EVALUATION OF AN ASPECT OF ENVIRONMENTAL QUALITY

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I

Environmental factors which have commanded attention of social scientists used to imply a social or cultural context. In more recent times, however, environmental factors to which we give consideration are increasingly involving aspects of the physical environment. Prominently in public discussion, political debate and legislative actions are the effects of industrial pollutants on the ambient environment. From the first law of thermal dynamics we know that all that goes into an industrial process by way of mass and energy also comes out, while changed in proportions and form, remaining unchanged in quantity (making allowances for transformations among solid, liquid and gaseous states).[1] Accordingly, the output of industrial activities is the combination of industrial goods, the object of production, and the residual industrial "bads" or "wastes." Waste disposal involves the attempt to distribute the residuals somewhere within the ambient environment and this gives rise to the degradation of the environment whether in the form of pollution of the earth mantle, air mantle or the hydrosphere.

A related aspect of environmental pollution is the degradation of the visual or aesthetic attributes of the environment. This may be the landscape, or through habitat modification, the biological diversity and ecological integrity of a site or an area. The latter represents a quasi-aesthetic dimension for those who comprehend and appreciate ecological homeostasis. This paper will address an example arising in the latter context. It deals with the comparative valuation of a geomorphologic-hydrologic phenomenon of unique characteristics, use of which is being contested by advocates of incompatible alternatives.[2] The area in question involves the Hells Canyon of the Snake River, forming the boundary between northeastern Oregon and southwestern Washington on the one hand, and a portion of the boundary of Idaho on the other. The Hells Canyon represents the deepest gorge on the North American Continent. Because of the variation in elevation from Canyon floor to the Seven Devils mountain peaks, through which the Canyon is cut, the varied ecology represents virtually all of the life zones found on the North American Continent. For this as well as other reasons it qualifies for preservation under the Wild and Scenic Rivers Act.[3] At the same time, because of narrowness of the gorge, steepness of its walls and the volume of flow in this reach of river, the Canyon provides exceptionally fine sites for hydro-electric development. The former use we shall refer to as the preservation alternative; the latter, as the developmental alternative.

This problem has several rather special features. The developmental alternative has an irreversible consequence for the ecology of the region. Once development occurs, reconsidering the decision is meaningless; i.e., no effective option remains. If the site is preserved in its present conditions all options are retained so long as no decision with an ecologically irreversible consequence is taken. Secondly, and perhaps related to the first, is that since electrical energy is so standardized a commodity, many competing prime movers can be substituted for kinetic energy of falling water in its production. From a scenic and/or recreational point of view, the services yielded by the Canyon in its preservation alternative are not a standard commodity; we find here, if not an absolute uniqueness, then certainly, a highly differentiated product for which demand is likely to be inelastic relative to the demand for services of the Canyon in its developmental alternative. Moreover, advances in technology are likely to have a differential effect on the valuation of the site for the two alternatives considered. We know that there have been rapid advances in the production of electrical energy from thermal sources, whether fossil fuel combustion or nuclear reaction. This will have a bearing on the value of the site if used for energy production. Since the Canyon, and its related ecology, is a gift of nature not produced or reproducible by man, advances in technology are not likely to affect adversely its value if dedicated to the preservation alternative. In fact, if advances in technology continue to achieve gains in productivity in the "produced goods" sector, thereby increasing real per capita income, the value of income elastic irreproducible assets is likely to be favorably affected by technological advance.[4] Accordingly we need to recognize an asymmetry in the implications of technological advance for the valuation of the site when considering the two alternatives.

In Section II, I investigate the significance of these observations in more detail. In Section III, I present quantitative results of an evaluation of the incompatible alternatives when asymmetry in the implications of technological progress is introduced in the evaluation procedure.

II

The Developmental Alternative

Consider now the proposed hydro-electric development. The technology of a given time is incorporated in the dam and powerhouse in such a facility at the time it is built, and will fix the costs of generation over the economic life of the facility. The benefit, on the other hand, being governed by the cost of the most economical

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[1] See [1] for elaboration of this point.

[2] See [4].

[3] Ibid., Exhibit No. R-624.

