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Forest Service Handbook 2609.13 – Wildlife and Fisheries Program Management Handbook
Chapter 70 - Analysis of Economic Efficiency of Wildlife and Fisheries Projects

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Digest: Following is an explanation of the changes throughout the directive by section.

This amendment is a reissuance of FSH 2609.13 to conform the format and structure of the Handbook to the requirements of electronic directive issuance.

70: Establishes new direction for conducting economic efficiency analysis of Wildlife and Fisheries projects.

This Handbook is now available electronically in the National Information Center in the same format as the paper copy. Henceforth, amendments to this Handbook will be issued to Forest Service units electronically on a document basis.

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77 - Computing Measures of Economic Efficiency

The primary measure of economic efficiency in Forest Service evaluations is present net value: discounted benefits less discounted costs. Present net value includes benefits expressed in dollars and appropriate monetary costs. Also compute benefit-cost ratios and rates-of-return in making comparisons among alternatives if they contribute to the analysis (FSH 1909.17, Economic and Social Analysis Handbook, sec. 15).

In addition to the above measures of economic efficiency, short-term analyses for programming, budgeting, and facility design may use cost-effectiveness analyses (FSH 1909.17, Economic and Social Analysis Handbook, sec.16.3).

77.1 - Discount Rate

For all long-term economic evaluations of investments and operations in land and resource management in the Forest Service use a four (4) percent real discount rate (FSM 1971.21 and FSH 1909.17 Economic and Social Analysis Handbook, sec. 15.42).

Other federal agencies prescribe different rates which may be used in calculations for comparability. The OMB policy of a lO-percent rate in Circulars A-94 and A-76 is also appropriate for comparison purposes.

77.2 - Economic Efficiency Calculations

This section will discuss the various tasks required to perform efficiency calculations and some alternative types of calculations.

77.21 - Determining the Amount of Outputs

Outputs that are monetarily evaluated for wildlife and fish projects are Wildlife and Fish User Days (WFUD's), pounds of fish, and pelts. These are obtained by observing changes in habitat capability expressed in animal numbers resulting from management actions. The first step in determining output changes is to describe the project and the resulting potential increase in numbers of animals by species.

Once the change in potential population numbers is estimated, calculate the impact on outputs. For WFUDs this can require determining the percent of the population increase that would be harvested and the length of time required to harvest an animal. This assumes that increases in animal population will translate into recreation opportunities that are actually used by the public. Individual States often have data on the number of days spent harvesting one animal and on the percent of the population harvested.

Similar data are required for commercial fish and pelts in terms of the percent of the increased population catchable and the resulting pounds or pelts.

To calculate the amount of WFUD's resulting from an increase in animals per year, use this formula:

WFUDs = Number of Animals X Percent Harvested X WFUDs per Animal Harvested

An example using the information in exhibit 01 and a project providing 200 deer per year is:

200 X .24 X 3.8 = 182 WFUDs.

Exhibit 01 is an example from the Rocky Mountain Region for game species showing the data used to compute WFUD's.

77.21 - Exhibit 01

Harvest and Effort Assumptions for Game Species
(Example taken from Rocky Mountain Region)**1/**

Species	Percent Harvested	WFUDs per Animal Harvested
Antelope	17	1.0
Bighorn Sheep	7	10.3
Deer	24	3.8
Elk	23	13.3
Mountain Goat	8	3.0
Turkey	16	6.3
Ducks	50	.25
Geese	40	1.0

1/ Source: Data from Today's Strategy . . . Tomorrow's Wildlife.
A Comprehensive Management Plan for Colorado's Wildlife, 1978-1982.

77.22 - Evaluating Outputs

Multiply the outputs by dollar values and the discounting factors for the years in which outputs are produced. Then sum these discounted benefits per year to provide total discounted project benefits.

For example, assume a project to enhance big game provides no outputs in years one and two but 30 WFUD's in year three, 42 WFUD's in year four, 58 in year five, and 12 in year six. These WFUDs are in addition to what would have been produced without the project. Assume the price of a big game WFUD is $50 and the discount rate is 4 percent. The calculation of yearly and project benefits is as follows:

Year	X	Outputs	X	Price	X	Discount Factor	=	Discounted Benefits
1		0		$50		.962		0.00
2		0		$50		.925		0.00
3		30		$50		.889		$1,333.50
4		42		$50		.855		$1,795.50
5		58		$50		.822		$2,383.80
6		12		$50		.790		$ 474.00
Total Project Benefits								$5,986.80

Prices for use in evaluation of outputs are shown in exhibits 01, 02, and 03, sec. 76.5. They are also available from the current RPA Program document based on the appropriate base year.

