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A proposal for amending administrative law to facilitate adaptive management

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Abstract

In this article we examine how federal agencies use adaptive management. In order for federal agencies to implement adaptive management more successfully, administrative law must adapt to adaptive management, and we propose changes in administrative law that will help to steer the current process out of a dead end. Adaptive management is a form of structured decision making that is widely used in natural resources management. It involves specific steps integrated in an iterative process for adjusting management actions as new information becomes available. Theoretical requirements for adaptive management notwithstanding, federal agency decision making is subject to the requirements of the federal Administrative Procedure Act, and state agencies are subject to the states' parallel statutes. We argue that conventional administrative law has unnecessarily shackled effective use of adaptive management. We show that through a specialized 'adaptive management track' of administrative procedures, the core values of administrative law—especially public participation, judicial review, and finality—can be implemented in ways that allow for more effective adaptive management. We present and explain draft model legislation (the Model Adaptive Management Procedure Act) that would create such a track for the specific types of agency decision making that could benefit from adaptive management.

1. Introduction

In this article we examine how federal agencies implement adaptive management. We propose changes in administrative law that will help to steer the current process out of a dead end.

Decision making by federal agencies has become circumscribed by a process based largely on comprehensive rational planning and prescriptive regulation (Ruhl and Fischman 2010). The current decision making process relies heavily on 'front-end' analytical tools comprehensively conducted and concluded before a final decision is made. In this approach, agency flexibility is hampered by extremely detailed impact assessments, sometimes intense public participation during decision making, and post-decision

hard look judicial review (Glicksman and Shapiro 2004). The combined effects of this process, codified in large part through the federal Administrative Procedure Act (5 U.S.C. §§ 551–559, 701–706, 2012) and its state analogues for state agencies, have been to encourage agencies to load all potential implications of their actions into single, broadly comprehensive decisions. Particularly in rulemaking and large infrastructure funding and approval decisions, the drive toward comprehensiveness on the 'front end' strongly encourages agencies to steamroll their decisions through public-comment scrutiny and judicial-review litigation and then never look back (Ruhl 2005). In such an environment, reopening a completed decision that has been judicially approved is anathema to any sane agency. This front-end mode of

decision making has been subjected to scathing criticisms that it ossifies agency practices, politicizes agency decisions, and hamstring flexibility (e.g. Rubin 2004, Jordan 2000, Seidenfeld 1997, McGarity 1992).

Adaptive management offers a much different alternative to the conventional front-end model of decision making. In adaptive management, multiple decisions are made, and the timing of those decisions is spread out into a repetitive process that makes differentiating between the 'front end' and the 'back end' of decision making much less relevant (Susskind *et al* 2012). Rather than make one grand decision and move on, agencies implementing adaptive management engage in structured decision making that follows an iterative multi-step process.

Adaptive management is often prescribed in policy as an ideal, but it has mainly been used opportunistically, where the usual front-end decision making has failed or needs help. Putting adaptive management broadly into practice has proven far more difficult than initially expected (e.g. Allen *et al* 2011, Allen and Gunderson 2011, Walters 2007, Doremus 2001). One problem has been translating the theory into the legal context of agency practice. Politicians may tell agencies to practice adaptive management, but if they do not simultaneously change the requirements of administrative law, there is little legal ability for agencies to engage in true adaptive management. In addition, agencies working in good faith on adaptive management may be suspected by the public of exercising unbounded agency discretion (Schultz and Nie 2012, Doremus *et al* 2011, Benson and Garmestani 2011) and judged based on the normal administrative law standards by courts unaccustomed to the 'dial twiddling' of adaptive management's decision making process (Ruhl and Fischman 2010). The double bind that agencies find themselves in is that they must implement adaptive management to keep in step with dominant management decision theory, but they face both a skeptical audience in the public and judicial forums and standard administrative law requirements that actively or effectively impede true adaptive management.

As a result, agencies attempting to pursue adaptive management have practiced instead what has been called 'a/m lite,' a watered-down form of adaptive management used to play it safe (Fischman and Ruhl 2015, Ruhl and Fischman 2010). 'A/m lite,' as described by Ruhl and Fischman (2010), almost always fails either to develop stable models as the basis for alternative management actions or to follow the structured process necessary for learning (Doremus 2007). A/m lite may also degenerate into 'basic trial and error learning in which explicit hypotheses are absent or vague,' or there may be no monitoring of outcomes or meaningful adjustments to management measures (Gregory *et al* 2006). At worst, a/m lite may be a pretext for postponing difficult decisions so that

constraints of budgets, politics, or scientific uncertainty can be avoided (Gregory *et al* 2006). The difference between adaptive management practiced as a/m lite and the adaptive management concept widely acknowledged as essential for managing the uncertainties of natural systems does not reflect disagreement about the process of adaptive management itself, but rather the budgetary, legal, and political limitations of the agencies implementing it (Ruhl and Fischman 2010, Gregory *et al* 2006).

It is legitimate to ask whether implementing a form of adaptive management consistent with its full theoretic model is actually possible for regulatory agencies, i.e. whether it can stand up to the administrative state's demands for comprehensive pre-decision impact assessments, pervasive public participation, and routine access to judicial review (e.g. Allen *et al* 2011, Angelo 2009, Karkkainen 2005). The reality may be that either administrative law is left untouched, in which case a/m lite is about as far as adaptive management by agencies will progress, or legislatures can design an alternative set of administrative procedures that allow agencies to practice a full and integrated form of adaptive management.

Although adaptive management is not appropriate in all administrative contexts (Craig and Ruhl 2014), it is difficult to imagine effective regulation in the future without agencies making use of full and integrated adaptive management. Natural resources and the environment are dynamic and unpredictable. Moreover, drivers such as climate change will further up-end regulatory contexts. In our opinion, it is not a question of whether regulation should be adaptive, but rather where and how to make it so. Therefore, we ask what kind of an alternative administrative law process could facilitate 'full' adaptive management.

The ideas presented here and in Craig and Ruhl (2014) represent the first comprehensive efforts in adaptive management theory to go beyond complaints about administrative law and suggest a solution. Beginning in the early 2000s, theorists (including two of us) began proposing the idea of a special procedural 'track' for adaptive management (e.g. Craig 2010, Karkkainen 2005, Ruhl 2002), but the devil is in the details. Writing primarily for legal scholars and practitioners, Craig and Ruhl (2014) proposed a detailed model statute to implement such a track for federal and state administrative law. In this paper, we outline those details in a frame directed primarily at non-lawyer scientists, theorists and practitioners of adaptive management, in the hope that doing so will promote a dialogue between legal and scientific communities to advance the implementation of adaptive management in public and private institutions. We review adaptive management and the conditions that warrant its 'full' practice, examine the core values of conventional administrative law and the obstacles they pose for agency implementation of full adaptive management, and then work through the

provisions of a new administrative law track for adaptive management that balances those values with the values and practical needs of adaptive management. The appendix contains the next iteration of the Model Adaptive Management Procedure Act (MAMPA) proposed by Craig and Ruhl (2012 2014).

2. When is the use of adaptive management warranted?

Many—and perhaps most—agency decisions and management responsibilities do not require adaptive management, which is why we propose to think of administrative process in terms of a ‘track’ for adaptive management rather than reforming administrative law for all federal and state agencies in all contexts. However, in order to formulate procedural rules governing adaptive management, as well as the criteria for determining when the proposed new track for adaptive management is warranted, we first draw on the work of adaptive management theorists to clarify the substantive contexts in which adaptive management is appropriate.

It is useful to consider adaptive management in the general context of natural resources management over time. Resources management generally consists of decision making, the implementation of decisions through management actions, and the tracking of their consequences, followed by more decision making. What makes such a process ‘adaptive’ is the explicit recognition of uncertainty and the use of management itself to reduce uncertainty and thereby improve management. That is, adaptive management is about ongoing resource *management* on the one hand, and learning-based *adaptation* on the other. The first element, management, deals with interventions over time through a process that typically is influenced by stakeholders, guided by management objectives, and constrained by feasible management alternatives. The second element, adaptation, involves changes in management strategy based on accrued learning about the resource system and the influence of management on it. The iterative application of these functions, in which management leads to learning and learning informs adaptation, is definitive of adaptive management.

