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Article

Adaptive Management to Protect Biodiversity: Best Available Science and the Endangered Species Act

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Abstract: Although flawed, the most powerful tool for protecting biodiversity in the United States is the Endangered Species Act, which requires the use of the best available science to ensure that endangered and threatened species are not put in jeopardy of extinction. Unfortunately, the best available science mandate is virtually meaningless and imposes no additional scientific rigor in agency decision making beyond what is normally required of administrative procedures. In this paper, we propose to define best available science in a way that shifts from a way of *using* science to a way of *doing* science, and a sound method of doing science for wildlife management and climate change is via the principles of adaptive management [1]. Adaptive management, as a means of data accumulation and continuous learning, can fulfill and give teeth to the best available science mandate while increasing the adaptive capacity of wildlife management agencies to protect biodiversity in an unpredictably dynamic environment.

Keywords: Endangered Species Act; adaptive management; best available science; climate change law; biodiversity; adaptive capacity; environmental law; front-end policy

1. Introduction

According to the UN Millennium Ecosystem Assessment, humans have increased the species extinction rate by 1,000 times background rates by activities such as deforestation and the commercialization and commodification of species, and presently 10–30% of mammal, bird, and amphibian species face extinction threats globally [2]. At the same time, human-induced climate change escalates extinction threats by shifting habitats and increasing variability in the hydrologic cycle. Resilience theory recognizes the negative anthropogenic effects on ecosystem services and the importance of biodiversity and its self-organizing capacities.

Resilience is the capacity of an ecosystem to withstand disturbance and maintain the same basic processes and structures [3]. If the resilience of an ecosystem degrades to a critical threshold, the ecosystem will cross the threshold (*i.e.*, a regime shift) and self-organize into an alternate regime characterized by a different set of processes and structures. This point is critical, as resilience is an emergent property in many ecosystems, and this means that ecosystems can exhibit multiple regimes and therefore non-linear dynamics [4]. In addition, climate change models forecast nonlinear environmental responses and feedback loops and a shift to the “no-analog future” which will exacerbate the challenges of managing social-ecological systems [5,6]. Thus, ecosystems are not readily managed with cooker-cutter, front-end management proscriptions [5]. Additionally, managing for resilience requires improved understanding of an entire system as opposed to specific, detailed knowledge of a single system component [7]. A proactive approach entails characterization of system aspects that contribute to the system’s resilience via a suite of methods. This is in stark contrast to reactive approaches, which presents problems from the legal perspective in the United States where upfront certainty is sought, and one of the ways in which this conflict can be resolved is through application of adaptive management to ecosystem management.

Adaptive management at its core is applied understanding about ecosystems drawn from resilience theory. This entails an iterative process of decision making that integrates uncertainty and the inevitability of “surprise” (*i.e.*, non-linear change) into the management process via a learning infrastructure [8]. Monitoring is an essential aspect of adaptive management, as information from the system (*e.g.*, monitoring data) feeds back into the management process in an iterative manner that allows managers to adapt to changing circumstances associated with managing ecosystems. Thus, management actions are hypotheses to be put “at risk” in an adaptive management framework, and information that allows for learning is generated to improve management decisions [8].

Arguably, the best legal tool for conserving biodiversity in the United States is the Endangered Species Act (ESA), although it has many pitfalls (16 U.S.C. § 1531 *et seq.*). According to the Supreme Court of the United States, the ESA is “the most comprehensive legislation for the preservation of endangered species ever enacted by any nation” whose policy exemplifies the “institutionalization of caution” [9]. However, the ESA’s approach of fractioning ecosystems into manageable components limits its capacity as a tool for biodiversity protection, especially considering the complexity of ecological systems and the unknown implications of a changing climate [10]. The goal of the ESA is not “to establish a

comprehensive biodiversity conservation program” or even to save species from extinction, but to simply ensure that proposed actions do not put endangered or threatened species in further jeopardy of extinction, a distinction with critical management implications [11].