Use the discounting factors in exhibit 01 for each year of a project from year one to 100. These are shown for several interest rate used by the Forest Service for comparative purposes in addition to the standard 4 percent real discount rate.

77.22 - Exhibit 01

Single Period Payment Multipliers for Discounting

YEAR	DISCOUNT RATE 4%	6%	7-3/8%	10%	12%
0	1.00000	1.00000	1.00000	1.00000	1.00000
1	.96154	.94340	.93132	.90909	.89286
2	.92456	.89000	.86735	.82645	.79719
3	.88900	.83962	.80778	.75131	.71178
4	.85480	.79209	.75229	.68301	.63552
5	.82193	.74726	.70062	.62092	.56743
6	.79031	.70496	.65250	.56447	.50663
7	.75992	.66506	.60768	.51316	.45235
8	.73069	.62741	.56595	.46651	.40388
9	.70259	.59190	.52707	.42410	.36061
10	.67556	.55839	.49087	.38554	.32197
11	.64958	.52679	.45716	.35049	.28748
12	.62460	.49697	.42576	.31863	.25668
13	.60057	.46884	.39651	.28966	.22917
14	.57748	.44230	.36928	.26333	.20462
15	.55526	.41727	.34392	.23939	.18270
16	.53391	.39365	.32029	.21763	.16312
17	.51337	.37136	.29830	.19784	.14564
18	.49363	.35034	.27781	.17986	.13004
19	.47464	.33051	.25873	.16351	.11611
20	.45639	.31180	.24096	.14864	.10367
21	.43883	.29416	.22441	.13513	.09256
22	.42196	.27751	.20899	.12285	.08264
23	.40573	.26180	.19464	.11168	.07379
24	.39012	.24698	.18127	.10153	.06588
25	.37512	.23300	.16882	.09230	.05882
26	.36069	.21981	.15722	.08391	.05252
27	.34682	.20737	.14642	.07628	.04689
28	.33348	.19563	.13637	.06934	.04187
29	.32065	.18456	.12700	.06304	.03738
30	.30832	.17411	.11828	.05731	.03338
31	.29646	.16425	.11015	.05210	.02980
32	.28506	.15496	.10259	.04736	.02661
33	.27409	.14619	.09554	.04306	.02376
34	.26355	.13791	.08898	.03914	.02121

77.22 - Exhibit 01--Continued

	DISCOUNT RATE				
YEAR	4%	6%	7-3/8%	10%	12%
35	.25342	.13011	.08287	.03558	.01894
36	.24367	.12274	.07718	.03235	.01691
37	.23430	.11579	.07188	.02941	.01510
38	.22529	.10924	.06694	.02673	.01348
39	.21662	.10306	.06234	.02430	.01204
40	.20829	.09722	.05806	.02209	.01075
41	.20028	.09172	.05407	.02009	.00960
42	.19258	.08653	.05036	.01826	.00857
43	.18517	.08163	.04690	.01660	.00765
44	.17805	.07701	.04368	.01509	.00683
45	.17120	.07265	.04068	.01372	.00610
46	.16461	.06854	.03788	.01247	.00544
47	.15828	.06466	.03528	.01134	.00486
48	.15219	.06100	.03286	.01031	.00434
49	.14634	.05755	.03060	.00937	.00388
50	.14071	.05429	.02850	.00852	.00346
51	.13530	.05122	.02654	.00774	.00309
52	.13010	.04832	.02472	.00704	.00276
53	.12509	.04558	.02302	.00640	.00246
54	.12028	.04300	.02144	.00582	.00220
55	.11566	.04057	.01997	.00529	.00196
56	.11121	.03827	.01860	.00481	.00175
57	.10693	.03610	.01732	.00437	.00157
58	.10282	.03406	.01613	.00397	.00140
59	.09886	.03213	.01502	.00361	.00125
60	.09506	.03031	.01399	.00328	.00111
61	.09140	.02860	.01303	.00299	.00099
62	.08789	.02698	.01213	.00271	.00089
63	.08451	.02545	.01130	.00247	.00079
64	.08126	.02401	.01052	.00224	.00071
65	.07813	.02265	.00980	.00204	.00063
66	.07513	.02137	.00913	.00185	.00056
67	.07224	.02016	.00850	.00169	.00050
68	.06946	.01902	.00792	.00153	.00045
69	.06679	.01794	.00737	.00139	.00040
70	.06422	.01693	.00687	.00127	.00036
71	.06175	.01597	.00640	.00115	.00032
72	.05937	.01507	.00596	.00105	.00029

