the corolla (Cronquist 1959).

Local field characters: Idaho phlox is the only *Phlox* occurring in the mountain meadows of northern Idaho. All other phlox species are shorter in stature and occur in dry habitats, such as canyon grasslands, ponderosa pine woodlands, or exposed subalpine ridges. The above characters can be used to easily distinguish it from other tall forbs in these habitats.

Photos and line drawings: A line drawing of Idaho phlox appears in Wherry (1955) and Cronquist (1959). A reproduction from the latter appears in Appendix 1. A close-up photograph appears in Wherry (1941). Numerous slides of Idaho phlox and its habitat are on file at the Forestry Research Herbarium at the University of Idaho and in the files of the Conservation Data Center. Several from the latter source are reproduced as Appendix 7 of this report.

DISTRIBUTION

Global distribution: Idaho phlox is known from four metapopulations in the upper tributaries of the Reeds Creek drainage, Clearwater County, Idaho. All known sites are within four miles of the village of Headquarters. The four metapopulations are mapped as eight occurrences in the Conservation Data Center data base.

Idaho distribution: Same as global range.

Precise occurrences in Idaho: The eight occurrences are as follows (the three digit code associated with the site name is the Conservation Data Center occurrence number used as reference number for that population):

001 CPTPA-Lower -
002 CPTPA-Upper -
003 North Casey Meadow -
004 Casey Meadow -

005 Parallel Creek -
006 Alder Creek -
007 Eureka Meadows -
008 Headquarters -

See Appendix 2 for maps of the distribution of Idaho phlox and Appendix 3 for further location information on the occurrences.

Historical sites: None.

Unverified/undocumented reports: Ray J. Davis collected Idaho phlox in 1941, from a site "2 miles east of Headquarters, elevation 3244." There does not appear to be suitable habitat in this area, which is in the upper reaches of the East Fork of Deer Creek. This may have been a mistake and he may have actually been along Highway 11, about 2 miles SSE of Headquarters at the CPTPA-Upper site; the elevation he listed is appropriate for the CPTPA site and not for the East Fork of Deer Creek. His collection is listed for this occurrence (002) in Appendix 3.

There has been some confusion in the past on the interpretation of collection locality names. To those unfamiliar with the area, the village of Headquarters and the CPTPA "Headquarters" appear to be the same site, because they are relatively close together along the highway and in the same township (T38N R5E). It appears that most specimens were collected from the CPTPA-Upper site (Appendix 3).

HABITAT

General habitat description: Crawford (1980) describes in detail the habitats of Idaho phlox; refer to this thesis for an in-depth treatment. Briefly, Idaho phlox occurs in three types of habitats: (1) open meadows dominated by herbaceous plants; (2) shrub communities dominated largely by thin-leaf alder (*Alnus incana*) or alder buckthorn (*Rhamnus alnifolia*); and (3) coniferous forest sites.

The phlox is most common in meadows surrounded by western redcedar forests. These open meadows are dense graminoid communities rich in forbs. Two distinct communities are discernable based of vegetation physiognomy: a "tall meadow" found on more mesic, relatively well-drained sites with a high water table, particularly in the early summer; and a "short meadow" found on less mesic, better drained sites with higher microrelief and lower water table. Sites intermediate to these also occur in the meadows. Both tall and short meadows are being invaded by trees, primarily grand fir and subalpine fir. Stumps of logged trees in most meadows indicate that the open-meadows were formerly at least partially forested.

The shrub community type is interspersed with the meadows. The dominant shrub, thin-leaf alder, is usually on wetter sites along streams where the water table is higher and the soil is rockier than in tall meadows. Stands dominated by the low shrub alder buckthorn occur on drier sites.

Phlox was only rarely observed in the forest community type, but the presence of stumps and invading trees indicate that the presence of trees was more common in the past. Forest sites are better drained, although they still occur on alluvial deposits of the valley bottom. No phlox was seen on adjacent forested slopes.

Geology and Soils: The soils are alluvial sandy-loams. Underlying bedrock in the Headquarters area is comprised of Precambrian coarse-grained, garnet-mica schist of the Wallace Formation (Rember and Bennett 1979).

Associated species: *Rhamnus alnifolia, Alnus incana, Carex aquatilis, Mertensia paniculata, Poa pratense, Geum macrophyllum, Solidago canadensis, Aster hesperius, Achillea millefolium, Agrostis alba, Penstemon procerus, Geranium viscosissimum, Veratrum californicum, Senecio pseudaureus, Rudbeckia occidentalis, Montia cordifolia,* plus others (Crawford 1980).

Other rare species: Phlox idahonis occurs with two species that are disjunct in this part of Idaho from the main part of their range west of the Cascades, *Veratrum californicum* var. *caudatum* and *Physocarpus capitatus*. Neither of these is considered to be of conservation concern in Idaho.

