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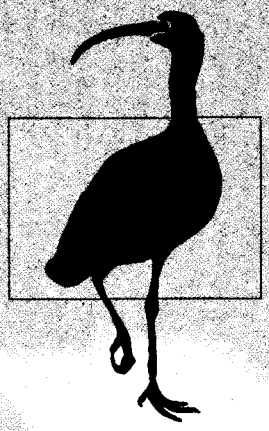

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL BIOLOGICAL SERVICE

INFORMATION AND TECHNOLOGY REPORT 2

EFFECTS OF FIRE ON THREATENED AND ENDANGERED PLANTS: AN ANNOTATED BIBLIOGRAPHY

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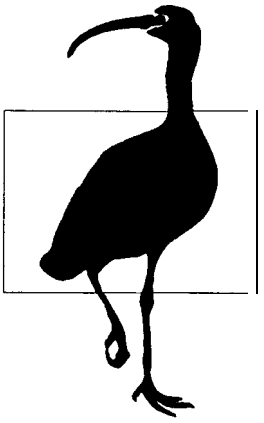

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INFORMATIONAND TECHNOLOGY REPORT 2
AUGUST **1995**

EFFECTS OF FIRE ON THREATENED AND ENDANGERED PLANTS: AN ANNOTATED BIBLIOGRAPHY

BY

Amy Hessl

and

Susan Spackman

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*Frontispiece: Peter's Mountain mallow (*Iliamna corei*), a federally listed endangered plant, responded favorably to fire. Photo courtesy of The Nature Conservancy, Virginia Field Office.*

Effects of Fire on Threatened and Endangered Plants: An Annotated Bibliography

by

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Abstract. This bibliography presents basic information about the effects of fire on plants that the U.S. Fish and Wildlife Service lists as endangered or threatened or as category-one (Cl) candidates for federal listing. We searched 23 databases for publications, unpublished reports, and records with pertinent information; summarized and compiled information on the effects of fire from all final rulings on endangered and threatened plants and from endangered species recovery plans for plants; and solicited information from key researchers and agencies involved in fire ecology. The bibliography includes 126 references to the effect of fire on 172 federally listed plant species, or on 26% of the total number of federally listed plant species in these categories. Our study revealed that the total number of relevant articles has been increasing since the 1970s and more rapidly since the 1980s. Although research on fire and rare plants is increasing, an absence of information on many species persists. We hope that this document will facilitate and encourage research in this increasingly important field of botanical conservation.

Key words: Bibliography, botanical conservation, endangered plants, fire ecology, threatened plants, rare plants.

Fire plays a role in the management of many threatened and endangered plant species. Fire helps maintain open habitat (**Rome 1987; Jacobson et al. 1991), encourages sexual and vegetative reproduction (*Boyd 1987; Hartnett and Richardson 1989; *Kirkman and Drew 1993). and affects competing or associated plant species (Stone and Scott 1985; Melgoza et al. 1990; *Fishbein and Gori 1992). Although fire may injure or kill plants (Dunwiddie 1990; *Cobb 1994), long-term effects on species may be beneficial. For example, the same fire that kills plants may also reduce competitors (*Folkerts 1977; *U.S. Fish and Wildlife Service 1986) or create beneficial openings for seedling establishment (Gankin and Major 1964; *U.S. Fish and Wildlife Service 1990a, 1993a; Menges and McAnlis 1994). Fire suppression may imperil some endangered plant species (Schwartz and Herman 1991; U.S. Fish and Wildlife Service 1990b; *Kagan 1992; *U.S. Fish and Wildlife Service 1994a). On the other hand, researchers in Hawaii fear that even a single fire would be a serious threat to the survival of some endangered plant species by either directly killing plants or by encouraging the invasion and competition from exotic species that are well adapted to tire (U.S. Fish and Wildlife Service 1985; *U.S. Fish and Wildlife Service 1990a; U.S. Fish and Wildlife Service 1990b, 199 la, 1992a, 1994a, 1994b).

Fire management must address the timing of a bum (i.e., timing in relation to the life cycles of the plants) and the area, frequency, and intensity of a bum (U.S. Fish and Wildlife

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[2] An asterisk denotes unpublished material.

Service 1987, 1992b, 1993b; S. Popovich, U.S. Bureau of Land Management, Shoshone, Idaho, personal communication). Ideally, natural processes and cycles do not have to be disrupted. However, land managers, particularly managers of small reserves, often face the challenge of mimicking natural fire regimes with prescribed burns. Bums in areas with endangered species must be carefully planned, and accurate information about plant-fire relations is essential for planning, restoration, or other management of endangered-plant habitat.

Investigations of rare plant populations and effects of tire are hindered by the difficulties associated with such research. For example, information on the taxonomy, habitat, and physiology of rare plants is often sparse (Owen and Rosentreter 1992). Experiments with rare plants that include prescribed bums are often limited in scope, cover a small geographic region, involve few plants, and are difficult to replicate. Time and funding for research are often unavailable for long-term studies of threatened or endangered plants.

Research into fire and rare plants is, however, vital to the recovery and management of some rare plant populations. Appropriate management requires scientific data on the role of fire in the biology and ecology of rare plants and their habitats. This bibliography presents basic information about the effects of fire on plant species listed as threatened, endangered, and category-one (Cl) on or before 30 September 1993 (U.S. Fish and Wildlife Service 1993c, 1993d). These categories as defined in the Endangered Species Act of 1973 are:

E	Endangered: taxa formally listed as endangered.
T	Threatened: taxa formally listed as threatened.
C1	Category 1: taxa with substantial biological information on file to support listing as endangered or threatened.
C2	Category 2: taxa for which current information indicates that listing as endangered or threatened is possible, but appropriate or substantial biological information for immediate rule making is not on file.
3C	Category 3: taxa are more abundant or widespread than previously believed or are not subject to any identifiable threat.
0	species that are not listed.

Other objectives of this project were to provide a synopsis of useful information for the management of rare plants with fire and to update and expand the Natural Heritage Program, The Nature Conservancy, and the National Biological Service databases with the addition of information on the effects of fire. The annotations present information that facilitates and encourages research in this important field of botanical conservation.

We used the key wordsfire, *burn, endangered, threatened, rare, plant, endemic, vegetation,* and *disturbance* to search the following databases:

AGRICOLA 1970–present (USDA)
Arizona Natural Heritage Program
California Natural Heritage Program
California Regional Office of The Nature Conservancy (TNC)
Colorado Alliance for Research Libraries (CARL)
Colorado Natural Heritage Program
Colorado State University Library System
Dissertation Abstracts Online 1990–present
Fire Effects Information System (FEIS)
Fish and Wildlife Reference Service
Florida Natural Areas Program
Georef™ 1989–present (Geological abstracts)
International Association of Wildland Fire
MELVYL (University of California Library System)
National Office of The Nature Conservancy (TNC)
Northeastern Regional Office of The Nature Conservancy (TNC)
Selected Water Resources Abstracts 1990–present
Southeastern Regional Office of The Nature Conservancy (TNC)
BIOSIS Previews 1989–present (Biological Abstracts)
University of Colorado Government Documents Library
U.S. Department of the Interior Reference Service Library
Western Regional Office of The Nature Conservancy (TNC)
Wildlife Review and *Fisheries Review*

We searched for publications, unpublished reports, final rulings on threatened and endangered plants, endangered species recovery plans (all recovery plans printed by August 1994 were reviewed for information on the effects of fire), research in progress, and anecdotal information. Although threatened, endangered, and category-one species were the target of our research, we also selected other pertinent references to the effects of fire. We searched for references to the effect of fire on rare but not federally listed plant species, to plant communities with rare plant species, and to some plant genera with one or more federally listed species.

After the literature search, we contacted key researchers and agencies involved with fire ecology. We posted electronic bulletins on Internet and on the U.S. Forest Service computer network and contacted federal, state, and local agencies to obtain access to unpublished reports, field notes, anecdotal information, and information on research in progress (Appendixes A-B).

We found 126 references to the effects of fire on 172 federally listed plants (26% of the plant species in these categories) and 36 references to the effects of fire on other rare plants (including some C2 plants). Of the total of 165 references, 39 are unpublished documents and 9 are personal communications.

The albeit limited number of references revealed that the number of relevant articles has been increasing since the 1970s and most rapidly since the late 1980s (Table 1). We found only three articles on threatened, endangered, or Cl species that were published before 1980. After 1980, the number of pertinent studies increased, probably in response to the Endangered Species Act of 1973 (P.L. 93-205 [87 stat. 884]) and the subsequent development of recovery plans. The total number of publications was greater in the 1990s (57) than in the 1980s (33). We also compared the number of references describing the effects of fire on endangered, threatened, and category-one plants in each state with the number of plant species in these categories currently or historically occurring in each state (Table 2; Figs. 1 and 2).

Although the preservation and management of botanical diversity requires an understanding of the relation of fire to plants, the variety of responses documented in this bibliography suggests that the role of tire in creating, maintaining, and destroying rare plants and their habitats can be complex and elusive. For example, long-term monitoring is necessary to establish the role of fire in succession and other vegetative processes (Owen and Rosentreter 1992; *Sutter 1994; D. Soblo, The Nature Conservancy, Columbia, South Carolina, personal communication); a minimum of 3 years may be needed to study and predict rare plant population dynamics (Menges 1986); and fire intensity, extent of bum, and season of bum must be measured to determine the variability of tire behavior (Pavlovic 1994). Fires may be detrimental to some species in spring but beneficial in summer or fall or vice versa (*Lesica 1992; D. Gori, The Nature Conservancy, Tucson, Arizona, personal communication). Similarly, anthropogenic disturbances, such as mowing or grazing, can mimic a historical fire regime if they occur with the correct frequency and intensity but can also be destructive (Pavlovic 1994).

Some authors (Campbell et al. 1991; Hardin and White 1992; *Gordon 1992a, 1992b) simply stated that a plant species occurs in a fire-adapted community. Because fire occurs in nearly all terrestrial environments at some time or another, we suspect that information about the effects of fire on plant communities may be important for the general management of endangered species. Although all plants are adapted to environmental stresses, plant morphology may provide additional information about adaptation to fire. For example, species with thick bark, hard-coated seeds, or fire-resistant foliage may benefit from fire during part of their life cycles (Agee 1994).

For each bibliographic entry, we summarized the information on the effects of fire, unless an abstract or other written summary was available. The nature of each summary is identified as AA (author's abstract of the publication), PA (partial abstract of the publication), AS (researcher's summary of the unpublished material), or PS (researcher's partial summary of the unpublished material). The absence of a designation denotes our summary of a publication, unpublished material, or record.

Additionally, we summarized the available information on the effects of fire on the species covered by this bibliography in a table that lists each species, its status, associated references, and known or suspected responses to fire (Table 3). This summary is not a comprehensive listing of rare species affected by tire, and the listed responses are not meant to be definitive information on the effects of fire on species. We refer readers to the original sources for more detailed information.

Table 1. Number of references by year and decade to the effects of tire on federally listed endangered, threatened, or category-one plants.

	Year														Decade			
Sources	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[a]	Pre 1970s	1970s	1980s	1990s
Printedarticles including government publications	0	2	4	9	4	4	3	4	3	9	16	12	14	6	1	2	33	57
Unpublished papers	1						1	2	2	0	2	7	6	5			6	20
Personal communication														6				6
Total	1	2	4	9	4	4	4	6	5	9	18	19	20	18	1	2	39	84

[a] Exclusive of references that became available after 31 August.

Table 2. Number of federally listed threatened, endangered, and category-one plants per state (U.S. Fish and Wildlife Service 1993c, 1993d or as of September 1993) and number of references to species in these categories by state.

State	Species	References	State	Species	References
Alabama	18	7	Montana	1	0
Alaska	1	0	Nebraska	4	2
Arizona	32	6	Nevada	20	0
Arkansas	23	0	New Hampshire	3	0
California	189	17	New Jersey	7	1
Colorado	18	1	New Mexico	17	1
Connecticut	3	1	New York	10	2
Delaware	8	2	North Carolina	27	20
Florida	52	29	North Dakota	1	0
Georgia	22	11	Ohio	4	1
Hawaii	113	16	Oklahoma	2	0
Idaho	11	1	Oregon	32	6
Illinois	10	3	Pennsylvania	6	0
Indiana	7	1	Rhode Island	3	1
Iowa	2	1	South Carolina	19	9
Kansas	3	0	South Dakota	1	0
Kentucky	7	3	Tennessee	21	6
Louisiana	2	0	Texas	32	8
Maine	3	1	Utah	27	0
Maryland	10	3	Vermont	4	0
Massachusetts	5	1	Virginia	13	3
Michigan	7	0	Washington	16	0
Minnesota	4	2	West Virginia	5	1
Mississippi	3	1	Wisconsin	7	1
Missouri	9	1	Wyoming	2	0

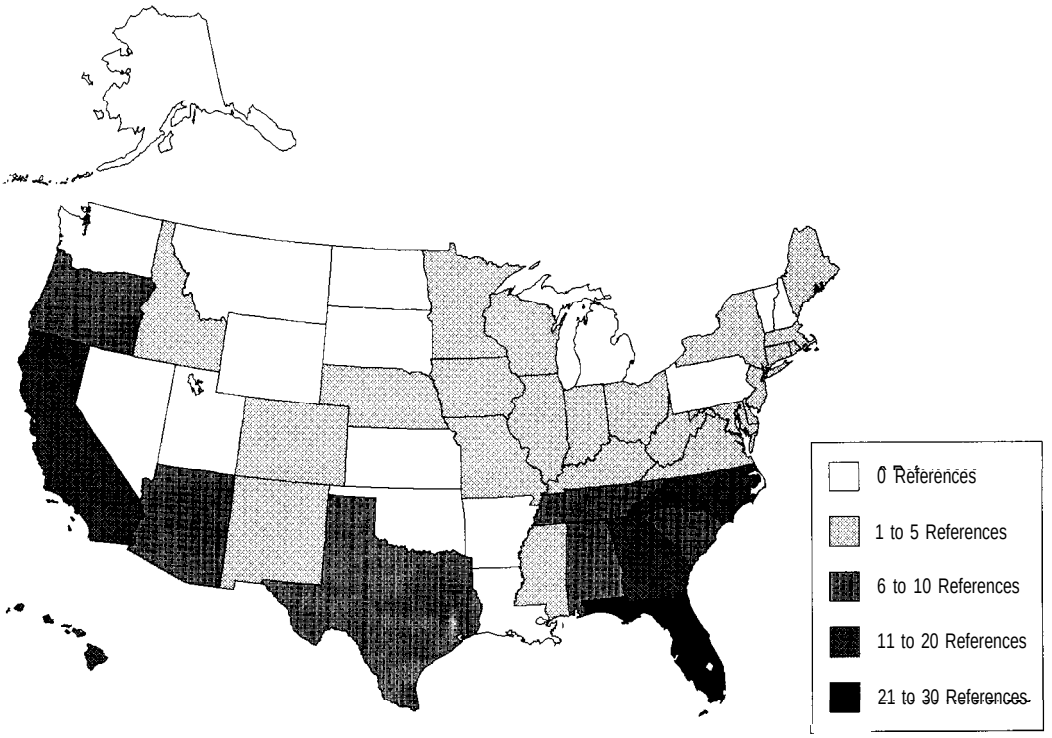

Fig. 1. Number of references by state to the effects of fire on federally listed endangered, threatened, and category-one plant species.

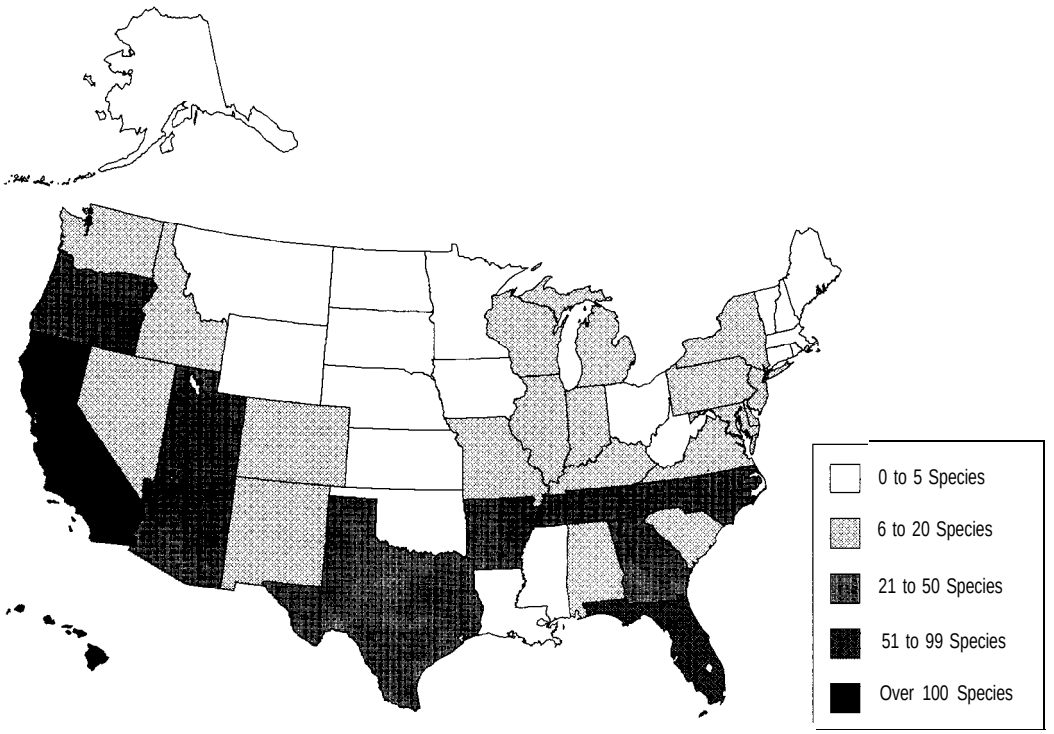

Fig. 2. Number of federally listed endangered, threatened, and category-one plant species per state as of September 1993.

Table 3. Scientific names, common names, federal statuses, references to species in this bibliography, and summaries of responses by these species to fire. Status codes: E = Endangered; T = Threatened; C 1 = Category-one candidate; C2 = Category-two candidate; 3C = Category-three species; 0 = not federally listed.

Scientific name	Common name	Status	Source[a]	Response
Abronia macrocarpa	Large-fruited sand verbena	E	USFWS[b] 1992e	Fire may maintain favorable habitat
Abutilon eremitopetalum		E	USFWS 1991f	Fire poses a significant threat
A. menziesii	Ko'ola'ula	E	USFWS 1986a	Threatened by fire
A. sandwicense		E	USFWS 1991a	Threatened by fire
Agalinis acuta	Sandplain gerardia	E	Jordon 1994	Fire may increase number of individuals
			USFWS 1989c	May require disturbance such as fue
Amorpha crenulata (S = A. herbacea var. crenulata)	Crenulate leadplant	E	USFWS 1988b	Fire may maintain suitable habitat
			Gordon 1992b	Occurs in a fire adapted community
Amsinckia grandiflora	Large-flowered fiddleneck	E	Pavlik 1991	Fire maintains favorable habitat
			Pavlik 1993	Mortality rates decreased and survivorship increased following a fall bum
			Pavlovic 1994	
			USFWS 1985e	Controlled bums may have adverse or positive effect on this species
Arctostaphylos glandulosa		0	Kelly and Parker 1990	Resprouts following fire
A. hookeri ssp. *montana*	Tamalpais manzanita	c2	Parker 1987	Decrease in germination following winter bum
A. myrtifolia	lone manzanita	Cl	Gankin and Major 1964	Fiie kills adults, but may encourage seedling establishment
			Wood and Parker 1988	Must regenerate from seed following fire, but fue may increase germination rates

Table 3. ***Continued.***

Scientific name	Common name	status	Source	Response
Argyroxiphium kauense	Ka'u silversword	E	USFWS 1993e	Threatened by fire
Aristida stricta		0	Hardin and White 1992	Occurs in a fire adapted community
A. tuberculosa		0	Bowles et al. 1990	Fire or disturbance that mimics fire results in increased survival rate
			Pavlovic 1994	
Asimina tetramera	Four-petal pawpaw	E	Johnson 1989	May require fire to maintain suitable habitat
			Johnson 1994	Fire maintains suitable habitat
			Kral 1993	May require fire to maintain open habitat
Astragalus atratus var. inseptus	Milkvetch	c 2	Popovich 1994	Stout caudex and deep taproot may allow plants to survive fire
A. oniciformis	Milkvetch	0	Popovich 1994	Low mortality due to fire because of deep taproot and stout caudex
A. schmolliae	Schmoll milkvetch	c 2	Collier 1994	
Astrophytum asterias	Star cactus	E	USFWS 1993h	Fire suppression may be detrimental
Baptisia arachnifera	Hairy rattleweed	E	Kral 1983	Observed in recently burned habitat
			USFWS 1984d	Large perennial rootstock suggests plants may tolerate fire; tire may also reduce competition and promote seedling establishment
Betula uber	Virginia roundleaf birch	E	Kral 1983	Not damaged by a prescribed bum
Bidens cuneata (S = B. molokaiensis)	Cuneate bidens	E	USFWS 1984c	Threatened by fire
B. wiebkei	Ko'oko'olau	E	USFWS 1992c	Threatened by fire
Bonamia grandiflora	Florida bonamia	T	Gordon 1992a	Occurs in fire adapted community
			Hartnett and Richardson 1989	Stem density and seed production increased following tire
			Kral 1983	May require fire to maintain open habitat
			USFWS 1990e	May require fire to maintain long-term viability of habitat
Brickellia mosieri (S = B. eupatorioides var. floridana)		c 2	Gordon 1992b	Occurs in fire adapted community
Brighamia insignis		E	USFWS 1994c	Threatened by fire
Buxus vahlii	Vahl's boxwood	E	USFWS 1985f	Threatened by fire
Calamintha ashei		c 2	Johnson 1994	Killed by fire but recovers from seed
			Menges and McAnlis 1994	
Calamovilfa curtissii	Sand grass	c 2	Johnson 1994	
			Johnson 1993a	Fire may maintain favorable habitat
			Johnson and Blyth 1988	Fire may increase flowering
Calochortus umpquaensis	Umpqua mariposa lily	C1	Kagan 1992	Fire suppression may be detrimental
Castanea pumila var. *ozarkensis*	Ozark Chinquapin	c 2	Campbell et al. 1991	Occurs in community that experiences frequent tires
Caulanthus amplexicaulis var. *barbarae*	Santa Barbara jewelflower	C1	Danielson 1993	May be fire tolerant
C. californicus (S = *Stanfordia californica)*	California jewelflower	E	USFWS 1991d	Threatened by alteration of its natural fire regime
Ceanothus ferrisiae	Coyote ceanothus	E	Freas 1993	No differences in germination between heat treated, scarified, and control seeds
C. ophiochilus	Vail Lake ceanothus	c 2	S haffer 1993	Seeds require heat or scarification for germination; adapted to summer and fall fires

