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Bridging Data Gaps through Modeling and Evaluation of Surrogates: Use of the Best Available Science to Protect Biological Diversity Under the National Forest Management Act

by Robert L. Glicksman*
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I. INTRODUCTION

The implementation of environmental law and policy often, if not typically, proceeds in the face of scientific uncertainty. Indeed, as Holly Doremus has explained, “[t]he most universally recognized feature of environmental problems is the pervasive uncertainty that surrounds them.”¹ Legislators or administrative agencies crafting programs to minimize the risk that exposure to pollution will cause adverse human health effects often lack information about the pathways of exposure, the levels at which exposure will cause adverse effects, or even about the kinds of adverse effects that may result from exposure. Nearly thirty years ago, Talbot Page described nine characteristics that exemplify the kind of “environmental risk” problems typified by the leakage of hazardous waste or the production of toxic chemicals. Four of those characteristics emphasized scientific uncertainty, and Page listed “ignorance of mechanism” as the first characteristic of an environmental risk problem.² Scientific uncertainty is no less endemic to natural resource management regimes,³ transforming scientific disputes concerning such regimes into judgment calls “about how incomplete data are interpreted

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¹ Holly Doremus, *Constitutive Law and Environmental Policy*, 22 STAN. ENVTL. L.J. 295, 319 (2003) [cited hereinafter as Doremus, *Constitutive Law*]. See also Carol Rose, *Environmental Law Grows Up (More or Less)*, and *What Science Can Do to Help*, 9 LEWIS & CLARK L. REV. 273 (2005) (stating that “in environmental areas the problem of decisionmaking under uncertainty is particularly acute”); Robert N. Stavins, *What Baseball Can Teach Policymakers*, 22 ENVTL. F. 14 (Sept/Oct. 2005) (asserting that “[u]ncertainty is an absolutely fundamental aspect of environmental problems and the policies that are employed to address those problems” and that “[a]ny analysis that fails to recognize this runs the risk not only of being incomplete, but misleading as well”).

² Talbot Page, *A Generic View of Toxic Chemicals and Similar Risks*, 7 ECOLOGY L.Q. 207, 208-09 (1978). Cass Sunstein distinguishes between “risk, for which probabilities can be assigned to various outcomes, and uncertainty, for which no probabilities can be assigned.” Cass. R. Sunstein, *Irreversible and Catastrophic*, 91 CORNELL L. REV. 841, 848 (2006).

³ See, e.g., John M. Volkman, *How Do You Learn from A River? Managing Uncertainty in Species Conservation Policy*, 74 WASH. L. REV. 719, 723 (1999) (stating that “[e]ven people aware of the problem of shrinking biodiversity are likely to be surprised by how much scientific uncertainty there is in species conservation policy”). See generally James Wilson, *Scientific Uncertainty, Complex Systems, and the Design of Common-Pool Institutions*, in THE DRAMA OF THE COMMONS 327, 335-47 (Elinor Ostrom et al. eds., 2002).

and applied.”⁴ In both areas, “the most important decisions must be made under extreme conditions of scientific uncertainty.”⁵

Despite this pervasive uncertainty, Congress has directed the agencies responsible for administering the environmental statutes to ground their policy decisions in science. The implicit assumption reflected in many of these laws is that “science would drive decision-making and that agencies could interpret scientific information to set the right policies.”⁶ For a variety of reasons, however, an inquiry that may be posed in scientific terms may have no single correct answer, or even no answer at all.⁷ These may include insufficient research, incomplete theoretical understandings, or “merely the great complexity of natural and human systems.”⁸ As a result, as one court put it in an early case involving regulation of toxic water pollutants, environmental statutes often present agencies with “a veritable paradox [by] calling . . . for knowledge of that which is unknown.”⁹

Agencies sometimes cope with the responsibility of making science-based decisions despite the presence of uncertainty by relying on scientific models or otherwise using the limited information available to them to make predictions about the impacts of agency decisions on the environment. In trying to ascertain the effects of a decision on a complex ecosystem, for example, an agency may use the known effects of the decision on one component of that ecosystem as a surrogate for the effects of the decision on the ecosystem as a whole. These techniques allow agency decisionmakers, by simulating reality, to organize available information and plug holes created by unavailable information to reach what appears to be a rational and objective conclusion about the environmental effects of the action being contemplated. The use of simulation modeling and surrogates in this fashion thus enables agencies to conform to their statutory responsibilities to base decisions on scientific considerations, even though a complete understanding of the relationships between the actions they are proposing to take, or authorize others to take, and the resulting environmental effects may be beyond their current capabilities or impossible ever fully to ascertain.

The reliance by pollution control and natural resource management agencies on scientific models or on surrogate parameters to make decisions under federal environmental legislation has generated significant controversy, despite its utility in addressing the paradox created by statutory mandates to make decisions based on unavailable information. Scientific models are built upon assumptions, which are often based on value judgments and therefore tend to be contested. Even if agreement exists on the assumptions upon which a model is based, there may be disagreements about the applicability of the model to a particular problem or situation. Moreover, competing

⁴ Holly Doremus & A. Dan Tarlock, *Science, Judgment, and Controversy in Natural Resource Regulation*, 26 PUB. LAND & RESOURCES L. REV. 1, 3 (2005).

⁵ A. Dan Tarlock, *Who Owns Science?*, 10 PENN. ST. ENVTL. L.J. 135, 141 (2002).

⁶ James D. Fine & Dave Owen, *Technocracy and Democracy: Conflicts Between Models and Participation in Environmental Law and Planning*, 56 HASTINGS L.J. 901, 909 (2005).

⁷ See STEPHEN BOCKING, *SCIENCE, POLITICS, AND THE ENVIRONMENT* 27 (2004).

⁸ *Id.* at 26.

⁹ *Envtl. Def. Fund v. EPA*, 598 F.2d 62, 81 (D.C. Cir. 1978).

models or differential applications of a single model may yield starkly divergent predictions about the effects of an agency's decision on the environment. As a result, litigation concerning the use of simulation models and surrogate parameters by environmental and resource management agencies has been plentiful.

This article considers the lessons that may be drawn from the recent controversy created by one federal agency's shifting approach to the use of models and surrogates. The National Forest Management Act (NFMA)¹⁰ delegates to the National Forest Service (Forest Service, or Service) the responsibility to develop land and resource management plans (LRMPs) for units of the National Forest System (NFS)¹¹ and to make site-specific decisions about the use of those units in a manner consistent with the plans.¹² The NFMA charges the Forest Service with the task of issuing regulations governing the land use planning process that, among other things, "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area."¹³ The Service has encountered difficulty in carrying out its responsibility to issue and apply those regulations because of the enormous complexity of the ecosystems within the forests under its jurisdiction. To minimize the uncertainty it faces in predicting what impact a particular proposed action, such as a timber sale, will have on the diversity of plant and animal species in the affected forest, the Forest Service has turned to the use of models and surrogates. For years, acting under land use planning regulations issued by the agency in 1982, it identified management indicator species (MIS) that it determined were representative of the health of the ecosystem as a whole. The MIS were supposed to act as surrogates for the impact of activities such as timber sales on plant and animal diversity. The agency's aim was to predict the effects of management actions on the selected MIS and to monitor the fate of the MIS after the action was taken to determine whether the action was interfering with diversity. If it was, suitable changes in management approaches could then be made.¹⁴

The process of monitoring the effect of management actions such as timber sales on MIS, however, turned out to be a burdensome one, requiring the Forest Service to count MIS populations. The Forest Service began using the health of the habitat of the MIS as a surrogate for the health of the MIS themselves. Thus, MIS habitat served as a surrogate, or proxy, for the health of the MIS, which in turn served as a surrogate for the diversity of plant and animal communities in the ecosystem as a whole. When litigants challenged this "proxy-on-proxy" approach to compliance with the Forest Service's requirement to provide for diversity in the planning process, the courts were unable to agree on whether this approach is consistent with the NFMA.¹⁵

In 2000, the Clinton Administration amended the NFMA planning regulations, but the Bush Administration quickly replaced those regulations with its own approach to

¹⁰ 16 U.S.C. §§ 1600-1687.

¹¹ 16 U.S.C. § 1604(a).

¹² 16 U.S.C. § 1604(i).

¹³ 16 U.S.C. § 1604(g)(3)(B).

¹⁴ See *infra* notes 143-50 and accompanying text.

¹⁵ See *infra* notes 156-66 and accompanying text.

planning. The Forest Service's 2005 regulations completely scrap the agency's obligation to track the impact of management actions on MIS, based on the agency's conclusion that the MIS approach had been unreliable and flawed. In its place, the regulations require that the Service ensure the maintenance of biological diversity by taking into account the "best available science" and by focusing in most cases on the effect of management actions on diversity at the ecosystem rather than the species level.¹⁶ The fate of the agency's latest approach to dealing with scientific uncertainty in fulfilling the NFMA's diversity mandate is not yet clear. A federal district court enjoined implementation of the 2005 regulations due to the Forest Service's noncompliance with the National Environmental Policy Act (NEPA)¹⁷ and the Endangered Species Act (ESA),¹⁸ but it did not address the legality of the regulations under the NFMA.¹⁹

This article explores the Forest Service's implementation of the NFMA's diversity mandate to illustrate the benefits and disadvantages of using scientific models and surrogates techniques that allow agencies to fulfill their mandates to make science-based decisions in the face of incomplete information and scientific uncertainty. Part II explores the paradox created when statutes require agencies to protect environmental resources by basing their decisions on science, despite limited knowledge of the manner in which the kinds of activities subject to the agency's jurisdiction have affected those resources in the past or will affect them in the future. It also describes the utility of modeling and surrogates as techniques for resolving the paradox, and how the federal courts have reacted to challenges to reliance on these analytical techniques. Part III analyzes the use of models and surrogates in the specific context of the Forest Service's efforts to comply with the NFMA's requirement to protect the diversity of plant and animal species in the land use planning process that governs use of the national forests. Part IV provides a list of criteria by which modeling and similar simulation techniques should be judged and assesses how the Forest Service's efforts to implement the diversity requirement fare using those criteria as standards. The criteria include recognition of the limits of scientific knowledge, collaboration, transparency, flexibility, and accountability.

II. BOUNDED RATIONALITY AND THE USE OF MODELING AND SURROGATES TO BRIDGE DATA GAPS

Because scientific uncertainty is such a pervasive feature of the analysis and resolution of environmental problems, administrative agencies responsible for protecting human health and the environment or for managing natural resources such as those contained on the lands owned by the federal government often must make decisions without access to what would appear to be crucial information.²⁰ The situation facing

¹⁶ See *infra* notes 198-239 and accompanying text.