POPULATION BIOLOGY

Phenology: Observations made by Crawford (1980) during the 1977 and 1978 field season revealed that Idaho phlox reaches maximum blooming in late June and early July, similar to most other associated forbs. Plants on wetter sites flower earlier and longer than on drier sites. Frequently, individuals are observed flowering in late August in alder stands along streams. Seeds are shed in mid-August. Rhizome sprouts are common, especially in the tall meadow habitats, but most of the shorter ones observed in July were chlorotic or dead by mid-August.

Population size and condition: Population data for each occurrence, as well as their aerial extent, can be found in Appendix 3. Using a digital planimeter, we estimate that the total area occupied by Idaho phlox is 75.5 acres. The number of individuals in a populations is difficult to estimate for two main reasons: (1) the plant is rhizomatous, so it is difficult to determine the limits of an individual; and (2) Idaho phlox produces two types of stems, tall flowering stems that are obvious in the field, and short vegetative stems that are hidden beneath a dense canopy. It should be noted that the estimates given for each occurrence in Appendix 3 are for above-ground stems (termed ramets) and not for genetically distinct individuals, and that the contribution to the populations made by the vegetative stems is probably under estimated. Given these qualification, however, it is clear that Eureka Meadows (007) contains the largest population in terms of both population numbers and aerial extent. It also has had the least amount of habitat destroyed by roads and railroad grades. The Alder Creek (006) and Headquarters (008) populations are the smallest and most impacted by past and ongoing disturbances.

In 1978, Crawford (1980) placed seven permanent monitoring plots in meadow habitats throughout the range of Idaho phlox. We reread these plots and the monitoring results are discussed in Section 2, and Appendices 4 and 5. Briefly, our data suggest that the overall population trend is stable, however, significant local changes have taken place at different sites. See Section 2 for more details. Descriptions and maps for locating the seven permanent plots are included in Appendix 6.

Reproductive Biology: Crawford (1980) found that reproductive output (seed production) is greatest where phlox grows most vigorously, in tall meadows and short shrub stands. The capsules are explosively dehiscent on hot days, but usually drop to the ground and open less dramatically. Seedlings were never observed under natural conditions.

Crawford (1980) conducted germination trials in both a natural setting in CPTPA-Upper and in a lathhouse in Moscow. A shade and a full sunlight treatment were administered to each trial. Germination rates were 40% in both the open and shaded treatments in CPTPA Meadow and a slightly higher rate resulted from the open treatment in Moscow than the shaded one. Seedling survival at CPTPA-Upper was lower in the shade (48%) than in the open (85%), suggesting an important role of light in establishment and survival of phlox.

Reproductive production (seeds/fruit x avg # capsules/plant x 40% germination) was calculated for four habitats (Crawford 1980), as follows:

Alder (tall) shrub	3.84
Meadow	3.69
Buckthorn (short) shrub	3.53
Forest	1.13

Biological Interactions: A fungal leaf rust infects all populations and has been observed to reduce plant vigor and in many cases inhibit flowering (Johnson 1976; 1977; 1981; Crawford 1980; Packard no date). The rust is most likely *Uromycus plumarus* or *Puccininea douglassii*, however, the exact identification is impossible until the intermediate host is discovered. The rust is either widespread or systemic because plants grown in Moscow were so heavily infested in 1979, that they did not flower (Crawford 1980). The rust was not prominent in the population in June 1993, and apparently it was not prominent in 1977-78 either. The rust usually appeared after flowering and fruiting, so it's affect on individuals in a natural population may not be great. It may, however, be a greater threat to long-term population viability.

Competition: Crawford (1980) observed that Idaho phlox was shade intolerant; stem length increases, stem numbers decrease, and flowering is inhibited under low light intensities. Shrub and conifer encroachment appear to be the most imminent threats in this regard.

To determine the response of Idaho phlox and associated vegetation to the removal of competition, Crawford (1977; 1980) conducted a prescribed burn in the CPTPA-Upper population during October 1977. This low-intensity, late-season fire was designed to reduce the cover of both low and tall shrubs and low and tall meadows, as well as provide a chance to evaluate its effects on phlox. He found that fire reduces shrub cover markedly and increases forb cover the first growing season. Phlox increased, as did *Aster hesperius, Penstemon procerus*, and *Senecio pseudaureus*. Shrubs affected the most by fire include *Amelanchier alnifolia, Cornus stolonifera, Alnus incana, Symphoricarpos albus*, and *Rhamnus alnifolia*. *Rhamnus alnifolia* resprouted from the base more vigorously the first growing season than any other shrub observed.