Table 3. *Continued.*

Scientific name	Common name	Status	Source	Response
Ceanothus roderickii	Pine Hill ceanothus	C1	Boyd 1987	Fall controlled burn increased seedling establishment
Centaurium sebaeoides	'Awiwi	E	USFWS 1991a	Threatened by fire
Ceratiola ericoides		0	Gordon 1992a	Occurs in fire adapted community
			Johnson 1994	Occurs in fire adapted community
			Menges and McAnlis 1994	
Chamaecrista lineata var. *keyensis*	Florida Keys senna	3C	Carlson et al. 1993	Occurs in fire adapted community
Chamaesyce celastroides var. *kaenana*	'Akoko	E	USFWS 1991a	Threatened by fire
C. deltoidea ssp. *deltoidea*	Deltoid spurge	E	Gordon 1992b	Occurs in fire adapted community
C. kuwaleana	'Akoko	E	USFWS 1991a	Threatened by fire
C. porteriana var. *scoparia*		0	Gorden 1992b	Occurs in fire adapted community
Chionanthus pygmaeus	Pygmy fringe-tree	E	Kral 1983	Occurs in fire adapted community
			USFWS 1990e	May require fire to maintain long-term viability of habitat
Chorizanthe pungens var. *pungens*	Monterey spineflower	T	USFWS 1994d	May require frequent fire or disturbance to maintain suitable habitat
Chrysopsis floridana	Florida golden aster	E	USFWS 1988c	May benefit from low intensity disturbance
Chrysothamnus molestus		C2	Cobb 1994	Spring and fall burns increased shoot growth; spring burns increased mortality
			Gori 1994	Spring burn increased seedling mortality; fall burns increased survivorship
C. viscidiflorus		0	Melgoza et al. 1990	Competing species increase following fire
Clematis socialis	Alabama leatherflower	E	Kral 1983	Not damaged by a prescribed burn
			USFWS 1989a	May require fire to maintain suitable habitat
			USFWS 1991k	May require disturbance such as fire to maintain suitable habitat
Clitoria fragrans	Pigeons wings	T	Hardin and White 1992	Occurs in fire adapted community
			Kral 1983	May require fire to maintain open habitat
Colubrina oppositifolia	Kauila	E	USFWS 1994b	
Conradina canescens (S = *C. brevifolia*)	Short-leaved rosemary	E	Johnson 1994	
			Kral 1983	May require fire to maintain open habitat
			USFWS 1993i	Threatened by fire
C. etonia	Etonia rosemary	E	Johnson 1994	Killed by fire but recovers from seed
C. glabra	Apalachicola rosemary	E	Gordon 1991	Fire may maintain suitable habitat
			Johnson 1994	Killed by fire but recovers from seed
			Kral 1983	Fire may increase reproduction
			USFWS 1993i	May require fire to maintain suitable habitat
Corema conradii		0	Dunwiddie 1990	Experienced high mortality and abundant seedling establishment following a prescribed burn
Corypantha scheeri var. *robustispina*		0	Robinett 1992	Plants sprouted and bloomed or flowered following a June burn
			USFWS 1993f	Occurs in fire adapted community but may experience high mortality following fire

Table 3. Continued.

Scientific name	Common name	Status	Source	Response
Corypantha sneedii var. leei (S = *Escobaria sneedii var. leei*)	Lee pincushion cactus	E	USFWS 1986d	Effects of fire not yet determined
Cupressus abramsiana	Santa Cruz cypress	E	USFWS 1987a	Natural fire frequency estimated at 50-100 years
Cyanea superba		E	USFWS 1991b	Threatened by stochastic extinction due to fire
Dalea foliosa	Leafy prairie clover	E	Campbell 1994	Results from controlled burn not available
			USFWS 1991c	Fire used to maintain habitat
Deeringothamnus pulchellus	Beautiful pawpaw	E	Hardin and White 1992	Occurs in fire adapted community
			Kral1983	May benefit from prescribed bums
D. rugelii	Rugel's pawpaw	E	Hardin and White 1992	Occurs in fire adapted community
			Kral 1983	Fiie stimulates rigorous flowering from storage roots and may reduce competition
Delphinium variegatum ssp. *kinkiense*	San Clemente Island larkspur	E	USFWS 1984g	May be adapted to dormant season fires
D. variegatum ssp. *thornei*	Thome's royal larkspur	C1	USFWS 1984g	Other species in this genus respond well to tire
Dicerandra christmanii	Garrett's mint	E	Johnson 1994	Killed by fire but recovers from seed
D. cornutissima	Longspurred mint	E	Johnson 1994	Killed by fire but recovers from seed
			Kral 1983	May require fire to maintain open habitat
			USFWS 1987b	May benefit from occasional fires
D. frutescens	Scrub mint	E	Johnson 1994	Killed by fire but recovers from seed
			Kral 1983	May require fire or other disturbance to maintain open habitat
			Menges 1992	Spring fue killed individual plants. Seedling recruitment followed fue. Fire probably beneficial
			Pavlovic 1994	
			USFWS 1987b	May benefit from occasional fires
D. immaculata	Lakela's mint	E	Johnson 1994	Killed by fire but recovers from seed
			Kral 1983	May require fire or other disturbance to maintain open habitat
			USFWS 1987b	May benefit from occasional fires
Diellia falcata		E	USFWS 1991a	Threatened by fire
Dionaea (genus)		0	Folkerts 1977	Species in this genus are generally recognized as tire dependent
Dubautia herbstobatae	Na'ena'e	E	USFWS 1991a	Threatened by fire
Dudleya traskiae	Santa Barbara Island liveforever	E	USFWS 1985g	Fire may be used to reduce spread of competing exotic plants
Echinacea laevigata	Smooth coneflower	E	Kral 1983	Probably tolerates fire by resprouting from corm
E. tennesseensis	Tennessee purple coneflower	E	Campbell 1994	Results following controlled bums are not yet available
			Kral 1983	Probably tolerates tire by resprouting from strong rhizomes
			USFWS 1982	Deep taproots may allow plants to survive low temperature bums of short duration. Fire may also reduce competing species from strong rhizomes

Table 3. *Continued.*

Scientific name	Common name	Status	Source	Response
Echinocereus pectinatus		0	Thomas 1988	Increased mortailty following fire. Flower production increased or remained neutral
E. reichenbachii	Black lace cactus	E	Bunting 1980	Significant mortality following spring bums
E. triglochidiatus	Hedgehog cactus	0	Thomas 199 1	General reference, responses of succulents to fire
Eremalche kemensis (S = E. parryi ssp. *kemensis)*	Kern mallow	E	USFWS 1991d	Threatened by alteration of natural fire regime
Eriastrum hooveri	Hoover's woolly star	T	USFWS 1991d	Threatened by alteration of natural fire regime
Eriogonum longifolium var. gnaphalifolium	Scrub buckwheat	T	USFWS 1993	
Eryngium aristulatum var. parishii	San Diego button celery	E	USFWS 1993a	May be negatively affected by fue
E. cuneifolium	Snakeroot	E	Menges and McAnlis 1994	
			USFWS 1990e	Occurs in habitat that may require fire for long-term viability
Escobaria sneedii var. sneedii (S = Coryphantha sneedii var. sneedii)	Sneed pincushion cactus	E	USFWS 1986d	Effects of fire not yet determined
Euphorbia deltoidea ssp. *deltoidea (S = Chamaesyce deltoidea var. deltoidea)*		0	USFWS 1988d	May require fire to maintain open habitat
E. garberi		E	USFWS 1988b	
E. telephioides	Telephus spurge	T	USFWS 1993b	Requires periodic winter season fires to maintain suitable habitat
Exocarpos luteolus	Leafy heau or leafy exocarpos	E	USFWS 1994c	Threatened by fire
Fremontodendron decumbens	Pine Hill flannelbush	Cl	Boyd 1987	Successful regeneration by resprouting and seedling recruitment followed controlled fall bum
			Boyd and Serafini 1992	Impermeable seed coats break following tire. Fire suppression detrimental to recruitment. Root sprouting occurs following fire
Fritillaria ojaiensis	Ojai fritillary	c2	Danielson 1993	May be fire tolerant
Galactia smallii	Small's milkpea	E	Gordon 1992b	Occurs in fue adapted community
			USFWS 1988b	Fire may maintain suitable habitat
Gouania hillebrandii		E	USFWS 1990f	May be vulnerable to extirpation if affected by brush fire
G. meyenii		E	USFWS 1991a	Threatened by fue
Hackelia gracilenta	Mesa Verde stickleaf	c2	Collier 1994	Effects of prescribed bum forthcoming
Haplostachys haplostachya		E	USFWS 1979	Individual plants killed. Fire may promote invasion by exotic plant species
Harperocallis flava	Harper's beauty	E	Godfrey 1976	Occurs in fire adapted community
			Hardin and White 1992	Occurs in fire adapted community
			USFWS 1983a	Occurs in fire adapted community
Hedeoma diffusa		0	Phillips et al. 1992	Cool bums may enhance recruitment and survivorship

Table 3. *Continued.*

Scientific name	Common name	Status	Source	Response
Hedeoma graveolens (S = Stachydeoma graveolens)	Mock pennyroyal	0	Hardin and White 1992	Occurs in fire adapted community
Hedyotis st.-johnii	Na Pali beach hedyotis	E	USFWS 199 1 h	Threatened by fue
Helianthemum dumosum	Bushy rush-rose	c 2	Dunwiddie 1990	Cover and flowering increased following spring bum
Helianthus eggertii	Eggert's sunflower	C1	Kral 1983	Occurs in habitat historically maintained by fue
H. schweinitzii	Schweinitz's sunflower	E	USFWS 1991j	Fire suppression may be detrimental
			Barden 1994a	Spring bum increased number of stems and number of flowers per plant. Fall bum reduced plant height and flowering
			Barden 1994b	Controlled spring bums caused increase in plant height and flowering. Fall bums resulted in minor height increase
Hibiscadelphus distans	Kauai hau kuahiwi	E	USFWS 1986b	Threatened by fire; single population close to a fire pit
Hudsonia montana	Mountain golden heather	T	USFWS 1983b	Fire may decrease competing plant species
H. tomentosa		0	Bowles et al. 1990	Fire or disturbance that mimics fire results in increased survival rates
			Pavlovic 1994	
Hymenoxys acaulis var. glabra (S = Tetraneuris herbacea)	Lakeside daisy	T	USFWS 1990g	Fire can kill emerging inflorescence buds and damage leaves. Fire may help maintain suitable habitat
Hypericum cumulicola	Highlands scrub hypericum	E	USFWS 1990e	Occurs in habitat that may require fire for long-term viability
Iliamna corei (S = Iliamna rivularis var. rivularis)	Peter's Mountain mallow	E	Jacobs 1993	Germination occurs if seed coats are broken by fire
			USFWS 1990d	Light fues may stimulate germination and maintain suitable habitat
Isodendrion hosakae	Aupaka	E	USFWS 1991e	Threatened by dry season range fires
I. pyrifolium	Wahine noho kula	E	USFWS 1994b	Threatened by fire
Jatropha costaricensis	Costa Rican jatropha	E	USFWS 1984b	Threatened by fire
Kalmia cuneata	White-whicky	C1	Hardin and White 1992	Occurs in fire adapted community
Kokia drynarioides	Koki'o or Hawaii tree cotton	E	USFWS 1984a	Threatened by fire
Lechea cernua		3 c	Gordon 1992a	Occurs in fire adapted community
L. deckertii		0	Gordon 1992a	Occurs in tire adapted community
Lembertia congdonii	San Joaquin woolly-threads	E	USFWS 1991d	Threatened by alteration of natural fire regime
Lespedeza leptostachya	Prairie bush clover	E	Smith 1994	Results not yet available
			USFWS 1988a	Prescribed bums may control encroaching shrubs and trees, but the effects of tire not fully known
Lesquerella filiformis	Missouri bladderpod	E	Thomas 1994	Results of 4-year study inconclusive
L. pallida	White bladderpod	E	USFWS 1992g	Fire may maintain suitable habitat
L. stonensis	Stone River bladderpod	C1	Kral 1983	May be disturbance dependent
Liatris helleri	Heller's blazingstar	T	Kral 1983	May benefit from prescribed bums
			USFWS 1989b	Species in this genus are generally recognized as fire dependent
L. ohlingerae	Scrub blazingstar	E	Kral 1983	May require fire to suppress competing species

Table 3. *Continued.*

Scientific name	Common name	Status	Source	Resnonse
			USFWS 1990e	Occurs in a habitat that may require fire for long-term viability
Liatris provincialis	Godfrey's blazingstar	c 2	Hermann 1988	Preliminary results inconclusive, further results forthcoming
			Johnson 1993b	Fiie may stimulate flowering. Fire suppression may be detrimental
			Johnson 1994	Fiie may stimulate reproduction
Limnanthesjloccosa ssp. *grandijlora*	Large-flowered meadowfoam	c 2	Borgias 1993	Increased in numbers 2 years post-fire
Lipochaeta fauriei		E	USFWS 1994c	Threatened by fire
L. lobata var. leptophylla	Nehe	E	USFWS 1991a	Threatened by fue
L. tenuifolia	Nehe	E	USFWS 1991a	Threatened by fue
L. venosa		E	USFWS 1979	Individual plants killed. Fiie may promote invasion of exotic plant species
Lobelia niihauensis		E	USFWS 1991a	Threatened by fire
Lomatium bradshawii	Bradshaw's desert parsley	E	USFWS 1993c	May require fire to maintain suitable habitat
L. cookii	Cook's lomatium	C1	Borgias 1993	Monitored following prescribed bum, results inconclusive
Lupinus aridorum (S = *Lupinus westianus var. aridorum)*	Scrub lupine	E	USFWS 1990e	Occurs in habitat that may require tire for long-term viability
Lysimachia asperulaefolia	Rough leaved loosestrife	E	Hardin and White 1992	Occurs in fire adapted community
			Kral 1983	May require fire to maintain open habitat
			Smith 1992	Requires fire; fire may stimulate flowering
			Sutter 1994	Five year study measured response to prescribed burning
			USFWS 1994a	May require periodic fire to maintain suitable habitat
Macbridea alba	White birds-in-a-nest	T	USFWS 1993b	Requires periodic winter fires to maintain suitable habitat
Manihot walkerae	Walker's manioc	E	USFWS 1993k	May require tire to maintain suitable habitat and promote seed germination
Marshallia mohrii	Mohr's Barbara's buttons	T	USFWS 1991k	May require fire or other disturbance to maintain suitable habitat
Matelea alabamensis	Angelpod	c 2	Gordon 1991	Fire may maintain suitable habitat
Melicope knudsenii	Alani	E	USFWS 1994c	Threatened by fire
M. pallida	Alani	E	USFWS 1994c	Threatened by fire
Muhlenbergia torreyana		0	Hardin and White 1992	Occurs in fire adapted community
Munroidendron racemosum		E	USFWS 1994c	Threatened by fire
Neraudia angulata		E	USFWS 1991a	Threatened by fue
Nothocestrum breviflorum	'Aiea	E	USFWS 1994b	Threatened by fire
N. peltatum	'Aiea	E	USFWS 1994c	Threatened by fire
Nototrichium humile	Kulu'i	E	USFWS 1991a	Threatened by fire
Ochrasia kilaueaensis	Holei	E	USFWS 1994b	Threatened by fire
Opuntia treleasei (S = *0. basilaris var. treleasei)*	Bakersfield cactus	E	USFWS 199ld	Threatened by alteration of its natural fire regime
Orcuttia californica	California orcutt grass	E	USFWS 1993e	May be negatively affected by fire
Oxypolis canbyi	Canby's dropwort	E	Kral 1983	May require fire to maintain open habitat
			Soblo 1994	Occurs in fire adapted community. Number of individuals increased

Table 3. Continued.

Scientific name	Common name	status	Source	Response
				following a hot wildfire. Same population has been declining since
			USFWS 1990a	Fiie may benefit by maintaining suitable habitat
Panicum abscissum	Cutthroat grass	c2	Gordon 1992a	Occurs in tire adapted community
			Myers and Boettcher 1987	Flowering increased following spring bum. Fiie maintains suitable habitat
P. fauriei var. carteri	Carter's panicgrass	E	USFWS 1983d	Single fire could destroy only known population
Paronychia chartacea	Papery whitlow-wort	T	Gordon 1992a	Occurs in fue adapted community
			Johnsonand Abrahamson 1990	May require fire to maintain suitable habitat
			Krall983	May require fire to maintain open habitat
			USFWS 1990e	Occurs in habitat that may require fire for long-term viability
Pediocactus paradinei	Kaibab pincushion cactus	Cl	Warren et al. 1992	Can survive low intensity fires, but high intensity bums may result in high mortality
Penstemon haydenii	Penland beardtongue	E	USFWS 1992b	Fire suppression has negatively affected habitat suitability
P. lemhiensis		0	Moseley et al. 1990	May be threatened by succession due to tire suppression
Peucedanum sandwicense	Makou	E	USFWS 1994c	Threatened by fire
Phlox idahonis	Clearwater phlox	Cl	Moseley and Crawford 1993	Decreased in density at one site, probably as a result of post-fire succession
P. nivalis ssp. *texensis*	Texas trailing phlox	E	USFWS 1991i	Fire is required to maintain suitable habitat
Phyllanthus pentaphyllus ssp. *pentaphyllus* var. *floridanus*		c2	Carlson et al. 1993	Occurs in fire adapted community
Pinguicula ionantha	Godfrey's butterwort	T	Folkerts 1977	Species in this genus are generally recognized as tire dependent
			USFWS 1993b	Requires periodic winter fires to maintain suitable habitat
			USFWS 1993i	May require frequent, low intensity fues to maintain suitable habitat
Platanthera hoobri		0	Bowles et al. 1990	Fire or disturbance that mimics fire results in increased survival rates
P. integra		0	Kral 1983	Fire dependent throughout range
			MacRoberts and MacRoberts 1990	Plants increased flowering and bloomed earlier following winter bums
P. integrilabia		c2	Kral 1983	Prescribed bums had no lasting effect
P. leucophaea	Eastern prairie fringed orchid	T	Currier 1984	Spring burning may induce flowering
			Jacobson et al. 1991	Fire may maintain suitable habitat
			Kral 1983	
			Pavlovic 1994	
P. praeclara	Western prairie fringed orchid	T	Smith 1994	Results not yet available
Pogogyne nudiuscula	Otay mesa mint	E	USFWS 1993e	Fire may damage seeds
Polygala smallii	Tiny polygala	E	Gordon 1992b	Occurs in fue adapted community
			USFWS 1988b	Fire may maintain suitable habitat

Table 3. Continued.

Scientific name	Common name	Status	Source	Response
Polygonella articulata		0	Bowles et al. 1990	Fire or disturbance that mimics fire results in increased survival rates
			Pavlovic 1994	
P. basiramia	Wireweed	E	Hawkes and Menges 1994	Fire maintains suitable habitat
P. macrophylla	Large-leaved jointweed	c2	Johnson 1993c	Observed to resprout and increase flowering following fire
Portulaca sclerocarpa	*Po'e*	E	USFWS 1994b	Threatened by fire
Pritchardia munroi	Loulu	E	USFWS 1992c	Threatened by fire
Prunus geniculata	Scrub plum	E	Kral 1983	Responds vigorously to fire and has a history of fire disturbance
			USFWS 1990e	Occurs in habitat that may require fire for long-term viability
Pteralyxia kauaiensis		E	USFWS 1994c	Threatened by fire
Ptilimnum nodosum	Harperella	E	Kral 1983	
			USFWS 1990b	Effects of fire and fue suppression unknown
Pyxidanthera barbulata	Well's pixie-moss	C1	Hardin and White 1992	Occurs in fire adapted community
Rhododendron chupmanii	Chapman rhododendron	E	Hardin and White 1992	Occurs in fire adapted community
			Kral 1983	Occurs in fire adapted community and resprouts following fire
			USFWS 1983c	Occurs in fire adapted community and resprouts following fire
Rhus michauxii	Michaux's sumac	E	Hardin and White 1992	Occurs in fue adapted community
			Krall983	
			USFWS 1993j	May require fire to maintain suitable habitat
			USFWS 19931	May require frequent fires to maintain suitable habitat
Rhynchospora knieskemii	Knieskem's beaked-rush	T	USFWS 1992f	May require fire to maintain suitable habitat
Ribes echinellum	Miccosukee gooseberry	T	USFWS 1985d	Fire could threaten with extinction
Sanicula mariversa		E	USFWS 1991a	Threatened by fue
Sarracenia alata		0	Barker and Williamson 1988	Winter fue increased foliage and seedling recruitment
S. flava		0	Folkerts 1977	Species in this genus are generally recognized as fire dependent
			Schnell 1982	Increased growth and seedling recruitment following mechanical disturbance
S. oreophila	Green pitcher plant	E	Benjamin 1992	Prescribed spring bum increased leaf production
			Bertram and Myers 1988	Fire maintains suitable habitat
			Folkerts 1977	Species in this genus are generally recognized as fire dependent
			Kral 1983	May require fire to maintain suitable habitat
			Troup and McDaniel 1980	Flowering and population size increased following fire
			USFWS 199 1 k	May require tire or other disturbance to maintain suitable habitat

Table 3. *Continued.*

Scientific name	Common name	status	Source	Response
Sarracenia psittacina		0	Barker and Williamson 1988	Winter fire increased total cover
S. purpurea		0	Folkerts 1977	Species in this genus are generally recognized as fire dependent
			Kral 1983	
			Schnell 1982	Increased growth and seedling recruitment following mechanical disturbance
S. purpurea ssp. *venosa*		0	Folkerts 1977	Species in this genus are generally recognized as tire dependent
			Schnell 1982	Increased growth and seedling recruitment following mechanical disturbance
S. rubra ssp. *alabamensis*	Alabama canebrake pitcher plant	E	Folkerts 1977	Species in this genus are generally recognized as fire dependent
			Kral1983	May require fire to maintain open habitat
			Schnell 1982	Increased growth and seedling recruitment following mechanical disturbance
			USFWS 1992a	Fire suppression may threaten existing populations
S. rubra ssp. *jonesii*	Mountain sweet pitcher plant	E	Folkerts 1977	Species in this genus are generally recognized as fue dependent
			Kral1983	
			Schnelll982	Increased growth and seedling recruitment following mechanical disturbance
			USFWS 199Oc	Fiie important for habitat maintenance
Schiedea adamantis	Diamond Head schiedea	E	USFWS 1984c	Threatened by fire
S. apokremnos	Ma'oli'oli	E	USFWS 1991h	Threatened by tire
S. kaalae		E	USFWS 1991a	Threatened by fire
S. lydgatei		E	USFWS 1992c	Fire promotes invasion of exotic plant species that may out-compete
Schwalbea americana	American chaffseed	E	Campbell et al. 1991	Occurs in a community that experiences frequent tire
			Kirkman and Drew 1993	Flowering occurs following fire, regardless of season
			Kral 1983	May benefit from prescribed bums
			USFWS 1992d	May require frequent, low intensity fires to maintain suitable habitat
Scutellaria floridana	Florida skullcap	T	USFWS 1993b	Requires periodic winter fires to maintain suitable habitat
S. montana	Large-flowered skullcap	E	USFWS 1986c	Fire may have adverse effect
Selaginella rupestris		0	Bowles et al. 1990	Fire or disturbance that mimics fire results in increased survival rate
			Kral 1983	
Sidalcea hickmanii ssp. *parishii*	Parish's sidalcea	C1	Danielson 1993	Thought to be fire tolerant
S. nelsoniana	Nelson's checkermallow	E	USFWS 1993g	May require fire to maintain suitable habitat
Silene alexandri		E	USFWS 1992c	Fire promotes invasion of exotic plant species that may out-compete
S. hawaiiensis		E	USFWS 1994b	May be threatened by fire
S. lanceolata		E	USFWS 1992c	Fire promotes invasion of exotic plant species that may out-compete
S. regia	Royal catchfly	3c	Menges 1988	Controlled bums enhanced plant growth rate
S. spaldingii	Spalding's catchfly or Spalding's silene	c2	Lesica 1992	Spring bum increased recruitment more than fall bum

Table 3. Continued.

