The Economics of Environmental Preservation: Comment

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In a recent paper in this *Review* by Anthony Fisher, John Krutilla, and Charles Cicchetti (F-K-C), an argument is developed concerning the preservation of natural environments which is fundamentally based on the assumption that in certain instances, conversion of natural environments for development purposes represents an *irreversible* investment. An economic model is proposed for the allocation of natural environments between preservation and development from which F-K-C conclude that "... it will in general be optimal to refrain from development even when indicated by a comparison of current benefits and costs if, in the relatively near future, . . . disinvestment, which is impossible, would be indicated" (p. 609). F-K-C continue with an interesting discussion of concepts regarding the measure of benefits and costs for evaluating projects involving the development of natural environments, and conclude with a case study of the Hells Canyon Project.

The purpose of this note is twofold. First, in Section I, we wish to suggest some serious weaknesses in F-K-C's rigid and sometimes ill-defined conception of irreversibilities, and to comment on the nature of the decisions which may be made if one accepts the direction suggested by F-K-C. In Section II, F-K-C's analytical model is extended to include a broader conception of the preservation-development problem. Concluding remarks are given in Section III.

I

We find a basic problem in the F-K-C paper which results from their nebulous and somewhat inconsistent distinction between preservation (*P*) and development (*D*) options, and the relationship of these to irreversible investments. F-K-C's examples of development include the following: the " . . . transformation and loss of whole environments as would result . . . from clear cutting a redwood forest, or developing a hydroelectric project in the Grand Canyon" (p. 605); the development of " . . . additional sites along the river, the construction of facilities to accommodate larger numbers of flat water recreation seekers, the penetration by roads of virgin sections, etc. . . . , an extinct species or ecological community that cannot be resurrected, a flooded canyon that cannot be replicated . . . " (p. 612).

In attempting to apply F-K-C's concept of development as implied by the diverse examples given above, consider a totally virgin area and the following sequence of possibilities. (a) Recreational use of the area is initiated but limited to hikers and backpacking with initial small investments made by the Forestry Service for clearing and marking specific hiking trails, and later, establishment of periodic shelters for camping. (b) The area is penetrated by access roads to allow more (low density) camping, but the "wilderness" nature of the area is maintained. (c) More roads are developed, higher intensity camping sites are provided, the area becomes a large recreation park. (d) The region's rivers are dammed for the purpose of power generation and flatwater recreation facilities are provided. Since F-K-C's *D* and *P* are, by assumption " . . . the highest valued use or combination of uses . . . " (p. 606), for *D* and *P*, it is necessary to distinguish between *D* (which according to F-K-C must be irreversible) and *P*; i.e , in the example above, which degree of investment is considered as *D* and which is considered as *P* for inclusion in the F-K-C model? Stated simply, in the sequence described above, when does *P* stop and *D* begin?

The implication of F-K-C's arguments is that *D* begins with irreversible investments;

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they state, "Clearly, were the converse true, i.e., were the transformation [from P to D] reversible, much of the conflict between preservation and development would vanish" (p. 607).[1] Once again, however, in the example given above, where does irreversibility begin? F-K-C argue, somewhat curiously, that "... irreversibility of development is fundamental to the problem" (p. 612), but need not be absolute. Two kinds of reversibilities are possible: the restoration of an area by a program of direct investment (but this has little relevance for the sorts of phenomena of concern to them) and a natural reversion to the wild, which they view as of little relevance to their main concerns.

Thus, the definitions of P and D as well as the "economics of preservation" as seemingly viewed by F-K-C, encompass those problems associated with *technically*[2] irreversible investments which affect natural environments. We view as important a recognition of this limitation of the F-K-C approach and would like to submit the following comments for consideration.

We grant that it may be technically impossible to restore a wooded area containing camp sites or a flooded canyon to their *exact* original state.[3] It is not clear, however, that such exactness is a prerequisite for the future generation of recreational benefits. Even a flooded canyon may be restored to *some* kind of a "natural" environment at a later date, and the issue is one of benefit-losses (or possibly gains?) associated with two forms of an open-space, or wilderness, environment.

Therefore, with the exception of an extinct species, we find it difficult to conceive of irreversible investment options,[4] but further, we are not convinced that it is useful to do so. It seems to us that the assumption, if not imposition, of irreversibility vis-à-vis the use of natural environments abstracts from a whole set of issues of paramount interest to the economist.

