10-1982

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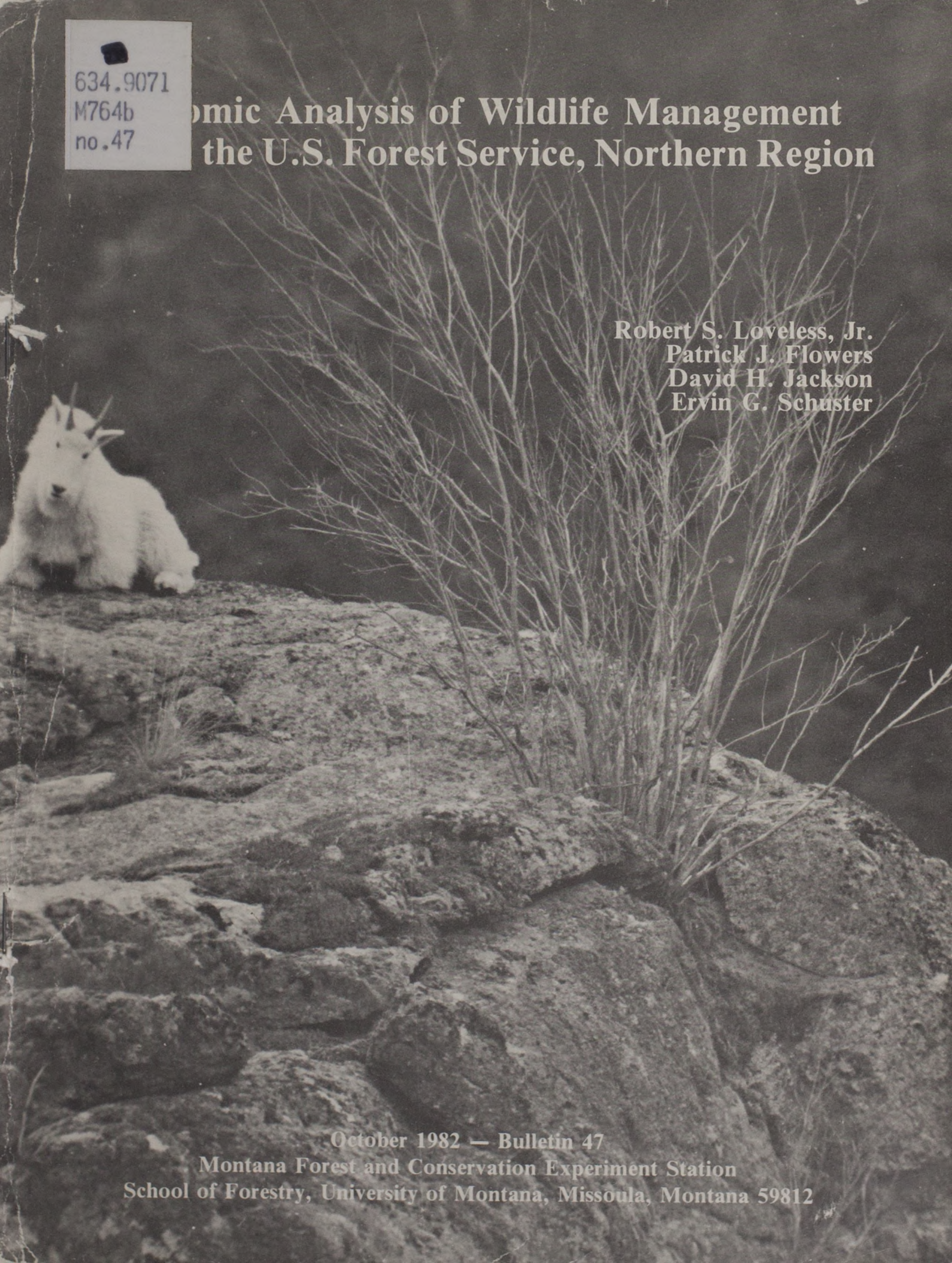

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October 1982 — Bulletin 47
Montana Forest and Conservation Experiment Station
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INTRODUCTION

The 1974 Forest and Rangeland Renewable Resources Planning Act (RPA) and the 1976 National Forest Management Act (NFMA) required the U.S.Forest Service to identify outputs, costs, priorities and benefits associated with the entire agency and each of its functional areas. Fish and wildlife habitat management, one of those functional areas, is the focus of this study. Information about the nature of outputs and associated costs of various fish and wildlife management practices is needed for efficient decision-making and planning on both the forest and project level.

Thus, this study was initiated to identify the direct costs of wildlife habitat management in the Northern Region. We define direct costs as agency expenditures. Specifically, our objectives were to: identify current and potential management practices in terms of the management information handbook (MIH) codes and practice purposes and to evaluate the importance of each activity in acres treated and budget, etc. Another objective of our study was to determine the average cost per treatment unit (acre or acre equivalent). This was done using accounting records for those management practices during fiscal years 1979 and 1980 identified as "on-the-ground" projects. Further, it may be possible to relate certain wildlife practices (timber coordination) to timber sale activity.

COSTS --- AN OVERVIEW

The theory of value includes the concept of cost. "The cost of any action is the associated reduction in total wealth" (Alchain and Allen, 1969). Wealth, in turn, is the current stock of economic goods. Thus, costs may or may not be recorded in an organization's accounts because the only requisite for a cost is a negative change in wealth. The implied breadth of the cost concept presents some problems for specific organizations and social accountants who want to do more than examine the ledgers of individuals and organizations that allocate resources.