Scientific name	Common name	Status	Source	Response
Sisyrinchium dichotomum	White irisette	E	USFWS 1991g	Fire or other disturbance may be required to maintain suitable habitat
Solanum sandwicense		E	USFWS 1994c	Threatened by tire
Solidago pulchra	Carolina goldenrod	C1	Hardin and White 1992	Occurs in fire adapted community
S. shortii	Short's goldenrod	E	USFWS 1988d	Historic range may be related to open habitat created by bison and by fires
Spiranthes delitescens	Madrean ladies'-tresses or Canelo Hills ladies'-tresses orchid	C1	Fishbein and Gori 1992	Associated species height decreased following experimental bums. No new recruits observed
			McClaren and Sundt 1992	Results inconclusive following experiments with spring bums and grazing. Many species in this genus respond well to tire
S. diluvialis	Ute ladies'-tresses	T	Arft 1994	Monitoring for 2 years following controlled bums indicates that fire may increase flowering
S. parksii	Navasota ladies'-tresses	E	USFWS 1984e	Fiie or other disturbance may be required to maintain suitable habitat
Stachydeoma graveolens		0	Hardin and White 1992	Occurs in fire adapted community
Stenogyne angustifolia var. angustifolia		E	USFWS 1979	Individual plants killed. Fire may promote invasion by exotic plant species
Stephanomeria malheurensis	Malheur wire lettuce	E	USFWS 19911	Fire promotes invasion of exotic plant species that may out-compete
Talinum rugospermum	Rough-seeded fameflower	C2	Bowles et al. 1990	Fire or disturbance that mimics fire results in increased survival rate
			Pavlovic 1994	
Tetramolopium arenarium		E	USFWS 1994b	Threatened by fire
T. filiforme		E	USFWS 1991a	Threatened by fire
T. remyi		E	USFWS 1991f	Threatened by tire
T. rockii		T	USFWS 1992c	Fire promotes invasion of exotic plant species that may out-compete
Thalictrum cooleyi	Cooley's meadowrue	E	Hardin and White 1992	Occurs in fire adapted community
			Kral 1983	May be dependent on fire to maintain open habitat
			Rome 1987	Fire creates favorable habitat. Winter or early spring may be best time to bum
			USFWS 1993a	May require fire to maintain suitable habitat
			Wilcyenski 1993	Fire frequency of 0 to 2 years had no effect on population size, plant size, or sex ratio
Thermopsis macrophylla var. agnina (S = Thermospsis macrophylla var. macrophylla)		0	Borchert 1989	Controlled bums monitored for 9 years demonstrated successful resprouting, seedling recruitment, and increased height of recruits
Tofieldia glutinosa ssp. *absona*		*c 2*	Jacobson et al. 1991	Fire may maintain suitable habitat
Torreya californica	California torreya	0	Esser 1993	Smoke may suppress parasitic fungus
T. taxifolia	Florida torreya	E	Schwartz and Herman 1991	Fire suppression contributed to decline
			Esser 1993	Smoke may suppress parasitic fungus
			Kral 1983	May be killed by tire
Tragia saxicola		*c 2*	Carlson et al. 1993	Occurs in fire adapted community

Table 3. Continued.

Scientific name	Common name	Status	Source	Response
Trifolium reflexum		0	Campbell et al.	Fire suppression may be detrimental
T. stoloniferum	Running buffalo clover	E	Campbell et al. 1988 Pavlovic 1994	Fire suppression may be detrimental
Urera kaalae	Opuhe	E	USFWS 1991a	Threatened by fire
Verbesina heterophylla		C1	Hardin and White 1992	Occurs in fiie adapted community
Vicia menziessi	Hawaiian vetch	E	USFWS 1984h	Fires have reduced suitable habitat
Warea carteri	Carter's mustard	E	Kral 1983	May require fire to reduce interspecific competition
			USFWS 1990e	Occurs in habitat that may require fire for long-term viability
Wyethia reticulata		0	Kral 1983 Boyd 1987	Fall controlled bum increased flowering
Zanthoxylum hawaiiense	A'e	E	USFWS 1994b	Threatened by fire
Ziziphus celata	Florida ziziphus	E	USFWS 1990e	Occurs in habitat that may require fire for long-term viability

[a] See the annotated entries.
[b] U.S. Fish and Wildlife Service.

A list of species addressed in each reference is provided at the end of each reference summary. The codes used to represent the federal listing conform to the Endangered Species Act of 1973 definitions previously given.

Also at the end of many summaries, we list the species state distributions as in U.S. Fish and Wildlife Service (1993c,1993d) publications.

The nomenclature follows Kartesz (1994), who also provides a complete list of synonyms. When plant names used by Kartesz did not coincide with the names in the cited reference or in U.S. Fish and Wildlife Service (1993b,1993c) documents, we provided Kartesz' name in parentheses.

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[3] An asterisk denotes unpublished material.

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U.S. Fish and Wildlife Service. 1991. Determination of endangered status for 26 plants from Waianae Mountains, island of Oahu, Hawaii. Federal Register 56(209):55770–55786.

U.S. Fish and Wildlife Service. 1992a. Determination of endangered status for 16 plants from the island of Molokai, Hawaii. Federal Register 57(196):46325–46344.

U.S. Fish and Wildlife Service. 1992b. Endangered status for ***Schwalbia americana*** (American chaffseed). Federal Register 57(189):44703–44708.

*U.S. Fish and Wildlife Service 1993a. Walker's manioc (***Manihot walkerae***) recovery plan. Albuquerque, N.Mex. Unpublished.

U.S. Fish and Wildlife Service. 1993b. Endangered and threatened status for five Florida plants. Federal Register 58(13 1):37432–37443.

U.S. Fish and Wildlife Service. 1993c. Endangered and threatened wildlife and plants. 50 CFR 17.11 & 17.12. U.S. Government Printing Office, Washington, D.C. 40 pp.

U.S. Fish and Wildlife Service 1993d. Endangered and threatened wildlife and plants: review of plant taxa for listing as endangered or threatened species. Federal Register 58(188): 51144-51190.

U.S. Fish and Wildlife Service. 1994a. Determination of endangered or threatened status for 24 plants from the island of Kauai, Hawaii. Federal Register 59(38):9304–9328.

U.S. Fish and Wildlife Service. 1994b. Determination of endangered or threatened status for 2 1 plants from the island of Hawaii, state of Hawaii. Federal Register 59(43): 10305-10325.

Annotated Bibliography on the Effects of Fire on Threatened and Endangered Plants[4]

1. ARFT, A. 1994. Final report on *Spiranthes diluvialis* to Colorado Natural Areas Program. Unpublished.

   Demographic plots were established at three locations in Boulder County, Colorado, to collect data on the life history of *Spiranthes diluvialis. The* author evaluated management techniques and environmental variables that may be necessary for the persistence of *S. diluvialis*. Thirty-four experimental and control plots were monitored between 1992 and 1993. All plots were monitored to determine the effects of mowing, grazing, and burning on *S. diluvialis*. Bum treatments consisted of an early bum to simulate fires in summer and a late bum to simulate fires in winter. By June of 1993 control plots and late bum plots had already produced significantly more inflorescence buds than the other treatment plots. The grazed, early bum, and late bum plots produced flowers before the other treatment plots. Orchids in the late bum plots suffered significantly high mortality in July-August. Long-term monitoring and observation will be continued by the personnel of Boulder County Open Space.

Spiranthes diluvialis (T)

2. BARDEN, L. S. 1994a. Recovery of Schweinitz's sunflower *Helianthus schweinitzii,* a federally listed endangered species, after early- and mid-growing season controlled bums in piedmont North Carolina. Bulletin Ecological Society of America 75:9.

   Recently, controlled burning during the growing season to kill woody competitors of perennial herbaceous plants has received increased emphasis despite the immediate damage to endangered herbaceous species. A controlled bum in North Carolina in early April 1993 [burned] newly sprouted (2-5 cm) Schweinitz's sunflowers. In October 1993, average height was reduced 44% compared to October 1992, but the number of stems per plant increased 200%, with an average of 27 flower heads/plant. In contrast, a controlled bum in mid-growing season (August 1992) [burned] nearly mature plants (average height 72 cm) which resprouted but reached only 10 cm height by October, with none flowering. At the same site, one year later (October 1993), survival was less than 80%, survivors were only 40% as tall as pre-fire plants, there was no increase in the number of stems, and only 30% of plants produced flowers. Negative effects of mid-growing season bums may be temporary but should be considered by managers of endangered species. [AA].

Helianthus schweinitzii (E)

3. BARDEN, L. S. 1994b. Recovery of Schweinitz's sunflower *Helianthus schweinitzii,* a federally listed endangered species, after early- and mid-growing season controlled bums in piedmont North Carolina. Paper presented at American Institute of Biological Sciences (AIBS), Knoxville, Tenn., August 1994.

   Controlled burning during the growing season to kill woody competitors of perennial herbaceous plants has received increased emphasis despite the immediate damage to endangered herbaceous species. A controlled bum at the Gar Creek NCNC site in North Carolina in early April 1993 [burned] newly sprouted (2-5 cm) Schweinitz's sunflowers. In October 1993 average height was reduced 44% compared to October 1992 (145 cm vs. 83 cm), but the number of stems per plant increased 300% (1.8 vs. 7.6 stems per plant). However, by July 1994, average height per plant was 108 cm and by October 1994 average height was 162 cm, 12% taller than pre-fire height in October 1992. Average number of stems per plant in July 1994 was 5.6, 200% greater than pre-fire stem number in October 1992.

   A controlled bum in mid-growing season (August 1992) at the Mineral Springs NCNC site [burned] nearly mature plants (avg height July 1992 was 68 cm). These plants resprouted but reached only 10 cm height by October 1992, with none flowering. One year later (July 1993) survival was less than 805, survivors were only 40% as tall as pre-fire plants and there was no increase in the number of stems. However, by July 1994 average height of survivors was 73 cm, 7% taller than pre-fire numbers, replacing the 20% mortality observed in 1993. The number of stems per plant did not change throughout the 2-year period. Thus, managers should be aware of negative effects of mid-growing season bums but should also realize that these negative effects may be temporary. Measurements documenting the effects of mid-season fires

[4] AA = Abstract of the publication, PA = Partial Abstract of the publication, AS = Researcher's summary of the unpublished material, or PS = Researcher's partial summary of the unpublished material. The absence of a designation denotes our summary of a publication, unpublished material, or record.

on existing populations of endangered species must be repeated for at least two years before the long-term effects become discernible. [AS].

Helianthus schweinitzii (E)

4. BARKER, N. G., AND G. B. WILLIAMSON. 1988. Effects of winter fire on *Sarracenia data* and S. *psittacina*. American Journal of Botany 75: 138-143.

The effects of a prescribed winter bum on two species of pitcher plant, *Surrucenia alata* and S. *psittucina,* were investigated by comparing changes in variables measured before and after the fire in randomly selected plots in a Louisiana savanna. Burned plots showed an increase in foliage and unburned plots showed a decrease in foliage, as measured in the total numbers of leaves (>25 cm) for S. *alata* and in total cover for S. *psittucina.* For S. *alata,* the gain in foliage in the burned plots was less than the loss in foliage in the unburned plots, but for S. *psittucina the* gain in burned plots was greater than the loss in unburned plots. Seedling recruitment of S. *alata* after the fire was exponentially related to the number of floral scapes produced in the year before the fire and was greater in the burned plots than in the unburned plots. Numbers of floral scapes of both pitcher plant species decreased in the year after the fire, but the decrease occurred equally in burned and unburned plots. [AA].

Sarracenia alata (0), Sarracenia psittacina (0)

5. BENJAMIN, S. 1992. Data summary and analysis for *Sarracenia oreophila,* Eller Preserve (1990-I 992) and Mull Preserve (199 1– 1992). The Nature Conservancy, Southeast Regional Office, Chapel Hill, N.C. Unpublished.

Populations of *Sarracenia oreophila* were monitored at two sites in the Eller Preserve, North Carolina, for a response to a prescribed bum in April 1992. Leaf production of S. *oreophilu* increased, presumably in response to the prescribed bum. Hardwoods developed quickly from rootsprouts. Hardwood and *Rubus* spp. may compete with the pitcher plant population and should be monitored.

Surrucenia oreophila (E)

6. BERTRAM, K., AND R. MYERS. 1988. Element stewardship abstract for *Surrucenia oreophilu.* Southeast Region Fire Ecology Program. Tall Timbers Research Station, Tallahassee, Fla. Unpublished.

Fire plays a major role in the maintenance of extant populations of *Sarracenia oreophila* in seepage bogs and in mixed oak flatwoods in Alabama, Georgia, and Tennessee. Historically, fire maintained the populations in a sub-climax stage. Interspecific competition should be reduced and light intensity should be increased for effective management.

Sarracenia oreophila (E)

7. BORCHERT, M. 1989. Post fire demography of *Thermopsis macrophylla* H.A. var. *angina,* J. T. Howell (Fabaceae), a rare perennial herb in chaparral. American Midland Naturalist 122: 120– 132.

Demography of the rare perennial herb Santa Ynez thermopsis *(Thermopsis macrophylla var. angina)* was monitored at two sites for 9 yr after a controlled bum in the Santa Ynez Mountains near Santa Barbara, California. One of the burned sites was located in chaparral and the other in a fuelbreak, an area purposely cleared of chaparral to slow the advance of wildfire. Numerous individuals resprouted in the 1st yr after the fire and thousands of seedlings established from heat-stimulated germination of refractory seed. Vegetation before and after the fire was markedly different between the two sites. Despite this difference, however, seedling production was very similar on the two sites. Losses of recruits-seedlings that survived beyond the 1 st yr-also were similar. Nine yr after the fire the density of recruits was equivalent on both sites, Recruits were significantly taller in the fuelbreak than in the chaparral but the average number of stems/individual was not different.

Individuals that resprouted after the fire produced more than 10^6 seeds/900 m^2 from 1980-1987. However, only 3.9% of the seed was present in the soil 8 yr after the fire. Seed production by recruits, in contrast, was very low and appeared to be declining. Thus, this species relies heavily on seed production by resprouts to maintain a sizable soil-seed bank. In addition to seed production by resprouts, the survival of recruits during the interfire period is a critical life history stage in the population biology of this species. Recruits that survive both the interfire period and the next fire show marked increases in stem production, seed output, and survivorship. [AA].

Thermopsis macrophylla var. angina (0)

8. BORGIAS, D. D. 1993. Fire effects on the Rogue Valley mounded prairie on the Agate Desert, Jackson County, Oregon. The Nature Conservancy, Portland, Oreg. Unpublished.

Two species, *Lomatium cookii and* ***Limnanthes floccosa*** ssp. ***grandiflora*** were monitored before and after a prescribed bum and wildfire in the Agate Desert mounded prairie of southwestern Oregon. Because the sampling design included only three replicates per treatment for each species, a determination of statistically significant effects of the fires was difficult. *Lomatium cookii* did not have an obvious negative response to the burns. *Limnanthes jloccosa* ssp. ***grandiflora*** recovered during the second year after the fires, and its abundance at that site was greater than previously.

Lomatium cookii (Cl), ***Limnanthes floccosa*** ssp. ***grandiflora (C2)***

9. BOWLES, M. L., M. M. DEMAURO, N. PAVLOVIC, AND R. D. HIEBERT. 1990. Effects of anthropogenic disturbances on endangered and threatened plants at the Indiana Dunes National Lakeshore. Natural Areas Journal 10: 187-200.

Populations of 81 endangered and threatened plants in the Indiana Dunes National Lakeshore were investigated and quantified during 1984-88. More than half of the populations occurred in naturally or anthropogenically disturbed habitats. The authors discuss different types of disturbance that affect these species and the history of fire in relation to *Habenaria* ***hookeri,*** *Aristida tuberculosa, Polygonella* ***articulata,*** *Hudsonia tomentosa, Selaginella rupestris,* and *Talinum rugosperma.* Fire or anthropogenic disturbance that mimics fire increased the survival of these species. Protection from tire led to the decline of fire-tolerant species of savanna, prairie, fen, and white pine communities.

Talinum rugosperma (C2)

10. BOYD, B. 1987. The effects of controlled burning on three rare plants. T. Elias, editor. Conservation and Management of Rare and Endangered Plants: proceedings from a conference of the California Native Plant Society held in Sacramento, Calif., 5-8 November 1986.630 pp.

A small-scale controlled bum was conducted in October 1983 at the Pine Hill Ecological Reserve, California, to determine the effect of fire on ***Fremontodendron decumbens,*** *Ceanothus roderickii,* and *Wyethia reticulata.* The three species possess varying combinations of adaptations to fire including re-sprouting, fire-stimulated flowering, and root-sprouting. After the bum, *F. decumbens* regenerated by root-sprouting. The increase of *F. decumbens* seedlings was 73 times greater in burned than in unburned plots; C. *roderickii* experienced a 23.5-fold increase in establishment after the fire, and *W. reticulata* flowering increased 23.5-fold after the fire. Appropriately timed controlled burning is not a threat to *W. reticulata's* existence but is a necessary component of its reproduction.

Ceanothus roderickii (Cl), Fremontodendron decumbens (Cl), Wyethia reticulata (C 1)

11. BOYD, R. S., AND L. L. SERAFINI. 1992. Reproductive attrition of the rare chaparral shrub *Fremontodendron decumbens* Lloyd (Sterculiaceae). American Journal of Botany 79(11): 1264-1272.

[The authors] examined reproductive attrition in ***Fremontodendron decumbens*** to characterize sexual reproduction in this rare California shrub. Most seeds (97.8%) were dormant due to an impermeable seed coat. Breaking of the coat, mechanically or by heat, allowed high levels of germination. Chamise charate and ash added to the potting medium resulted in the highest levels of germination and emergence. Most seedlings produced in unburned chaparral by planting heat-treated seeds in openings between shrubs were destroyed by predators (rodents and insects). All seedlings that escaped predation died during the summer drought. [The authors] concluded that sexual reproduction was limited by (in order of importance): 1) lack of fire, 2) pre-dehiscence consumption by insects, 3) post-dehiscence consumption by rodents. Size distributions from two populations revealed that, despite the apparent absence of sexual reproduction in unburned chaparral, two unburned sites contained a large proportion of individuals in small size classes. Excavation of several small individuals demonstrated that they were sprouts from the roots of nearby larger shrubs. Because asexual reproduction by rootsprouting circumvented the high attrition of sexual reproductive effort on unburned sites, sprouting from roots may be a significant reproductive strategy of some 'sprouter' species in chaparral. [PA].

Fremontodendron decumbens (C 1)

12. **BUNTING, S. C., H. A. WRIGHT, AND L. F.** NEUENSCHWANDER. 1980. Long-term fire effects on cactus in the southern mixed prairie of Texas. Journal of Range Management 33:85–88.

Few *Opuntia phaeacantha* (brownspine pricklypear) were immediately killed by the direct effects of fire. Most plants resprouted after burning in the spring, but mortality averaged 70% by the end of the fourth year

after burning. Interactions of fire with insects and rodents caused most of the *O. phaeacantha* mortality. *Opuntia imbricata* (walkingstick cholla) and *O. leptocaulis* (tasajillo cactus) were more directly affected by fire than *O. phaeacantha*. First-year mortality was 40–65%, respectively; and fourth year mortality was 57–80%. Mortalities of other minor species of cactus varied from 49–100%. [AA].

Echinocereus reichenbachii (E), *Opuntia imbricata* (0), *O. leptocaulis* (0), *O. phaeacantha* (0)

13. CAMPBELL, D. L. 1994. The Nature Conservancy, Nashville, Tenn. Personal communication.

    Controlled burns were conducted on three different limestone cedar glades in central Tennessee to enhance habitat conditions for *Echinacea tennesseensis* and *Dalea foliosa*. Population size and vigor were sampled for 1 year prior to the burns and for 3 years after the burns. The study is still underway, and results have not been analyzed or discussed.