Despite this, the ESA has long been the law of choice for biodiversity protection advocates, and case law has evolved to define statutory terms such as take, habitat, and jeopardize broadly so that natural resource managers may consider ecosystem-scale implications of endangered species protection. The ESA contains no explicit prohibition against taking ecosystem considerations into account when managing species and is not completely void of ecosystem dynamics as evidenced by the aim to “provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved” (16 U.S.C. § 1531(b)) [12]. In addition, the “sleeping giant” statutory provision in Section 7(a) (1) imposes a duty to *conserve* species which could arguably be interpreted to require adaptive management for broader ecosystem protection (16 U.S.C. § 1536(a) (1)) [7,13].

Extinction is to be avoided at all costs, but the preservation focus on individual species weakens the ESA as a tool for protecting ecosystem integrity [5]. Despite the statutory recognition of habitat conservation and, arguably implicitly, the nonlinearity of biological processes, J.B. Ruhl, among others, argues that ESA implementation takes a “reductionist, linearist, and predictivist” approach to protecting a single species at a time and that ecosystem scale protection only occurs as incidental to species-based decisions [14]. While some may argue that a new legal paradigm is necessary to shift from front-end policies (discussed *infra*) to a more adaptive process, this paper addresses how to work within the existing legal framework by defining a single statutory phrase: best available science (described *infra*) [15,16]. This slight shift to define best available science to institute learning infrastructure for iterative endangered species management does not completely solve the problems of front-end environmental decision making, but it is a more realistic goal because it could be achieved by means that do not require a new, radically different environmental law out of the legislative branch.

1.1. Statutory Background

When a federal agency proposes an action or any actor (e.g., private, municipal, state) requests a federal permit or license or federal funding for any action that may affect species protected by the ESA, the federal agency must consult with one of two expert wildlife agencies, either the Fish and Wildlife Service or the National Oceanic and Atmospheric Administration Fisheries Service (the “Services” collectively), to ensure the action will not jeopardize the continued existence of any protected species.¹

¹ Likewise, private action is prohibited from harming protected species, even where federal action is not involved. Actions taken on private land by private actors are covered by § 9 of the ESA (16 U.S.C. § 1538). Under § 10, a private actor may obtain an incidental take permit (ITP) if the federal agency approves a habitat conservation plan. The ITP grants a landowner assurance that, if following the habitat conservation plan, an act that harms (or “takes”) a protected species will not result in ESA civil or criminal liability. This article focuses almost exclusively on federal actions, although some important case law has come from cases concerning private acts (16 U.S.C. § 1539).

The ESA explicitly requires that every consultation process utilize the “best scientific and commercial data available” in determining whether an action is likely to jeopardize species, what is more commonly referred to as the best available science (BAS) mandate (16 U.S.C. § 1536(a)(2) & (c)).² This consultation process begins as an informal exploration of potential impacts of the proposed action, and most inquiries end at this step with a determination that the action will not affect a listed species or critical habitat. If adverse effects are likely, then a formal consultation process is initiated.

Formal consultations pursuant to ESA § 7 are conducted cooperatively between the acting agency (e.g., the agency proposing the action or issuing the permit, license, or funds) and the consulting wildlife service to avoid, minimize, or mitigate the impacts of agency activities on protected species (16 U.S.C. § 1536). The results of the consultation process are reported in a Biological Opinion (BiOp) that includes a summary of the information upon which the opinion is based, descriptions of the action’s effects on listed species or critical habitat, and the consulting agency’s jeopardy determination—“whether the action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat” (16 U.S.C. § 1536(a) (2)) [17]. The aim of the consultation process is not to save a species from extinction but to more narrowly ensure that federal actions do not “jeopardize the continued existence” of any protected species or adversely modify or destroy habitat.³ The BiOp may include conservation provisions to avoid or minimize adverse effects or impose reasonable and prudent action alternatives to mitigate effects. BiOps may also require monitoring and reporting to ensure adequate compliance. Throughout the consultation process, agencies must use the BAS to assess, avoid, and mitigate potential adverse effects.

