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Implementing the Safe Minimum Standard Approach: Two Case Studies from the U.S. Endangered Species Act

Robert P. Berrens, David S. Brookshire, Michael McKee, and Christian Schmidt

ABSTRACT. *In situations characterized by true uncertainty and potential irreversibility, the safe minimum standard (SMS) approach is a decision rule to protect some critical natural resource—unless the social costs of doing so are somehow "intolerable." The SMS has been discussed widely, but actual case studies remain rare. We present two case studies, focusing on endangered fishes in the Colorado and Virgin River systems, demonstrating that the legal framework of the U.S. Endangered Species Act (ESA) is consistent with the SMS. The case studies incorporate the results from applied general equilibrium modeling and provide an avenue for investigating excessive economic consequences.* (JEL Q20)

I. INTRODUCTION

The protection against potentially irreversible losses of at-risk species and the preservation of biodiversity feature prominently in ongoing sustainability debates. As part of this discussion, the safe minimum standard (SMS) approach to the conservation of renewable resources, first proposed by the early resource economist S.V. Ciriacy-Wantrup (1952), is receiving renewed attention by a selection of both economists and non-economists.[1] As a collective choice rule, the SMS approach is to preserve some minimum level or safe standard of a renewable resource unless the social costs of doing so are somehow "intolerable," "unacceptable," or "excessive." The SMS approach has been viewed as falling somewhere between weak and strong sustainability criteria (Turner, Doktor, and Adger 1994). Consistent with strong sustainability criteria, the SMS approach recognizes the imperative to protect critical natural capital (e.g., habitat for at-risk species), but stops short in the conditional nature of the imperative, specifically, the sensitivity to the level of social costs.[2]

The SMS approach has been discussed widely, but implementation attempts remain conspicuously rare (Bishop and Woodward 1994).[3] This is surprising, as a variety of environmental legislation, both in the United States and other countries, is considered to be consistent with the SMS (Foy 1990; Bishop 1993). In the United States, the piece of legislation most directly related is the Endangered Species Act (ESA) of 1973, as amended.

We present two regional case studies from the southwestern U.S., which concern endangered fishes in the Colorado and Virgin River systems, respectively, and are the result of U.S. Federal Court–ordered implementation of the provisions of the ESA. For species re-

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[1] Interest in the SMS has been substantially motivated by the writings of Richard Bishop (1978, 1980, 1993; Bishop and Woodward 1994; Ready and Bishop 1991) and Alan Randall (1986, 1988, 1991, 1994; Randall and Farmer 1995). A selection of writings in the 1990s, across various disciplinary outlets, include: Berrens 1996; Castle and Berrens 1993; Castle, Berrens, and Polasky 1996; Foy 1990; Hohl and Tisdell 1993; Loomis and White 1996; Norton and Ulanowicz 1992; Perrings and Pearce 1994; Rolfe 1995; Russell 1995; Tingey, Hodsett, and Henderson 1990; Tisdell 1990; Toman 1994; and Vatn and Bromley 1994.

[2] A distinction between weak and strong sustainability is in the structure that each perspective would impose on the capital bequest package passed on to the future (Norton 1995). Weak sustainability perspectives would impose little structure, requiring only that the total capital stock be non-declining. Strong sustainability perspectives advocate a non-declining stock of natural capital, and especially recognize some elements of "critical" natural capital (e.g., biodiversity). In implicitly accepting some notion of critical natural capital, the SMS has been recognized elsewhere as equivalent to a structured social bequest (Bromley 1995).

[3] Exceptions include: Bishop 1980; Ciriacy-Wantrup and Phillips 1970; and Hyde 1989.

covery, conditions in these river systems must be changed to more closely mimic some determination of natural or original conditions. Alteration of biological conditions, through the listing procedures and designation of critical habitat on behalf of the endangered species, potentially alters human uses of the river systems and thus generates direct and indirect economic impacts. The case studies incorporate the results from applied general equilibrium analyses to provide insights into the direct and indirect economic consequences of critical habitat designation. The case studies provide an avenue for investigating a potential definition of what might constitute intolerable economic impacts. Furthermore, they demonstrate that implementation of U.S. Fish and Wildlife Service (USFWS) rules following the ESA is consistent with the SMS approach.

II. THE SMS APPROACH

Welfare maximization remains the dominant economic perspective for approaching questions of biodiversity and species preservation. Cost-benefit analysis (CBA) provides the decision criteria for determining the optimal level of preservation for environmental public goods.[4] In present value terms, if aggregated individual benefits of a preservation action outweigh the aggregated individual costs, social welfare is increased. In the case of negative net benefits, society gains from forgoing the preservation action (Brown and Szweirbinski 1988).

The use of CBA decision rules has been criticized extensively in the context of preserving biodiversity and at-risk species (e.g., Norton 1987). Criticisms include the problem of determining the social discount rate, capturing ecosystem complexity, accurate valuation of nonmarket benefits including existence values and complete identification of all consequences, as well as philosophical criticisms of the utilitarian/welfarist framework (e.g., Hanley 1992; Hubin 1994; Sagoff 1988).[5]

Irreversible species losses involve intergenerational equity issues since they constrict the choice sets of future generations (Norton 1987; Perrings 1994). CBA decision rules neglect such fundamental issues as the intergenerational allocation of natural endowments.[6] If such neglect puts future generations in potential disadvantage, then it may be necessary to go beyond efficiency criteria in the case of preserving biodiversity and at-risk species (Bishop 1993).