77.22 - Exhibit 01--Continued

YEAR	DISCOUNT RATE 4%	6%	7-3/8%	10%	12%
73	.05709	.01421	.00555	.00095	.00026
74	.05490	.01341	.00517	.00086	.00023
75	.05278	.01265	.00481	.00079	.00020
76	.05075	.01193	.00448	.00071	.00018
77	.04880	.01126	.00417	.00065	.00016
78	.04692	.01062	.00389	.00059	.00014
79	.04512	.01002	.00362	.00054	.00013
80	.04338	.00945	.00337	.00049	.00012
81	.04172	.00892	.00314	.00044	.00010
82	.04011	.00841	.00292	.00040	.00009
83	.03857	.00794	.00272	.00037	.00008
84	.03709	.00749	.00254	.00033	.00007
85	.03566	.00706	.00236	.00030	.00007
86	.03429	.00666	.00220	.00028	.00006
87	.03297	.00629	.00205	.00025	.00005
88	.03170	.00593	.00191	.00023	.00005
89	.03048	.00559	.00178	.00021	.00004
90	.02931	.00528	.00165	.00019	.00004
91	.02818	.00498	.00154	.00017	.00003
92	.02710	.00470	.00144	.00016	.00003
93	.02606	.00443	.00134	.00014	.00003
94	.02505	.00418	.00124	.00013	.00002
95	.02409	.00394	.00116	.00012	.00002
96	.02316	.00372	.00108	.00011	.00002
97	.02227	.00351	.00101	.00010	.00002
98	.02142	.00331	.00094	.00009	.00002
99	.02059	.00312	.00087	.00008	.00001
100	.01980	.00295	.00081	.00007	.00001

77.23 - Evaluating Outputs on an Annual Basis

In cases of uncertainty about how outputs resulting from a project over a given number of years will be produced year by year, use the following technique of annual averaging to estimate outputs resulting from a project over a given number of years. This technique can also be used if outputs occur rather evenly over a project's life. To calculate average annual units, estimate total output over time resulting from the project, that is, outputs with the project versus outputs without the project (sec. 71.21 and 71.22). Then divide the outputs attributable to the project by its life expectancy. Life expectancy is the number of years over which outputs will continue to occur as a result of the project. In formula form:

$$\text{Average Annual Units} = \frac{\text{Total Units Resulting from a Project}}{\text{Project Life in Years}}$$

Exhibit 01 provides factors representing average annual benefit flows of one dollar per year. The average annual benefit is based on average annual units for various project lives from 1 year to 90 years discounted at four percent. Multiplying the factor from the table times the dollar value of the output produced times the number of units produced each year equals the project benefits discounted to the present.

$$\text{Discounted Project Benefits} = \text{Average Annual Units of Output X Value of Output X Discount Factor for n Years}$$

For example, if Wildlife/Fish User Days (WFUDs) are priced at $50 and the project life is five years, then 4.45 times $50 equals 222.50 which is the factor for one WFUD.

77.23 - Exhibit 01

Factors for Determining Present Value of Average Annual Benefits 1/

Years Effective	Factor
1	0.96154
2	1.88609
3	2.77509
4	3.62990
5	4.45182
6	5.24214
7	6.00205
8	6.73274
9	7.43533
10	8.11090
11	8.76048
12	9.38507
13	9.98565
14	10.56312
15	11.11839
16	11.65230
17	12.16567
18	12.65930
19	13.13394
20	13.59033
21	14.02916
22	14.45112
23	14.85684
24	15.24696
25	15.62208
26	15.98277
27	16.32959
28	16.66306
29	16.98371
30	17.29203
35	18.66461
40	19.79277
45	20.72004
50	21.48218
55	22.10861
60	22.62349
70	23.39451
80	23.91539
90	24.26728

1/ Based on 4% discount rate from Tables of Compound-Discount Interest Rate Multipliers for Evaluating Forestry Investments by Allen L. Lundgren, USDA Forest Service Research Paper NC-51, 1971.