¹⁷ 42 U.S.C. §§ 4321-4370f.

¹⁸ 16 U.S.C. §§ 1531-1544.

¹⁹ *Citizens for Better Forestry v. U.S. Dep't of Agric.*, 481 F. Supp. 2d 1059 (N.D. Cal. 2007).

²⁰ The scientific uncertainty that surrounds many environmental problems is multi-faceted. In some cases, scientific uncertainty exists because research that is currently feasible has not yet been conducted. In others, it may exist because ethical prohibitions, resource constraints, or limits on available experimentation methods make it impossible to generate the information that would reduce the uncertainty. See Wendy E. Wagner, *Congress, Science, and Environmental Policy*, 1999 U. ILL. L. REV. 181, 190-91.

these agencies involves what may be called “bounded rationality”; the decisionmaker’s effort to understand the implications of its actions is bounded by constraints on its ability to gather or analyze information. Yet the statutes under which these agencies operate typically require that their decisions be the product of scientific analysis.

At times, Congress has recognized the uncertain milieu in which an agency’s decisionmaking process is steeped by allowing the agency to make its decisions based on the “best *available* science,” usually without defining, however, what constitutes the best available scientific information or how the agency is supposed to go about accumulating or assessing it. Agencies have developed different methods for enabling them to make decisions with potential effects on the environment despite missing or incompletely understood information. Among these important techniques is the use of models or surrogates that produce simulations of the real world based on limited information. This part discusses the problem of bounded rationality, how it affects the statutory obligations of agencies to factor science into their determinations, and both the benefits and limits of modeling and the use of surrogates as techniques for dealing with bounded rationality.

A. Bounded Rationality, Science, and Value Judgments In Environmental and Natural Resource Management Laws

The need to make decisions in the absence of complete information is not unique to the federal agencies responsible for protecting human health and the environment or for managing the federal lands and the resources they contain. The behavioral school of economics posited during the 1950s that various kinds of institutional decisionmaking are subject to what advocates of that school of thought referred to as “bounded rationality.”²¹ The essential insight of the behavioral economists

was that decision-making in any institution is “bounded” by time, resources, and cognitive constraints that make it virtually impossible to verify that the solution chosen is optimal. In other words, an effort to find the “best” solution to a problem will be hindered by time and cost constraints that limit the search for alternative solutions and information for measuring which solution is better. In addition, individuals are subject to significant cognitive limitations that restrict their ability to make the judgments necessary to pick an optimal solution.²²

If the desire to reach the optimal decision were not to be crippled by the presence of bounded rationality, the decisionmaker would have to find a solution to the problem at hand that was “good enough,” such as by basing the solution on the known factors that the decisionmaker regards as most relevant and important. As a result, the best that organizations facing bounded rationality can do is to rely on “rules of thumb” or ‘heuristics,’ that take into account real-world limitations.”²³ Although this kind of decisionmaking is not based on “comprehensive rationality,” it is nevertheless rational

²¹ SIDNEY A. SHAPIRO & ROBERT L. GLICKSMAN, RISK REGULATION AT RISK: RESTORING A PRAGMATIC APPROACH 23 (2003).

²² *Id.*

²³ *Id.*

because it seeks to advance the organization's goals despite the existence of limited knowledge and uncertainty.

Environmental agencies often engage in the kind of decisionmaking techniques described by the behavioral economists. They do so, as Carol Rose has explained, because policymaking bodies such as legislatures and administrative agencies, unlike scientists, "have to make up their minds on the basis of very incomplete information. . . . Doing nothing is a decision too, and — like doing the wrong thing — it can be a decision that makes environmental problems much worse."²⁴

Reliance on rules of thumb, heuristics, or other techniques for facilitating decisionmaking in the face of scientific uncertainty necessarily requires that the agencies employing those techniques move beyond science as the sole basis for decision.²⁵ An agency that relies on heuristics to make decisions based on limited information generally seeks to extrapolate the available information to a different context. Suppose, for example, that an agency that has conducted tests in which animals were exposed to toxic chemicals at high doses wants to determine the likely effects of exposing humans to those same chemicals at much lower doses. If the agency has no data points in the low-dose region at which humans are likely to be exposed, it must extrapolate the test data in the high-dose region of the dose-response curve to the low-dose region for which information is lacking. If an agency responsible for protecting the vitality of an ecosystem decides that it is impractical to accumulate the information needed to assess the impact of a management action on the entire ecosystem, it may decide to focus on the status of one resource as a proxy for the status of the ecosystem as a whole.

Those kinds of extrapolations, however, are no longer exclusively scientific determinations. Instead, they depend on value judgments inherent in the selection of the methods by which the extrapolation from known to missing information will be made, as there may be multiple possible methods, all of which fit the known facts equally well.²⁶

²⁴ Rose, *supra* note 1, at 290.

²⁵ As Wendy Wagner has explained:

"Science" has been conveniently, albeit roughly, defined by the Supreme Court as that knowledge "derived by [or grounded in] the scientific method." Information is generally not scientific knowledge . . . unless it can be supported by a "scientifically valid" "reasoning or methodology." In most cases this requires the ability to test a hypothesis in a replicable way or to use methods that scientists have generally accepted as valid. When an experiment or observation cannot realistically be conducted (or replicated) to answer a hypothesis or question, the question leaves the province of science and must be resolved in some other way.

Wagner, *supra* note 20, at 188.

²⁶ See *id.* at 189. See also Cass R. Sunstein, *The Arithmetic of Arsenic*, 90 *Geo. L.J.* 2255, 2256 (2002) (quoting PHILLIP L. WILLIAMS ET AL., *PRINCIPLES OF TOXICOLOGY* 456 (2000)) ("Because the shape of the dose-response curve in the low-dose region cannot be verified by measurement, there is no means to determine which shape is correct [W]hen modeling the risks associated with lower doses, the dose/risk range in which regulatory agencies and risk assessors are most frequently interested, there is a wide divergence in the risk projected by [different models, all of which fit existing evidence.] ... In fact ... the risks predicted by these ... models produce a 70,000-fold variation in the predicted response."); ROBERT L. GLICKSMAN ET AL., *ENVIRONMENTAL PROTECTION: LAW AND POLICY* 723 (5th ed. 2007) (displaying results of alternative extrapolation models for the same data points on dose-response curve for tests to assess carcinogenicity of chemical in mice). "[U]nderstanding the strengths and weaknesses of any particular

Thus, as Wendy Wagner has explained, “not only must policymakers gather available positive knowledge, but they also must appreciate where this information leaves off and the various, scattered uncertainties begin. In fact, determining the nature and importance of these various knowledge gaps is an unusually esoteric inquiry” that involves a mix of science and policy issues.²⁷ Moreover, although some questions are posed in terms that may appear to be entirely scientific — such as whether a given level of exposure to a pollutant is safe, or whether a proposed activity will “jeopardize” an endangered species — their resolution inevitably requires the decisionmaker to make policy judgments, regardless of the breadth of scientific information available.²⁸

Thus, in many situations in which Congress has required agencies to justify their decisions on “scientific” grounds, the existence of scientific uncertainty prevents the agency from restricting the factors it considers to those that are exclusively scientific. Although an agency’s consideration of available scientific knowledge in these contexts may help to “legitimize” its decisions, the agency cannot avoid the need to make value judgments and policy determinations in reaching its ultimate conclusion about whether to permit a certain activity with potential adverse effects on the environment to proceed and, if so, to what extent.²⁹

B. Accommodating Bounded Rationality in Environmental Policy Decisions

Faced with the impossibility of eliminating scientific uncertainty, both Congress and the federal agencies responsible for protecting the environment and preserving the nation’s natural resource base have taken steps to accommodate bounded rationality, while retaining a science-based focus for addressing environmental problems. Some of the federal environmental laws require that agencies base their decisions on the “best available science,” thereby recognizing that complete information may never be available. In such situations, the statutes charge the agencies with doing the best they can to mine the information that it is practical to obtain before discharging their statutory responsibilities. Some agencies, including the Forest Service, have interpreted statutory

model is essential to understanding the relevance of specific target organ toxicities to what would be expected in humans.” Carl F. Cranor & David A. Eastmond, *Scientific Ignorance and Reliable Patterns of Evidence in Toxic Tort Causation: Is There A Need for Liability Reform?*, 64-AUT. L. & CONTEMP. PROBS. 5, 33 (2001).

²⁷ Wagner, *supra* note 20, at 193.

²⁸ In deciding whether a given level of exposure to pollution is safe, for example, an agency may have to decide whether it is “safe” for humans to experience an excess risk of contracting cancer of one in a million or one in 100,000. The agency will have to make that policy determination even if it has epidemiological data upon which it may make an accurate assessment of the risk of exposure.

²⁹ Tarlock, *supra* note 5, at 142-43. See also RICHARD J. LAZARUS, *THE MAKING OF ENVIRONMENTAL LAW* 224 (2004) (asserting that “[s]cience will not supply the fixed standard for what constitutes the appropriate level of ecosystem protection for simple application by environmental lawmakers”); DAVID SCHOENBROD, *SAVING OUR ENVIRONMENT FROM WASHINGTON: HOW CONGRESS GRABS POWER, SHIRKS RESPONSIBILITY, AND SHORTCHANGES THE PEOPLE* 69 (2005) (contending that the “finely calibrated techniques” of science “provide no right answer to many questions of the greatest [environmental] policy consequence”).

provisions requiring that decisions be based on science as permitting decisionmaking based on the best available science.

Agencies also have frequently accommodated bounded rationality by resorting to simulation techniques such as modeling and the use of surrogates. Reliance on modeling or surrogates allows the decisionmaker relying on these techniques to extrapolate from known information to realms of uncertainty, thereby plugging data gaps that otherwise might have prevented the decisionmaker from justifying its decisions in scientific terms.

The remainder of this part describes these techniques for accommodating bounded rationality. Part III analyzes the efforts of the Forest Service to use best available science mandates, modeling, and surrogates to carry out its responsibility under the NFMA to protect plant and animal diversity in the national forests.

1. “Best Available Science” Mandates

Provisions requiring that federal environmental and natural resource management agencies base their decisions on consideration of the “best available science” are common. Perhaps the best known of these is the provision of the ESA requiring the Interior and Commerce Departments to base their decisions on whether or not to list a species as endangered or threatened “solely on the basis of the best scientific and commercial data available.”³⁰ But Congress has used the same or similar language in a variety of other pollution control and natural resource management statutes.³¹

Although Congress has never defined the term “best available science” in any of the environmental statutes in which that term is used,³² it has explicitly recognized in directing that agencies make decisions on that basis that the optimal amount of scientific evidence for making the decision involved may not be available.³³ As Holly Doremus has explained, a “best available science” mandate may serve multiple purposes. These include ensuring that an agency’s decisions accurately reflect known scientific information, imposing a mandate on the agency to make its best efforts to ferret out available information,³⁴ placing an imprimatur of objectivity on agency decisions to

³⁰ 16 U.S.C. § 1533(b)(1)(A).