[4] See for example [6, 7].

alternative source,[5] does not remain constant over the life of the hydro-electric facility. The cost of thermal power generation has declined progressively over the past half century, and by about 4.5% per year over the past two decades. Part of this was due to the decrease in capital investment per kilowatt of capacity (capacity costs); part was due to the increased efficiency in the utilization of fuel (energy costs). If the life of the alternative source is shorter than that of the hydro-electric facility (and the real cost of the more technologically advanced replacement capacity is lower than at the time of hydro-project construction), then the capacity benefits of the hydro-electric facility will be lower upon the hypothesized retirement and replacement of the thermal alternative with which the hydro is being compared.

The effects of advances in technology of thermal generation, however, have not been restricted to the capacity component of costs. Gains in efficiency with which fuel is used have occurred and also have implications for the valuation of the hydro facility. As the plant factor on technologically advanced new plants will be higher than the system load factor, the difference in factors represents the percentage of a new plant's capacity which can generate "economy energy" to displace energy produced by the most uneconomic plant in the system during off-peak periods. A given plant, when new, will enter the system at, say, 90 percent plant factor. As it ages, it will be used a progressively smaller proportion of the time so that by the twentieth year it may operate only 30 percent of the time.[6] Accordingly, the relevant energy cost will be that given by the weighted average of today's and tomorrow's technology, with the costs related to future technology figuring progressively more significantly as the relevant annual energy costs until the original thermal alternative is replaced (say, in the thirtieth year). At that time both the energy and capacity values would be governed by the state of technology of the thirty-first, not the original year. Thereafter, the capacity value will remain constant from the thirty-first to the fiftieth year,[7] but the energy values will again begin to decline because the relevant costs used for evaluation purposes will again become a blend of the level of technology of the thirty-first year, and the advances in technology from the thirty-first to the fiftieth year.[8]

The Preservation Alternative

Consider next the preservation alternative. The value of any quantity of service consumed per unit time is measured by the area under the demand schedule. When the facility providing the service is a reusable, non-depreciating asset, such as a natural environment protected against destruction or degradation, the value of benefits is the area under the demand curve for each time period the natural area is used. If time is given the customary value of one year, the gross benefit of the natural area would be approximated by the sum of discounted annual benefits. The present value can then be compared with the capital investment (if any) the present value of annual operating costs (if any) and also the opportunity cost, or net present value of the most economical alternative use precluded by retention of the area for uses compatible with existing environmental conditions in the Canyon.[9]

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[5] The benefit from hydro-electric development can be represented as below:

$$b_d = B_d - C_d - B_a + C_a$$

Where:

- b_d = net benefit from hydro-electric development
- B_d = gross benefit from hydro-electric development
- C_d = cost of hydro-electric production
- B_a = gross benefit from alternative source of power
- C_a = cost of alternative source of power production.

Since the alternative to the hydro-electric development, for comparative purposes, is designed to produce identical services, $B_d = B_a$. Accordingly, the net benefit, b_d is equal to $C_a - C_d$, or the resource savings, if any, from development of the hydro-electric resource. See [10].

[6] Federal Power Commission studies indicate that historically, for fossil fuel plants, the plant factor has fallen to 20 percent by the twentieth year. For computational convenience I use an initial plant factor of 90 percent, a 3 percentage point per year plant factor decay to give us a plant factor of 30 percent in the twentieth year and retirement in the thirtieth year.

[7] The relevant planning horizon for the hydro-electric facility.

[8] Allotted space does not permit presentation of the technological change computational model. The interested reader may refer to [4] Exhibit No. R-670 for details of the model.

[9] Note, to establish the consistency in the treatment of the developmental and preservation benefits, we represent the benefit derivation model for the preservation alternative as below:

$$b_p = B_p - C_p - B'_a + C'_a$$

Where:

- b_p = net benefit from preservation alternative
- B_p = gross benefit from preservation alternative
- C_p = cost of providing services from the preservation alternative
- B'_a = gross recreation benefit from alternative to preservation
- C'_a = cost of providing recreational services alternative to the services provided by the Canyon.