Permanent plot #7 was established in the burned area in June 1978, to determine the post-fire response of the vegetation and phlox density. Results from the monitoring are reported in Section 2 and Appendices 4 and 5. Both phlox ramet density and forb cover have declined during the 15 year monitoring period, while graminoids increased and shrub cover stayed about the same. The initial measurement for forbs and phlox density were taken during the post-fire flush of growth that is common the first few years after a fire. Their decline may represent post-fire succession to near pre-burn levels. It appears that shrubs were the most affected life-form, having recovered very little from initial post-fire levels. Overall the monitoring results are somewhat ambiguous, however, because phlox density increased significantly during the same period in an adjacent, unburned plot.

Herbivory: Population trend data from the seven permanent monitoring plots indicate that livestock grazing exerts significant pressure on phlox and its habitat. Both community structure and composition, as well as phlox population dynamics, are related to grazing intensities (see Section 2 for monitoring results). It appears that heavy livestock grazing has eliminated Idaho phlox from the plot in North Casey Meadow (003). This corroborates our observations of phlox distribution in Casey Meadow (004) where it is restricted to the shrub habitats along the creeks where the heavy grazing pressure by horses and cattle is physically restricted. Moderate levels of grazing, as seen in Eureka Meadows, appear not to affect Idaho phlox or possibly may enhance it.

Many vegetative shoots, found beneath the canopy of meadow habitats, are nipped by an unknown herbivore, probably a small mammal. They appear to be selectively chosen, as no adjacent stems of other species are so eaten. The stems are nipped 1-3 nodes above the ground and, with the apical dominance removed, axillary shoots are produced.

Land ownership: Nearly all populations are owned by Potlatch Corporation (73.8 acres or 98%). A small portion of the Parallel Creek population (005) is public land, managed by the Idaho Department of Lands (1.7 acres or 2%)

Land use: All populations have experienced direct habitat loss due to transportation, industrial, and residential development associated with timber harvest activities. Numerous active and abandoned roads and old logging railroad grades traverse the riparian communities containing Idaho phlox. The village of Headquarters and the CPTPA compound were built in phlox habitat. This activity took place prior to Crawford's studies in 1977 and 1978, so we have no baseline from which to estimate the extent of this loss.

In addition to active transportation routes, livestock grazing is the predominant land-use currently active in several of the populations (North Casey Meadow 003, Casey Meadow 004, Eureka Meadows 007, CPTPA-Lower 001, and possibly Parallel Creek 005 and Alder Creek 006).

ASSESSMENT AND RECOMMENDATIONS

Threats to currently known populations: Losses due to transportation and other related developments are largely irretrievable. The greatest impact to the extant portions of the populations is livestock grazing. Fifteen-year monitoring results clearly documented the loss of Idaho phlox from the permanent plot established in a heavily grazed meadow.

The report of increased competition from shrubs and conifers in prime phlox habitat is not borne out by our data. No conifers were found in the plots and shrub cover remained constant throughout the monitoring period. The effects of fire on competition removal are somewhat ambiguous. Either shrub and conifer competition is not a problem or the 15 year monitoring period is too short to detect any meaningful change regarding the invasion of shrubs and conifers into the meadow habitat. The long-term effects of the leaf rust on species viability are still largely unknown and is a subject needing further investigation.

Recommendations: Section 3 contains a management plan with several specific recommendations concerning the long-term management and protection of Idaho phlox habitat. Regarding the conservation status of Idaho phlox, the U.S. Fish and Wildlife Service should maintain it as a category 1 candidate and

we believe that listing as Threatened is warranted. This is unlikely to happen, however, for the following reason. Unlike wild animals, which are considered public property under jurisdiction of the state, plants are considered private property. This fundamental difference has its roots in English common law and has been incorporated into all U.S. law since the country was founded, including the Endangered Species Act. It is unlikely then that the U.S. Fish and Wildlife Service will make Idaho phlox a high priority for listing when it has virtually no jurisdiction over the species. They tend to place greater emphasis on listing plant species for which they do have jurisdiction, that is, species with at least a significant portion of their distribution occurring on public land.

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SECTION 2

MONITORING RESULTS

This section contains a manuscript for submission to the peer-reviewed *Bulletin of the Torrey Botanical Club*. The form and style differ from the rest of the report in order to conform with editorial guidelines of the journal.

Fifteen-year population and habitat changes in a narrow Idaho endemic, *Phlox idahonis* Wherry[1]

