Wildland Fire Management Economics: A State of the Art Review and Bibliography

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Past wildfire management strategies have neglected the fact that wildfire may have beneficial as well as undesirable effects and that fire management should be viewed, not in isolation, but within the context of overall land management objectives (Barney 1975, Lotan 1979). As a result, management strategies were framed with the objective of minimizing the time required to control fires, the number of fires, the size of fires, or the acreage burned. Scant attention was paid to the economic consequences of these strategies.

However, more and more fire management agencies are now being asked to justify the usefulness of their programs in terms of economic efficiency and to fully recognize the potential beneficial effects of some fires as well as the necessity to view fire management as an integral part of land management. Attempts have been made to determine: appropriate fire management budgets; proper allocation of expenditures between various fire management functions; and costs, damages, and benefits of wildland fire and fire management programs.

The objective of this review and interpretation of the literature pertaining to fire economics is to provide essential background information for selecting, developing, and applying appropriate techniques for evaluating fire management programs.

**METHODS**

The bibliography includes references concerned with applying economic techniques to solve wildland fire management problems. It was compiled from an extensive search of a wide variety of sources. Some citations were obtained locally, either from the USDA Forest Service North Central Forest Experiment Station Fire Management Project files or the Michigan State University library. Others were obtained from bibliographic data bases such as FIREBASE and the DIALOG service of Lockheed Information Services, which includes AGRICOLA (Bibliography of Agriculture). Generous support was obtained from USDA Forest Service and university researchers with past or current interest in wildland fire economics. Additional citations and information were obtained from key USDA Forest Service Cooperative Fire Protection, Research, and National Forest System staffs. State foresters and other Federal land management agencies were contacted by letter and asked to contribute relevant materials and we received a reply from fire management agencies from 26 States.

Even given the effort described above, the bibliography is not exhaustive. However, we feel it represents the directly relevant literature, particularly since 1960, and accurately describes the current state of the art in wildfire economics.

Annotations and key words are provided for a majority of the references. They are, however, omitted if a copy of the document or abstract could not be obtained or if the title seemed to adequately describe the content of the material. Several books that provide good general background in wildland fire management or in resource economics are listed separately at the end of the bibliography.

One or more of the following criteria were used for including references:

1. The reference provided an example of how existing economic theory might be applied to fire management.

2. The reference described a practical example of the use of economics in wildland fire management using real data.
(3) The reference reflected the use of economics in past or current research and/or policy direction of the USDA Forest Service or other fire management agency.

(4) The reference contained a useful bibliography of related material and/or synthesized a large volume of loosely connected information.

(5) The reference was current or its message had retained importance in essentially unchanged form.

ECONOMIC THEORY

Gorte and Gorte (1979) explore the history and evolution of economics as applied to fire management, particularly the cost-plus-loss concept. They trace the development of this concept beginning with the work of Sparhawk (1925) and Flint (1928) who were among the first to develop least-cost-plus-loss models. Next, they reviewed the work of Hornby (1936) who used acreage burned rather than suppression expenditure as the independent variable. They then discussed the research of Headley (1943) who provided “the first attempt at a thorough analysis of fire control policy alternative.”

The work of Craig et al. (1945) who recognized the need for marginal analysis is described as are the findings of Arnold (1949) who developed a model to derive suppression-cost-plus-damage for a number of suppression levels measured by attack time, and Maclay (1965) who worked with an expanded version of Arnold’s model. Parks’ (1964) model, which was “analogous to the first step of Arnold’s model,” is noted as is the work of Davis (1971) who explicitly recognized some limitations of the least-cost-plus-loss models. Finally, they describe the work of Simard (1976) who augmented the cost-plus-loss concept by equating the ratios of marginal factor costs to marginal value products among the various fire management inputs. He also explicitly recognized the possible beneficial effects of fire using the same analytical technique.

Mills (1979, 1980) also explicitly recognizes the possibility of beneficial wildfire effects noting that the “cost-plus-loss” concept would be more properly labeled “cost-plus-net value change.” He also correctly points out that minimizing “cost-plus-net value change” leads to the same program selection as maximizing financial return expressed as present net worth. Similarly, the last program increment added before reaching the minimum has a benefit-cost ratio of 1.0 and an internal rate of return equal to the next best alternative rate. Gorte and Gorte (1979) describe the work of several researchers (O’Connell 1971, Zivnuska 1972, Jischke and Shambline 1974) who have used variations of benefit-cost analysis in analyzing fire management economics. Nautiliy and Doan (1974) used an indifference approach with which a manager can trade harvested acres for burned acres and offset protection costs with timber sale receipts.

All in all, the economic theory of fire management is compatible with basic applied production, or microeconomic theory, and is well accepted. Some models needed to determine the economic efficiency of some components of fire management programs are available and others are being developed. The “cost” component needed as input for the models is reasonably easy to obtain with good bookkeeping. The basic difficulty lies in determining and predicting losses and benefits, or the net value changes wildfires have caused or are likely to cause. These crucial elements for any of the economic models cited above are virtually impossible to determine precisely. Even for timber, the questions of what the appropriate discount rate should be for future market values or what the future value will be, are unresolved. Nonmarket values and off-site values are even more difficult to determine precisely.

VALUE-AT-RISK AND APPRAISAL OF NET VALUE CHANGE

It has been recognized that past fire damage appraisal systems have not been adequate to serve the needs of the basic theoretical economic fire management models. Economic studies to determine an “adequate level” of fire protection or “justifiable expenditures” were undertaken by Davis (1965), Vogenberger et al. (1957), Miller (1968) and Arnold (1949). All emphasized the difficulty inherent in measuring the value changes caused by fires and prefire values that could be affected by fire. All finally resorted to limiting their analysis to a few of the more measurable market values or to including subjective approximations for some values to at least show how their models might work. Noste and Davis (1975) demonstrated the inconsistencies in appraisal techniques by comparing appraisals by the USDA Forest Service and the Bureau of Land Management following two large fires.

Wildfire value change appraisal has been receiving increasing attention. Crosby (1977) developed a general guide for appraising wildfire damages, benefits, and resource values protected. Marty (1979) developed an
economic valuation system for fire management planning on the National Forests. Gorte (1979) is completing a new system that permits more accurate appraisal of wildland fire damage in Wisconsin. This system recognizes that some fire effects are beneficial and carefully considers nontimber values. Lewis et al. (1979) are studying the “values-at-risk” from wildfire in Alabama.

APPLICATION

Although the solution of prefire value and postfire value change problems is incomplete, several recent studies have attempted to apply the best information available in benefit-cost or cost-plus-loss economic models. Winkworth et al. (1979) are conducting a benefit-cost analysis of progress in forest fire protection in North Carolina while Carmichael et al. (1979) have completed a benefit-cost study in California. Schweitzer et al. (1980) evaluated four levels of initial action and aviation program input using the FOCUS simulation model (Flatman and Storey 1979).

Researchers and policy directors in the USDA Forest Service have recognized the need for better economic information on fire management program alternatives. A policy analysis staff report (Gale 1977) included the following recommendations:

I. Develop new fire management policies that provide a broader, more positive approach to fire.

II. Establish procedures for determining reliable estimates of forest values.

III. Develop an integrated fire management planning process.

IV. Improve the accounting and budgeting systems of fire management.

V. Develop and implement a comprehensive evaluation system.

Item I. was largely accomplished in February 1978 when a revised fire management policy became effective stating: the basic fire management policy on National Forest System land is to provide well planned and executed fire protection and fire use programs that are cost-effective, responsive to land and resource management goals and objectives, and supportive of the 1974 Forest and Rangeland Renewable Resources Planning Act resource outputs. Efforts to accomplish recommendations II., III., and V. are reflected in the work of Schweitzer et al. (1980) entitled “A partial efficiency analysis of the fire management program on six National Forests.” This work will be discussed in greater detail because it represents very well the state of the art in evaluating the economic efficiency of USDA Forest Service fire management programs.