77.24 - Calculating Cost

Acquire accurate cost data from accounting records, bids to do work, or other sources discussed in the Analyzing Costs (sec. 75). Discount cost computations the same as benefits if they occur in the future.

Use locally developed costs if available. If not, some Regions have developed tables of average costs by activity types from historical records. These should be applied with care and judgement.

To illustrate the process of calculating costs assume a project involving a spawning bed improvement where the forest has an estimate for a similar job done in 1985. The cost in 1985 was $15,000 per acre on a four acre site. The proposed project planned for 1992 is on a three acre site with the cost per acre equivalent to 1985. Thus, the project, based on 1985 experience, will cost $15,000 X 3 acres = $45,000. This figure must be adjusted for the inflation that has occurred since 1985. In addition to this cost, this site is less accessible than the 1985 site so an additional charge of $8,000, expressed in 1992 dollars, will be needed. There will also be a maintenance cost 10 years hence to be discounted and added to the calculation of costs. Finally, this improvement will also require the deferral of a timber sale planned 10 years hence to year 22 such that an opportunity cost must be calculated. If, however, substitute timber volume were available for harvest there would be no opportunity cost.

The total cost of this 3 acre project can be expressed with the formula:

Total 1992 Project Cost = (1985 cost) X Inflation Factor) + Access Cost + Discounted Maintenance Cost in Year 10 + Opportunity Cost

1985 Cost X Inflation Factor = $45,000 X (140.88/110.15) = $57,555 (The GNP deflators of 110.15 and 140.88 are for 1985 and 1992, respectively, and are based on data as of June 1991.

--Access Cost = $8,000
--Maintenance Cost in Year 10 = $3,000 x .67556 = $2,025
(Cost in year 10 discounted to the present at 4%)

Opportunity cost is based on the volume and the real price of timber foregone in year 10 and sold in year 22. Both timber volume and real price will increase from the l0th to the 22nd year. If the sale planned for the 10th year was 43 MBF at $110 per MBF, by the 22nd year the volume has increased to 48 MBF and the real price (price adjusted for inflation) is $124 per MBF. Compute the opportunity cost as follows:

Year	MBF	Price	Discount	Gain or Loss
10	43	$110	.6756	$3,195.58
22	48	$124	.4220	$2,511.74
Opportunity Cost				$ 683.84

The total cost of this 3 acre project is:
$57,555 + $8,000 + $2,025 + $683.84 = $68,263.84.

77.25 - Calculating Present Net Value

Calculate Present Net Value (PNV) by subtracting Present Value (discounted) Costs from Present Value (discounted) Benefits or PNV = PVB - PVC. For example, if the Present Value of Benefits resulting from the spawning bed improvement project in sec. 77.24 is $102,348, then PNV = $102,348 - $68,264 = $34,084.

77.26 - Calculating Benefit/Cost Ratios

Benefit/Cost Ratios are the quotient of present value of benefits (PVB) divided by present value of costs (PVC) or B/C = PVB/PVC. For the example above, $102,348/$68,264 = 1.5 or 1.50 to 1.

77.27 - Analysis and Display of Results

Exhibit 01 is a sample format showing one way of considering Wildlife and Fish variables in economic analysis and displaying results. It provides the necessary information to defend and explain an economic analysis of a Wildlife and Fish project. The numbers used are the differences between the current situation and the proposed action (sec. 71.2). The spreadsheet should have as many year columns as necessary to cover the life of the project plus a column for any residual benefits (benefit remaining after project life). The number of rows should be expanded to account for as many inputs or outputs as the project produces, including non-wildlife products. The final result is the calculation of Present Net Value and Benefit/Cost Ratio. Discounting factors come from exhibit 01, section 77.22.

77.27 - EXHIBIT 01 IS A SEPARATE DOCUMENT.

Exhibit 02 is an example of a project analysis using economic efficiency calculations and a display spreadsheet.