2. Best Available Science Mandate of the Endangered Species Act

The ESA was the first and most explicit federal environmental law putting science at the forefront of decision making [18]. However, through decades of litigation over species protection, the ESA mandate for scientifically legitimate decisions has been narrowed to a requirement concerning how agencies use science, instead of requiring agencies to conduct science to inform and support their decisions. In contrast to interpretations of similar mandates in other federal environmental laws, such as the best technology available standards of the Clean Water Act, the emphasis in interpreting the BAS in the ESA is not on the term *best* but instead is on the term *available* [19].

While the requirement to use the BAS seems intuitive, especially given the lofty purpose of the ESA (see note 3, *supra*), the standard is not statutorily defined, nor is it clarified in the debates regarding the

² The process of determining whether to list a species for protection and to designate critical habitat must also utilize the best science available, as described in §4 of the ESA (16 U.S.C. § 1533). This article focuses primarily on the BAS mandate of §7, but they are, for most purposes, synonymously interpreted by courts.

³ This is despite the purpose of the Act to “provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved [and] to provide a program for the conservation of such endangered species and threatened species...” (16 U.S.C. § 1531(b)).

passage of the ESA (*i.e.*, legislative history). According to the U.S. Supreme Court, the “obvious purpose” of the BAS standard “is to ensure that the ESA not be implemented haphazardly, on the basis of speculation or surmise” [20]. Because the ESA provides no guidance as to the interpretation of BAS, courts interpret the prohibition against haphazard decision making through an analogous standard in the Administrative Procedures Act (APA), the statute that governs how agencies make decisions (5 U.S.C. § 500 *et seq.*). An agency action may be set aside under the APA if it is “arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law” [20]. Some experts assert that this interpretation renders the BAS mandate virtually meaningless.⁴

Under APA-based judicial review, an agency decision is arbitrary and capricious only if the agency has “entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise” [24]. An agency “must examine the relevant data and articulate a satisfactory explanation for its action including a rational connection between the facts found and the choices made” [24]. This standard grants great deference to agency decisions.

As applied in the ESA context, this standard of review has resulted in the emergence of three rules for BAS-based challenges to an agency decision, standards which are nearly identical to arbitrary and capricious APA review:

- (1) Agencies are not required to generate more conclusive data than what is available;
- (2) Agencies may not ignore relevant data;
- (3) Agencies retain the discretion to accept or reject scientific evidence after conducting a reasonable evaluation and articulating a rational connection between the facts found and the choices made.

2.1 Agencies Do Not Have to Generate Data

Surprisingly, the ESA does not require agencies to produce data, only to consider what is already available. “Even if the available scientific and commercial data are quite inconclusive,” the BAS standard “makes it clear that the Service has no obligation to conduct independent studies” [25]. Courts do not have the authority to compel an agency to generate more data, even if the existing data are inconclusive on an important issue [25]. As the U.S. Court of Appeals for the District of Columbia Circuit stated, the “superficial appeal [of requiring the Service to conduct further studies] cannot circumvent the statute’s clear wording: The Secretary must make his decision as to whether to list a species as threatened or endangered solely on the basis of the best scientific and commercial data available to him...” [25].

⁴ “It is not possible to extract from case law, administrative policy, or legislative intent any independent mandate of agency decision-making method or standard of judicial review the [BAS] provision adds to the picture” [21]; “The best available science mandate essentially duplicates the background requirements of the [APA] and other general limitations on agency decision making” [22]; “Without this standard, under the [APA], the Services would still be required to evaluate all available data, to consider proposed alternatives, and to rationally justify their ultimate decisions” [23].

Importantly, the flip side of this rule prevents agencies from using the lack of conclusive data as a scapegoat for indecision [1,26]. For many protected species, scientific studies are incomplete, inadequate, or nonexistent. Despite this, agencies must structure BiOp analysis using the best information available, rather than delay decision making due to lack of perfect information [27]. The ESA requires the Services to “utilize the best scientific...data available, not the best scientific data possible” [27]. As such, the iterative aspects of an adaptive management based learning infrastructure are compatible with the ESA whereby agencies act in the face of uncertainty and continuously return to the decision-making process as information on the results of that act becomes the BAS and is fed back into the process.