³¹ See Michael J. Brennan et al., *Square Pegs and Round Holes: Application of the “Best Scientific Data Available” Standard in the Endangered Species Act*, 16 TUL. ENVTL. L.J. 387, 402-03 (2003) (citing various federal and state laws, including the Safe Drinking Water Act, the Marine Mammal Protection Act, and the Magnuson-Stevens Act); Holly Doremus, *Listing Decisions Under the Endangered Species Act: Why Better Science Isn’t Always Better Policy*, 75 WASH. U. L.Q. 1029, 1033-34 (1997) [cited hereinafter as Doremus, *Listing Decisions*] (listing natural resource management statutes that use variants of the “best available science” terminology). See also A. W. Harris, *The Best Scientific Evidence Available: The Whaling Moratorium and Divergent Interpretations of Science*, 29 WM. & MARY ENVTL. L. & POL’Y REV. 375 (2005) (discussing efforts by the International Whaling Commission to limit whaling).

³² Doremus, *Listing Decisions*, *supra* note 31, at 1033-34. See also Brennan, *supra* note 31, at 390 (stating that, although Congress placed a “near-talismanic reliance” on the use of the best available science in the ESA, it “failed to provide guidance on how to determine whether particular data meets this standard”).

³³ Doremus, *Listing Decisions*, *supra* note 31, at 1075.

³⁴ “[T]he ESA’s best available science mandate might impose . . . an affirmative obligation to find data, rather than to simply evaluate what others present. A few courts have interpreted the [ESA’s] best

increase public trust and enhance the agency's credibility,³⁵ and creating a basis for resolving judicial challenges to agency decisions.³⁶ Ultimately, it is possible for the adoption of a statutory or regulatory mandate that an agency base its decisions solely on the "best available science" to make it harder for environmental agencies to weaken environmental and natural resource protection mechanisms by relying on political opposition or on factors, such as economic considerations, that tend to cut against stringent pollution control requirements or meaningful constraints on natural resource development.³⁷

2. *Modeling and Reliance on Surrogates*

The environmental and natural resource management agencies have sought to accommodate bounded rationality in two other, related ways. First, agencies have created models that enable them to predict the impacts of their decisions on the environment by simulating real world conditions. Second, they have focused their

available science mandate to impose precisely such an obligation," although some have refused to do so. Holly Doremus, *The Purposes, Effects, and Future of the Endangered Species Act's Best Available Science Mandate*, 34 ENVTL. L. 397, 424 (2004) [cited hereinafter as Doremus, *Best Available Science Mandate*]. Compliance with a mandate to engage in the agency's best efforts could involve a change in the ways in which the agency accumulates or interprets scientific information, such as engaging in peer review before determining whether to credit a particular piece of evidence. *Id.* at 432-33.

³⁵ Professor Doremus has explained:

When they first developed the best available science mandate, legislators and regulators alike might well have believed that it would increase public acceptance of ESA decisions. People are more likely to accept outcomes that prove unfavorable to their interests when they trust the motives of the actor. The apparent objectivity of science seems ideally suited to enhancing trust. It is no surprise, therefore, that politicians have often cloaked decisions made on other grounds in the garb of science.

Id. at 426-27. In addition, Professor Doremus speculates that a "best available science" mandate may have the effect, if not the purpose, of shifting decisionmaking authority within the agency from political appointees to scientists, many of whom are likely to be career employees. If such a shift were to occur, it might actually result in a decisionmaking process that relies more heavily on objective assessments of scientific evidence and less on raw political determinations.

³⁶ A best available science mandate might prompt more deferential substantive review if the courts are inclined to defer to an agency's scientific and technical determinations. *See, e.g.*, *Baltimore Gas & Elec. Co. v. Natural Res. Def. Council, Inc.*, 462 U.S. 87 (1983) (enunciating deferential standard of judicial review of agency technical determinations). On the other hand, a "best available science" mandate may provide a basis for a court to scrutinize the agency's explanation to determine whether it has adequate support in the record. *See Doremus, Best Available Science Mandate, supra* note 34, at 430; Brennan et al., *supra* note 31, at 412 (stating that "many courts applying the best scientific data available standard under the ESA have imposed an affirmative obligation on the agency to explain why, when faced with two contradictory scientific conclusions, it chooses one over the other").

³⁷ *See, e.g.*, Doremus, *Best Available Science Mandate, supra* note 34, at 435-36:

[T]he best available science mandate may be playing a vital role in stiffening agencies' conservation backbones. It prevents the agencies from openly making decisions based on the costs of conservation or expected political opposition. Undoubtedly, expected economic and political costs still figure in, but they cannot be openly acknowledged as the basis for a decision. Decisions must be scientifically defensible, even if other unacknowledged factors contribute to them. The mere suggestion that a decision expressly considered political or economic factors can make judicial reversal more likely.

See also Doremus & Tarlock, supra note 4, at 22 (arguing that the ESA's "best available science" mandate amounts to "a finger on the scale, of some indeterminate size, on the side of the species").

analysis on a small component of a particular human-nature interaction and used it as a surrogate for the larger problem to which they are responding or which they are attempting to manage. The two mechanisms for accommodating bounded rationality are interrelated because one of the primary challenges for modelers is to “find reliable surrogate variables to permit the [agency] to ‘scale up’ the more finely scaled measurements researchers typically collect.”³⁸ Simulation techniques can facilitate decisionmaking in the face of scientific uncertainty by allowing agencies to extrapolate from observed data to situations in which apparently crucial information is missing. Modeling exercises cannot eliminate uncertainty, however, and they create a risk that those conducting the modeling exercise can mask value judgments behind a façade of technical objectivity.

a. The Ubiquity of Modeling in Environmental Policymaking

Modeling and other simulation techniques have become important components of policymaking in many fields, including environmental law.³⁹ Modeling is an integral part of the process of the implementation of pollution control statutes. The federal Clean Air Act (CAA) is perhaps the best example of the wide variety of uses to which modeling may be put in efforts by federal and state agencies to minimize risks to public health and the environment resulting from pollution. Both the United States Environmental Protection Agency (EPA) and state agencies have relied on modeling to designate air quality control regions under the program for achieving the national ambient air quality standards (NAAQS).⁴⁰ EPA has used models to establish emission limitations for individual sources of air pollution in crafting nationally uniform emission standards for stationary sources⁴¹ and state pollution control agencies have done so in developing state implementation plans (SIPs) for achieving the NAAQS.⁴² Indeed, the CAA requires that

³⁸ Fred L. Bunnell & Mark Boyland, *Decision-Support Systems: It's the Question Not the Model*, 10 J. FOR NATURE CONSERVATION 269, 274 (2003). Bunnell and Boyland add:

The advantages gained in assisting management emphasize the importance of developing reliable, interim surrogate variables for those portions of the real world amenable for aggregation. When we make decisions we incorporate only a few variables effectively. Again it is apparent that the largest benefit gained from the system is in thinking through the questions, variables, and choices carefully.

Id.

³⁹ See, e.g., Antje Kann & John P. Weyant, *Approaches for Performing Uncertainty Analysis in Large-Scale Energy/Economic Policy Models*, 5 ENVTL. MODELING AND ASSESSMENT 29, 29 (1999) (asserting that, “[w]ith rapid advances in computing power over the last decade, large-scale models have become essential to decision making in public policy”).

⁴⁰ See, e.g., PPG Indus., Inc. v. Costle, 630 F.2d 462 (6th Cir. 1980) (holding, however, that modeling exercise was based on erroneous data). See generally Bruce M. Kramer, *Air Quality Modeling: Judicial, Legislative and Administrative Reactions*, 5 COLUM. J. ENVTL. L. 236 (1979).

⁴¹ See, e.g., Lignite Energy Council v. EPA, 198 F.3d 930 (D.C. Cir. 1999) (upholding new source performance standards based on extrapolation of one industry’s performance to another industry). Cf. 42 U.S.C. § 7412(k)(3)(D) (authorizing the use of modeling in the development of a national strategy for controlling emission of hazardous air pollutants in urban areas).

⁴² See, e.g., BCCA Appeal Group v. EPA, 355 F.3d 817 (5th Cir. 2004) (upholding EPA’s reliance on photochemical grid model in approving Texas’s demonstration that Houston SIP would achieve attainment of ozone NAAQS, despite the model’s inability to replicate the city’s unique meteorological conditions); Pan Am. Grain Mfg. Co. v. EPA, 95 F.3d 101 (1st Cir. 1996); Cincinnati Gas & Elec. Co. v. EPA, 578 F.2d

certain demonstrations that an SIP will provide for attainment of the NAAQS be based on photochemical grid modeling or similar analytical techniques approved by EPA.⁴³ The agencies have relied on models to decide whether to issue permits specifying emission limitations and to establish the limitations set forth in those permits.⁴⁴ Models also have been used to assist in the implementation of emissions trading programs.⁴⁵

Modeling is also potentially useful in protecting other resources from the adverse effects of pollution. Modeling can provide a basis for predicting the impact of oil spills and hazardous substance releases on groundwater quality.⁴⁶ Models are used in conducting risk assessments to determine the potential carcinogenicity of tested chemical substances to extrapolate the dose-response data obtained in high-dose animal tests to the levels of likely human exposure, for which there is no data or insufficient data.⁴⁷

660 (6th Cir. 1978); *Ohio v. EPA*, 784 F.2d 224 (6th Cir. 1986); *Cleveland Elec. Illuminating Co. v. EPA*, 572 F.2d 1150 (6th Cir. 1978). See also Michael S. McMahon & Steven D. Hinkle, Note, *State of Ohio v. EPA: Does the Sixth Circuit Have A New Standard for Its Review of the EPA's Use of Air Quality Modeling?*, 18 U. TOLEDO L. REV. 569 (1987).

⁴³ 42 U.S.C. § 7511a(c)(2)(A). In *Env'tl. Def. v. EPA*, 369 F.3d 193 (2d Cir. 2004), the court interpreted the statute as requiring only that grid modeling form the "foundation and principal component of the attainment demonstration." See also *Sierra Club v. EPA*, 356 F.3d 296 (D.C. Cir. 2004) (construing § 7511a(c)(2)(A) as allowing EPA to adjust results of photochemical grid modeling to assure consistency with real-world observations as a means of demonstrating attainment of ozone NAAQS).

