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EFFECTS OF FIRE ON SENSITIVE PLANT SPECIES OF THE
CLEARWATER NATIONAL FOREST: AN ANNOTATED BIBLIOGRAPHY

by

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Introduction

The following is an annotated bibliography of published and unpublished references that contain information regarding the effects of fire on selected rare plant species. The species targeted were those listed as Sensitive on the Clearwater National Forest (CNF), north-central Idaho, plus Idaho's four federally listed species (Table 1). The scope of the literature search was limited to information specific to these plants. Good general references that address fire effects on vegetation in the western U.S. include Miller and Findley (1994) and Brown and Smith (In press).

References were located primarily through the use of the Idaho Conservation Data Center's (CDC) Source Abstract database, which is published in part in Moseley et al. (1992). This database is the result of searching at least eight different bibliographic databases for published literature on each of Idaho's rare plants, and is the only compilation of unpublished reports on Idaho's rare flora and vegetation. Most of the sources listed in the database are on file at the CDC. Two queries were done of the Source Abstract database, one using the scientific names of all target species, and the other using the keyword "fire." The database Agricola (1984-2000) was also searched using scientific names, and the resulting citations were screened for references to "ecology," "management," "habitat," "fire," or "burning." Two annotated bibliographies, available on-line, were consulted with few results. One is the U.S. Forest Service's Fire Effects Information System (Fischer, no date), which contains numerous common species, and the other is Hessel and Spackman (1995), which includes only species with federal status. In addition to the bibliographies and database queries, a number of regional botanists and ecologists were contacted (Table 2).

In the case of species whose habitat rarely if ever burns (e.g., *Carex leptalea*, *Botrychium* spp., *Buxbaumia viridis*, and *Howellia aquatilis*), references were included that did not address fire specifically, but the species' tolerance of disturbance in general. In situations where periodic progress reports were written for a single study, such as Lesica's work on *Silene spaldingii*, only the most recent reference was cited if it summarized results from the previous reports.

Although a great deal has been written on the subject of fire and its effects, information on its effects on specific rare plants is scarce. A total of 44 pertinent references were found for 20 of the 35 target species (Table 1). There are empirical data related to fire for nine species. For six species there are published data. These references comprise an initial bibliography which can be amended as new information becomes available.

Information was found in references of two general types: original research, based on population or community monitoring, and management documents (conservation strategies, management plans, Section 6 reports etc.). In a few instances, most notably for mosses, information related to fire was found in published sources, but without data. In one instance, the CDC's rare plant database was useful in supplying supporting data for anecdotal information found in a conservation assessment (Greenlee 1997).

Management documents often synthesize information from a variety of sources including the author's own field observations. Comments on fire and disturbance effects are often speculative, but are generally based on the author's familiarity with the plant and its habitat. However, one problem inherent in using unpublished references in an annotated bibliography is that you can find multiple sources containing similar information, but all might be predicated on a single research study. To avoid misinterpretation of the information in this bibliography, sources cited by an author were included in the annotation.

Few of the references found relate to understory burning. Most of the data available are from post-logging broadcast burning, and these generally entail clearcutting in addition to burning. Pre-burn population data are not always available, and often the season and severity of the burn are not specified.

Nine CNF sensitive species are disjunct from Pacific-coastal forests where they are common. Information on two of these, *Carex hendersonii* and *Blechnum spicant*, comes from monitoring studies on the Clearwater and Idaho Panhandle National Forests. Several sources contain references to fire effects on *Cornus nuttallii* and Roper (1970) provides a good overview of successional relationships of the species in its disjunct, inland range.

In his survey of six Idaho endemics, Crawford (1980) used field observations to deduce their response to various disturbance factors including fire. His work represents the only information available for fire effects on *Dasynotus daubenmirei*, *Synthyris platycarpa*, and *Waldsteinia idahoensis*.

Both published and unpublished fire effects data are available for *Cypripedium fasciculatum* and several additional studies are underway. The amount of information available for this species is partly a result of its wide distribution (8 western states). This species also occupies a range of fire regimes.

The federally listed species *Silene spaldingii* and *Spiranthes diluvialis* each have one, well documented monitoring study related to the effects of fire, neither of them from Idaho habitats. Only anecdotal evidence exists for *Mirabilis macfarlanei*. Fire is certain to have detrimental effects on *Howellia aquatilis* via elimination of shade and/or disruption of hydrology. None of these federal species are currently known from the CNF.

Several target species are considered sensitive to environmental fluctuation (e.g., *Buxbaumia viridis*, *Carex leptalea*, *Hookeria lucens*, and *Howellia aquatilis*). Although their habitats rarely if ever burn, numerous indirect effects of fire might be detrimental.

Even where data are available for a given species, they are specific to a narrow set of conditions determined by site, pre-burn management of the site, season and severity of the fire, and local factors affecting post-fire succession. For this reason, authors of research papers and monitoring reports often include cautions for the extrapolation of

their data to different regions or sites. These cautions often include consideration of anomalous fuel build-ups in forests; the presence of exotic weeds in grassland and dry forests; and the timing of the burn relative to plant phenology.

The bibliography

Citations in the bibliography are organized by plant species, which occur in alphabetical order. For each citation there is an annotation which contains information from the reference related to fire effects. This can be a summary of research results or excerpts taken from the reference. It was usually necessary to paraphrase the author(s) in order to include only the pertinent information. As much information as possible was included concerning the nature of the fire, and the vegetation type was described briefly. All of the information in the annotation was taken from the reference and summarized as accurately as possible. Editorial comments are enclosed in brackets ([]). Citations that address multiple species are listed under each, and the additional target species involved are listed below the annotation.

Acknowledgments

I was encouraged by the interest and enthusiastic support of everyone contacted about this project and am grateful to all of you. George Stephens performed the bibliographic search of the CDC's database. Betsy Hammet, Dottie Knecht, Marla Knight, Lynn Riedel, Nan Vance (all in Table 2), and Sarah Walker provided data or reports. Michael Mancuso served as guide to the CDC filing system.