Organizations frequently make a dichotomy between fixed and variable costs. Overhead items such as administrative salaries are difficult, if not impossible, to allocate to particular economic events. Thus, these costs are considered fixed because they do not depend on the organization's output level.

Organizations' budgets are a crucial element in goal accomplishment. Typically, budgets reflect expenditure limits for organizations and their components for a specified period of time. Economists often view an organization's budget as incongruous with the definition of cost.

One reason for the difference between budgets and costs stems from the theory of externalities or the lack of cost specificity. The action of one agent may have a negative effect on another agent's wealth. For example, an increase in suspended stream sediments resulting from logging activity may reduce fish populations. Thus, the cost of logging often excludes the fishery costs. Costs and budgets differ for another reason. When capital goods are included in the production process, the time dimensions of budgets may result in asymmetric costs and budgets. For example, trucks and airplanes are frequently purchased in one budget time period and used in subsequent ones. For this reason, Alchain and Allen (1969) divide the traditional dichotomy of fixed and variable costs into three, more useful categories:

1. Acquisition costs. These are usually construed as the purchase prices of economic goods. For example, the cost of adding an automobile to an organization's fleet is ordinarily part of a budget request.

2. Costs of continued possession. Capital goods usually lose value over time because of use and obsolescence. For example, if an organization keeps a vehicle for several years, its decreasing value (wealth) over time is a cost of continued possession.

3. Operating costs. These are often considered variable costs; they should be considered as the day-to-day costs of managing capital projects. For example, certain kinds of manpower, fuel, minor equipment repairs, stationery, light and heat are considered operational costs.

Increasing interest in costs stems, in part, from recent legislation. The RPA, as amended by the NFMA, requires agencies to examine and report costs to Congress. The law requires that specific investment opportunities be "...differentiated between activities of a capital nature and those of an operational nature." Furthermore, Congress required "specification and identification of program outputs, results anticipated, and benefits associated with investments in such a manner that the anticipated costs can be directly compared with the total related benefits and the direct and indirect returns to the Federal Government" (RPA, Sec. (1), (2).)

Operational costs are different from capital costs but both can be included as investment costs. This makes the earlier classification of acquisition, continued possession and operation costs seemingly relevant.

The effects of wildlife habitat treatments are frequently durable; the production of benefits has a time dimension. Furthermore, capital equipment is often used in a project, so the question of possession costs and costs for replacement or acquisition is also relevant.

Most organizations have some form of budgeting and associated cost-accounting procedures. In the U.S. Forest Service, the budget preceded cost accounting by almost 80 years: not until the 1970s was an agency-wide cost-accounting procedure instituted. In 1978, after a trial in one region, the PAMARS accounting system was installed. This system is designed for integration with a complex coding system of management activities (Management Information Handbook, or MIH, codes) to determine historical costs and outputs of management activities. Because of the short time that the PAMARS system has existed and the numerous changes within the system, there are not enough data for time-series analysis of management costs.

For wildlife habitat management projects within the U.S. Forest Service, the PAMARS system includes but is not limited to manpower and equipment costs. Equipment often is part of the agency's fleet. A use rate for trucks or helicopters owned by the Forest Service and used on a project is charged to that project. However, the rates are based on several of the previously noted economic costs. When the regional office charges a national forest for equipment use on projects, the payment is made to the working capital fund (WCF). Included in the use charges are provisions for operating costs, replacement costs and equipment depreciation. Thus, the national forest budget that incorporates fleet use includes several economic costs. From a planning perspective, this suggests that equipment costs incurred by a forest actually reflect the major costs of ownership even though the forest does not purchase equipment. In principle, these equipment charges are not different from an alternative arrangement where the Forest Service leases equipment from a private firm. The WCF operates as a revolving fund. In effect, funds appropriated to a forest are transferred to the WCF where maintenance and replacement takes place.

The costs analyzed in this paper are forest-level costs. They do not reflect the opportunity costs of resource inventories. They might be thought of as "out-of-pocket costs" and reflect the manner in which appropriations are expended. Where project cost variation is analyzed, the dependent variable (project cost) includes equipment costs. The working capital fund (WCF) includes provisions for acquisition, replacement and operating costs when equipment is rented. If these cost-factors are used in national forest plans, planners must determine the relationship of these costs to budget requests for the forest, regional and national forest system. This will align the forest's budget with national budget requests and appropriations. Only when this is done can the cost equations presented here be properly interpreted and used.

DATA SOURCES AND RESEARCH METHODS

Data analyzed in this study were collected from the following sources.

1. The Region One Forest Service office supplied annual fish and wildlife function budgets for each forest and the wildlife activity report for each national forest.

2. Project Manager's statements (PMS) and Project Work Plans (PWP) from each national forest supervisor's office were used to analyze wildlife habitat projects.

3. Data from district level records were collected for analysis of prescribed burn projects.

One research objective was to determine the relative importance of various fish and wildlife habitat treatments. To do this, the percentage of total expenditures spent on each practice was determined from information in the annual wildlife reports from fiscal years 1976-1980. Another objective was to determine the average cost of each treatment for each practice in terms of the measured output (acres or acre equivalents). After widlife and fishery personnel were consulted, the ratios of acre equivalents to acres treated for management practices was developed as illustrated below. Acre equivalents are output measures used by the Forest Service in planning and reporting. In principle, acre equivalents allow project outputs to be expressed on common terms; building nest boxes can be evaluated and reported with prescribed burning.