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ABSTRACT

Moseley, R.K. and R.C. Crawford (Conservation Data Center, Idaho Department of Fish and Game, P.O. Box 25, Boise ID 83707). Fifteen-year population and habitat changes in a narrow Idaho endemic, *Phlox idahonis* Wherry. Bull. Torrey Bot. Club XXX:xxx-xxx. 1994. -- *Phlox idahonis* is a narrow endemic known from four metapopulations in north-central Idaho. Due to its extreme rarity, past habitat loss, and ongoing disturbances, *Phlox idahonis* is a candidate for listing under the Endangered Species Act. Seven permanent plots were established in mountain meadows containing *Phlox* in 1978, and reread in 1993. Direct gradient analysis of vascular plant cover data indicated that livestock grazing intensity explained a majority of the floristic variation in the plots. Two secondary variables, physiognomic meadow type and soil water content, explained much of the remaining variation. Summary of ramet density for all plots indicates that *Phlox idahonis* remained stable over the 15 year monitoring period. There was, however, significant intersample differences. Ramet density increased in one plot, the cause of which is unexplainable to us, and decreased in another, probably resulting from post-fire succession at this plot. *Phlox* disappeared completely from one plot. Ramet density and vegetation composition and structure data indicate that heavy livestock grazing caused the disappearance. Our data indicate that no grazing and moderate levels of grazing are not detrimental. We recommend that all populations be protected, grazing be excluded from heavily grazed meadows, permanent plots be read every five years, and management remain adaptive to new information.

Key words: *Phlox idahonis*, population monitoring, livestock grazing, endangered species.

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Idaho phlox (*Phlox idahonis* Wherry) is a narrow endemic known from four metapopulations within a 6 km radius of Headquarters, Clearwater County, Idaho (43º 37' N latitude; 115º 48' W longitude). *Phlox idahonis* is without close relatives in western North America, being related instead to *P. maculata* and *P. carolina* of eastern North America and separated from them by at least 2000 km (Wherry 1955). The three species may have shared a common ancestor that grew as part of a late-Miocene flora that was split into east and west vicariads by the Rocky Mountain orogeny and Pleistocene glaciation (Wherry 1955; Daubenmire 1975). Further isolation of *Phlox idahonis* occurred as the Cascade Range arose, creating an unsuitable environment along the west coast and a favorable environment in the northern Rockies. Daubenmire (1975) postulated that the lack of summer heat along the coast is critical in the distribution of other Miocene floristic elements now largely endemic to the Clearwater River basin, Idaho.

Phlox idahonis is a rhizomatous herb with two types of above-ground stems: Flowering stems are up to 1 m tall and are topped by a compound cyme that contains approximately 50, large lavender flowers. The second type are shorter, up to 3 dm, and are entirely vegetative. The reproductive stems are similar in height to the canopy of associated herbaceous vegetation, while the vegetative stems occur below this dense canopy.

Phlox idahonis is one of six plants endemic or near-endemic to the Clearwater River basin that were recommended by the Smithsonian Institution in 1975 and 1976, for Threatened or Endangered status under the Endangered Species Act (Henderson *et al*. 1977). Crawford (1980) investigated the conservation status of the Clearwater endemics and concluded that only the *Phlox* warranted further consideration for federal listing. *Phlox idahonis* is currently a category 1 candidate for listing under the Endangered Species Act, meaning the U.S. Fish and Wildlife Service has substantial information on hand to support the biological appropriateness of proposing to list it as endangered or threatened (U.S. Fish and Wildlife Service 1993).

As part of Crawford's (1980) investigations, he established seven permanent plots containing *Phlox idahonis* in four meadows throughout its range in 1978. Recent interest in the long-term management of this rare species by Potlatch Corporation, who owns all but a small fraction of *Phlox* habitat, gave us the opportunity to reread these plots in 1993, to determine the 15-year trend of the species.

Study Area. Headquarters lies in the Clearwater Mountains of north-central Idaho. The landscape in this locale consists of rounded ridges and summits with broad intervening valleys. Local relief is not more than 500 m. Dense coniferous forest covers the uplands while relatively open riparian communities occur in the valley bottoms. Headquarters, elevation 950 m, has a mean annual temperature of 6.1ºC, a mean growing season (June-August) temperature of 11.3ºC, mean annual precipitation of 1039 mm, and a growing season precipitation of 417 mm (Crawford 1980).

Phlox idahonis is restricted to valley-bottom, riparian communities that are traversed by low gradient, meandering streams. The substrate in all occupied areas is deep, sandy-loam alluvium. Within the riparian zone, *Phlox* occurs in three types of habitats: meadow, shrub, and forest, although stumps of logged trees occur in most meadows indicating that they were at least partially forested. *Phlox* densities were observed to decrease with an increase in canopy along a gradient from meadow (high density) to forest (low density). The meadow habitat is dominated by several grasses and forbs, including *Aster hesperius*, *Poa pratense*, *Carex aquatilis*, and *Phlox idahonis*. Two types of meadows can be differentiated based on the physiognomy of dominant species. Tall meadows have an average canopy height of up to 1 m or more, while the vegetation of short meadows is less than 50 cm. Sites with intermediate stature also occur. The shrub habitat occurs adjacent to streams and is dominated by *Alnus incana*, with a tall herbaceous understory. Occasionally, phlox can be found at low densities in the understory of coniferous forest stands, with *Abies grandis* being the usual dominant.