Many view adaptive management as primarily focused on the process of decision making, and in particular the engagement of stakeholders and the public in decisions. From this perspective, the issues are how to identify stakeholders and how to provide a framework and opportunity for their meaningful engagement in the decision process. Others see adaptive management in terms of monitoring and data collection, where the issues are how to track management actions and their resource consequences. Still others see it as evaluation and learning, leading to an improved understanding of the linkages between

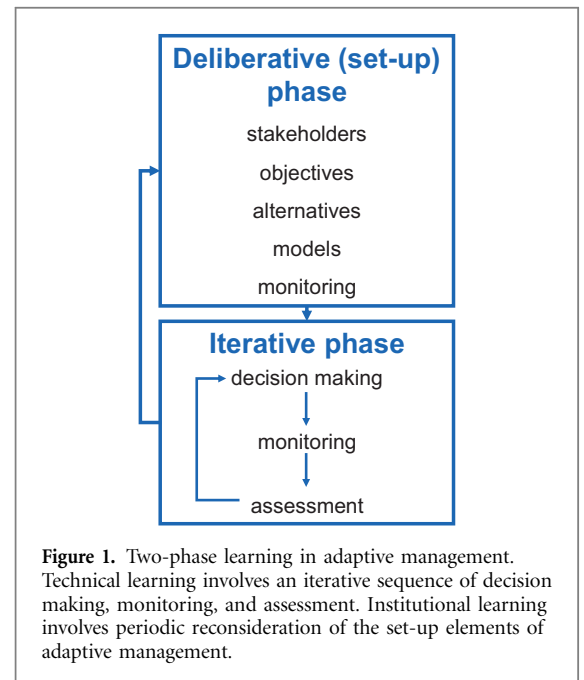


Figure 1. Two-phase learning in adaptive management. Technical learning involves an iterative sequence of decision making, monitoring, and assessment. Institutional learning involves periodic reconsideration of the set-up elements of adaptive management.

management actions and resource dynamics. In fact, adaptive management encompasses all these things and cannot be properly understood in the absence of any of them.

2.1. Theoretical basis of adaptive management

Here we take a decision analytic approach to adaptive decision making, which promulgates a formal structured decision making process (McFadden *et al* 2011) that includes stakeholder involvement, management objectives, management actions, models, and monitoring plans, and the incorporation of these elements into decision making and evaluation (Williams 2011, Williams and Brown 2012). It is the integration of an objective-driven and learning-based structure into the decision-making process that differentiates adaptive management from mere trial and error and contingency planning (Karkkainen 2005, Williams 2011).

2.1.1. Framework of Adaptive Management

The process of decision making and adaptation that is adaptive management can be formally articulated in terms of a two-stage process, consisting of a deliberative or set-up phase, in which the ‘architecture’ of decision making is identified, and an iterative phase, in which its components fold into decision making, monitoring, and adaptation (figure 1 [adapted from Williams and Brown 2016]). The building blocks of adaptive management include stakeholder involvement, management objectives, management alternatives, models that project the consequences of management, and monitoring protocols. These elements are in turn folded into a process of decision making, the monitoring of post-decision responses, and adaptation based on what is learned about the managed resource. The structured and iterative sequencing of management and evaluation provides

an opportunity for simultaneously learning about resources while managing them.

Each of the elements of the deliberative phase in figure 1 is critical in adaptive management. The role of stakeholders is widely recognized as important to all aspects of adaptive decision making, so much so that the failure to engage stakeholders meaningfully is a common stumbling block that can impede and ultimately undermine resource management. Project objectives serve as guides for decision making and benchmarks for performance. Management alternatives provide feasible options for managers to consider in their decision making. Predictive models are used to project the responses of resources to fluctuating environmental conditions and management actions. Monitoring protocols play a critical role in guiding the collection of field data for use in evaluation and learning. The identification of objectives, models, and monitoring protocols often are thought to be the purview of scientists and technicians, with input by managers. On the other hand, stakeholder engagement and the identification of feasible alternatives are usually seen as the purview of managers, often with input from scientists (Nichols and Williams 2012).

Once identified and agreed upon, the 'architectural elements' mentioned above are folded into an iterative phase of adaptive management, in which decision making is followed by post-decision monitoring, the evaluation of monitoring data, and management adaptations based on what is learned (figure 1). In this sequence, decision making can be seen to influence learning, and learning can be seen to influence management. This is the gist of adaptive decision making.

2.1.2. Technical and institutional learning

The learning that is a hallmark of adaptive management can be technical, in which understanding about a natural resource system and how it responds to management interventions is produced through management interventions themselves. But adaptive decision making can also involve learning about the decision making process itself. A typical situation involves multiple iterations of the technical learning cycle shown in figure 1, during which the institutional framework remains more or less unchanged, followed by revisiting and potentially restructuring some of the institutional elements (Williams and Brown 2014). Together the two forms of learning constitute 'double-loop learning' (Agyris and Shon 1978).

Pahl-Wostl (2009) expanded the model of double-loop learning to include a third learning form, by distinguishing socio-political and governance aspects of stakeholder involvement as yet another cycle. Each learning mode corresponds to a distinct question, i.e. 'Are we doing things right?' (technical learning loop); 'are we doing the right things?' (process learning loop); and 'who has the rights?' (socio-political and governance loop) (Johnson *et al* 2014). Learning

about institutional arrangements and societal structures and processes requires the development of social capacity and a willingness to participate actively in the learning process. Critical components are an expanded role for stakeholders and a more open decision process where learning capacity is valued.

Though adaptive learning initially focused on improving technical understanding (Walters 1986), in more recent applications institutional learning is frequently emphasized (Williams and Brown 2016). The need to revisit and adjust the set-up elements of adaptive management often becomes more pressing as management proceeds over time. For example, stakeholder perspectives and values can shift as management progresses, particularly as previously unanticipated patterns in resource dynamics are exposed and changes in social and cultural values and norms occur. These changes can lead to adjustment of objectives, alternatives, and other set-up elements. In some extreme instances, for example, changes in stakeholder, societal, and political values may result in a re-valuation of the adaptive management approach itself, perhaps requiring the implementing agency to abandon adaptive management entirely.

An expanded learning framework that includes both technical and institutional learning presents substantial challenges in the implementation of adaptive management. One such challenge involves the identification of criteria for when to break out of the technical learning cycle and revisit the decision process elements. If the re-visitation is too frequent, the effects of change at the technical and institutional levels become confounded, significantly slowing the rate of learning for both. If it is too infrequent, there is a risk of the loss of commitment of stakeholders as values change, alternatives are marginalized, models cease to perform effectively in predicting system dynamics, objectives lose their relevance, or other changes arise (Williams and Brown 2016). The frequency and method for addressing changes of the decision architecture is a rarely addressed but important challenge in applications of adaptive management.

2.2. Practical aspects of adaptive management

Core assumptions about necessary conditions for successful implementation of adaptive management (e.g. Doremus *et al* 2011, Benson 2010) fall into two general categories, involving: (1) the attributes of the management-problem context; and (2) the practical, political, and normative constraints operating in the decision-making environment.

2.2.1. Characteristics of management issues

Suppose a series of dams is impeding fish passage, leading several species to become endangered. Can adaptive management help? Adaptive management can be successful only when applied to certain kinds of

management issues, those with the right constellation of uncertainty, controllability, and risk characteristics (Allen and Gunderson 2011)—to which some theorists add a fourth characteristic, a dynamic system (Williams 2011). Uncertainty refers to the decision maker's level of understanding and information regarding the attributes and behavior of the system being managed and its response to the environment and management interventions, as well as the regulatory context (Allen and Gunderson 2011, Williams 2011). As uncertainty increases, front-end decision making, with its 'all in' bet on the agency's big decision, becomes less and less effective for management purposes. With regard to fish passage, for example, there might be uncertainty regarding both the type of spillway to construct to aid fish passage and the proper timing of spill for optimal fish survival. Building a new spillway, like many infrastructure decisions, is probably *not* amenable to adaptive management because of the time and expense involved: an agency cannot change this aspect of the dam every year to allow proper experimentation. In contrast, the amount and timing of spill probably can be adjusted from season to season and year to year and hence *could* be the subjects of experimentation and adaptive management.

Controllability turns on the degree to which the decision maker can manipulate the regulatory environment (Allen and Gunderson 2011). With higher controllability, decision makers are more able to intervene in the management-problem context and thus can engage explicitly in learning-based management. In our dam example, structural modification of the dam may not be within the agency's control but rather may require congressional authorization. In contrast, yearly plans for spill probably *are* within the agency's control and discretion (albeit probably subject to some environmental assessment requirements), and hence again, experimentation with the amount and timing of spill could support adaptive management.

Risk describes the chance that experimentation and other interventions in management can lead to irreversible adverse consequences (Allen and Gunderson 2011). Suppose certain species of fish are so endangered that experiments with dam spill run the risk of rendering them extinct. For those species, experimentation and adaptive management might be too risky to attempt. In contrast, experiments with dam spill with species that are only threatened or at risk of becoming threatened might pose less risk—and might also provide experimental data that could also eventually aid the endangered fish.

System dynamism hinges on the stability of the management-problem context over time, both inherently and in response to management interventions (Williams 2011). If a regulatory problem is dynamic, the fundamental question is whether our understanding of its processes is sufficient (uncertainty) to manage them

(controllability) without serious negative outcomes (risk). Thus, adaptive management is called for when a management issue presents a dynamic system for which uncertainty and controllability are high and risk is low (Allen and Gunderson 2011, Williams 2011, Williams *et al* 2009). In our dam spill scenario, for example, extreme drought and climate change might alter system dynamics so much that controllability becomes unacceptably low (not enough water with which to experiment) and risk unacceptably high (all species are facing extinction).