Some authors have argued that CBA at least must be augmented by additional sustainability constraints (Hanley 1992; Pearce

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[4] Some authors (e.g., Lesser and Zerbe 1995) distinguish CBA from benefit-cost analysis (BCA) on the basis that the latter is simply an information system, rather than an explicit decision rule. Adopting such a distinction, we focus our discussion on CBA. The practical context of endangered species policy requires that a decision process be articulated. Further, some proposed "economic" reforms to the ESA have focused on the requirement that preservation actions pass a net-benefits test; e.g., a recent congressional proposal (H.R. 1490, 103 Cong., 1st Sess., 1993) would amend the ESA to require CBA of critical habitat designation.

[5] In neither of the case studies were nonmarket benefit assessments undertaken, nor were they required under the ESA. The SMS is not dependent on the valuation of nonmarket benefits that individuals hold for preserving endangered species. These values may be heavily motivated by nonuse (e.g., existence) values. The assessment of such values is dependent upon survey-based techniques such as the contingent valuation method (CVM). Professional opinion on the validity of CVM for measuring nonuse values remains mixed. For example, in the case of applying CVM to individual at-risk species, respondents may have trouble isolating values from the larger habitat or general preservation program (Stevens et al. 1991). A conceptual alternative is to value broader ecological composites (e.g., biodiversity protection), but this may suffer from the lack of a precisely defined commodity (Vatn and Bromley 1994). Reviews of the literature applying CVM to habitat and endangered species are presented in Hanley and Spash (1993) and the meta-analysis of Loomis and White (1996). The SMS has been viewed ambiguously as both a substitute for the estimation of existence values or as a complement to such measurements (see Berrens 1996). We adopt the latter perspective. Reinforced by an SMS decision rule, continued refinement of the measurement of the nonmarket benefits of species preservation and biodiversity may help provide relative information in a kind of "gross disproportionality" test with social benefits and costs (Randall and Farmer 1995).

[6] Explicitly raising the intergenerational equity issue for any CBA involving an endangered species, Bishop (1980, 209) restates the decision problem as: "To what extent is it fair for the current generation to bear costs in order to reduce uncertainty faced by future generations? An efficiency-oriented approach would completely overlook this ethical issue."

1976; Randall 1994; Toman, 1994) for decisions involving long time horizons, true (Knightian) uncertainty, and potentially irreversible changes.[7] In response to perceived limitations of CBA, especially in the context of preserving at-risk species and biodiversity, the SMS is frequently suggested as an alternative collective choice rule (Bishop 1993; Bishop and Woodward 1994; Castle and Berrens 1993; Loomis and White 1996; Norton 1987; Randall 1986, 1988, 1991; Vatn and Bromley 1994).

The SMS was first proposed by Ciriacy-Wantrup in 1952 as a flexible policy tool to ensure the preservation of renewable natural resources. Ciriacy-Wantrup was not concerned with substantially extending the theory of optimal social choice, but with developing a pragmatic tool for collective choices in the face of high degrees of uncertainty and limited scientific information, and potentially irreversible losses (Castle, Berrens, and Polasky 1996).[8]

The SMS can perhaps best be conceptualized as a burden-of-proof switching device (Batie 1989; Randall 1986, 1988; Tisdell 1990). While conventional economic analysis strives to determine the net benefits of preservation actions, SMS starts with the assumption that preservation of an at-risk species is a priori beneficial, but remains sensitive to the social costs of any preservation action. The burden of proof lies in demonstrating that the opportunity costs of preservation activities are intolerable. The determination of intolerable costs is crucial for the successful operationalization of the SMS concept and entails a larger collective choice process beyond that of demarcating a simple physical standard (Norton 1987).

The initial element of the SMS involves identifying a critical biological threshold or zone below which it is impossible or highly uneconomical to reverse the trend toward extinction.[9] The process avoids the ''routine trade-off'' between costs and benefits set forth by the CBA framework while recognizing that potentially intolerable costs might justify a sacrifice of biodiversity (Randall and Farmer 1995). Randall (1991) characterizes this process as rejecting ''trump card'' status for biodiversity preservation, while requiring an ''extraordinary decision making process'' to forgo preservation.[10]

III. THE ENDANGERED SPECIES ACT

The ESA of 1973, as amended, is a multifaceted legislative initiative. Key portions of the ESA that are consistent with the SMS approach are the designation of a proposed critical habitat and the subsequent economic analysis and exclusion process, and the ''God Committee'' exemption process.

A species under the protection of the ESA must be listed either as 'threatened' or 'en-

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[7] The scale and motivation for such offered constraints will differ greatly. In the case of protecting biodiversity, Perrings and Pearce (1994) endorse micro-level standards motivated by concern for discontinuities and threshold effects in complex ecological systems.

[8] Well-known attempts have been made to operationalize the SMS in game theoretic terms (Bishop 1978; Ready and Bishop 1991; Tisdell 1990). However, the predictions of such models are ambiguous as results are sensitive to the initial framing of the game against nature. Ready and Bishop (1991) conclude that the SMS may be without rigorous theoretical foundations, and yet still yield the ''right'' social choice (see Hohl and Tisdell 1993).