References cited

Brown, J.K. and J.K Smith. In press. Wildland fire in ecosystems - effects of fire on flora. [www.fs.fed.us/rm/pubs/rmrs_gtr42_2]

Fischer, William C., compiler. The Fire Effects Information System [Database]. USDA, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory, Missoula, MT. [www.fs.fed.us/database/feis/plants/index]

Hessl A., and S. Spackman. 1995. Effects of fire on threatened and endangered plants: an annotated bibliography. USDI, National Biological Service, Information and Technology Report 2. The Nature Conservancy, Colorado Natural Heritage Program. 55 pp. [[www.http://fire.r9.fws.gov/ifcc/T&Eplants/T&Eplants](http://fire.r9.fws.gov/ifcc/T&Eplants/T&Eplants)]

Miller, M. and J. Findley. 1994. Chapter VI - plants. Pages VI-1 to VI-29 in: National Wildfire Coordinating Group, Prescribed Fire and Fire Effects Working Team, Fire effects guide. NFES #2394. National Interagency Fire Center, Boise, ID.

Moseley, R.K., M. Mancuso, A. Hedrich, and N.L. Shaw. 1992. Idaho's rare vascular flora: bibliography, 1896-1991. USDA, Forest Service, General Technical Report INT-292. Intermountain Research Station, Ogden, UT. 78 p.

Table 1. Target plants for the bibliography on fire effects.

	Fire effects references	Published references	Data	Published data
Federally listed species (Idaho)				
<i>Howellia aquatilis</i>	3			
<i>Mirabilis macfarlanei</i>	1			
<i>Silene spaldingii</i>	4	X	X	X
<i>Spiranthes diluvialis</i>	3		X	
Forest Service Sensitive Species				
<i>Asplenium trichomanes</i>				
<i>Blechnum spicant</i>	2	X	X	
<i>B. crenulatum</i>				
<i>B. lanceolatum</i> var. <i>lanceolatum</i>				
<i>B. minganense</i>	1*			
<i>B. montanum</i>				
<i>B. simplex</i>	1		X	
<i>Buxbaumia aphylla</i>	4	X		
<i>Buxbaumia viridis</i>	2*	X		
<i>Calochortus nitidus</i>	2			
<i>Cardamine constancei</i>	3		X	
<i>Carex hendersonii</i>	2		X	
<i>Carex leptalea</i>	1			
<i>Cetraria subalpina</i>				
<i>Cladonia anderegii</i>				
<i>Cornus nuttallii</i>	7	X	X	X
<i>Cypripedium fasciculatum</i>	6	X	X	X
<i>Dasynotus daubenmirei</i>	1			
<i>Haplopappus hirtus</i> var. <i>sonchifolius</i>				
<i>Hookeria lucens</i>	1*	X		
<i>Lomatium salmoniflorum</i>				
<i>Mimulus alsinoides</i>				
<i>Mimulus ampliatus</i>				
<i>Pentagramma triangularis</i> ssp. <i>triangularis</i>				
<i>Petasites frigidus</i> var. <i>palmatus</i>				
<i>Polypodium glycyrrhiza</i>	1*	X	X	X
<i>Rhizomnium nudum</i>				
<i>Synthyris platycarpa</i>	1			
<i>Thelypteris nevadensis</i>				
<i>Triantha occidentalis</i> ssp.				

<i>brevistyla</i>				
<i>Waldsteinia idahoensis</i>	1			

* Source refers to the species' tolerance of disturbance, but not to fire specifically.

Table 2. Experts contacted, their affiliation, and reason for the contact.		
Gamon, John	Washington Natural Heritage Program	<i>Silene spaldingii</i> , <i>Howellia aquatilis</i>
Goodnow, Val	Idaho Panhandle National Forests	Sensitive species
Hall, Fred	USFS, Region 5	Disjuncts, publications
Hammet, Betsy	Idaho Panhandle National Forests	<i>Blechnum spicant</i>
Harrod, Richy	Wenatchee National Forest	<i>Cypripedium fasciculatum</i>
Hill, Janice	The Nature Conservancy of Idaho	<i>Silene spaldingii</i> , <i>Calochortus nitidus</i>
Kagan, Jimmy	Oregon Natural Heritage Program	<i>Calochortus nitidus</i> , <i>Mirabilis macfarlanei</i> , <i>C. fasciculatum</i>
Knecht, Dottie	Wenatchee National Forest	<i>Cypripedium fasciculatum</i>
Knight, Marla	Klamath National Forest	<i>Cypripedium fasciculatum</i>
Latham, Penny	Oregon State University	<i>Cypripedium fasciculatum</i>
Lowry, Mark	Bureau of Land Management, Cottonwood Resource Area	<i>Mirabilis macfarlanei</i> , <i>Silene spaldingii</i> , <i>Calochortus nitidus</i>
Mancuso, Michael	Idaho Conservation Data Center	Various species
Riedel, Lynn	City of Boulder Open Space, Boulder, CO	<i>Spiranthes diluvialis</i>
Van Heusen, Beth	Colorado Natural Heritage Program	<i>Spiranthes diluvialis</i>
Vance, Nan	Pacific Northwest Research Station, Corvallis, OR	<i>Cypripedium fasciculatum</i>

**Annotated Bibliography: Effects of Fire on Sensitive Plant
Species of the Clearwater National Forest, and
Threatened and Endangered Plants of Idaho**

***Blechnum spicant* (deerfern)**

Hammet, Anna. 2001. Table summarizing the results of the *Blechnum spicant* monitoring plots at Distillery Bay, Priest Lake Ranger District, Idaho Panhandle National Forests (1991-1997). Unpublished. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 1 p. [Methods of this project can be found in: Blake, J. and C. Ebrahimi. 1992. Species conservation strategy and monitor plan for *Blechnum spicant* (deerfern). Appendix E. Unpublished report for the Idaho Panhandle National Forests. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 14 p plus appendices.]