Now, since the Canyon in an undeveloped state is a gift of nature, the costs (other than opportunity costs accounted for in b_d, footnote 5) are

(continued on next page)

If the demand for the services of the area grows, a point may be reached beyond which the use of the area by one more individual per unit time either results in a lessening of the utility obtained by others due to the well known congestion phenomenon, or to the destruction of the environmental characteristics of the area. In the case of Hells Canyon, it must be recognized that a recreational carrying capacity, for example, will be reached in time and if a given quality of recreational experience is to be maintained, resort to rationing is imperative.

Growth in the demand for services of the area and a capacity constraint introduce some complexity in analysis. First, income and population change through time, reflecting increases in the demand for services of the Canyon, other things remaining equal. But as the supply is not augmentable, the Canyon being an irreproducible asset, we would expect the annual value of the services to grow as the demand curve in conventional analysis shifts outward, reflecting income and population growth. Such growth in annual value of services must be incorporated in the benefit estimation procedure. Secondly, the capacity constraint adds to the complexity in quantitative evaluation, since it sets a limit on the range over which the quantity demanded can be summed without adjustment.

The analytic and computational models developed to deal with this problem are too involved to permit their treatment in the space allotted here. Accordingly, only a rough schematic of the argument is presented below to indicate the rationale underlying the analysis.[10] In Figure 1 we have the conventional price-quantity axis, with D_oD_o' the initial period's demand for the recreational services of the Canyon. The vertical SS' represents the non-augmentable supply of services of a constant quality. In the initial period there is an excess supply, relative to quantity demanded at zero price, and all who seek the services can be accommodated without utility-diminishing congestion externalities. The annual benefit, therefore, would be equal to the total area (b_o) under the initial period's demand curve D_oD_o'. At some time (t+n), the quantity demanded at zero price will exceed the supply and to retain quality of the service, rationing must be introduced. P_{t+n}, P_{t+n}' represents the schedule which

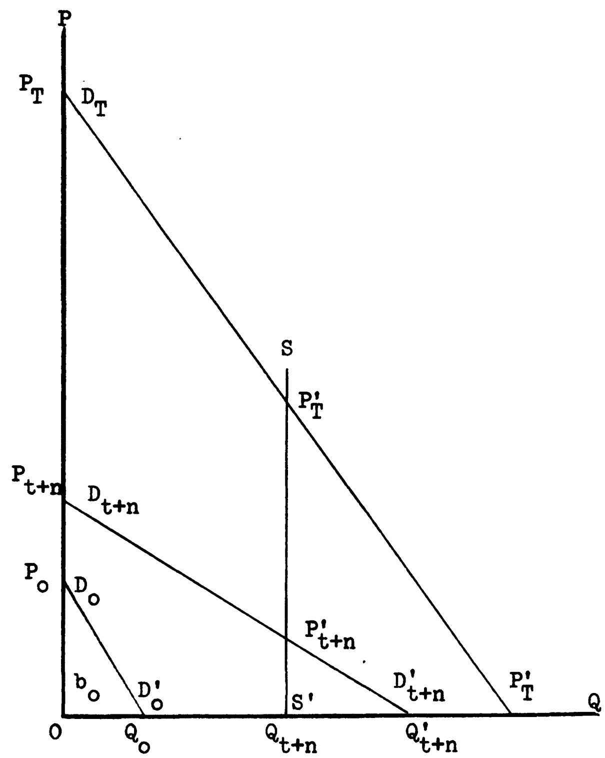

Figure 1.

a discriminating monopolist could exact as prices, and the total value under the demand curve D_{t+n}, D_{t+n}', less that represented by the area under the excess demand portion of the schedule (Q_{t+n}, P_{t+n}', Q_{t+n}') represents the annual value for the transaction period given the schedules in question.

A simplifying assumption would be that the demand curve shifts out uniformly from the origin, but investigation suggests this assumption should be modified in the interest of greater realism. As a result, taking what evidence we have on the growth in demand for primitive area recreation generally, and the income elasticity and related phenomena for this type of service,[11] we relate the shift in the demand function intercept of the price axis (r_y) to the projected growth in real per capita income. We relate the shift along the horizontal, or quantity, axis intercept to the recorded rate of growth in quantity demanded at zero price (γ) dampened to eventually equal only the rate of growth of population. The resulting shifts will produce both demand schedules with changing slopes and also, given the capacity constraint, changing geometric shapes in the relevant areas under the demand curve. These observations are illustrated in the three time-dated demand schedules in Figure 1.