Schweitzer et al. (1980) evaluated the economic efficiency of the initial attack and aviation component of the fire management program on six widely spaced National Forests using a marginal analysis format. Minimizing the program cost plus the net change in the value of response outputs and structures was the economic efficiency criterion. Four program levels were evaluated. The results of this study included the following:

1. “The lowest program tested was the most efficient in the majority of the simulated fire years, 12 out of 17 years.”

2. “The most efficient initial attack and aviation program level was not affected by the severity of the fire year in four of the six case study forests.”

3. “The simulated fire suppression cost drops in response to increases in the initial attack and aviation program levels in all case studies.”

4. “The net value change of resource outputs and structures caused by fires was a very small percentage of the total cost + net value change in 13 of the 17 years studied.”

5. “The vast majority of the net value change in these cases was the loss of commercial timber and structures.”

The authors also document the limitations of this study that must be overcome before a complete economic analysis of alternative fire management programs can be conducted. Included are:

1. “Effectiveness estimates of program alternatives and mixes for all five major components of the fire management program (prevention, detection, initial attack, escaped fire suppression, and fuel treatments) must be incorporated within a single model construct.”

2. “The range of the program levels tested should be wider than the 1979 - 20 percent to 1979 + 40 percent tested in this study to ensure that the minimum cost + net value change is located.”

3. “The stochastic element must be more completely incorporated throughout the entire analysis from its source in fire occurrence and fire weather variations through to a probability.
distribution of resource impacts and cost + net value change itself."

(4) “Even though the preliminary sensitivity analysis in this study demonstrated that errors in the fire effects and resource value estimates would not materially affect the answers on economic efficiency, the accuracy of some of these estimates is still quite suspect.”

This study demonstrates that economic efficiency analysis for wildland fire management can be practically applied. At the present time it can indicate general management guidelines using the best resource value figures and prediction techniques available. As these improve, more specific guidelines can be developed. The sensitivity analysis provides important clues as to which resource value and value change variables are most crucial in their influence on the analysis. Research is currently underway (e.g., Althaus 1980, Mills 1980, Simard et al. (1980) that should improve resource value, value change, and value-at-risk information including nonmarket, secondary, and off-site values.

The few economic studies of State fire management programs have indicated that past and current fire protection programs have been cost effective and that additional investments in these programs are justified. For example, Winkworth et al. (1979) concluded “with every passing year, the timber values at risk in North Carolina are growing, not only due to the success of public incentive programs but as a result of real price increases for standing timber. Using economic guidelines, greater expenditures for fire protection are justified (moreover they are essential) when values at risk increase . . . . North Carolina has not yet reached the point of diminishing returns in wildfire protection.” The preceding results are in contrast to those obtained for National Forests, which often indicated that the lowest fire protection level examined was the most cost effective. The contrasting results are not necessarily inconsistent because the fire management programs examined for the National Forests are much more intensive and thus more likely to have reached a point of diminishing returns.

EQUITY

The state of the art in applying economic principles to wildfire management programs appears to be sufficiently developed to provide general guidelines and evaluations. Current research holds the promise of improving the state of knowledge and providing more specific results. Unfortunately, however, this is true only for evaluating economic efficiency. Further, much of the efficiency analysis has focused on the needs of Federal land managers, particularly the USDA Forest Service, in western States containing large acreages of National Forests. In this case it seems reasonable that the costs and benefits of public wildland fire management should be examined from a societal viewpoint because public land management plans and objectives are clearly intended to serve the public interest.

The use of economic analysis to examine the equity of wildfire management programs either separately or in combination with efficiency analysis has been limited. The question of equity is much more important when developing an economic rationale to evaluate programs for managing wildfire on State and private land. To indicate the costs and benefits associated with wildland fire management and assume that they accrue to some vaguely defined unit called “society” is insufficient. Equity analysis is necessary to determine who pays (or should pay) the costs or who reaps the benefits of wildfire management programs. Specific questions that must be addressed were posed in a State and Private Forestry status report on Cooperative Fire Protection Economic Analysis at a USDA Forest Service Regional Foresters and Directors meeting in Missoula in July 1980. They are:

(1) “What level of fire protection and cost is most appropriate and commensurate with management objectives and investments for land protected by States?”

(2) “For lands protected by States, who has interest and derives benefits from fire protection efforts and costs?”

(3) “What protection level and cost is required to protect national interest in the lands protected by States?”

(4) “Who should pay the cost of fire protection and why?”

Harden (1980) addressed the first question. He attempted to measure the cost effectiveness of potential increases and decreases in a State fire protection budget using information developed in the National Forest System’s Fiscal Year 1980 Budget Analysis for the Mark Twain National Forest in Missouri. He extrapolated this information to State and private land in Missouri and obtained additional data from the Missouri Department of Conservation to estimate the cost effectiveness. He concluded that reducing suppression expenditures could result in large increases in timber damage and that increasing such expenditures would be cost effective in eastern Mis-
souri and marginally cost effective in western Missour-
ri. This approach gives a partial answer to question (1)
but it is still primarily concerned with economic effi-
ciency rather than equity. Questions (2), (3), and (4)
involve equity and remain largely unanswered.

Only a few studies have dealt with the question of
equity in fire management programs in conjunction with economic efficiency. Kling (1951) and Swager et al. (1958) analyzed the cooperative
forest fire program. Kling was primarily concerned
with a nonquantitative description and evaluation of
policy and administrative programs. Swager et al.
attempted to determine appropriate funding levels
for adequate fire protection on non-Federal forest
land and how the costs should be shared by Federal,
State, and private parties. Although this research
provides a gross estimate of equity for sharing costs
between Federal and State governments and private
sources, it does not indicate how Federal funds
should be distributed among States or how States
should distribute costs and benefits internally.

We did not locate any references since the work of
Swager et al. (1958) that dealt explicitly with the
question of equity in wildland fire management pro-
grams. Although we could have missed some, a decid-
ed gap in the state of the art of fire economics is
clearly indicated. This is surprising, because ques-
tions of equity would appear to be addressable. Rel-
vant data should be available, although somewhat
tedious to collect, and conventional welfare economics
and public finance theory should be applicable.

**SUMMARY**

In terms of economic efficiency, the state of the art
for using economics in wildland fire management has
made significant advances. Partial economic efficien-
cy models have been developed, are being applied,
and are capable of providing general guidelines for
some aspects of public wildland and fire man-
agement. Further advances are likely, such as the
development of more complete economic models as
well as improved resource value, value change, and
value-at-risk information. Recent work by Schweitzer
et al. (1980) and its expansion in the 1980 Budget
Analysis (U.S. Department of Agriculture, Forest
Service 1979b) for the National Forests is
representative of the current state of the art. Harden
(1980) has shown that there are cases in which
pecific National Forest analyses can be extrapolated
to nearby State land, at least in terms of area-wide
economic efficiency.

Several problems remain, however, even for eco-
nomic efficiency analysis. A gap will always exist
between what is theoretically desirable and what is
practical to apply, given the limitations of time availa-
ble for management decisions and the cost of informa-
tion needed for available models. The models are
compromises between what should and what can be
done. A similar situation exists for values, value
changes, and values-at-risk. Theoretically, these
should all be measured and expressed in monetary
terms but this may not be practical. For example,
much controversy occurs as to how losses should be
appraised even for timber, one of the most marketable
resources. Selecting the proper method to use for
measuring nonmarket values is even more difficult
and will always be somewhat subjective and arbitrary.
At the far extreme of measurement and monetary
expression difficulty are noneconomic resource val-
ues, such as endangered species habitat. The
noneconomic value must be recognized and consid-
ered, however, in determining fire management policy
and practice. The potential for rare but large and
disastrous conflagrations must also be considered
even though conventional economic efficiency analy-
ses are poorly suited to incorporate such events.