[9] Common candidates for physical thresholds include minimum viable populations or habitat areas, minimum instream flows, and possibly indices of biological integrity or diversity (see Schaeffer and Cox 1992). Some authors argue that the SMS cannot be operationalized; for example, the knowledge of what constitutes a minimum viable population and therefore the minimum necessary habitat by a species is only just emerging (Hohl and Tisdell 1993). While ecologists may often be able to provide only crude approximations and rules of thumb (Soulé 1986), the SMS is a collective choice process designed to avoid *paralysis by analysis* (Andrews 1984), and is likely more robust than decision-making processes resting on the notion of *fully synoptic* assessments, including CBA. In their recent position piece on strengthening the Endangered Species Act, the Ecological Society of America (1995) endorses the use of procedures such as population viability analysis in determining minimum viable populations and critical habitats, while recognizing the difficulties involved and encouraging an ecosystem orientation. Finally, a related 1994 U.S. Supreme Court ruling (*PUD No. 1 v. Washington Department of Ecology*) upheld state authority to establish minimum instream flow guidelines under the Clean Water Act. At issue in the original appeal was the inherent uncertainty in establishing minimum standards to protect fish and wildlife.

[10] For further discussions see Norton (1995), Rolfe (1995), and Toman (1994).

dangered'.[11] The listing determination is to be made utilizing the best scientific data available, and cannot be based on any economic analysis. Upon listing, the next step in the process involves the designation of proposed critical habitat under Section 3(5)(A) of the ESA.[12] The extent and delineation of the proposed critical habitat is based on the recovery implementation plan for the listed species. That is, habitat is designated as critical based on its contribution to the conservation and recovery of the listed species. The notion of critical habitat corresponds to Ciriacy-Wantrup's concept of a critical threshold or zone under the SMS.

The USFWS follows a set of steps in arriving at the final critical habitat designation.[13] The designation of the final critical habitat is made only after an economic analysis of the resulting impacts. Designating critical habitat involves a reallocation of economic resources and the economic analysis is to determine the effects of such action on the output of the economy. A public comment period allows interested parties to provide additional evidence of impacts that can be incorporated. The final economic analysis is used along with physical and biological data as inputs into the exclusion process, where a decision is made as to whether any portion of the proposed critical habitat may be excluded. The ESA (4(B)(2)) directs the Secretary of the Interior to consider economic and other relevant impacts in determining whether to exclude proposed areas from the designated critical habitat. Such exclusion cannot jeopardize the conservation and recovery of the listed species and be likely to cause extinction. In practice, the exclusion process requires that some criterion must be developed to judge whether the associated economic impacts are excessive or severe.[14]

The exclusion process has sometimes resulted in a substantial reduction of the proposed critical habitat. In the case of the northern spotted owl in the Pacific Northwest, approximately 40 percent of the proposed critical habitat was excluded on economic impact grounds, where the focus was on employment impacts in the logging industry.[15]

To review, the SMS calls for the preservation of a species as long as preservation costs are not intolerable (Randall 1991). Analogously, the exclusion process under the ESA allows for the exemption of individual areas from the designated critical habitat if inclusion would entail severe economic impacts. In both cases, a threshold must be developed beyond which preservation should be forgone, or, in the context of critical habitat designation under the ESA, individual areas should be excluded from the critical habitat in order to avoid excessive economic consequences. The SMS would allow for the extinction of a species if the economic consequences of preservation were judged to be intolerable—there is no trump card. It would seem that the ESA exceeds the SMS provisions by permitting exclusion if and only if doing so means the species is not threatened with extinction. However, the ESA contains a second level exemption opportunity beyond the critical habitat exclusion process.

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[11] The ESA defines *threatened* as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (Sec. 3(20)) and *endangered* as "any species which is in danger of extinction throughout all or a significant portion of its range" (Sec. 3(6)).

[12] Once critical habitat has been designated, Sections 7 and 9 of the ESA come into play. Section 7 applies exclusively to federal agencies requiring them to ensure that "their actions do not jeopardize the continued existence of listed species or destroy or adversely modify species' critical habitats" (Rohlf 1989, 29). Section 9 applies to private citizens and restricts them from "taking" listed species. While such taking has been interpreted to include habitat destruction, the federal nexus of the Act is only established on private lands if there is evidence of the current presence of the species on this land. On federal lands it is only necessary to show that the lands are suitable habitat. A taking under the ESA means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect or attempt to engage in any such conduct" (Rohlf 1989, 60). In a recent Supreme Court case "take" has been interpreted to include adverse modification of the habitat (*Babbitt v. Sweet Home Chapter, No. 94-589*).

[13] The USFWS (1994, 13381) outlines these steps in the context of the Colorado River fishes final rule on critical habitat designation. For a more general review see Williams (1994).

[14] In the exclusion process on the Colorado River fishes, the USFWS (1994, 13381) cites the need to "provide a method by which the severity of economic impacts could be assessed."

[15] See Mulder et al. (1992, 35), which is an insert to the Schamberger et al. (1992) study.