By implementing a learning infrastructure, agencies would have to generate data because monitoring is fundamental to learning [4]. Data accumulation and analysis should lead to better understanding of the ecological system and the environmental impacts of management decisions. In scenarios where uncertainty is high, as in most environmental systems, increased understanding of cause and effect relationships and correlations help to reduce the risk of making the wrong management decision. Given the projections of increased dynamism in hydrologic cycles due to climate change, the stakes for making the wrong decision are even higher and the need for reducing uncertainty greater.

2.2. Agencies Cannot Ignore Relevant Data

Agencies cannot ignore relevant available data, but after reviewing the data, they do not have to use it in the final decision [28]. When challengers present a court with superior data that were ignored by the agency, a court is more likely to invalidate the decision than when challengers attempt to poke holes in the data relied upon by the agency [29]. Courts have overturned agency decisions on such grounds when agencies engaged in biased structuring of data analysis, refused to consider relevant studies, and inconsistently used data sets to achieve certain goals [29]. Likewise, courts do not look fondly on agencies that site insufficient data as the rationale for not making a final decision when studies are in fact available, even if those studies were conducted by other parties (e.g., academic researchers) [29].

Uncertainty does not deter action in the ESA context, and some courts are beginning to accept the importance of uncertainty and requiring consideration of climate change projections in decision making, and at least one court struck down a BiOp for being “unlawfully silent” on the impacts of global climate change on critical habitat [30]. The U.S. District Court for the Eastern District of California (a trial court) held that agencies cannot base decisions purely on historic data when models indicate that climate change will impact listed species [30]. This case concerned contentious water supplies, endangered aquatic species, and projections of prolonged drought in California. The court cited the agency’s “total failure to address, adequately explain, or analyze the effects of global climate change on the species” when it held that the agency’s no jeopardy determination was not in accordance with the BAS [30].

If BAS is defined to mandate adaptive management techniques in decision making, agencies would be required to generate data that they would have to consider. Professor Doremus describes the large amounts of data required of adaptive management protocols as an “information problem” [31]. If learning is not feasible, then no amount of information will improve a management decision. But when additional

information can supplement an inadequate information base, implementing the adaptive management principles of experimenting, monitoring, and adjusting may lead to better decisions in the future [8].

2.3. After Reasonable Evaluation, Agencies May Reject or Accept Data

In the specific context of ESA, courts have granted “extreme” deference to agency evaluation of data within its technical expertise as long as the agency provides a reasonable explanation [32]. This is particularly true when an agency engages in “making predictions, within its area of special expertise, at the frontiers of science” [33]. More recently, courts have begun acknowledging the uncertainty inherent in environmental decision making and granted high levels of deference to agency predictions of future conditions and estimates of “likelihood, extent, and duration of injury to a species” that are sensitive to the vagaries of the hydrologic cycle [34].

The generous degree of deference leads to mixed environmental outcomes. Some agencies are ambitious data collectors and experimenters while others lack resources or initiative to generate basic baseline monitoring studies. If adaptive management is defined as the BAS process, this principle would still shield agencies from being required to accept the data they themselves generate if there is a rational reason for rejecting the data. However, observers would undoubtedly notice systemic rejection of an agency’s own data and call for either change in the decision-making process or in the method of data collection.

3. Adaptive Management—Managing for Resilience

Scholars often criticize the modern approach to environmental regulation and natural resource management as “piecemeal, attempting to fraction ecological complexes into smaller, putatively manageable components, and parceling out management responsibilities among mission specific agencies and programs” and offer adaptive management as a more integrated solution to complex environmental problems, such as biodiversity loss [10,14,35]. Over 14 years ago, J.B. Ruhl called for a “long jump” to a new policy domain that reinvents environmental law as a complex adaptive system. He argued that the costs associated with the abrupt change are necessary and justifiable given the magnitude of our “environmental mess” [14]. An important aspect of making this shift is to “unclog” the pipes through which information flows. He argued that the clogs are the result of “idiosyncrasies of bureaucracies that are fundamentally reductionist in organization, linearist in perspective, and predictivist in purpose” [14]. The process component of this paradigm shift is adaptive management as opposed to traditional, rigid methods of command-and-control styled cooperative federalism [14,36]. The measure of success of this shift would be richness of biological diversity as opposed to “bean counter” approaches whereby success is measured by the volume of contaminants contained or sum of species or habitats listed for protection.