All Fisheries	1:1
Prescribed Burning	5:1
Protective Pruning	5:1
Release Pruning and Pushing	5:1
Seeding and Planting	5:1
Browseway Openings	5:1
Perch/Roost Structure (upland)	1:Structure
Den/Nest Structure (upland)	1:Structure
Nest Structure (wetland)	1:Structure
Marshes	3:1
Potholes	1:1
Food Planting (wetland)	5:1
Brushpile Cover (upland)	5:1
Nesting Cover (upland)	5:1

Water Development (big game)	640:Development
Water Development (small game)	160:Development

As a possible aid in forest planning, it was necessary to determine whether important practices were related to other planned forest outputs. In particular, it was essential to know whether timber management coordination is functionally related to the volume of timber sold in a forest. If so, certain wildlife activities might be projected with harvest levels. A regression equation was used to analyze these issues.

Finally, for "on-the-ground" projects, a cost-per-treatment unit is calculated based on information from the PMS and PWP. A sufficient sample of prescribed burning practices allowed multiple regression analysis. Variation was explored in both total and average cost using several site descriptors, fire management decision variables, and personnel considerations. A computer program using the stepwise regression technique was used to develop the models. The simple correlation matrix was used to identify possible multicollinearity between variables.

RESULTS

As can be seen in Table 1, which shows only the most common practices during the five-year period, four practices constituted more than half of total wildlife and fisheries management activities. Land use planning, timber management project planning and other resource coordination constituted 36 percent of the summarized wildlife and fisheries management activity from 1976 to 1980. Prescribed burning to improve wildlife habitat became relatively and absolutely less important during this period, while timber management coordination followed the opposite trend.

Table 1. Major Wildlife Activities as Percent of Total Activities ($) Reported on Wildlife Activity Report

Practice	Purpose	MIH Code	Year					
			1976	1977	1978	1979	1980	x1
Land Use Planning	Multiple Use Planning	C01	14.73	23.21	14.53	8.12	10.96	14.31
Timber Management and Coordination	Coordination with Timber Sales, Thinnings, etc.	C02	7.86	11.13	16.69	16.25	21.88	14.76
Other Resource Coordination	Coordination with other Resources uses, personnel	C02	9.87	9.43	2.62	6.33	6.73	7.00
Prescribed Burning	Habitat Improvement	C03	34.71	20.09	6.30	10.72	13.20	17.00
	Total		67.17	63.86	40.14	41.42	52.77	53.07

During the period studied, the wildlife reports documented prescribed burning as the most prevalent activity; however, further inquiry revealed that the wildlife reports contain most prescribed burns, whether funded by the wildlife function or not. The portion of funding for prescribed burns supported by wildlife budgets is not known, and an effort to separate timber- and range-supported burns proved fruitless because these reports also overlap. Project expenditures are allocated to a functional area's budget by the nature of the benefits produced making it difficult to classify prescribed fires when there are joint benefits. One controlled burn could be allocated to more than one functional budget area (e.g., timber and wildlife). In order to allocate the costs in some proportional manner, an accountant would need an estimate of the marginal change in each valued benefit. The Appendix describes in more detail the annual wildlife reports used in this study.

Table 2 summarizes by national forest the wildlife budget versus the expenditures reported in the wildlife activity reports during the five-year period. An average of 50.7 percent of the total individual national forest budgets were included in the wildlife activity report. Because the report lists only "on-the-ground" activities, the balance of the budget contains, among other things, indirect costs and program administration. A telephone interview with a Forest Service accountant[1/] revealed that 16 percent of the gross forest wildlife budget is subtracted as indirect costs for overhead such as building rent and maintenance. Another three percent is taken from the gross wildlife budget for program management costs. It is not possible to explain the rest of the budget, about 30 percent, in terms of the activity report or known overhead expenses. This portion of the budget may be largely

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1/ Richard Seitz, Lolo National Forest, Budget and Accounting Officer, February, 1982.

Table 2. The allocated budgets and reported expenditures by forest for the wildlife and fisheries function. Expressed in thousands of dollars, unadjusted for inflation (current dollars).

F.Y.	1976		1977		1978		1979		1980	
Forest	Budget	Wildlife Report	Budget	Wildlife Report	Budget	Wildlife Report	Budget	Wildlife Report	Budget	Wildlife Report
Gallatin	63.4	23.3	101.1	32.7	180.5	40.6	206.1	104.5	322.5	148.9
Helena	27.7	40.1	94.9	58.2	64.9	23.4	120.5	31.5	142.6	35.7
Kootenai	83.9	23.5	149.6	54.1	148.1	51.3	182.3	63.8	227.2	217.2
Lewis and Clark	73.5	27.6	79.5	29.8	157.6	125.2	110.8	28.9	196.0	58.7
Lolo	77.2	43.4	107.3	21.7	248.4	62.6	238.1	67.4	251.7	73.2
Nez Perce	59.2	10.0	56.7	22.5	87.3	13.3	110.7	48.3	222.2	113.5
Beaverhead	56.9	154.7	92.8	8.6	85.1	22.7	153.7	69.3	121.8	76.9
Bitterroot	110.9	24.5	114.5	14.9	213.2	40.7	130.9	73.9	263.8	81.8
Idaho Panhandle	132.8	215.2	118.7	109.6	351.5	109.5	311.2	133.1	239.5	100.2
Clearwater	122.1	90.2	117.6	120.9	348.8	203.6	139.9	205.1	242.1	107.8
Custer	59.0	32.7	66.0	52.8	105.0	105.4	262.7	193.2	139.2	46.0
Deerlodge	32.5	6.1	49.5	13.3	126.3	19.1	96.8	142.8	110.1	183.7
Flathead	95.6	8.1	89.7	0.3	101.6	5.6	97.3	22.3	209.8	38.3
TOTAL	994.7	699.4	1237.9	539.3	2218.3	823.0	2161.0	1186.2	2688.0	1281.9
% of Budget	70.3		43.6		37.1		54.9		47.7	