So much for the outline of the argument and computational models. One additional point merits mention before the quantitative results of analysis are presented. Ideally one would wish to develop a demand schedule for each of the several recreational activities which one could anticipate

9 (continued from previous page) taken to be negligible. Accordingly, we have:

$$b_p = B_p - B_a' + C_a'$$

However, since we look to produced assets' services as alternatives, and assuming free entry into the recreational services industry, we would expect that the leisure formerly consumed in Hells Canyon facilities would be distributed across the alternatives impinging at the margins. Now, since the benefits at the margin under the circumstance would equal the costs at the margin, B_a' and C_a' would be equal. Accordingly, $b_p = B_p$, which corresponds to the results presented in Table IV, section III below.

10 The interested reader may consult [6,7] for the details of the model.

11 See [4]. Witness Krutilla Transcript, pp. R-5859-69.

being enjoyed in the area, e.g., fishing, white-water boating, hunting, backpacking, etc. These demand functions could be estimated whether jointly where merited, or independently, by procedures developed in the evolving literature in recreational demand estimation.[12] Were information available, the behavior of such schedules for each separable activity could be projected and the specific present worths computed, taking into account congestion costs, if any, of two or more distinctly different recreational activities indulged in simultaneously by different individuals. Unfortunately, time was not available to undertake this kind of analysis. Instead, a "composite demand function" was contrived so that, as implied in Figure 1, only one shifting demand schedule was employed as a proxy for the combination of independent and related demand functions. Moreover, since no less time would have been required to estimate such a hybrid function than to estimate the individual demand functions, an alternative strategem was adopted. The question was asked, in effect, "What would the benefit from preservation need to be to be equal to, or exceed, the developmental benefit?"

This question can be answered by determining what the initial year's benefit from preservation would need to be, growing at the rate (α) implied by the annual shifts in the composite demand function, to be equal to the present value of the developmental alternative. This would be desirable, for example, if we were not able to obtain any adequate estimates of the initial year's preservation benefits and would need to have some threshold value on which to base a judgment. We could obtain such a threshold value by computing the present value of a dollar's worth of initial year's benefits growing at the rate of α and discounted appropriately for time. The result of such a present value computation, divided into the present value of the hydro-electric development, would yield the estimate of the initial year's preservation benefit which would be required to justify economically, the preservation alternative; i.e., would be equal to the opportunity cost of foregoing the development. The results of performing such an exercise are given in section III.

III

In this section I display the results obtained when the asymmetry in the implications of technological progress is considered explicitly in the evaluation of the two incompatible alternative uses of Hells Canyon.

In the case of introducing technological advance in thermal alternatives to hydro-electric development, the quantitative results will depend on investment per kilowatt capacity[13] of the alternative thermal source, itself partly depending on the interest rate. In addition, the results will depend on the cost per kilowatt hour of thermal energy.[14] Finally, the rate of advance in technical efficiency itself enters into the calculation of the difference between the results obtained when technological advance is, and when it is not, introduced explicitly into the analysis. For our purposes, we have relied on construction cost data provided by a Federal Power Commission expert;[15] have used opportunity cost of capital of 9 percent, but with estimates provided alternatively using 8 percent and 10 percent for purposes of sensitivity analyses; rates of technological progress of between 3 percent and 5 percent per year, to bracket what is believed to be the relevant range;[16] and energy costs, again supplied by FPC staff witnesses, of 0.98 mills per kilowatt hour in the early stage and ranging up to 1.28 mills per kilowatt hour in the later period of analysis.[17] The adjustment factors for introducing the influence of technological change into the analysis are given in Table I following.

Accordingly, for any given interest rate, rate of technological change, and energy costs in mills per kilowatt hour; the generation costs estimated by traditional methods (sum of capacity and energy costs) would be divided by the values given in Table I to obtain the adjusted alternative costs -- hence, the benefits of the proposed hydro-electric development. While the gross benefits of hydro appear to be only marginally affected by introducing technological change into the analysis, i.e., are reduced by only five to ten percent, the net benefits and hence present value of the site for hydro development is reduced to a half. This result follows from the fact that the thermal alternative to hydro was a close cost competitor; thus a five to ten percent change in gross benefits had a large effect on the net value of the developmental alternative.[18]

In connection with the benefit computations for the preservation alternative, the present value of a dollar's worth of initial year's benefit is a function of both the rate of growth in annual benefits, α, and the discount rate, i. But, annual benefits grow at a non-uniform rate over time depending on the values which are taken by γ, r_y, k and m. (See Table II for definition of terms.) Since k represents the "recreational carrying capacity" which is given by the capacity of the area to accommodate recreation seekers without eroding the quality of the recreational experience, the k's and γ's are related.