The current approach to administrative action tends to be front-end whereby predictions of environmental risks, costs, and benefits influence the decision-making process, and once a decision is made, the process is, for most intents and purposes, closed. This approach assumes these predictions can be accurately made. Professors Shapiro and Glickman make a strong case for shifting to a pragmatic approach that rejects the notion that all impacts of a decision can be studied in advance and instead takes a

back-end approach [37]. A back-end process would study the actual impacts of decisions upon implementation and make incremental adjustments in the regulations to adapt to changing circumstances [38].

The front-end approach is exemplified in the ESA consultation process where the impacts of proposed actions on listed species are evaluated. Combined with cumulative effects, the service decides if the proposed action is likely to jeopardize the continued existence of protected species or adversely affect critical habitat (50 C.F.R. § 402.14(g) (3–4) (2009)). Once a jeopardy determination is made, the decision to act is final, though it may be reopened in certain circumstances. Ruhl describes this approach as flipping the “toggle switch” between the black and white options of action or no action as opposed to the adaptive management approach that “twiddles the dial” throughout the process of decision making and action [39].

Adaptive management is best implemented by incorporating resilience theory and is particularly apt for managing risk and uncertainty. However, adaptive management is not a panacea and should be applied in situations in which it has the greatest capacity for resulting in good environmental management [36]. Managing for resilience involves anticipation and prevention of undesirable regime shifts, diversity and feedback interaction maintenance, and reduction of system crash probability [7]. The front-end approach of modern resource management addresses only the first aspect of managing for resilience. Further, the species-specific approach is inappropriate for maintaining diversity, where conservation should rather be focused on maintaining structures and processes [7,36]. In contrast, adaptive management protocol utilizes iterative safe-to-fail experimentation and continuous learning to ameliorate uncertainty via extensive monitoring and information feedback [4,5]. Structured incorporation of monitoring data facilitates increased understanding and management of the social-ecological system [8].

However, there is a gap in resilience theory and adaptive management practice, resulting in what Ruhl and Fischman call “a/m-lite” at best [39]. Ruhl and Fischman contend that as resilience theory is translated into policy and adaptive management in practice, important components are lost in each step, resulting in agencies that practice a/m-lite, a compromised version of adaptive management. The scaling back of adaptive management often stems from a lack of resources—time, funding, and expertise—problems that can be addressed by shifting to back-end methods and increased appropriations [40]. To counter these compromises, resilience theory should be grounded in enforceable regulatory frameworks, such as the BAS mandate, so that enforcement actions would ensure the integrity of the process [8].

Although compromised, a/m-lite may still serve as an effective tool for agency decision makers as long as they withstand the temptation to “employ adaptive management to dodge burdensome procedural requirements, committing to substantive management criteria, and engaging contentious stakeholder participation” [39]. Some argue that a/m-lite is abused as a pretext for putting off decisions. Doremus warns of a “smokescreen to cover politically adaptive evasion of agency responsibilities” [26]. As long as it is not used as an excuse to delay decision-making, a/m-lite is preferable to no adaptive aspect to management decisions.

In some respects, the requirement to “utilize the best scientific...data available, not the best scientific data possible” is compatible with the iterative nature of adaptive management [27]. Agencies are not inhibited from making decisions in the face of uncertainty. However, the front-end approach has no mechanism for revising decisions when species decline further. Section 4 requires monitoring every five

years, but that is not sufficient for adaptive management, which requires structured learning and back-end modification [7]. This restriction is magnified by the narrow focus on specific imperiled species, as opposed to managing for ecosystem health [7].