The additional level of exemption was introduced in the 1978 amendments to the ESA establishing a cabinet-level committee, nicknamed the "God Committee." This committee possesses the authority to permanently exempt species from protection under the ESA.[16] In practice the critical habitat exclusion process is commonly used, while the higher level God Committee exemption process has been "virtually unused" (Rohlf 1989). Taken in combination, the critical habitat exclusion process and God Committee exemption process of the ESA are consistent with Randall's (1991) SMS notion of an extraordinary decision making process. Thus, while we are aware of no evidence that the framers of the ESA, or the authors of subsequent amendments, were aware of economic writings on the SMS, the ESA is generally consistent with an SMS-type approach.[17]

However, our case studies differ from traditional theoretical discussions of the SMS in an important respect. While most discussions of the SMS are framed in terms of "social costs," the case studies are restricted to presenting economic impact analyses from regional modeling. While the true Hicksian surplus measures of social costs (and benefits) are preferred, economic impact analyses are often the only practical alternative. *A fortiori,* the ESA directs that probable economic "impacts" be considered in the exclusion process for proposed critical habitat.[18] Aside from this pragmatic perspective, changes in economic activity (rather than strict welfare measures) will often be the center of public attention and debate in ESA cases (e.g., the controversial case of the northern spotted owl [Schamberger et al. 1992]). Thus, we argue that earlier literature on the SMS may have been too narrow in its conceptualization of how society views the sacrifices associated with preservation.

IV. CASE STUDIES AND REGIONAL IMPACT MODELING

The economic impacts of critical habitat designation arise from the implied resource reallocation. The impacts are typically regional, rather than local, and thus necessitate regional economic modeling. Appropriate modeling must capture both aggregate economic impacts and distributional consequences resulting from the resource reallocation caused by the designation of critical habitat. Applied general equilibrium models, either input-output (I-O) models or computable general equilibrium (CGE) models, are suitable for these purposes.[19]

Both CGE and I-O analyses permit the determination of a variety of impact measures. In the case studies, impacts are measured as changes in output and employment. Impacts of actions taken on behalf of endangered species can be measured at three levels: the subregional level, the regional level, and the national level. Our two case studies present both regional and subregional impacts.[20] Depending on the scope of the study, the subregional level differs considerably in size. In the Colorado study, where the region comprises seven states, individual states are the lowest level at which impacts are deter-

[16] See 16 U.S.C. § 1536 (a–h). God Committee exemptions are made only after it is determined that development actions have no reasonable and prudent alternatives, and development benefits clearly outweigh the preservation of the species (Rohlf 1989). Of course even when a God Committee decision rejects exemption, as in the infamous snail darter case, congressional legislation can always supersede ESA protection (see Norton 1987).

[17] While the intent of both may be proactive, implementation of the ESA often fails to be. It has not been uncommon for more than a decade to pass between an initial petition for listing and the actual listing decision (Berrens 1996; Loomis and Helfand 1993). A primary reason for these lags is the limited funding available to the federal agencies charged with the ESA's implementation (U.S. Congress OTA 1987). The failure of being proactive in certain cases due to problems of implementation does not alter the fact that *conceptually* the exclusion process under the ESA adopts the SMS concept. More recently there has been the outright interruption of ESA funding. In April 1995, Congress passed P.L. 104-6 placing a moratorium on additional funding and all work on final listings and determinations of critical habitat.

[18] See CFR § 402.01 [chap. IV, 10-1-94 edition, p. 533].

[19] For reviews, see Miller and Blair (1985) and Shoven and Whalley (1992).

[20] Full national modeling was not undertaken. Instead, Brookshire, McKee, and Watts (1993, 1994) and Brookshire, McKee, and Schmidt (1995) report national impacts based on the outputs of the regional models and the assumption of negligible spillover effects (positive and negative) outside the regions of interest.

TABLE 1
SUMMARY OF THE TWO CASE STUDIES

	Colorado River Study[a]	Virgin River Study[b]
Listed Species	Colorado squawfish, humpback chub, bonytail, razorback sucker	woundfin, Virgin River chub
Proposed Critical Habitat	3350 km of river	330 km of river
Proposed Changes	operation pattern of federal reservoirs, conservation levels	minimum flow requirements
Impacted Region	Arizona, California, Colorado, New Mexico, Nevada, Utah, Wyoming	four counties in Nevada, Utah, and Arizona
Time Horizon	1995–2020	1995–2040
Regional Impact Modeling	I-O, CGE	I-O
Number of Economic Sectors	20	16
Number of Scenarios	1	2

[a]*Source:* Brookshire, McKee, and Watts (1993).
[b]*Source:* Brookshire, McKee, and Schmidt (1995).

mined. For the Virgin River case study, the county is the first level, the next level being a three-county region. The attributes of the two studies are summarized in Table 1.

The two case studies analyze the impacts of critical habitat designation on two regions greatly differing in size. The Colorado study calls for the designation of 3,350 km of river as critical habitat. The impacts from this designation affect all seven states in the Colorado river basin: Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. The critical habitat proposed by the USFWS in the Virgin study covers 330 km of river flowing through three counties in Arizona, Nevada, and Utah.

Not only do the areas of the two study regions differ considerably, but also the size of their economies. The output of the region in the Colorado study is approximately $1.3 trillion annually, compared to $28 billion for the Virgin study region. The Colorado study region constitutes a diversified economy that has experienced growth above the national average during the last several decades. The region of the Virgin study is currently one of the fastest growing areas in the United States, with continued high population growth rates projected for the time horizon of the study. The time horizons of the studies coincide with the time span of the proposed recovery plans for the species: 1995 to 2020 in the Colorado study, and 1995 to 2040 in the Virgin study.