⁴⁴ See, e.g., *Sur Contra La Contaminacion v. EPA*, 202 F.3d 443 (1st Cir. 2000); *Northern Plains Res. Council v. EPA*, 645 F.2d 1349 (9th Cir. 1981). See generally James A. Westbrook, *Air Dispersion Modeling: Tools to Assess Impacts from Pollution Sources*, 13 NAT. RESOURCES & ENV'T 546 (Spring 1999).

⁴⁵ See generally Camille V. Otero-Phillips, *What's in the Forecast? A Look at the EPA's Use of Computer Models In Emissions Trading*, 24 RUTGERS COMPUTER & TECH. L.J. 187 (1998).

⁴⁶ See generally Michael Sklash et al., *Groundwater Models: Can You Believe What They Are Saying?*, 13 NAT. RESOURCES & ENV'T 542 (Spring 1999).

⁴⁷ See, e.g., John S. Applegate & Celia Campbell-Mohn, *Risk Assessment: Science, Law and Policy*, 14 NAT. RESOURCES & ENV'T 219, 220 (2000) (explaining that epidemiologists "must rely on animal testing to estimate the likelihood that cancer will be induced at a given level of exposure" and that "[t]o predict the dose response in humans at low levels of exposure over long periods of time, risk assessors must use theoretical models because direct observation is impossible"); Michael Schon, Comment, *Susceptible Children: Why the EPA's New Risk Assessment Guidelines for Children Fail to Protect America's Future*, 36 ARIZ. ST. L.J. 701, 704 (2004) (stating that "risk assessment creates an equation that allows regulators to predict what the probable risk of cancer would be when people are exposed to a chemical at a particular level or concentration," that, "[i]n formulating this equation, . . . the EPA makes assumptions and develops mathematical models to fill in gaps (or 'uncertainties') caused from lack of scientific knowledge," and that risk assessment therefore "blends scientific knowledge with probabilistic assumptions"); Vern R. Walker, *The Myth of Science as a "Neutral Arbiter" For Triggering Precautions*, 26 B.C. INT'L & COMP. L. 197, 209-10 (2003) (stating that "[t]oxicologists and exposure modelers often use linear regression models to characterize the incremental contributions of multiple hazards (e.g., asbestos exposure and cigarette smoking) to the total risk of an adverse effect (e.g., lung cancer)" and that "scientists use a variety of mathematical models to characterize the quantitative relationships among multiple variables"); Peter C. Wright et al., *Twenty-Five Years of Cancer Risk Assessment*, 19 NAT. RESOURCES & ENV'T 31, 34 (Spring 2005) (explaining that "EPA has for many years employed the multistage dose-extrapolation model, which generally predicts the highest cancer risk of all the most commonly used models and then increases the prediction of risk by estimating the statistical upper bound on the best estimate of the multistage model at low doses"); Thomas R. Head, III, *PCBs — The Rise and Fall of an Industrial Miracle*, 19 NAT. RESOURCES & ENV'T 15, 18 (Spring 2005).

The federal agencies responsible for managing publicly owned lands and resources also commonly engage in modeling exercises. The Coastal Zone Management Act explicitly authorizes modeling to assess water quality in coastal waters and the Great Lakes.⁴⁸ The Fish and Wildlife Service uses modeling to assist in listing and delisting decisions,⁴⁹ in designating critical habitats,⁵⁰ and in allowing incidental takings under the ESA and the Marine Mammal Protection Act.⁵¹ Land management agencies such as the National Park Service also rely on modeling exercises to assist in the development of standards to guide decisions on which uses to permit or prohibit.⁵² These agencies, among others, also use modeling in the preparation of environmental assessments and environmental impact statements under NEPA.⁵³

b. The Benefits of Modeling

A model has been defined as “a tool used to simulate some aspect of the real world”⁵⁴ or as “a simplified representation of some aspect of the real world” that allows its user to accomplish a “purposeful reduction of a mass of information to a manageable size and shape.”⁵⁵ Some models or other proxies for reality seek to extrapolate data from small-scale phenomena (such as the effects of a timber harvest on a single animal species) to predict the effects on a larger whole (such as an ecosystem in which the single species lives). Others use observations on a relatively large scale (such as the observed effects of exposing laboratory animals to maximum tolerated doses of toxic chemicals) to predict the effects of smaller-scale activity (such as the effects of low-level human

⁴⁸ 16 U.S.C.A. § 1451(g)(2)(B) (requiring evaluation of “research programs on the causes, characteristics, and impacts of hypoxia, including recommendations of how to eliminate significant gaps in hypoxia modeling and monitoring data”).

⁴⁹ See, e.g., Endangered and Threatened Wildlife and Plants; Designating the Greater Yellowstone Ecosystem Population of Grizzly Bears as a Distinct Population Segment; Removing the Yellowstone Distinct Population Segment of Grizzly Bears From the Federal List of Endangered and Threatened Wildlife, 70 Fed. Reg. 69,854, 69,859 (Nov. 17, 2005).

⁵⁰ See, e.g., Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Bull Trout, 70 Fed. Reg. 56,212, 56,237 (Sept. 26, 2005).

⁵¹ See, e.g., Marine Mammals; Incidental Take During Specified Activities, 68 Fed. Reg. 66,744, 66,745 (Nov. 28, 2003) (discussing model that simulated the effects of oil spills on estimated polar bear survival in the Beaufort Sea).

⁵² See, e.g., Clarification of the Term the Day in the Definition of Substantial Restoration, 68 Fed. Reg. 63,129, 63,130 (Nov. 7, 2003) (discussion of computer modeling for analyzing effects of aircraft operations on noise levels within the Grand Canyon).

⁵³ See, e.g., Utah Env'tl. Cong. V. Richmond, 483 F.3d 1127, 1140 (10th Cir. 2007) (describing the Forest Service's use of two computer models to calculate the amount of expected runoff resulting from timber sale project and the effect on stream channels); *Lands Council v. Powell*, 395 F.3d 1019, 1031-32 (9th Cir. 2005) (challenge to the Forest Service's use of the Water and Sediment Yields (WATSED) model for assessing cumulative effects of timber harvest projects on in-stream sedimentation); Basin Creek Fuels Reduction Project, Beaverhead-Deerlodge National Forest, Silver Bow, County, MT, 68 Fed. Reg. 17,906, 17,906 (Apr. 14, 2003) (discussing use of fire simulation models to determine where fuels treatments would be the most effective in slowing fire while minimizing the number of acres needing to be treated); Phase II Amendment of Black Hills National Forest Land and Resource Management, 66 Fed. Reg. 59,406, 59,406 (Nov. 28, 2001) (referring to recalculation of allowable timber sale quantity and other forest outputs based on Forest Vegetation Simulator (FVS), Habitat Capability (HABCAP), and spatial analysis models).

⁵⁴ Fine & Owen, *supra* note 6, at 903 n.1.

⁵⁵ *Id.* (quoting EDITH STOKEY & RICHARD ZECKHAUSER, A PRIMER FOR POLICY ANALYSIS 8 (1978)).

exposure to those chemicals).⁵⁶ Models serve as “decision support systems” that both simplify the physical reality being analyzed and translate observed results into predictions that would not be available simply by observing that reality.⁵⁷ Models can increase the analyst’s understanding of the relationships at issue (*e.g.*, between a timber sale and its impact on biological diversity) by combining or presenting data in a way that provides new insights or extends those relationships beyond the range of observed measurement. If the predictions provided by a model turn out to conform to subsequently observed real world developments, the modelers gain confidence in the accuracy of the assumptions upon which the model is based concerning the relationships between human activities and environmental effects.⁵⁸

Models are particularly well suited to large-scale planning efforts. Because they are capable of “represent[ing] mathematically complex chemical, physical and social relationships,” they allow planners “to make predictions and test assumptions in ways that otherwise would not be possible. Not surprisingly, models have become essential and ubiquitous planning tools, our dependence upon them making their abandonment all but unthinkable.”⁵⁹ Two observers recently described the attractiveness of modeling to planners in the following terms:

Policymakers often must predict outcomes of complicated processes, and making those predictions would be all but impossible without models. Complex environmental systems often involve more variables, data, and interdependent feedback processes than people reasonably can organize in their minds, and interactions within these systems may create counterintuitive, nonlinear responses that are impossible to understand without models. Models can organize, manipulate, and process vast quantities of data and can simulate complex multivariable processes, and these capacities allow them to predict the future, compare alternative possible futures, test the ramifications of assumptions, and contribute to improved understanding of system interactions. These powers are invaluable in planning efforts.⁶⁰

Moreover, modeling is an efficient analytical technique because it reduces the time and expense needed to gather information, even when acquiring the relevant data through

⁵⁶See Rose, *supra* note 1, at 291 (asserting that policymakers extrapolate both from large to small and vice versa, but that “the large-to-small extrapolation . . . is especially common in environmental policy”). For a discussion of the validity of conducting animal tests for carcinogenesis at maximum tolerated doses, see GLICKSMAN ET AL., *supra* note 26, at 722-24.

⁵⁷Bunnell & Boyland, *supra* note 35, at 270. See also Fine & Owen, *supra* note 6, at 912 (“models allow scientific knowledge to be codified and standardized”).

⁵⁸Bunnell & Boyland, *supra* note 38, at 272-73.

⁵⁹Fine & Owen, *supra* note 6, at 904.

⁶⁰*Id.* at 912-13. See also Hanna J. Cortner & Dennis L. Schweitzer, *Institutional Limits and Legal Implications of Quantitative Models in Forest Planning*, 13 ENVTL. L. 493, 497 (1983) (arguing that “[q]uantitative analytical procedures are necessary to utilize fully data describing complex situations. Computers make the use of sophisticated mathematical models possible. They provide the mechanism to organize and manipulate data, to formulate and project management alternatives into the future, and to assess physical and socioeconomic implications.”).

real-world experiments and observation rather through simulation exercises is both possible and ethically appropriate.⁶¹

c. The Limits of Modeling

Modeling and other simulation techniques (such as the use of surrogate variables to represent more complicated relationships between human activities and the resulting environmental effects) allow environmental and natural resource management agencies to make decisions, despite the presence of scientific uncertainty about some aspects of those relationships. They allow agencies whose statutory mandates compel decisions based on science to make decisions even when significant scientific information does not yet exist, or at least when that information is not currently available to the agency. Models do not eliminate uncertainty, however, and may even exacerbate it if the models provide a distorted representation of the real world. Nor, despite their façade of objectivity, do models eliminate the subjective component of environmental decisionmaking or prevent agencies from making value judgments. Finally, the technical nature of modeling exercises may shield the agency's assumptions and value judgments from public scrutiny, thereby precluding meaningful public participation in agency decisionmaking processes.