Fire is the most important natural disturbance in forests of the northern Rocky Mountains, however, they are episodic in the mesic *Thuja plicata* communities, with estimated return frequencies of between 50 and 200 years or more (Arno and Davis 1980). On a smaller-scale, pocket gophers (*Thomomys* sp.) are an important disturbance factor by churning considerable amounts of soil in meadow and forest habitats. Several past and ongoing anthropogenic disturbances take place in *Phlox* habitat. An extensive transportation system for timber harvest has been built through the riparian zones of the Headquarters area, including an extensive network of active and abandoned roads and, historically, logging railroads. The village of Headquarters and associated railroad and log handling facilities were built in the riparian zone containing one population. Considerable direct loss of habitat has resulted from these developments. Livestock grazing by cattle and horses takes place throughout the range of *Phlox*, although some areas have little to no grazing pressure. No detailed livestock grazing records are kept for the area, so we were unable to determine past or present stocking levels, grazing seasons, or use patterns.

Methods. Seven permanent 90 m^2 plots containing *Phlox idahonis* were randomly established during June 1978, in the meadow habitat type at four areas: Eureka Meadows, Alder Creek, North Casey Meadow, and the Clearwater-Potlatch Timber Protective Association (CPTPA) Meadow (Table 1). Elevations of the plots range from 850 m to 990 m. Each plot was rated for three environmental attributes (numeric values shown for each attribute were used in the gradient analysis explained below): a) grazing intensity - none to low (0), moderate (1), high (2); b) soil mottling as a proxy for high soil water content and/or poor drainage at least part of the year - absent (0), present (1); and c) physiognomic meadow type based on mean height of *Phlox idahonis* ramets - short (1), intermediate (2), tall (3) (Crawford 1980).

Within the macroplot, vegetation and *Phlox* population data were collected in 40 0.1 m^2 microplots (Daubenmire 1959; Bonham 1989) distributed at 1 m intervals along four parallel 10 m transects that were 3 m apart. The two outside lines were permanently located with steel stakes. In 1978, cover was estimated and frequency was calculated for all species and density of *Phlox idahonis* ramets was counted in each microplot. In 1993, we again calculated species frequency and *Phlox* ramet density in the microplots, but estimated cover only for three life-form classes, shrubs, forbs and graminoids.

Species cover data were used to ordinate the seven plots along environmental gradients with canonical correspondence analysis (CCA), a multivariate direct gradient analysis technique (Ter Braak 1991). The axes extracted by CCA represent those directions of variation in species composition that are related to supplied environmental variables (Ter Braak 1987). All species were used in the ordination and their scores were relativized to 100. Fifteen-year differences in the cover of forbs, graminoids, shrubs, and *Phlox* ramet density within each plot were analyzed using a t-test (Zar 1974).

Results. Figure 1 displays the ordination diagram of permanent plots and environmental variables along the first two axes extracted by CCA. Plots are arranged in the ordination space based on species composition. The main direction of change for each of the environmental variables is illustrated by an arrow, with the length of the arrow corresponding to the relative importance of that variable in explaining floristic change. The regression coefficients (called canonical coefficients) given in Table 2 indicate a strong dominance of grazing intensity in explaining floristic variation along axis 1, while soil mottling and meadow type almost equally dominate axis 2. The eigenvalue and species-environment correlation for the first axis are lambda = 0.38, R = 0.99, respectively, while lambda = 0.29 and R = 0.98 for axis 2. The first two axes account for 73% of the variance in species ordination scores with respect to environmental variables.

The summary of *Phlox idahonis* ramet density for all plots indicate that the populations in sampled meadows have been stable over the last 15 years (Fig. 2). There was, however, significant changes in density in at least two meadows; *Phlox idahonis* no longer occurs in Plot 4 and, therefore, significance was untestable. The large increase in ramet density in Plot 1 is largely unexplainable to us. It

is in the same meadow as Plot 2, which was static through the monitoring period. No obvious change in land use has taken place in Eureka Meadow since 1978. It is particularly intriguing given the large decrease in forb cover and increase in graminoid cover that took place through the monitoring period (Table 3).

A portion of the CPTPA Meadow where Plot 7 was established burned in October 1977. No preburn data were gathered. The initial measurement may reflect the initial flush of growth following the fire seen in *Phlox* and other forbs in June 1978 (Crawford 1980), and the subsequent decline may result from post-fire succession. Current densities are probably indicative of preburn levels.

The most dramatic change was the complete loss of *Phlox idahonis* from Plot 4 in North Casey Meadow. The structure of the vegetation in this plot also changed significantly, with an increase in coverage of both graminoids and forbs (Table 3). It was the only plot to have an increase in forb cover during the 15 year monitoring period. These increases were made largely by exotic pasture grasses, *e.g*., *Poa pratense* and *Phleum pratense*, and weedy forbs, *e.g*., *Cerastium vulgatum, Trifolium repens* and *Taraxacum officinale*. The cover of native forbs declined and seven natives disappeared from the plot. Plot 4 had the highest grazing intensity in 1978, and that relative level appears to have been either maintained or increased over the 15 year period.