3.1. Judicial Scrutiny of Adaptive Management

Given the uncertainty of climate change on biodiversity, we must have a regulatory hook to continuously re-evaluate decisions to address unforeseen consequences of our decisions, and iterative action is especially important when uncertainty is high. In the ESA context, this regulatory hook must be firmly grounded in the “reasonable certainty” standard. The reasonable certainty standard of ESA requires more than “promises to plan, collaborate, or manage toward compliance should environmental conditions degrade below the substantive management criterion” [30,39]. There is growing precedent concerning adaptive management based environmental management decisions, and courts increasingly require agencies purporting to utilize adaptive management to establish goals and a learning infrastructure specifically designed to meet those goals [30,39,41].

To ensure that adaptive management protocols pass judicial review, the flexibility required of adaptive management must be coupled with certainty, specificity, and resource commitments required of the ESA. According to the courts, adaptive management for the sake of knowledge is not an appropriate goal for natural resource managers. Instead, they should use adaptive management as a process toward specific environmental objectives [39]. The ESA requires mitigation measures that are “reasonably specific, certain to occur, and capable of implementation; they must be subject to deadlines or otherwise-enforceable obligations; and most important, they must address the threats to the species in a way that satisfies the jeopardy and adverse modification standards” [41].

Further, an agency must demonstrate a “clear, definite commitment of resources” to show it is bound to specific future improvements [42]. Those adaptive management plans that have survived judicial review contain enforceable, non-discretionary, and specific requirements [30]. Successful adaptive management based species recovery plans must contain more than “mere process,” even if elaborate; plans that describe particular thresholds that trigger *consideration* of changing the management protocol have been struck down while plans that contain explicit, substantive thresholds that trigger definite and enforceable actions, such as re-initiation of the consultation process, have been upheld [30,39,41]. A BiOp should set the boundaries of permissible agency action, and adaptive management based management decisions enjoy flexibility as long as they do not cross the substantively defined threshold of jeopardizing species. If the jeopardy line is crossed, then agencies must be *bound* to act.

By incorporating adaptive management controls and operations from the BiOp’s mitigation measures into the Incidental Take Statement⁵ (ITS), one successful (judicially speaking) adaptive management plan made these measures explicitly non-discretionary and subject to civil and criminal enforcement [41]. The Eastern District of California, the trial court hearing litigation over the contentious San Francisco Bay

⁵ See note 1, *supra*.

Delta, has been described as providing “the most thorough judicial discussion to date of adaptive management’s strengths and weaknesses,” and in that court at least, inclusion of adaptive management mitigation measures in the ITS has proven key to establish the substantive specificity, certainty, and enforceability required [39]. Specifically, the adaptive management aspects of a BiOp concerning protected salmonids were upheld in *Pacific Coast Federation of Fishermen’s Associations v. Gutierrez* in 2008 because standards (“action-mitigation measures”) were defined as triggers for adaptive management. “Action-mitigation” thresholds concerning the placement of temperature compliance points,⁶ reservoir carryover storage (for use as a cold water resource), and major diversion operations were detailed in the BiOp and found to be definite and sufficiently certain to be enforceable steps to minimize the impacts on migrating salmonids. Because each action-mitigation measure constituted a finite standard and was included in the terms and conditions of the BiOp and ITS, they were non-discretionary and enforceable under criminal and civil law. The court distinguished this plan’s use of setting a standard, for example temperature of 56 degrees at a particular point, and utilizing adaptive management only when that standard cannot be achieved (e.g., extreme years) from other plans that failed to meet the reasonable certainty standard [30].

For example, in a related case the same trial court rejected an adaptive management plan that lacked “finite standards... enforceable through the ITS” [41]. Instead of substantive requirements, this plan was process-focused, requiring that a working group convene anytime certain environmental triggers were met. Without “quantified objectives or required mitigation measures,” the adaptive management *process* failed to satisfy the reasonable certainty standard. Essentially, the plan only guaranteed that recommendations would be made and that meetings would be held, but there was no guarantee that any action would be taken. The court held that the ESA does not permit this much agency discretion.

Likewise, the U.S. District Court for the District of Maryland, also a trial court, acknowledged that adaptive management may “ultimately be the best way to reduce the risk of death and injury” to listed species, but rejected an adaptive management plan because it did not *require* implementation of any “minimization or mitigation techniques,” requiring only consultation regarding the “potential for adaptive management” without defining explicit triggers for initiating adaptive management measures [43].

