THE FIRE EFFECTS INFORMATION SYSTEM: A COMPUTERIZED ENCYCLOPEDIA OF FIRE ECOLOGY

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ABSTRACT

The Fire Effects Information System (FEIS), a "new generation" computer knowledge management tool, is designed to store and provide easy user access to the state of the knowledge regarding the effects of fire on plant species, plant communities, and associated animal species. Essentially, FEIS contains mostly text-type information organized in an encyclopedic fashion. The unique capabilities of the system are the result of software development using artificial intelligence concepts, methods, and techniques. Presently, the FEIS knowledge base includes fire effects and related information for more than 200 plant species in 34 forest and range ecosystems.

INTRODUCTION

The use of prescribed fire on forests and rangelands has increased dramatically during the past several decades, especially in the western United States. A significant aspect of this increase involves the purposes for which prescribed fires are conducted. Consider, for example, the use of prescribed fire during 1979 compared to 1987 on the 13 national forests that make up the Forest Service Northern Region. Prescribed fire was applied to 44,554 acres in 1979 and to 80,443 acres in 1987. The 1987 prescribed fires represent an 81 percent increase over 1979. Of greater significance, however, is the relative change in number of acres burned by management objective. In 1979, 97 percent of the acres burned involved treatment of logging slash associated with timber management activities. In 1987, slash treatment accounted for 67 percent of the total acres burned while burning in mostly natural fuels for silviculture, range, wildlife, and ecosystem maintenance objectives accounted for 33 percent of the total.

Note: The use of trade or firm names in this paper is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Burning plans of state and federal agencies in Colorado present a more extreme example of the shift in prescribed fire objectives. Of the combined total of 71,663 acres planned for burning during 1988, more than 80 percent involved vegetation management in mostly natural fuels. Similar trends of increased burning for vegetation management are reported for forest and rangelands throughout the interior West, the region encompassing Alberta, Colorado, Idaho, Kansas, Montana, Nebraska, North Dakota, South Dakota, and Wyoming (Simmerman and Fischer in press).

The fire management literature indicates that increased use of fire for vegetation management is occurring nationwide on federal, state, and private wildlands. And all this refers to management-ignited prescribed fires only. Many thousands of acres of prescribed natural fires occur annually in national parks and national forest wildernesses.

An immediate consequence of the increased use of prescribed fire for vegetation management is an unprecedented demand for information related to the effects of fire on individual plants and plant communities. This demand evolved as fire and resource management specialists recognized that to obtain a specific desired result from a fire treatment, the fire prescription must be based on the variable response of target plant species to such factors as fire severity, season, phenological state, successional status, site characteristics, and other biological and environmental considerations. Several surveys indicate that many managers perceive a lack of prescribed fire effects information and that this lack is a barrier to the effective use of fire for vegetation management (Kilgore and Curtis 1987, Noste and Brown 1981, Kickert et al. 1976, Taylor et al. 1975). However, familiarity with the literature indicates that a substantial body of information does in fact exist about fire effects generally and plant response to fire in particular, especially for many species of primary management concern. The problem, largely one of accessibility of such information, has two facets: (1) there is no single "best" route for identifying and obtaining available information, and (2) the information is generally unorganized and uninterpreted for the purpose of aiding fire management decisions in general or prescribed fire planning in particular. The Fire Effects Information System is a unique solution to this problem.

DESCRIPTION OF THE SYSTEM

The Fire Effects Information System (FEIS) is a computerized knowledge management system that stores and retrieves state-of-the-knowledge, English-language textual information organized in an encyclopedic fashion. For those abreast of computer science trends, FEIS is an object-oriented, frame-based, knowledge-based system implemented in a LISP programming environment. FEIS was developed using concepts, methods, and techniques from the field of artificial intelligence (AI), but it is not an expert system. The design and structure of FEIS and development of its software are described by Fischer and Wright (1987). FEIS was conceived and is being developed by the Forest

Service, U.S. Department of Agriculture, at the Intermountain Research Station's Fire Sciences Laboratory in Missoula, Montana. System software was developed in cooperation with the Computer Science Department of the University of Montana, Missoula.

The Fire Effects Information System consists of three components: the knowledge base, the query program, and the builder program. The knowledge base contains the fire effects and related information that is available to users of the system. The query program allows access to the knowledge base but does not allow any changes. It is designed for people who are unskilled in computer use. On-screen prompts and menus guide the user to the desired information. The builder program is used by those who are adding to or editing the knowledge base. The user of the builder program is expected to be familiar with the structure of the knowledge base and is expected to be skilled in computer use. Access to the builder program is restricted to system management staff. Because it is the object of the system, the knowledge base is described in more detail below.