In contrast to the well developed state of the art for
economic efficiency, the issue of economic equity has
received little attention. Serious attention should be
devoted to the question of who pays, or should pay,
the costs and who obtains the benefits of wildfire
management programs. With such information, more
complete economic efficiency models, and improved
resource value data, it should be possible to provide
improved and more specific guidelines for fire man-
agement, which will result in economically efficient
and equitable programs.
ANOTATED BIBLIOGRAPHY OF SELECTED REFERENCES APPLYING ECONOMIC TECHNIQUES TO WILDLAND FIRE MANAGEMENT

Advisory Commission on Intergovernmental Relations
1979.

KEYWORDS:
Alston, Richard M., and David M. Freeman
1975.
The natural resources decision-maker as a political and economic man: toward a synthesis. J. Environ. Manage. 3:167-183.
Examines two sets of decision rules for planning--the economic benefit-cost analysis and the sociological approach--and demonstrates the usefulness of integrating the two.

KEYWORDS: decisions, natural resources, benefit-cost analysis, sociology

Althaus, Irene A.
1980.
Pac. Southwest For. and Range Exp. Stn., Riverside, Calif.

KEYWORDS:
Anon.
1965.
Describes fire economic research in California and makes suggestions for future work and revision.

KEYWORDS: operations research, cost effectiveness, production relationships

Arnold, R.K.
1949.

KEYWORDS:

Arrow, K.J.
1966.

KEYWORDS:
Askew, Arthur J.
1975.
Chance-constrained dynamic programming. Water Resources Research
KEYWORDS:

Baker, Junius O., Jr.
Collins. 25p.
KEYWORDS:

Baker, Junius O.
1975a.
A selected and annotated bibliography for wilderness fire managers.
KEYWORDS:

Baker, J. O., Jr.
1975b.
Wilderness fire management: policy development and implementation.
KEYWORDS:

Bakker, Pieter
1975.
Economic impacts of forest fires: the Entiat case. M.S. Thesis,
Univ. Wash., Seattle. 113 p.
KEYWORDS:

Barney, Richard J.
1975.
Defines fire management as "the integrating of fire related biological,
ecological, physical and technological information into land management
to meet desired objectives."
KEYWORDS: fire management, land use

Barney, Richard J.
1979.
Wildland fire research needs in the west: Forest Service managers'
Mtn. For. and Range Exp. Stn., Ogden, Utah.
Provides guidance for defining and setting priorities in wildfire
research in the western regions of the USDA Forest Service.
KEYWORDS: wildfire, research needs, problem definition

KEYWORDS:

Baumol, William J. 1969.

KEYWORDS:

An outline of forest fire protection standards. For. Chron. 25(2): 82-106.
Develops standards of fire protection adequacy for Canada. Primary objectives are defined in terms of acceptable burned area.

KEYWORDS: fire protection standards, Canada, acceptable burn

Beichler, W.K. 1940.
Discusses the proper objectives for a fire control agency and provides a detailed recommendation as to how to obtain adequate, justifiable funding.

KEYWORDS: fire control, public finance, funds, objectives

Uses a systems model to interpret the persistance of an unsuccessful wildfire exclusion policy.

KEYWORDS: wildfire, watershed management, forest management, systems analysis, decision-making models, land use, fire management, fuel management, fire control, ecosystem

Describes a new technique to harmonize forest management actions for multiple benefits, to give all interested parties an opportunity to participate in the selection of biologically possible combinations of benefits, and to provide alternatives for management previously not available.

KEYWORDS: multiple benefits, silviculture, forest management, system dynamics
Brady, R. Paul
1978.
Forest fire value appraisal, fire effects--values-at-risk. Can.
Examines forest fire value appraisal, fire effects and values-at-risk in Canada.
KEYWORDS: fire value appraisal, fire effects, values-at-risk

Brady, R. Paul
1979.
Forest fire value appraisal. 6p. [Presented at International Fire Management Workshop, Edmonton, Alberta, October 31-November 1, 1978.]
Describes the general kinds of forest resource values, the general trends in Canadian practice for evaluating fire effects and the kinds of improvements that are being tested.
KEYWORDS: value appraisal, Canada, fire effects

Bratten, Fredrick W.
1980.
22 p. Pac. Southwest For. and Range Exp. stn., Riverside, Calif.
KEYWORDS: 

1980.
KEYWORDS: 

Brodie, J.D., D.M. Adams, and C. Kao
1978.
KEYWORDS: computer techniques, systems analysis, simulation

Broido, A., R.J. Mc Conne, and W.G. O'Regan
1965.
Some operations research applications in the conservation of wildland resources. Manage. Sci. 11(9):802-814.
Indicates some of the limited operations research done on wildland problems and calls attention to the ever increasing opportunity for more effort.
KEYWORDS: planning, fire costs, model, resources

KEYWORDS:


KEYWORDS: fire use, economic evaluation, fire hazard reduction, chaparral conversion

Brown, Thomas C., and Ron S. Boster 1978. On the economics of timber damage appraisal for public forestry. J. For. 76(12):777-780. Demonstrates the difference in damage appraisal methods needed if ownership aim is maximum mean annual increment rather than maximum site rent.

KEYWORDS: damage appraisal, suppression expenditures, public forests


KEYWORDS: chaparral control, multiple use, economic evaluation, cost estimation


KEYWORDS: fire danger classes, number of fires, frequency, mathematical relationships
Bruce, N.G.
KEYWORDS:

Buhyoff, G.J., W.A. Leuschener, and J.D. Wellman
1979.
Studies the aesthetic impact of southern pine beetle damage using a
paired-comparisons method to determine the preferences of subjects
differing in their socialization of forest management.
KEYWORDS: landscape preference, aesthetic impact, insect damage

Burtner, C. E.
1966.
The economics of a fire protection program. Fire Technology 2(1):5.
Discusses a method for quantitatively evaluating cost, not from an
economist's point of view, but as an engineering analysis. Describes the
method and gives an example of its application.
KEYWORDS: fire protection, cost

Burton, Ian, and Robert W. Kates
1964.
The perception of natural hazards in resource management. Nat. Res. J.,
Jan., pp.412-41.
KEYWORDS:

Capel, R.E., and A.G. Teskey
1970.
Efficiency in suppressing forest fires: a study of the Southeast area
Winnipeg, Manitoba.
Evaluates criteria for expenditures on forest fire control, with special
application to the Southeast forest area of Manitoba.
KEYWORDS: suppression, area burned, efficiency criteria

Carlson, Gerald A., and Donald V. DeBord
1976.
Public mosquito abatement. J. Environ. Econ. and Manage. 3(2): 142-153.
Develops a simultaneous model for mosquito abundance and abatement response.
KEYWORDS: mosquito abatement, economic model
Prepared for U.S. Department of Agriculture, Forest Service by
Prepresents an analysis of the economic costs and benefits which are
expected to result from implementing any one of three candidate wildfire
protection systems.
KEYWORDS: firescope, benefit-cost analysis, fire protection, California

Carroll, Franklin O.
1975.
Shows that inspection of fire and logging equipment is an effective method
to reduce number of fires and acres burned.
KEYWORDS: inspection, equipment, fire prevention

Chandler, Craig C.
1960.
How good are statistics on fire causes? J. For. 58(7):515-517.
Discusses the reliability of fire statistics in planning.
KEYWORDS: statistics, planning, fire causes, accuracy