A common criticism, but not a requirement, of the ESA and its implementation is a single-species emphasis. In both of the case studies the implementation of species recovery actions and the evaluation of economic impacts is for multiple species.[21] In this way the case studies reflect ongoing policy change in the USFWS to focus on related groups of species as part of an evolving reorientation towards ecosystem protection (see Smith 1996). The Colorado study estimates the economic impact of critical habitat designation for four listed fish species in the Colorado River basin: Colorado squawfish (*Ptychocheilus lucius*), the razorback sucker (*Xyrauchen texanus*), the humpback chub

[21] Of note, a recent out-of-court settlement by the USFWS formalizes a commitment to multiple species listings and proposals that address entire ecosystems. See the editor's note by J. Jaffe following LaRoe (1993), and further discussion in Ecological Society of America (1995). As others have noted (e.g., Williams 1994), the authors of the original ESA clearly intended a focus on ecosystems. In the USFWS final rule for critical habitat for the four fish species in the Colorado River (USFWS 1994, 13377), the original intent of the ESA is cited as the reason for including all four fish in the analyses and designation. The opening stated purpose of the ESA reads: ". . . to provide a means whereby the entire ecosystems upon which endangered and threatened species depend may be conserved . . . ,"

(*Gila sypha*), and the bonytail (*Gila elegans*). The Virgin study estimates the economic impacts of habitat designation for the woundfin (*Plagopterus argentissimus*) and the Virgin River chub (*Gila seminuda*).[22]

The development of the two case studies share a similar history; they were both initiated by lawsuits over the failure to designate critical habitat as required by earlier species listings. For brevity we detail only the time line of events in the Colorado study. In October 1991 the USFWS received notice of intent to sue by the Sierra Club Legal Defense Fund for the failure to designate critical habitat concurrent with the listing of the razorback sucker. Subsequently, in December 1991 the USFWS concluded that such a designation was "prudent and determinable." It was also decided to propose critical habitats for the Colorado squawfish, humpback chub, and bonytail, given overlaps in their habitats (Maddux et al. 1993). The Sierra Club Legal Defense Fund filed suit in May 1992 on behalf of a number of environmental and interest groups. After an earlier summary judgment and USFWS request for delay, the Court ruled in October 1992 that the USFWS had violated the ESA in failing to designate critical habitat. Responding to a 90-day time limit, the USFWS published the proposed rule in January 1993. Final designation of critical habitat had to be completed by April 1995, following a ruling of the Court in March 1994 (see USFWS 1994). Thus, a fairly strict time limit was imposed for completing the subsequent economic analysis and concomitant exclusion process. A similar set of events and time constraints was imposed on the smaller Virgin study.

In the context of this historical development, the first step in the required process was the biologically based determination of potential critical habitats (Maddux et al. 1993, 1995). The present range of the razorback sucker and the Colorado squawfish is about 30 to 35 percent of the historical habitat. The humpback chub occupies 25 to 30 percent and the bonytail is believed to occur in 15 to 20 percent of their historical habitats. The Virgin River chub occupies about half and the woundfin is extirpated from almost all of the historical habitat. In the Colorado study, the critical habitat proposed for the listed fishes ranges from 15 percent of the historical habitat for the bonytail to 52 percent for the razorback sucker. In the Virgin study, the critical habitat consists of 14 percent for the woundfin and 71 percent for the Virgin River chub.

Endemic fish populations in both study regions have been declining since the turn of the century. The declines are a result of physical and biological changes in the river systems: streamflow alterations, habitat fragmentation and modification, water temperature changes, and introduction of contaminants and nonnative species. The natural hydrographs of the systems have been significantly altered. Consumptive water uses include agricultural, municipal, and industrial uses, and reservoir evaporation (Maddux et al. 1993, 1995).

The critical habitat designated in both studies is aimed at creating those biological conditions that enhance the "constituent elements" for the target species. Determination of critical habitat requires consideration of physical and biological features that are essential to species conservation. These features, referred to as constituent elements, include: (1) space for populations; (2) food, water, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, and rearing of offspring; and (5) habitats that are protected from disturbance or are representative of the historical and ecological distribution of the species. In the Colorado study the constituent elements call for a critical habitat including both altered flow levels and the timing of flows. Recommended changes in flow patterns to achieve recovery of the species vary across the Colorado River system. Recovery

[22] The Colorado squawfish and the humpback chub were listed as endangered species on March 11, 1967 (32 Federal Register 4001), and thus were originally listed under the auspices of the Endangered Species Preservation Act of 1966. The razorback sucker was listed as endangered in October 1991 (56 Federal Register 54957), the bonytail in April 1980 (45 Federal Register 27713). The listing of the woundfin was in October 1970 (35 Federal Register 16047), the listing of the Virgin River chub in August 1989 (54 Federal Register 35305).

plans include reduced diversion from the river by more than 50 percent during the winter and increased diversion during the summer by the same order of magnitude. The constituent elements in the Virgin River necessitate the designation of a critical habitat that imposes a minimum flow requirement in the river system throughout the year. This translates into increasing flow by more than 70 percent during the winter in some parts of the river system.