THE KNOWLEDGE BASE

The FEIS knowledge base is designed to accept 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 type or plant community level. For each category and level, the knowledge base contains state-of-the-knowledge information as text for various predetermined topics for several subject areas. Topics by subject for each category are listed in Table 1. The knowledge base will accept information only for the predetermined topics listed in Table 1. Addition of other topics is relatively simple for someone who is familiar with the structure of the system and capable of programming in the LISP language. Fischer (1987) and Fischer and Wright (1987) provide examples of FEIS output essentially as it would be displayed on the screen of a user's computer terminal.

Knowledge Base Development

Information in the FEIS knowledge base is a product of a rigorous procedure that includes (1) making a thorough bibliographic search to identify literature related to the topics listed in Table 1; (2) obtaining hard copy of all such literature; (3) reading the literature, evaluating its reliability, and summarizing useful information; (4) resolving conflicts, if possible, between contradictory information; (5) synthesizing fire effects and related information; (6) obtaining review from co-workers, copy editor, and supervisor; and (7) entering the information into the knowledge base. The research team currently responsible for knowledge-base development consists of graduate biologists trained in botany, plant ecology, wildlife biology, range science, and forestry. On the average, it takes about 10 days to complete a species or cover

Table 1 — Information by category, subject matter area, and topic contained in the FEIS knowledge base.

Plant Species Category

Species name
Abbreviation
Synonyms
Common names
Taxonomy
Life form
Compiled by and date
Last revised by and date
References

DISTRIBUTION & OCCURRENCE

General distribution
Ecosystems
States
Administrative units
BLM-HLM physiographic regions
Kuchler plant associations
SAF cover types
Habitat types
References

VALUE AND USE

Wood products value
Importance to livestock & wildlife
Palatability
Food value
Cover value
Value for rehabilitation of disturbed sites
Other uses and values
Management considerations
References

BOTANICAL & ECOLOGICAL CHARACTERISTICS

General botanical characteristics
Growth form
Raunkiaer life form
Grime plant strategy class
Grime regenerative strategy class
Regeneration processes
Site characteristics
Successful status
Seasonal development
References

PLANT ADAPTATIONS TO FIRE

General adaptations to fire
Lyon-Stickney survival strategy
Noble-Slatyer vital attributes
Rowe mode of persistence
References

FIRE EFFECTS

Fire effects on plant
Discussion and qualification
Plant response to fire
References

FIRE CASE STUDY

Case study name
Reference
Season-severity class
Study location
Preburn vegetation
Target species phenological state
Site description
Fire description
Fire effects on target species
Fire management implications

Wildlife Species Category

Species name
Abbreviation
Common name
Taxonomy
Order
Class
Compiled by and date
Last revised by and date
References

DISTRIBUTION & OCCURRENCE

General distribution
Ecosystems
States
Administrative units
BLM physiographic regions
Kuchler plant associations
SAF cover types
Plant communities
References

BIOLOGICAL DATA & HABITAT REQUIREMENTS

Timing of major life history events
Preferred habitat
Cover requirements
Food habits
Predators
References

FIRE EFFECTS & USE

Direct fire effects on animal
Habitat-related fire effects
Fire use
References

Ecosystems Category

ECOSYSTEM LEVEL

Ecosystem name
Compiled by and date
Last revised by and date
Classification key
FRES number
Kuchler vegetation types
Ecosystem distribution
References

PRODUCTIVITY

Characteristics/productivity classes
Dominant species/productivity classes
Potential production
References

CONDITION & TREND

Characteristics of condition classes
Indicators of trend
Qualification & discussion
References

FIRE ECOLOGY & EFFECTS

Fuels, flammability & fire occurrence
General fire effects
References

Ecosystems Category (cont.)

COVER TYPE LEVEL

Cover type
Compiled by and date
Last revised by and date
Abbreviation
Classification key
Distribution
Site characteristics
Vegetative composition
Successional trends
References

VALUE & USE

Wood products
Livestock range
Wildlife habitat
Other values and uses
References

FIRE ECOLOGY & EFFECTS

Fuels, flammability & fire occurrence
Immediate fire effects on site
Initial vegetative response
Long-term vegetative response
Fire effects on grazing potential
Fire effects on wildlife habitat & populations
Fire use potential
Rehabilitation of burned sites
Fire management considerations

PLANT COMMUNITY LEVEL

Community or group name
Abbreviation
Description
Community type composition
Distribution & occurrence
Site characteristics
Vegetative composition
Productivity
Successional trends

MANAGEMENT CONSIDERATIONS

Wood products
Livestock range
Wildlife habitat
Other considerations
References

FIRE EFFECTS

Fuels, flammability & fire occurrence
Initial community response
Long-term community response
Fire effects on grazing potential
Fire effects on wildlife habitat and populations
Fire use potential
References
Fire case studies

type writeup and enter it into the knowledge base. Following the entry, a hard copy of the writeup is sent for technical review by scientists, staff specialists, and managers who have expert knowledge of the species or ecosystem. The information is revised, as necessary, to reflect this technical review. New knowledge may be incorporated at any time.