Source: Jeff Mann, Office of Programming, Planning and Budgeting, U.S. Forest Service, Region 1; and Wildlife Activity Report, U.S. Forest Service, Region 1.

consumed by wildlife staff salaries and other activities such as employee training and attending professional meetings. Because only half of a forest's gross wildlife budget is included in the wildlife activity reports, forest planners should be aware that for every dollar reported as wildlife activity, there is another, unreported, dollar spent for activities such as overhead, program management, and training. There is no ready method to account for all of the unreported portion of the wildlife budget; it is not known whether any of this portion is transferred to the working capital fund (WCF). If these funds are transferred from the forest to the WCF, double counting in the budget is a distinct possibility.

Average Costs for "On-the-Ground" Projects

By combining information from Project Work Plans (PWP) and Project Manager's Statements (PMS), some average real costs for "on-the-ground" Projects were calculated for fiscal years 1979 and 1980 (Table 3). Unfortunately, there are too few practices in any category for statistical analysis. Only those practices that could be identified specifically are listed. Quite often, a PWP was vague and did not describe actual activities. For example, PWP would specify spawning channel maintenance but failed to describe the work involved, such as installing gabions or gravel placement. Other problems with the data included no reported output (acres treated), and some Project Manager's Statements had no Project Work Plans.

Project costs are the total paid and unpaid amount expressed in constant 1972 dollars, on the PMS. Marginal costs were not estimated because of small sample sizes; apparent large variability of individual projects and a short time span.

Table 3. Average direct costs for wildlife and fisheries projects.

Source: Project Manager's Statements, U.S. Forest Service.

Practice Description	f.y. 1979 Average Cost/A.E.	f.y. 1979 Number	f.y. 1980 Average Cost/A.E.	f.y. 1980 Number
Nesting Facility (Build boxes/sites)	$ 1.15	1	$ 1.56	3
Planting (usually willows and aspen sprouts)	$ 90.41	1	$ 57.29	2
Seeding (grasses, clovers)	$ 6.39	2	$ 15.89	2
Protective Fencing (maintenance)	$ 2.29	1	$ 2.33	1
Protective Fencing (construction)	$ 3.95	4	$ 1.23	2
Gates for Road Closure	$ 0.20	1	$ 0.20	1
Stream & Bank Stabilization	$190.30	2	$ 32.03	1
Stream Clearing & Debris Removal	$114.83	7	$ 37.69	7
Pond and Lake Development	$ 8.83	4	$ 32.50	2
Fence Maintenance	$ 0.05	2		0
Spawn Channel Maintenance (install gabions)	$431.24	2	$131.61	3
Spawning Channel (Construction)		0	$ 33.35	1
Exist. Vegetation (slash willow, put up hay, Christmas tree sales)	$ 5.64	3		0

Prescribed Burning for Wildlife Habitat Improvement

Prescribed burning for habitat improvement had the most complete set of records; its sample size was sufficient for statistical analysis. Consequently, data were collected from PWP and a survey of prescribed burns conducted for wildlife habitat improvement in 1979 and 1980. Several variables are hypothesized as important when predicting prescribed burning costs. The following lists this study's hypotheses:

Site descriptors:

1. Slope measured in percent. The project cost is a function of the site measured in percent sideslope. Sideslope can affect how well a fire carries through the burn area, as well as the amount of fire line built.
2. Aspect. North facing slopes are more costly to burn than others because there are fewer suitable burning days in these areas.
3. Fuel model. Fuel models measure a combination of fuel types and quantities. These, in turn, affect the rate of fire spread and burn intensity, possibly affecting project costs.
4. Distance to private land. The U.S. Forest Service spends more on prescribed burns adjacent to private lands to reduce the probability of payment liability.
5. Miles traveled one way. The farther the prescribed burn is from the district ranger's office, the more expensive the project becomes.

Management decision variables:

6. Acres burned. The total project cost is an increasing function of project size measured in acres.

7. Man hours. Labor is a traditional factor of production; the greater the labor used per project, the higher the cost.
8. Helicopter use. Helicopter use increases costs.
9. Season burned. Since fuel moisture is normally higher in the spring and fires easier to control, spring burns cost less than fall ones.
10. Under burning. Prescribed burns on timber sites often use pre-fire fuel treatments that move fuels away from stems and reduce fire-caused stem defects. Thus, timber-covered burns cost more than grass- or brush-covered burns.
11. Amount of fire line constructed. There is a possible interaction between fire line construction and man hours but in general, the more fire line built the higher the costs.
12. Head-fire versus back-fire ignition techniques. Back-fires are more expensive because they burn more slowly as ignition progresses downslope, increasing the need for labor and materials.