Models allow decisionmakers to simulate reality in situations in which direct observations of the phenomenon being analyzed are either impossible or impractical.⁶² Models, however, are only “placeholders for reality.”⁶³ They are capable neither of providing a completely accurate representation of reality nor of eliminating the scientific uncertainty that induces the decisionmaker to resort to modeling in the first place.⁶⁴ Errors in the design and application of models are common, but may not be easy to discover. The inability of models to provide perfect replications of reality becomes a problem if the administrative agencies using the models to make decisions fail either to recognize or acknowledge these imperfections. If they fail to recognize them, they may continue to rely on models that provide flawed output. The result may be that the agency

⁶¹ See Fine & Owen, *supra* note 6, at 913. The authors state:

Policymakers rarely can perform real-world experiments; large-scale experiments upon the environment are generally prohibitively time-consuming and expensive, and the threat of human injury or irreparable environmental harm makes some experimentation ethically suspect at best. Models avoid these problems by performing their tasks in controlled settings, without experimentation upon the actual environment. [Although g]athering model input data can require extensive effort — indeed, data gathering is often the most expensive and time-consuming task in a modeling study. . . the financial costs of modeling, while often quite large in actual dollar terms, can pale in comparison to the costs of other planning methods.

⁶² Cf. Sklash, *supra* note 46, at 542 (defining a model as “any simulation of a real thing”).

⁶³ Thomas O. McGarity & Wendy E. Wagner, *Legal Aspects of the Regulatory Use of Environmental Modeling*, 33 ENVTL. L. REP. (ENVTL. L. INST.) 10751, 10763 (2003).

⁶⁴ See Fine & Owen, *supra* note 6, at 904; *id.* at 922 (contending that, because “no model can incorporate all real data or simulate all of the processes that might influence an outcome” and “every model is necessarily an approximation of reality, models' predictions unavoidably contain some error”). Uncertainty in models take two forms: “parametric uncertainty, which arises due to imperfect knowledge,” and “stochasticity, which is due to inherent variability in certain processes.” Kann & Weyant, *supra* note 39, at 30. Whereas the first kind of uncertainty decreases over time as scientists accumulate additional factual knowledge, “stochastic uncertainty is not reduced over time” because “natural variability will always occur.” *Id.*

makes decisions that conflict with governing statutory criteria or with the agency's own stated goals.⁶⁵ The limitations on data that initially prompted resort to the models may hinder the modelers' ability to assess whether the models are working in the intended manner.⁶⁶ If an agency using simulation techniques is aware of modeling flaws but fails to disclose them, not only may the decisions based on the model deviate from statutory norms, but affected entities and the public at large may have difficulty discovering the deviation.

Models not only fail to provide complete representations of objective reality. By their very nature, they are also incapable of providing analysis that is entirely objective, although they may be perceived in that manner.⁶⁷ Models are built upon assumptions. Those assumptions inevitably reflect value judgments. These value judgments can affect the selection of a model from among several alternatives, the design of the model, and the manner in which modeling results are interpreted and communicated.⁶⁸ If toxicologists use models to provide estimates of the risk of getting cancer as a result of long-term, low-level exposure to cancer-causing substances, for example, they may assume that there is no safe level of exposure in the absence of data to the contrary. Alternatively, they may take the position that the absence of data demonstrating a risk at low levels of exposure should be interpreted as evidence that a safe threshold level of exposure exists at the lowest point on the dose-response curve at which known adverse effects have occurred. The choice between these two competing assumptions requires the analyst or policymaker to make a judgment call. The first assumption reflects a decision to err on the side of safety, while the second may be based on a desire not to restrict economically productive activity that creates potentially carcinogenic exposures in the absence of a demonstrable threat to the public health. Similarly, a model that seeks to compare the costs and benefits of implementing an environmental protection measure will have to incorporate a discount rate to compute the number (and perhaps the value) of lives saved in the future and the costs that will result from alternative levels of regulation.⁶⁹

The necessity of making value judgments in the design of models or other simulation techniques is not problematic, as long as those judgments are disclosed so the impacts of those judgments on the modeling results can be assessed. As two observers of the use of modeling by the Forest Service have put it:

⁶⁵ See, e.g., Falk Huetmann, *Databases and Science-Based Management in the Context of Wildlife and Habitat: Toward a Certified ISO Standard for Objective Decision-Making for the Global Community by Using the Internet*, 69 J. OF WILDLIFE MGMT. 466, ___ (April 2005) (stating that “[d]ecisions based on soft foundations can harm wildlife and habitat and threaten future survival”).

⁶⁶ See Fine & Owen, *supra* note 6, at 924-25.

⁶⁷ See Cortner & Schweitzer, *supra* note 60, at 516 (contending that “[v]alue-laden considerations permeate both the formulation of the model and the application of model results” and that “[q]uantitative models are subject to the same qualitative and subjective influences as the beyond-the-model portion of the decision process”).

⁶⁸ See Fine & Owen, *supra* note 6, at 927-29.

⁶⁹ See Kann & Weyant, *supra* note 39, at 30 (referring to policy choices about protecting future generations involved in the selection of a discount rate); *id.* at 29 (stating that different underlying assumptions, such as how to value a human life, can lead to widely varying results among different models). See generally Lisa Heinzerling, *Environmental Law and the Present Future*, 87 GEO. L.J. 2025 (1999); Lisa Heinzerling, *Discounting Our Future*, 34 LAND & WATER L. REV. 39 (1999).

Values are unavoidable. The use of quantitative planning models, specifying ways of doing things in a reproducible manner and seeking to substitute mathematical algorithms for intuitive judgments, appears to make the planning process more rational and scientific. The danger is that the planning agency, the courts, and the public may all lose sight of where and how these unavoidable values enter quantitative models and the impact they have on the use of analytical results.⁷⁰

Indeed, the value judgments reflected in quantitative models may be less problematic than those built into nonquantitative scientific hypotheses based on analogies or metaphors, provided the modeler discloses the algorithm upon which the model is based. The underlying assumptions of a mathematical model may be more easily examined, assessed for potential bias, and falsified than the less visible assumptions and value judgments built into a non-mathematical model. One criterion for determining whether an analytical technique qualifies as “scientific” is whether the theories upon which it proceeds are falsifiable.⁷¹ To the extent that a quantitative model lends itself more readily to falsification, its use fits more comfortably within the framework of scientific analysis than an analogical model whose underlying assumptions are hidden.

According to some who have analyzed science-based decisionmaking by the federal land management agencies, the use of modeling by those agencies is susceptible to the criticism that the agencies, intentionally or not, have masked their value judgments in the language of technical determinations. As a result, “outsiders are frequently unable to discover exactly what [the Forest Service has] done or to determine if bias has crept into analysis. For example, management activities thought to be undesirable might be eliminated from consideration without explicit analysis, or constraints judged overly restrictive relaxed to give the decisionmaker a greater range of discretion.”⁷² Decisions by the Interior Department’s Fish and Wildlife Service and the Commerce Department’s National Oceanic and Atmospheric Administration Fisheries under the ESA have provoked a similar charge:

Rather than achieving either value-neutral or politically invulnerable decisionmaking, the strictly science mandate [of § 4 of the ESA] has encouraged the listing agencies to devise an inscrutable listing policy hidden behind a wall

⁷⁰ Cortner & Schweitzer, *supra* note 60, at 495-96. See also Doremus, *Constitutive Law*, *supra* note 1, at 334-35:

The obsessive search for objective bases for decisions also creates a temptation to disguise non-objective decisions as scientific, a practice that skews the political process and can interfere with our ability to achieve our real goals. Where science or economics cannot provide the answers that policy decisions require, seemingly objective criteria are more likely to hide than to overcome the biases of decisionmakers, and are not likely to produce consistent or predictable decisions.

⁷¹ See *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 593 (1993) (quoting KARL POPPER, *CONJECTURES AND REFUTATIONS: THE GROWTH OF SCIENTIFIC KNOWLEDGE* 37 (5th ed. 1989) (“[T]he criterion of the scientific status of a theory is its falsifiability, or refutability, or testability”) (emphasis deleted).)

⁷² Cortner & Schweitzer, *supra* note 60, at 503.

labeled science. The mandate has produced listing decisions which are often incomprehensible even to informed observers, and nearly inaccessible to the general public.⁷³

d. Judicial Review of Model-Based Decisionmaking by Environmental and Natural Resource Management Agencies

Litigants have challenged decisions by environmental agencies based on the use of models, surrogates, or other simulation techniques. In some of these cases, the challengers have asserted procedural errors in the agency's decisionmaking process, while in others the litigants have claimed that the decisions were substantively flawed.

In reviewing challenges to the use of agency models, the courts in environmental cases have recognized the importance of disclosing and providing an opportunity to comment upon the model's assumptions.⁷⁴ "In particular, the Agency must provide clear notice of the possibility that it will rely upon a particular model and provide sufficient information about that model to allow the public to comment upon its use of the model in the rulemaking proceeding."⁷⁵ In one case, the D.C. Circuit rejected the claim that EPA failed to afford adequate notice of its intention to rely on a model in deciding whether to list a substance as hazardous air pollutant under the CAA. It found that EPA had explained the basis for the model in the notice of proposed rulemaking, set forth its rationale for making various assumptions, requested comments on those assumptions, addressed significant comments in documents that accompanied the final rule, and made revisions in modeling parameters based upon the comments it received.⁷⁶ As long as the agency follows these steps, the courts are unlikely to invalidate the agency's model-based decision on the ground that it failed to provide proper notice of the model's role in the decisionmaking process.⁷⁷

⁷³ Doremus, *Listing Decisions*, *supra* note 31, at 1129.

⁷⁴ In *Lands Council v. Powell*, 395 F.3d 1019 (9th Cir. 2005), the court held that the Forest Service violated NEPA by approving a timber harvest as part of a watershed restoration project. In particular, the court found that the agency's "heavy reliance" on the WATSED model to analyze the cumulative effects of timber harvests on in-stream sedimentation violated NEPA

because there was inadequate disclosure that the model's consideration of relevant variables is incomplete. Moreover, the Forest Service knew that WATSED had shortcomings, and yet did not disclose these shortcomings until the agency's decision was challenged on the administrative appeal. We hold that this withholding of information violated NEPA, which requires up-front disclosures of relevant shortcomings in the data or models.

Id. at 1032.

⁷⁵ McGarity & Wagner, *supra* note 63, at 10755. See also Fine & Owen, *supra* note 6, at 911 (stating that "[t]he judiciary does acknowledge an obligation to carefully review the procedural integrity of agency decision-making" that is based on the use of models).