Seven monitoring plots were established in a *Blechnum spicant* population the year after a portion of its habitat (old-growth cedar-hemlock) was clearcut and burned. The stand was very moist, with *Oplopanax* and *Athyrium* in the understory. Because *B. spicant* occurred primarily in the riparian zone, it is unlikely to have burned, but its canopy cover was removed. Plots were placed in undisturbed (2 plots), clearcut (3), and edge positions (2). No pre-harvest data are available. Data were collected in 1991 (1 yr post-disturbance), 1994, and 1997. Seven years after canopy removal, the total number of plants had increased in all plots relative to 1991. The number of plants more than doubled in 4 plots, including 2 of the disturbed plots. A consistent increase each year is characteristic of 4 of the plots, including 2 disturbed plots. There tends to be greater sporophyll production in the open (disturbed) sites. Data are broken down by juveniles, reproductive juveniles, adults, and reproductive adults.

Lenihan, J.M. 1990. Forest associations of Little Lost Man Creek, Humboldt County, California: reference-level in the hierarchical structure of old-growth coastal redwood vegetation. *Madrono* 37(2):69-87.

Frequent, light surface fires encourage the *Sequoia sempervirens* (redwood)/*Blechnum spicant* forest association in northern California.

***Botrychium minganense* (Mingan moonwort)**

Achuff, P.L. 1992. Status review of *Botrychium minganense*, U.S.D.A. Forest Service - Region 1, Lolo National Forest. Unpublished report. Montana Natural Heritage Program, Helena, MT. 26 p.

Regarding potential threats to the species the author states: "Nothing is known of the specific responses of *Botrychium minganense* to grazing or timber harvest. However, given its restriction to a fairly specialized habitat and obligate relationship with

mycorrhizal fungi, it likely would not respond well to such practices.” [p 10; no reference to fire.]

***Botrychium simplex* (least moonwort)**

Johnson-Groh, Cindy and Donald Farrar. 1989. Ecological monitoring of *Botrychium campestre* and a new species of *Botrychium* in western Minnesota. Unpublished report on file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 6 p.

Botrychium species are monitored in permanent plots within two prairie preserves, including within burned areas. At one site, 22 *Botrychium simplex* and 53 *Botrychium* sp. nov. were found in 1986, but no plants were found in 1987 or 1988, presumably due to burning at the time the plants were emergent. At another site, a population returned 3 years after a spring burn, at less than half its original size. Effects of burning have been confounded by drought and high variability in plant numbers at all sites. The timing of the burn appears to be most critical for the prairie moonworts. Early May fires when plants are emerging appear to be most damaging. The authors recommend burning prior to mid-April or in the fall.

***Buxbaumia aphylla* (leafless bug-on-a-stick moss)**

Crum, H. 1973. Mosses of the Great Lakes Forest. Contributions from the University of Michigan Herbarium 10:1-404. [Cited in: Steven, G. and D.G. Long. 1989. An update on the status of *Buxbaumia aphylla* on Bings in central Scotland. Transactions of the Botanical Society of Edinburgh 45:389-395.]

Throughout most of the range of *Buxbaumia aphylla*, the favored habitat is bare ground on heaths and openings in coniferous forest, often showing a preference for recently burnt places. [p 346-348]

Hancock, J.A., and G.R. Brassard. 1974. Phenology, sporophyte production, and life history of *Buxbaumia aphylla* in Newfoundland, Canada. The Bryologist 77(4):501-513.

In southeastern Newfoundland, four sites where *B. aphylla* was very abundant in 1971 were burned respectively in 1957, 1958, 1961, and 1962. Referring to the work of Uggla (1958) the authors conclude that: “If *B. aphylla* succeeds fires in Newfoundland, it does so after a shorter time interval than in Sweden.”

Jones, E.W. 1968. The ecology of *Buxbaumia aphylla* Hedw. Transactions of the British Bryological Society 6:139.

This Bryological Note points out the work of Uggla (1958), in Sweden, which the author feels may help explain the sporadic appearance of *Buxbaumia aphylla*. “In 1947 Uggla [working in an area of virgin pine forest] found that *Buxbaumia* was

characteristic of sites which had been severely burned in 1933, and were fully exposed to the sun. He was unable to relocate it in the same sites in 1949, 1953, or 1957, nor was he able to find it in areas which had been burned in 1920 or in 1941. He concluded therefore that the spores probably germinated after the fire, and that sporophytes were produced at a certain stage in the succession after fire.”

Taylor, Jennifer. 1972. The habitat and orientation of capsules of *Buxbaumia aphylla* in the Douglas Lake region of Michigan. *The Michigan Botanist* 11:70-73.

“Investigations into the local occurrence of *Buxbaumia* were made in areas of second-growth aspen. *Buxbaumia aphylla* grows in disturbed places, especially where there has been a fire, where larger, more vigorous plants have not yet had a chance to take hold and provide competition. It is most readily found on decayed wood or wood humus. ... great numbers of *B. aphylla* occur as scattered individuals or in clusters in open, pioneer situations in the young aspen forest. No doubt the history of cutting and burning of forests can account, in part, for the local abundance of a species ordinarily considered very rare and localized in distribution.” [p 70]

Uggla, E. 1958. Skogsbrandfält i Muddus Nationalpark. *Acta phytogeogr. suec.* 41, 116.

[See Jones (1968)]

***Buxbaumia viridis* (green bug-on-a-stick moss)**

FEMAT. 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. Appendix A. Forest Ecosystem Management Assessment Team. USDA Forest Service, Portland, OR. 73 p plus standards and guidelines.

Standards and guidelines for the management of nonvascular plants in the range of the northern spotted owl specify that, where *Buxbaumia viridis* occurs, mitigation activities should include maintaining decay class 3, 4, and 5 logs and greater than 70 percent closed-canopy forest habitats for shade.

Laaka, Sanna. 1992. The threatened epixylic bryophytes in old primeval forests in Finland. *Biological Conservation* 59:151-154.