2.2.2. Decision context

Adaptive management is a useful approach to many, though certainly not all, renewable natural resources problems (Williams *et al* 2009). However, it is often a long-term management commitment that requires certain kinds of institutional support and context in order to be successful. Elements that characterize most applications include iterative decision making, resource responsiveness to management, and uncertainty about the consequences on resource status of management. Because adaptive management entails upfront and ongoing costs and effort, it is important at the outset of a project to assess whether it should be addressed through adaptive decision making. At a minimum, one should look for five conditions that typically are in place for the successful application of adaptive management (Williams and Brown 2012).

First and foremost is the necessity to manage the resource system, notwithstanding the uncertainty about the effects of management. That is, there is an imperative to make management decisions (which in some cases may include making no decision), even though one cannot be certain about the consequences. In our dam hypothetical, imperiled species often create management imperatives under both state and federal law, but so might water rights, flood control requirements, or hydropower needs.

A second requirement is the articulation of management objectives by which to guide and evaluate management actions. Objectives incorporate values that are associated with the resources being managed and often are represented as accumulations of those values over time. In the absence of objectives and the metrics used for their evaluation, it is not possible to determine the most appropriate actions to take at each point in time, or to ascertain whether the actions actually have the intended effect. The lack of prioritized management objectives has been a severe impediment to proper adaptive management in many river systems in the United States, including for example the Klamath River and the Missouri River, often effectively requiring the federal Endangered Species Act to play that prioritizing role (Adler *et al* 2013).

Third, it must be possible to apply what is learned through time to future decision making, which entails both a range of management options from which to select a particular action, as well as adequate flexibility

in the management environment to allow for changes in management as understanding accumulates. It is the prospect of adjustments in management strategy as learning accrues that makes management 'adaptive.' On the other hand, adaptive management is not warranted if the cost of obtaining information to improve understanding exceeds the increase in value from potential management improvements. Again, this is the difference between structurally changing a spillway (expensive, not flexible) and experimenting with dam spill amount and timing (flexible range of options).

Fourth, monitoring programs should be in place, or possible to put in place, that focus on and facilitate the reduction of uncertainty. It is through the analysis and assessment of monitoring data that learning can occur and management strategy can be adapted based on what's learned. Without periodic monitoring of informative resource attributes, it is not possible to improve understanding and adjust strategy, i.e. to conduct adaptive management. With respect to dam spill, for example, fish survival rates at each dam and through the entire series are likely to be important monitoring criteria—but so will dissolved gas concentrations and temperature.

Fifth, for an adaptive management project to succeed it is important to sustain the commitment of stakeholders over the time frame of the project. Stakeholders need to be engaged at some level throughout the project, from the identification of objectives and management alternatives, to the collection of monitoring data, to the assessment and interpretation of results in the process of strategy adaptation. Stakeholders often bring different social, cultural, economic, and biological perspectives that can result in conflict and stalemate. However, a good-faith engagement throughout an adaptive management project can help to reconcile different perspectives, and facilitate the compromise and collaboration that is almost always required in complex decision making. If our dam spill experiment is taking place in the Columbia River, for example, the relevant state agencies, the relevant federal agencies, the Tribes with treaty-based fishing rights, the commercial fishers, the recreational fishers, and local and national environmental non-government organizations will all be important stakeholders whose input and cooperation will be highly desirable.

Unfortunately, practical suitability for adaptive management is no guarantee of political suitability. Adaptive management is a resource-intensive method that relies on continuous agency monitoring, learning, and assessment (e.g. Moore *et al* 2011), unlike front-end decision making, where most of the decision making costs are front loaded. Because adaptive management requires the consistent financial support of legislative funding and agency allocation of funds over extended time frames, legislative and agency-level leaders—i.e. policy-

makers—must agree that learning about the regulatory problem justifies the costs (Biber 2013, Camacho 2009). In addition, political support for adaptive management must be ongoing beyond the initial authorization—the legislature cannot micromanage agencies' adaptive decisions and expect agencies to break out of the a/m lite mold (Doremus *et al* 2011). Of course, the agency itself also must support a culture of adaptive management (Allen and Gunderson 2011, Moore *et al* 2011, Williams 2011). The possibility always exists that even with a robust protocol and implementation, some decisions will be lead to adverse outcomes. If 'heads roll' when that happens, agency personnel will have little motivation to move beyond a/m lite. Finally, the relevant political actors must understand and accept the management consequences of the temporal and spatial scale of the adaptive management project being undertaken. For example, the nutrient reduction goals for the Chesapeake Bay watershed depend on the cumulative impacts of a variety of projects occurring throughout the five-state watershed, with results not expected to be measurable for several decades. Chesapeake Bay restoration thus represents a different scale of political commitment than salmon restoration, which can often be keyed to the three-year life cycles of many important and threatened species.

Overall, the ideal policy medium for adaptive management includes the following:

- The management-problem context changes dynamically over time in response to environmental conditions as well as management interventions. This applies to natural resources like biological populations or hydrological systems, but not to built infrastructure like dams that can only be constructed (or removed) once.
- Decision makers have incomplete knowledge of the management-problem context's dynamic processes (uncertainty is high) but can manipulate various features of the problem context through interventions (controllability is high) without causing substantial damage (risk is low). An example is grazing lands management, in which the timing and intensity of grazing can be precisely controlled but responses are subject to considerable uncertainty because of the system's complexity.
- The management-problem context allows for iterative decision making. Classic examples involve annual regulation of the sport hunting of migratory species, or seasonal interventions like water releases in response to spring and fall rainfall patterns.
- Decision makers have clear management objectives and the methodological capacity to use experimentation, monitoring, and assessment to

learn about the system and adjust management decisions in policy-relevant timeframes. Examples might include targets for biological population numbers, as in endangered or invasive species management, or the management and monitoring of biological diversity in an ecosystem.

- Decision makers have both sufficient funding and staffing and the political and stakeholder support needed to implement the full adaptive management decision process, at whatever temporal and spatial scale is relevant, nor will implementing adaptive management offend inviolable norms associated with the management-problem context.

An important aspect of this framework concerns the potential to produce greater benefit when learning-based management is implemented. In particular, a motivation for adaptive management is the anticipation that strategy adjustments based on what is learned through management practice can add value (Williams and Brown 2014, 2016). Adaptive management has the potential to produce greater benefit by means of a more informed strategy, and hence a key consideration is the amount of additional value that can be expected with the elimination of some or all of the uncertainty facing a decision maker. For example, finding the optimal dam spill for various species of fish might be valueless if the amounts of spilled water required cannot be maintained over time, either because of reduced flow rates in the river or because of other legal demands for that water (or possibly both). Metrics for improvement involve the ‘value of information,’ which compares the value of management in the absence of uncertainty against management value in the presence of uncertainty. It is noteworthy that the value in the presence of uncertainty coincides with adaptive management, in other words with decision making under uncertainty that accounts for both immediate benefits and the learning needed to enhance long-term benefits (Williams and Johnson 2013).

The difference between optimal valuations with and without uncertainty, known as the ‘expected value of perfect information’ (Raiffa and Schlaifer 1961), represents the improvement in value that can be expected by eliminating uncertainty (Williams and Johnson 2015a), on the assumption that one manages optimally in its presence. The magnitude of improvement depends on the type and amount of uncertainty, as well as the range of strategy options (Williams *et al* 2011, Williams and Johnson 2015a). Analogous metrics have been developed for the partial elimination of uncertainty for one or a few uncertainty sources but not all (the expected value of partial perfect information), and the reduction of uncertainty with the collection of additional information (the expected value of sample information) (Yokota and Thompson 2004, Williams and Johnson 2015b).

If we keep in mind considerations about the value of information and other conditions for applicability, it is clear that adaptive management is not suitable for all, or even most, administrative agency decision making. Nevertheless, there is a subset of contexts where full adaptive management clearly can be advantageous compared to front-end decision making. The contexts in which adaptive management may well be applicable and useful are those in which: management occurs periodically over time so that learning is possible, there is substantial uncertainty about resource behaviors and the influence of management on them, uncertainty limits management effectiveness but decisions nevertheless must be made, and learning can be used to influence decision making as it accumulates. In the following sections we examine how current administrative law hinders adaptive management and consider how to design new administrative law principles to facilitate adaptive management in those contexts.

3. Adaptive management and key values of administrative law

How does administrative law hinder adaptive management, and how can we design new administrative law principles to expedite use of adaptive management in appropriate contexts? By means of procedural requirements, administrative law seeks to protect values such as due process and public participation. Because the resulting body of law creates barriers to agency use of adaptive management, however, both federal and state legislators must recognize these barriers and adjust administrative law if it is to accommodate adaptive management (e.g. Camacho 2011, Garmestani *et al* 2009, Light 2006, Karkkainen 2005, Davidson and Geu 2001). In this section we review the chief aspects of administrative law (both state and federal) that hamstringing an agency’s ability to implement full adaptive management even in otherwise appropriate contexts. These three aspects are: public participation in agency decision making; judicial oversight over most agency decisions and processes; and the requirements that impel agencies toward finality.