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[12] For a survey of the literature as of 1969, see [2, 3, 9].

[13] A fixed cost for capacity to meet peak requirements.

[14] A variable cost for fuel, supplies, etc., related to the production of energy invariably at a rate below system peak capacity.

[15] See [4]. Witness Jessell's Exhibit No. R-54-B.

[16] See [13] for basis of computing technological progress, 1950-1968.

[17] See [4]. Witness Chavez's Exhibit No. R-107-B.

[18] See [4]. Witness Krutilla, Transcript pp. R-5842-43 and Exhibits No. R-671 and R-671-A, for detailed explanation of the derivation of benefits using technological change model.

Table I

OVERSTATEMENT OF HYDRO-ELECTRIC CAPACITY AND ENERGY VALUES BY NEGLECTING INFLUENCE OF TECHNOLOGICAL ADVANCES

Discount Rate/Year	Technological Advance Rate/Year	Estimated Capacity Values	Conventionally Estimated Benefits as a Percentage of Actual Benefits when Adjusted for Influence of Technological Advance, for Various Capacity and Energy Costs		
i =	r_t =	$/KW	Percent at 0.98 mills per kwh	Percent at 1.22 mills per kwh	Percent at 1.28 mills per kwh
	0.03		107.4	107.9	108.0
0.08	0.04	$27.43	109.0	109.6	109.7
	0.05		110.2	110.9	111.1
	0.03		105.9	106.4	106.5
0.09	0.04	$30.08	107.2	107.7	107.8
	0.05		108.2	108.8	108.9
	0.03		104.8	105.1	105.2
0.10	0.04	$32.89	105.8	106.2	106.3
	0.05		106.5	107.1	107.2

Source: [4], Exhibit R-670, Table I, page 3.

Table II

PRESENT VALUE OF ONE DOLLAR'S WORTH OF INITIAL YEAR'S BENEFITS GROWING AT α

i = 8%, m = 50 years			
r_y	γ=7.5% k=25 yrs.	γ=10% k=20 yrs.	γ=12.5% k=15 yrs.
0.04	$ 134.08	$ 169.86	$ 173.90
0.05	211.72	263.49	262.12
0.06	385.10	467.30	449.00

i = 9%, m = 50 years			
r_y	γ=7.5% k=25 yrs.	γ=10% k=20 yrs.	γ=12.5% k=15 yrs.
0.04	$ 93.67	$ 120.07	$ 125.89
0.05	136.12	172.35	176.25
0.06	214.76	267.10	264.49

i = 10%, m = 50 yrs.			
r_y	γ=7.5% k=25 yrs.	γ=10% k=20 yrs.	γ=12.5% k=15 yrs.
0.04	$ 69.28	$ 89.45	$ 95.71
0.05	95.15	121.91	127.68
0.06	138.17	174.85	178.66

Where:

i = discount rate

r_y = annual rate of growth of price per recreation day

γ = annual rate of growth of quantity demanded at given price

k = number of years after initial year in which carrying capacity constraint becomes effective

m = number of years after initial year in which gamma falls to rate of growth of population.

The particular values taken, i.e., γ of 10 percent and k of 20 years, with alternative assumptions for purposes of sensitivity analyses, were chosen for reasons given elsewhere.[19] A discount rate of 9 percent, with alternatives of 8 and 10 percent was the result of independent study.[20] The selection of the value for m of 50 years, with alternative assumptions of 40 and 60, was governed by both the rate of growth of general demand for wilderness or primitive area recreation, and the estimated "saturation level" for such recreational participation for the population as a whole. Finally, the range of values for r_y was taken from what we know about the income elasticity of demand for this kind of recreation activity[21] and growth in per capita income over the past two or three decades.