Personnel considerations. Variation in prescribed burning costs can be explained by the fire management officer's experience. We attempted to measure this in three ways:

13. The number of broadcast burns the fire officer has conducted--fire management experience could affect costs.
14. The number of months the fire officer has been in his/her present position--this variable could be an alternative measure of experience.
15. The percentage of prescribed fires that have escaped from the fire officer--a fire control officer's record could affect project costs.

Project Costs of Prescribed Burns

A total project cost equation is shown below. Project cost, the dependent variable, is the total cost reported on the PMS. As such, it includes manpower, equipment and material costs. Several of the hypothesized variables are useful in predicting the cost of a prescribed burn for wildlife habitat improvement. Perhaps most interesting is the percent fire-escaped variable. We asked the fire control officer to report what percentage of his or her previous burns had escaped.

$$\hat{Y}_1 = -254.164 + 20.869\text{ (percent escaped)} + 3.005\text{ (acres)} - 0.119\text{ (fire line)} + 7.594\text{ (man hours)} + 635.166\text{ (ignition technique)} + 89.760\text{ (type of burn)} - 2.937\text{ (acres x ignition technique)} + 6.879\text{ (man hours x helicopter)} - 4.761\text{ (man hours x type of burn)} \quad \ldots (1)$$

Adj. R^2 = .83; Std. Dev. as percent of mean Y = 35 percent

$F_{(9,51)} = 34.10$

This equation indicates that as the percentage of escaped fires increases, the total project cost goes up. Perhaps this is because fire management officers who have a record of escaped prescribed burns use more manpower, equipment and other control measures to manage subsequent prescribed burns. This should not be interpreted as a uniform rule, or as an indication of managerial inefficiency. Optimum control of a prescribed burn presupposes knowledge well beyond the scope of this project. Fire management officers may overreact after a few bad experiences, and this study's findings could be used in employee training. Also, the amount of fire line is negatively associated with total project cost. Fire line probably interacts with both significant and insignificant site variables. However, the simple correlation coefficients examined were low so that interaction was not readily apparent.

As expected, fire project costs increase with man hours used; the predicted rate of payment is $7.59/hour. Also, as anticipated, back-fire ignition techniques cost considerably more than head-fire techniques. Burns in areas of dominant tree cover were expected to cost more than brush or range fires, but results show that the opposite is true. This may be the result of the need for repeated ignition, and this study controlled the other variables, such as man hours, that affect this difference between timbered and non-timbered burns.

Total project cost is an increasing function of acres burned. A variety of curval relationships between acres burned and project costs were tried, but a straight line relationship was found to be the best. The interaction terms in the equation result from fundamental hypothesis testing when using dummy variables in multiple regression (Kleinbaum and Kupper 1978). Simply stated, if any of the interaction terms involving dummy variables are statistically significant, the models' slopes are not parallel. The first equation actually contains eight equations based on the eight combinations of the three 0-1 dummy variables used (ignition technique, type of burn and helicopter use). For example, if a helicopter is used (dummy = + 1), the regression equation does not parallel the equation when this dummy is 0. This can be interpreted by stating that the contribution man hours makes to total project cost is substantially greater when a helicopter is used.

As reported, the first equation is potentially useful for regional fire management personnel when analyzing a fire manager who has suffered escaped fires. But, from a forest planning perspective, a project cost equation that excludes the percent fires-escaped variable might be more useful. Forest planners would not have to project the percent fires-escaped variable in order to use equation (1). Therefore, the first equation was recomputed to exclude the percent fires-escaped variable. This yielded a project cost estimate where the variance associated with the discarded variable was redistributed in the other regression coefficients and the error term. The result below is equation (2).

$$\hat{Y}_1 = -260.888 + 3.247 \text{ (acres)} - 0.137 \text{ (fire line)} + 8.082 \text{ (man hours)} + 608.000 \text{ (ignition technique)} + 185.070 \text{ (type of burn)} - 2.938 \text{ (acres x ignition technique)} + 6.317 \text{ (man hours x helicopter)} - 5.600 \text{ (man hours x type of burn)} \quad (2)$$

Adj. $R^2 = .83$ Std. Dev. as percent of mean Y = 36.0 percent

$F_{(8,52)} = 36.46$

From a statistical perspective, the second equation is almost as good a predictor as the first. The difference in the adjusted R^2 and error of the estimate between the two equations is small.

Per-Acre Costs of Prescribed Burns

Foresters frequently think of costs on a per-acre basis. This is natural because growth and yield estimates are usually stated in a similar manner. Economists like to think of per-acre costs as average costs, but several words of caution are warranted before the two can be thought of as synonymous. For example, the cost per acre of the 61 prescribed burns in this study was \$9.12 in 1972 dollars. This probably is the kind of per-acre cost figure that project managers typically use. However, there are two alternative methods to clarify some of the confusion in discussions of per-acre cost figures. One is the standard economics approach in which cost per acre is a function of the acres burned. The other is a statistical analysis of per-acre costs.