Dalea foliosa (E), *Echinacea tennesseensis* (E)

14. CAMPBELL, J. J., M. EVANS, M. E. MEDLEY, AND N. L. TAYLOR. 1988. Buffalo clovers in Kentucky (*Trifolium stoloniferum* and *T. reflexum*): historical records, presettlement environment, rediscovery, endangered status, cultivation and chromosome number. Rhodora 90(864):399.

    Currently, Kentucky's two native *Trifolium* species, *T. stoloniferum* and *T. reflexum*, are each known from only one locality. Historical records indicate that *T. stoloniferum* was widespread on moist, fertile soils in the Bluegrass Region, and that *T. reflexum* occurred on drier or less fertile soils in the former Big Barrens Region and the Shawnee Hills. Many old records are from areas with open woodland or grassland disturbed by Indians and buffalo (*Bison bison*), and recent records are mostly from roadsides or trails through woods. The decline of these species may be attributed to changes in disturbance and consumer patterns since settlement. In cultivation, *T. stoloniferum* is a vigorous perennial, easily propagated from stolons, but it requires moist, fertile soil, and is sensitive to competition and herbivory. *Trifolium reflexum* grows more slowly and is typically biennial. [PA].

Trifolium reflexum (0), *Trifolium stoloniferum* (E)

15. CAMPBELL, J. J., D. D. TAYLOR, M. E. MEDLEY, AND A. C. RISK. 1991. Floristic and historical evidence of fire-maintained, grassy pine-oak barrens before settlement in southeastern Kentucky. Pages 359–375 *in* S. C. Nodvin and T. A. Waldrop, editors. Fire and the environment: ecological and cultural perspectives, proceedings of an international symposium; 20–24 March 1990; Knoxville, Tenn. Southeastern Forest Experiment Station, Asheville, N.C.

    Several rare plant species in the Appalachian region of Kentucky have been found generally on sandy ridges of the southern Cliff Section in native grassy roadside vegetation or young brushy pine-oak (*Pinus-Quercus*) woods, and almost never in areas with less human disturbance. They include *Agalinis decemloba*, *Aster concolor*, *Castanea pumila*, *Cirsium carolinianum*, *Eryngium yuccifolium*, *Gymnopogon ambiguus*, *Helianthus atrorubens*, *Liatris squarrosa*, *Lilium philadelphicum*, *Oenothera perennis*, *Parthenium integrifolium*, *Phlox amoena*, *Polygala polygama*, *Rhynchosia tomentosa*, *Robinia hispida* var. *rosea*, *Sanicula marilandica* (var. *petiolulata*), *Schwalbea americana* (a federally endangered plant species) and *Sporobolus clandestinus*. Most are concentrated in the southeastern United States, and several are typical of open pine or oak woods with frequent fire. Either these species have invaded roadsides and other disturbed areas after settlement, or they are relicts from openings that were maintained by fire, Indians, and large herbivores before settlement. The latter hypothesis is supported by the virtual absence of these species in recent clearings, suggesting low reproductive rates; some species have disappeared since 1950. Also, there are historical indications that fire did maintain some open pine-oak barrens, together with an associated federally endangered animal—the red-cockaded woodpecker (*Picoides borealis*). [AA].

Castanea pumila var. *ozarkensis* (C2), *Schwalbea americana* (E)

16. CARLSON, P. R., G. W. TANNER, J. M. WOOD, AND S. R. HUMPHREY. 1993. Fire in key deer habitat improves browse, prevents succession and preserves endemic herbs. Journal of Wildlife Management 57:914–928.

    The continued existence of key deer (*Odocoileus virginianus* var. *clavium*) and several endemic plants of the Florida rockland pine community depend on periodic fires. The authors measured use and nutrient content of browse for 1 year after a fire, monitored vegetation growth after fire, and documented succession since the last fire. Endemic herbaceous species were generally unaffected by fire in the pine savannah, showing no increase in frequency, but were rare

or absent where succession had advanced to mixed pine-hammock composition.

Chamaecrista lineata (C 3), *Phyllanthus pentaphyllus* (C2), *Tragia saxicola (C2)*

17. COBB, N. *1994.* The effects of grazing and prescribed burning on plant performance and population dynamics of *Chrysothamnus molestus.* Northern Arizona University..Unpublished.

The effects of grazing, prescribed burning, season of bum, and climate on *Crysothamnus molestus* on the Coconino Plateau in Northern Arizona are evaluated. Burning in spring or in fall increased shoot growth. However, mortality was high after burning in spring and negligible after burning in fall. Shoot production was less among the plants burned in spring than those burned in fall. Cobb concluded that fall burning should be employed on C. *molestus* and that managers should consider large scale climatic variations when evaluating long-term frequency and time of bum.

Chrysothamnus molestus (C2)

18. COLLIER, M. 1994. Natural Resources, Mesa Verde National Park, Colorado. Personal communication.

Prescribed bums of areas with *Astragalus schmolliae* will be conducted in the Mesa Verde National Park, Colorado, during summer 1994. Results from M. Collier will be available in fall 1994. Collier observed that *Hackelia gracilenta* was more prevalent after an earlier bum in the Mesa Verde National Park.

Astragalus schmolliae (C2), *Hackelia gracilenta (C2)*

19. CURRIER, P. J. 1984. Response of prairie fringed orchid to fire and reduction in grazing (Nebraska). Restoration and Management Notes (2):28.

Traditional grazing practices and prescribed burning are used to manage native grasslands at Crane Meadows, Nebraska, which contains more than 50 prairie white fringed orchids *(Platanthera leucophaea).* The orchids were discovered after a bum in spring. Season-long grazing during the last 50 years maintained the orchids in a non-flowering state. Abundant moisture, less intense grazing, and fire probably contributed to the pulse of flowering.

Platanthera leucophaea (T)

20. DANIELSON, K. 1993. Marre fire rehabilitation plan summary. Botany Technical Report. U.S. Forest Service, Los Padres National Forest, Calif. Unpublished. 18 pp.

Three sensitive plant species occur inside the perimeter of the 1993 fire in the Los Padres National Forest: *Caulanthus amplexicaulis* var. *barbarae, Sidalcea hickmannii ssp.parishii,* and *Frittillaria ojaiensis.* All three species benefit from fire and are expected to recover from this fire.

Caulanthus amplexicaulis var. *barbarae (C I), Frittillaria ojaiensis* (C2), *Sidalcea hickmannii* ssp. *parishii* (Cl)

21. DUNWIDDIE, P. W. 1990. Rare plants in coastal heathlands: observations on *Corema conradii* and *Helianthemum dumosum.* Rhodora 92(869):22–26.

Dunwiddie describes the effects of prescribed burning on two coastal heathland species, *Corema conradii* and *Helianthemum dumosum,* in New England. Fire killed adult C. *conradii* individuals but generated abundant seedlings. After a spring bum, the cover and flowering of *H. dumosum* increased. Occasional fire may be necessary to maintain healthy, reproductive populations of these species.

Corema conradii (0), Helianthemum dumosum (C2)

22, ESSER, L. L. 1993. *Torreya taxijiolia. In* W. C. Fischer, compiler. The Fire Effects Information System [Database]. Missoula, Montana: U.S. Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Unpublished.

Published research on tire adaptations of *Torreya taxifolia* (Florida torreya) is lacking. A related species, *T. californica* (California torreya), sprouts from roots, root crowns, and boles after fire. *Torreya taxifolia* may respond to fire in a similar manner. Until recently, ground fires were a constant influence on the neighboring long-leaf pine (*Pinus palustris)* forest community. The smoke from these fires may have operated as a natural fungicide by suppressing a fungus that now infects *T. taxifolia. Torreya taxifolia* is known from northern Florida and southern Georgia.

Torreya californica (0), Torreya taxifolia (E)

23. FISHBEIN, M., AND D. GORI. 1992. The effect of prescribed burns on the composition and structure of Cienega vegetation, with special emphasis on the Canelo Hills ladies' tresses orchid, *Spiranthes delitescens*: post-bum responses. Report to the Nature Conservancy. The Nature Conservancy, Tucson, Ariz. Unpublished.

The effects of prescribed burning on *Spiranthes delitescens* and the vegetation of its Cienega habitat 3 months after a treatment bum are reported. Nine plots

without *Spiranthes* (referred to as experimental plots) and two plots with *Spiranthes* were established. One plot with *Spiranthes* and ail experimental plots were burned. Vegetation height decreased in the burned plot with *Spirunthes* and in all experimental plots. No new *Spiranthes* recruits were evident in the *Spiranthes* plots, and the abundance of flowering stems did not increase. Because of the variation in weather conditions, several bum treatments may be necessary to gain a better understanding of the effects of burning on Cienega vegetation composition.

Spirunthes delitescens (C 1)

24. FOLKERTS, G. W. 1977. Endangered and threatened carnivorous plants of North America. Pages 301-3 13 *in G.* T. Prance and T. S. Elias, editors. Extinction is forever: proceedings of a symposium held at the New York Botanical Garden, Bronx, N.Y., 11-13 May 1976.

Three genera of carnivorous plants, *Surruceniu, Dionaea,* and *Pinguicula are* fire dependent. Moderate tires reduced competition from woody species and stimulated growth of the species in these genera. Fire suppression increased woody undergrowth and the threat of severe fire. *Surruceniu alata* produced larger rhizomes and more leaves per rhizome on burned sites. Fire was an important part of carnivorous plant habitat and must be taken into account in future management. The genus *Surruceniu* has three listed and two candidate species, *Dionaea* has one candidate species, and *Pinguicula* has one listed and one candidate species.

Dionaea spp., *Pinguicula* spp., *Sarracenia* spp.

25. FREAS, K. E. 1993. Letter to Field Supervisor regarding proposed endangered status for three serpentine plant species. U.S. Fish and Wildlife Service, Sacramento, Calif.

Ceanothusferrisae appears to be primarily threatened by development and lack of recruitment in existing populations. During three years of monitoring three populations of C. *ferrisae* [the author] found no evidence of recruitment; ail populations were composed of mature and senescent individuals. Based on [the author's] experience with greenhouse propagation in study done at Stanford's Center for Conservation Biology, the species apparently does not require fire for germination, as is believed to be the case for many chaparral shrub species. In that study, there were no significant differences in germination rates between heat treatment, stratification, and no treatment of seeds, although stratification resulted in more rapid germination than did the other two treatments. The smallest C. *ferrisae* population burned during the summer of 1992. On December 31, 1992, approximately 5% of the individuals survived the fire. All of these individuals were damaged by the fire and currently support only one to several live branches. Potential seed production in the population has been severely reduced. [PS].

Ceanothus ferrisae (E)

26. GANKIN, R., AND J. MAJOR. 1964. *Arctostaphylos myrtifolia*, its biology and relationship to the problem of endemism. Ecology 45:792–808.

Fire plays an important role in chaparral plant communities and is extremely important in the Ione region of California. *Arctostaphylos myrtifolia* is killed by tire. However, tire creates open areas in which new seedlings establish.

Arctostaphylos myrtifolia (C 1)

27. GIBSON, D. J., AND L. C. HULBERT. 1987. Effects of fire, topography and year to year climatic variation on species composition in tallgrass prairie. Vegetation 72:175–185.

Described are compositional changes in response to fire and topography during a 5-year period in native unplowed tallgrass prairie at Konza Prairie, Kansas. The percentage and cover of all C4 species and grasses decreased when the prairie did not bum. A secondary gradient reflected topography (upland versus lowland soils).

28. GLENN, S. M., AND S. L. COLLINS. 1992. Effects of scale and disturbance on rates of migration and extinction of species in prairies. Oikos 63:273–280.

Relations between local annual immigration and extinction rates of plants and total species richness were determined from long-term data in tallgrass and shortgrass prairies in Kansas. The researchers tested the hypothesis that extinction rates are higher on burned than on unburned grasslands. Extinction rates positively correlated with the number of species at a site, and this relation was unaltered by burning.

29. GODFREY, R. K. 1976. Harper's beauty (*Harperocallis flava* McDaniel). Pages 89-90 *in* J. N. Layne, editor. Inventory of rare and threatened biota of Florida. Florida Audubon Society and Florida Defenders of the Environment.

Harperocallis jlava occurs in only one bog in the Apalachicola National Forest, Franklin County, Florida. Other plants associated with *H. flava are* adapted to fire. Whether *H. flava* is similarly adapted should be determined.

Harperocallis flava (E)

30. **GORDON,** D. **1991.** Response of two rare species to manipulation: effects of fire on *Matelea alabamensis* and effects of transplanting and shade on *Conradina glabra.* The Nature Conservancy, Gainsville, Fla. Unpublished.

Matelea alabamensis was examined for its response to burning. Individuals were marked and measured prior to burning. Results indicate that plants under an open canopy are more robust and are more likely to flower than plants under a closed canopy. Fire suppression and upland site preparation may have caused less robust vines. The effects of fire on *Conradina glabra* were also examined. The author concluded that burning under natural conditions may be required to sustain this species. These observations were based on preliminary data obtained in Florida.

Conradina glabra (E), *Matelea alabamensis (C2)*

31. **GORDON,** D. 1992a. Element stewardship abstract report for Florida scrub community. The Nature Conservancy in association with the Network of Natural Heritage Programs and Conservation Data Centers. Arlington, Va. Unpublished.

The role of tire in maintaining the Florida scrub community is discussed. The Florida scrub community and the neighboring longleaf pine (*Pinus palustris)* community are maintained by fire. Fire often spreads from the longleaf pine community into the Florida scrub community. *Cerutiola ericoides, Panicum abscissum, Bonamia grandijlora, Lechea deckertii, L. cernua,* and *Paronychia chartacea are* members of the Florida scrub community, and their habitats may depend on fire.

Bonamia grandiflora (T), *Ceratiola ericoides (0), Lechea cernua* (3C), *Lechea deckertii (0), Panicum abscissum* (C2), *Paronychia chartucea* (T)

32. GORDON, D. 1992b. Element stewardship abstract for pine rockland community. The Nature Conservancy, Arlington, Va. Unpublished.

Persistence of the pine rockland community depends on fire. Human development reduced the distribution of this community. *Amorpha crenulata, Brickellia* mosieri, *Chamaesyce deltoidea* ssp. *deltoidea, C. porteriana var. scoparia, Galactia smallii,* and *Polygala smallii* occur in this community.

Amorpha crenulata (= A. herbacea var. crenulata) (E), *Brickellia mosieri (= B. eupatorildes* var. *floridana)* (C2), *Chamaesyce deltoidea* ssp. *deltoidea* (E), *Chamaesyce porteriana* var. *scoparia* (C2), *Galactia smallii* (E), *Polygala smallii* (E)

33. GORI, D. 1994. The Nature Conservancy, Tucson, Ariz. Personal communication.

The Nature Conservancy in Arizona conducted prescribed bums of *Chrysothamnus molestus* in spring and fall to determine the effect of the season of bum on this species. Bums in spring were detrimental because they occurred during the primary growing season and caused high seedling mortality. Burns in fall reduced shrub cover and increased survivorship. The frequency of presettlement fires is approximately 7-12 years.

Chrysothamnus molestus (C2)

34. **HARDIN,** D. E., **AND** D. L. White. 1992. Rare vascular plant taxa associated with wiregrass *(Aristidu stricta)* in the southeastern United States. Natural Areas Journal 9:234–245.

[The authors] list 191 rare plant taxa that occur in ecosystems in the southeastern United States (Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina) where wiregrass *(Aristida stricta)* is an important component. Wiregrass ecosystems throughout the Southeast have been greatly reduced and continue to be threatened by conversion to other uses and inappropriate fire management. [PA].

Aristidu stricta (0), Clitoria fragrans (Cl), Deeringothamnus pulchellus (E), *Deeringothamnus rugelii* (E), *Harperocallis flava* (E), *Hedeoma graveolens (= Stachydeoma gruveolens) (0), Kalmia cuneata* (Cl), *Lysimachiu asperulifolia* (E), *Muhlenbergia torreyana (0), Pyxidanthera barbulata* ssp. *brevifolia (= P. brevifolia)* (Cl), *Rhododendron chapmanii* (E), *Rhus michauxii* (E), *Solidagopulchra (C* 1), *Thalictrum cooleyi* (E), *Verbesina heterophylla (C* 1)

35. **HARTNETT,** D. C., AND D. R. RICHARDSON. 1989. Population biology of *Bonamiu grandiflora* (Convolvulaceae): effects of fire on plant and seed bank dynamics. American Journal of Botany 73:361–369.

The effects of disturbance on reproduction and plant and seed bank dynamics of *Bonamia grandiflora are* discussed. Several populations of *B. grandiflora* were

studied during 3 years. Sites were either burned, mechanically disturbed, or left undisturbed. Fire increased stem densities, the percentage of flowers producing seeds, and the number of capsules and seeds per plant. Fire caused a significant turnover in the seed bank but no immediate change in population size.

Bonamia grandiflora is only known from Florida.

Bonamia grandiflora (T)

36. HAWKES, C. V., AND E. S. MENGES. 1995. Density and seed production of a Florida endemic, *Polygonella basiramia,* in relation to time since fire and open sand. The American Midland Naturalist 133:138–145.

Density and reproductive output in relation to fire, open sand, and other site factors were determined for *Polygonella basiramia.* This federally endangered species is endemic to only three ridges in central Florida and found primarily in rosemary *(Ceratiola ericoides)* dominated sand pine (*Pinus clausa*) shrub. Twenty-two sites ranging from 5 to >26 yr post-fire were sampled. Site factors of openness, time since last fire, dominant species, ground cover, elevation and soil type were examined. Multivariate analyses identified the amount of open sand habitat at a site as the only variable having a significant positive relationship with both plant density and seed production. Seed production actually increased with conspecific density, suggesting that the lack of interspecific competition in open sand gaps helps define *P. basiramia* microhabitat. Open sand habitat is critical in the life history strategy of this obligate-seeding, perennial herb in a community where it must compete with larger, resprouting shrubs and herbs both immediately after fire and during fire-free intervals. [AA].

Polygonella basiramia (E)

37. HERMANN, S. M. 1988. Preliminary report on the impact of a mid-summer fire on *Liatris provincialis* at the J. H. Phipps Preserve. Tall Timbers Research Station, Tallahassee, Fla. Unpublished.

Two plots with *Liatris provincialis* were burned and two unburned plots served as controls. The response of *L. provincialis* to fire was measured. Additional years are required to confirm benefits of fire to *L. provincialis.*

Liatris provincialis (C2)

38. JACOBS, J. 1993. New hope for the Peter's Mountain Mallow. Endangered Species Technical Bulletin 18(3):13–14.

The seeds of Peter's Mountain Mallow *(Iliamna corei)* must be scarified to germinate. The Nature Conservancy in Virginia and biologists with the Virginia Natural Heritage Program are using prescribed bums to manage the only known population of this species. This population had declined from 50 individuals in 1927 to 3 individuals in 1986. The first prescribed bum in 1992 resulted in 12 new seedlings, 4 of which survived the first year. A bum in May 1993 resulted in 500 new seedlings.

Iliamna corei (= I. rivularis var. rivularis) (E)

39. JACOBSON, G. L., H. ALMQUIST-JACOBSON, AND J. C. WINNE. 199 1. Conservation of rare plant habitat: insights from the recent history of vegetation and fire at Crystal Fen, northern Maine, USA. Biological Conservation 57:287–314.

Crystal Fen in north-central Maine is a well known locality of several rare plants. Recent drying and an increase in woody vegetation in the fen may threaten the habitat of *Platanthera leucophaea* and *Tofieldia glutinosa.* The adjacent railroad bed and drainage ditch may be causing the changes. Changes were described with aerial photos (1938–present), present vegetation, evidence of fire, and a pollen record of the last 200 years. A decline in frequency of bums increased the abundance of woody plant species. However, the pollen record shows that this rare plant habitat was created by the adjacent railroad tracks built in 1893 and was subsequently maintained by fires caused by drifting ash from steam locomotives. When steam locomotives were replaced by diesel engines, the fire regime was altered. The plants are now threatened by the lack of fire and increasing woody vegetation.

Platanthera leucophaea (T), *Tofieldia glutinosa* var. *absona* (C2)

40. JOHNSON, A. F. 1989. Four petal pawpaw *(Asimina tetramera)* summary report. Florida Natural Areas Inventory, Tallahassee, Fla. Unpublished.

The author observed two neighboring sites of *Asimina tetramera* among white sand scrub in Florida. One site was composed of open vegetation and the other was overgrown with woody vegetation. Data from these two sites and observations by other researchers suggest that *A. tetramera* is more abundant after disturbance such as fire, hurricane, or cutting by humans.

Asimina tetramera (E)

41. JOHNSON, A. F. 1993a. Population status survey of *Calamovilfa curtissii* (Vassey) Lamson-Scribner. Florida Natural Areas Inventory, Tallahassee, Fla. Unpublished.

Calamovilfa curtissii is endemic to the Florida panhandle and occurs in association with wiregrass (*Aristida stricta*) and flatwood areas. A population in the Merritt Island National Wildlife Refuge is burned frequently (every 3 years) and had been burned in spring before the author visited the site. Younger plants were frequent on bare ground between the mature clumps of sandgrass. Fire prevented C. *curtissii* habitat from being invaded or shaded by shrubs. Mechanical disturbance, which affects C. *curtissii*, is common because the plant occurs in roadside ditches and along powerline rights-of-way.

Calamovilfa curtissii (C2)

42. JOHNSON, A. F. 1993b. Population status survey of *Liatris provincialis* Godfrey. Florida Natural Areas Inventory, Tallahassee, Fla. Unpublished.

Information on the taxonomy, range, habitat, and management of *Liatris provincialis* is provided. Recent observations suggested that clear-cuts in and around *L. provincialis* populations mimic the stimulatory effects of fire. *Liatris provincialis* produces an underground corm, indicating that it can persist for some time under a dense canopy in a suppressed state until tire or clear-cutting removes the canopy and stimulates the plant to flower. The author suggests, however, that the absence of fires for a long period would probably be detrimental to the species because eventually the corms, suppressed under dense canopies, may begin to die off and not be replaced by new seedlings.