The results of our "preferred" values, with alternatives given for changes in assumptions are displayed in Table II. Each of these present value computations can be divided into the net present value of the water resource development project -- i.e., the hydro-electric power value, along with incidental flood control and related multi-purpose development benefits -- to yield the initial year's preservation benefit which (growing at α and discounted at i) would have a present value equal to the present value of development. The corresponding initial year's preservation benefits are displayed in Table III.

Now what does this tell us which the traditional analysis of comparable situations requiring the allocation of "gifts of nature" between two incompatible alternatives does not?

Let us take for illustration, subject later to sensitivity analysis, the computed initial year's preservation benefit corresponding to i of

19 *Ibid*. Transcript pp. R-5864-66 and R-5872.

20 See [5, 8].

21 See [3,7].

9 percent, r_t of 0.04, γ of 10 percent and k of 20 years, m of 50 years and r_y of 0.05; namely, $80,122. Is this a preservation benefit we might expect to be equaled or exceeded by the first year the hydro-electric project would otherwise go into operation? In many cases we would have only the sketchiest information and would have to make such a comparison on a judgmental basis. In the case of Hells Canyon, we obtained rather better information and shall return to the matter subsequently. But for now, we have $80,000 as threshold value which we feel is necessary to justify, on economic grounds, allocation of the resource to uses compatible with retention of the area in its present condition. This sum of $80,000 compares with the sum of $2.9 million, which represents the "levelized" annual benefit from the hydro-electric development, when neither adjustments for technological progress have been made in hydro-electric power value computations, nor any site value (i.e., present value of opportunity returns foreclosed by altering the present use of the Canyon) is imputed to costs.[22] Typically then, the question would be raised whether or not the preservation value is equal to or greater than the $2.9 million annual benefits from development.

Let us consider the readily quantifiable benefits from the existing uses of the Canyon. These are based on studies conducted by the Oregon and Idaho Fish and Game Departments, in collaboration with the U.S. Forest Service, and are displayed along with my imputation of values per user day in Table IV below. From Table IV one could argue, for example, that the preservation benefits shown are roughly only a third as large as would be required based on traditional analysis of similar cases. By introducing differential incidence of technological progress on the mutually exclusive alternatives for Hells Canyon, we have a different conclusion. The initial year's preservation benefit ($900,000), subject to re-evaluation on the basis of sensitivity tests, appears to be an order of magnitude larger than it needs to be to have a present value equal to or exceeding that of the development alternative. Thus introducing differential incidence of technological progress affects the conclusions in a significant way.

What about the sensitivity of these conclusions to the particular values of the variables used in our two simulation models? Sensitivity tests can be performed with the data contained in Tables II and III, along with additional information available from computer runs performed. Some of these checks are displayed in Table V.

Given the estimated visitor days and imputed value per visitor day, it follows that the conclusions regarding the relative economic values of the two alternatives are not sensitive, within a reasonable range, to the particular values chosen for the variables and parameters used in the two computational models.

There is need, however, for another set of tests when geometric growth rates are being used. We might regard these as "plausibility analyses." They would test, for example, the plausibility of the ratio of the implicit price to the projected per capita income in the terminal year, to ensure credibility of the results. Similarly for the plausibility of the ratio of the terminal year's preservation benefit, say, to the GNP in the terminal year. The year at which the growth rate in quantity of wilderness type outdoor recreation services demanded falls to the rate of growth of the population must also be checked to ensure that the implicit population participation rate is something one would regard as reasonable. Such tests were performed in connection with the Hells Canyon case in order to avoid problems which otherwise would stem from use of unbounded estimates.

Finally, since the readily observed initial year's benefits appeared to be in excess of the minimum which would be required to have such preservation benefits equal or exceed in present worth the developmental benefits, the analysis

TABLE III

INITIAL YEAR'S PRESERVATION BENEFITS (GROWING AT THE RATE α) REQUIRED IN ORDER TO HAVE PRESENT VALUE EQUAL TO DEVELOPMENT

r_y	γ=7.5%, k=25 yrs.	γ=10%, k=20 yrs.	γ=12.5%, k=15 yrs.
i=8%, m=50 years, r_t=0.04, PV_d=$18,540,000*			
0.04	$138,276	$109,149	$106,613
0.05	87,568	70,363	70,731
0.06	48,143	39,674	41,292
i=9%, m=50 years, r_t=0.04, PV_d=$13,809,000*			
0.04	$147,422	$115,008	$109,691
0.05	101,447	80,122	78,336
0.06	64,300	51,700	52,210
i=10%, m=50 years, r_t=0.04, PV_d=$9,861,000*			
0.04	$142,335	$110,240	$103,030
0.05	103,626	80,888	77,232
0.06	71,369	56,397	55,194

* Source: [4], Exhibit No. R-671.