The rapid decrease and fragmentation of primeval forests in Finland has caused a serious threat to bryophytes that grow on decaying wood [including *Buxbaumia viridis*]. Most of these epixylic bryophytes have specific site preferences and are sensitive to changes in the forest microclimate caused by intensive forest management [Abstract]. Epixylic bryophytes require a constantly humid, shady microclimate. The main substrate requirement is the decay stage of the wood. Each has a maximum frequency and abundance in a certain stage of decay. Most of the rare and threatened epixylic bryophytes may be considered ‘satellite species’ which are limited by inefficient dispersal and by difficulties in establishing themselves [p 1; citing Soderstrom (1989), citation not available].

***Calochortus nitidus* (broad-fruit mariposa lily)**

Caicco, Steven L. 1988. Status report for *Calochortus nitidus*. Unpublished report. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 54 p plus appendices.

Under “Dependence of this taxon [*Calochortus nitidus*] on natural disturbance” the author states: “Fire was an important ecological factor in maintaining the open nature of the plateau grasslands and woodlands, and thus may have been important to the [*C. nitidus*] sites of deep loessal soils and moist bottomlands.” [p 20] *Calochortus nitidus* also grows in rocky habitats which are naturally open and do not carry fire well. Under “Dependence on dynamic biotic features” the author states “some of the historical populations were probably subject to periodic wildfires. Most of the known habitats for the mariposa probably burn on occasion. Whether or not the mariposa is in some sense dependent on recurring fire in some or all habitats, however, is unknown.” [p 23]

Mancuso, M. and R. Moseley. 1994. Vegetation description, rare plant inventory, and vegetation monitoring for Craig Mountain, Idaho. Unpublished report for the Bonneville Power Administration. On file at: Idaho Department of Fish and Game Conservation Data Center, Boise, ID. 146 p plus appendices.

This inventory covers numerous, rare grassland plants. Regarding the ecology of *Calochortus nitidus* the authors state: “Its deep seated bulb would survive most fires. Wildfires were an important ecological feature of grasslands. It does not appear to readily colonize disturbed areas”; and in the conservation assessment: “Disturbed areas are especially prone to invasion by weedy exotics, replacing the native vegetation, including broad-fruit mariposa lily.” [p 56]

***Cardamine constancei* (Constance’s bittercress)**

Crawford, R.C. 1980. Ecological investigations and management implications of six northern Idaho endemic plants on the proposed endangered and threatened lists. Thesis. University of Idaho, Moscow, ID. 200 p.

Based on his observations of past burns and interpretation of stand history, the author concludes: “*Cardamine* responds favorably to disturbances that open the canopy. Fire evidently plays a significant role in this regard in natural stands. ...fire appears to stimulate growth of *cardamine*. Both crown fires that remove the tree canopy and ground fires that kill overtopping shrubs and decadent trees appear to increase rhizome production and flowering.” He further concludes that clearcutting, hot broadcast burning, or scarification would be harmful to *C. constancei*, whereas a light selective cut would likely be favorable, and that “management for *cardamine* in areas where logging is prohibited should include light surface fires.”

Also: *Dasynotus daubenmirei*, *Synthyris platycarpa*, *Waldsteinia idahoensis*

Lichthardt, J. 2000. Monitoring of rare plant populations on the Clearwater National Forest: fourth annual summary report, Clustered lady’s slipper orchid–Aquarius RNA, Henderson’s sedge–Aquarius RNA, crinkle-awn fescue–Aquarius RNA, Constance’s bittercress–North Fork Ranger District. Unpublished report for the Clearwater National Forest. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 15 p.

Four populations of *Cardamine constancei*, in stands of different seral stage, are monitored, one at a site that was clearcut and broadcast-burned in 1993. Prior to harvest this was a mature *Thuja plicata*/*Adiantum pedatum* stand. No pre-harvest data on *C. constancei* were available. The density of *C. constancei* stems at this site more than doubled between 1996 and 1997, four years after harvest, then did not fluctuate much over the following 2 years. Large variation in stem numbers has also been observed in undisturbed stands. There is also evidence that the population in the clearcut is spreading. Plants are “very small, and the leaves are thick and rubbery in texture, and very dark green.”

Also: *Carex hendersonii*

Lichthardt, J. and R.K. Moseley. 1994. Ecosystem analysis and conservation planning for the Clearwater Refugium, Clearwater and Nez Perce National Forests. Unpublished report for the Clearwater and Nez Perce National Forests. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 40 p plus appendices.

Based on field observations the authors agree with Crawford (1980) that populations of *Cardamine* are likely maintained by periodic underburns that open the canopy, but believe that shaded microsites are important [p 13]. Two populations affected by a 1991 fire along the Selway River produced prolific ramets and flowered profusely in the two following years. *Cardamine* may survive for a period following [tree] canopy

removal, but cannot be expected to persist or reproduce. [Flowering is not necessarily followed by seed-set.]

***Carex hendersonii* (Henderson's sedge)**

Lichthardt, J. 1998a. Monitoring of rare plant populations on the Clearwater National Forest. Unpublished report for the Clearwater National Forest. On file at: Idaho Department of Fish and Game, Conservation Data Center. 14 p plus appendices.

Seven monitoring plots were established in *Carex hendersonii* populations both within and outside cutting units. The site is in an area of western redcedar habitat types. At the time of this report, two plots had been subjected to clearcutting followed by broadcast burning. In plot 6, the number of individuals slowly declined in the 4 years since logging/burning and the proportion of reproductive individuals had decreased. In plot 7, the number of individuals was the same, but most appear to be new recruits rather than residual plants. Populations in the control plots changed little over the same time period. Different responses in the two logged plots may be due to variability in post-harvest burning. From photos it appears that the prescribed fire did not burn through plot 6.

Lichthardt, J. 1998b. Monitoring of rare plant populations on the Clearwater National Forest: Third annual summary report: clustered lady's slipper orchid–Aquarius RNA, Constance's' bittercress–North Fork, Steep Creek timber sale. Unpublished report for the Clearwater National Forest, on file at Idaho Department of Fish and Game Conservation Data Center, Boise, ID. 15 p plus appendices.

Numbers of *Carex hendersonii* plants dropped sharply after clearcutting, then increased slightly the year after burning. Two years after a low-intensity burn the population had returned to pre-disturbance numbers. Two years after a higher intensity burn, the number of mature plants was 1/3 of that pre-disturbance, but numerous seedlings were present.