The literature for use in developing or revising a species or ecosystem writeup is keyworded and entered into a computerized bibliography that is an adjunct to the knowledge base. This bibliography can be searched to obtain complete literature citations for the author-date references provided by the knowledge base. It can also be searched using designated subject matter keywords including scientific names of plant species and common names of wildlife species.

Knowledge Base Content

As of August 1, 1989, the FEIS knowledge base contained information for 210 plant species (43 trees, 84 shrubs, 65 graminoids, and 18 forbs), 8 wildlife species, and 10 sagebrush cover types. Distribution of plant species according to their occurrence among the 34 Forest and Range Environmental Study ecosystems described by Garrison et al. (1977) is presented in Table 2. To date, knowledge base development has been supported by the Bureau of Land Management (BLM) and the National Park Service (NPS), U.S. Department of the Interior. Consequently, a majority of the species presently included in the knowledge base are those common to the semi-arid western rangelands managed by the BLM and to the ponderosa pine and plains grasslands ecosystems of Wind Cave National Park, South Dakota. The NPS designated Wind Cave National Park as a prototype for knowledge-base development. Currently, plant species in Yellowstone National Park and in the chaparral-mountain shrub ecosystem of southern Oregon and California are being added to the knowledge base.

The initial emphasis on plant species rather than wildlife species reflects the expressed needs of the agencies supporting knowledge-base development. This is a logical decision because most fire effects of concern to wildlife managers are secondary effects caused by fire-related changes in wildlife habitat.

USER EVALUATION OF THE SYSTEM

During the early stages of system development, a prototype FEIS was demonstrated at several dozen field locations in Arizona, Idaho, Nevada, Oregon, South Dakota, and Utah. At the conclusion of each demonstration, participants were asked to respond to a series of questions regarding the utility of FEIS in relation to their fire effects information needs. Of 146 responses, 143 individuals were favorably impressed by the system and 138 said they would

Table 2. Number of plant species by ecosystem and life form represented in the FEIS Knowledge base (as of August 1, 1989).

Ecosystem	Trees	Shrubs	Graminoids	Forbs	Total
FOREST & WOODLAND ECOSYSTEMS					
White-red-jack pine	2	1	-	-	3
Spruce-fir	4	1	-	-	5
Longleaf-slash pine	-	-	-	-	0
Loblolly-shortleaf pine	-	-	1	-	1
Oak-pine	2	-	-	-	2
Oak-hickory	10	9	15	5	39
Oak-gum-cypress	3	-	1	-	4
Elm-ash-cottonwood	12	18	26	3	59
Maple-beech-birch	6	2	1	-	9
Aspen-birch	7	-	2	-	9
Douglas-fir	19	27	30	8	84
Ponderosa pine	33	49	52	12	146
Western white pine	4	4	-	-	8
Fir-spruce	18	22	25	7	72
Hemlock-Sitka spruce	4	5	-	-	9
Larch	2	3	-	-	5
Lodgepole pine	14	10	3	1	28
Redwood	3	1	-	-	4
Western hardwoods	16	12	4	2	34
SHRUBLAND ECOSYSTEMS					
Sagebrush	25	60	52	15	152
Desert shrub	11	48	32	7	98
Shinnery	-	3	3	1	7
Texas savanna	2	1	9	1	13
Southwestern shrubsteppe	1	5	8	2	16
Chaparral-mountain shrub	22	50	48	6	126
Pinyon-juniper	24	55	51	12	142
GRASSLAND ECOSYSTEMS					
Mountain grasslands	12	39	45	11	107
Mountain meadows	-	-	-	1	1
Plains grasslands	16	29	48	10	103
Prairie	10	15	30	5	60
Desert grasslands	7	36	27	6	76
Wet grasslands	1	-	3	-	4
Annual Grasslands	1	-	1	-	2
ALPINE ECOSYSTEMS					
Alpine	2	6	6	3	17

definitely use the system if it was available. When asked, "For what tasks would you use FEIS, if it was available?" responses were as follows.