3.1. Public participation

Public participation is one of the crucial values embodied in contemporary administrative law. For example, under the federal Administrative Procedure Act (5 U.S.C. §§ 551–559, 2012) federal agencies are required: (1) in informal rulemaking to give both the general public ‘notice of proposed rulemaking[s]’ and any ‘interested persons an opportunity to participate in the rulemaking’ (5 U.S.C. § 553(b), (c)); (2) in adjudications to ‘give all interested parties opportunity for’ various forms of participation (5 U.S.C. § 554(c)); (3) in the context of any agency proceeding to give

'prompt notice' to interested persons 'of the denial in whole or part of a written application, petition, or other request' (5 U.S.C. § 555(e)); and (4) in receiving a petition for agency action, which can be made by any interested person, to respond to that petition (5 U.S.C. §§ 553(e), 555(b)).

Adaptive management threatens, or at least is seen to threaten, the promotion of public participation in traditional administrative law. A basic tension exists between ongoing public deliberation over an agency's action and the agency's commitment to an integrated application of adaptive management over time. Inescapably, the trade-off is that 'the black-letter law. . . constrains how far agencies can go with a/m lite, as truly iterative 'learning while doing' may at some point run afoul of. . . the demands of public notice and comment' (Ruhl and Fischman 2010).

Nevertheless, it is possible to align public participation requirements with the structured decision making process of adaptive management, thus achieving a balance between public participation and effective adaptive management. For example, adaptive management already encourages stakeholder participation in the set-up phase, and return to this set-up phase constitutes the institutional learning part of adaptive management most conducive to public participation. Structurally, moreover, this phase lends itself well to traditional modes of public participation in agency decision making, especially informal rule-making.

In contrast, the iterative phase of adaptive management, where an agency is engaging in technical learning, is not as conducive to direct public participation because the agency is testing the effects of management actions according to a pre-determined plan. Nevertheless, the law can easily accommodate agency transparency concerns by requiring regular public reports on implementation of 'dial twiddling' and monitoring results. In addition, the iterative structure of adaptive management—if coupled with legal provisions that require agencies periodically to return to the set-up phase (as we propose below in section 4.2)—provides parallel iterative opportunities for public participation.

3.2. Judicial review

Judicial review, in which courts evaluate agency decisions using standards set out in the Administrative Procedure Act (or state equivalents) and other relevant statutory criteria, is one of the hallmarks of contemporary administrative law in the United States (Hammond and Markell 2013, Stewart 2003). Judicial review furthers several important values in administrative law, especially by ensuring that agencies comply with congressional dictates and hence allowing oversight of exercises of agency discretion (e.g. Leonetti 2012, Wagner 2012, Biber 2008, Glicksman 2005). Judicial review is also praised because it prevents agencies from being 'captured' by regulated

entities contrary to the broader public interest (Wagner 2012, Sunstein 1985) and promotes reasoned and reasonable agency decision making (e.g. Hammond and Markell 2013, Wagner 2012, Krotoszynski 2006, Croley 1999, French 1993). Finally, judicial review provides another route for enhancing transparency in agency decision making and public participation in agency processes (Groves 2010).

However, judicial review does impose two main obstacles to effective adaptive management. First, the very availability of judicial review for each final agency decision threatens agencies' authority and practical ability to adjust management decisions during the iterative phase of adaptive management, as new information becomes available, without being hauled into court each time. Specifically, an agency risks that courts will classify each management adjustment (or at least the more significant ones) as 'final agency action' subject to judicial review, even if those adjustments occur in accordance with an adaptive management plan. Second, current standards for judicial review do not match the process of adaptive management. For example, agencies must demonstrate that their decisions are reasonable (not arbitrary and capricious) attempts to fulfill statutory mandates and goals. However, recent comprehensive studies of how courts have treated agency attempts to use adaptive management in natural resources law concluded that 'adaptive management procedures, no matter how finely crafted, cannot substitute for showing that a plan will meet the substantive management criteria required by law' (Fischman and Ruhl 2015, Ruhl and Fischman 2010). Thus, administrative law's emphasis on final agency decisions and judicial review of those decisions trumps adaptive management's emphasis on structured learning processes.

While courts will support the use of adaptive management when administrative law can accommodate it, that does not stop them from curtailing agency use of adaptive management when they are not convinced that the agency's adaptive management plan will achieve substantive statutory requirements (Ruhl and Fischman 2010). Furthermore, it is currently difficult for courts to 'directly distinguish legitimate adaptive management from imposter[s]' (Ruhl and Fischman 2010), in part because no legislation requires an agency to comply with legitimate adaptive management methodology, thus leaving courts with inappropriate procedural requirements against which to judge the application of adaptive management (Ruhl and Fischman 2010). Thus, administrative law needs to provide courts both with a new approach to finality and a new set of standards for judging whether an agency is engaged in legitimate adaptive management.

3.3. Finality

Another key value of contemporary administrative law is finality—meaning insistence on final resolutions by

administrative agencies that will be definitively upheld or rejected by the courts. While ‘agency action’ subject to the Administrative Procedure Act includes a variety of activities—the whole or a part of an agency rule, order, license, sanction, relief, or the equivalent or denial thereof, or failure to act’ (5 U.S.C. § 551(15), 2012)—agency actions for judicial review are limited to those ‘made reviewable by statute and *final agency action* for which there is no other adequate remedy in a court’ (emphasis added; 5 U.S.C. § 704, 2012). More generally, nonfinal agency action is of no legal effect.

When agency actions are subject to additional requirements for regulatory impact analyses beyond the basic explanations needed for the Administrative Procedure Act’s (or state equivalent’s) ‘arbitrary and capricious’ standard, investments in up-front decision making, and therefore an agency’s drive toward finality, are only increased. Numerous regulatory impact analyses may be required of federal agencies, and one of the most intensive is environmental-impact analysis, as in the National Environmental Policy Act and other laws (see Ruhl and Fischman 2010).

The emphasis on finality in administrative law is part of a more general valuation of finality in American law (Tarlock 1994). However, the many procedural drivers toward finality in administrative law—the extensive requirements for front-end justification to produce a judicially defensible final agency action—effectively end further deliberation and debate over the agency’s decision, both publicly and within the agency. (Ruhl and Fischman 2010). As such, the drive toward finality acts as a barrier to full agency implementation of true adaptive management. Administrative law both assumes and concretizes a world where agency decisions are basically one-time, isolated events, not an evolving series of management adjustments. For example, under contemporary administrative law, each rulemaking effort—even the modification of an earlier rule—is evaluated as a separate legal event, not an ongoing process of agency learning and adaptation. In contrast, adaptive management allows—even demands—managerial flexibility during continued learning in the face of system complexity (Ruhl and Fischman 2010). Thus, administrative law must adjust its emphasis on finality in agency decision making if true adaptive management is to occur.

4. A new adaptive management track for administrative law

Agencies trying to implement adaptive management usually do so at the limits of their administrative discretion (Susskind and Secunda 1999). Concerns over agency discretion, as well as mechanisms to limit discretion, have been a substantial focus in administrative law from its beginnings (Stewart 1975), and there is no debate that true adaptive management vests

an agency with considerable managerial discretion, especially in the iterative phase. Because adaptive decision making can be such a valuable management tool, it would be useful to provide agencies with explicit statutory authority to engage in it rather than have agencies push the limits of their existing discretion to produce nothing better than ‘a/m lite’ (Ruhl and Fischman 2010, Susskind and Secunda 1999). As an added benefit, new statutory authority could also simultaneously address the administrative law barriers to adaptive management identified above while constraining agency discretion in normatively acceptable ways. In this section, we examine how we can preserve traditional administrative law values in an administrative law model that allows for fully integrated adaptive management.

4.1. Preservation of administrative law values

We do not think it necessary to abandon traditional administrative law values in order to allow for true adaptive management. The key to preserving these values while allowing agencies to implement full adaptive management is for administrative law to embrace adaptive management’s periodicity. Specifically, we should recast administrative procedure as a recurring process of punctuated ‘final’ decision making, public participation, and judicial review—rather like continuing jurisdiction in the courts—instead of as a process of one-time, final agency decision followed by judicial review.

4.1.1. Public participation

The issue of public participation in agency adaptive management should be framed in terms of *when* the public gets to participate in the agency’s decision making rather than *whether*. The formulation of an adaptive management plan lends itself to public input, as does the adaptive management requirement for periodic evaluations of progress toward pre-identified objectives, and periodic comprehensive revisitation of management alternatives and other set-up elements. This periodicity allows for recurring, rather than continual, public participation.

Amendments to administrative law that mandate full adaptive management by agencies, instead of a/m lite, could increase public participation by means of multiple, periodic opportunities for public involvement as the project evolves over time in an iterative process. Reformed procedures would require agencies to evaluate and adjust their adaptive management projects and management alternatives, goals, and monitoring periodically, subject to public notice and comment, instead of forcing them to detail the full range of administrative discretion up front.