Chandler, Craig C.
1961.
Develops a new system of risk rating designed to compare areas with
radically different prevention problems.
KEYWORDS: risk rating, fire prevention, weather, fuels, risk,
prevention effectiveness

Chandler, Craig C., and James B. Davis
1961.
Shows how much different types of people know about fire prevention.
KEYWORDS: fire prevention, education, survey, people

Chandler, Craig C., and Charles F. Roberts
Problems and priorities for forest fire research. J. For. 71(10):625-628.
Shows how forestry is changing in orientation and focus and the resulting
need for new direction in formulating fire protection policy and identi-
fiying fire research needs.
KEYWORDS: hazard reduction, fire behavior and effects, policy,
risk reduction
Childs, Dan, Gerald Doesken, and Jack Frye
1977.
Economics of rural fire protection in the Great Plains. Economic De-
velopment Division, Economic Research Service, USDA Agriculture Information
Prepresents data and procedures to help local decision makers analyze
alternative rural fire protection systems.
KEYWORDS: Oklahoma, rural fire protection, economics

Ciriacy-Wantrup, S.V.
1964.
"Benefit-cost analysis and public resource development." In Smith,
S.C., and E.N. Castle, eds., Economics and Public Policy in Water Re-
source Development. Iowa State Univ. Press, Ames.
KEYWORDS:

Cobb, Steven A.
1977.
Site rent, air quality, and the demand for amenities. J. Environ. Econ.
and Manage. 4(3):214-218.
Discusses the meaning of the hedonic equation.
KEYWORDS: site rent, air quality, demand for amenities, hedonic function

Cohen, Alan S.
1975.
Note on "benefit-cost analysis: a questionable part of environmental
KEYWORDS:

Connaughton, Charles A.
1970.
Fire related research and development needs. In The Role of Fire in the
Intermountain West: Symposium Proceedings. Fire Research Council, Missoula,
Mont., pp. 199-201.
KEYWORDS:

Countryman, C.M.
1966.
Rating fire danger by the multiple basic index system. J. For. 64(8):
531-536.
Breaks down fire danger into its component parts and determinants that con-
trol them. Explains advantages of the multiple index system.
KEYWORDS: basic indexes, fire danger, rating system

Cowles, Floyd R.
1972.
Railroad-caused fires: what starts them, what keeps them going. Fire
Causes of railroad fires and what has been done to prevent them.
KEYWORDS: equipment, heat, fire, prevention
Coyle, Leonidas
1929
A basis for determining proper expenditures for fire protection.
J. For. 27(2):148-150.
Compares the fire protection results from funds spent as opposed to
the potential results of spending none at all.
KEYWORDS: risk, cost, money, fire protection

Craig, R.B., B. Frank, G.L. Hayes, and G.M. Jemison
1945.
Fire losses and justifiable protection costs in the southern piedmont of
Virginia. USDA For. Serv., Appalachian For. Exp. Stn., Asheville, N.C.
KEYWORDS:

Craig, R.B., B. Frank, G.L. Hayes, and T.F. Marburg
1946a.
Fire losses and justifiable protection costs in the south-western
coal section of Virginia. USDA For. Serv., Appalachian For. Exp. Stn.,
Asheville, N.C.
KEYWORDS:

Craig, R.B., T.F. Marburg, and G.L. Hayes
1946b.
Fire losses and justifiable protection costs in the coastal plain region
of South Carolina. USDA For. Serv., Appalachian For. Exp. Stn., Asheville,
N.C.
KEYWORDS:

Crosby, John S.
1954.
Probability of fire occurrence can be predicted. USDA For. Serv., Tech.
Shows how a danger meter can be used to predict the number and size of
fires in the Central States.
KEYWORDS: fire danger, risk factor, fire size, budgeting, effectiveness

Crosby, John S.
1977.
A guide to the appraisal of wildfire damages, benefits, and resource
values protected. USDA For. Serv., Res. Paper NC-142, 43 p., illus.
A set of value concepts and methods for appraising both values-at-
risk and changes in value resulting from wildfire are presented. Emphasis
is placed on the effects of forest fires in terms of their effects on
human and organizational goal achievement.
KEYWORDS: forest fire damage appraisal, forest fire benefits,
values-at-risk, forest fire planning

14
Cunningham, A. A., and D. L. Martell
1976.
KEYWORDS: fire danger, assessment, fire control

Curry, John R.
1938.
Uses damage costs, suppression costs and preparedness costs to demonstrate the most efficient size of force and the resulting acceptable acreage burned.
KEYWORDS: fire protection, damage, suppression costs, guard costs

Davis, James B., and Craig C. Chandler
1961.
Discusses what people in California know about fire law enforcement.
KEYWORDS: fire law enforcement, people, California

Davis, James B., and Robert L. Irwin
1976.
FOCUS: a computerized approach to fire management planning. J. For. 74(9):615-618.
Explains how FOCUS, a computerized approach to fire management planning, works.
KEYWORDS: computer program, fire management, FOCUS

Davis, James B., et al.
1977.
Shows how the economics of fire management planning can be tied directly to land management planning as part of the overall RPA requirements and schedules.
KEYWORDS: economics, fire management, land management

Davis, James B.
1979.
KEYWORDS:
Davis, Lawrence S.
1965.
The economics of wildfire protection with emphasis on fuelbreak systems. Calif. Div. For., Sacramento. 166 p.
Develops a production model of wildfire protection that includes the multiple inputs of suppression and fuel modification. Uses the model to estimate the productivity of protection activities in California and to investigate the economic potential of large scale fuel modification.
KEYWORDS: production economics, wildfire protection, fuel breaks

Davis, Lawrence S.
1971.
KEYWORDS:

Davis, Lawrence S.
1974.
An exploration of the economics of fire management programs in the Rocky Mountains with emphasis on information needs. Unpublished manuscript. 19 p.
Defines fire management, develops a general economic model for program evaluation, classifies benefits, costs and damages related to fire management, and suggests some procedural and research activities.
KEYWORDS: fire management model, program evaluations, individual fire evaluations

Deeming, John E., James W. Lancaster, Michael A. Fosberg, R. William Furman, and Mark J. Schroeder
1972.
KEYWORDS:

Devet, David D.
1975.
KEYWORDS:

Donoghue, Linda R.
1979.
KEYWORDS:

Dunwoody, Charles G. 1929. Who should bear the responsibility of providing fire protection on lands outside the national forests? J. For. 27(2):151-154. KEYWORDS: California

Eckels, Karen L., and Alan R. Taylor 1979. FIRE BASE. The wildland fire bibliographic information system. Environ. Manage. 3:21-27. KEYWORDS:


Egging, Louis T., Richard J. Barney, and Rita P. Thompson 1980. A conceptual framework for integrating fire considerations in wildland planning. USDA For. Serv., Res. Note INT-278. 11p. Intermt. For. and Range Exp. Stn., Ogden, Utah. Offers a system for land management planning to enable managers to include and evaluate the effects of wildfire or prescribed burning on resources. KEYWORDS: fire management, land use planning

Ewart, Jerry
1976.
Shows that hot shot crews that are trained to work together and who know
fire behavior, fire weather and their equipment are effective on fires.
   KEYWORDS: costs, training, suppression

Fischer, D.W., and G.S. Davies
An approach to assessing environmental impacts. J. Environ. Manage.
   KEYWORDS:

Fischer, D.W.
1975.
Willingness to pay as a behavioural criterion for environmental decision-
Attempts to summarize and pull together the structure for showing the
economic nature of the perception problem and to demonstrate the inherent
problems in the use of willingness to pay as a behavioural criterion for
environmental managers and researchers.
   KEYWORDS: willingness to pay, environmental decision-making,
economic nature of perception