The economic treatment of cost per acre can be derived analytically from equation (1) or (2). First note that the marginal cost of an extra acre burned can be derived directly from equation (1). If the factor in question is acres, the marginal cost is:

$3.005 - $2.937 (mean ignition technique value)

= 3.005 - 2.937 (0.148)

= 3.005 - .435

= $2.57

or the derivative of total project cost with respect to acres. A short-run, average-cost function can also be estimated from equation (1). Recalling that the short-run is characterized as all but one variable held fixed, the sample means can be substituted for the independent variables other than acres in equation (1) and the equation then solved on a per-acre basis. Thus, average cost per acre would be estimated analytically for a "typical" prescribed burn. Holding these mean values fixed and dividing both sides of equation (1) by acres produces equation (3):

Total project cost/acre = 376.242/acre + 2.570 . . . . (3)

Thus the short-run, average-cost function is a hyperbola. As acres increase, costs per acre decrease and approach marginal cost ($2.570) assymtotically from above. Short-run average costs per acre fall and do not intersect marginal costs within the range of the data and in the form of the total cost equation estimated.

At first glance, diminishing average costs suggest that the size of the prescribed burn is suboptimal. This is true only if two assumptions are made. The first is that wildlife habitat benefits are either independent of, or increase with, the size of the burn. If so, managers have a good argument to increase the size of the prescribed burns. The second assumption is that the probability of an escape fire and resulting damage is independent of or inversely related to burn size. Again, if this is true, fire managers can build a case for increasing the size of prescribed burns.

Keep in mind, however, that the value of the other independent variables have been fixed at their sample means. There is a positive, albeit small, simple correlation between these variables and fire size. Thus, for larger than marginal changes in burn size, one would also expect increased changes in man hours, increased amount of fire line and so on. These shift the short-run, average-cost function.

As part of the study plan, the variation in per-acre costs of prescribed burns was examined. The dependent variables thus became project cost per acre for the 61 projects. Again, here are two regression equations. Equation (4) is analogous to equation (1) because percent fires-escaped is included. Equation (5) is analogous to equation (2) because percent fires-escaped is excluded. In both instances, all of the independent variables used in equations (1) and (2) were divided by acres.

$$\text{cost/acre} = 1.805 + 17.420\,(\text{percent fires-escaped/acre}) + 4.334\,(\text{man hours/acre}) + 972.785\,(\text{ignition technique/acre}) - 5.912\,(\text{ignition technique}) + 8.580\left(\frac{\text{man hours x helicopters}}{\text{acres}}\right) - 2.393\left(\frac{\text{man hours x type of burn}}{\text{acres}}\right) \quad \text{. . . . . (4)}$$

Adj. R^2 = .94 Std. Dev. as percent mean Y = 37.5

$F_{(6,54)}$ = 149.85

$$\text{cost/acre} = 2.659 + 4.219\ (\text{man hours/acre}) + 1001.025\ (\text{ignition technique/acre}) - 6.956\ (\text{ignition technique}) + 7.855 \left(\frac{\text{man hours x helicopter}}{\text{acres}}\right) - 2.109 \left(\frac{\text{man hours x type of burn}}{\text{acres}}\right) \quad \ldots\ldots\ldots\ (5)$$

Adj. R^2 = .93 Std. Dev. as percent of mean Y = 38.8

$F_{(5,55)}$ = 164.48

In contrast to equation (1), the fire line variable is not useful in predicting cost per acre when expressed on a per-acre basis, and percent fires-escaped is retained in the equation on a per-acre basis. This is discernible from the variable list found in equation (4). Equation (5) is the result of attempts to convert equation (2) on a per-acre basis. When the percent fires-escaped per acre was excluded, the type of burn per acre did not enter the predictive model. The type of burn is insignificant in equations (1) and (2) but is included because it makes other variables significant in the equation. This apparently does not happen when expressed on a per-acre basis. In neither case is fire line per acre useful in explaining per-acre project costs.

It should be mentioned that adding acres as another independent variable to both equations (4) and (5) was attempted. In neither equation was acres useful as a predictor. Thus further reinforces the linear relationship between total project cost and acres burned found in equations (1) and (2). The summary statistics for equations (1), (2), (4) and (5) are found in Table 4.

Table 4. Summary statistics for regression models.

Variable	Equation 1		Equation 2		Mean	Range
	β coefficient	Partial t	β coefficient	Partial t		
Cost	--	--	--	--	669.36	89.44 to 2759.25
Constant	-254.164	--	-260.888	--	--	--
Percent escaped	20.869	1.774	--	--	3.13	0 to 8
Acres	3.005	7.268	3.247	8.148	118.74	10 to 535
Fireline	- 0.119	-2.495	-0.137	-2.854	415.41	0 to 5610
Manhours	7.594	4.794	8.082	5.077	87.85	6 to 280
Ignition technique	635.166	4.177	608.000	3.938	0.148	0 or 1
Type of burn	89.760	0.602	185.070	1.303	0.672	0 or 1
Acres x Ignition technique	- 2.937	-4.012	-2.938	-3.931	21.541	0 to 535
Manhours x Helicopter	6.879	5.062	6.317	4.685	9.016	0 to 184
Manhours x Type of burn	- 4.761	-2.836	-5.600	3.407	56.492	0 to 280
	Equation 4		Equation 5			
Cost/acre	--	--	--	--	9.118	1.39 to 99.87
Constant	1.805	--	2.650	--	--	--
Percent escaped/acre	17.420	2.252	--	--	0.0427	0 to .250
Manhours/acre	4.334	13.151	4.219	12.504	1.3795	0.032 to 7.67
Ignition technique/acre	972.785	13.328	1001.025	13.433	0.0025	0 to 0.067
Ignition technique	- 5.912	-3.386	-6.956	-3.987	0.148	0 or 1
Manhours x Helicopter/acre	8.580	4.730	7.855	4.246	0.0692	0 to 1.143
Manhours x Type of burn/acre	- 2.393	-4.518	-2.109	-3.956	0.6677	0 to 5.0