Ideally, periodic public participation would occur when the agency returns to the set-up phase and engages in institutional learning, and this should be the preferred approach when the iterative phase of technical learning is relatively short (say, on the order

of five years). However, just as administrative procedures have to change to accommodate real adaptive management, the adaptive management process may need to make a few concessions to administrative procedure, particularly when system response is slow. While the technical learning that occurs during the iterative phase of adaptive management needs to be free of both active public participation and judicial review (see below), so that managers are free to test hypotheses and management methods, administrative law norms may require agencies to ‘check in’ with stakeholders and other members of the public before the iterative phase has generated sufficient information to allow true institutional learning to occur. This compromise—an abbreviated return to the set-up phase—is most likely to be necessary when the system and processes being studied have long response times and hence require longer iterative cycles for technical learning. While hard-and-fast legal timelines are inappropriate given the variety of systems and natural resource management problems for which adaptive management would be helpful, agencies should be aware that iterative phases lasting ten years or longer are likely to generate demand for ‘pause points’ that allow public intervention, even if technical learning is still ongoing. In these cases, the ‘pause point’ would not constitute a true re-invocation of the set-up phase; instead, it would probably entail little more than an agency’s presentation of its data and findings to date with an explanation of why the management plan being implemented is still a viable and helpful management approach.

4.1.2. Judicial review

Likewise, the question of judicial review is not *whether* there should be judicial review of agency adaptive management, but *when*. The availability of judicial review of adaptive management should by and large correspond to the availability of public participation. Hence, judicial review thus would be cyclical and mainly available during returns to the set-up phase when institutional learning occurs and management plans are revised, or, for projects with long iterative phases, during the interim ‘pause points’ to affirm the viability of the current management plan.

Of course, it may happen that implementation of an adaptive management plan unintentionally creates disastrous unintended consequences. Therefore, administrative law governing agency adaptive management needs an ‘escape valve’ that allows outside intervention, such as a judicial injunction, or a sudden change of course within the agency itself when such emergencies occur. The goal, however, would be to keep the opportunity for emergency intervention narrow, which could be best accomplished by a heavy burden of proof (either beyond a reasonable doubt or clear and convincing evidence) and strict standard for judicial action (strict scrutiny).

4.1.3. Finality

Finality is, perhaps obviously, the traditional administrative law value most in tension with adaptive management. Even here, however, we can accommodate traditional values, given that commentators expect visible progress toward, if not achievement of, stated goals within a reasonable period of time (Susskind *et al* 2012)—‘reasonable’ being judged by the management project’s scale (Chesapeake Bay restoration versus salmon restoration). In other words, we should judge finality in this context not by the administrative process itself but rather by the goals that the adaptive management project is trying to achieve.

Unlike traditional agency decision making in rulemaking and adjudication, adaptive management decision making by its very nature is not—or at least not immediately—final. Nevertheless, the adaptive management process already includes periodic ‘reset points.’ In particular, adaptive management is already seen as an iterative process with reflective ‘pause points’ that require decision makers—here, the administrative agency—to evaluate past actions and reassess its future course, particularly in the institutional learning cycle and deliberative set-up phases. These pause points provide appropriate opportunities for the public processes of administrative law to intervene in ongoing adaptive management, thus satisfying needs for temporary certainty regarding the agency’s next course of action as well as allowing for meaningful public participation and judicial review.

Importantly, adaptive management temporally separates two aspects of agency finality that typically occur together in conventional front-end, yes/no agency decision making. The first aspect of finality is the completion of the decision making process itself—such as the end of a rulemaking, the order in an agency adjudication, or the final decree in court. Administrative law for adaptive management preserves this sense of finality by focusing on each round of the deliberative set-up phase and the institutional learning that occurs there as a legally final ‘event’: emergencies excepted, at the end of the judicial review period, the adaptive management plan will govern the management project for the time period designated. As noted, however, for projects where the iterative phase and technical learning requires significantly longer than roughly five or ten years, periodic ‘check-in’ procedures that allow public participation and judicial review even in the absence of institutional learning may be necessary or advisable to satisfy administrative law norms. (At the very least, such ‘check in’ procedures for longer-term projects may increase the political acceptability necessary for the new procedures to be enacted into law.) In these cases, ‘finality’ would be achieved through the agency’s confirmation that its current plan for adaptive management is still viable and producing useful data.

However, by definition, each iteration of an adaptive management plan probably will *not* be the substantively final implementation of overall legislative intent or policy goals, which compose the second aspect of finality in agencies' traditional decisions. In the legal track we propose for adaptive management, substantive finality (or at least the illusion of it) is purposely delayed until the future; moreover, depending on the management project involved—such as dealing with climate change impacts on an ecosystem—there may never be a 'finally final' determination at all. Several implications for the administrative law to govern adaptive management follow. First, an adaptive management administrative law track should be more transparent than current administrative law regarding the agency's ability to meet (and its process for achieving) legislative goals, and the adaptive management plans required in the proposed new track seek to lay bare the agency's degree of uncertainty regarding specific management measures and its plans for actively improving the efficacy of its management 'best guesses.' Second, adaptive management administrative law needs to provide a procedure whereby an agency can take a project off the adaptive management track—most likely because the agency has resolved, through trial and error, all or most of the uncertainties that were making management difficult, in situations where continual change is not a complicating factor. Finally, judicial review should evaluate the reasonableness of the adaptive management plan in making progress toward management goals, for example in terms of reducing uncertainties regarding the system's function and complexity or of measuring the system's response to management actions. In sum, an adaptive management plan should be judged adequately 'final' if it proposes a well-defined and reasonable strategy that will result in progress toward the overall legislative goal.

4.2. Amending administrative law for adaptive management

In this section we describe how these key features would function in the proposed new Model Adaptive Management Procedure Act (MAMPA), a full version of which is included with the online materials. There are several key features that should be included in any legislation explicitly allowing agencies to implement fully integrated adaptive management. These features include criteria for defining the kinds of projects and management measures that qualify for the special legislation (Susskind and Secunda 1999); requirements that agencies define project objectives and their relative priorities (Ruhl and Fischman 2010); and requirements for monitoring targeted at evaluating the outcomes of management interventions (Ruhl and Fischman 2010, National Research Council 2004), with progress measured against concrete standards (Ruhl and Fischman 2010, National Research Council 2004, Susskind and Secunda 1999).

Furthermore, agency decision making after getting on the adaptive management track should be mostly free of additional external procedural requirements (Schultz and Nie 2012), such as the National Environmental Policy Act (NEPA) and its requirement for an environmental impact statement (42 U.S.C. § 4332(C)); the Endangered Species Act's 'jeopardy' consultations and habitat conservation plan requirements (16 U.S.C. §§ 1536(a), 1539(a)); and multiple rounds of regulatory impact analyses, including cost-benefit analyses. Finally, the new administrative procedures should allow agencies to exit the adaptive management track when the implementation measures meet the objectives or when it becomes clear that adaptive management is not working.

4.2.1. Three ways to enter the adaptive management track

Establishing an alternative set of administrative law procedures for adaptive management—i.e. the adaptive management track—raises the question of how to decide whether an agency can use the adaptive management track for a particular application. This decision, in turn, depends upon whether the agency itself has chosen to use adaptive management, or whether the relevant legislature has specified what the agency must do. There are three potential situations regarding the agency's ability to use the adaptive management track. Section 2 of the MAMPA addresses these situations.

The three situations are as follows. First, the legislature might instruct an agency to use adaptive management for a specific management context application. Second, conversely, the legislature might expressly forbid an agency to use adaptive management for particular kinds of decisions or for any decision. In either case, the legislature's statement would be final, and any consideration of the adaptive management track would be minimal, especially if the legislature had expressed itself clearly: the agency must follow the legislature's direction.

Third, the legislature might leave it up to the agency whether to use the adaptive management track, either expressly or through statutory silence on the issue. (We regard statutory silence and express statutory delegation of the decision to choose the adaptive management track to the agency as legally equivalent.) When the choice is up to an agency, the MAMPA requires the agency to make a positive decision to pursue the adaptive management track through standard notice-and-comment (informal) rulemaking. The MAMPA thereby views standard administrative procedures as the default rules for agency action: federal agencies, for example, would follow the Administrative Procedure Act *unless* Congress instructs otherwise *or* Congress gives the agency the choice (or is silent on the issue) and the agency decides to pursue the adaptive management track. By means of this default, administrative law's

status quo is preserved and overall disruption is minimized when a legislature decides to introduce the adaptive management track.