⁷⁶ *Chem. Mfrs. Ass'n v. EPA*, 28 F.3d 1259, 1263 (D.C. Cir. 1994).

⁷⁷ See McGarity & Wagner, *supra* note 63, at 10756 (stating that "an EPA modeling exercise conducted in the context of notice-and-comment rulemaking should not suffer reversal on notice grounds if the Agency is careful to describe the model in some detail; identify the assumptions upon which the model relies; explain why those assumptions are valid in the particular context in which it is applying the model; and specifically request comments on the validity of the assumptions and their use in the modeling exercise").

Substantive challenges to an agency's use of modeling in environmental decisionmaking typically face an uphill battle. The courts have been wary of second-guessing the manner in which the environmental agencies have interpreted and applied science.⁷⁸ They also have recognized that, in many environmental decisionmaking contexts, the use of modeling is essential to the ability of the agency to implement its statutory responsibilities.⁷⁹ As a result, judicial review of agency modeling decisions has tended to be very deferential.⁸⁰ The courts typically have not been impressed by claims that an agency chose the wrong model from among competing alternative models,⁸¹ that deficiencies in the data the agency plugged into the model invalidated the results,⁸² that the model did not accurately predict or was not capable of actually predicting real world results,⁸³ or that the agency should have deferred its decision until it could accumulate more information instead of relying on modeling results.⁸⁴

⁷⁸ See, e.g., *id.* at 10757 (claiming that “[t]he general rule for the courts' substantive review of technical models under the informal rulemaking provisions of the APA is deference to the agency's technical and policy choices as long as the agency explains its choices, especially the controverted ones, in an accessible and complete way”); Fine & Owen, *supra* note 6, at 911-12 (asserting that “[r]espect for agencies' interpretations of science . . . [has] become deeply institutionalized within the judiciary” and that “[d]eference to agency judgment is a core element of judicial review of environmental decisions, and judicial opinions are filled with statements about how agencies, not judges, hold technical expertise”).

⁷⁹ See Fine & Owen, *supra* note 6, at 915 (quoting *Sierra Club v. Costle*, 657 F.2d 298, 332 (D.C. Cir. 1981)) (stating that, “[r]ealistically, computer modeling is a useful and often essential tool for performing the Herculean labors Congress imposed on EPA in the Clean Air Act”). One court assessed the utility of groundwater flow modeling as a technique for helping to allocate the costs of responding to groundwater contamination among multiple responsible parties as follows:

If properly used, computer models appear to be an invaluable tool in approximating the complexities of underground fluid flow. Without these models, the scientists and engineers would be limited to guessing at sources and fluid flow characteristics based on the limited number of wells that penetrate the aquifer. Through modeling, reservoir flow and contaminant transport can be calculated using complex mathematical operations that simulate the aquifer characteristics. From that effort, the model can simulate the progression of contaminant plumes from each source, thereby providing an estimate of the size of each plume at any given time. Unfortunately, there are no true crystal balls – the models are only as good as the data placed into them. In this case, the data inputs and methods for configuring the models provided fertile ground for disagreement. Nonetheless, the court concludes that computer modeling of plume size is an appropriate basis for allocating costs.

City of Wichita v. Tr. of the Apco Liquidating Trust, 306 F. Supp. 2d 1040, 1106-07 (D. Kan. 2003).

⁸⁰ *Doremus & Tarlock*, *supra* note 4, at 19 (stating that “[s]cientific judgments are generally set aside only in the most egregious situations, as when it is clear that there is a major inconsistency between the underlying information and the ultimate conclusion”).

⁸¹ See, e.g., *Cleveland Elec. Illuminating Co. v. EPA*, 572 F.2d 1150 (6th Cir. 1978).

⁸² See *McGarity & Wagner*, *supra* note 63, at 10765.

⁸³ See, e.g., *Appalachian Power Co. v. EPA*, 135 F.3d 791 (D.C. Cir. 1998); *Cincinnati Gas & Elec. Co. v. EPA*, 578 F.2d 660 (6th Cir. 1978); *Oceana, Inc. v. Evans*, 384 F. Supp. 2d 203, 221 (D.D.C. 2005) (holding that model used to assess impact of scallop fishing on turtles bore a reasonable relationship to the reality it purported to represent, despite uncertainties in its application), *appeal dismissed sub nom. Oceana, Inc. v. Gutierrez*, 179 Fed. Appx. 703 (D.C. Cir. 2006). *But cf.* *Nuclear Energy Inst., Inc. v. EPA*, 373 F.3d 1251, 1268 (D.C. Cir. 2004) (stating, in the course of holding that EPA violated the Energy Policy Act by choosing a 10,000-year compliance period for its radiation-exposure standards, “that there is still considerable uncertainty as to whether current modeling capability allows development of computer models that will provide sufficiently meaningful and reliable projections over a time frame up to tens-of-thousands to hundreds-of-thousands of years,” and that “[s]imply because such models can provide projections for those time periods does not mean those projections are meaningful and reliable enough to

A case that illustrates the judicial inclination toward deference to agency modeling choices involved an Indian tribe's challenge to the Corps of Engineers' decision to implement a flood control program in the Florida Everglades that entailed the construction of structures such as pump stations and seepage reservoirs. The tribe focused on the Corps's failure to provide information to the FWS based on computer modeling about the effect of the construction on endangered birds before the latter issued its biological opinion on the program. According to the tribe, this failure violated the ESA's mandate that agencies use "the best scientific and commercial data available to ensure the protection" of listed species.⁸⁵ The court refused to find that the Corps violated the ESA, concluding that it was appropriate to defer to the Corps's decision "to proceed with imperfect information."⁸⁶ The Corps did not act in an arbitrary and capricious fashion by relying on limited modeling information, particularly because it feared that awaiting the results of further modeling would allow additional damage to the birds' habitat to occur.⁸⁷

The courts have invalidated agency decisions that relied on modeling or simulation exercises, however, in cases in which they have found that a particular model was ill-suited to the activities to which it was applied⁸⁸ or that the agency was unable to justify building the model on apparently arbitrary assumptions.⁸⁹ Another ESA case provides a natural resources law example of the willingness of the courts to reverse an agency's reliance on modeling or simulation techniques on these grounds. The ESA allows the FWS to issue an incidental take statement (ITS)⁹⁰ that allows federal agencies to engage in activities that otherwise would have violated the ESA's prohibition on the taking of endangered species.⁹¹ When the FWS decides to issue an ITS, it must specify

establish a rational basis for regulatory decisionmaking"); *Ohio v. EPA*, 638 F.2d 910 (6th Cir. 1980) (concluding that EPA's reliance on air quality model was arbitrary in the absence of any effort to test the model's results against actual monitoring data).

⁸⁴ See McGarity & Wagner, *supra* note 63, at 10765.

⁸⁵ 16 U.S.C. § 1536(a)(2).

⁸⁶ *Miccosukee Tribe of Indians v. United States*, 420 F. Supp. 2d 1324, 1337 (S.D. Fla. 2006).

⁸⁷ *Id.*

⁸⁸ See, e.g., *Chlorine Chemistry Council v. EPA*, 206 F.3d 1286 (D.C. Cir. 2000) (invalidating EPA decision to establish zero-level maximum contaminant level goal under the Safe Drinking Water Act for chemical based on application of linear, no-threshold model of carcinogenesis, despite existence of evidence that there was a safe threshold level of exposure); *Columbia Falls Aluminum Co. v. EPA*, 139 F.3d 914, 922 (D.C. Cir. 1998) (invalidating treatment standard for hazardous waste established by EPA under the Resource Conservation and Recovery Act because the assumptions on which a test for determining whether a waste is hazardous was based did not fit the situation to which EPA applied it; the court stated flatly that, as EPA admitted, "the model does not work"); *Edison Elec. Inst. v. EPA*, 2 F.3d 438 (D.C. Cir. 1993) (concluding that EPA failed to demonstrate a rational relationship between test used to measure toxicity and the mineral processing wastes to which it was applied).

⁸⁹ See, e.g., *Chem. Mfrs. Ass'n v. EPA*, 28 F.3d 1259, 1265-66 (D.C. Cir. 1994) (holding that EPA improperly listed a pollutant as a high-risk, hazardous air pollutant based on the use of a generic air dispersion model that included assumptions that EPA conceded were not accurate for that particular pollutant). See generally McGarity & Wagner, *supra* note 63, at 10759-61; Fine & Owen, *supra* note 6, at 915-16.

⁹⁰ 16 U.S.C. § 1536(b)(4).

⁹¹ 16 U.S.C. § 1538(a)(1)(B).

in the ITS, among other things, the amount of the incidental taking that is permitted.⁹² Although the courts have indicated that, ideally, that amount should take the form of a specific number, they have allowed the FWS to substitute a “meaningful surrogate” for the amount of the permissible incidental take if identification of a specific number is not practical.⁹³ In one case, the court held that the FWS violated the ESA by using ecological conditions as a surrogate for the amount of the permissible incidental take because it failed to establish a link between the conditions chosen by the FWS in the ITS and the extent of the incidental taking that would be caused by the Bureau of Land Management’s authorization of off-road vehicle use within the habitat of the listed species.⁹⁴

C. Summary

The federal statutes that delegate authority to administrative agencies to protect the environment from pollution or manage publicly owned land and resources require that the agencies base many of their decisions on scientific determinations, and sometimes require decisions to be based exclusively on scientific grounds. These mandates create difficulties for the agencies when, as is often the case, the relevant scientific knowledge is incomplete. Statutes that permit agencies to premise their decisions on the best available science recognize that demanding that decisions be based on scientific certainty is a chimerical objective in many environmental policy contexts. These statutes address the reality of bounded rationality by requiring that agency decisions conform to the known evidence and to reasonable extrapolations from that evidence. Best available science mandates have the capacity to enhance public trust in agency decisions and provide a standard for judicial review of those decisions.

The environmental and natural resource management agencies have reacted to bounded rationality by adopting a variety of models and related techniques that permit them to simulate the unknown effects of human activities subject to the agencies’ jurisdiction based on organization and manipulation of a relatively small and manageable body of available information. These proxy regimes, like mandates that agencies act on the basis of the best available evidence, may counter the tendency to defer making decisions on important issues until agencies believe that they have mastered all aspects of the particular problem being addressed.

Models and the use of other simulation techniques such as reliance on surrogates, however, are incapable of eliminating bounded rationality, and may even exacerbate preexisting uncertainty if they are built upon flawed input or if their output is improperly interpreted or applied. By mandating that agencies act on the basis of the best available scientific evidence, and by endorsing (explicitly or implicitly) the use of models,

⁹² 50 C.F.R. § 402.14(a)(1)(i).