Where:
i = discount rate
r_y = annual rate of growth in price per user day
γ = annual rate of growth of quantity demanded at given price
k = number of years following initial year upon which carrying capacity constraint becomes effective
m = number of years after initial year upon which gamma falls to rate of growth of population
PV_d = present value of development
r_t = annual rate of technological progress.

[22] Derived from Exhibit No. R-671 of [4] (exclusive of adjustments for technological change).

TABLE IV

ILLUSTRATIVE OPPORTUNITY COSTS OF ALTERING FREE FLOWING RIVER AND RELATED CANYON ENVIRONMENT BY DEVELOPMENT OF HIGH MOUNTAIN SHEEP

Quantified losses	Visitor Days 1969[2]	Visitor Days 1976
Stream Based Recreation:[1]		
Total of boat counter survey	28,132	51,000
Upstream of Salmon-Snake confluence	14,439	26,000
Non-boat access:		
Imnaha-Dug Bar	14,517	26,000
Pittsburgh Landing	14,464	26,000
Hells Canyon Downstream:		
Boat anglers	1,000	1,800
Bank anglers	2,333	4,000
Total stream use above Salmon River	46,753 plus[3]	84,000 at $5.00/day=$420,000
Hunting, Canyon Area[4]		
Big Game	7,050	7,000 at 25.00/day= 175,000
Upland Birds	1,110	1,000 at 10.00/day= 10,000
Diminished value of hunting experience[5]	18,000	29,000 at 10.00/day= 290,000

Total Quantified losses . . . . $895,000 ± 25%

Unevaluated Losses:

A. Unmitigated anadromous fish losses outside impact area.
B. Unmitigated resident fish losses:
   1) Stream fishing downstream from High Mountain Sheep.
C. Option Value of rare geomorphological-biological-ecological phenomena.
D. Others.

1 Source: An Evaluation of Recreational Use on the Snake River in the High Mountain Sheep Impact Area, Survey by Oregon State Game Commission and Idaho State Fish and Game Department in cooperation with U.S. Forest Service, Report dated January 1970 and Memorandum, W.B. Hall, Liaison Officer, Wallowa-Whitman National Forest, dated January 20, 1970.

2 "Visitor Day" corresponds to the President's Recreational Advisory Council (now, Environmental Quality Council) Coordination Bulletin No. 6 definition of a visitor day as a twelve-hour day. Operationally, the total number of hours, divided by twelve, will give the appropriate "visitor day" estimate.

3 Not included in the survey were scenic flights, nor trail use via Saddle Creek and Battle Creek Trails. Thus, estimates given represent an under-reporting of an unevaluated amount.

4 "Middle Snake River Study, Idaho, Oregon and Washington," Joint Report of the Bureau of Commercial Fisheries and Bureau of Sports Fisheries and Wildlife in Department of the Interior Resource Study of the Middle Snake, Tables 10, and 11.

5 The figure 18,000 hunter days is based on Witness Pitney's estimate of 15,000 big game hunter days on the Oregon side, and estimated 10,000 hunter days on the Idaho side (provided in letter from Monte Richards, Coordinator, Idaho Basin Investigations, Idaho Fish and Game Department, dated February 13, 1970), for a total of 25,000 hunter days (excluding small game, i.e., principally upland birds) in the Canyon area, less estimated losses of 7,000 hunter days. This provides the estimated 18,000 hunter day, 1969 total, which growing at estimated 5 percent per year for deer hunting and 9 percent per year for elk hunting would total 29,000 hunter days by 1976.