An agency deciding to use the adaptive management track must demonstrate, on the basis of ‘the best evidence available,’ that the application at issue is appropriate for adaptive management, as per the factors we discussed in Part 2. The ‘best evidence available’ standard is meant to preclude courts from demanding perfect information about adaptive management, whereas the factors are meant to ensure that the agency can still show that adaptive management would be a good fit for the particular project. Moreover, as specified in section 6 of the MAMPA, the agency’s decision to use the adaptive management track, expressed in a final rule, is judicially reviewable but subject to a 90 day statute of limitations. The short statute of limitations limits the time delay between an agency’s decision to use adaptive management and its ability to begin the process if there are no challenges to the propriety of its decision. In the case of judicial review, the reviewing court (we propose for federal agencies the US Courts of Appeals) can assess both the legislature’s intent regarding adaptive management and the propriety—under standard arbitrary and capricious review—of the agency’s decision to use adaptive management for the particular project. Judicial review for alleged procedural and constitutional violations is also available.

Finally, an agency’s choice to use the adaptive management track would be subject to all other applicable procedural and evaluative requirements that would normally apply to agency rulemaking under the appropriate state or federal laws. For example, a federal agency’s initial decision to use the special track could be subject to cost-benefit analyses (e.g. under the Unfunded Mandates Reform Act) and review by the Office of Management and Budget, various regulatory-impact analyses (e.g. under the Regulatory Flexibility Act), environmental impact assessment requirements under the National Environmental Policy Act, or consultation requirements under the Endangered Species Act. Subjecting the agency’s decision to these traditional requirements both reflects the MAMPA’s provision that normal administrative law procedures remain the default set of requirements and ensures at the outset that the agency’s decision to change procedural tracks will not in and of itself violate existing statutory and executive limitations on agency actions.

4.2.2. *The initial adaptive management plan in the first set-up phase*

Once an agency’s adaptive management project, or category of projects, is on the adaptive management track, the agency should fully enter the set-up (deliberative) phase of adaptive management. For administrative law purposes under the MAMPA, the end product of this phase—the ‘final’ agency action—

is the adoption of an initial adaptive management plan that addresses the factors laid out in section 3 of the act. For the agency, the adaptive management plan will guide the iterative technical learning phase of the project and hence should reflect all of the decisions regarding proper monitoring, management alternatives, modeling and expected outcomes, and so forth. For purposes of judicial review, the factors in MAMPA provide courts with a standardized basis to guide their evaluation of the plan, helping both to educate courts regarding ‘proper’ adaptive management and to prevent agencies from slipping into either ‘a/m lite’ or adaptive management that lacks accountability.

Five key substantive components keep the MAMPA’s plan requirement consistent with adaptive management theory. First, as adaptive management theory demands, the agency must identify specific management goals and objectives, both for the system overall and for its initial management measures. These goals and objectives provide the overall measures against which both the agency and the courts can measure progress in the adaptive management process.

Second, the agency must identify, to the extent possible, potential threats to its management goals and potential stressors and perturbations to the managed system. These threats, stressors, and perturbations should already be incorporated within the models that the agency is using to describe the system and predict its responses to management measures. However, identifying these threats, stressors, and perturbations in the management plan will better convey to courts and members of the interested public the management challenges that the agency faces.

Third, monitoring is a critical component of ensuring that adaptive management actually progresses in learning, and hence several elements of the management plan focus on monitoring. For example, as part of its monitoring program, the agency must identify what exactly it is measuring in targeting its monitoring of system features and attributes. In addition, the agency must explain how these measurements and the features and attributes it has chosen give the agency an ability to comprehensively and meaningfully assess the system and how it is changing in light of the management actions and objectives.

Fourth, the agency must develop a monitoring plan or monitoring protocols. The monitoring plan must be defensible under the best practices of the professional discipline most relevant to the project or management action (for example, a forest-management action would turn to biology). It must also use a standardized and accepted methodology that the agency implements consistently so that the agency can compare the resulting data over time. In addition, the agency must provide for the periodic release of monitoring data to the general public in a comprehensible and usable form. The MAMPA suggests that such public reports on the agency’s activities be spaced

no more than 6 months apart, although we acknowledge that longer or shorter periods might be appropriate for different kinds of agency activities.

Fifth, and perhaps most importantly, the agency must identify in its initial adaptive management plan changes in studied system's state that are relevant to evaluating the agency's progress toward the identified management objectives (Schultz and Nie 2012). Specifically, the agency must describe changes in the monitored features and attributes that would suggest that either the system is moving in a positive direction (i.e. toward achieving management goals) or that the system is moving in a negative direction. As part of this process, the agency must also identify means by which it can determine whether the changes in the indicators are in fact caused by its management measures or by other factors (or some combination). Finally, the agency should identify changes in system indicators, individually and collectively, so negative that they counsel in favor of aborting the current management plan. These 'abort indicators' will become the primary measures through which either the agency can justify abrupt changes in its adaptive management plan or the general public can justify emergency intervention.

Procedurally, the MAMPA requires the agency to adopt its initial adaptive management plan—and subsequent revisions resulting from double-loop learning—through notice-and-comment rulemaking. As such, the process of formulating each adaptive management plan is subject to public notice, comment, and hearings when appropriate, just as under traditional administrative law. The MAMPA expands upon this traditional public participation, however, by requiring the agency to actively invite more public involvement in the plan's formulation through representatives of interest groups and stakeholders. The requirement, specifically, is that the agency make reasonable efforts to involve and accommodate these groups. However, the Act also leaves the agency with considerable discretion to limit the number of participants to a level that will be both manageable and helpful. The intention, as adaptive management theory recommends, is for agencies to involve interested stakeholders, through their representatives, during each revisitation of the set-up phase of the adaptive management process, which is in fact earlier than standard notice-and-comment rulemaking would allow. This requirement holds, moreover, even when agencies engage in 'check in' public participation procedures to confirm the viability of the current adaptive management plan.

The MAMPA incorporates two innovations to current Administrative Procedure Act requirements for standard judicial review of an agency's initial adaptive management plan. First, judicial review is subject to a short (30-day) statute of limitations. This brief period is intended to recognize that increased stakeholder involvement in planning will ideally eliminate many conflicts and reduce the need for

extensive judicial review, and to encourage stakeholders to follow the adaptive management effort closely. Second, through the MAMPA's section 3 requirements, courts engaged in judicial review of management plans have a substantial structural guide for ensuring that agencies are implementing full adaptive management, because failure to include or adequately explain any required plan element would be grounds for remanding the entire plan to the agency.

Importantly, in its procedures for the initial adaptive management plan, the MAMPA generally exempts plans from the substantive and procedural requirements of any statutes, regulations, or executive orders other than the statute that authorized the agency to engage in the relevant management activities in the first place; however, as explained above, the *initial decision to choose* the adaptive management track is subject to the full range of substantive and procedural requirements. As such, once an agency is on the adaptive management track, it is free from ongoing procedural and assessment requirements—including but not limited to those under the National Environmental Policy Act, Endangered Species Act, and those imposed by the Office of Management and Budget—unless the agency's authorizing statute provides otherwise. This exemption is intended to provide agencies with a *quid pro quo* for engaging in the rigorous process of adaptive management planning and implementation, by relieving them of the prospect of ceaseless litigation challenges under these ancillary programs. Notably, however, nothing in the MAMPA prohibits agencies from following these requirements voluntarily, and the relevant legislature can always specifically require continued compliance for specific adaptive management applications. Moreover, the explanations required in the management plan will often duplicate or go beyond the information that would be required in environmental analyses under NEPA and the Endangered Species Act.

4.2.3. *The iterative phase and emergency interventions*

Once the critical elements of adaptive management have been identified in the set-up phase (figure 1), the process shifts to an iterative application of decision making, monitoring, assessment, and learning. The iterative application of management and learning is referred to as technical or 'single-loop' learning (Pahl-Wostl 2009, Williams and Brown 2014), which emphasizes the improvement of technical understanding, leading to the improvement of decision making.

One of the MAMPA's most important innovations for administrative procedure is the specification that once an agency has actually begun to implement adaptive management in the iterative technical learning phase, no judicial review of its interim decisions is available unless emergency intervention is appropriate. The general unreviewability of the

iterative phase under the MAMPA gives agencies considerable discretion to pursue adaptive management, thus correcting one of the most important limitations of conventional administrative law for adaptive management.

This increased agency discretion may nevertheless make many people and interest groups uncomfortable (Hammond and Markell 2013, Schultz and Nie 2012, Nylen 2011). To assuage this discomfort while still giving agencies what we consider necessary additional discretion, the MAMPA incorporates mechanisms whereby interested members of the public can follow the process during the iterative phase and can intervene in true emergencies or if the agency has completely abandoned the project. First, the agency must make public its monitoring data in an understandable and usable form on a regular basis (we suggest at least every 6 months as a default). Second, the agency must report regularly to the general public (we suggest a default of at least once per year) regarding how it is implementing its adaptive management plan (including adjustments of its management measures). If the agency fails to provide monitoring data or required reports within two months of their due dates, members of the public can sue for the limited purpose of compelling production. Third, either members of the public or the agency itself can abort the current adaptive management plan under two circumstances: (1) the monitored system attributes indicate that the system has changed in a direction and to a degree that the current management plan should be abandoned, a system status identified as an ‘abort indicator’ in the management plan; or (2) an unanticipated severe disturbance occurs in the system, such as an unanticipated natural disaster, economic collapse, or act of war or terrorism. Finally, if the agency clearly and completely abandons its adaptive management plan (as narrowly defined in the MAMPA’s judicial review provisions in section 6), members of the public can sue the agency to compel compliance or to force the agency to formally abandon the adaptive management track.