Although the Phlox density decline in Plot 3 was not significant, structural and compositional data (Table 3 and unpublished data) indicate that there is increasing soil moisture as evidenced by the increase or addition of several *Carex* and *Scirpus* species. Plot 3 is surrounded by deep fill material from an abandoned railroad grade and a main timber haul road. The hydrologic changes may be due to a disruption in the drainage pattern caused by the fill, although no obvious changes have taken place since 1978. We may be monitoring a trend that began prior to plot establishment.

Discussion. Livestock grazing exerts significant pressure on *Phlox idahonis* and its habitat. The extirpation of *Phlox* from the plot in North Casey Meadow, along with a dramatic shift in the composition and structure of that community can be attributed to heavy grazing intensity. In North Casey Meadow, *Phlox* is now restricted to very wet, little grazed portions of the meadow or in the understory of shrub stands where livestock grazing is physically limited.

Phlox idahonis and several other forbs appear to be intolerant of the trampling by cattle and horses that occurs at high grazing intensities. *Phlox* has brittle stems and a shallow rhizome (Wherry 1955; Cronquist 1959; Crawford 1980). Under heaving grazing it seems reasonable to assume that photosynthetic tissue, rhizome production, and consequently, seed production are detrimentally affected. Sod-forming grasses and low-growing forbs, such a *Poa pratense* and *Trifolium repens*, can withstand grazing and trampling, and therefore, increase.

Moderate levels of grazing, as experienced at Eureka Meadow (Plots 1 and 2), appears not to be detrimental to the *Phlox* population, at least during the last 15 years. *Phlox* may be able to withstand trampling when grazed only at moderate levels, and may possibly be enhanced by light to moderate grazing by producing more stems from axillary buds.

Our data corroborates, at least in part, the conclusions of several other studies regarding the impact of livestock grazing on mountain meadows in northern and central Idaho (Mueggler 1962; Kowalsky 1964; Wing 1969; Leege *et al*. 1981). Mueggler (1962) noted that when subjected to continual heavy grazing, soils of mountain meadows become compacted and the meadows take on the characteristic of a lawn. In this lawn, *Poa pratense* and *Trifolium* sp. form a dense, low-vigor sod. Upon continued heavy grazing intensity, this sod is broken up allowing for the invasion of unpalatable forbs such as *Achillea millefolium, Potentilla gracilis, Taraxacum officinale,* and *Rumex acetosella*. It appears that Plot 4 in North Casey Meadow has degenerated to the *Poa-Trifolium* lawn and is headed for the next stage, as evidenced by the increase in frequency in all four of the unpalatable forbs mentioned by Mueggler (1962).

Similar to our results, Leege *et al*. (1981) found that *Phleum pratense* and *Trifolium* sp. were significantly more abundant in heavily grazed areas outside of 12 year old exclosures. Wing (1969) found that under intensive livestock grazing, mountain meadows on the dry and mesic end of the soil moisture gradient, comparable to Plot 4, there is an increase in less palatable, weedy forbs than in comparable ungrazed meadows.

Kowalsky (1964) found that grazing would have less detrimental impact on meadow vegetation if it was done early or late in the growing season. Because the period between mid-June and mid-August is critical for flowering, seed production, and germination of *Phlox idahonis* (Crawford 1980), late season grazing would be best here.

Soil mottling and meadow type, variables aligned with CCA axis 2, appear to be related to one another in our study area. Other mountain meadow studies found that soil moisture gradients drive species composition in these communities (Wing 1969; Leege *et al*. 1981) and that the physiognomy of the vegetation is correlated with soil moisture (Wing 1969). It is not surprising, therefore, that meadow vegetation had a similar response in CCA to our surrogate variable for soil moisture, soil mottling, as it did for meadow type, which is a surrogate for physiognomy.

Our data suggest that the present conservation status for Idaho phlox, federal category 1 candidate, is appropriate. Listing as Threatened under the Endangered Species Act is probably warranted, but because 98% of the species occurs on private land, the U.S. Fish and Wildlife Service has little jurisdiction to affect protection and recovery. We recommend that (1) all populations be protected and that there be no more direct loss of habitat, (2) grazing be, at least temporarily, excluded from North Casey and Casey meadows to facilitate recovery of *Phlox idahonis* and its habitat, (3) the permanent plots be read every five years, and (4) management remain adaptive to new information.

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Table 1. Site names and environmental attributes of seven permanent plots containing *Phlox idahonis* in Clearwater County, Idaho.