The Relationship Between Timber Coordination Practices and Timber Sales

One of the principal wildlife management practices is coordination of individual timber sale development. Here, a wildlife biologist recommends modifications to benefit wildlife (at times, admittedly, under some rather adverse circumstances). To determine whether the direct cost of this kind of wildlife activity can be predicted by the level of timber sales, data were assembled from a four-year period on 12 Region One forests. The dependent variable predicted was timber management coordination activity per fiscal year in 1972 dollars as reported in the annual wildlife report. The independent variable was volume sold on a calendar-year basis. Thus, there was a three-month time lag between timber management coordination and volume sold.

$$\text{Tim. Mgt. Coord.} = 30.828 + .459 \text{ Vol. Sold (sales} \geq \$2000) \quad . \ . \ . \ . \ (6)$$

$R^2 = .345$ Std. Dev. as percent mean Y = 78

$F_{(1,42)} = 22.09$ n = 44

The results are modest. A relationship exists, as expected, but it is not very strong. Time lag periods of 15 and 27 months were also tried, but the statistics are not as good as those associated with equation 6.

The Appendix indicates that there was a change in emphasis in wildlife management activities during the period studied. Sales volume may not be a very good measure of the time involved in timber sale preparation. It may take as much wildlife input on a timber sale in northern Idaho with large volume as it does on a small volume sale in eastern Montana. Yet the two sales could involve similar acreages. Ready access was not available to data on acres of timber sold or volume of sales put up but not sold.

DISCUSSION

Data and information relatively new to the U.S. Forest Service was used during the course of this research. To some extent, the cost and output data used are still in the development stage; some mention of the problems encountered in this study may aid the system's continued progress.

Forest planning is currently perceived as a linear programming problem. Thus, measures of output variables and input costs and levels are influenced by the manner in which these parameters are expected to be used. The output measures of acre equivalents have been increasingly perplexing. Whether a water development for big game has an acre equivalent of 640 acres is an empirical issue. In effect, water is one of a complex set of factors influencing big game populations. A development may serve 640 acres in one place and 30 acres in another. Not only does the arbitrary assignment of a 640-acre output equivalent per water development for big game deny the complex ecological reality of the animals and their habitat, it also will never be very useful in analyzing the costs of alternative big-game water-development projects. Project costs will differ because of differences in project characteristics such as capital, labor and raw materials. To attempt to explain these costs in terms of acre-equivalents treated serves no useful purpose.

Many of the problems encountered in the PAMARS data base can be explained by its recent installation. One cannot explain project cost variation if the labor, capital and material costs are reported for several projects in one report without allocating the costs to individual projects. The concern with management costs is a relatively new venture for the U.S. Forest Service and, no doubt, additional reports are not welcomed when the work load has increased under conditions of fixed man power. It is expected that employees will gradually learn that social efficiency has recently become a dominant part of the U.S. Forest Service mission. With that growing awareness, employees will become cost- and benefit-conscious and somewhat less resistant to filing forms for the cost accounting system.

Even if the problems of estimating direct projects costs of habitat manipulations are solved for activities other than controlled burning, there still should be concern about the value of benefits produced. In principle, the value of habitat factors is derived from the value of the populations produced; this results from an empirical wildlife production function (model) that integrates habitat factors with population dynamics. This study, particularly in the area of controlled burning, indicates that unit factor pricing (cost per acre treated) is a complex problem. Cost per acre varies with site factors and management decision variables. Thus, the accuracy of estimated dollars per acre can be improved by *a priori* knowledge of these other contributing variables. More important, prescribed burning is not a homogeneous factor of production. Its per-acre cost depends on project characteristics. It is suggested that the benefits are dependent on project characteristics not included in the cost analysis. For example, if a burn opens a stand and increases forage, the benefits will also depend on the characteristics of the surrounding unburned (cover) areas, as well as the current reproduction potential of the affected wildlife populations.

In attempting to integrate the cost analysis research into the most recent guidelines in the Federal Register on economic analysis, considerable time was spent attempting to decipher what kinds of costs were being analyzed. These costs were determined to be "investment" costs. Yet other categories of costs raise some concerns. For example, "fixed variable general administration costs" is a category, and it is unclear whether project costs include it in some manner. The current definition of costs is confusing. It is suspected that others, including members of Congress, may be confused as well.

CONCLUSION

The most significant results found were that prescribed fire is the most used management tool to increase wildlife benefits. This activity is sufficiently frequent so that a sufficient sample of burns was generated and analyzed for cost variation. Internal cost variation indicates that larger burns are less expensive on a per-acre basis than smaller ones. However, until wildlife benefits as a function of burn size are analyzed, an efficiency analysis is not possible.

As mentioned, this study found that managerial skills affect the cost of prescribed burning, although evaluation of the fire control officer was extremely simplistic. Fire managers cannot be stereotyped, and different managers might prescribe a different type of fire for the same control burn situation. Management style is not usually included in traditional economic analysis, although it is somewhat similar to the entreprenurial factor of production in standard price theory. It is suspected that a valuable cost analysis could be done with more extensive analysis of the variation in fire management decisions among different fire control officers for a given prescribed burning opportunity.