***Carex leptalea* (bristle-stalked sedge)**

Bursik, R.J., and R.K. Moseley. 1992. Vegetation and water chemistry monitoring and twenty-year floristic changes at Huff Lake Fen, Kaniksu National Forest. Unpublished report for the Idaho Panhandle National Forests. On file at: Idaho Department of Fish and Game, Conservation Data Center. 27 p.

Carex leptalea was extirpated from Hager Lake Fen between 1972 and 1992. Documented changes in water chemistry in the lake from 1952 to 1992 were the most likely cause. Water chemistry changes are most likely due to the effects of forest fires and logging in uplands surrounding the lake prior to 1956. Forest clearing would have increased runoff of nutrient-rich groundwater into Hager Lake. Peatland species [such as *C. leptalea*] are adapted to very specific nutrient levels, water levels, and periodicity of flooding. Hager Lake has also been affected by ditching and clearing episodes.

***Cornus nuttallii* (Pacific dogwood)**

Dyrness, C.T. 1973. Early stages of plant succession following logging and burning in the western Cascades of Oregon. *Ecology* 54(1):57-69.

Five years after logging and burning *Cornus nuttallii* had increased slightly in frequency relative to pre-logging conditions (6.6% relative to 4.9%), but had regained little of its original cover (0.4% relative to 2.6%).

Halpern, D.B. 1989. Early successional patterns of forest species: interactions of life history traits and disturbance. *Ecology* 70(3):704-720.

After clearcutting and burning of stands of mature to old growth Douglas-fir, *Cornus nuttallii* showed relatively minor long-term changes in abundance. Constancy and cover were initially reduced and changed little over the next 20 years.

Harrison, Wayne. 1986. Management of giant sequoia at Calaveras Big Trees State Park. Pages 40-42 in: Weatherspoon, C.P., Y.R. Iwamoto, and D.D. Piirto, technical

coordinators, Proceedings of the workshop on management of giant sequoia. May 24-25, 1985, Reedley, CA. USDA, Forest Service, General Technical Report PSW-95. Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.

Due to the thin bark of *Cornus nuttallii*, the immediate effect of a cool to moderate burn is damage to the cambium layer, resulting in top-kill of the tree.

Kauffman, J.B. and R.E. Martin. 1990. Sprouting shrub response to different seasons and fuel consumption levels of prescribed fire in Sierra Nevada mixed conifer ecosystems. *Forest Science* 36(3):748-764.

After cool to moderate burns, *Cornus nuttallii* resprouts vigorously from the root crown. These sprouts are not shade tolerant, as are saplings from seed, and flourish after a fire.

Lichthardt, J. 1994. Population monitoring of disjunct Pacific dogwood (*Cornus nuttallii*) on the Clearwater and Nez Perce National Forests: three-year summary. Unpublished report for the Clearwater and Nez Perce National Forests. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 10 p.

In October, 1991 a prescribed burn escaped and spread to the canyon bottom on the north side of the Selway River, affecting *Cornus nuttallii* trees in or near three demographic monitoring plots. Twelve burned trees were tagged shortly after the fire and revisited in 1992. Only five of the twelve resprouted, two with more than 40 sprouts. Leaves on the new sprouts were very abnormal, with mealy, discolored surfaces.

Roper, L.A. 1970. Some aspects of the synecology of *Cornus nuttallii* in northern Idaho. Thesis. University of Idaho, Moscow, ID. 81 p.

Roper investigated disjunct, inland populations of *Cornus nuttallii* in the late 1960s, prior to the onset of disease and precipitous population decline. He concluded that *C. nuttallii* was either a component of the climax community or a long-lasting seral plant able to take advantage of any disturbance which either opens or removes the forest overstory. It is capable of vegetatively layering or sprouting after fires or cutting. However, reproduction by seed occurs primarily in seral stages after conifers or paper birch (*Betula papyrifera*) begin to dominate, and in the climax stage it is the dominant understory shrub. He suggested that periodic controlled burning of seral stands containing *C. nuttallii* should prove beneficial to big game because it increases the palatability and availability of *C. nuttallii* and other preferred browse. His management recommendations for the inland range of *C. nuttallii* included maintaining a mosaic of communities varying from seral shrub habitats to mature forests. In his management scenario, mature stands in Apgar Creek would be protected and allowed to develop to climax condition.

Yerkes, Vern P. 1960. Occurrence of shrubs and herbaceous vegetation after clear cutting old-growth Douglas-fir. USDA, Forest Service, Research Paper PNW-34. Pacific Northwest Forest and Range Experiment Station, Portland, OR. 12 p.

In Pacific-coastal forests, *Cornus nuttallii* will invade clearcuts and burns from adjacent forests by dissemination of seeds by birds and small mammals.

***Cypripedium fasciculatum* (Clustered lady's-slipper orchid)**

Greenlee, J. 1997. *Cypripedium fasciculatum* conservation assessment. Unpublished Report for USDA, Forest Service, Region 1, Missoula, MT. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 23 p.

On the Powell Ranger District, Clearwater NF, *Cypripedium fasciculatum* plants were found within a burned area two years after a variable-intensity wildfire. The tree canopy was gone and the plants were growing under a dense cover of fireweed (*Epilobium angustifolium*). [EOR #046, Idaho Conservation Data Center database states: "*Thuja plicata*/*Adiantum pedatum* community. The stand burned in 1988; most of the large overstory trees are dead...Population Data: 1993: A total of 81 mature genets in flower in all subpopulations. Population vigor assessed as good. Observation on a thorough survey of the area on 7-12."] Plants may be adversely affected by canopy opening. Plants growing in open situations tend to senesce earlier than plants in more shaded conditions. For several years after a blowdown, only 2 plants out of a population of 58 could be found. In Montana, *C. fasciculatum* occurs primarily in Douglas-fir/ninebark and grand fir/ninebark habitat types which historically experienced frequent, low to moderate intensity surface fires. Due to an absence of underburns, stands in these habitat types are now more densely stocked and have greater canopy closure. In Idaho and the Swan Valley of Montana, *C. fasciculatum* occurs in moister forest communities which experienced longer fire intervals. In the queencup beadlely, oakfern, and wild ginger unions of the western redcedar series, current stand structure may be within the range of natural variability. Regarding management of *C. fasciculatum* in drier Douglas-fir habitat types, the author states that "we need to maintain occupied habitats even as some occupied and unoccupied habitats are treated with silvicultural prescriptions that mimic natural processes." The temporal scale of metapopulation dynamics in western redcedar habitat types is probably much longer.