Task	Percentage of respondents selecting
Prescribed fire plans	63
Vegetation management plans	36
Rehabilitation plans	25
Reference	24
Environmental assessments and environmental impact statements	22
Fire management plans	17
Land use plans	10
Training	6
Research	4
Escape fire situation analysis	2
Exotic control plans	1

Slightly over half (52 percent) of the respondents were field level resource managers or resource specialists; 30 percent were fire managers; 10 percent were line officers; and the rest were training, planning, administrative, or research specialists. Agency affiliation of the respondents included the Bureau of Land Management, National Park Service, Bureau of Indian Affairs (BIA), and Fish and Wildlife Service (FWS) of the U.S. Department of the Interior; the Forest Service (FS) and Soil Conservation Service (SCS) of the U.S. Department of Agriculture; forestry and fish and game agencies in the states of Colorado, Idaho, and Minnesota; and the Canadian Park Service.

CURRENT ACCESS TO THE SYSTEM

FEIS was developed on a Digital Equipment Corporation (DEC) VAX 750 computer at the University of Montana and now resides on a Data General (DG) MV 4000 computer at the Intermountain Fire Sciences Laboratory in Missoula, Montana. A copy of the knowledge base and query also resides on the BLM DG MV 10000 computer at the Boise Interagency Fire Center, Boise, Idaho. Bureau of Land Management personnel access the system at Boise using IBM-compatible personal computer (PC), a 1200 baud phone modem, and terminal emulation/communications software that can emulate a DG 400 terminal. Forest Service personnel have access to the system at the Fire Sciences Laboratory via the service wide DG electronic communications system. A PC version of the query and knowledge base is available at Wind Cave National Park for operational evaluation.

OPERATIONAL IMPLEMENTATION

Planning is under way for operational implementation of FEIS under the auspices of the National Wildfire Coordinating Group (NWCG). The NWCG consists of members from the Forest Service, Bureau of Land Management, National Park Service, Bureau of Indian Affairs, Fish and Wildlife Service, and the National Association of State Foresters. The purpose of NWCG is to coordinate the development and implementation of products that improve development and implementation of products that improve the overall effectiveness of fire management in member agencies.

In January 1989 the NWCG established a technology transfer team to develop an FEIS implementation plan for presentation in September 1989. This team consists of BLM, NPS, BIA, and FS fire management staff specialists and the FS fire research personnel responsible for developing FEIS. During a June 1989 meeting the technology transfer team identified criteria for an acceptable implementation of FEIS. These criteria include, among other items, maintenance of a single "master" knowledge base, access for all potential users, capability for delivery of hard copy of system output, and expansion of the knowledge base to serve national needs for fire effects information.

Expansion of the present knowledge base to reflect national needs for fire effects information will be a challenging task. The first step in addressing this task will be to identify the species that should be added to the knowledge base. To this end, individuals engaged in planning and conducting prescribed fires, especially in the central and eastern portions of the United States, are invited to suggest knowledge-base additions necessary to satisfy fire effects information needs in familiar vegetation types. Written requests to selected individuals will be forthcoming soon.

KNOWLEDGE MANAGEMENT AND FEIS

In a recent essay describing the need for better knowledge management, Rauscher (1987) compared the immense body of scientific and technical knowledge that humans have created to a huge pile of bricks because it is fragmented, unwieldy, and time-consuming to use. He correctly observed that our current demand for useful knowledge to solve specific problems has overloaded the ability of our present methods for creating, storing, and retrieving such knowledge. He added: "At present, our knowledge management tools are not powerful enough to save researchers and practitioners precious time and money currently used to collect and digest endless papers and books, filtering out unneeded information, and transforming available relevant knowledge to focus on the problem at hand (Etzioni 1971). The knowledge base is too often largely ignored because it is too costly to find and process the needed information. In other words, much of our scientific and technical knowledge is not useful."

The solution to this dilemma is knowledge management, which involves structuring knowledge, which means assimilating, and thereby compacting, research results into an organized framework (Rauscher 1987).

While it certainly is not the ultimate knowledge processor, the Fire Effects Information System does possess many of the attributes advocated by Rauscher and an increasing number of other scientists and information specialists active in the knowledge management field. Rauscher (1987) classifies FEIS as a knowledge processor of the document database type and, in fact, uses it as an example of document database systems. While FEIS was not explicitly designed and developed to conform with a preconceived knowledge management model, it most certainly contributes to the knowledge management solution rather than to the information problem.

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