Liatris provincialis (C2)

43. JOHNSON, A. F. 1993c. Population status and survey of *Polygonella macrophylla* Small. Florida Natural Areas Inventory, Tallahassee, Fla. Unpublished.

Polygonella macrophylla is endemic to scrubs along the mainland coast of the Florida panhandle. It resprouts after fire, and anecdotal reports indicate that fire may enhance flowering. The author suggests that management of *P. macrophylla* requires the preservation of the stable communities in which it occurs. Naturally occurring salt winds and fires should not be obstructed.

Polygonella macrophylla (C2)

44. JOHNSON, A. F. 1994. Florida Natural Areas Inventory, Tallahassee, Florida. Personal communication.

Asimina tetramera (Annonaceae)—Comparison of shaded and unshaded shrubs on two sites a few city blocks apart (unpublished data) shows that shading adversely affects percent of shrubs flowering-indicating the plant needs fire to maintain low stature of surrounding scrub plants to permit flowering. Observations during a survey for *[A. tetramera]* in 1988 indicate that cutting or mowing appears to stimulate the species to re-sprout and flower. Species produces a very deep taproot. *Calamovilfa curtissii* (Poaceae)—Observations during a survey for this species in 1987-88 in the Florida Panhandle (Johnson, A. F., 1988) indicate that it requires cutting or mowing to stimulate it to flower. *Liatris provincialis* (Asteraceae)—Observations during a 1993 status survey for this species indicate that reproduction in this species is also reduced by shading, indicating that fire is necessary to stimulate reproduction. The species flowers vigorously after clearcutting-a process that may mimic the effects of tire in a natural situation. *Polygonella macrophylla* (Polygonaceae)---This species has been observed to resprout following fire. It is found in open salt sprayed prune oak scrub *(Quercus myrtifolia, Q. geminata)* on coastal terraces in Okaloosa and Walton Counties. It also grows with rosemary *(Ceratiola ericoides)* under open sand pine (*Pinus clausa*) canopies, but has not been found where the sand pine canopy closes to produce dense shade. It appears to flower vigorously a few years after a fire, but this may also be because its flowering stems are more conspicuous when the surrounding shrubs are lower. [Johnson] observed that several shrubby members of the mint family (*Conradina canescens, Calamintha ashei) are* killed by fire and recover from seed. This also appears to be the case for *Dicerandra frutescens* (Menges, E. S. 1992). If this generalization holds for other shrubby species in these genera, it would include *Conradina brevifolia, C. glabra, C. etonia, Dicerandra comutissima, D. immaculata,* and *D. christmanii* on the list of rare species in Florida. [AS].

Asimina tetramera (0), Calamintha ashei (C2), *Calamovilfa curtissii* (C2), *Ceratiola ericoides* (0), *Conradina brevifolia (= C. canescens)* (E), *Conradina etonia* (E), *Conradina glabra* (E), *Dicerandra christmanii* (E), *Dicerandra cornutissima* (E), *Dicerandrafrutescens* (E), *Dicerandra immaculata* (E), *Liatris provincialis* (C2), *Polygonella macrophylla (C2)*

45. JOHNSON, A. F., AND W. G. ABRAHAMSON. 1990. A note on the fire responses of species in rosemary scrubs on the Southern Florida Lake Wales Ridge. Florida Scientist 53: 138-l 43.

Three herbaceous species (*Lechea deckertii, L. cernua,* and *Paronychia chartacea)* appeared in postburn samples of plots in rosemary scrubs, that were rare or absent in prebum samples of the same plots and were also rare in samples of plots in unburned scrubs. Changes in cover levels with stand age suggest that these species are displaced by the increasing cover of rosemary and reindeer lichens within 9-12 years, their populations then being rejuvenated by periodic fires. [AA].

Lechea cernua (3C), *L. deckertii (0), Paronychia chartacea* (T)

46. JOHNSON, A. F., AND A. BLYTH. 1988. Re-discovery of the *Calamovilfa curtissii* (Gramineae) in Florida Panhandle. Sida 13: 137-140.

The range of *Calamovilfa curtissii* in the Florida panhandle was re-examined and expanded. The plant is associated with wiregrass *(Aristidu stricta)* flatwoods that are considered a fire-managed community. Populations of C. *curtissii* that were either recently burned or mechanically disturbed flowered profusely.

Calamovilfa curtissii (C2)

47. JORDAN, M. J. 1994. The Nature Conservancy, Cold Spring Harbor, New York. Personal communication.

The abundances of two subpopulations of *Agalinis acuta* increased drastically in 1993, after prescribed bums at the Hampstead Plains North, Nassau County, Long Island, New York, in 1992. A conclusion that fire was responsible because populations typically fluctuate widely from year to year is premature. Populations also increased at another Long Island site (Sayville Grassland) that was not burned but was extensively brushhogged and mowed. Fire and mowing were probably responsible for the increases at the Hampstead Plains North and Sayville, especially because populations at all other Long Island sites either decreased or remained unchanged.

Agalinis acuta (E)

48. KAGAN, J. 1992. Draft species management guide for *Calochortus umpquaensis* Fredricks. Roseburg District of the Bureau of Land Management and Umpqua National Forest. Unpublished.

Calochortus umpquaensis occurs in Douglas-fir (*Pseudotsuga menziesii*), mixed conifer forests in Oregon with a natural tire frequency of 10-20 years. Fire suppression during the past 80 years changed the open habitat into a closed canopy forest that is dominated by Douglas-fir. Without the reintroduction of fire, populations of this species may disappear over time.

Calochortus umpquaensis (C 1)

49. KAYE, T. N., K. CONNELLY, AND K. FINLEY. 1994. Population viability analysis of an endangered plant, *Lomatium bradshawii,* under three prairie burning treatments. Supplement to Bulletin of the Ecological Society of America 75: 106.

Lomatium bradshawii is an endangered plant species of western Oregon prairies that were burned annually by Native Americans prior to Euro-American settlement. The plants are perennial, reproduce by seed only, and do not maintain a persistent soil seed bank. We used transition matrix models incorporating observed environmental stochasticity to determine the effects of prescribed fires on the viability of two populations. Three fire treatments were used: burned three times in six years (1988–1993), twice in six years, and not burned (control). Burning tended to improve fruit production and subsequent seedling recruitment, and lower mortality of seedlings and small vegetative plants. In addition, fire increased the equilibrium population growth rate (h) of both populations from 0.943 and 0.928 (respectively for each population) without burning, to 1.110 and 0.976 when burned in two years, to 1.190 and 1.014 when burned three times. The risk of extinction declined sharply with increased fire frequency, from 100% without fire at both populations, to 100% and 52% when burned twice, to 0% when both populations were burned three times. Fire is an effective tool for maintaining viable populations of this endangered species. Our results suggest that in the absence of fire, even large populations will eventually decline to extinction. [AA].

Lomatium bradshawii (E)

50. KELLY, V. R., AND V. T. PARKER. 1990. Seed bank survival and dynamics in sprouting and nonsprouting *Arctostaphylos* species. American Midland Naturalist 124:114–123.

Species of the genus *Arctostuphylos* in the chaparral regenerate after fire either by obligate seeding or by sprouting. The authors tested the hypothesis that sprouting species do not differ from nonsprouting species in flower, fruit, and seed production. The productions of

inflorescence, infructescence, and fruit do not differ significantly between *A. canescens* and *A. glandulosa.* Results suggested that the reproduction of sprouting and nonsprouting chaparral species after fire do not consistently differ.

Arctostaphylos glandulosa is known only from California.

Arctostaphylos glandulosa (C 1)

51. KIRBY, R. E., S. J. LEWIS, AND T. N. SEXSON. *1988.* Fire in North American wetland ecosystems and fire-wildlife relations: an annotated bibliography. U.S. Fish and Wildlife Service Biological Report 88(1). 146 pp.

This is a comprehensive bibliography of fire in wetland communities. Also provided are limited references to fire in grassland, forest, scrub, desert, chaparral, tropical boreal, and subalpine vegetation types and to the relation between tire and wildlife in these areas.

52. KIRKMAN, L. K., AND M. B. DREW. 1993. Season of fire effects on the federally endangered *Schwalbea americana:* preliminary results. Joseph W. Jones Ecological Research Center, Ichauway, and the Georgia Institute of Ecology. Unpublished.

The authors experimentally examined the responses of *Schwalbea americana* populations to season of bum. Flowering occurred in response to burning regardless of season. Fire management practices that vary from the traditional tire regime in winter may not be devastating to the population because flower production is delayed until post-fire conditions again exist. *Schwalbea americana* is known from the eastem United States.

Schwalbea americana (E)

53. KRAL, R. 1983. A report on some rare, threatened, or endangered forest-related plants of the south. U.S. Forest Service, Atlanta, Ga. Technical Publication R8-TP 2. 1,305 pp.

Kral's two volume set details the taxonomy, phenology, distribution, ecology, and habitat of more than 300 forest-related rare, threatened, and endangered vascular plants of the South. A table is provided for each species and includes information about the species' response to several management practices, including prescribed bums.

54. LESICA, P. 1992. The effects of fire on *Silene spaldingii* at the Dancing Prairie Preserve. Nature Conservancy progress report. The Nature Conservancy, Helena, Mont. Unpublished.

Results suggest that recruitment of *Silene spaldingii* is enhanced in grasslands following fire. There was a modest trend for increased flowering in bum plots, but there was no evidence for increased growth. These effects may become more apparent in subsequent years as nutrients released by fire are absorbed by the plants. There was no evidence for increased mortality in bum plots. Density of S. *spaldingii* was greatest in spring bum plots compared to fall bum plots. Spring bum plots generally had a lower intensity. It is not known whether the positive effects of the spring bum are the result of the cooler bum conditions or the early phenology of the plants. Results from subsequent years will provide further information on the effects of fire on S. *spaldingii.* [AS].

Silene spaldingii (C2)

55. MACROBERTS, M. H., AND B. R. MACROBERTS. 1990. Notes on the occurrence of *Platanthera integra* (Nutt.) A Gray Ex Beck (Orchidaceae) in West Central Louisiana. Phytologia 69:378–38 1.

The authors surveyed bogs in the Kisatchie District of the Kisatchie National Forest in west-central Louisiana. *Platanthera integra* occurred in 35% of the bogs. None of the bogs had been burned in the year preceding the survey; however, all but one had been burned in winter 1989-90, the last year of the survey. Flowering of *P. integra* after fire increased in most bogs. The only bog that did not bum in 1989-90 did not increase in flowering. Blooming peaked 2-3 weeks earlier in the burned bogs than in the unburned bog.

Platanthera integra (0)

56. MCCLARAN, M. P., AND P. C. SUNDT. 1992. Population dynamics of the rare orchid *Spiranthes delitescens*. Southwestern Naturalist 37:299–333.

Spiranthes delitescens is known from only four locations in southeastern Arizona. A prescribed bum in April 1979 was used in an attempt to increase flowering. Although flowering increased after the burn, it also increased in other burned and in unburned sites. In May 1986, another bum was conducted at the same site, but no plants flowered in the following summer. The authors compared grazed and burned sites with control sites but stress that possible inherent site differences prohibit conclusions about the effects of grazing and burning. Because many *Spiranthes* species favorably respond to fire, the authors recommend that a controlled experiment be performed to assess the effects of burn-

ing, grazing, and mowing on the population dynamics of *S. delitescens.*

Spirunthes delitescens (C 1)

57. MELGOZA, G., R. S. NOWAK, AND R. J. TAUSCH. 1990. Soil water exploitation after fire: competition between *Bromus tectorum* (cheatgrass) and two native species. Oecologia 83:7–13.

Bromus tectorum becomes abundant after fire in semiarid areas of western North America. The authors examined this phenomenon in relation to plant-water potential and competition with the native plants *Stipa comata* and *Chtysothamnus viscidiflorus*. They measured soil water content, plant water potential, aboveground biomass production, and water-use efficiency to determine whether *B. tectorum* competes with either of the two native species. Soil water content was significantly lower around native species in association with *B. tectorum* than around individuals without the presence of *B. tectorum*.

Bromus tectorum (0), Chrysothamnus viscidiflorus (C2), *Stipa comata (0)*

58. MENGES, E. S. 1986. Predicting the future of rare plant populations: demographic monitoring and modeling. Natural Areas Journal 6: 13-25.

Conservation biology desperately needs techniques to predict the future of small populations and endangered species, and to guide conservation strategy and management tactics. In particular, information is required on extinction probability and minimum viable population. Techniques in population viability analysis are just being developed; they have the potential for providing such information, but have not yet been applied to plants. Most techniques focus on genetic factors rather than environmental or demographic, although the last two may constitute more immediate threats to small plant populations. This paper reviews modeling and data collection approaches to predicting rare plant populations. The projections are driven by empirical data on life history components: mortality, growth, and fecundity of individuals grouped by defined life history stages. To fully utilize the techniques, a long-term commitment (three years or more) to data collection of moderate intensity is required. Data collection issues and methods are illustrated by referring to an ongoing study of Furbish's lousewort in Maine. [PA].

59. MENGES, E. S. 1988. Population biology of a rare prairie forb: *Silene regia* 1987-1988. Report to the Ohio Department of Natural Resources and the Indiana Academy of Sciences. Holcomb Research Institute, Indianapolis, Ind. Unpublished.

Described are the effects of habitat fragmentation on population viability of *Silene regiu,* a midwestem plant species. The growth rates of this plant were the highest in populations that had been subjected to controlled burning. Most *S. regia* become more productive with plant size. Menges recommends burning, control of woody vegetation, and maintenance of other hummingbird food plants to sustain the habitat of S. *regia.*

Silene regiu (C3)

60. MENGES, E. S. 1992. Habitat preferences and response to disturbance for *Dicerandra frutescens,* a Lake Wales Ridge (Florida) endemic plant. Bulletin of the Torrey Botanical Club 119:308–3 13.

Dicerundru frutescens is restricted to drained yellow sands with evergreen oak-dominated scrub vegetation. Fires in spring, manual defoliation, or removal of above ground tissues killed 100% of *D. frutescens* in a field experiment. After fire, *D. frutescens* recruited from seed stored in soil. Fire is probably beneficial to *D. frutescens.* Populations that were burned in the previous decade tend to be the most vigorous.

Dicerandra frutescens (E)

61. MENGES, E. S., AND N. M. KOHFELDT. 1994. Life history strategies of Florida scrub plants in relation to fire. In Preparation. Archbold Biological Station, Lake Placid, Fla. Unpublished.

Ninety-eight species found in either rosemary scrub or scrubby flatwoods were placed into guilds based on recovery mechanisms. Most (92%) of species are in 4 guilds: resprouters (mainly woody shrubs), resprouters and seeders (small-statured shrubs, palms, and herbaceous perennials), obligate seeders (mainly herbs), and resprouters and clonal spreaders. Herbaceous plants tended to decrease with time since tire. Vegetative recovery modes generally increased in frequency with time since fire. In rosemary scrub, seedling recovery has been favored, whereas vegetative recovery has come to predominate in scrubby flatwoods. In managing Florida scrub, a variety of fire-return intervals at any site are needed to promote diversity of both life history and species. [AS].

62. MENGES, E. S., AND J. MCANLIS. 1994. Microhabitat and time since fire: effects on demography of a Flor-

ida scrub endemic plant. In preparation. Archbold Biological Station, Lake Placid, Fla.

The effects of 22 microhabitat characteristics on survival, growth, and fecundity of 1,287 *Eryngium cuneifolium* were examined during 4 years. Survival increased with distance to the nearest shrub and size of open spaces. *Ceratiola ericoides* and *Calamintha* ashei seemed to increase the mortality of *E. cuneifolium* more than other shrub species. Sand accretion increased growth and fecundity of *E. cuneifolium.* This herbaceous endemic is dependent on an open habitat, which is maintained by disturbance such as fire. [AS].

Calamintha ashei (C2), *Ceratiola ericoides (0), Eryngium cuneifolium* (E)

63. MOSELEY, R. K., AND R. C. CRAWFORD. 1993. Population monitoring and management plan for the Idaho phlox *(Phlox idahonis).* Idaho Department of Fish and Game, Natural Resource Policy Bureau, Boise, Idaho. Unpublished.

Direct gradient analysis of plant cover data indicate that livestock grazing intensity explained a majority of floristic variation in plant monitoring 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 fifteen year period (of study). 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 the 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 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 5 years, and management remain adaptive to new information, among others. [PA].

Phlox idahonis (C 1)

64. MOSELEY, R. K., M. MANCUSO, AND J. HILTY. 1990. Field investigation and status survey of *Penstemon lemhiensis* (Lemhi penstemon) in Idaho. Idaho Department of Fish and Game, Boise, Idaho. Unpublished.

Numerous and varied human-caused threats to Lemhi penstemon have been recognized throughout its range. These include road building, road maintenance activity, mining, botanical and horticultural collecting, herbicide spraying, and livestock grazing. Although not previously recognized by other investigators, we believe that the unnatural rate of vegetative succession due to fire suppression is the greatest threat to the long-term viability of the species in Idaho. Although most surveys have relied on the occurrence of Lemhi penstemon on roadcuts to find populations, these plants from artificial habitats contribute little to the overall viability of the species. Conservation planning for Lemhi penstemon should focus on natural populations in natural habitats. [PA].

Penstemon lemhiensis (C2)

65. MYERS, R. L. 1989. Condominiums, trailer parks and high intensity fires: the future of sand pine scrub preserves in Florida. Proceedings of the 17th Tall Timbers Fire Ecology Conference. Tallahassee, Fla.

Sand pine scrub, a sand pine/evergreen sclerophyllous shrub community endemic to Florida, is maintained by infrequent high-intensity fires. Scrub is habitat for 2 1 federally listed endangered or threatened species, all of which depend on the scrub fire regime. This paper reviewed the biological attributes of the scrub, the role fire plays in maintaining various scrub habitats, and management implications for the community as Florida's burgeoning population and phenomenal rate of development threaten remaining scrubs. [PA].

66. MYERS, R., AND S. BOETTCHER. 1987. Flowering response of cutthroat grass *(Panicum abcissum)* following fire. Bulletin of the Ecological Society of America 68:375.

Cutthroat grass forms a continuous cover on seepage slopes in central Florida. The grass is flammable and will carry fire throughout the year. In the absence of tire, these cutthroat glades are invaded by pines and hardwoods. Burns were conducted monthly in four glades, each with a known fire history. In one glade, additional plots received the following monthly treatments: mowed, fertilized, or mowed and fertilized. Flowering occurred after summer burns, but not after winter bums. A few blooms appeared on control plots in glades with a history of recent fire, but none appeared on control plots that had not been burned

recently. The greatest number of flowering stalks appeared on plots that were mowed and fertilized rather than burned, but both mowing and fertilizing alone also stimulated flowering. It appears that the persistence of cutthroat glades depends not only on the flammability of the grass limiting the encroachment of woody species but also on flowering stimulated by summer bums. [AA].

Panicum abscissum (C2)

67. OWEN, W. R., AND R. ROSENTRETER. 1992. Monitoring rare perennial plants: techniques for demographic studies. Natural Areas Journal 12:32–39.

Demographic monitoring of rare plant species is an essential component of an effective species management program. Traditional demographic techniques may fail to provide a clear view of the population processes of rare species because of statistical and logistical problems associated with small sample sizes, and because of the particular biological properties of rare perennial species. Managers need to be aware of these potential barriers to the interpretation of demographic data and know how to compensate through adjustments in their monitoring program. [AA].

68. PARKER, V. T. 1987. Effects of wet-season management bums on chaparral vegetation: implications for rare species. Pages 233-237 *in* T. Elias, editor. Conservation and Management of Rare and Endangered Plants. Proceedings from a conference of the California Native Plant Society, held in Sacramento, Calif., 5-8 November 1986.

Many chaparral species, including most rare and endangered chaparral species, depend on seed banks in the soil for recovery after fire. The author examines the effects of a prescribed bum in winter on the regeneration of several chaparral species, including *Arctostaphylos hookeri* ssp. *montanu.* Prescribed bums in Marin County, California, were studied for three growing seasons. Field and experimental data indicated decreasing germination of shrubs and herbaceous species after bums during winter. Parker recommended that the effects of prescribed bums during moist conditions on species regeneration should be carefully considered.

Arctostaphylos hookeri ssp. *montana (C2)*

69. PAVLIK, B. M. 1991. Reintroduction of *Amsinckia grandiflora* to three sites across its historic range. State of California, Department of Fish and Game, Endangered Plant Program, Sacramento, Calif. Unpublished.

Using methods developed on this and other endangered plants, Pavlik succeeded in creating a new, vigorous population of *Amsinckia grandiflora* within its historic range. An experimental design with demographic monitoring was used to test the effects of burning, hand clipping, and a grass-specific herbicide on the fates of 3,460 *A. grandifora* nutlets. The study concluded that new populations of *A. grandiflora* could be created in mesic annual grassland if the habitat is treated to minimizecompetition with annual grasses. [PA].

Amsinckia grandiflora (E)

70. PAVLIK, B. M., D. L. NICKRENT, AND A. M. HOWALD. 1993. The recovery of an endangered plant: creating a new population of *Amsinckia grandifora.* Conservation Biology 7:5 10-526.

Amsinckia grandiflora is an annual plant of the winter-wet, summer-dry grasslands of northern California. The authors discuss initial efforts to recover A. *grandiflora* by re-establishing the species in its historical range and evaluate the effects of habitat manipulations such as fire, herbicide application, and clipping of its regrowth. Five of 20 2x2-m plots were burned on 20 October 1989 immediately after seeding. Researchers monitored in situ germination, stress factors (desiccation, etiolation, and grazing), mortality, phenology, reproductive survivorship, and nutlet production per plant and per plot. One month after the first rains, live grasses constituted 44% of the total cover on control plots and between 17% and 23% on treatment plots; the burned plots had the smallest percentages of cover. Fire significantly reduced mortality early in the growing season and increased survivorship and plant size at maturity. The nutlet production per plant was unaffected by fire.

Amsinckia grandijlora (E)

71. PAVLOVIC, N. B. 1994. Disturbance-dependent persistence of rare plants: anthropogenic impacts and restoration implications. *In* M. L. Bowles and C. Whelan, editors. Recovery and Restoration of Endangered Species. Cambridge University Press, Cambridge. 28 pp.