⁶ “Project operations affect salmon which travel from their spawning grounds to and from the ocean. The BiOp contains the following reasonable and prudent measure: ‘Reclamation shall manage the cold water supply within Shasta Reservoir and make cold water releases from Shasta Reservoir to provide suitable habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley Steelhead in the Sacramento River between Keswick Dam and Bend Bridge.’... The Supreme Court has defined the word “shall” used in a BiOp to generally indicate a command that admits of no discretion on the part of the person instructed to carry out the directive. [citation omitted] The following temperature control obligation is non-discretionary in the BiOp: ‘Reclamation shall target daily average water temperatures in the Sacramento River between Keswick Dam and Bend Bridge as follows: I. Not in excess of 56°F at compliance locations between Balls Ferry and Bend Bridge from April 15 through September 30 and not in excess of 60°F at the same compliance locations between Balls Ferry and Bend Bridge from October 1 through October 31, provided operations and temperature forecast demonstrate the capability to achieve and sustain compliance’” [30].

“Guidelines, monitoring, and promises, or good intentions for future actions...are not adequate regulatory mechanisms when there is no way to enforce them or to ensure they will occur” [44].

In the context of climate change, adaptive management plays an especially important role in plans of long duration. “The varying degrees of uncertainty characterizing the explanation and prediction of natural phenomena highlight the importance of continually evaluating models and theories in light of new evidence” [45]. Ruhl and Fischman assert that Southern District of California nearly “required adaptive management in holding that ESA habitat conservation plans must contain some provision to respond to unforeseen circumstances” in a case involving a plan that failed to evaluate impacts at particular sites, leaving those sites to be evaluated in future permit procedures [39,46]. At the same time, the service issued assurances of “no surprises” that virtually insulated the developer from additional mitigation measures should negative impacts be discovered in the future. The court asserted that a proper Habitat Conservation Plan (HCP)⁷ should “include constant monitoring *and revision* based on that data” and provide for unforeseen consequences [46]. The decision insisted on including a learning infrastructure into mitigation protocols for long-term HCPs, including specific monitoring procedures and methods for project revision based on site-specific experience.

3.2. *Applying Adaptive Management*

Doremus points out several challenges of applying adaptive management principles in the current administrative state stemming from the conflicting requirements of adaptive management where flexibility is key, but legal and political institutions rely on certainty [26]. As an iterative process, adaptive management decisions are necessarily tentative, subject to change should new information point to a better approach [4]. Yet, as Shapiro and Glicksman describe, federal environmental law is almost entirely front-end, with final decisions made and long-term permits granted before any action takes place [38]. If the initial assessment was based on inconclusive, incomplete or inaccurate science, the mechanisms for reversal or adjustment are riddled with challenges [26]. Even worse, there may be no method of reversal in cases such as logging and construction, where once the action is taken the damage is done.

Many agencies already use adaptive management, and there are several options for getting the rest on board: an executive order,⁸ a statutory amendment defining BAS in adaptive management terms, a rulemaking process within the Services,⁹ and judicial decree that finds adaptive management is the BAS.

⁷ See note 1, *supra*.

⁸ For example, Executive Order 13508 directs the U.S. Environmental Protection Agency to base pollution-control strategies and actions for the Chesapeake Bay watershed “on sound science” that “reflect adaptive management principles” and also directs the Departments of Interior and Commerce to use “adaptive management to plan, monitor, evaluate, and adjust environmental management actions” in the same watershed (74 Fed. Reg. 23099, 23101 & 23103 (May 15, 2009)).