This example uses a spreadsheet in a form modified for the project. Remember that headings, rows, and columns can be modified to fit any need.

The sample project is a hypothetical water development designed to relieve a water shortage for deer, thus increasing their population which in turn will result in increased hunting opportunities for the public. It will also provide water for many other wildlife species thus increasing other recreational opportunities. The values or prices are all in 1989 real dollars based on market clearing prices from the 1990 Resources Planning Act (RPA) Program document. The project site is on the edge of a range allotment and will be fenced to keep livestock out. Consequently, a loss of Animal Unit Months (AUM's), as an opportunity cost, should to be considered.

The costs consist of construction of the water development, seeding and planting the buffer area, fencing out the livestock, and maintaining these improvements over the project life of 22 years. The columns have been deleted for years where no costs are incurred.

The Habitat Capability (HC) information shows how the species are expected to respond over the life of the project as a result of the improvements. The objective is improvement of deer habitat, but habitats for other species are influenced as well. While the impacts are favorable for deer, rabbits, threatened and endangered water snakes and song birds (even though it is not known how much), the project will make the area less favorable for the Desert Turkey who, preferring a drier environment, will leave the area. The table displaying Habitat Capability information shows gains or losses in the number of animals per year expected to result from implementation of the project. For the two columns showing multiple years, for example, year 3-18, the numbers shown are the increase for one year. Thus for deer, the number 12 represents one year's production and for the entire 16 years (years 3-18) the total production is 16 years X 12 deer/year = 192 deer.

The Output section shows the response in Wildlife and Fish User Days (WFUD's) to the change in numbers of animals shown in the habitat capability table. Since recreational uses such as hunting and wildlife observation are affected by animal populations, changes would be expected in recreational use patterns with changes in animal populations. The Output section represents an estimate of these changes in use expressed in WFUDs. As with the previous table, these estimates are expressed in annual terms and as net changes. In addition to the wildlife outputs, the loss of Animal Unit Months (AUMs) is shown here as a negative benefit rather

than in the cost section. This is done because they are outputs foregone rather than cash costs.

In the Dollar Value of Outputs Information section, values for each year by Output Type are derived by multiplying the WFUDs and AUMs shown in the Outputs table by the appropriate output price shown in the second column. These Output Type values are summed for each single year (for example, Value year 1 = 1,360) and multiplied by a 4% discounting factor (for year 1 = .96154) representing the number of years from the present that the outputs occur. The result is the total discounted benefit for each single year (for year 1 = 1,308). The total of discounted benefits from all future years is the project's present value of benefits. The discounting factors used for the multiple year columns (year 3-18 & 19-22) are noteworthy and need further explanation. The factors for year 0, 1, and 2 at 4% come directly from exhibit 01, sec. 77.22. The factor for year 3-18 is the sum of all the 4% factors for years 3 through 18. Year 19-22 is the sum of the 4% factors for years 19 through 22 (.47464 + .45639 + .43883 + .42196 = 1.7918). This procedure can be followed when the data shown for one year is constant) through a series of years. Mathematically it is a shortcut alternative to multipling 16 separate years of the same data with different discount factors. Instead, report only one year's data set and accumulate (sum) the discount factors. An even easier approach is to use the factors in exhibit 01 in section 77.23. This table already presents the factors summed from year one up to the year of interest, for example, year 5 represents the summation of years 1-5 at 4% from exhibit 01, sec. 77.22. Using exhibit 01, section 77.23 calculate the discount rate for the 16 year period years 3-18 by subtracting the factor for year 2 from the factor for year 18, that is, 12.65930-1.88609 = 10.77321.

77.27 - EXHIBIT 02 IS A SEPARATE DOCUMENT.