In both case studies, the designation of critical habitat increases the demand for water to be left instream on behalf of the recovery of the endangered species (and see Tyus 1992). As overall flows in the river systems are limited, the reallocation of resources away from human uses becomes necessary. The direct economic impacts of critical habitat designation thus depend on which human uses have to be reduced as a consequence of critical habitat designation.

In the Colorado study, changing the timing of flows in the Colorado River system, together with prescribed minimum flow levels in some river stretches requires changed operation patterns of the river system's dams. The new patterns are expected to affect power generation in economically adverse ways.[23] In addition, developing new water projects in the Colorado basin will be restricted by increased competition for the water between human needs and those of the endangered fishes. The expansion of agricultural production will be consequently constrained.[24]

In the Virgin study area, water is being redirected from the currently dominant use, irrigated agriculture, to municipal and industrial (M&I) uses in order to satisfy the demands of a rapidly growing population. The demands for the endangered fishes will compete with M&I demands for water currently used in agricultural production. It should be emphasized that the designation of critical habitat is not the primary cause of declining agricultural production, but merely accelerates the ongoing conversion from agricultural to other, predominantly M&I, uses.

As mentioned above, both studies employed applied general equilibrium analysis. In the Colorado study, the state level impacts were estimated using I-O models while the regional impacts were estimated using both an I-O and a CGE model. In the Virgin study, both the county-level impacts and the regional impacts are estimated using I-O models. The primary data source for both studies is the USDA IMPLAN database (U.S. Department of Agriculture 1993). This database includes the input-output accounts and the Social Accounts Matrix both at the county and state levels. The IMPLAN database is augmented by a variety of additional sources, such as Census of Agriculture data on employment and land use (U.S. Department of Commerce 1987). In the Virgin study, projections produced by local water authorities were used to derive population projections at the county level. The actual I-O and CGE models were written in the GAUSS programming language.

To determine the economic impacts of habitat preservation, scenarios were constructed to compare economic activity with and without taking the needs of the endangered fish species into account. In both studies, baselines of projected economic activity were constructed. The baseline estimated the development of the regional economy over the studies' time without any changes in economic activity on behalf of protecting the fish species. Then, economic impacts were determined by comparing the baseline scenario to scenarios incorporating protective measures on behalf of the endangered fish species. For the Colorado study, these measures included altered operation patterns of dams and increased conservation efforts. For the Virgin study two scenarios were developed. The construction scenario meets the increased instream water demand for the

[23] The loss in hydroelectric power generation due to timing of water releases would be made up by increased thermal generation to meet peak demands. Stone and Webster Management, Inc. conducted simulations utilizing their EGEAS model and projected that 121 MW of additional generation capacity would be required to offset the losses in hydroelectric power generation (Brookshire, McKee, and Watts 1993).

[24] Agriculture uses are the lowest valued in the Upper Basin of the Colorado River system. Thus, these uses are projected to be curtailed first to provide the additional flows required to provide habitat for the endangered fishes (Brookshire, McKee, and Watts 1993).

TABLE 2
REGIONAL IMPACTS OF CRITICAL HABITAT DESIGNATION

	Output Changes— ($Millions) NPV at 3%	Percentage Deviations from Baseline	Employment: Average Annual Jobs Change
Colorado Study[a]	1,294.0	0.003	1,820
Virgin Study[b]			
Construction Scenario	−119.6	−0.0003	−60
Conservation Scenario	−41.9	−0.0001	−9

[a]Output results for the Colorado study are reported in 1991 dollars.
[b]Output results for the Virgin study are reported in 1990 dollars.

fishes by bringing proposed structural water delivery projects on-line earlier than previously planned, and accelerating ongoing conversion from agricultural to M&I uses. The conservation scenario, in addition to accelerated construction of water projects, assumes that increased water demands are met by reducing per-capita water consumption through a series of water conservation measures.[25] These measures include more efficient appliances and plumbing as well as xeriscaping (native landscaping with low water needs).

V. RESULTS

In this section we present the regional and subregional impacts computed in each case study, beginning with the Colorado River study and then following with the Virgin River study.[26]

For the Colorado River study, the impacts at the regional level are actually positive (see Table 2). To restore flows to historical patterns requires that some upstream diversions be reduced, and the modeling assumes that lowest valued uses will be retired first. The released water is available for use downstream after it has provided fish habitat. The downstream uses in the Colorado River Basin are typically higher valued than the upstream uses. Thus the region as a whole experiences positive impacts when the critical habitat is provided. At a 3 percent discount rate, the present value (PV) of the regional impacts for the study period is $1.294 billion.[27] While positive, these impacts are very small compared to the overall economic activity, consisting of no more than a 0.003 percent increase over the baseline.[28] Employment is expected to increase by an average

[25] Per capita water use in the St. George, UT, area is considerably greater than in other southwestern urban areas. Current use is 465 gallons per capita per day (gpcd). For the conservation scenario this was reduced to approximately 260 gpcd which is comparable to Phoenix, AZ, and well above Tucson, AZ (which has a use rate of 160 gpcd). Conservation requires expenditures which raises the effective cost of water and this was incorporated into the scenario (Brookshire, McKee, and Schmidt 1995).