⁹ The Services collaboratively developed a HCP Handbook which describes adaptive management use in management decisions in which they explicitly reject the “scientific” definition of adaptive management and opt for this definition instead: a method for examining alternative strategies for meeting measurable biological goals and objectives, and then, if necessary, adjusting future conservation management actions according to what is learned. The Services are incorporating a broad

Doremus argues the BAS mandate could be administratively interpreted to induce greater information gathering [22]. For example, the Services could issue a regulation defining BAS. In that case, learning must be systematically rewarded to overcome the inertia of tradition and temptation to hide behind adaptive management as an excuse for not deciding, and these incentives could be established by the executive or legislative branch [48]. In addition, legislatures must appropriate greater resources to sustain a learning infrastructure. As described above, the judiciary plays an important role in holding agencies accountable to a learning process. With BAS defined, judicial scrutiny will play an even larger role because courts will have a discernible standard against which to review an agency's supposed adaptive management approach. To address accountability concerns, the high levels of judicial deference afforded to agencies (discussed *supra*) would be curbed in the adaptive management context to ensure that agencies apply a learning infrastructure and not abuse adaptive management as a stalling device for making decisions [48]. Without giving adaptive management firm legal standing, courts will not force structured learning on agencies, as that would violate the extreme deference granted to expert agencies, especially when evaluating an agency's use of science [49–51].

Additionally, Congress could fix problems with a/m-lite by requiring agencies to set clear goals for adaptive management plans, establish a means of learning through experimentation, and describe exactly how experimentation will be measured for success [39]. Likewise, funding must be committed beyond the typical appropriation of resources for initial studies and planning but no funding for follow-up monitoring and subsequent adjustment of operations.

4. Conclusions

Agencies are not required to gather data or improve existing data before making management decisions that may jeopardize protected species, but they should, especially in circumstances facing sufficient uncertainty in the impact of the decision [31]. To date, the BAS mandate serves front-end agency actions, such as the decision to list a species and pre-decisional assessment of impact [15]. By defining BAS to include adaptive management processes, agencies would then be required to employ a learning infrastructure that inherently entails collection of large amounts of monitoring data. Further, under the BAS rules, they will have to *consider* this monitoring data, preferably in such way that it feeds back into subsequent decisions. Thus, an agency would be using BAS in the beginning and throughout its management protocol. While limited judicial review does not require an agency to accept scientific

perspective of adaptive management, with the key components that make an adaptive process in HCPs meaningful. These components include careful planning through identification of uncertainty, incorporating a range of alternatives, implementing a sufficient monitoring program to determine success of the alternatives, and a feedback loop from the results of the monitoring program that allows for change in the management strategies.

They then assure that this approach to adaptive management is consistent with the “no surprises” policy, whereby landowners are relieved of any future ESA liability as long as the HCP is followed, because these elements are provided up front. Thus, the Services continue to take a front-end approach while calling it adaptive management [47].

evidence in the decision-making process, the agency would have to provide a rational basis for rejecting their own data, which may prove politically difficult.

An adaptive management framework can be an effective tool for biodiversity conservation, but it must operate under the constraints of ESA in the United States. The legal criticisms of adaptive management have centered on agencies using the term adaptive management as a means to allow for informal management or to shirk management responsibility altogether. In order for the courts to allow adaptive management plans to proceed under the current legal framework, the iterative aspects of adaptive management would have to be linked to specific thresholds at which adaptation would be warranted in the process. For example, researchers in Africa identified thresholds in a national park system and focused monitoring on those critical slow variables (*i.e.*, thresholds) [50]. If monitoring data indicate a threshold is being approached, a management response is triggered (e.g., direct action, more research). Specifically, if elephant density reaches a level that cannot be sustained by the park due to landscape constraints (e.g., vegetation), actions to reduce the population (e.g., culling, relocation) must be taken [52]. If an adaptive management plan were linked to specific thresholds as in this example, it should pass legal review by American courts.

On the ground, resource managers have made many attempts to implement adaptive management with varying degrees of success both environmentally and when challenged in court. Some plans have withstood judicial review while others have been remanded to square one. Outside of a courtroom, adaptive management experts have characterized much of adaptive management practice as falling short of its core principles. But let us not allow the ideal to be the enemy of the good. With a few substantive tweaks, agency actions may withstand judicial scrutiny, fulfill legislative and regulatory mandates, and proceed iteratively to a management regime that better protects biodiversity in a changing climate.

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