F-K-C's arguments concerning increasing future demand for recreation due to rising incomes may be extended to argue that future generations will be capable of paying higher costs for *reversing* earlier development projects. Should we not therefore be inquiring as to alternative project designs that might be developed which allow tradeoffs between current efficiency (present benefits) and less costly future reversals? It is important to note that the approach taken by F-K-C, i.e., that of assuming the highest valued use for each P and D, forces the choice to a specific D. This prevents the possibility of choosing a lower valued but relatively reversible use of D.

Finally, a host of issues are relevant concerning equity and income distribution. For example, in some cases it may be argued that major users of wilderness areas are relatively wealthy and have access to various alternative areas and types of recreation; the "development" of a given wilderness area *could* result in income (taxes or charges) which could be used elsewhere for the establishment of parks for ghetto children.[5]

II

We have argued that technical irreversibilities of investments for development must be viewed as a most special case, but that costs of reversals may be so large relative to benefits as to make investments for development *economically* irreversible. The latter statement requires empirical measure, however, and suggests the need for an analytical

[1] This distinction becomes fuzzy later in the paper, however. F-K-C later view D as including simply an increase in the intensity of use of a recreational area (see p. 612). This inclusion is somewhat odd given the arguments which follow.

[2] "... a program of direct investment [for reversing D] ... would seem to have little relevance ... for the sorts of phenomena with which we are mainly concerned ..." (p. 612).

[3] William Lord suggests that "... every decision is irreversible in the strict sense that all previous conditions can never be restored exactly. By the same token, it is difficult to conceive of a situation in which some of the previous conditions could not be restored by some conceivable alternative action" (February 9, 1973 letter to the authors).

[4] Nor, unless one insists on the *exact* replication of an area by investment, do the examples given in F-K-C make the task simpler.

[5] It is tempting to draw an analogy between F-K-C's irreversibility arguments relating to natural resources and to human resources; e.g., are environmental effects (which may be affected by transfers) on ghetto children irreversible?

model for the generation of such measures. Following F-K-C's suggestion, p. 612, we wish to offer such a model, and demonstrate that the F-K-C optimization approach to the preservation-development allocation may be viewed as a special case of an optimization problem for the intertemporal determination of production and investment rates for natural resource industries in general. Both ends may be realized by simply applying the production-investment model for natural resource industries given in Oscar Burt and Cummings to the environment-preservation problem.[6] To facilitate comparisons, F-K-C's notation and assumptions are used. We wish to maximize:

$$(1) \quad \sum_{t=1}^{T} [B_1^t(P^t) + B_2^t(D^t) - I^t - G^t]\beta^t$$

subject to the restrictions

$$(2) \qquad D^{t+1} = D^t + \sigma I^t - \gamma G^t$$

$$(3) \qquad P^{t+1} = P^t + \gamma G^t - \sigma I^t$$

$$(4) \qquad P^t + D^t = L$$

all $0 \leq t \leq T$, all variables are nonnegative.

In (1) through (4), I^t is investment in development, as in the F-K-C paper; G^t is investment in preservation, i.e., G^t converts developed land into a natural, or preserved, environment, and is a convenient method for allowing reversibilities for I^t;[7] B_1 and B_2 are benefit functions for preservation and development, respectively; β^t is the discount factor, $(1+r)^{-t}$. Equations (1), (2), and (4) correspond to F-K-C's equations (1), (4), and (2), respectively. For completeness, we include an explicit transition equation for preserved land P^t, recognizing that the interdependence between P and D would allow its elimination.

Assume that at least some small portion of the natural environment L is in D and P during all periods, i.e., D^t and P^t are positive for all t.

Using (1) through (4), the following Lagrangian expression is formed.

$$(5) \quad H = \sum_{t=1}^{T} \{ [B^t(P^t) + B^t(D^t) - I^t - G^t]\beta^t - \lambda^{t+1}\beta^{t+1}[D^{t+1} - D^t - \sigma I^t + \gamma G^t] - \Gamma^{t+1}\beta^{t+1}[P^{t+1} - P^t - \gamma G^t + \sigma I^t] - \alpha^t\beta^t[P^t + D^t - L] \}$$