Many rare plant species are successional and require disturbances for their regeneration. Their persistence depends on concordance of their life histories with the temporal and spatial patterns, and intensity or severity of disturbance regimes. These species are classified into three response categories: 1)species that persist

only under natural disturbance regimes in natural habitats and decline under human impact, 2) species that occur under both natural and anthropogenic disturbance regimes and habitats, and 3) species that no longer occur under natural habitats, but persist in anthropogenically disturbed habitats. Managing or restoring disturbance-dependent rare plant species requires an understanding of the relationship between the scale of suitable patch disturbance regimes and population dynamics. [PS].

Amsinckia grandiflora (E), *Aristida tuberculosa (0), Dicerandra frutescens* (E), *Hudsonia tomentosa (0), Platanthera leucophaea* (T), *Polygonella articulata (0), Talinum rugospermum (C2) Trifolium stoloniferum* (E)

72. PHILLIPS, B. G., H. GREEN, S. DUDLEY, AND R. GALEANO-POPP. 1992. Prescribed fire research on Flagstaff pennyroyal *(Hedeoma diffusum* Greene). Pages 162-169 *in* Southwestern Rare and Endangered Plants. R. Sivinski and K. Lightfoot, editors. Proceedings of the Southwestern Rare and Endangered Plant Conference held in Santa Fe, N.Mex., 30 March-2 April 1992.

A prescribed bum study on *Hedeoma diffusum* is being conducted in the Coconino National Forest, New Mexico. Preliminary results after two years indicate pre- and post-monsoon cool bums may yield increases in plant numbers through successful survivorship and enhanced recruitment. The responses after the bums were highly variable from plot to plot, however, further analysis of the data and continued monitoring for several years will be necessary to provide definitive conclusions. [AA].

Hedeoma diffusum (= H. diffusa) (C3)

73. POPOVICH, S. 1994. Bureau of Land Management, Shoshone, Idaho. Personal communication.

Astragalus oniciformis occurs in sagebrush steppe communities and is endemic to Blaine, Minidoka, and Lincoln counties in south-central Idaho. Although tire before settlement in this area occurred with an estimated frequency of 20-80 years, it has been suppressed since the early 1900s. Because fire suppression and the invasion of exotic annuals created increased fuel loads, fires now bum more frequently and more intensely. The U.S. Bureau of Land Management and the National Biological Service initiated a 5-year study of the demography and the effects of fire on *A. oniciformis.* As of 1994, 2 years of unpublished data are available. The initial results suggest that *A. oniciformis* has a low mortality when subjected to high-intensity fires because of a deep taproot and a stout caudex that remain unburned. Personal observations indicate a vigorous return of *A. oniciformis* during the first year after fire. *Astragalus atratus* var. *inseptus* is endemic to ephemeral swales of a mound-intermound sagebrush complex of the Bennett Hills of south- central Idaho. This portion of the community is rocky and burns infrequently. Fires tend to be cool and irregular. However, *A. atratus* also occurs in the flat areas of a community that is composed of sagebrush and bunchgrasses. Here, tires are more frequent and more intense. Personal observations revealed that the plant's stout caudex and deep taproot often promote its survival in fire.

Astragalus atratus var. inseptus (C2), *Astragalus oniciformis (C2)*

74. ROBINETT, D. 1992. Letter to Sue Rutman, U.S. Fish and Wildlife Service, Ecological Services, Phoenix, Ariz.

In June 1991, Robinett, in conjunction with the Arizona State Land Department and the State Department of Agriculture, performed a controlled bum on a pasture with several *Corypantha scheeri* var. *robustispina* plants. On 5 June 1992, he observed that all the plants had been burned, all sprouted, and all the large plants were in bloom. One plant that was completely scorched had sprouted and was blooming. Robinett plans to continue monitoring the effects of fire on this species.

Corypantha scheeri var. robustispina (T)

75. ROME, A. 1987. Element stewardship abstract report for *Thalictrum cooleyi.* The Nature Conservancy, Carrboro, N.C. Unpublished.

Thalictrum cooleyi is an early successional species that requires open habitat. Without a regular disturbance regime, the species will be eliminated by competition from other species. Fire suppression reduces open habitat and is therefore detrimental to this plant. Other disturbances such as mowing, plowing, and clear-cutting were recently substituted for tire. In the absence of disturbance, some populations may be endangered. The appropriate frequency of disturbance has not yet been determined. However, the author recommends that controlled bums, if conducted, should be in winter or in early spring when reproductive plant parts would be spared.

Thalictrum cooleyi is known from North Carolina and Florida.

Thalictrum cooleyi (E)

76. SCHNELL, D. E. *1982.* Effects of simultaneous draining and brush cutting on a *Surruceniu* L. population in a southeastern North Carolina pocosin. Castanea 47:248–260.

The cutting, burning, and ditching of a very large pocosin in southeastern North Carolina for silviculture afforded the opportunity to observe the response of three species of *Surruceniu* growing in the dense brush. Prior to disturbance (the last fire was some twenty years previously), pitcher plants were growing poorly but maintained a presence. Subsequent to clearing, the immediate effects of increased light and decreased aerial competition became apparent with an exuberant growth release wherein the *Surrucenius* became dominant and there was an increase in seedling activity. The effects of ditching lagged and the soil did not begin to dry for one to two years after clearing at which time the *Surrucenius* promptly decreased, even though shrub sprouting had recurred sufficiently to provide significant competition. The events in the pocosin are compared to reports of savanna burnings and the possible significance of burning the cut brush of the pocosin after drying is discussed along with the various previous and current soil analyses. It is concluded that the effects of mechanical clearing followed by decreasing hydration were probably the most important factors involved in *Surruceniu* reaction. [AA].

Sarracenia flava (0), Surruceniupurpureu ssp. *venosa (0), Surruceniu rubru* ssp. *alabamensis* (E), *Surruceniu rubru* ssp. *jonesii* (E).

77. SCHWARTZ, M. W., AND S. HERMAN. 1991. The role of fire suppression in the catastrophic decline of the endangered conifer, *Torreyu tuxifoliu.* Bulletin of the Ecological Society of America 72:244.

[The authors] present evidence that fire suppression may have contributed to the fungal decline of torreya *(Torreyu tuxifoliu).* During the 1950s torreya suffered a catastrophic die-back. The torreya die-back was probably caused by needle pathogens induced through environmental stress. Several environmental stresses were concurrent with the decline of the torreya. One of these stresses may have been fire suppression. Torreya grows within ravines, where fires usually do not occur. However, smoke from the frequent natural upland fires settled into ravines. [The authors] present data showing that several needle pathogens isolated from torreya have reduced germination and growth rates on substrates treated with smoke. Succession, as a result of fire suppression, also reduced light incidence within ravines. [The authors] show that torreya growth is correlated with light incidence. [The authors] discuss the fire hypothesis in the context of other hypotheses for the torreya decline. [AA].

Torreyu tuxifoliu is known from Florida and Georgia.

Torreyu tuxifoliu (E)

78. SHAFFER, K. 1993. Report to the Fish and Game Commission on the status of Vail Lake ceanothus *(Ceunothus ophiochilus).* Natural Heritage Division Status Report #93-3. Unpublished.

Like many other members of the *Ceunothus* genus, C. *ophiochilus* is an obligate seeder. Germination of its seeds requires heat or scarification, making C. *ophiochilus* fire dependent. The season, frequency, intensity, and duration of the fires are important variables in the long-term viability of the species. The maintenance of populations of members of the Cerastes section of the *Ceunothus* genus, of which C. *ophiochilus* is a member, require high-intensity tires at long intervals. This species is particularly well adapted to the duration and frequency of fires, which occur in summer and late fall.

Ceunothus ophiochilus is known from California.

Ceunothus ophiochilus (C2)

79. SMITH, I. 1992. Element stewardship abstract for *Lysimuchiu usperulifoliu. The* Nature Conservancy, Chapel Hill, N. C. Unpublished.

Lysimuchiu usperulifoliu is shade intolerant and requires a regular fire regime. However, the effect of the season of bums on populations of this species is not known. The North Carolina Office of the Nature Conservancy initiated a long-term study of the effects of fire on *L. usperulifoliu* in 1987. Studies at the Green Swamp Preserve, North Carolina, revealed that fires may stimulate the flowering of the species.

Lysimuchiu usperulifoliu (E)

80. SMITH, W. 1994. The Nature Conservancy, Minneapolis, Minn. Personal communication.

The Minnesota field office of The Nature Conservancy has been monitoring the effects of prescribed burning on *Plutuntheruprueclur* and *Lespedeza leptostuchyu.* As of 1994, 10 years of data were collected but will not be synthesized or available for approximately 5 years.

Lespedeza leptostachya (E), *Platanthera praeclara* (T)

81. SOBLO, D. *1994.* The Nature Conservancy, Columbia, S.C. Personal communication.

Fire is extremely important for *Oxypolis canbyi,* which occurs in habitat with a regular tire frequency. The Nature Conservancy observed an increase from fewer than 50 individuals to more than 200 after a hot wildfire in 1980. Since the 1980s, the same population decreased to approximately 10 plants. The Nature Conservancy is planning to research the effects of fire frequency, intensity, and season of bum on 0. *canbyi.*

Oxypolis canbyi (E)

82. STONE, C. P., AND J. M. SCOTT. 1985. Hawaii's terrestrial ecosystems:preservation and management. Cooperative National Park Resources and Studies Unit, University of Hawaii, Manoa, Hawaii.

This book covers various aspects of species conservation and preservation in Hawaii. Several chapters provide relevant information on fire and the habitat of federally listed species. However, no species-specific effects of fire are mentioned. Because the frequency of natural tires before human habitation was relatively low, fire is detrimental to most of the native plants of the islands. Fire has also played a key role in encouraging the spread of non-native species in Hawaii.

83. SUTTER, R. D. 1994. Summary of "The effect of varied fire frequency on *Lysimachia asperulifolia"* study in North Carolina, 1987-1992. Unpublished Report to The Nature Conservancy, Chapel Hill, N.C. Unpublished.

The North Carolina Office of The Nature Conservancy performed a 5-year study to measure the response of *Lysimachia asperulifolia* to prescribed burning. Three treatment levels were assigned to 12 plots of variable size: bum every year, bum every other year, and bum every fourth year. The effects of the treatments did not differ.

Lysimachia asperulifolia (E)

84. THOMAS, P. A. 1988. Mechanisms by which cacti persist in tire-prone habitats of Arizona. Preliminary Report to the British Ecological Society. Unpublished.

Fourteen months after a prescribed bum, Thomas examined the effect of fire on several species of cacti. The mortality of *Echinocereus pectinatus* 14 months after the fire was 12% higher than on a control site but was only 4% higher immediately after the fire. Cacti can make use of internal reserves for months or years despite being severely damaged. Cactus plants that survived burning recovered primarily by regrowth from the apex. Regrowth was often prolific. Flower production after burning was the same or better than on unburned control sites.

Echinocereus pectinatus (0)

85. THOMAS, P. A. 1991. Response of succulents to tire: a review. International Journal of Wildland Fire 1: 1 1–22.

Many succulents live in fire-prone habitats with fire frequencies ranging from l-3 years (Canadian Prairies) to >250 years (Sonoran Desert). Mortality after tire is often >50% but rarely total. A few plants are left unburnt in refugia but most cacti and leaf succulents persist by survival of the apical meristem, an adaptation to the normal climate of such habitats. Similarly, reproduction is governed by weather patterns, not fire. Apex survival is critical because growth from other meristems (above or below ground) is rare except in the leaf succulents, *Agave* and *Aloe.* Survival is consequently dependent upon the frequency and intensity of fire. [AA].

Echinocereus triglochidiatus (E)

86. THOMAS, L. 1994. Wilson's Creek National Battlefield, National Park Service, Republic, Missouri. Personal communication.

During four seasons, Thomas collected data on tire and *Lesquerella filiformis. Lesquerella filiformis,* a winter annual, experienced high mortality in response to bums in spring but demonstrated no distinct response to bums in late summer. However, the treatment plots were small (3 x 3 meters), and the intensity of the fire was low. A second study incorporated larger plot sizes (15 x 15 meters), a bum of the entire community, and fires in late summer. Although the data have not yet been analyzed, Thomas observed that fires in June caused no distinct response on *L. filiformis,* but tires in late August produced a flush of germination. Because the population size of *L. filiformis* is intensely variable from year to year, it is difficult to attribute this flush of germination to the late August tires.

Lesquerella filiformis (E)

87. TROUP, R. L., AND S. MCDANIEL. 1980. Current status report on *Sarracenia oreophila.* Washington D.C.

Office of Endangered Species. U.S. Fish and Wildlife Service. Unpublished.

Sarracenia oreophila reproduces primarily by vegetative means, with seedlings found only in a few populations. Species appear to be adapted to fire with an increase in flowering after fire and an increase in population size in sites managed by fire. [PA].

Sarracenia oreophila is known from Alabama, Georgia, and Tennessee.

Surruceniu oreophilu (E)

88. U.S. FISH AND WILDLIFE SERVICE. 1979. Determination that three Hawaiian plants are endangered species. Federal Register 44(211):62468–62469.

Accidental tires set by hunters or the military destroyed vegetation surrounding *Stenogyne angustifolia var. angustifolia*, *Huplostuchys haplostuchya var. ungustifoliu,* and *Lipochuetu venosu.* Fires may destroy established plants and thereby create open habitat and promote invasion by exotic species that harm native taxa. The three species were extirpated in part of their range by these processes.

Huplostuchys huplostuchya var. ungustifoliu (= H. haplostachya) (E), *Lipochuetu venosu* (E), *Stenogyne angustifolia* var. *ungustifoliu* (E)

89. U.S. FISH AND WILDLIFE SERVICE. 1982. Tennessee coneflower recovery plan. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Fire is a natural and common phenomenon in cedar glades because of frequent dry conditions. How *Echinacea tennesseensis* responds to tire is not known, but deep, fibrous taproots enable the plant to survive low-temperature bums of short duration that often occur in the glades. *Echinuceu tennesseensis* may also benefit from reduced competition caused by fire. The recovery plan recommends that observations of the effects of fire on *E. tennesseensis* be made over many years to determine long-term effects.

Echinuceu tennesseensis is known only from Tennessee.

Echinuceu tennesseensis (E)

90. U.S. FISH AND WILDLIFE SERVICE. 1983a. Harper's beauty recovery plan. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Harperocallis flava is found in and adjacent to open bogs. In one location, its habitat is surrounded by longleaf pine (*Pinus palustris*) woods, which occasionally bum. The U.S. Forest Service has managed the habitat of *H. flava* since 1983.

Harperocallis flava is known only from Florida.

Harperocallis flava (E)

9 1. U.S. FISH AND WILDLIFE SERVICE. 1983b. Mountain golden heather recovery plan. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Limited to quartzite ledges and outcrops, *Hudsoniu montuna* depends on fire to decrease competition. Two other species of *Hudsoniu* respond favorably to light fire, suggesting *H. montana* may as well. The recovery plan recommends that research be conducted to determine *H. montunu's* relation to fire.

Hudsoniu montunu is known only from North Carolina.

Hudsonia montunu (T)

92. U.S. FISH AND WILDLIFE SERVICE. 1983c. Recovery plan for Chapman's rhododendron. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Rhododendron chupmunii occurs in scrubby flatwoods that are exposed to frequent fires. *Rhododendron chupmunii* vigorously resprouts from roots or from the base when the tops of the plants are killed by fire or cutting. The absence of fire increased competition between *R. chupmunii* and other associated scrub species that may not be as well adapted to fire.

Rhododendron chupmanii is known only from Florida.

Rhododendron chupmunii (E)

93. U.S. FISH AND WILDLIFE SERVICE. 1983d. Rule to list *Punicum carteri* (Carter's panicgrass) as an endangered species and determine its critical habitat. Federal Register 48(198):46328–46333.

Panicum carteri (Punicumfuuriei var. *carteri*) inhabits dry lowland habitats on Mokoli'i, Hawaii, and is primarily threatened by stochastic extinction. A single fire or act of vandalism could deplete or destroy the single known population.

Punicum fuuriei var. *carteri* (E)

94. U.S. FISH AND WILDLIFE SERVICE. 1984a. Determination of endangered status and critical habitat for *Kokiu drynarioides* (koki'o). Federal Register 49(234):47397–47401.

Kokiu drynarioides occurs in forested habitat on the island of Hawaii, Hawaii. This single population of *K. drynarioides* is threatened by fires near or in its habitat. The recent invasion of *Pennisetum setaceum* (fountain grass) inhibited *K. drynarioides* regeneration and increased the frequency, intensity, and extent of fires in and around its habitat.

Kokia drynarioides (E)

95. U.S. FISH AND WILDLIFE SERVICE. 1984b. Determination of endangered status for *Jutropha costuricensis* (Costa Rican jatropha). Federal Register 49(146):30199–30201.

Dry season fires, often started by vandals and carried by dry conditions, threaten *Jatropha costaricensis* with extinction.

Jutropha costuricenis is known only from Costa Rica.

Jutropha costuricensis (E)

96. U.S. FISH AND WILDLIFE SERVICE. 1984c. Final rule to list *Bidens cuneata* and *Schiedea adamantis* as endangered species. Federal Register 49(34):6099-6101.

Bidens cuneata and *Schiedea adamantis are* known from one small population on the rim of the Diamond Head crater in Honolulu, Hawaii. Fires pose a significant threat to both of these taxa, especially during the dry season (April through September). *Schiedea adamantis* is especially susceptible to fire because of its location on windward slopes. Fire could cause the extinction of S. *adamantis* through either the immediate mortality of established individuals or eradication of available habitat.

Bidens cuneata (= B. molokaiensis) (E), *Schiedea adamantis* (E)

97. U.S. FISH AND WILDLIFE SERVICE. 1984d. Hairy rattleweed recovery plan. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

The large perennial rootstock of *Baptisia arachniferu* is characteristic of a fire-tolerant species and suggests that fire is important for maintaining favorable habitat for this species. The recovery team recommended experimental burns to test the frequency, intensity, and season of bum that are appropriate for *B. arachnifera*. Fire management may help reduce competition and promote seedling establishment.

Baptisia arachnifera is known only from Georgia.

Baptisia arachniferu (E)

98. U.S. FISH AND WILDLIFE SERVICE. 1984e. Navasota ladies'-tresses recovery plan. U.S. Fish and Wildlife Service, Albuquerque, N.Mex. Unpublished.

Spiranthes parksii is part of a subclimax community type. Therefore, the persistence of habitat of S. *parksii* may require disturbances, such as fire or grazing. In the absence of disturbance, succession would proceed to another seral stage, eliminating habitat for S. *parksii.*

Spiranthes parksii is known only from Texas.

Spiranthes parksii (E)

99. U.S. FISH AND WILDLIFE SERVICE. 1984f. Raven's manzanita recovery plan. U.S. Fish and Wildlife Service, Rockville, Md. Unpublished.

Fire maintains the coastal chaparral and coastal scrub communities where *Arctostaphylos hookeri* ssp. *ravenii occurs.* The species may require fire to break the dormancy of its seeds or to prepare a seed bed. The authors recommend that more specific information about the effects of fire on *A. hookeri* ssp. *ravenii* be established.

Arctostaphylos hookeri ssp. *ravenii* is known only from California.

Arctostaphylos hookeri var. ravenii (E)

100. U.S. FISH AND WILDLIFE SERVICE. 1984g. Recovery plan for the endangered and threatened species of the California Channel Islands. U.S. Fish and Wildlife Service, Portland, Oreg. Unpublished.

Delphinium variegatum ssp. *kinkiense,* known from at least seven grassland sites, is thought to be adapted to fires, which occur during its dormant season. *Delphinium variegatum* ssp. *thornei* is known from two grassland sites on the San Clemente Island. Because other species of *Delphinium* respond favorably to fire, both of these species may be similarly adapted.

Delphinium variegatum ssp. *kinkiense* and *D. variegatum* ssp. *thornei are* known only from California.

Delphinium variegatum ssp. *kinkiense* (E), *Delphinium variegatum* ssp. *thornei (C* 1)

101. U.S. FISH AND WILDLIFE SERVICE. 1984h. *Viciu menziessii* recovery plan. U.S. Fish and Wildlife Service, Portland, Oreg. Unpublished.

Although the decline of *Vicea menziessii* was primarily caused by grazing, the authors also mention the

role of forest fires and logging in the reduction of suitable habitat on Mauna Kea, Hawaii.

Vicia menziessii (E)

102. U.S. FISH AND WILDLIFE SERVICE. 1985a. Determination of threatened status for *Ribes echinellum* (miccosukee gooseberry). Federal Register 50(133):29338-29341.

Known from Florida and South Carolina, *Ribes echinellum* exists only in two small populations. Because of its small numbers and narrow distribution, fires and other disturbances pose a significant threat to this species. Lightning fires are frequent in this region and threaten this taxa with extinction.

Ribes echinellum (T)

103. U.S. FISH AND WILDLIFE SERVICE. 1985b. Determination that *Amsinckia grandijlora* is an endangered species and designation of critical habitat. Federal Register 50(89): 19374-19377.

Amsinckia grandijlora occurs in grassland habitat in northern California. Controlled bums near *A. grandiflora* habitat may have adverse effects on the plant. The California Native Plant Society suggested that controlled bums may help suppress competing exotic species and may be beneficial to *A. grandiflora.*

Amsinckia grandiflora (E)

104. U.S. FISH AND WILDLIFE SERVICE. 1985c. Final rule to determine *Buxus vahlii* (Vahl's boxwood) as an endangered species. Federal Register 50(156): 32572-32574.

Fire is a significant threat to *Buxus vahlii,* which occurs in semi-evergreen seasonal forests in northern and northwestern Puerto Rico. During the dry season, *B. vahlii* habitat is susceptible to fire. The increase in beach use by surfers and campers may cause accidental fires that may spread to *B. vahlii* habitat.

Buxus vahlii (E)

105. U.S. FISH AND WILDLIFE SERVICE. 1985d. Santa Barbara Island liveforever *(Dudleya traskiae)* recovery plan. U.S. Fish and Wildlife Service, Portland, Oreg. Unpublished.