⁹³ *Ctr. for Biological Diversity v. Bureau of Land Mgmt.*, 422 F. Supp. 2d 1115, 1137-38 (N.D. Cal. 2006) (citing *Arizona Cattle Growers’ Ass’n v. U.S. Fish and Wildlife Serv.*, 273 F.3d 1229, 1249, 1250 (9th Cir. 2001)).

⁹⁴ *Ctr. for Biological Diversity*, 422 F. Supp. 2d at 1138. See also *Arizona Cattle Growers’ Ass’n v. U.S. Fish and Wildlife Serv.*, 273 F.3d 1229, 1250-51 (9th Cir. 2001) (reaching a similar result in the context of an ITS for livestock management that would result in the incidental taking of the desert tortoise).

Congress, in a variety of pollution control and natural resource management contexts, has decided that the risks of doing nothing pending elimination of scientific uncertainty outweigh the risks of erroneous action in the face of uncertainty.

The use of best available science mandates and modeling to address bounded rationality has the potential to subvert the legislative agenda, however, if agencies abuse their statutory discretion to proceed in the face of uncertainty by failing to disclose the inevitable value judgments they must make when they engage in analytical efforts such as modeling or by disguising such judgments in objective terminology. Some of the decision in which the courts invalidated decisions that stemmed from the application of models may provide examples of such failures.

The next part of this article explores how the Forest Service has reacted to bounded rationality in its attempts to comply with its obligation under the NFMA to protect the biological diversity of the national forests. The final part provides suggestions for how to structure the Forest Service's efforts to promote diversity using techniques such as modeling and decisions based on the best available evidence so that the risk of unaccountable decisionmaking and subversion of statutory goals is minimized.

III. RELIANCE ON MODELING AND THE USE OF SURROGATES TO PROTECT BIOLOGICAL DIVERSITY IN THE NATIONAL FORESTS

The NFMA creates a planning process that requires the Forest Service, among other things, to provide for the diversity of plant and animal communities in the national forests.⁹⁵ Part A below briefly describes the NFMA planning process as well as the diversity protection component of that process. Part B explores several contexts in which the Forest Service has used modeling to implement the NFMA's planning provisions. Part C explores in greater detail the approaches to implementation of the diversity mandate reflected in the agency's 1982, 2000, and 2005 land use planning regulations. In particular, it describes the agency's adoption of an approach to diversity protection that relied on the identification and protection of management indicator species and the subsequent abandonment of that approach and its replacement by a much vaguer, self-imposed "best available science" mandate. The discussion seeks to assess whether the Forest Service has succeeded in crafting an approach to decisionmaking in the face of scientific uncertainty that achieves the benefits of modeling and the use of surrogates while avoiding some of the pitfalls described above.

A. The National Forest Management Act's Planning Process and the Diversity Provision

Although the Forest Service engaged in planning efforts before the adoption of the NFMA in 1976, that statute created a more detailed, congressionally directed planning regime than had previously existed.⁹⁶ Spurred in part by excessive use of

⁹⁵ 16 U.S.C. § 1604(g)(3)(B).

⁹⁶ Congress had previously directed the Forest Service to promulgate long-range, systemwide plans in the Forest and Rangeland Renewable Resources Planning Act of 1974. 2 GEORGE CAMERON COGGINS &

clearcutting practices, the NFMA planning provisions require the Forest Service to prepare an assessment every ten years that describes the renewable resources in all of the national forests,⁹⁷ a program every five years that includes planning objectives over a forty-year period for all Forest Service activities,⁹⁸ and an annual report evaluating actual activities in the national forests in relation to the program planning objectives.⁹⁹

Of more direct relevance to this article are the provisions governing the planning process for individual units of the NFS. The NFMA mandates that the Forest Service develop, maintain, and revise as appropriate LRMPs for each unit of the NFS, using a “systematic interdisciplinary approach to achieve integrated consideration of physical, biological, economic, and other sciences.”¹⁰⁰ The planning process for individual units of the NFS entails three steps: the Forest Service’s promulgation of planning regulations,¹⁰¹ the adoption of land use plans for individual units that comport with the regulations,¹⁰² and the authorization of management actions (such as timber sales, grazing permits, or special use permits for recreational uses) in conformity with the applicable plan.¹⁰³

The NFMA specifies that the Forest Service’s planning regulations include guidelines for insuring “consideration of the economic and environmental aspects of various systems of renewable resource management” in protecting forest resources.¹⁰⁴ The statute also requires that plans achieve the goals set forth in the five-year programs by “provid[ing] for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives.”¹⁰⁵ The NFMA directs that, in promoting the substantive purposes of the NFMA planning requirements, including the provision of plant and animal diversity, the Forest Service appoint a committee of scientists to “provide scientific and technical advice and counsel on proposed guidelines and procedures to assure that an effective interdisciplinary approach is proposed and adopted.”¹⁰⁶

The NFMA neither defines the term “diversity of plant and animal communities” nor provides any yardstick for determining whether it exists.¹⁰⁷ The absence of a

ROBERT L. GLICKSMAN, PUBLIC NATURAL RESOURCES LAW § 10F:29 (1990, updated periodically). The most comprehensive discussion of the NFMA’s planning requirements for the national forests is Charles F. Wilkinson & H. Michael Anderson, *Land and Resource Planning in the National Forests*, 64 OR. L. REV. 1 (1985-86). See also Michael J. Gippert & Vincent L. DeWitte, *The Nature of Land and Resource Management Planning Under the National Forest Management Act*, 3 ENVTL. LAW. 149 (1996).

⁹⁷ 16 U.S.C. § 1601(a).

⁹⁸ 16 U.S.C. § 1602.

⁹⁹ 16 U.S.C. § 1606(c). For additional description of all aspects of the NFMA planning process, see 2 COGGINS & GLICKSMAN, *supra* note 96, at §§ 10F:31-10F:51.

¹⁰⁰ 16 U.S.C. § 1604(a)-(b).

¹⁰¹ 16 U.S.C. § 1604(g).

¹⁰² 16 U.S.C. § 1604(e).

¹⁰³ The NFMA provides that “[r]esource plans and permits, contracts, and other instruments for the use and occupancy of [NFS] lands shall be consistent with the land management plans.” 16 U.S.C. § 1604(i).

¹⁰⁴ 16 U.S.C. § 1604(g)(3)(A).

¹⁰⁵ 16 U.S.C. § 1604(g)(3)(B).

¹⁰⁶ 16 U.S.C. § 1604(h)(1).

¹⁰⁷ For a discussion of the justifications for preserving biological diversity, see Holly Doremus, Comment, *Patching the Ark: Improving Legal Protection of Biological Diversity*, 18 ECOLOGY L.Q. 265 (1991). On

definition may reflect Congress's recognition of its lack of technical expertise and its recognition that scientific understanding of the concept would evolve over time.¹⁰⁸ Although the absence of a definition of diversity reflects a decision to afford the Forest Service considerable discretion in pursuing the diversity mandate, the procedural requirements that govern the planning process and the requirement that the agency seek input from a Committee of Scientists it is required to appoint were to serve as constraints on that discretion.¹⁰⁹ The Forest Service in fact shaped its initial planning regulations, adopted in 1982, to conform to the recommendations of the Committee. Among other things, the Committee urged the Forest Service to adapt its approach to the preservation of diversity to conform to advances in scientific understanding.¹¹⁰ One way to read the statutory mandate to provide diversity is that it endorses ecosystem-based management.¹¹¹

B. Modeling and the National Forest Management Act

1. *The Demand for Forest Service Modeling*

The need for the Forest Service to engage in modeling exercises to implement its planning responsibilities under the NFMA stems from bounded rationality. As two observers described the situation just a year after the adoption of the Service's 1982 NFMA planning regulations, "[t]he data required to satisfy [the NFMA's] legal requirements [for planning] are far beyond those ever compiled by the Forest Service or anyone else. The Forest Service, therefore, relies on judgment to fill gaps in empirical knowledge and on quantitative, computerized, systematic, and standardized analytical procedures."¹¹² Similarly, a more recent analysis posits that:

The complexity of forest ecosystems allows scientists to possess detailed knowledge of ecosystem processes for only a few locations where case studies have been done. Thus, managers are often faced with making decisions that affect an entire landscape with only rudimentary information on ecosystem parameters for the vast majority of the area involved. Models that simulate forest

the many possible meanings of biodiversity, see Fred Bosselman, *A Dozen Biodiversity Puzzles*, 12 N.Y.U. ENVTL. L.J. 364 (2004).

¹⁰⁸ See Greg D. Corbin, Comment, *The United States Forest Service's Response to Biodiversity Science*, 29 ENVTL. L. 377, 380 (1999).

¹⁰⁹ *Id.* at 380-81.

¹¹⁰ *Id.* at 381. For a description of the role of the Committee of Scientists in the promulgation of NFMA planning regulations, see Brian Scott Pasko, Comment, *The Great Experiment that Failed? Evaluating the Role of a "Committee of Scientists" as a Tool for Managing and Protecting Our Public Lands*, 32 ENVTL. L. 509 (2002).

¹¹¹ See Robert B. Keiter, *Beyond the Boundary Line: Constructing a Law of Ecosystem Management*, 65 U. COLO. L. REV. 293, 309-10 (1994) (arguing that the diversity provision "incorporates conservation biology considerations into the national forest planning and management process").

¹¹² Cortner & Schweitzer, *supra* note 60, at 497. See also *id.* at 502 (asserting that NFMA planning requirements "exceed the current state of knowledge about critical variables and their relationships. The scientifically validated, empirical knowledge base underlying forest planning is typically, rather than exceptionally, inadequate.").

succession under various conditions that may be of interest to managers often require a higher level of detail.¹¹³

The process of compiling and analyzing the information necessary to conduct the kind of planning envisioned by the NFMA has prompted the agency to rely on the use of “quantitative, computerized, systematic, and standardized procedures. The quantitative models the Forest Service has developed to meet the analytical requirements that flow directly from the complexity of planning laws and regulations have become a central feature of the current planning process in the United States.”¹¹⁴ By one account, an inventory of simulation models available in 1993 for forest planning and ecosystem management identified 250 different software tools.¹¹⁵

The Forest Service’s reliance on modeling programs did not convert the planning process into a purely technocratic exercise, devoid of discretion and divorced from the need to exercise judgment. As explained above, efforts to address bounded rationality through modeling and similar regimes cannot eliminate the need to exercise judgment or the need to make value judgments in selecting a particular model for a particular analytical purpose, deciding what information to feed into the model, and interpreting the results provided by the model.¹¹⁶ Moreover, land use planning generally and Forest Service planning in particular involves a mix of technical expertise and value judgments.¹¹⁷ According to one observer, despite “strenuous efforts to quantify important ecological processes to support a body of theory in simulation model form, by far the larger body of what we know can only be expressed qualitatively, comparatively, and inexactly.”¹¹⁸

2. *The Forest Service’s Experience with Modeling*

The Forest Service has long relied heavily on computer modeling in fulfilling its planning responsibilities under the NFMA.¹¹⁹ For years, the Forest Service used a computer program called FORPLAN (Forest Planning) in its planning efforts. FORPLAN projected the possible production of goods and services from a NFS unit under different management options. The agency entered a resource inventory into the computer and used the program to calculate the forest’s “benchmark” capacity to produce goods and services under options that included maximum commodity production, maximum amenity value, and maximum present net market value. FORPLAN then

¹¹³ Tester et al., *Modeling for Ecosystem Management in Minnesota Pine Forests*, 80 *BIOLOGICAL CONSERVATION* 313, 313 (1997).