Fisher, Anthony C., and John V. Krutilla
1974.
Valuing long run ecological consequences and irreversibilities. J. Environ.
Econ. and Manage. 1:96-108.
Uses central Florida as an example of reversible vs. irreversible decisions,
i.e., perpetuating the area for nature vs. draining for agriculture.
   KEYWORDS: irreversible, reversible, economics

Flatman, George T., and Theodore G. Storey
1979.
Decision techniques for evaluating fire plans using FOCUS simulation.
USDA For. Serv., Res. Note PSW-338. 6p. Pac. Southwest For. and Range
Exp. Stn., Berkeley, Calif.
Describes and illustrates how the cost-plus-loss and benefit-cost
methods, in conjunction with FOCUS simulation, can help to quantify
the evaluation of a variety of fire planning decisions.
   KEYWORDS: fire suppression strategy, benefit-cost analysis, fire damage,
decision making, computer programs, FOCUS

Flint, Howard R.
1924.
The appraisal of forest fire damages. J. For. 22(2):154-161.
Discusses the uses of forest fire damage information and appraisal methods.
   KEYWORDS: fire damage, definition, damage, appraisal, values
Flint, Howard R.  
1928.  
Suggests a working definition for the term "adequate fire control."  
KEYWORDS: adequate fire control, adequate fire protection, cost, losses

Flora, D. F.  
1968.  
Pooh on damage appraisal. J. For. 66(1):12-16.  
Reviews alternative damage appraisal measures, their merits and limitations.  
KEYWORDS: physical measures, economic measures

Folkman, William S.  
1965.  
Forest fires as accidents: an epidemiological approach to fire prevention research. (speech) 15p. [Presented at "Keep Green" Luncheon, 56th Western Forestry Conference of the Western Forestry and Conservation Association, Vancouver, B.C., December 8, 1965.]  
Compares accident research to forest fire prevention research.  
KEYWORDS: fire prevention, epidemiology, accidents

Forstall, Fred, William F. Hyde, and J. Michael Vasievich [n.d.]  
KEYWORDS:

Fulcher, G.D.  
1977.  
KEYWORDS:

Gale, Robert D.  
1976.  
Establishing the benefit of fire management. (Speech) 9p. [Presented at Colloq. Fire Econ., Denver, Colo., Sept. 9, 1976.]  
KEYWORDS:

Gale, Robert D.  
1977.  
Evaluates fire management practices, procedures and management strategies of the U.S. Forest Service, and examines the appropriateness of achieved results.  
KEYWORDS: policy, management strategies, economics, National Forests
Gamache, Adrien E.
1969.
Develops a simulation model through which the classical objective of forest fire protection, that of "least cost-plus-loss," might be implemented.
KEYWORDS: fire suppression, economic theory, simulation model

Gibson, H. P., Lance F. Hogdin, and John L. Rich
1976.
Evaluating national fire planning methods and measuring effectiveness of presuppression expenditures. USDA, For. Serv., Washington, D.C.
KEYWORDS:

Gisborne, H.T.
1939.
Outlines Hornby's principles of fire control planning. Emphasizes the major features which have too often been obscured by the detailed technical procedures.
KEYWORDS: fire control planning, fuel types, research

Gisborne, H.T.
1940.
Comparison of intensive versus limited forest fire control action. USDA For. Serv., Res. Note 10. 5p. Northern Rocky Mt. For. and Range Exp. Stn., Missoula, Mont.
Compares the economic impact of fires on an intensively protected area in Idaho and Montana and an adjacent area with limited protection in Canada.
KEYWORDS: intensive protection, limited protection, Idaho, Montana, British Columbia

Gorte, Julie K., and Ross W. Gorte
1979.
Discusses both the historic and contemporary influences of economics in formulating USDA, Forest Service fire management policy in allocating money for fire management and in appraising fire effects. Includes a partial listing of publications that deal with resource valuation.
KEYWORDS: economics, fire management, benefit-cost analysis, damage appraisal
Gorte, Ross W.  
1979.  
Develops a new fire effects appraisal system for Wisconsin which recognizes non-timber wildland values and the possible beneficial effects of fire.  
KEYWORDS: fire effects appraisal, economics, Wisconsin

Grah, Rudolf F., and Alan Long  
1971.  
Discusses the construction of fuelbreaks in central California.  
KEYWORDS: cost effectiveness, cost benefit, timber value, fuelbreaks

Greenlee, Jason, and Carl Wilson  
1979.  
KEYWORDS:

Haines, Donald A., Von J. Johnson, and William A. Main  
1975.  
Describes patterns of forest fire activity across the Northeastern and North Central United States. Gives average dates of greening and curing of herbaceous plants, median size of fires in various fuels, and annual profiles of peak fire activity. It also examines combinations of major fire causes and day-of-week activity.  
KEYWORDS: fire danger rating, herbaceous stage, fire season, national forests

Harden, Charles H.  
1980.  
Forest fire protection economic analysis, Missouri Department of Conservation. USDA For. Serv., Cooperative Fire Protection.  
Measures the cost effectiveness of potential increases and decreases in a State fire protection budget.  
KEYWORDS: cooperative fire protection, economic analysis, cost effectiveness
Harrison, H. Ames
1977.
Rural community fire protection program: two years of accomplishment. J. For. 75(12):780-781.
Describes the operation of the Rural Community Fire Protection Program (RCFD) and cites examples of its accomplishments in 1975 and 1976.
KEYWORDS: fire protection, rural communities, cooperative fire management

Headley, Roy
1916.
Fire suppression district 5. USDA For. Serv., May 1, 1916. 58p.
KEYWORDS:

Headley, Roy
1943.
North. Rocky Mt. For. and Range Exp. Stn., Missoula, Mont.
KEYWORDS:

Helliwell, D. R.
1974.
Discount rates in land-use planning. Forestry 47(2):147-152.
Suggests that discounting procedures employing rates similar to the current bank rates are not appropriate in forest planning and that much lower discount rates should be used, together with an assessment of the ratio of expected income to capital investment.
KEYWORDS: discounting, forest planning, land-use planning

Holley, Lester
[n.d.]
An illustration of "least-cost-plus-loss" and "benefit-cost" in determining the optimum level of forest fire protection. Draft Manuscript, N. Carolina Division of For. Resources. 11p.
Illustrates "least-cost-plus-loss" and "benefit-cost" models in the context of a fire budgeting problem to show that they are equivalent.
KEYWORDS: fire protection, least-cost-plus-loss, benefit-cost, budgets

Hornby, L.G.
1936.
Fire control planning in the northern Rocky Mountain region. USDA For. Serv., Missoula, Mont. 179p.
KEYWORDS:

Hubert, C.A.
1959.
Hughes, Jay M.
1976.
The Resources Planning Act and some gut issues for forest economists.
KEYWORDS:

Jeffers, J.N.R.
Systems modeling and analysis in resource management. J. Environ. Manage.
Reviews some of the current developments in systems modeling and analysis
in resource management, and also discusses the application of mathematical
models and techniques to the problems which particularly interest ecolo-
gists, geographers, geologists, meteorologists and other branches of the
environmental sciences.
KEYWORDS: systems modeling, resource management

Jischke, M., and J. Shamblin
1974.
Chapter 1: introduction, section c, wildland fire management, volume 1:
prevention methods and analysis. Stein Weissenberger, ed. Stanford
KEYWORDS:

Jones, T. Morris, and M. B. Badenhop
1977.
U. of Tenn., Ag. Exp. Stn.
KEYWORDS:

Kalter, R.J., W.B. Lord, D.J. Allee, E.N. Castle, M.M. Kelso, D.W.
Bromley, S.C. Smith, S.V. Ciriacy-Wantrup, and B.A. Weisbrod
1969.
Criteria for federal evaluation of resource investments. Water Resources
and Marine Sciences Center, Cornell University, Ithaca, New York.
KEYWORDS:

Kates, Robert W.
1962.
Hazard and choice perception in flood plain management. Dept. of Geog.
KEYWORDS:
Kelso, M.M. 1977. Natural resource economics: the upsetting discipline. Amer. J. Agr. Econ. 59(5):814-823. Demonstrates the incompatibility between natural resource economics (which should perceive nature as a closed system) and the conventional economic wisdom.