Appendix. Expenditures in nominal dollars for wildlife habitat treatments in USDA Forest Service Region One - Source: Wildlife Activity Report from Region One, U.S. Forest Service.

PRACTICE	MIH CODE	F.Y. 1976		F.Y. 1977		F.Y. 1978		F.Y. 1979		F.Y. 1980	
		F.S.$	OTHER $	F.S.$	OTHER $	F.S.$	OTHER $	F.S.$	OTHER $	F.S.$	OTHER $
Multiple Use Land Planning	C01	103,007	1,100	125,175	1,500	119,648	200	96,307	400	140,501	0
Timber Management Coordination	C02	54,990	2,700	60,010	500	137,413	1,300	192,721	700	280,453	11,300
Other Resource Coordination (Non-timber)	C02	69,040	5,700	50,850	2,000	21,638	10,720	75,058	1,500	86,283	1,500
Prescribed Burning	C03	242,755	14,860	108,337	3,200	51,888	5,860	127,155	36,780	169,169	15,267
Channel Stabilization	C07	101,000	5,100	69,800	34,700	135,442	500	17,135	2,200	77,020	63,600
Stream Barrier Removal	C04	70,550	14,100	31,600	63,500	62,702	3,044	50,131	4,732	75,718	8,931
Seeding and Planting	C03	17,570	45,071	45,500	28,500	54,350	23,500	42,930	18,000	52,872	18,837
Protective Fencing	C06 or C09	7,540	369	17,200	350	38,799	18,600	105,995	6,760	45,182	25,757
Release Pruning and Pushing	C03	4,748	400	--	--	30,411	4,800	101,941	3,850	33,095	36,046
Water Development	C06	4,343	1,605	500	0	16,525	1,600	102,999	604,225	29,950	74,778
Food Planting	C03	1,150	0	--	--	500	0	200	0	--	--
Designated Areas for Threatened and Endangered Species	C01	1,000	0	500	0	1,950	0	--	--	--	--
Stream Channel Structures	C07	700	1,000	9,000	200	250	3,000	21,451	25,790	25,065	39,520
Fishways	C07	642	0	0	100	1,000	0	581	0	2,761	0
Nesting Cover	C06	300	200	200	0	500	300	1,360	450	40	260
Marshes	C06	200	0	1,700	0	--	--	--	--	4,000	1,000
Den/Nest Structures Upland Wildlife	C06	100	0	750	420	1,200	900	10,821	5,698	11,506	3,700
Spawning Facilities	C04	60	60	500	0	--	--	--	--	724	0

Appendix (continued).

PRACTICE	MIH CODE	F.Y. 1976		F.Y. 1977		F.Y. 1978		F.Y. 1979		F.Y. 1980	
		F.S.$	OTHER $	F.S.$	OTHER $	F.S.$	OTHER $	F.S.$	OTHER $	F.S.$	OTHER $
Studies, Non-threatened Species	C01	3,100	18,000	--	--	--	--	--	--	--	--
Studies and Plans, Threatened and Endangered Species	C01	--	--	7,130	5,000	24,380	17,200	36,725	18,000	2,829	12,000
Potholes	C06	--	--	600	0	5,400	0	3,790	0	9,503	0
Browseway Openings	C03	--	--	300	300	20,627	7,900	14,100	5,600	3,437	500
Fish/Animal Population Control, Threatened and Endangered Species	C04	--	--	500	0	00	00	00	00	10,000	0
Habitat Coordination, Threatened and Endangered Species	C02	--	--	300	0	7,534	1,440	28,250	300	28,796	1,300
Structural Improvements, Threatened and Endangered Species	C06	--	--	30	0	1,000	200	4,700	300	2,654	30
Fish Population Control	C04	--	--	100	0	100	250	--	--	900	1,984
Regulating Dams	C07	--	--	--	--	50	0	500	0	302	0
New Lakes	C07	--	--	--	--	60,000	0	45,000	0	118,800	0
Perch, Roost Structures	C06	--	--	--	--	750	500	5,380	150	700	400
Lake Fertilization	C04	--	--	--	--	400	0	--	--	--	--
Brushpile Cover	C06	--	--	--	--	250	0	0	0	10,795	0
Plant Control in Lakes and Potholes	C04	--	--	--	--	2,000	0	--	--	--	--
Spawning Beds	C07	--	--	--	--	12,580	0	0	0	28,700	0
Non-structural Habitat Improvements for Threatened and Endangered Species	C03	--	--	--	--	--	--	1,800	0	--	--

Appendix (continued).

PRACTICE	MIH CODE	F.Y. 1976		F.Y. 1977		F.Y. 1978		F.Y. 1979		F.Y. 1980	
		F.S.$	OTHER $	F.S.$	OTHER $	F.S.$	OTHER $	F.S.$	OTHER $	F.S.$	OTHER $
Miscellaneous Maintenance and Improvement Projects	C09, C10 or C11	16,560	2,150	8,750	600	9,650	2,500	95,577	2,360	18,565	7,500
Miscellaneous Maintenance and Improvement Projects Threatened and Endangered Species	C05,C06, C08, or C11	--	--	--	--	700	0	700	0	8,100	0
Nest Structures, Wetland Species	C06	--	--	--	--	3,810	1,100	3,374	4,570	3,330	0
TOTALS		699,355	112,415	539,332	140,980	823,447	97,564	1,186,181	742,365	1,281,750	324,210
		811,770		680,202		921,011		1,928,546		1,605,960	

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