[26] Some caveats are in order concerning results. First, although both CGE and I-O models were constructed for the Colorado River region, only the latter are presented (facilitating comparison to the Virgin study). CGE and I-O results were consistent although minor differences did appear due to underlying differences in the models. The CGE model permits greater substitutions and thus reports lower overall impacts (McKee et al. 1997). Second, the USFWS (1994) draws a distinction between economic impacts due to listing of endangered species and due to the designation of critical habitat. Brookshire, McKee, and Watts (1994) and Brookshire, McKee, and Schmidt (1995) report both the aggregate (listing plus critical habitat) impacts and separate critical habitat impacts. The SMS is consistent with consideration of total impacts, which are focused on here. Further, there is no clear basis for proportioning impacts between listing and critical habitat designation, the separation of which was the basis for the original lawsuits. Finally, impacts reported here refer to changes in output rather than value added, and thus overstate the impacts to regional and state economies.

[27] In the Colorado study, impacts are presented at 0, 3, 5, and 10 percent discount rates. As these are real interest rates, Brookshire, McKee, and Watts (1993) argue a discount rate in the range of 3 to 5 percent to be the most relevant. In the Virgin study only a 3 percent rate is employed. Unless stated otherwise, a 3 percent rate is used throughout the discussion here.

[28] Impacts are extremely small, and we report percent deviations from baseline to illustrate this point. Neither the data nor the models are sufficiently precise to allow us to state that percentage values are statistically different from zero.

TABLE 3
DISTRIBUTION OF IMPACTS WITHIN STUDY REGIONS

Colorado Study			
	Output: ($1991 millions) NPV at 3%	Percentage Deviations from Baseline	Employment: (Average Annual Jobs Change)
Arizona	−210.0	−0.008	−100
California	3,335.0	0.007	3,980
Colorado	−169.7	−0.006	−150
Nevada	1,402.9	0.148	1,060
New Mexico	−2,454.6	−0.279	−2,010
Utah	−725.5	−0.06	−350
Wyoming	−71.7	−0.02	−20

Virgin Study			
	Output: ($1990 millions) NPV at 3%	Percentage Deviations from Baseline	Employment: (Average Annual Jobs Change)
Construction Scenario			
Washington County (UT)	−94.9	−0.0032	−26
Clark County (NV)	−20.8	−0.00002	−1
Conservation Scenario			
Washington County (UT)	−27.5	−0.00093	−4

of 1,820 jobs over the study period, and by 6,250 jobs in 2020 (the last year of the study period), a 0.002 percent increase over the baseline.[29]

Although overall regional impacts are positive in the Colorado River study, impacts at the state level vary considerably within the study region (see Table 3).[30] The exclusion process is initiated when impacts are negative and is usually conducted at a smaller geographic scale. Thus, there was a requirement to assess the impacts at the state level in the Colorado study. Among the seven states, positive impacts accrue to California and Nevada for reasons noted above. For California the predicted impact is an increase in output of 0.07 percent over the baseline, corresponding to an increase of $3.335 billion. Employment increases by 0.04 percent. On the other hand, impacts to Arizona, Colorado, New Mexico, Utah, and Wyoming are all negative and must be evaluated when consideration is given to excluding portions of the habitat. The predicted impacts to New Mexico are a reduction of output by 0.279 percent, equivalent to lost output with a PV of $2.454 billion. Employment is predicted to fall by 0.10 percent as a result of actions taken on behalf of the endangered fishes. Changes over the baseline are very small for each of these states and the impacts to the other states lie between those for California and New Mexico.

For the Virgin study, the regional impact due to the designation of critical habitat is projected to decrease output by a PV of $119.6 million for the construction scenario, a deviation of 0.0003 percent from the baseline. For the conservation scenario, the PV of

[29] Based on the assumption that a person that loses a job will not stay unemployed for the remainder of the period, a cumulative measure for unemployment is inappropriate. Employment impacts are presented in terms of deviation from the baseline in the last year of the study period.

[30] The regional impact and the sum of individual state impacts will not match exactly since state impacts were computed from state-level I-O models while the region was modeled as a complete entity. Differences are due to leakages at the state level captured by the larger region.

lost output is $41.9 million, a deviation from the baseline by less than 0.0001 percent. In terms of employment, the designation of critical habitat reduces the number of incremental jobs by 60 under the structural scenario and by 9 under the conservation scenario (see Table 2).

In the Virgin study, subregional impacts are determined for two counties: Clark County, Nevada, and Washington County, Utah. The impacts in Clark County include those to the small section of Mohave County, Arizona, that is included in the study region.[31] Under the construction scenario, the PV of output losses in Clark County is $20.8 million, a reduction of 0.00002 percent from the baseline. For Washington county, impacts under the construction scenario are slightly larger, but still small. The PV of lost output is $95 million, a reduction in economic activity by 0.0032 percent from the baseline. The average number of jobs forgone annually is one for Clark County and 26 for Washington County.

Under the conservation scenario, no direct impacts accrue to Clark County, and only impacts in Washington County are presented. Implementing the conservation scenario reduces the PV of output by $27.5 million, a change of less than 0.00093 percent from the baseline. In terms of output, impacts are actually positive after the year 2025, when increased construction costs for more efficient buildings are offset by reduced expenditures on water. The designation of critical habitat will reduce the number employed on average by four persons per year.