KEYWORDS: conventional economics, land economics, policy


KEYWORDS:


KEYWORDS: Clark-McNary Act, cooperative fire protection, administration


KEYWORDS: natural resource policy, economics, environmental resources


KEYWORDS:


KEYWORDS: resource allocation, decision makers, operations research, Canada


Loveridge, Earl W. 1944. The fire suppression policy of the U.S. Forest Service. J. For. 42(8): 549-554. Discusses the Forest Service's 10:00 a.m. policy. KEYWORDS: fire suppression, costs, fire control
Lowe, Philip O., Peter F. Ffolliott, John H. Dieterich, and David R. Patton
1978.
Shows that although wildfires are frequently destructive to the timber resource, wildlife may not be so adversely affected. Selected species of wildlife are studied.
KEYWORDS: fire effects, fire economics, wildlife populations, Arizona, ponderosa pine

1978.
KEYWORDS:

Mactavish, J.S.
1965.
Uses flood control planning techniques to construct an economic model for forest fire control even though recognizing that the required information to practically apply the model is probably not available.
KEYWORDS: economics, fire control, flood control

Mactavish, J.S.
1966.
Appraising fire damage to mature forest stands. Can. Dept. of Forestry and Rural Development, publication no. 1162. 31 p.
Discusses an approach to the standardization of appraising forest fire damages.
KEYWORDS: fire damages, economic, fire control, Canada

Mar, B.W.
1974.
Problems encountered in multidisciplinary resources and environmental simulation models development. J. Environ. Manage. 2(1):83-100.
Conducts an experiment to assess and document interdisciplinary environmental modeling activities.
KEYWORDS: multidisciplinary resources, environmental simulation models

Marglin, S.A.
1963.
KEYWORDS:

KEYWORDS:


KEYWORDS:


KEYWORDS: fire management, National Forests, economic valuation


KEYWORDS: fire management, National Forests, economic valuation

McDougall, Gerald S., and Colin Wright. 1980. A proposal for improving the measurement of benefits from pollution abatement. J. Environ. Econ. and Manage. 7(1):20-29. Shows that conditions will often exist when the property value approach will not accurately measure all benefits and conditions will always be present that cause health damage function approaches to underestimate benefits.

KEYWORDS: pollution abatement, property value, health-damage function, benefits


KEYWORDS:
Mc Intyre, Robin T., and Roswell K. Miller
1979.
KEYWORDS: fixed costs, stumpage value, damage appraisal, harvest decisions

Mc Lean, D. L.
1968.
Proposes damage appraisal method designed to increase the accuracy of damage estimates of immature stands to the same level as mature stands.
KEYWORDS: damage appraisal, fire, estimate

Mc Lean, D. L.
1970a.
KEYWORDS: damage appraisal, fire control, economics

Mc Lean, D.
1970b.
Presents a model for investigating the derived demand for fire protection and discusses its implications and limitations.
KEYWORDS: fire protection, economics, derived demand, timber

Mc Lintock, T. F.
1968.
Identifies appraisal of values-at-risk and the nature, extent and controllability of damage as the most important problems in establishing protection priorities.
KEYWORDS: values-at-risk, management, protection, damage appraisal

Mc Nasser, K. W.
1959.
Cites developments in California, North Carolina and Georgia as examples of the cooperation between state and federal agencies needed for successful fire research.
KEYWORDS: fire research, cooperative fire management
McTheven, Ian R. 1974. Development of a numerical index to quantify the aesthetic impact of forest management practices. Can. For. Serv., Info. Rep. PS-X-51. 9 p. Petawawa For. Exp. Stn., Chalk River, Ont. Develops a simplified numerical index to quantify the aesthetic impact of forest practices on particular stands or operating units. KEYWORDS: numerical index, aesthetics


Miller, Charles W. 1968. A method of economic analysis and data required to determine justifiable expenditure for protection of tangible forest values from fire. M.S. Thesis, Ore. St. Univ., Corvallis. 228 p. Develops a classical economic model for determining justifiable protection expenditures and describes the data which would be needed to implement it. KEYWORDS: economic theory, fire protection, tangible value


Mills, Thomas J. 1979a. Calculation of financial return and determination of budget levels for fire protection programs. USDA For. Serv., manuscript on file. 18 p. Pac. Southwest For. and Range Exp. Stn., Riverside, Calif. KEYWORDS:

Mills, Thomas J.
1980.

KEYWORDS:

Mitchell, J. A.
1954.
Suggests that for statistical purposes, fire damage estimates should be based upon depreciation in present worth.

KEYWORDS: damage appraisal, fire loss, present worth

Miyagawa, R. S., and E. V. Stashko
1971.
Fire size and cost. Forest Protection Branch, Alberta Forest Service.
Investigates the curvilinear relationship between fire size and cost to formulate mathematical models of cost.

KEYWORDS: fire size, cost, economics

Moak, James E.
1976.
Uses the benefit-cost analytical technique to give the fire manager a quantitative basis for decision making.

KEYWORDS: benefit-cost, fire damage, suppression and prevention costs

Mobley, Hugh E.
1974.

KEYWORDS:

Morrell, Fred
1931.

KEYWORDS:

Murphy, James L.
1965.

KEYWORDS:
Uses a "protection possibility" curve and "iso-dissatisfaction" curves to demonstrate that existing levels of fire protection expenditures, if considered adequate by the forest manager, give an idea of the nonwood value of a forest as seen by him.
KEYWORDS: fire protection, economics, planned cut

Discusses the results of a policy change from "fire control" to "fire management" after one year.
KEYWORDS: fire control, fire management, policy

Develops a probability model to evaluate the effectiveness of fire prevention efforts applied under specific weather conditions.
KEYWORDS: fire prevention, model, weather

Establishes the economic impact on the statistical region of Maryborough, Queensland, of the conversion of all, or part, of the forest resources of Fraser Island to a national park.
KEYWORDS: resource management, economics

North, D. Warner, Fred L. Offensend, and Charles N. Smart 1975.
KEYWORDS:

Noste, Nonan V., and James B. Davis 1975.
Demonstrates inconsistency of current appraisal efforts by comparing appraisals by the USFS and the BLM following two large fires.
KEYWORDS: fire management, damage appraisal, benefit-cost analysis
O'Connell, Paul F.  
1971.  
KEYWORDS:

Oregon State Forestry Department  
1972.  
The fire control program: a cost analysis of fire control activities.  
Fire Control Division, Oregon State Forestry Department.  32p.  
KEYWORDS:

Parks, George M.  
1964.  
Development and application of a model for suppression of forest fires.  
Suggests a model to describe the spread of free burning wildland fires and the effect of various types of suppression activity.  
KEYWORDS: model, cost, suppression application

Parvin, Manoucher, and Gus W. Grammas  
1976.  
Optimization models for environmental pollution control: a synthesis.  
J. Environ. Econ. and Manage. 3(2):113-128.  
The optimization models presented here represent a synthesis between input-output analysis and mathematical programming models for environmental pollution control.  
KEYWORDS: optimization models, environmental pollution control, input-output analysis, mathematical programming

Rapport, David J., and James E. Turner  
1977.  
Shows how the economics of resource allocation provides a framework for viewing ecological processes.  
KEYWORDS: economics, ecology

Richardson, J. H.  
1971.  
Discussess how the BLM in Alaska allocates fire control resources during critical situations according to resource values, fire danger and numbers of personnel committed to fires.  
KEYWORDS: fire control, resources, values, allocation
1964.