Most of these innovations are relatively straightforward, but the ‘abort indicators’ deserve further consideration. As part of their adaptive management plans, agencies must identify abort indicators (MAMPA sections 3(B), 4(B)). Abort indicators are a specified set of statuses for the system features and attributes being monitored that, if they occur either collectively or individually, signal to the agency that its management measures are taking the system grossly off any path toward achieving management objectives. For example, in the dam spill hypothetical, fish survival rates 75% less than the status quo might serve as an abort indicator, a signal that this experiment is failing. In the terms of adaptive management theory, if the monitored features and attributes achieve the statuses specified as ‘abort indicators,’ there are serious

flaws in the system models, requiring both technical and institutional learning and an immediate return to the set-up deliberative phase; current management measures based on those models are putting the system at risk. Under sections 3(C)(1), 4(C)(1), and 5 (B) of the MAMPA, if the abort indicators are achieved, the agency can terminate the management plan simply by giving notice in the Federal Register (or the state equivalent) and waiting 30 days; no rulemaking is required for termination, although it will be required for the new adaptive management plan, which is subject to the provisions of section 4. Alternatively, if the agency fails to terminate, under section 5(D), members of the public can file a mandamus action in federal district court or the designated state court, subject to any jurisdictional limitations such as standing and the traditional requirements and limitations governing mandamus.

Given that the agency must identify its own triggering conditions for terminating the adaptive management plan through the abort indicators, we purposely designed the MAMPA’s provision for ‘true’ emergency termination in sections 5(C) and 5(E) to be extremely limited; moreover, the statute instructs the courts to narrowly interpret these provisions. To terminate agency implementation because of an emergency, either the agency or members of the public petitioning for mandamus must show that: (1) a severe disturbance to the system occurred; (2) the adaptive management plan did not anticipate the disturbance; and (3) the disturbance fundamentally altered the information or system status that formed the basis of the adaptive management plan.

4.2.4. *Resetting after technical learning: the next set-up phase*

The agency’s implementation of its adaptive management plan during the iterative phase of adaptive management will eventually end, at which point the agency proceeds through the double-loop learning process to take its technical learning into institutional learning, returning to the set-up or deliberative phase. At this point, in MAMPA’s administrative law terms, the agency drafts a new management plan. The MAMPA envisions three ‘natural’ triggers for ending the iterative phase, spelled out in sections 3(C) and 4 (C). First, as discussed in the previous section, the agency should terminate its adaptive management plan when the system achieves the abort indicators. Second, and conversely, the system might achieve the plan’s ‘finished indicators.’ Like the abort indicators, finished indicators are specific statuses identified for the monitored system features and attributes. However, unlike abort indicators, finished indicators are signals that the agency’s current management measures have done their job—assuming that no other cause explains their achievement—and that it is time for the agency to make additional progress toward its ultimate management goals. In adaptive management

terms, the agency has achieved a workable model of the system, where the predicted outcomes of management measures match the actual system's responses. Third, the implementation period might end simply as a result of the passage of time. In the absence of an express, legislatively imposed time limit on the implementation period, the MAMPA requires the agency to choose and justify an appropriate length of time as part of the adaptive management plan, and that time limit would govern termination. However, the MAMPA also imposes a default outer limit of five years. Ideally, this natural termination period would correspond to the need to return to an institutional learning cycle, but, as noted above, for projects dealing with longer-term system responses, administrative law norms might require an agency to report during an iterative phase before institutional learning legitimately can actually occur. The agency should identify as part of its adaptive management plan the circumstances under which institutional learning would be appropriate and necessary and when those circumstances are likely to be achieved; if that period is significantly long, it should also identify interim reporting periods and measures to ensure that management is not going awry.

Through section 4, the MAMPA presumes that the agency will continue through successive rounds of setup/deliberative phases and adaptive management plans that reflect ongoing institutional learning. The agency adopts subsequent plans, like the first, through notice-and-comment rulemaking, subject to the same additional public participation requirements, substantive plan component requirements, and judicial review. However, after the first round of implementing adaptive management, the agency must also: (1) explain what it has learned about managing the system, both in the immediately previous implementation period and over the entire adaptive management process; (2) adopt new management measures based on that evaluation; and (3) explain any and all changes to the adaptive management plan based on new information, changes to the system or its components, or changes to the law that the agency is implementing. Once the agency adopts a new adaptive management plan (and survives any judicial review), it proceeds into a new implementation period/iterative phase and process of technical learning. It continues through rounds of planning and implementation, deliberative and iterative phases, until it has scientific reason and the legal ability to remove the project, management action, or category of projects or management actions from the adaptive management track.

4.2.5. *Exiting the adaptive management track*

Some management problems may require continual learning about the system, so that there is no reason for the agency ever to take its management action off the adaptive management track. For example,

managing systems impacted by climate change may require continual adaptive management. In these situations, adaptive management becomes the single best means of managing the system.

In other cases, the initial problems, such as lack of knowledge about the system or how it responds to management, can actually be solved through adaptive management, so that valid models of the system exist and management can be stabilized. At that point, the agency may find that the adaptive management track is no longer necessary or helpful. Alternatively, after a trial period, the agency may find that conditions do not, after all, warrant adaptive management. If it was an agency decision to use the adaptive management track in the first place, and the agency has made a good faith effort albeit to little avail, it should have the option to remove its project from the adaptive management track.

Section 4 of the MAMPA outlines four situations in which leaving the adaptive management track is appropriate. First, Congress or the relevant state legislature may have intervened since the agency began its adaptive management process and ordered the agency to take its project off the adaptive management track, and agencies must obey such legislative mandates. Second, even if Congress or the state legislature ordered the use of adaptive management, it may also have specified when the agency would be 'done.' If the agency's adaptive management measures have achieved the legislative criteria for leaving the adaptive management track, the agency can—and possibly must—do so. Third, even when an agency chose the adaptive management track, it may be able to identify clear criteria for achievement of all management goals. If the adaptive management process brings the agency to the point where its management measures meet these criteria, and if the agency can now stably manage the system to maintain the management goals, it may conclude that the adaptive management track has served its purpose and that it can now operate effectively through traditional front-loaded administrative rulemaking and planning. The MAMPA allows agencies in this situation to leave the adaptive management track.

Finally, an agency may find that adaptive management is not working, even after initially showing that its management situation fit the criteria in section 2 of the MAMPA for entering the adaptive management track. The MAMPA effectively requires that the agency make a good faith effort at using adaptive management. However, the agency can leave the adaptive management track if the agency can show that: (1) its reasonable management measures repeatedly take the system to the point where criteria for aborting adaptive management are met; or (2) the system has changed significantly since the agency decided to enter the adaptive management track; or (3) new information gathered during adaptive management significantly undermines the agency's

prior conclusion that adaptive management is appropriate.

Section 4(A) of the MAMPA requires the agency to make and justify its decision to take a project or management action off the adaptive management track through notice-and-comment rulemaking. The final rule is subject to fairly standard judicial review requirements.

5. Conclusion

The proposed adaptive management track outlined herein (which emphasizes agency models and double-loop learning) and in Craig and Ruhl (2014) (which did not) is the first detailed blueprint for a new legal structure to match adaptive management's decision-making structure. Recognizing that some tradeoffs are inevitable, the proposed statute retains the core values of administrative law to the maximum extent possible in a procedural framework that allows agencies to engage in full adaptive management. However, to avoid a/m lite, the proposal is simultaneously designed with this new track to help ensure that agencies apply adaptive management effectively and only in appropriate settings. Finally, the adaptive management track's processes, standards, and requirements should actively educate judges and the public as to how adaptive management can be as rigorous and transparent as traditional agency decision making.

Tough decisions face any effort to redesign administrative law for adaptive management, and some of our choices may spark debate. We welcome that debate, because we consider the proposed Model Adaptive Management Procedure Act to be an open-source work-in-progress and have every expectation that it can and will be improved. Indeed, we believe all adaptive management theorists and practitioners and all administrative law theorists and practitioners have a mutual stake in the project of designing administrative law for adaptive management. We hope they will consider this article and our previous work (Craig and Ruhl 2014) to be an invitation for interdisciplinary teams to take our blueprint to their drawing boards for more work.