In reviewing the impacts, two points should be emphasized. In both case studies, the impacts of listing and critical habitat designation are extremely small. Actions taken on behalf of the endangered fishes are not expected to affect economic activity in the study regions to any significant level. However, as the Colorado study has shown, impacts can be unevenly distributed. Different areas may be more dependent, both directly and indirectly, on the affected resource and these differences may lead to an area of habitat being excluded. Nevertheless, even when differences in state impacts are accounted for, impacts are quite small.

In both case studies, the question of whether impacts are sufficiently excessive or severe to exclude areas from the critical habitat was answered by comparing the estimated future impacts of habitat preservation to the historical development of the regional economies. It was argued that if the impacts of habitat preservation are well within the historic fluctuation of the regional economy, habitat preservation should not be forgone and the area should not be excluded (USFWS 1994). In the case of the Colorado study, the regional economy grew on average by 2.85 percent in the years 1959 to 1991. The standard deviation of the growth rate was 2.26 percent. In the Virgin study, the regional economy grew on average by 3.01 percent, with a standard deviation of 2.12 percent between 1959 and 1994.

For both case studies, the recommended threshold for exclusion was 1 percent deviation from the baseline projection of aggregate economic activity. The estimated impacts in both studies were orders of magnitude lower than the proposed threshold and, consequently, no areas were recommended for exclusion. This threshold constituted a change of less than half of the standard deviation of historic growth, and would be considerably lower than others suggested in the SMS literature. For example, Randall and Farmer (1995, 41) conclude that, if the argument is based on moral principles, intolerable costs could be defined as "extreme deprivation" for society. In the northern spotted owl study (Schamberger et al. 1992), the threshold was defined in terms of change in employment in the logging industry within the respective county. That case involved a single species and the direct impacts were concentrated in one industry. In the Colorado and Virgin River studies the direct impacts reached across many economic sectors and the appropriate threshold was a measure of aggregate economic activity.[32]

[31] Given no direct impacts to Iron County, UT, no separate county impacts are calculated.

[32] In fact, there is likely no universal standard or metric for what constitutes excessive impacts, nor do we endorse one here. However, as we interpret the current ESA, agency policymakers will require some stated criterion.

The above discussion addressed the issue of excessive economic impacts in terms of aggregate measures such as regional output. However, the SMS decision process may also be amended to include distributional considerations or constraints (Randall and Farmer 1995), including potential compensation for those hardest hit. It is generally true that the economic consequences of actions taken to protect and preserve endangered species are not distributed evenly across economic sectors and geographic areas (e.g., Waters, Holland, and Weber 1994). The type of regional modeling undertaken in these case studies allows explicit consideration of these distributional factors. For example, multi-sector models allow identification of gainers and losers by economic sector (McKee et al. 1997). Modeling at the regional and subregional areas makes it possible to identify gainers and losers geographically. In the case studies the distributional consequences were evaluated and not judged to be sufficiently severe as to preclude an area from being designated critical habitat (USFWS 1994). As of early 1997, no such areas have been identified in either the Colorado River or Virgin River designated critical habitat and no portions have been excluded.

VI. DISCUSSION AND CONCLUSIONS

In the conditional nature of the imperative to protect at-risk species, the SMS will be unpalatable to some strong sustainability advocates. Likewise, by reversing the burden of proof in favor of species preservation, the SMS will be equally unpalatable to unfettered CBA advocates. As such the SMS approach may be identified as falling between weak and strong sustainability perspectives—it acknowledges the importance of biodiversity as critical natural capital without providing "trump card" status. Even among those accepting the logical underpinnings of the SMS, we expect that any proffered definition of what might constitute excessive economic consequences will be the source of considerable consternation. Using regional economic analyses, historical fluctuations in regional economies are a natural standard to gauge the severity of economic impacts. By this standard the two ESA case studies did not find the economic impacts of these particular multi-species preservation actions to be excessive.

The evidence of applying the SMS comes from two case studies undertaken within strict Federal Court–ordered time frames to satisfy the requirement that listing be accompanied by the designation of critical habitat. In each of these studies the determination of regional economic impacts was made for particular preservation plans, rather than developing full impact functions or even true social cost functions for the preservation of the species (see Hyde 1989; Montgomery, Brown, and Adams 1994). An essential input to the construction of such a function is the species' probability of survival function (e.g., relating survival probability to habitat volume). This was not available for the two riverine case studies recounted here. Thus, the more pragmatic approach was adopted, and may be the only option for many endangered species cases. The presence of ecological thresholds and discontinuities in complex ecosystems complicates the estimation of such functions and may be an argument for increased reliance on safety standards (Perrings and Pearce 1994). However, this is an important avenue for future research collaboration between ecologists and economists.

The ESA is likely to continue to be an evolving piece of environmental policy and we do not pretend to capture the full debate here. Of note though, the shift away from a single-species emphasis and toward broader ecosystem protection is under way, and is not precluded by the ESA or the SMS approach. The two regional case studies involve critical habitat designations for *multiple* species, and reflect ongoing policy change in the USWFS to focus on groups of species as part of an evolving ecosystem orientation. While often discussed in a single-species context, we see no barriers to applying SMS approaches in this broader context. The SMS approach was never conceptualized to be kept on the shelf while we search for complete information on social values and understanding of complex ecological systems. As revealed in the case studies, the SMS emerges as a fairly coarse but pragmatic collective choice process.

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