Sackett, Stephen S.
1964.
Guides for allocating forest fire protection budget in Wisconsin. M.S. Thesis., Univ. of Wisc.

KEYWORDS:

Sackett, S.S., H.H. Webster, and W.B. Lord
1967.
Economic guides for allocating forest fire protection budgets in Wisconsin. J. For. 65(9):636-641.
Examines the relationship between costs and losses associated with high versus low intensity protection among three fire situations.

KEYWORDS: fire protection, Wisconsin, benefit-cost analysis

Sandberg, D.V., J.M. Pierovich, D.G. Fox, and E.W. Ross
1979.

KEYWORDS:

Schafer, Elwood L., John F. Hamilton, Jr., and Elizabeth A. Schmidt.
1969.
Identifies what quantitative variables in photographs of landscapes were significantly related to public preference for those landscapes.

KEYWORDS: natural landscape preference, predictive model

Schafer, Elwood L., Jr., George Moeller, Douglas A. Morrison, and Russell Getty
1974.

KEYWORDS:

Schramm, G.
Accounting for non-economic goals in benefit-cost analysis.
J. Environ. Manage. 1(2):129-150.

KEYWORDS: benefit-cost analysis
Schuler, A., and J.C. Meadows
1975.
Addresses the question of how to put values on recreation, wildlife, aesthetic experiences and watershed potential.
KEYWORDS: multiple objectives, values, goal programming

Schultz, R. D.
1966.
Game simulation and wildland fire. J. For. 64(12):791-800.
KEYWORDS:

Schweitzer, Dennis L., Ernest Y. Anderson, and Thomas J. Mills
1980.
Evaluates the economic efficiency of the initial attack and aviation component of the fire management program on six widely placed National Forests.
KEYWORDS: fire management, national forests, economics, marginal analysis, cost-plus-net value change

Schwing, Richard C.
1979.
Suggests increased longevity as an alternative to "lives saved" as a measure of benefits derived from large-scale risk-reduction programs and demonstrates graphically the cost-effectiveness of various public programs.
KEYWORDS: risk, benefit-cost, analysis

Sewell, W.R.D.
Examines the extent to which present procedures for evaluation are able to provide the data that decision-makers require at various stages of that process.
KEYWORDS: resources management, decision-making
Sheehan, Michael, and K. C. Kogiku
[n.d.]a
Provides models and analyses to elaborate a method for making location specific allocations so as to minimize fire losses in a national forest or other relatively large area.
KEYWORDS: dynamic programming, value at risk, budget allocation

Sheehan, Michael, and K. C. Kogiku
[n.d.]b
A system simulation analysis of new strategies for long-run cost minimization in wildfire control. Dept. of Economics, Univ. of Calif., Riverside, Calif.
KEYWORDS:

Shideler, E. Ann
1957.
Selected references on the economics of forest fire protection. 18 p.
KEYWORDS:

Simard, A. J.
1976.
Traces the historical development of practical and economic wildland fire management policies and demonstrates the application of economic theory in fire control decision making.
KEYWORDS: economic theory, fire management, production function, costs

Simard, A. J.
1979.
Describes a computer simulation model which evaluates air tankers' productivity and effectiveness.
KEYWORDS: suppression, costs, air tankers, simulation, systems analysis

Simard, Albert J., David C. Baumgartner, Robert M. Loomis, and Richard W. Blank
1980.
KEYWORDS:
Slovic, Paul, Baruch Fishhof, and Sarah Lichtenstein
1979.
Explains the routes by which we arrive at our personal hazard assessments.
KEYWORDS: risks, judgments, hazards

Smith, J. Harry G.
1971.
Briefly discusses costs of fire control economic considerations in relation to value of timber, etc.
KEYWORDS: fire control, fire losses, benefit-cost, values-at-risk

Smith, V. Kerry
1979.
Uncertainty and allocation decisions involving unique environmental resources. J. Environ. Econ. and Manage. 6(3):175-186.
Examines the implications of the treatment of uncertainty in the definition of optimal investment criteria for irreversible allocations of unique environmental resources.
KEYWORDS: uncertainty, allocation decisions, environmental resources

Smyth, J. H., and I. R. Methven
1978.
Applies numerical index developed by Methven to quantify the aesthetic impact of forest management practices on particular stands or operating units.
KEYWORDS: numerical index, harvesting, aesthetic values

Sparhawk, W. N.
1925.
The use of liability rating in planning forest fire protection. J. of Agric. Res. 30(8):693-762.
KEYWORDS:

Stanford, Robert E.
1976.
Historical fire damage related to fire management decisions. Research proposal, Graduate School of Administration, University of California. Riverside, Calif. 18 p.
Proposes methods to model the relationship between suppression activity and fire damage and discusses the use of various methods for the valuation of non-market goods.
KEYWORDS: damage appraisal, non-market values, data requirements, suppression costs
Starr, Chauncey, and Chris Whipple
1980.
Shows that societal risk decisions made under conflict represent political compromises, and the resulting decision process creates substantial conflict costs which may be reduced by using quantitative risk criteria or "safety targets."
KEYWORDS: risk, societal decisions, intangibles

Storey, D.J., and M. Walker
1978.
Provides a framework within which alternative policies can be objectively compared.
KEYWORDS: water pollution, economics

Storey, Theodore G.
1972.
FOCUS: a computer simulation model for fire control planning. Fire Tech. 8(2):91-103.
Describes FOCUS, a computer simulation model for fire planning.
KEYWORDS: computer program, fire control, modules

Streeby, L.L.
1971.
Outlines the foundations of a fire damage appraisal system designed to improve the information for the fire protection decision-making process. Includes consideration of redistribution effects.
KEYWORDS: fire protection, appraisal, fire damage

Sutherland, Charles F., Jr.
Cost of forest closure in two Oregon counties. J. For. 71(10):644-647.
Examines actual costs of forest closure to woods operations in times of high fire danger.
KEYWORDS: fire danger, costs, losses, woods operations, Oregon

Swager, W.L., L.G. Fetterman, and F.M. Jenkins
1958.
A study of the cooperative forest-fire-control problem. Battelle Memorial Institute, Columbus, Ohio. 121 p.
Study contracted by the Forest Service to determine an appropriate level of spending for adequate fire protection on non-federal forest lands and the way costs should be shared by federal, state and private parties.
KEYWORDS: cooperative fire control, non-federal lands, cost sharing
Thompson, W.A., C.S. Holling, D. Kira, C.C. Huang, and I. Vertinsky 1979. Evaluation of alternative forest system management policies. The case of the spruce budworm in New Brunswick. J. Environ. Econ. and Manage. 6(1):51-68. Demonstrates that by making reasonable and easily verifiable assumptions about some properties of preference profiles of participants in the system, it is possible to produce an effective algorithm for forest policy evaluation.

KEYWORDS: forest management policy, algorithm, forest simulation

Thor, Edward C., Gary H. Elsner, Michael R. Travis, and Kathleen M. O'Loughlin 1978. Forest environmental impact analysis—a new approach. J. For. 76(11):723-725. Explains IMPACT, a new computerized approach that has been developed by the U.S. Forest Service to simplify the work of land management agencies in conducting environmental impact analyses and in preparing impact statements.