77.28 - Important Non-Economic Effects

Inform decision makers about any important non-economic effects that will result from management actions. These effects may be environmental impacts, social impacts, cultural changes, and other changes which cannot be expressed in economic terms. These results may be very important to the making of a decision and should be displayed along with the economic benefits and costs. The format for this display is flexible but should include the year of impact. It could include changes in the number of animals that, while not hunted, are nevertheless important. For example, in the case where a proposed action will influence an endangered species recovery in a negative way, the result should be documented as a major part of an Environmental Impact Statement. In the case of a positive impact on recovery, the results will likewise be important to any decision. Whenever these non-economic values occur, they should be displayed. An example of a display is a trend table, in this case showing the status of various species used as Management Indicators:

Management Indicator	Breeding	Feeding	Resting
Eagles	0	0	+
Field Mice	++	++	+++
Mouse Hawk	--	++	--

\- = Negative effect
0 = No effect
\+ = Positive effect

In the case of an economic analysis an example could be a project that is expected to add six Grizzly Bears within the project area by 1995. Because these bears are not hunted and no resulting increase in animal viewing is anticipated, there will be no additional recreational user days to evaluate. However, this increase is an important beneficial effect and should be documented. In this case, if there are any economic costs of management associated with the increase in the bear population, document these also.

78 - Supplemental Analytical Procedures

78.1 - Breakeven Analysis

A breakeven analysis determines the maximum amount that a project can cost to be feasible, that is, a break even point where the project has a benefit cost ratio of 1:1 or a present net value of zero. Exhibit 01 in section 77.23 provides the discount rates needed to do a breakeven analysis.

Examples Using Exhibit

1. A fisheries project which produces an annual flow of benefits has a life of 40 years and a discount factor of 19.79. Further, the project generates 7 WFUDs per year priced at $40/WFUD. The calculation follows the formula:

(WFUDs/Year X Price/WFUD) X Discount Factor = Breakeven Cost

(7 WFUDs/Year X $40/WFUD) X (19.79 Disc. Factor) = $5,541.20

For the project to be feasible, the costs must be less than $5,541.20.

2. A wildlife project of burning elk winter range has a project life of 15 years and a WFUD worth $50. If the project proposed is 500 acres and generates 40 WFUD's per year, the calculation is:

(WFUDs/Year X Price/WFUD) X Discount Factor = Breakeven Cost (40 WFUDs/Year X $50/WFUD) X 11.12 Discount Factor = $22,240. For the project to be feasible, the project costs must be less than $22,240 or $44.48 per acre.

78.2 - Least Cost Analysis (Cost Effectiveness)

Evaluations seeking to determine the most cost effective means of attaining specified objectives or results may simply determine the relative costs of each alternative project. The project lowest in cost is preferred. Determining the output value for the specified goal is not necessary.

In certain situations, with resources such as threatened and endangered species or maintaining viable populations, output values are not usually available but law still requires management action. In these situations least cost or cost effectiveness analyses apply.

78.3 - Sensitivity Analysis

To increase the reliability of economic efficiency analyses, decisionmakers may want to know the effects of changing the assumptions of the study. Sensitivity analysis is used after the primary analysis is complete to systematically vary selected

assumptions, objectives, constraints, or values of selected inputs or outputs, and then recompute schedules of benefits and costs, and measures of economic efficiency.

An economic efficiency analysis of any activity related to wildlife and fish could be subject to sensitivity analysis.

78.4 - Threatened and Endangered Species Analysis

Since these species are not valued in either a market or non-market sense, they are instead viewed as a goal or objective of management actions and habitat activities.

If values are not calculated or deemed necessary to calculate, the appropriate measure of output may simply be expressed as potential number of animals. Once this output level is established by recovery plan or some other process, the economic evaluation technique to apply is least cost analysis, also called cost effectiveness analysis. This means the activity or alternative project providing the required level of output at lowest cost is the option most economically desirable.

Another economic concept useful in analysis of threatened and endangered species is opportunity cost. This is the value of other opportunities foregone when measures are adopted to protect a species or its habitat. The appropriate procedure to do this is the same as a sensitivity analysis. When using a computer analysis (FORPLAN for example), by varying a resource constraint which simulates species habitat manipulation or by varying output constraints which simulate species population, the change in present net value represents the opportunity cost of that species. For the procedure to be acceptable, all other attributes of the analysis must remain unchanged.

If a constraint or objective is modeled which meets endangered species goals but also meets other management objectives such as visual or wilderness requirements, it is inappropriate to attribute the entire opportunity cost of the constraint to the endangered species unless the other objectives are satisfied prior to the imposition of this last constraint.

The concern should be to satisfy as many requirements as possible using opportunities for joint production when designing endangered species constraints. This is least costly to all resources. But in doing so, the ability to measure opportunity cost of any one resource is lost.