Harrod, R.J., D.E. Knecht, E.E. Kuhlmann, M.W. Ellis, and R. Davenport. 1997. Effects of the Rat and Hatchery Creek fires on four rare plant species. Pages 311-319 in: J.M. Greenlee (ed.), Proceedings—Fire Effects on Rare and Endangered Species and Habitats Conference, Nov. 13-16, 1995. Coeur d'Alene, ID. International Association of Wildland Fire, Fairfield, WA. 343 p.

This paper investigates changes in population size and plant morphology of *Cypripedium fasciculatum* between 2 years at 4 sites (3 unburned and 1 burned). The fire occurred between the two years of measurement and was primarily an underburn

that burned “at varying intensities throughout the plot burning some plants and not others.” There was an increase in number of aerial stems in all plots in the second year [apparently not significant] despite the fact that there were 4 fewer clumps of stems at the burned site. The number of plants with fruits decreased by 33% at the burned site but by no more than 4% at unburned sites [apparently not tested]. There were no significant differences in numbers of clumps/plot between the two years. There was a significant decrease in the number of fruits per stem at the burned site only. There were no significant differences following the fire in flowers/stem, plant height, leaf width, or leaf length. In locations where the duff layer had been eliminated by fire, plants were killed.

Kagan, J. 1990. Species management guide for *Cypripedium fasciculatum* for southwestern Oregon: Klamath National Forest (in Oregon), Rogue River National Forest, Siskiyou National Forest, Umpqua National Forest, and Medford District of the Bureau of Land Management. Oregon Natural Heritage Data Base. Portland, OR. Unpublished report. 19 p.

The historical distribution and population biology of *Cypripedium fasciculatum* [in western Oregon and northwestern California] have some relationship to wildfire, because wildfire is a critical determinant of the species composition, stand structure and canopy cover of almost all the forests in this region. All known populations in wildfire areas appear to have disappeared following fire. No specific information was available on the nature of the fires affecting *C. fasciculatum* populations. The author speculates that *C. fasciculatum* could survive underburns of the type common in presettlement times, but that current fuel loads in its habitat would support hot fires that destroy populations.

Knecht, D.E. 1996. The reproductive and population ecology of *Cypripedium fasciculatum* (Orchidaceae) throughout the Cascade Range. Thesis. Central Washington University, Ellensburg, WA. 64 p.

It appears that *Cypripedium fasciculatum* cannot tolerate fires intense enough to burn out the duff layer. Fire appears to decrease the abundance of *C. fasciculatum* pollinators and thus fruit-set for at least the first post-fire year. *Cypripedium fasciculatum* is sensitive to disturbance of both habitat and the individual plant. Removal of aerial stems can decrease the plant’s ability to store nutrients or interfere with seed production. Regarding management the author states: “Any management activity that would reduce the canopy closure below 60% should be avoided.”

Seevers, Joan. and F. Lang. 1998. Management recommendations for clustered lady slipper orchid (*Cypripedium fasciculatum* Kellogg ex S. Watson). v. 2.0. Bureau of Land Management, Portland, OR. 27 p.

The shallow rhizome system of *Cypripedium fasciculatum* may exacerbate the deleterious effects of fire. Because rhizomes are 3-12 cm (1-5 in) below the soil surface, intense fire can damage or kill the plants at any level. There are conflicting

opinions on the effect of low-intensity fires. Some *C. fasciculatum* sites that burned at low intensity showed increased numbers of stems, expanded population areas, and many small individuals that were perhaps seedlings (Knorr, pers. comm. [not in list of references]). However, the work of Harrod et al. (1997) suggests that the species cannot tolerate low intensity fire that eliminates the duff layer. Regarding management within habitat areas, the authors state: "Avoid activities that alter soil, duff, down wood, and the mycorrhizal community in the habitat area." Because observations on the effect of fire seem to be in conflict, a carefully planned experimental burn should be conducted and analyzed before fire is used as a management tool.

Vance, Nan and Leonard Lake. 2001. Response of clustered ladyslipper (*Cypripedium fasciculatum*) to partial overstory removal and prescribed fire in north central Idaho. Preliminary draft. USDA, Forest Service, Pacific Northwest Research Station, Corvallis, OR. 4 p.

On the Nez Perce National Forest, a silvicultural treatment that included a shelterwood cut and broadcast burning was carried out in spring 1997, affecting a portion of a large population of *Cypripedium fasciculatum*. The area is primarily in the *Pseudotsuga menziesii*/*Physocarpus malvaceus* habitat type. The result of the treatment was partial overstory removal and a low-intensity burn. Monitoring plots for *Cypripedium fasciculatum* were established, 4 each, inside and outside of the burned area. There were no pre-burn data. Plots have been revisited annually through 2000. In the year following the fire, only 1 out of 100 total plants flowered in the burned plots, indicating that a season of vegetative growth may be required to furnish energy stores for flowering the following season. Recruitment has exceeded losses in both burned and unburned treatments for each of the 3 post-fire monitoring years (i.e., numbers of plants have increased in both treatments). Seed-set, as measured by number of capsules/flowering plant was lower in the burned plots each year, as was the number of capsules/flower. Reduced capsule production in the burn may be due to loss of cover resulting from the fire. It is speculated that heat and direct sunlight caused the plants to senesce prematurely, before development was complete. The study suggests that the most detrimental effect of fire to long-term population viability may be the loss of appropriate habitat.