KEYWORDS: impact statements, computer program, forest management


KEYWORDS:


KEYWORDS:


KEYWORDS:


KEYWORDS: value, G.N.P., dollars, benefits
U.S. Department of Agriculture, Forest Service
1972a.
KEYWORDS:

U.S. Department of Agriculture, Forest Service
1972b.
KEYWORDS:

U.S. Department of Agriculture, Forest Service
1973a.
KEYWORDS:

U.S. Department of Agriculture, Forest Service
1973b.
KEYWORDS:

U.S. Department of Agriculture, Forest Service
1974a.
Fire management considerations for land use planning. Washington, D.C.
KEYWORDS:

U.S. Department of Agriculture, Forest Service
1974b.
KEYWORDS:

U.S. Department of Agriculture, Forest Service
1976.
An approach to determining cost effectiveness and economic value of expenditures for wildland fire control. Southeastern Area, State and Private Forestry, Atlanta, GA.
KEYWORDS:

U.S. Department of Agriculture, Forest Service
1977.
KEYWORDS:

U.S. Department of Agriculture, Forest Service
1978a.
KEYWORDS:
U.S. Department of Agriculture, Forest Service  
1978b.  
KEYWORDS:  

U.S. Department of Agriculture, Forest Service  
1979a.  
Establishes the results of comparing benefits to costs at three budget levels in three kinds of fire severity years on six National Forests.  
KEYWORDS: budget analysis, policy, benefit-cost analysis, National Forests, fire management  

U.S. Department of Agriculture, Forest Service  
1979b.  
Describes methodology to be used in collecting and analyzing data from a sample of National Forests to establish the relationship among budget levels and provide for a cost-efficient fire management program consistent with management objectives.  
KEYWORDS: budget '80 analysis, National Forests, fire management  

1967.  
KEYWORDS:  

Van Wagner, C. E.  
1979.  
Presents the case for basing damage estimates on the change in value of the whole forest of which the burned area is a part.  Provides examples to show that this method yields much lower estimates than conventional present value methods for immature stands.  
KEYWORDS: damage appraisal, whole forest concept  

Vasievich, J. Michael  
1976.  
KEYWORDS:  


Vasievich, J. Michael
1978.
Economic risk from fire. (speech) 16 p. [Presented at Southern Econ.
Emphasizes the land manager's need for fire loss expectation informa-
tion and describes a model to analyze the data and determine
the economic risk from fire on individual stands.
KEYWORDS: fire hazard, fire loss model, risk rating

Vogenberger, Ralph A., Earl F. Olson, and B.H. Corpening
1957.
A method for determining public fire control expenditures for private
lands. N.C. Dep. of Con. and Dev. and TVA Div. of For., Relations, 22 p.
Prepresents a comprehensive method for arriving at a goal for allowable burn
and for estimating funds needed to achieve it. Only timber values
are considered in the cost-plus-loss estimates for a 15-county
area of North Carolina.
KEYWORDS: North Carolina, budgets, private lands, fire expenditures

Wade, Dale D., and Darold E. Ward
1975.
Management decisions in severely damaged stands. J. For. 73(9):573-577.
Evaluates management options following severe damage by comparing
rates of return on investments. Shows that when recovery is uncertain
it often pays to delay the decision.
KEYWORDS: economics, costs, damage appraisal, value

Wagner, C.E.
1974.
Annotated bibliography of Forest Experiment Station 1961-1974.
Petawawa, Ont.
KEYWORDS:

Walter, G.R.
1977.
Economics of multiple-use forestry. J. Environ. Manage.
KEYWORDS: forestry economics, multiple use, market failure,
management institutions, resource evaluation

Walter, G.R.
1978.
Market methods of multiple use reconciliation. J. Environ. Manage.
7(3):291-296.
Discusses the problem in multiple use management of land-based
resources caused largely because of attempts to treat marketable
services as though they were non-marketable "public" goods.
KEYWORDS: multiple use, marketability, spatial management,
special interest areas, generalized access areas
Wells, Carol G., Ralph E. Campbell, Leonard F. DeBano, Clifford E. Lewis, Richard L. Fredriksen, E. Carlyle Franklin, Ronald C. Frelich, and Paul H. Dunn
1979.

KEYWORDS:

Westman, Walter E.
1977.
How much are nature's services worth? Sci. 197(9):960.
Illustrates both the importance of accounting for the benefits of nature's service in socially equitable decisions and the difficulties in doing so.

KEYWORDS: value, costs, services, nature

Williams, B. E., and A. D. Smith, Jr.
1966.

KEYWORDS: damage appraisal, fire losses, fire damage

Williams, D. E.
1969.
Discusses history of early fire control in Canada, and how and why fire economics started.

KEYWORDS: law of diminishing returns, fire control, least loss theory

Winkworth, Ralph, John Shepherd, and Lester Holley
1979.
Compares loss prevented in severe fire years (benefits) with North Carolina's fire protection budget levels (costs) to determine benefit-cost ratios.

KEYWORDS: fire protection, budgets, benefit-cost analysis, North Carolina

Wood, Donald B.
1979.
Examines economic feasibility of managing nonslash fuels in mature timber to reduce the costs and damages of wildfire.

KEYWORDS: forest fuels, fire management, hazard reduction, fuel management
Worrell, Albert C.  
1955.  
Economics of fire detection in the South.  J. For. 53(9):639-644.  
Discusses the economics of fire detection in fourteen counties in South-eastern Georgia.  
KEYWORDS: economics, fire detection, fire tower, air patrol

Zivnuska, J. A.  
1968.  
Discusses the economics of using fire in watershed management.  
KEYWORDS: economics, watershed, fire, controlled burning

Zivnuska, John A.  
1972.  
Maintains that the data of fire management are inadequate for making sound quantitative estimates of the relationships involved precluding economic analysis.  Uses prescribed burning as an example of the complexity of the problem.  
KEYWORDS: economics, prescribed burning
BOOKS

Brown, Arthur A., and Kenneth P. Davis

Chapman, Herman Haupt, and Walter H. Meyer
1947.

Ciriacy-Wantrup, S.V.
1968.

Clawson, Marion
1974.

Clawson, Marion
1975.

Clawson, Marion
1976.

Clawson, Marion
1977.
Research in forest economics and forest policy. 555 p. Resources for the future, Washington, DC.

Clawson, Marion
1979.

Duerr, William A.
1960.
Duerr, William A., Dennis E. Teeguarden, Sam Guttenberg, and Neils B. Christiansen
1974.
Forest resource management: decision-making principles and cases.
O.S.U. Book Stores, Inc., Corvallis, OR.

Gaylor, Harry P.
1974.

Gregory, G. Robinson
1972.

Herfindahl, Orris C., and Allen V. Kneese
1974.
Economic theory of natural resources. 405 p. Merrill Publishing Co., Columbus, OH.

Krutilla, John V., and Anthony C. Fisher
1975.
The economics of natural environments: studies in the valuation of commodity and amenity resources. 292 p. The Johns Hopkins Univ. Press, Baltimore, MD.

McHarg, Ian L.
1969.
Design with nature. 197 p. Doubleday - Natural History Press, Garden City, NJ.

Mishan, E. J.
1976.

Page, Talbot
1977.

The President's Advisory Panel

Quade, E.S.
1975.
Robinson, Glen O.
1975.

Seneca, Joseph J., and Michael K. Taussig
1974.

Shands, William E., and Robert G. Healy
1977.

Worrell, Albert C.
1959.

Reviews and summarizes the literature concerned with applying economic theory and techniques to solve wildland fire management problems.

KEY WORDS: Economic models, economic theory, wildfire economics, net value change, economic efficiency, economic equity