Maximization of H requires conditions which include the following:[8]

$$(6) \quad \Gamma^{t+1} = \sum_{\tau=t+1}^{T} \left(\frac{\partial B^\tau}{\partial P^\tau} - \alpha^\tau \right) \beta^{\tau-(t+1)} + \Gamma^{T+1}\beta^{T-t}$$

$$(7) \quad \lambda^{t+1} = \sum_{\tau=t+1}^{T} \left(\frac{\partial B^\tau}{\partial D^\tau} - \alpha^\tau \right) \beta^{\tau-(t+1)} + \lambda^{T+1}\beta^{T-t}$$

$$(8) \quad (1+r) = \sigma(\lambda^{t+1} - \Gamma^{t+1}), \quad \text{if } I^t > 0$$
$$(1+r) > \sigma(\lambda^{t+1} - \Gamma^{t+1}) \rightarrow I^t = 0$$

$$(9) \quad (1+r) = \gamma(\Gamma^{t+1} - \lambda^{t+1}), \quad \text{if } G^t > 0$$
$$(1+r) > \gamma(\Gamma^{t+1} - \lambda^{t+1}) \rightarrow G^t = 0$$

Conditions (8) and (9) imply that $(I^t)(G^t) = 0$; i.e., at any t, investment for development *and* preservation may not take place. Equation (8) may be used to deduce F-K-C's development in their equations (17) through (20); equation (8) is, of course, their equilibrium condition (14) with $I^t > 0$.

In equations (6) and (7), Γ^{T+1} and λ^{T+1} may be shown to measure the marginal value of terminal stocks of preserved and developed land,[9] and may be treated as zero,

[6] In the interest of conserving space, the entire Burt-Cummings model is not repeated here.

[7] As suggested to the authors by Darrell Hueth, we have earlier argued that investment G^t which reverts land from D to P may not be exact; i.e., earlier environments may not be exactly replicated. In such cases a unit problem arises in terms of G and P which may be corrected either by introducing a factor f which converts G into units of P ($P^{t+1} = P^t + \gamma f G^t - I^t$ in equation (3)) or by using two state variables for P: P_1 for the natural environment and P_2 for the "near" or "man-made" environment. Further, as Charles Howe has suggested to the authors, the taxonomy of P and D precludes forms of I^t which simply involve more intensive utilization of the same acreage. This form of I^t, however, may remove land from P via externalities as opposed to actual land occupancy.

[8] See George Hadley, pp. 190–93, or Burt and Cummings, pp. 579–82.

[9] See equations (8) and (9) in Burt and Cummings, p. 580.

particularly as T becomes large.[10] The coefficients Γ^{t+1} and λ^{t+1} measure, respectively, the present value (evaluated at t) of the flow of benefits in all future periods associated with an incremental change in preserved and developed land in period t. Their difference, of course, $\lambda^{t+1}-\Gamma^{t+1}$ or $\Gamma^{t+1}-\lambda^{t+1}$ measures the *net* return from an increment of developed or preserved land in t, respectively.

The economic interpretation of the decision rules (8) and (9) is immediately obvious. If *net* benefits to development are at least as great as the marginal cost of development (which implies $G^t=0$), development is carried to the point where marginal costs and benefits are equated; using F-K-C's terminology, I^t lies in a free interval and G^t *must* lie in a blocked interval. Similarly for the *reversal* of development, G^t, $G^t>0$ implies that I^t lies in a blocked interval. It is plausible to expect that during some periods *net* returns to I or G may be positive, but less than the marginal costs of investment. During such periods I^t and G^t are both zero—they both lie in F-K-C's blocked intervals.

The model given in (1) through (4) may serve several purposes. First it allows for explicit consideration of future costs of reversibility—a consideration which we have argued deserves major attention. Second, some insight is provided for the problem which was not clear to F-K-C: the potential flexibility which reversibility may give to current investment policy. Finally, and perhaps most important, this view of the preservation-development investment problem provides for the input expected from economists, viz., the evaluation of a wide range of alternatives in time, as opposed to the "all or nothing" decisions which may result from the F-K-C irreversibility framework.

[10] The problem of allowing $T\rightarrow\infty$ is discussed in the Appendix to Burt and Cummings.

III

In conclusion, we argue that F-K-C's interesting arguments regarding environmental preservation not only apply to an extremely limited set of circumstances, which exclude the bulk of examples suggested in their paper, but also have the potential of encouraging decision makers to overlook flexible or reversible investments. If (as we suggest the reader of F-K-C has every reason to conclude) F-K-C's major concern is with technically irreversible investments, we suggest that these problems arise only with an extremely rigid definition of reversibility—specifically, one that insists on an exact resurrection of a natural environment. We are not convinced that social benefits from recreation are materially affected by such exactness, in which case the environmental preservation argument concerns *economic reversibility.* Viewing the problem in this broader perspective opens, we suggest, a number of lines of inquiry which may be useful in future evaluations of development projects.

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