***Dasynotus daubenmirei* (Daubenmire's dasynotus)**

Crawford, R.C. 1980. Ecological investigations and management implications of six northern Idaho endemic plants on the proposed endangered and threatened lists. Thesis. University of Idaho, Moscow, ID. 200 p.

Under natural conditions *Dasynotus daubenmirei* requires some disturbance factor to open the canopy and provide seedbeds. Fire is the most likely factor. *Dasynotus* is fire-tolerant, even of high intensity fires. Sprouts were present at the site of a recently burned slash pile. In cool, fall broadcast burns following clearcutting, *Dasynotus* is one of the first plants to resprout and flower the following spring.

Also: *Cardamine constancei*, *Dasynotus*, *Synthyris platycarpa*, *Waldsteinia idahoensis*

Hookeria lucens

Bohlin, A., L. Gustafsson, and T. Hallingback. 1977. Skirmossan, *Hookeria lucens*, i Sverige. [*Hookeria lucens* (Musci) in Sweden.] Svensk Bot. Tidskr. 71:273-284.

Hookeria lucens is probably very sensitive to environmental changes, such as clearing of trees and drainage, which may make the microclimate change.

***Howellia aquatilis* (water howellia)**

Shelly, J.S. 1994. Conservation strategy for *Howellia aquatilis* A. Gray. Unpublished report for the Flathead National Forest, Kalispell, MT. 25 p.

Although stating that “the relationship [of *Howellia*] to fire is largely unknown” the author speculates on the potential effects of fire: “Fire may have historically influenced the distribution of *H. aquatilis* in the Swan River valley [Montana]. For example, an intense fire late in the growing season, after an occupied pond is dried out, might have burned through the dried vegetation therein. If so, the seeds would be unlikely to survive (they do not become very deeply buried in the sediments), and the occurrence could be extirpated. In such a case, clusters of occurrences in adjacent ponds would be more likely to survive an intense, hot fire than a single, isolated occurrence. On the other hand, fire may also have the potential to benefit *H. aquatilis*. As organic mats build up in the ponds, the latter [ponds] may become unsuitable habitat (as the water table is lowered relative to the substrate surface). Cooler ground fire could serve to offset this organic matter build-up, and maintain the habitat suitability of the ponds [citing John Pierce, pers. comm.]. The primary way in which fire may influence *H. aquatilis* habitats, though, is probably by its influence on the adjacent forests; crown fires that remove trees shading the pond could in turn influence the drying regime of the ponds (i.e., increased evaporation and/or reduced transpiration rates). In summary, the potential effects of a prescribed fire should be carefully examined prior to burning in areas containing occurrences. Early season

burns and controlled ground fires, conducted while the ponds still contain water, would not be likely to adversely affect the pond habitats.” [p 15-16]

Shelly, J.S. and R.K. Moseley. 1988. Report on the conservation status of *Howellia aquatilis*, a candidate threatened species. Unpublished report for the U.S. Fish and Wildlife Service, Regions 1 and 6. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 166 p.

Howellia aquatilis is ecologically restricted to a narrowly defined aquatic habitat, making it particularly sensitive to impacts on its habitat. Habitat typically consists of ephemeral ponds with firm, consolidated organic clay bottom sediments. An increase in siltation rate into the ponds, such as after deforestation, could have an adverse effect on the viability of *H. aquatilis* populations [p 56-57].

U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants; the plant, water howellia (*Howellia aquatilis*), determined to be a threatened species. Final rule. Federal Register 59(134):35860-35864.

Removal of trees from around *Howellia* ponds may cause an increase in water temperature, evaporation, and wetland drying and thus affect plant succession. An increase in bottom sedimentation and subsequent competition from other vegetation could have an adverse effect on *Howellia* populations. The species may be vulnerable to random environmental events or habitat alterations due to its low genetic variability.

***Mirabilis macfarlanei* (Macfarlane’s four-o’clock)**

Mancuso, M. 1996. Plant characterization abstract for *Mirabilis macfarlanei*. Idaho Conservation Center website: www.state.id.us/fishgame/cdchome.htm.

At one site in Idaho, the number of *M. macfarlanei* plants appears to be stable several years after a range fire. An increase in *Bromus tectorum*, however, suggests that habitat degradation is an ongoing problem. The underground stems of *M. macfarlanei* would survive most natural fires, especially since they would likely occur later in the summer, when the plant is dormant. [Based on conversations with Craig Johnson, Cottonwood District BLM, concerning an Idaho population affected by wildfire.]

***Polypodium glycyrrhiza* (Licorice fern)**

Halpern, C.B. and T.A. Spies. 1995. Plant species diversity in natural and managed forests of the Pacific Northwest. *Ecological Applications* 5(4):913-934.

Polypodium glycyrrhiza was extirpated from experimental plots by canopy removal [logging without burning; p 922]. Fourteen years after harvest it had not returned to the site.

***Silene spaldingii* (Spalding’s catch-fly)**

Kagan, J. 1989. Draft species management guide for *Silene spaldingii*. Report to the Wallowa Whitman National Forest on file at: Oregon Natural Heritage Data Base, Portland, OR. 10 p plus appendices.

The author states that “the fire resistance of [*Silene spaldingii*] is not known.” Wildfire tends to be most common in late July and August, which is the peak flowering time for this plant. Drawing upon personal communications with Steve Shelly and Peter Lesica concerning the condition of some Montana populations, the author speculates that one Oregon population may be stagnating due to heavy duff layers built up in the absence of fire.

Lesica, P. 1997. Demography of the endangered plant, *Silene spaldingii* (Caryophyllaceae) in northwest Montana. *Madrono* 44(4):347-358.

Results of a vegetation analysis at Dancing Prairie Preserve north of Eureka, Montana support the hypothesis that *Silene spaldingii* reaches its greatest abundance in sites with reduced interference from the dominant grass (*Festuca scabrella*). Thus, disturbances such as grazing or fire may be important to the long-term persistence of this species in northwest Montana. Prescribed fire may be a useful tool for managing *S. spaldingii* at this site, but should not be reintroduced without further study. Disturbance may have adverse effects, such as exotic weed encroachment, even in fire-adapted systems. Results obtained from Dancing Prairie cannot necessarily be extrapolated to populations remaining in the Palouse region, because demographic patterns may change with location and habitat.