Plot No.	Site/Plot Name	Grazing Intensity	Soil Mottling	Meadow Type
1	Eureka Meadows (Upper)	Moderate	Absent	Short
2	Eureka Meadows (Lower)	Moderate	Absent	Short
3	Alder Creek	Moderate	Present	Tall
4	North Casey Meadow	High	Absent	Short
5	CPTPA Meadow (Upper)	None	Present	Tall
6	CPTPA Meadow (Middle)	None	Present	Intermediate
7	CPTPA Meadow (Lower)	None	Present	Tall

Table 2. Canonical coefficients from CCA of the permanent plots with grazing intensity, soil mottling, and meadow type as external (environmental) variables.

	Axis 1	Axis 2
Grazing	0.98	-0.03
Soil Mottling	-0.74	0.66
Meadow Type	-0.69	0.67

Table 3. Change in plant life-form cover between 1978 and 1993 in seven permanent plots containing Phlox idahonis. Values are % cover.

Plot	Shrubs		Graminoids		Forbs	
	78	93	78	93	78	93
1 Eureka Meadows (Upper)	0	0	78	86*	99	55**
2 Eureka Meadows (Lower)	0	0	34	52	100	84**
3 Alder Creek	4	8	55	61**	70	40**
4 North Casey Meadow	0	0	68	78**	61	86**
5 CPTPA Meadow (Upper)	6	4**	21	92**	100	79**
6 CPTPA Meadow (Middle)	3	1	18	56**	100	87**
7 CPTPA Meadow (Lower)	6	9	38	71**	99	86**
MEAN FOR ALL PLOTS	3	3	45	71	90	74

* significant at P < 0.05; ** significant P < 0.01.

Figure 1. CCA ordination diagram with permanent plots ( ) and environmental variables (arrows); first axis is horizontal, second axis is vertical. Arrows denote main direction of change and relative importance of the three environmental variables.

Figure 2. Comparison of Phlox idahonis ramet density in seven permanent plots as measured in 1978 and 1993. Plot 1 and Plot 7 are significantly different ($P < 0.01$ and $P < 0.05$, respectively); Plot 4 data is untestable; all others had no significant difference.

SECTION 3

MANAGEMENT PLAN

PROTECTION

Idaho phlox remains one of the rarest members of Idaho's flora. Due simply to this rarity, all known populations of the phlox should be protected from direct loss of habitat. In the mid-1970's, considerable correspondence took place between Bruce Edwards, Research Forester at Potlatch, Fred Johnson, University of Idaho, Chuck Wellner, Idaho Natural Areas Coordinating Committee, and The Nature Conservancy concerning the protection of Idaho phlox populations. Much of this discussion took place when the CPTPA meadow contained the only known population. The result was that in 1976 or 1977, Potlatch "set side" a portion of the CPTPA meadow and agreed to whatever protection or management is necessary to maintain a healthy population. In a letter from Bruce Edwards to Fred Johnson, who identified the area to be protected in the fall of 1976, the CPTPA meadow was included in the system that Potlatch had set up for protecting research plots and unique areas. Discussions in 1977 between The Nature Conservancy, Chuck Wellner, and Royce Cox, of Potlatch, on protecting features of natural diversity on Potlatch land apparently did not lead anywhere.

No direct loss of habitat appears to have taken place in phlox habitat since the 1970's. Potlatch should continue to use whatever system it has devised to identify and protect sensitive areas on its lands. Our phlox survey maps have been digitized and entered in the Potlatch GIS to facilitate this.

MANAGEMENT

Over and above habitat protection, three main threats to Idaho phlox viability have been identified in the past that need to be addressed: effects of a leaf rust, shrub and tree invasion of prime meadow habitat, and livestock grazing. Each is discussed below in the context of the 15-year population trend data.

Leaf Rust - Of the three, this is the one we know least about. Basic information, such as the identity of the fungus and the alternative host, is still lacking. Also, the short- and long-term effects of rust infection on population and species viability are not known. Although this may explain some of the population dynamics experienced in the last 15 years, it is probably a lower priority than other protection and management actions.

Shrub and Tree Invasion - This was considered a serious threat in the 1970's, and an experimental burn was done in the CPTPA meadow to study the effects of fire on phlox habitat. According to our data, however, this is not a problem, at least over the last 15-years; shrub and tree cover in the seven plots did not change through the period. Continued monitoring will determine if this is a threat in the longer-term.

Livestock Grazing - Our data indicate that livestock grazing is a severe threat at high intensity, but not at moderate to low intensities. Unfortunately, we have no grazing records, such as the number of animals, season of use, and use patterns, from which to quantify intensities. These data would be useful in determining grazing levels that will sustain the Idaho phlox population. Meanwhile, grazing should be terminated or drastically reduced in North Casey Meadow and Casey Meadow. If it is not terminated, it should be restricted to late in the season, after September 1, to allow the phlox to complete most of its reproduction and growth. Another option may be to fence only those portions of the meadow that are prime phlox habitat. This is a costly option, in terms of both initial and maintenance costs, and may preclude phlox expanding into what

is currently unoccupied but suitable habitat. Grazing use in Eureka Meadow appears to compatible with maintenance of Idaho phlox.