Dudleya traskiae is a part of the coastal sage scrub community. Anthropogenic activities such as fire, grazing, cultivation, and construction altered the natural structure of communities on the Santa Barbara Islands. Although Native Americans used fire in much of the coastal region of California and the Channel Islands, the role of fire on the Santa Barbara Islands is not known. Fire-adapted genera such as *Adenostoma* and *Ceanothus are* absent from the island, suggesting that fire has been infrequent. Furthermore, *D. traskiae* habitat is primarily steep rocky slopes that do not carry fire. However, a fire in 1959 burned two-thirds of the island and caused the decline of the exotic species *Gasoul (Mesembryanthemum) crystallinum.* Fire may be employed to reduce the spread of this exotic plant, which competes heavily with *D. traskiae.*

Dudleya traskiae (E)

106. U.S. FISH AND WILDLIFE SERVICE. 1986a. Determination of endangered status for *Abutilon menziessii* (ko'oloa'ula). Federal Register 51(187):34412-34415.

Known from only three small populations, *Abutilon menziesii* is threatened by fire, especially during dry periods. A single fire could destroy an entire population.

Abutilon menziesii is known only from Hawaii.

Abutilon menziesii (E)

107. U.S. FISH AND WILDLIFE SERVICE. 1986b. Determination of endangered status for *Hibiscadelphus distans* (Kauai hau kuahiwi). Federal Register 51(82):15903–15905.

Hibiscadelphus distans is threatened by fire because of the proximity of its single population to a fire pit. This danger is exacerbated by drought and fuel buildup during the dry season.

Hibiscadelphus distans is known only from Hawaii.

Hibiscadelphus distans (E)

108. U.S. FISH AND WILDLIFE SERVICE. 1986c. Determination of endangered status for *Scutellaria montana* (large-flowered skullcap). Federal Register 51(119):22521–22524.

Scutellaria montana is primarily threatened by anthropogenic changes in its habitat. These changes are caused by logging, wildfire, and residential development. Fire adversely affects this taxa.

Scutellaria montana is known only from Georgia and Tennessee.

Scutellaria montana (E)

109. U.S. FISH AND WILDLIFE SERVICE. 1986d. Sneed and Lee pincushion cacti *(Corypantha sneedii var. sneedii* and *Corypantha sneedii var. leei*) recovery plan. U.S. Fish and Wildlife Service, Albuquerque, N.Mex. Unpublished.

Coryphuntha sneedii var. leei is restricted to the Tansil Limestone Formation in eastern New Mexico and western Texas. Interspecific competition in this limited habitat is intense. As a result, a tire could destroy C. *sneedii var. leei.* Fire may increase mortality but may benefit the species if it reduces or eliminates competition from other species. Controlled experiments are needed to determine the effect of fire on C. *sneedii var. leei* and C. *sneedii var. sneedii.* Until more is known about tire and *Coryphantha* species, prescribed burns should be directed away from these species.

Coryphunthu sneedii var. leei (= Escoburiu sneedii var. leei) (E), *Coryphunthu sneedii var. sneedii (= Escoburiu sneedii var. sneedii)* (E)

110. U.S. FISH AND WILDLIFE SERVICE. 1987a. Determination of endangered status for *Cupressus abramsiana* (Santa Cruz cypress). Federal Register 52(5):675–679.

Cupressus ubrumsiunu groves have been shaped by periodic fires. Cones of this species are serotinous and may not open until exposed to tire. Human development, logging, and recreation altered the frequency of natural fires in C. *ubrumsiunu* habitat. When fires are too frequent, trees are not able to reach seed-bearing age before the next fire. Because C. *ubrumsiunu* cannot resprout, the grove may be unable to survive frequent fires. However, if the fire interval is too long, competing plants become established, constricting or destroying entire groves. The natural tire frequency is an estimated 50-100 years.

Cupressus ubrumsiunu is known only from California.

***Cupressus** ubrumsiunu (E)*

111 .U.S. FISH AND WILDLIFE SERVICE. 1987b. Recovery plan for three Florida mints. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Dicerundru immaculutu, D. cornutissima, and *D. frutescens* depend on habitat of bare sand that borders scrub vegetation. Their habitat requirements suggest that these mints may benefit from occasional fires that occur in the sand pine and scrub oak communities. Protected sites should be kept open by prescribed burning, cutting, brush-hogging, or maintenance of fire lanes.

Dicerundru cornutissimu (E), *Dicerundru frutescens* (E), *Dicerundru immuculutu* (E)

112. U.S. FISH AND WILDLIFE SERVICE. 1988a. Recovery plan for a rare prairie bush-clover (*Lespedeza leptostuchyu).* U.S. Fish and Wildlife Service, Twin Cities, Minn. Unpublished.

Prescribed bums may be useful for the control of encroaching shrubs and trees in the habitat of *Lespedeza leptostuchyu,* but the direct effects of fire on this species are not known. If tire is used in management, it should be restricted to early spring (before May 15) to avoid destroying seedlings. If bums in spring are ineffective in controlling shrubs, some other form of management such as cutting by hand may be necessary. No more than half of any population should be burned or cut in any one year. Several populations of *L. leptostuchyu* were mowed, burned, or grazed, but no specific studies of the effects of these treatments were conducted.

Lespedeza leptostuchyu is known only from Illinois, Iowa, Minnesota, and Wisconsin.

Lespedezu leptostuchyu (E)

113. U.S. FISH AND WILDLIFE SERVICE. 1988b. Recovery plan for five pine rockland plant species. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Pine rocklands in Florida are kept in a sub-climax seral stage by fire, which suppresses hardwood growth and maintains an open canopy. The recovery team recommended experimentation with varying fire intervals to maintain pine dominance, suppress hardwoods, and create more habitat for *Euphorbiu deltoideu* ssp. *deltoideu, E. garberi, Amorphu crenulata, Guluctiu smullii,* and *Polygala smullii.*

Amorphu crenulatu (= A. herbuceu var. crenulatu) (E), *Euphorbiu deltoideu* ssp. *deltoideu (= Chamaesyce deltoideu* ssp. *deltoideu) (0), Euphorbiu garberi (= Chamaesyce gurberi) (0), Guluctiu smullii* (E), *Polygala smullii* (E)

114. U.S. FISH AND WILDLIFE SERVICE. 1988c. Recovery plan for Florida golden aster. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Chrysopsis floridana occurs in sand pine scrub vegetation. All sites where C. *floridana* presently occurs have been disturbed by either bulldozing, pedestrian traffic, grazing, or fire. Although *C. floridana* benefits from limited disturbance, intense disturbance may

eliminate the species and its habitat. Management should include low-intensity disturbance such as prescribed bums but should exclude excessive disturbance.

Chrysopsis floridana is known only from Florida.

Chrysopsis floridana (E)

115. U.S. FISH AND WILDLIFE SERVICE. 1988d. Short's goldenrod recovery plan. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

The historic range of *Solidugo shortii* may be related to the open habitat created by bisons *(Bison bison)* and by tire. Since settlement, secondary succession occurred in the absence of these types of natural disturbance. *Solidago shortii* habitat disappeared as a result of these changes in the vegetation and continues to be threatened by increased woody cover.

Solidago shortii is known only from Kentucky.

Solidago shortii (E)

116. U.S. FISH AND WILDLIFE SERVICE. 1989a. Alabama leather flower recovery plan. U.S. Fish and Wildlife Service, Jackson, Miss. Unpublished.

Clematis socialis occurs in natural and anthropogenic openings of a grass-sedge-rush community in northeastern Alabama. This species may benefit from limited disturbance, which creates an early successional stage or open habitat. Prescribed burning at a site that is managed by The Nature Conservancy in St. Clair County suppressed competing vegetation.

Clematis socialis (E)

117. U.S. FISH AND WILDLIFE SERVICE. 1989b. Heller's blazing star recovery plan. U.S. Fish and Wildlife Service, Atlanta. Ga. Unpublished.

The effects of tire on *Liutris helleri are* not known, however, other species in the genus *Liutris* depend on disturbance for the maintenance of their early successional habitat. The recovery team recommends that the effects of past and current disturbances on *L. helleri be* studied.

Liutris helleri is known only from North Carolina.

Liatris helleri (T)

118. U.S. FISH AND WILDLIFE SERVICE. 1989c. Sandplain gerardia (*Agalinis acutu)* recovery plan. U.S. Fish and Wildlife Service, Newton Corner, Mass. Unpublished.

Agalinis acuta may require regular disturbance to maintain viable populations over time. Locations of all extant populations of *A. acutu* evidence various forms of disturbance, including small confined or sporadic fires. Fire suppression led to increased competition and cover by woody vegetation.

Agalinis acutu is known only from Connecticut, Massachusetts, Maryland, New York, and Rhode Island.

Agalinis acutu (E)

119. U.S. FISH AND WILDLIFE SERVICE. 1990a. Canby's dropwort recovery plan. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Oxypolis cunbyi occurs in bays or ponds with little or no canopy cover. Several populations of this species may require aggressive management, such as prescribed burning, to maintain open habitat conditions. Fire may also play a role in the interactions between 0. *cunbyi* and associated species.

Oxypolis canbyi is known only from Delaware, Georgia, Maryland, North Carolina, and South Carolina.

Oxypolis cunbyi (E)

120. U.S. FISH AND WILDLIFE SERVICE. 1990b. Harperella *(Ptilimnium nodosum)* recovery plan. US. Fish and Wildlife Service, Newton Comer, Mass. Unpublished.

Little is known about the habitat requirements of *Ptilimnium nodosum,* including the effects of fire and fire suppression.

Ptilimnium nodosum is known only from Alabama, Georgia, Maryland, North Carolina, South Carolina, and West Virginia.

Ptilimnium nodosum (E)

121. U.S. FISH AND WILDLIFE SERVICE. 1990c. Mountain sweet pitcher plant recovery plan. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Sarracenia rubra ssp. *jonesii* is dependent on boggy subclimax communities that are dominated by shrubs. In the past, these communities were kept open by drought, water fluctuation, climate extremes, fire, and other natural disturbances. Moderate fires cause reduced competition and induced flowering in other species of *Sarracenia*. By causing heavy litter accumulation and high intensity fires, fire suppression has not been favorable for S. *rubra* ssp. *jonesii* habitat. Experimentation should address the role of fire in maintaining S. *rubra* ssp. *jonesii*.

Sarracenia rubra ssp. *jonesii* is known only from North Carolina and South Carolina.

Sarracenia rubra ssp. *jonesii* (E)

122. U.S. FISH AND WILDLIFE SERVICE. 1990d. Peter's Mountain mallow *(Iliamna corei) recovery* plan. U.S. Fish and Wildlife Service, Annapolis, Md. Unpublished.

Known from only one site, *Iliamna corei* declined from 50 individuals in 1927 to 4 individuals in 1990. Because I. *corei* plants prefer open sites without competing vegetation, fire suppression may have increased competition from weedy plant species and decreased germination. Historical references indicate that *I.corei was* exposed to more direct sunlight in the past. Concern over the absence of regeneration sparked several studies on seed germination. Recent evidence suggests that heat and light stimulate germination. The author recommends further research into this topic.

Iliamna corei is known only from Virginia.

Iliamna corei (= Iliamna rivularis var. rivularis) (E)

123. U.S. FISH AND WILDLIFE SERVICE. 1990e. Recovery plan for eleven Florida scrub plant species. U.S. Fish and Wildlife Service, Jacksonville, Fla. Unpublished.

Fires historically occurred in Florida scrub vegetation at long intervals. *Bonamia grandiflora, Chionanthus pygmaeus, Eryngium cuneifolium, Hypericum cumulicola, Liatris ohlingerae, Lupinus aridorum, Paronychia chartacea, Prunus geniculata, Warea carteri,* and *Ziziphus celata* occur in scrub habitat in Florida and may require fire for long-term viability.

Bonamia grandiflora (T), *Chionanthus pygmaeus* (E), *Eryngium cuneifolium* (E), *Hypericum cumulicola* (E), *Liatris ohlingerae* (E), *Lupinus aridorum (= L. westianus* var. *aridorum)* (E), *Paronychia chartacea* (T), *Prunus geniculata* (E), *Warea carteri* (E), *Ziziphus celata* (E)

124. U.S. FISH AND WILDLIFE SERVICE. 1990f. Recovery plan for *Gouania hillebrandii* (Rhamnaceae). U.S. Fish and Wildlife Service, Portland, Oreg. Unpublished.

The authors express concern over the effects of fire on *Gouaniu hillebrandii.* Historically, brush fires, grazing, exotic species, and the development of agricultural land eliminated native vegetation throughout the Hawaiian islands. Both extant populations of G. *hillebrandii* may be vulnerable to extirpation from brush fire. The natural role of fire in this ecosystem is not well understood. Prior to human settlement, fire was not a major influence. Although fire has not been reported at either site, several grass species may be fuel for fire during the dry season. The authors recommend the protection of G. *hillebrandii* from brush fire.

Gouaniu hillebrandii (E)

125. U.S. FISH AND WILDLIFE SERVICE. 1990g. Recovery plan for the lakeside daisy *(Hymenoxys acaulis* var. *glabru).* U.S. Fish and Wildlife Service, Twin Cities, Minn. Unpublished.

Hymenoxys acaulis var. glabra requires open habitat. Past disturbances and post-settlement fire suppression created favorable conditions for the invasion by woody and exotic species. Little is known about the seed ecology of *H. acaulis var. glabru* or its response to prescribed burning. Restored populations of this species occur in state nature preserves, which are currently managed with prescribed burning. The effects of a bum in spring in the Lockport Prairie indicate that fire can kill emerging inflorescence buds and damage leaves. Permanent plots should be established in these burned areas to determine the specific effects on reproduction, plant growth, and general vigor.

Hymenoxys acaulis var. *glabra* is known only from Illinois, Ohio, and Ontario.

Hymenoxys acaulis var. glabra (= Tetraneuris herbacea) (T)

126. U.S. FISH AND WILDLIFE SERVICE. 1991a. Determination of endangered status for 26 plants from Waianae Mountains, island of Oahu, Hawaii. Federal Register 56(209):55770–55786.

Fire threatens 16 of the 26 taxa covered by this final rule. Plants that are upslope from the Makua Military Reservation and the Schofield Barracks are threatened by the large number of fires generated by military exercises. Because Hawaiian plants have rarely experienced fire, they are poorly adapted to fire and seldom recover from bums.

Abutilon sandwicense (E), *Centaurium sebaeoides* (E), *Chamaesyce celastroides var. kaenana* (E), *Chamaesyce kuwaleana* (E), *Dielliafalcata* (E), *Dubautia herbstobatae* (E), *Gouania meyenii* (E), *Lipochaeta lobata var. leptophylla* (E), *Lipochaeta tenuifoliu* (E), *Lobelia niihauensis* (E), *Neraudia angulata* (E), *Nototrichium humile*(E), *Sanicula mariversa* (E), *Schiedea kaalae* (E), *Tetramolopium filiforme* (E), *Urera kaalae* (E)

127. U.S. FISH AND WILDLIFE SERVICE. 1991b. Determination of endangered status for *Cyanea superba,* a

Hawaiian plant. Federal Register 56(176):46235-46238.

Cyunea superba exists in only two wild populations of less than 20 individuals. Therefore, C. *superba* is most seriously threatened by stochastic extinction caused by fires, pig damage, competition from non-native plants, and general habitat degradation.

Cyanea superba (E)

128. U.S. FISH AND WILDLIFE SERVICE. 1991c. *Dalea foliosa* (leafy prairie-clover) determined to be endangered. Federal Register 56(84):19953–19959.

Most populations of *Dalea foliosa* are currently threatened by adverse modification and destruction of habitat. Competitive woody and herbaceous species may invade and displace *D. foliosa* by competition. The maintenance of open habitat requires aggressive management. In Illinois, fire has been used to manage *D. foliosa* habitat. Results of this work are unavailable at this time.

Dalea foliosa is known only from Alabama, Illinois, and Tennessee.

Dalea foliosa (E)

129. U.S. FISH AND WILDLIFE SERVICE. 1991d. Determination of endangered status for five plants from the southern San Joaquin Valley. Federal Register 55(139): 29361-29370.

Caulanthus californicus, Eremalche kernensis, Eriastrum hooveri, Lembertia congdonii, and *Opuntia treleasei* inhabit the grassland and neighboring scrub communities of the San Joaquin Valley, California. The five species are threatened by the alteration of their natural tire regime. Exotic grasses, which compete for nutrients and water, may also threaten the native plants by providing finer, more flammable fuels, thereby increasing the frequency and intensity of fire.

Caulanthus californicus (= Stanfordia californica) (E), *Eremalche kernensis (= E. parryi* ssp. *kernensis)* (E), *Eriastrum hooveri* (E), *Lembertia congdonii* (E), *Opuntia treleasei (= 0. basilaris var. treleasei)* (E)

130. U.S. FISH AND WILDLIFE SERVICE. 1991e. Determination of endangered status for *Isodendrion hosakae* (aupaka), a Hawaiian plant. Federal Register 56(9):1454–1457.

Like most other native Hawaiian taxa, *Isodendrion hosakae* (aupaka) is harmed by fire. Most of I. *hosakae* habitat is affected by cattle grazing. Range tires also pose a serious threat to this species, especially during the dry season.

Isodendrion hosakae (E)

13 1. U.S. FISH AND WILDLIFE SERVICE. 199 1 f. Determination of endangered status for six plants from the island of Lanai, Hawaii. Federal Register 56(183):47686-47694.

Tetramolopium remyi and *Abutilon eremitopetalum are* threatened by fire. These species grow on dry, low elevation ridges where fires occur. A single tire could have a devastating effect on populations of either species.

Abutilon eremitopetalum (E), *Tetramolopium remyi* (E)

132. U.S. FISH AND WILDLIFE SERVICE. 1991g. Determination of endangered status for the plant *Sisyrinchium dichotomum* (white irisette). Federal Register 56(187):48752–48754.

Maintenance of the open habitat of *Sisyrinchium dichotomum* depends on disturbance. Periodic fires and grazing historically provided this disturbance. Fires seem to reduce competition from woody species and remove the litter layer, allowing germination and survival of seedlings. The four remaining populations of this species exist in disturbed habitat, indicating that fire may be important for this species. *Sisyrinchium dichotomum* is known only from North Carolina.

Sisyrinchium dichotomum (E)

133. U.S. FISH AND WILDLIFE SERVICE. 199 1 h. Determination of endangered status for two Na Pali coast plants: *Hedyotis st. johnii* (Na Pali Beach hedyotis) and *Schiedea apokremnos* (Ma'oli'oli). Federal Register 56(189):49639–49634.

Fire is an immediate threat to *Hedyotis st. johnii* and *Schiedea apokremnos.* During dry conditions, fires started by humans spread rapidly in the habitat of these two species. Also, stochastic events, such as tire, threaten to destroy the remaining populations.

Hedyotis st. johnii and *Schiedea apokremnos* are known from Hawaii.

Hedyotis st. johnii (E), *Schiedea apokremnos* (E)

134. U.S. FISH AND WILDLIFE SERVICE. 199 li. Final rule to list the plant *Phlox nivalis* ssp. *texensis* (Texas trailing

phlox) as endangered. Federal Register 56(189):49636–49639.

Phlox nivalis ssp. *texensis occurs* in grassy openings dominated by longleaf pine. Because these openings were historically maintained by frequent fires, fire suppression reduced *P. nivalis* ssp. *texensis* habitat by allowing woody species to invade. Prescribed burning on The Nature Conservancy property enhanced habitat for this species.

Phlox nivalis ssp. *texensis* is known only from Texas.

Phlox nivalis ssp. *texensis* (E)

135.U.S. FISH AND WILDLIFE SERVICE. 1991j. *Helianthus schweinitzii* (Schweinitz's sunflower) determined to be endangered. Federal Register 56(88):21087-21091.

Helianthus schweinitzii is threatened by adverse modification and destruction of its habitat. Approximately one third of the known populations of *H. schweinitzii are* extirpated, mainly because of fire suppression and grazing suppression. Fire, grazing, controlled burning, or other disturbance is necessary to maintain the prairie remnants, which compose *H. schweinizii* habitat. In the absence of disturbance, woody species encroach on *H. schweinitzii* habitat and inhibit the plant by competition. Of the 15 remaining populations, 11 are in disturbed areas.

Helianthus schweinitzii is known only from North Carolina and South Carolina.

Helianthus schweinitzii (E)

136.U.S. FISH AND WILDLIFE SERVICE. 1991k. Recovery plan for Mohr's Barbara's buttons. U.S. Fish and Wildlife Service, Jackson, Miss. Unpublished.

Marshallia mohrii typically occurs in moist, prairie-like openings of woodlands in the southeastern United States. These openings were historically maintained by occasional fire. *Clematis socialis* and *Sarracenia oreophila* often occur with *M. mohrii* and occur in habitat that is characterized by frequent tires. Managers should address the problems associated with competing woody species and should experiment with the use of prescribed burning with various intervals and seasons.

Clematis socialis (E), *Marshallia mohrii* (T), *Sarracenia oreophila* (E)

137.U.S. FISH AND WILDLIFE SERVICE. 19911. *Stephanomeria malheurensis* (Malheur wire lettuce) recovery plan. U.S. Fish and Wildlife Service, Portland, Oreg. Unpublished.

Stephanomeria malheurensis is known from a single site in the big sagebrush community of Hamey County, Oregon. The site is dominated by sagebrush *(Artemisia tridentata)* and cheatgrass *(Bromus tectorum),* an exotic species. Cheatgrass rapidly colonizes sagebrush areas after fire. *Stephanomeria malheurensis* does not compete well with cheatgrass. A fire lane was established and maintained around critical S. *malheurensis* habitat to enhance the plants' survival. The author recommends experimental bums to determine the effects of fire on the growth and reproduction of S. *malheurensis.*

Stephanomeria malheurensis (E)

138.U.S. FISH AND WILDLIFE SERVICE. 1992a. Agency draft Alabama canebrake pitcher plant recovery plan. U.S. Fish and Wildlife Service, Jackson, Miss. Unpublished.

Sarracenia rubra ssp. *alabamensis,* known from 12 sites in seeps, bogs, and swamps in central Alabama, depends on the maintenance of early successional habitat in which competing woody vegetation is suppressed. Historically, natural fires controlled these woody species and maintained open habitat for S. *rubra* ssp. *alabamensis.* Fire suppression and the encroachment of woody species remain a severe threat to existing populations. Management should be focused on controlling woody vegetation through mowing, pruning, and burning.