was terminated. Following Weisbrod,[23] however, while an excess of benefits as estimated above from the preservation of an irreplaceable asset is sufficient to justify its retention on economic grounds, it need not be necessary. Two reasons can be given; one relates to the matter of option value, i.e., the value of retaining an effective option when faced with a decision having irreversible consequences. This value was not included in the above estimation procedure. The second relates to the particular measure of consumer surplus used in estimating the benefit, i.e., whether the aggregate willingness of users to pay for the services of the Canyon preserved in its present condition -- the measure implied in the analysis above -- or the aggregate sum which would need to be provided users of the Canyon retained in an unaltered condition to have them voluntarily relinquish their claims to its use. These measures are not identical except in a special case, and the one used in the analysis results in only a lower bound estimate. Since

23 See [12].

TABLE V

SENSITIVITY OF ESTIMATED INITIAL YEAR'S REQUIRED PRESERVATION BENEFITS TO CHANGES IN VALUE OF VARIABLES AND PARAMETERS (AT i = 9%)

Variable	Variation in Variable From	To	Percent Change	Percent Change in Preservation Benefit
r_y	0.04	0.05	25	39 - 49
r_t	0.04	0.05	25	25
k^*	20 yrs.	25 yrs.	25	30 - 40
γ	10%	12.5%	25	-4 to +7
m	40 yrs.	50 yrs.	25	3

* The 25 percent change in years before capacity is reached translates into a 40 percent change in carrying capacity at the growth rate of 10% used here.

these considerations were not essential to the analysis, i.e., the lower bound estimate exceeded the required total, I mention then only in passing.[24]

IV

In this paper I have reported on a study directed toward aiding a resource allocation decision involving amenity aspects of the environment. The problem contains a number of considerations which are either novel, or at least considered only for the first time in any quantitative sense. Perhaps the reason the heretofore elusive elements were considered at all in this case relates to the Federal Power Commission's interest in responding to the Supreme Court's directive to give the visual and related aesthetic aspects of the environment explicit consideration in reaching a decision as to whether the remaining portion of the Hells Canyon should or should not be licensed for development.[25]

As a first venture in this area there is no reason to pretend that it represents the ultimate development of analytic means for dealing with problems of this sort. The sensitivity tests have revealed in fact, that while the conclusions would not be reversed were the assumed values of the parameters to be changed within any reasonable range in the Hells Canyon case, there is evidence that in cases where the results of analysis would fall within a narrower range, the particular values which the parameters were assumed to take could be critical to the outcome. Accordingly, there is need to investigate, both theoretically and empirically, a number of problems to further sharpen the analysis for cases in the future where the problem of choice would be less clear cut.

Among problems rating high priority would be the further investigation of the asymmetric effects of technological progress particularly as they influence the value of the r_y parameter (note Table V). Another problem demanding additional attention is the problem of developing an operational measure for optimal recreation capacity for such low density recreational resources. Now while an estimate of option value was not necessary in the Hells Canyon case, the results in its absence being sufficient to justify retaining the Canyon in its present state, in future cases the value of retaining an option when faced with a decision having an irreversible result might be the critical element on which the decision would turn. Accordingly, additional work in the area of developing operational measures for the value of such options ranks among the priority research tasks to aid making similar decisions in this general area in the future. Finally, since the Supreme Court in recent decisions appears to have granted the aggrieved public "standing" in court when common property resources are being used to the detriment of the general public, the measure of the damages stemming from a change in the natural environment deserve careful consideration. Typical of traditional benefit-cost analysis, as well as in the measure employed in the study reported on above, has been an estimate of the willingness of beneficiaries of the unaltered environment to pay the prospective developer to dissuade him from modifying the status quo. With the standing accorded the public in such cases the nature of the measure changes. It now becomes the amount which the party proposing to alter the environment must pay the aggrieved public to just compensate it for losses it suffers in altering the environment. As this measure (price equivalent measure of consumer surplus) is normally greater than the conventional measure used (price compensating measure of consumer surplus) the difference in measures employed may become critical in future cases where the outcome from traditional analysis is insufficient to support preservation of the existing environment in unaltered form. This problem merits joint economic and legal investigation in order that consistency in legal and economic doctrine be achieved and methods of measurement consistent with this be developed for application in future cases of the nature reported on in this paper.

[24] See [7].

[25] See [11].

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