We also recommend the following management inventory, and, research actions:

Retake Historical Photographs - Because it took longer than expected to locate the plots, we didn't have time to retake photographs. Bob Moseley will do this in June, 1994, the same time of year that most historical photos were taken.

Monument Plots - Metal fence posts were used to mark two corners of Plots 5, 6 and 7 at CPTPA Meadow. Plots 1-4 were only marked with a small piece of rebar, however, and finding them was difficult. In June 1994, Bob Moseley will monument two corners at each of these plots with metal fence posts.

Rereading Plots - The plots have yielded very useful management information. We recommend that they be reread at five year intervals. This is a long enough frequency that it is not too burdensome financially, but short enough to yield useful and timely information. The CDC is willing to continue the monitoring program.

Idaho Phlox Survey - Potlatch should consider conducting additonal surveys for Idaho phlox on their land. Although Bob Steele and Fred Johnson did not find any new populations in their searches in the early 1970's, Rex Crawford found several new sites without too much trouble in 1977. In a limited survey in 1993, Bob Moseley extended the limits of the Headquarters 008 population at least one mile upstream from where it was previously known. Additional surveys over a wider area in the Headquarters area may yield similar results.

Population Genetics - Idaho phlox is rare enough that protection of all populations are needed to maintain viability. Obtaining information on the inter- and intra-population genetic variability will help in adapting future management to maintain the evolutionary potential of the species. The population genetics laboratory in the Forest Resources Department at the University of Idaho has extensive experience in rare plant genetics.

Management Flexibility - Management of Idaho phlox should remain flexible enough to adjust to new information as it comes to light.

PARTNERSHIPS

Conservation Agreement between U.S. Fish and Wildlife Service, Potlatch, and Idaho Department of Lands - Conservation Agreements are pre-listing conservation strategies for candidate species developed between the Fish and Wildlife Service and the owners or agency with management responsibility. It is hoped that agreements such as these will preclude listing under the Endangered Species Act. A majority (98%) of the phlox is owned by Potlatch, with a small portion of the Parallel Creek 005 population occurring on state ownership, managed by the Department of Lands. This report can serve as the basis for the Conservation Agreement, which contains a status review, management strategies to assure long-term persistence, and monitoring management and agreement implementation.

Cooperative management agreement between Potlatch, Idaho Department of Fish and Game - Conservation Data Center, and The Nature Conservancy - This report can also serve as the basis for a cooperative management arrangement, whereby Potlatch can benefit from natural area and rare plant population management expertise of the Conservation Data Center and The Nature Conservancy. Surveys, monitoring, management, and research can be coordinated through this forum.

Appendix 1

Line drawing of *Phlox idahonis* (from Cronquist 1959).

Appendix 2

Distribution of *Phlox idahonis*.

Map 1. CPTPA-Lower 001 and CPTPA-Upper 002 occurrences.

Map 2. North Casey Meadow 003, Casey Meadow 004, Parallel Creek 005, Alder Creek 006, and Eureka Meadows 007 occurrences.

Map 3. Headquarters 008 occurrence.

Appendix 3

Occurrence records from the Conservation Data Center for *Phlox idahonis*.

NOT INCLUDED IN THE CDC HOME PAGE VERSION OF THIS REPORT

Appendix 4

1978 and 1993 frequencies for vascular plant species in seven *Phlox idahonis* plots.

Appendix 5

15-year changes in cover of shrubs, graminoids, and forbs in seven *Phlox idahonis* plots (this is a graphical representation of Table 3 in Section 2).

Appendix 6

Location of the seven permanent *Phlox idahonis* monitoring plots.All plots are 10 m x 9 m in dimension. Forty 0.1 m^2 (20 cm x 50 cm) microplots are distributed at 1 m intervals along four parallel 10 m transects that are 3 m apart (hence the 9 m side). FURTHER INFO NOT INCLUDED IN THIS VERSION OF THE REPORT.

Appendix 7

Slides of *Phlox idahonis* and its habitat.

Slide 1. Close-up of inflorescence.

Slide 2. Meadow habitat at Plot 7, above CPTPA office.

Slide 3. Rex Crawford at the Plot 5 fence post; tall meadow habitat above CPTPA office.

Slide 4. Rex Crawford estimating upper canopy cover in microplot at Plot 5 above CPTPA office.

Slide 5. Rex Crawford estimating lower canopy cover in microplot at Plot 5 above CPTPA office.

Slide 6. Bob Moseley using metal detector to find rebar at Plot 2, lower Eureka Meadows.