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References

Adler R W, Craig R K and Hall N D 2013 *Modern Water Law: Private Property, Public Rights, and Environmental Protections* (St. Paul, MN: West Academic/Foundation Press)

- Allen C R, Fontaine J J, Pope K L and Garmestani A S 2011 Adaptive management for a turbulent future *J. Environ. Manage.* **92** 1339–45
- Allen C R and Gunderson L H 2011 Pathology and failure in the design and implementation of adaptive management *J. Environ. Manage.* **92** 1379–84
- Angelo M J 2009 Stumbling toward success: a story of adaptive law and ecological resilience *Nebr. Law Rev.* **87** 950–1007
- Argyris C and Shon D 1978 *Organization Learning: A Theory of Action Learning* (Reading, MA: Addison-Wesley)
- Benson M H 2010 Adaptive management approaches by resource management agencies in the United States: implications for energy development in the interior West *J. Energy Nat. Resour. Law* **28** 87–118
- Benson M H and Garmestani A S 2011 Embracing panarchy, building resilience and integrating adaptive management through a rebirth of the National Environmental Policy Act *J. Environ. Manage.* **92** 1420–7
- Biber E 2008 The importance of resource allocation in administrative law *Admin. Law Rev.* **60** 1–63
- Biber E 2013 Adaptive management and the future of environmental law *Akron Law Rev.* **46** 933–62
- Camacho A E 2011 Transforming the means and ends of natural resources management *NC Law Rev.* **89** 1405–54
- Camacho A E 2009 Adapting governance to climate change: Managing uncertainty through a learning infrastructure *Emory Law J.* **59** 1–77
- Craig R K 2010 'Stationarity is dead'—long live transformation: five principles for climate change adaptation law *Harvard Environ. Law Rev.* **34** 9–75
- Craig R K and Ruhl J B 2014 Designing administrative law for adaptive management *Vanderbilt Law Rev.* **67** 1–87
- Croley S P 1999 State administrative law reform: recent experience in Michigan *Widener J. Pub. Law* **8** 347–417
- Davidson J H and Geu T E 2001 The Missouri River and adaptive management: protecting ecological function and legal process *Nebr Law Rev.* **80** 816–90
- Doremus H 2001 Adaptive management, the endangered species act, and the institutional challenges of 'new age' environmental protection *Washburn Law J.* **41** 50–89
- Doremus H 2007 Precaution, science, and learning while doing in natural resource management *Wash Law Rev.* **82** 547–79
- Doremus H *et al* 2011 Making good use of adaptive management. Center for Progressive Reform White paper no. 1104 (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1808106) (Accessed: 30 December 2016)
- Fischman R L and Ruhl J B 2015 Judging adaptive management practices of US agencies *Conserv. Biol.* **30** 268–75
- French S T 1993 Judicial review of the administrative record in NEPA litigation *Calif. Law Rev.* **81** 929–90
- Garmestani A S, Allen C R and Cabezas H 2009 Panarchy, adaptive management, and governance: policy options for building resilience *Nebr Law Rev.* **87** 1036–54
- Glicksman R L 2005 Securing judicial review of agency inaction (and action) in the wake of Norton v. Southern Utah Wilderness Alliance *Strategies for Environmental Success in an Uncertain Judicial Climate* ed M A Wolf (Washington, DC: Environmental Law Institute)
- Glicksman R L and Shapiro S A 2004 Improving regulation through incremental adjustment *Univ. Kansas Law Rev.* **52** 1179–248
- Gregory R, Ohlson D and Arvai J 2006 Deconstructing adaptive management: criteria for applications to environmental management *Ecol. Applic.* **16** 2411–25
- Groves M 2010 Should we follow the gospel of the Administrative Decisions (Judicial Review) Act 1977 (CTH)? *Melbourne Univ. Law Rev.* **34** 736–72
- Hammond E and Markell D L 2013 Administrative proxies for judicial review: building legitimacy from the inside-out *Harvard Environ. Law Rev.* **37** 313–64
- Johnson F A, Jensen G H, Madsen J and Williams B K 2014 Uncertainty, robustness, and the value of information in managing an expanding Arctic goose population *Ecol. Modelling* **273** 186–99

- Jordan W S III 2000 Ossification revisited: does arbitrary and capricious review significantly interfere with agency ability to achieve regulatory goals through informal rulemaking? *Northwestern Univ. Law Rev.* **94** 393–450
- Karkkainen B C 2005 Panarchy and adaptive change: around the loop and back again *Minn. J. Law Science Technol.* **7** 59–77
- Krotoszynski R J Jr 2006 'History belongs to the winners': the Bazelon-Levanthal debate and the continuing relevance of the process/substance dichotomy in judicial review of agency action *Admin. Law Rev.* **58** 995–1015
- Leonetti C 2012 Watching the hen house: judicial rulemaking and judicial review *Nebr Law Rev.* **91** 120
- Light A R 2006 Tales of the Tamiami Trail: implementing adaptive management in everglades restoration *J. Land Use Environ. Law* **22** 59–99
- McFadden J, Hiller T L and Tyre A J 2011 Evaluating the efficacy of adaptive management approaches: is there a formula for success? *J. Environ. Manage.* **92** 1354–59
- McGarity T O 1992 Some thoughts on 'deossifying' the rulemaking process *Duke Law J.* **41** 1385–462
- Moore C T, Lonsdorf E V, Knutson M G, Laskowski H P and Lor S K 2011 Adaptive management in the U.S. National Wildlife Refuge System: science-management partnerships for conservation delivery *J. Environ. Manage.* **92** 1395–402
- National Research Council 2004 *Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery* (Washington, DC: National Academies Press)
- Nichols J D and Williams B K 2012 Adaptive management *Encyclopedia of Environmetrics* 2nd edn ed A H El-Shaarawi and W W Piegorsch (Hoboken, NJ: Wiley)
- Nylen N G 2011 To achieve biodiversity goals, the new Forest Service planning rule needs effective mandates for best available science and adaptive management *Ecol. Law Quart.* **38** 241–93
- Pahl-Wostl C 2009 A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes *Glob. Environ. Change* **19** 354–65
- Raiffa H and Schlaifer R 1961 *Applied Statistical Decision Theory* (Boston, MA: Harvard University)
- Rubin E 2004 It's time to make the Administrative Procedure Act administrative *Cornell Law Rev.* **89** 95–190
- Ruhl J B 2002 A manifesto for the radical middle *Idaho Law Rev.* **38** 385–407
- Ruhl J B 2005 Regulation by adaptive management—is it possible? *Minn. J. Law Science Technol.* **7** 21–57
- Ruhl J B and Fischman R L 2010 Adaptive management in the courts *Minn. Law Rev.* **95** 424–84
- Schultz C and Nie M 2012 Decision-making triggers, adaptive management, and natural resources law and planning *Nat. Res. J.* **52** 443–521
- Seidenfeld M 1997 Demystifying deossification: rethinking recent proposals to modify judicial review of notice and comment rulemaking *Tex. Law Rev.* **75** 483–524
- Stewart R B 2003 Administrative law in the twenty-first century *NY Univ. Law Rev.* **78** 437–60
- Stewart R B 1975 The reformation of American administrative law *Harvard Law Rev.* **88** 1667–813
- Sunstein C R 1985 Reviewing agency inaction after Heckler v. Chaney *Univ. Chicago Law Rev.* **52** 653–83
- Sunstein C R 1985 Interest groups in American public law *Stanford Law Rev.* **38** 29–87
- Susskind L E and Secunda J 1999 'Improving' Project XL: helping adaptive management to work within EPA *UCLA J. Environ. Law Policy* **17** 155–70
- Susskind L, Camacho A E and Schenk T 2012 A critical assessment of collaborative adaptive management in practice *J. Appl. Ecol.* **49** 47–51
- Tarlock A D 1994 The Nonequilibrium paradigm in ecology and the partial unraveling of environmental law *Loyola L.A. Law Rev.* **27** 1121–44
- Wagner W 2012 Revisiting the impact of judicial review on agency rulemakings: an empirical investigation *William Mary Law Rev.* **53** 1717–95
- Walters C J 1986 *Adaptive Management of Renewable Resources* (Caldwell, NJ: Blackburn)
- Walters C J 2007 Is adaptive management helping to solve fisheries problems? *Ambio* **36** 304–7
- Williams B K 2011 Adaptive management of natural resources—framework and issues *J. Environ. Manage.* **92** 1346–53
- Williams B K and Brown E D 2012 *The US Department of the Interior Adaptive Management Applications Guide* (Washington, DC: U.S. Department of the Interior)
- Williams B K and Brown E D 2014 Adaptive management: from more talk to real action *Environ. Manage.* **53** 465–79
- Williams B K and Brown E D 2016 Technical challenges in the application of adaptive management. *Biol. Conserv.* **195** 255–63
- Williams B K, Eaton M and Breininger D R 2011 Adaptive resource management and the value of information *Ecol. Modelling* **222** 3429–36
- Williams B K and Johnson F A 2013 Confronting dynamics and uncertainty in optimal decision making for conservation *Environ. Res. Lett.* **8** 025004
- Williams B K and Johnson F A 2015a Value of information and natural resources decision making *Wildl. Soc. Bull.* **39** 488–96
- Williams B K and Johnson F A 2015b Value of information in natural resource management: technical developments and application to pink-footed geese *Ecol. Evolu.* **5** 466–74
- Yokota F and Thompson K M 2004 Value of information literature analysis: a review of applications in health risk management *Med. Decision Making* **24** 287–98

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