Sarracenia rubra ssp. *alabamensis* (E)

139.U.S. FISH AND WILDLIFE SERVICE. 1992b. Blowout penstemon *(Penstemon haydenii)* recovery plan. U.S. Fish and Wildlife Service, Denver, Colo. Unpublished.

Penstemon haydenii is restricted to blowouts in the sandhills of Nebraska. Historically, fires eliminated stabilization of the vegetation from the sand dunes, allowing blowouts. In the absence of fires, vegetation has advanced and stabilized the dunes, resulting in a decline in suitable habitat for *P. haydenii.* Research should address the use of fire and grazing for management.

Penstemon haydenii (E)

140.U.S. FISH AND WILDLIFE SERVICE. 1992c. Determination of endangered status for 16 plants from the island of Molokai, Hawaii. Federal Register 57(196):46325–46344.

Fire is a major threat to native plant species in dry to mesic habitats on the island of Molokai. Fire not only

can kill native plants but encourage competition from exotic fire-adapted species with native taxa that cannot tolerate fire. Although one species listed here, Silene *lanceolata*, may be tolerant of fire, the exotic grasses compete with the native plant after burns. This process is converting shrubland to grassland. Fire is a serious threat to *Bidens weibkei, Pritchardia munroi, Scheidea lydgatei, Silene alexandri*, *Silene lanceolata,* and *Tetramolopium rockii.*

Bidens weibkei (E), *Pritchardiu munroi* (E), *Scheidea lydgatei* (E), *Silene alexandri* (E), *Silene lanceolata* (E) and *Tetramolopium rockii* (T)

141. U.S. FISH AND WILDLIFE SERVICE. 1992d. Endangered status for *Schwalbea americana* (American chaffseed). Federal Register 57(189):44703–44708.

Schwalbea americana, known from the eastern United States, is dependent on disturbance such as fire, mowing, or fluctuating water to create open habitat. Historically, the species occupied openings created by fire in savannas and pinelands. *Schwalbea americana* grows vigorously at sites that were burned. Although fire is integral to the long-term viability of S. *americana,* it may be important in ways that are not yet understood. In the past, fires may have been frequent and of low intensity. Questions remain about the timing, frequency, and intensity of fires required by this species.

Schwalbea americana (E)

142. U.S. FISH AND WILDLIFE SERVICE. 1992e. Large-fruited sand-verbena *(Abroniu macrocarpa)* recovery plan. U.S. Fish and Wildlife Service, Albuquerque, N. Mex. Unpublished.

Abronia macrocarpa occurs in post oak savanna. Human activities have suppressed fire and other natural disturbances, reducing the number of these natural openings. The authors recommend further research on the genesis of these openings, their frequency, and their seral stage.

Abronia macrocarpa is known only from Texas.

Abronia macrocarpa (E)

143. U.S. FISH AND WILDLIFE SERVICE. 1992f. Kniesker's beaked-rush *(Rhynchosporu knieskernii)* recovery plan. U.S. Fish and Wildlife Service, New Jersey Field Office, Pleasantville, N.J. Unpublished.

Rhynchospora knieskemii requires early successional habitat and is generally found on bare substrates with open vegetation. Periodic fire may have maintained populations of this plant. One extant population of *R. knieskernii* exists on a burned pitch pine site. Before settlement, fires occurred in the pitch pine *(Pinus rigidu)* forests of the pine barrens community. Further experimentation on the effects of habitat disturbance by fire, mowing, and water fluctuation are recommended by the author.

Rhynchosporu knieskernii is known only from Delaware and New Jersey.

Rhynchosporu knieskernii (T)

144. U.S. RSH AND WILDLIFE SERVICE. 1992g. White bladderpod (*Lesquerella pallida)* recovery plan. U.S. Fish and Wildlife Service, Albuquerque, N.Mex. Unpublished.

Lesquerella pallida occurs in eastern Texas. This species is primarily threatened by the invasion of woody and herbaceous plants. Some of the competitive species are native to this region and in the past were controlled by a natural fire regime. Introduced shrubs also compete with L. *pallida* for open habitat. The use of fire or brush-hogging may improve habitat by helping control woody and herbaceous species. Studies of fire, shading, competition, and grazing should be initiated because these factors significantly affect populations of *L. pallida.*

Lesquerella pallida (E)

145. U.S. FISH AND WILDLIFE SERVICE. 1993a. Agency draft recovery plan for Cooley's meadowrue. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Thalictrum cooleyi grows in moist to wet savannas that are kept open by frequent natural fires or prescribed burns. Fire is currently used in several *T. cooleyi* habitats. However, information on the frequency and seasonality of fire best suited to *T. cooleyi* is not known.

Thalictrum cooleyi is known only from Florida and North Carolina.

Thalictrum cooleyi (E)

146. U.S. FISH AND WILDLIFE SERVICE. 1993b. Agency technical draft recovery plan for four plants of the lower Appalachicola region, Florida: *Euphorbia telephioides* (telephus spurge), *Macbridea alba* (white birds-in-a-nest), *Pinguicula ionantha* (Godfrey's butterworth), and *Scutellaria floridana* (Florida skullcap). U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Euphorbia telephioides, Macbridea alba, Pinguicula ionantha, and Scutellaria floridana inhabit poorly drained, coastal pinelands that are subject to periodic fires. The absence of fire during the dormant winter season is detrimental to much of the pineland flora. The U.S. Fish and Wildlife Service has used controlled burning to manage habitat for these species.

Euphorbia telephioides (T), *Macbridea alba* (T), *Pinguicula ionantha(T), Scutellaria floridana* (T)

147. U.S. FISH AND WILDLIFE SERVICE. 1993c. Bradshaw's lomatium recovery plan. U.S. Fish and Wildlife Service, Portland, Oreg. Unpublished.

Secondary succession is occurring in most open grassland habitats with *Lomatium bradshawii. The* recovery team recommends fire to control secondary succession because *L. bradshawii* responded well to fire in the past. Seasonality, frequency, and intensity of bums, the effects of tire on exotic species, and the effects of fire on other sensitive species associated with *L. bradshawii* should be considered prior to burning.

Lomatium bradshawii is known only from Oregon.

Lomatium bradshawii (E)

148. U.S. FISH AND WILDLIFE SERVICE. 1993d. Determination of endangered status for *Argyroxiphium kauense* (ka'u silversword). Federal Register 58(65): 18029-18041.

Argyroxiphium kauense, a Hawaiian endemic with only two extant populations, is threatened by stochastic extinction caused by lava flows or wildfires.

Argyroxiphium kauense (E)

149. U.S. FISH AND WILDLIFE SERVICE. 1993e. Determination of endangered status for three vernal pool plants and the riverside fairy shrimp. Federal Register 58(147):41384–41391.

Fire may harm several rare species that occur in the vernal pools of California. In summer 1992, one quarter of a *Pogogyne nudiuscula* population was burned, possibly resulting in seed damage.

Eryngium aristulatum var. parishii (E), *Orcuttia californica* (E), *Pogogyne nudiuscula* (E)

150. U.S. FISH AND WILDLIFE SERVICE. 1993f. Determination of endangered status for the plant pima pineapple cactus *(Coryphantha scheeri* var. *robustispina).* Federal Register 58(183):49875–49879.

Although *Coryphantha scheeri var. robustispina* occurs in semi-desert grasslands that experience frequent tires, little is known about the effect of fire on this species. Small cacti experience high mortality when exposed to high temperatures from tires. Mortality does not always occur immediately after tire but can be delayed for 1 year or longer. Resource managers at the Buenos Aires National Wildlife Refuge in Arizona use controlled burning to suppress non-native grasses and to encourage recovery of the bobwhite *(Colinus virginianus ridgwayi).* Some of these bums may affect C. *scheeri var. robustispina,* and refuge staff plan to collect survivorship information about this cactus. The cactus may survive fires by becoming established in open microsites that do not carry fire. The spread of non-native grass species converted many of these open spaces into grassland that is susceptible to fire. This transformation may leave fewer sites available for C. *scheeri* var. *robustispina.*

Coryphantha scheeri var. robustispina (E)

15 1 .U.S. FISH AND WILDLIFE SERVICE. 1993g. Determination of threatened status for *Sidalcea nelsoniana* (Nelson's checker mallow). Federal Register 58(28): 8235-8242.

Prairies inhabited by *Sidalcea nelsoniana* were historically maintained by fire. Because of recent fire suppression, much of S. *nelsoniana* habitat is invaded by non-native species that reduce habitat for S. *nelsoniana.* Fires occur at the sites with the most vigorous growth of S. *nelsoniana;* fire may be beneficial for managing this species.

Sidalcea nelsoniana is known only from Oregon.

Sidalcea nelsoniana (T)

152. U.S. FISH AND WILDLIFE SERVICE. 1993h. Determination of threatened status for the plant *Astrophytum asterias* (star cactus). Federal Register 58(199): 53804-53807.

Current management threatens the habitat of *Astrophytum asterias* that occurs in grasslands and shrublands of Texas and Tamaulipas, Mexico. Mechanical clearing, chemical clearing, exotic species, and suppression of the natural tire cycle harm the species and threaten to eliminate its habitat.

Astrophytum asterias (E)

153. U.S. FISH AND WILDLIFE SERVICE. 19933. Endangered and threatened status for five Florida plants. Federal Register 58(131):37432–37443.

Conradina glabra occurs in open areas of mixed hardwoods or pines (*Pinus* spp.), suggesting that it requires habitat that may be frequently burned. *Conradina brevifolia* are killed by fire but reproduce from seed. *Pinguicula ionantha* occurs in savanna vegetation maintained by frequent, low intensity fires. The frequency and season of bums are critical to many plant species that occur in the savanna, but the effects of fire on various taxa can be subtle. More research is required before effective fire management can be applied to conserve these species.

Conradina brevifolia (= C. canescens) (E), *Conradina glabra* (E), *Pinguicula ionantha* (T)

154. U.S. FISH AND WILDLIFE SERVICE. 1993j. Michaux's sumac recovery plan. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Rhus michauxii grows in sandy or rocky open woods, and the maintenance of its habitat depends on disturbance. Anthropogenic disturbances currently mimic the historic fires that kept the woods in a subclimax condition. Widespread fire suppression degraded habitat of *R. michauxii* and caused the loss of populations in several areas. Staff at Fort Bragg, a U.S. Department of Defense facility, manage a population of *R. michauxii* by burning its habitat every 3 years during the growing season.

Rhus michauxii is known only from Georgia, North Carolina, and South Carolina.

Rhus michauxii (E)

155. U.S. FISH AND WILDLIFE SERVICE. 1993k. Walker's manioc *(Manihot walkerae)* recovery plan. U.S. Fish and Wildlife Service, Albuquerque, N.Mex. Unpublished.

Manihot walkerae is primarily threatened by destruction and modification of its habitat. Mechanical and chemical disturbance and prescribed burning fragmented and eradicated the native brush that neighbored *M. walkerae* habitat since the early 1900s. However, fire may play a role in creating *M. walkerae* habitat or in promoting seed germination. The effect of fire on *M. walkerae* should be investigated in greater detail.

Manihot walkerae is known only from Texas and Mexico.

Manihot walkerae (E)

156. U.S. FISH AND WILDLIFE SERVICE. 19931. Regional news. Endangered Species Technical Bulletin 18(3). Unpublished.

Biologists of the Virginia Natural Heritage Program extended the known range of *Rhus michauxii* into Virginia and possibly discovered the largest population of this species. Frequent fires seem to create favorable habitat for *R. michauxii.* Natural Heritage Program staff are currently developing a management plan for the species in Fort Pickett, Virginia.

Rhus michauxii (E)

157. U.S. FISH AND WILDLIFE SERVICE. 1994a. Agency draft rough leaved loosestrife recovery plan. U.S. Fish and Wildlife Service, Atlanta, Ga. Unpublished.

Lysimachia asperulifolia occurs in the ecotone between longleaf pine (*Pinus palustris)* and shrub-dominated plant communities. The open habitat this species requires is maintained by periodic fires. Fire suppression is a threat to the survival of *L. asperulifolia.* Federal and state agencies and The Nature Conservancy personnel manage populations of *L. asperulifolia* with prescribed burning. The recovery team recommends further research on tire frequency.

Lysimachia asperulifolia is known only from North Carolina and South Carolina.

Lysimachia asperulifolia (E)

158. U.S. FISH AND WILDLIFE SERVICE. 1994b. Determination of endangered or threatened status for 2 1 plants from the island of Hawaii, state of Hawaii. Federal Register 59(43):10305–10325.

Pennisetum setaceum is a tire-adapted bunch grass that invaded much of the open areas and lava flows on the island of Hawaii since it was introduced there in the early 1900s. This exotic species disrupts plant regeneration, invades open areas, and alters the natural fire regime by carrying fires more frequently than they would naturally occur. *Pennisetum setaceum* threatens *Colubrina oppositifolia, Isodendrion pyrifolium, Nothocestrum breviflorum, Ochrosia kilaueaensis, Tetramolopium arenarium,* and *Zanthoxylum hawaiiense.* Exotic species are often better adapted to fire than native species and invaded much of Hawaii's shrubland. The presence of these alien species during the dry season or during drought, increases the extent, intensity, and frequency of fires. Fires can destroy the seed bed and entire plants. Fire is a threat to C. *opposi-*

tifolia, I. pyrifolium, N. breviflorum, 0. kilaueaensis, P. sclerocarpa, S. hawaiiensis, T. arenarium, and Z. *hawaiiense.*

Colubrina oppositifolia (E), *Isodendrion pyrifolium* (E), *Nothocestrum breviflorum* (E), *Ochrosia kilaueaensis* (E), *Portulaca sclerocarpa* (E), *Silene hawaiiensis* (T), *Tetramolopium arenarium* (E) and *Zanthoxylum hawaiiense* (E).

159. U.S. FISH AND WILDLIFE SERVICE. 1994c. Determination of endangered or threatened status for 24 plants from the island of Kauai, Hawaii. Federal Register 59(38):9304–9328.

Before the Hawaiian islands were colonized by people, the Hawaiian flora was not subjected to tire, except in areas of volcanic activity or by occasional lightning strikes. Therefore, many Hawaiian plant species are not adapted to recurring fires and are unable to recover from tire. Exotic plants are often better adapted to fire and are widespread on the islands. The presence of these fire-adapted exotic species increases the intensity, extent, and frequency of fires. Fire can destroy native seed banks and plants. Fire is a threat to *Brighamia insignis, Exocarpos luteolus, Lipochaeta fauriei, Melicope knudsenii, Melicope pallida, Munroidendron racemosum, Nothocestrum peltatum, Peucedanum sandwicense, Pteralyxia kauaiensis,* and *Solanum sandwicense.*

Brighamia insignis (E), *Exocarpos luteolus* (E), *Lipochaeta fauriei* (E), *Melicope knudsenii* (E), *Melicope pallida* (E), *Munroidendron racemosum* (E), *Nothocestrum peltatum* (E), *Peucedanum sandwicense* (E), *Pteralyxia kauaiensis* (E), and *Solanum sandwicense* (E).

160. U.S. FISH AND WILDLIFE SERVICE. 1994d. Endangered status for three plants and threatened status for one plant from sandy and sedimentary soils of central coastal California. Federal Register 59(24):5499–5509.

Chorizanthe pungens var. pungens is known from sedimentary soils of central coastal California. The highest densities of C. *pungens var. pungens* occur where disturbances are most frequent. This species is probably adapted to open conditions created by frequent disturbance. Prior to human disturbance, these areas were probably kept open by wildfires.

Chorizanthe pungens var. pungens (T)

161. U.S. FOREST SERVICE. 1994. Fire effects information system [database]. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory. Magnetic tape reels; 9 track; 1600bpi, ASCII with Common LISP present. Unpublished.

The Fire Effects Information System is a database of the U.S. Forest Service that contains references on the effects of tire on species and vegetation community types. As of December 1994, information on only one threatened or endangered plant species, *Torreya taxifolia,* was included in the database.

Torreya taxijolia (E)

162. WARREN, P. L., R. J. FRYE, D. GORI, AND A. LAURENZI. 1992. Population biology of *Pediocactus paradinei,* a rare cactus from northern Arizona. Pages 132-143 *in* R. Sivinski and K. Lightfoot, editors. Southwestern rare and endangered plants: proceedings on the southwestern rare and endangered plant conference, held 30 March-2 April 1992, in Santa Fe, N. M. New Mexico Forestry and Resources Conservation Division, Santa Fe, N.Mex.

Recruitment, growth, and mortality of almost 100 *Pediocactus paradinei* were monitored for 4 years. The authors also monitored the effects of two fires of different intensities, one accidental and one prescribed bum, on *P. paradinei. The* plants were rated according to their degree of fire damage. The following year, evidence of new growth on these plants was recorded. Results indicated that *P. paradinei* can survive low-intensity fires, but as in other cacti, high-intensity bums result in high mortality. Data also indicate that burning does not significantly reduce the reproduction of surviving individuals. The authors recommend that prescribed bums in *P. paradinei* habitat be kept cool and conservative.

Pediocactus paradinei (C 1)

163. WEBBER, H. J. 1935. The Florida scrub, a fire-fighting association. American Journal of Botany 22: 138– 143.

The author describes the inability of Florida scrub to endure fires, which is in contrast to the neighboring longleaf pine (*Pinus palustris)* association that bums annually. Because the scrub community is deciduous and does not accumulate much litter, it does not tend to carry fire. The author also describes a natural fire break between the scrub and the pine communities that may help to prevent the spread of fire to the scrub association. The article contains useful information about rare species that exist in this association.

164. WILCYZNSKI, C. J. 1993. A three year study on the population dynamics of Cooley's meadowrue *(Thalictrum cooleyi)* at Lanier Quarry, Pender

County, North Carolina. The Nature Conservancy, Carlboro, N.C. Unpublished.

Thalictrum cooleyi was monitored at a site in Pender county, North Carolina, during 1988-90. A census was taken of all flowering stems in 18 plots. Each plot was assigned a bum frequency. For this population, a frequency of O-2 years had no effect on population size, plant size, or sex ratio. A study of fire seasonality is recommended to determine a beneficial tire regime.

Thalictrum cooleyi (E)

165. **WOOD, M. K., AND V. T. PARKER.** 1988. Management of *Arctostaphylos myrtifolia* at the Apricum Hill Ecological Reserve. California Department of Fish and Game, Rancho Cordova, Calif.Unpublished.

As an obligate seeder, *Arctostaphylos myrtifolia* is killed by fire; stand regeneration depends on seedling establishment. During the authors' study, *A. myrtifolia* responded unlike other members of the genus. Seeds do not respond to stimulatory treatments that normally promote germination in other chaparral species. A high germination rate in response to tire has been observed and can be seen at several sites with documented fire histories. *Arctostaphylos myrtifolia* will probably respond to fire similarly to other *Arctostaphylos* species if no exotic species invade and dominate the site first. However, no prescribed burning is recommended at the Apricum Hill Ecological Reserve before further studies with tire are conducted elsewhere.

Arctostaphylos myrtifolia (Cl)

Appendix A. Agencies from which the authors requested information about rare, threatened, and endangered plants in relation to fire.

The Nature Conservancy
Arizona Field Office
Arkansas Field Office
Colorado Field Office
Great Basin Field Office
Illinois Field Office
Massachusetts Field Office
Missouri Field Office
National Office
Nebraska Field Office
New York Field Office
North Carolina Field Office
Northeast Regional Office
Oregon Field Office
South Carolina Field Office
Southeast Regional Office
Tennessee Field Office
Texas Field Office
Virginia Coast Preserve
Virginia Field Office
West Virginia Field Office

Heritage Programs
California
Colorado
Florida
Georgia
Idaho
Indiana
Kentucky
Minnesota
New Jersey
New Mexico
Ohio
South Carolina
Utah
Virginia
Virginia
Wisconsin
Wyoming

Government Agencies
Buenos Aires National Wildlife Refuge, Arizona
Bureau of Land Management, Idaho
California Department of Fish and Game, California
Coronado National Forest, Arizona
U.S. Forest Service Western Region, California
Yellowstone National Park, Wyoming
Yosemite National Park, California
Ohio Department of Natural Resources, Ohio
U.S. Forest Service, S.E. Forest Experiment Station, South Carolina
Georgia Department of Natural Resources, Georgia
Indiana Dunes National Lakeshore, Indiana
Chattahouchee National Forest, Georgia

Other Organizations
Archbold Biological Station, Florida
California Native Plant Society, California
Joseph W. Jones Ecological Research Center, Florida
Tall Timbers Research Station, Florida

Appendix B. Individuals, by region of the United States, who provided information about rare, threatened, and endangered plants in relation to fire.

Region	Contact[a]	Address	Telephone number
Northeast	Peter Dunwiddie	Lost Farm, Hummock Pond Road Nantucket, Massachusetts 02554	
Southeast	Anne Johnson	Florida Natural Areas Inventory 1018 Thomasville Road Tallahassee, Florida 32303	(904)224-8207
Southeast	Eric Menges	Archbold Research Station P.O. Box 2057 Lake Placid, Florida 33852	(813)465-2571
Southeast	Margit Bucher	The Nature Conservancy, North Carolina Field Office Carrboro, North Carolina	(919)967-7007
Southwest	Rick Young	The Nature Conservancy, Arizona Field Office Tucson, Arizona	(602)622-3861
Midwest	Doug Ladd	The Nature Conservancy, Missouri Field Office St. Louis, Missouri	(3 14)968-l 105
Northwest	Steve Popovich	Bureau of Land Management, Shoshone District Shoshone, Idaho	(208)886-2206
Northwest	Jason Greenlee	International Association of Wildland Fire Spokane, Washington	(509)283-2397
West	Ronnie Glick	California Native Plant Society Sacramento, California	

[a] The contacts permitted the mention of their names in this appendix.

Author Index

Geographic Index

Species Index

A list of current *Information and Technology Reports* follows:

1. Population Biology of the Florida Manatee, edited by Thomas J. O'Shea, Bruce **B.** Ackerman, and H. Franklin Percival. 1995.287 pp.

NOTE: The mention of trade names does not constitute endorsement or recommendation for use by the Federal Government.

U.S. Department of the Interior
National Biological Service

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This responsibility includes fostering the sound use of our lands and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities.