

The Fire Effects Information System¹

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Abstract: Lack of information regarding fire effects is perceived by many fire and resource managers as a barrier to the effective application of prescribed fire. This lack of information, in many instances, is the result of poor diffusion of existing knowledge rather than lack of knowledge. A computerized Fire Effects Information System can make existing fire effects knowledge easily available to wildland managers. The system incorporates recent advances in the field of artificial intelligence to produce a virtual encyclopedia of fire effects information for plant species, plant communities, and associated wildlife species. At present, the system contains information pertaining to the sagebrush and pinyon-juniper ecosystems.

Prescribed burning is a popular and traditional forestry and range management practice. On western wildlands, fire is most frequently used to reduce fuel hazard, to increase quality and quantity of browse and forage, to enhance wildlife habitat, to prepare sites for regeneration, and to control undesirable vegetation. Using prescribed fire--including the prescribed use of chance ignitions--to maintain a more natural

(presettlement period) environment in Wildernesses and on other essentially undeveloped tracts of Federal wildlands, is a relatively recent practice. It has significantly increased annual prescribed burned acres in many western National Parks and National Forests (Kilgore 1983).

Despite the current widespread use of prescribed fire, evidence suggests that its use would be even greater but for certain manager-perceived barriers. Several recent surveys of western wildland managers identified insufficient knowledge of fire effects and inadequate information for prescription development as the two most serious barriers to fire use (Noste and Brown 1981, Kilgore and Curtis in press). These surveys document a general need for fire effects information and prescribed fire guidelines, but specific information needs are not defined. The specific nature of these information needs was, however, reflected in the results of a delphi method survey of over 300 wildland managers and scientists regarding important research needs for understanding the effects of fire in western coniferous forests (Taylor and others 1975, Kickert and others 1976). Commenting on the results of this survey, Taylor and others (1975) make a significant observation regarding fire effects and prescribed fire information needs. They emphasized that answers to many of the questions asked by survey participants are already available in the existing literature, but that there is poor information diffusion from researchers to practitioners. This observation is reinforced by Thompson and others (1976) who note that only a small percentage of existing knowledge is being effectively applied by wildland managers.

This situation has not gone unnoticed. Recent attempts to better disseminate fire

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effects and fire use information abound. They include published literature reviews in the form of reports and textbooks, published and computerized bibliographies some of which contain abstracts, periodic lists of current literature, document delivery services, countless symposia on fire effects and prescribed fire along with their published proceedings, and a substantial increase in fire effects and use training opportunities. These information sources have undoubtedly resulted in improved application of fire effects information, especially by those managers willing to invest the time and effort to seek them out and use them. There are, however, shortcomings inherent in these forms of information diffusion. Literature reviews are often too general to apply to specific situations. And they are always dated: they only reflect the state of knowledge existing at the time they were written. Bibliographies and document delivery are invaluable for locating and obtaining literature, but the user still must extract, synthesize, and interpret the information in relation to his or her project. Most importantly, the results of diligent knowledge retrieval, synthesis, and interpretation are rarely preserved for use by others.

The Fire Effects Information System described here can provide wildland managers with ready access to fire effects information in a manner that avoids the shortcomings of current information dissemination techniques noted above.

DESCRIPTION OF THE SYSTEM

System Development

The Fire Effects Information System is being developed by the USDA Forest Service Intermountain Research Station at its Fire Sciences Laboratory, in Missoula, Montana. The system, developed in cooperation with the University of Montana Computer Sciences Department, is essentially a computerized fire effects knowledge base. Artificial intelligence concepts (AI) and techniques were used to design the system. AI is a subfield of computer science concerned with the concepts and methods of symbolic representation of knowledge to be used in making inferences (Feigenbaum and McCorduck 1984). AI was developed and continues to be developed for the purpose of creating knowledge-based systems. Knowledge-based

systems are characterized by their ability to understand images and their reliance on a large knowledge base. Much of the current research and development in AI is directed toward construction of expert systems. An expert system is a knowledge-based program intended to take the place of a human expert by codifying the knowledge and rules the expert uses to reach his or her conclusion (Foster 1985). A major consideration for using AI techniques to design the Fire Effects Information System, which is not an expert system, was to ensure that its knowledge base would be compatible with future efforts to develop fire effects-related expert systems.

Information Provided

The Fire Effects Information System provides mostly text-type fire effects-related information in three major categories: plant species, ecosystems, and wildlife species. The ecosystem category includes three levels of classification: an ecosystem level, a cover type level, and a habitat or community type level. Within each of these categories information related to the following subject matter areas is provided by the system:

<u>Category</u>	<u>Subject Matter</u>
Plant species	Nomenclature and taxonomy
	Distribution and occurrence
	Value and use
Ecosystem	Botanical and ecological characteristics
	Plant adaptations to fire
	Fire effects
	Ecosystem level
	General description and characteristics
	Productivity
	Condition and trend
	Fire ecology and effects

Cover type level	General description and site characteristics
	Value and use
	Fire ecology and effects
Habitat type level	General description and site characteristics
	Fire effects and use
	Fire effects case studies
Wildlife Species	Nomenclature and taxonomy
	Distribution and occurrence
	Biological data and habitat requirements
	Fire effects and use

Within each subject matter area information is provided for a number of predetermined topics. For example, topical information contained in the fire effects subject matter area for plant species is as follows:

Fire effect on plant
Discussion and qualification of fire effect
Plant response to fire
Discussion and qualification of plant response
References
Fire effects case studies

In some cases topical information is presented with the aid of subtopics. For example, "Fire effects case studies" information in the preceding example is presented as follows:

Case name
Reference
Season-severity classification
Study location
Preburn vegetative community
Target species phenological state
Site description
Fire description
Fire effects on target species
Fire management implications

A portion of the information (species information, adaptation to fire, and fire effects) contained in the system knowledge base pertaining to bottlebrush squirreltail (Elymus elymoides), a widely distributed bunchgrass in semiarid regions of the West, is appended to this paper. This information is as a sample of the nature and organization of information provided by the Fire Effects Information System. Presented as part of the system in a similar manner, but not appended, is information on distribution and occurrence, value and use, botanical and ecological characteristics and fire case studies.

The above listed subject matter titles and the plant species information in the appendix show that the Fire Effects Information System provides more than the results of documented fire effects studies. Information on biological and ecological attributes of species is provided as an aid in understanding the documented fire effects and for inferring probable fire effects where documentation is scant or lacking. Information on seasonal development, for example, can aid in timing of fire treatments to obtain desired plant response. Value and use-related information is meant to aid in assessing potential damage from fire and for evaluating appropriateness of fire treatments in terms of management objectives. Information on distribution and occurrence should assist a user in identifying species and plant communities that should be considered when planning fire treatments. Much of the information related to classification systems--such as Raunkiaer life form, Grime plant and regenerative strategy classifications, Lyon-Stickney fire survival strategy, and Noble-Slatyer vital attributes--are included in the knowledge base for eventual use in conjunction with development of fire effects related expert systems.

System Design

As noted earlier AI concepts and techniques were applied to the design of the Fire Effects Information System. Foremost among these applications is the use of the LISP programming language, which is a symbol-manipulation language. The concept of symbol manipulation or symbolic processing is inherent in any AI system. Symbolic processing is a departure from the traditional use of computers to manipulate numbers (numeric processing). LISP has many desirable features for the development of a large, text-type knowledge base system. For

example, the programmer need not identify in advance the exact size and structure of the data (knowledge) that will be processed by the program. Another desirable feature allows the integration of program instructions with data.

Frame-based knowledge representation is another AI technique applied to the design of the Fire Effects Information System. Knowledge representation refers to the technique used to store information in a knowledge base. Frames are a technique for representing knowledge that stores a list of an object's typical attributes together with the object. Each specific attribute of the object is stored in a separate slot. In the plant species information in the appendix, the frames are identified between the hatched lines. The slots are the information items or attributes listed beneath the hatched lines. For the FRAME TYPE: DISTRIBUTION AND OCCURRENCE, for example, the slots are GENERAL DISTRIBUTION, ECOSYSTEMS, STATES, ADMINISTRATIVE UNITS, BLM PHYSIOGRAPHIC REGIONS, KUCHLER PLANT ASSOCIATIONS, SAF COVER TYPES, HABITAT TYPES AND PLANT COMMUNITIES, and REFERENCES.

The use of LISP, frames, and other AI techniques resulted in the construction of a prototype Fire Effects Information System in a less time than was anticipated. This was due in part to the relative ease with which the programmers were able to make the many changes required during the early phases of system development.

System Structure

The Fire Effects Information System is made up of three main components: (1) the knowledge base, (2) the query system, and (3) the builder system. The knowledge base contains two types of information: (1) the plant, ecosystem and wildlife information provided by the system: and (2) the procedural information that tells the system how to do such things as display a data frame of a particular type, add or delete information from frames or frames from the knowledge base, and search for particular information (Mitchell 1986). Two components that can be considered as subsidiary to the knowledge base are the knowledge base interface and the print package. The knowledge base interface provides access to the knowledge base, while the print package controls the display of information from the knowledge base to the system user.

The query system is the user component of the Fire Effects Information System. In computer jargon, the query provides the user with a user friendly interaction interface to the knowledge base (Mitchell 1986). To the general user the query is the Fire Effects Information System. It displays the various information categories and subject matter area alternatives available and allows the user, through on-screen menus and prompts, to easily access any or all of the plant, ecosystem, or wildlife related information contained in the knowledge base. The information contained in the appendix for bottlebrush squirreltail is exactly as provided by the query system, only the on-screen menus and prompts have been eliminated to save space.

The builder system is a separate program that is used to add new information to the knowledge base or to update or otherwise change existing information in the knowledge base. It is assumed that access to the builder system would be restricted in to protect the integrity of the information provided by the Fire Effects Information System.

STATUS OF THE SYSTEM

An operational quality prototype Fire Effects Information System has been developed. Its knowledge base, built with strong support from the Bureau of Land Management (BLM), contains information for nearly 80 plant species, 10 wildlife species, and several cover types that occur in the sagebrush and pinyon-juniper ecosystems of the semi-arid West. The information in the knowledge base represents a painstaking effort on the part of fire research personnel to identify, locate, obtain, and then summarize existing fire effects and related information for the included species and communities.

The prototype Fire Effects Information System has recently been installed on a BLM Data General MV 10000 computer at the Boise Interagency Fire Center. The installation of this prototype will be operationally tested by the BLM during the late spring and summer of 1987. The prototype system was built on the University of Montana VAX 750 computer under the direction of Dr. Alden Wright. Knowledge base development continues to be accomplished on this machine. Knowledge base development will shift to a Data General MV 10000 computer at the

Intermountain Fire Sciences Laboratory, upon its installation during the summer of 1987.

A personal computer (PC) version of the query system has also been built. This PC version of the query is designed to run on IBM compatible machines with at least 640k of memory and hard disk capability. The compiled version of the builder system will also run on 640k; otherwise an AT-type machine with 2 megabits of memory is required. Software requirements include a Common LISP language package for main frame computers and Golden Common LISP for PCs.

Work is under way, with the cooperation and support of the National Park Service (NPS), to fashion the Fire Effects Information System to NPS needs. To this end, a knowledge base for Wind Cave National Park containing information on species and plant communities of the prairie ecosystem is being built. The system will be modified, as appropriate, to fit NPS needs.

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APPENDIX

An example of the type of plant species information and its organization provided by the

Fire Effects Information System. This example is for bottlebrush squirreltail (Elymus elymoides), a native perennial bunchgrass.

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SPECIES : Elymus elymoides

FRAME TYPE : SPECIES

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SPECIES

Elymus elymoides

ABBREVIATION :

ELEL

SYNONYMS

Sitanion hystrix

Sitanion hystrix var. brevifolium

Sitanion hystrix var. californicum

COMMON NAMES

bottlebrush squirreltail

squirreltail

TAXONOMY

Barkworth and Dewey's 1985 treatment of the Triticeae combines the genus Sitanion with the genus Elymus on the basis of morphological and cytological evidence. Thus, Sitanion hystrix (Nutt.) J.G. Smith is now recognized as Elymus elymoides (Rafin.) Swezey. Varieties of S. hystrix recognized by other authors include: var. californicum (J.G. Smith) F.D. Wilson and var. brevifolium (J.G. Smith) C.L. Hitchcock. These are now considered E. elymoides [1]. Based on Wilson's study of Sitanion, Barkworth, and Dewey consider a third variety, hordeoides (Suksd.) C.L. Hitchcock, to be a separate species and recognize it as E. hordeoides (Suksd.) Barkw. & D.R. Dewey [1,6].

In southern Idaho at the Saylor Creek Experimental Range, field studies comparing growth and development between two varieties of S. hystrix (var. hystrix and var. californicum) showed differences in biomass and rate of development characteristics. Net photosynthesis, respiration, and transpiration per unit leaf area were higher for var. hystrix. Optimum soil temperature for seedling growth for both varieties was 13 deg. F (25 deg. C) [3].

LIFE FORM

Graminoid

COMPILED BY AND DATE

W. Fischer, May 1986

LAST REVISED BY AND DATE

K. Ahlenslager, November 1986

REFERENCES

- 1: Barkworth and Dewey 1985
- 2: Barkworth, Dewey. and Atkins 1983
- 3: Hironaka and Tisdale 1972
- 4: Hitchcock 1951
- 5: Hitchcock, Cronquist, and Ownbey 1969
- 6: Wilson 1963

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SPECIES : Elymus elymoides
FRAME TYPE : PLANT ADAPTATIONS TO FIRE
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GENERAL ADAPTATIONS TO FIRE
    The growth form of squirreltail is characterized by loosely clustered
    coarse culms (stems) with a minimum of leafy materials. During a fire, these
    culms usually burn rapidly with little heat transferred downward into
    meristematic tissue. Little charring of the crown below the soil surface
    occurs.

LYON-STICKNEY FIRE SURVIVAL STRATEGY
    Ground-stored residual colonizer; fire-activated seed on-site in soil

NOBLE-SLATYER VITAL ATTRIBUTES

SPECIES TYPE
    VT

TIME UNTIL ARRIVAL ON SITE (p) :
    0-1 year

TIME UNTIL MATURITY (m) :
    0-1 year

TIME UNTIL SENESCENCE (l) :
    Infinity

TIME UNTIL EXTINCTION (e) :
    Infinity

ROWE MODE OF PERSISTENCE :
    Endurer

REFERENCES
    1: Lyon and Stickney 1976
    2: Noble and Slatyer 1977
    3: Rowe 1983
    4: Wright 1971
    5: Wright and Klemmedson 1965
    6: Young and Miller 1985

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SPECIES : Elymus elymoides

FRAME TYPE : FIRE EFFECTS

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FIRE EFFECT ON PLANT

Squirreltail is one of the most fire-resistant bunchgrasses. Its coarse leaves and low density of dead plant material within the bunch contribute to making it less susceptible to damage by fire. This is due to its rapid combustion with little downward transfer of heat into the root-shoot transition zone, located about 2 in. (4 cm) below the soil surface. Crown consumption by fire usually results in either no mortality or only slight damage.

DISCUSSION AND QUALIFICATION OF FIRE EFFECT

Older, ungrazed plants may be more vulnerable to injury because they often contain large quantities of dead material. Consequently, they burn hotter thereby increasing the probability of charring the plant below the soil surface, especially during severe burning conditions when upper soil moisture is often low. The probability of damage is less when plants are fully dried and dormant than when green and growing. Several instances of moderate to severe damage have been reported and are associated with burning in May [5,7]. Plants burned in mid-May in a drought year had 30 pct. mortality (73 pct. basal area reduction) while those burned in mid-June and October resulted in no mortality (48 pct. basal area reduction) [7]. In a sagebrush-grass range in southern Idaho, burns at 200 deg. F (93 deg. C) and 400 deg. F (200 deg. C) were conducted in each of three summer months. Plants burned in July showed a reduction in basal area, but were not killed. The production of flowering stalks decreased the year following the burn.

PLANT RESPONSE TO FIRE

Squirreltail often increases in abundance after a fire [2]. Preburn levels of annual production are usually achieved within 3 years, but often much sooner. Shoot biomass and density, and the proportion of reproductive shoots to all shoots may increase dramatically during the first postfire year [10].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE

A seasonal reduction in basal area and reduction in herbage production may result from burning, especially in spring under severe burning conditions and on older plants containing large amounts of dead materials; but it may increase several years after burning [4].

REFERENCES

- 1: Blaisdell, Murray, and McArthur 1982
- 2: Countryman and Cornelius 1957
- 3: Mangan and Autenrieth 1984
- 4: Range, Veisze, Beyer, and Zschaechner 1982
- 5: Wright 1971
- 6: Wright and Klemmedson 1965
- 7: Wright, Neuenschwander, and Britton 1979
- 8: Young 1983
- 9: Young and Miller 1985
- 10: Zschaechner 1984