Lesica, P. 1999. Effects of fire on the demography of the endangered, geophytic herb *Silene spaldingii* (Caryophyllaceae). *American Journal of Botany* 86(7):996-1002.

The effects of spring and fall fires on *Silene spaldingii* were studied in a northwest Montana grassland. Individual *S. spaldingii* plants were mapped, and size and flowering were recorded for 1 yr prior and 5 yr subsequent to the burn treatments. Enhanced seedling recruitment (70-410%) and a 22% increase in population size were the principal effects of fire on *S. spaldingii*, and fall burn plots had lower recruitment than spring burn plots. These effects were apparent for 2-3 yr following the treatments. Fire had no detectable effect on the survival of adults or recruits of *S. spaldingii*. *Silene spaldingii* exhibits prolonged dormancy in which plants do not produce above-ground vegetation for one to several consecutive years. Results suggest that fire has a positive effect on the population dynamics of *S. spaldingii* by removing litter and creating safe sites for recruitment. Prescribed fire should be an important tool for managing populations of this rare plant. [From author's summary]

U.S. Fish and Wildlife Service. 1999. Endangered and threatened wildlife and plants; proposed threatened status for the plant *Silene spaldingii* (Spalding's catchfly). Federal Register Part 17 RIN 1018-AF79.

Habitat changes associated with fire suppression threaten this species. Fire suppression can cause habitat deterioration in condition by facilitating encroachment of woody vegetation and contributing to a build-up in the litter or duff layer. Prescribed fire may have a positive effect on *Silene spaldingii* by removing litter and creating suitable sites for recruitment [citing Lesica (1999), then in press]. However, the effects of fire will vary due to factors such as fuel moisture content, species composition, and season and intensity of burning (Lesica 1997).

***Spiranthes diluvialis* (Ute's ladies tresses)**

Arft, Anna. 1994. Final report on *Spiranthes diluvialis* to Colorado Natural Areas Program. Unpublished report for the Colorado Natural Areas Program. Abstract. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 1 p.

Thirty-four experimental and control plots in Boulder County, Colorado were monitored between 1992 and 1993. Plots were monitored to determine the effects of mowing, grazing, and burning on *Spiranthes diluvialis*. Burn treatments consisted of an early burn to simulate fires in summer and a late burn to simulate fires in winter. By June, control plots and late burn plots had already produced significantly more inflorescence buds than the other treatments. The grazed, early burn, and late burn plots produced flowers before the other treatments. Orchids in the late burn plots suffered significantly high mortality in July-August. Long-term monitoring and observation will be continued by City of Boulder Open Space.

Arft, Anna. 1995. The genetics, demography, and conservation management of the rare orchid *Spiranthes diluvialis*. University of Colorado, Boulder, CO. Dissertation. 170 p.

Few individuals within either the “early burn” (prior to onset of growth) or “late burn” (post seed dispersal) plots produced an inflorescence by 1994 [2 yrs post burn]. A larger proportion of plants were absent from the early burn plots relative to the late burn, suggesting that fall burning, when the orchid is finished with seed dispersal and going into seasonal dormancy, may carry less of a risk of negative effects.

Riedel, Lynn. 2001. Effects of prescribed fire on *Spiranthes diluvialis*. Memo from Lynn Riedel of City of Boulder Open Space, Boulder, CO. On file at: Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 2 p.

We have monitored 10 of Anna Arft's *Spiranthes diluvialis* plots annually from 1996-2000 [Arft 1995]. We burned one of the plots on April 6, 2000, and the number of orchids in the burned plot in the first season following the burn (2000) was nearly the same as in 1999. In each area where we have conducted March or April burns in known orchid occurrences over the last 3 years [2-3 areas/yr], we have seen positive results in terms of numbers of individuals flowering. These recent burns I refer to, where orchid flowering increased after spring burning, have been in irrigated, floodplain meadows that are not hayed, and are only grazed (winter - May 15

approximately). In those areas that are not irrigated, or are at the drier edges of irrigated meadows, we have not seen an increase in flowering individuals after spring burns—when we have a dry, late spring and summer. On the other hand, we have seen a decline in flowering and above ground growth during drought years in all of the orchid patches (burned recently or not) that occur at those drier, marginal edges of the habitat. [Summary by Lynn Riedel]

***Synthyris platycarpa* (evergreen synthyris)**

Crawford, R.C. 1980. Ecological investigations and management implications of six northern Idaho endemic plants on the proposed endangered and threatened lists. Thesis. University of Idaho, Moscow, ID. 200 p.

Based on observations of 3 clearcut/burned stands, *Synthyris platycarpa* is apparently fire tolerant [p 140]. Individuals were rare where slash piles had been burned, but synthyris was invading where shade was present. In broadcast burns, synthyris appeared to resprout and reproduce successfully. Although a climax species, it successfully maintains healthy populations following logging and burning, when disturbance is not deep enough to kill roots.

Also: *Cardamine constancei*, *Dasynotus daubenmirei*, *Waldsteinia idahoensis*

***Waldsteinia idahoensis* (Idaho barren strawberry)**

Crawford, R.C. 1980. Ecological investigations and management implications of six northern Idaho endemic plants on the proposed endangered and threatened lists. Thesis. University of Idaho, Moscow, ID. 200 p.

Based on field observations, broadcast burns in clearcuts did not appear to inhibit the growth of *Waldsteinia idahoensis*. The development of large, dense mats of *Waldsteinia* was greater on burned cuts than in unburned or scarified cuts. “Fire appears to reduce competition and open sites for invasion by rhizomes. Intense, prolonged heat generated beneath deep slash piles would probably kill waldsteinia as it would any plant. However, waldsteinia favors toe-slopes, an area where heavy slash piles are not normally accumulated, thus most sites are not in danger of harm from burning slash piles.” [p. 152]

Also: *Cardamine constancei*, *Dasynotus daubenmirei*, *Synthyris platycarpa*