¹¹⁴ Cortner & Schweitzer, *supra* note 60, at 515-16.

¹¹⁵ H. Michael Rauscher, *Ecosystem Management Decision Support for Federal Forests in the United States: A Review*, 114 *FOREST ECOL. & MGMT.* 173, 184 (1999).

¹¹⁶ See *supra* notes 62-73 and accompanying text.

¹¹⁷ Cf. Cortner & Schweitzer, *supra* note 60, at 499 (asserting that “planning is fundamentally a political process that defines winners and losers rather than simply a technical enterprise to define truth”).

¹¹⁸ Rauscher, *supra* note 115, at 184.

¹¹⁹ See, e.g., Land and Resource Management Planning, 53 *Fed. Reg.* 26,807, 26,816 (1988) (referring to “[v]arious analytical models such as FORPLAN, IMPLAN, simulation models, fire analysis models, transportation analysis models, cost-benefit tools, and fish and wildlife habitat capability models [that] may have been used during the planning process”).

selected the management course that represented the greatest net public benefit.¹²⁰ The Forest Service eventually abandoned the use of the FORPLAN program when it determined that it had become obsolete.¹²¹

For the most part, challenges to the Forest Service's use of FORPLAN to comply with its land use planning obligations met a hostile judicial reception. In an early attack on a NFMA land use plan, a district court described FORPLAN as "a widely recognized and respected planning tool generally accepted by the planning community."¹²² The Ninth Circuit rejected claims that the NFMA did not permit the Forest Service to base its comparison of various management alternatives for grazing levels on FORPLAN analysis derived from the use of management estimates as inputs into the computer program. Holding that the agency did not act improperly, the court stated that "[i]t is enough that there is evidence in the record that the grazing output levels were derived by professional estimation and were not arbitrarily selected."¹²³ The same court later refused to overturn a computer-generated conclusion that wilderness designation was inappropriate. The court declared that it was not "in a position to prefer [the environmental group plaintiff's] view of the [Forest Service's] software over the [Forest Service's] explanation. [The plaintiff] may well disagree with the substantive decisions informing the program design. Nevertheless, it has given us no reason to doubt the Forest Service's position."¹²⁴ Still later, the Ninth Circuit, in rejecting the claim that a LRMP improperly authorized grazing, disagreed with the contention that the Forest Service had improperly fed "predetermined" grazing outcomes into its FORPLAN computer program. The court characterized the attack as one based on a misapprehension of the function of FORPLAN.

At least at this stage of its development, FORPLAN is not an artificial life form. It is, purely and simply, an analytic modeling tool. It provides, among other things, an analysis of the economic consequences of various planning assumptions. Plaintiffs complain that some of these assumptions included grazing. However, examination of alternatives is precisely what is required of the Forest Service.¹²⁵

¹²⁰ 2 COGGINS & GLICKSMAN, *supra* note 96, at § 10F:37 (quoting Constance Brooks, *Multiple Use Versus Dominant Use: Can Federal Land Use Planning Fulfill the Principles of Multiple Use for Mineral Development?*, 33 ROCKY MT. MIN. L. INST. 1-1, 1-20 to 1-23 (1988)).

¹²¹ Land and Resource Management Planning, 61 Fed. Reg. 58,370, 58,370 (1996) (describing amendment to Forest Service directives that "removed requirements that have become obsolete — such as mandating the use of FORPLAN, now an outdated computer model").

¹²² Griffin v. Yeutter, 20 Env'tl. L. Rep. (Env'tl. L. Inst.) 20400 (S.D. Cal. 1990). On appeal, the 9th Circuit held that the Forest Service violated neither its own NFMA regulations nor NEPA in relying on FORPLAN during the planning process. The court labeled the attacks as challenges to the agency's "choice of methodology," and concluded that reliance on FORPLAN did not preclude consideration of a reasonable range of alternatives. Griffin v. Yeutter, 944 F.2d 908 (Table), 1991 WL 178134, at *3 (9th Cir. 1991).

¹²³ Nevada Land Action Ass'n v. United States Forest Serv., 8 F.3d 713, 717 (9th Cir. 1993).

¹²⁴ Idaho Conservation League v. Mumma, 956 F.2d 1508, 1522 (9th Cir. 1992).

¹²⁵ Wilderness Soc'y v. Thomas, 188 F.3d 1130, 1135-36 (9th Cir. 1999).

Ultimately, the court held that the Forest Service was “plainly entitled to identify ‘parameters and criteria’ in generating alternatives for final consideration, and that the agency did not violate the NFMA in using FORPLAN to assist its analysis.”¹²⁶

The Ninth Circuit was not the only inhospitable forum for attacks on the Forest Service’s use of FORPLAN. In another case, an environmental group challenged a LRMP by charging that the Forest Service relied on inappropriate assumptions regarding the recreation values of timbering that provided input into the FORPLAN model. The Forest Service’s overestimate of the benefits of timbering to recreation allegedly caused the program to assume that timber harvesting was necessary for recreation. The district court found nothing in the record to support the claim that the input was unreasonable and rejected the challenge.¹²⁷

An attack on the Forest Service’s use of the FORPLAN model to perform its planning functions succeeded in one case, in which the court agreed with an environmental group’s argument that the timber price assumptions that FORPLAN incorporated were biased and obsolete. The agency violated its own regulations by using ten-year old information instead of current inventory data based on the “best available data.”¹²⁸ Because the agency was unable to show that use of the erroneous data did not appreciably affect planning results, the court rejected that portion of the plan,¹²⁹ although it rejected challenges to other aspects of FORPLAN’s application.¹³⁰

The courts were therefore very deferential to the manner in which the Forest Service used the FORPLAN model to assist in its NFMA planning functions. In the only reported case in which a court accepted a FORPLAN-based attack, the court found that the Forest Service violated its own regulations in providing input for the computer analysis. Absent that kind of demonstrable mistake, litigants could not convince the courts to closely scrutinize the analysis generated by FORPLAN or the manner in which it affected the Forest Service’s planning decisions.

The few efforts by litigants to challenge Forest Service planning decisions based on the use of other computer models in contexts other than those involving alleged noncompliance with the NFMA’s diversity mandate tended to be similarly unsuccessful. In one case, for example, a group of recreation outfitters criticized a travel zone model

¹²⁶ *Id.* at 1136.

¹²⁷ *Sierra Club v. Robertson*, 845 F. Supp. 485, 500 (S.D. Ohio 1994), *rev’d on other grounds*, 105 F.3d 248 (6th Cir. 1997), *vacated sub nom.* *Ohio Forestry Ass’n, Inc. v. Sierra Club*, 523 U.S. 726 (1998).

¹²⁸ *Citizens for Env’tl. Quality v. United States*, 731 F. Supp. 970, 993 (D. Colo. 1989) (quoting 36 C.F.R. § 219.12).

¹²⁹ *Id.* *Cf.* *Sierra Club v. U.S. Dep’t of Agric.*, 116 F.3d 1482 (Table), 1997 WL 295308 (7th Cir. 1997). In that case, the court accepted a challenge to a LRMP based on the contention that the Forest Service used outdated data in running a computer program known as HEP (Habitat Evaluation Program) that was designed to predict how the plan would affect population levels of animal species. Although the court found that the agency had adequately defended the use of the HEP computer program, it also concluded that the agency did not respond sufficiently to the charge that the data fed into the program were flawed. “As the plaintiffs point out, a computer program is only as reliable as its input; thus, they argue that if you put garbage in, you get garbage out.” *Id.* at *13.

¹³⁰ *Citizens for Env’tl. Quality*, 731 F. Supp. at 991.

that the Forest Service used to project travel patterns in a wilderness area. In rejecting the attack, the court noted that the model “was developed over nearly two decades and includes extensive studies based on travel diaries, as well as expert opinion and a computer model. The Outfitter Plaintiffs’ challenge to these evaluation techniques is not well taken. The law is clear that a court may not ‘second-guess methodological choices made by an agency in its area of expertise.’”¹³¹

3. *Modeling to Protect Biological Diversity*

a. Modeling Choices

In seeking to protect wildlife from human activities, government and private planners have used two different simulation approaches. The first is population viability analysis (PVA), which involves the incorporation of information on habitat quality into models used to predict wildlife population viability. The second seeks to simulate the effects of various human activities (such as management actions approved by government agencies) on the landscapes in which wildlife is found.¹³² PVA analysis is based on a species census and an evaluation of the direct impact of the activities being contemplated on population numbers. A habitat-based model uses habitat loss as a proxy for the impact of the actions being considered on species viability.¹³³ Both approaches rely on assumptions about the manner in which humans and wildlife interact, and both produce projections of future conditions that are of uncertain accuracy.¹³⁴ The Forest Service has employed both in its efforts to protect plant and animal diversity through the adoption of land use plans and the implementation of site-specific management actions that are consistent with those plans.

b. The 1982 Planning Regulations

The Forest Service adopted its initial NFMA planning regulations in 1979, after extensive consultation with the Committee of Scientists.¹³⁵ Three years later, the Forest Service amended the 1979 regulations¹³⁶ “to streamline the land management planning

¹³¹ *County of St. Louis v. Thomas*, 967 F. Supp. 370, 375 (D. Minn. 1997) (quoting *Inland Empire Pub. Lands Council v. Schultz*, 992 F.2d 977, 981 (9th Cir.1993)). Attacks on the use of Forest Service computer models have also arisen in the context of the Forest Service’s alleged noncompliance with NEPA. *See, e.g.*, Cortner & Schweitzer, *supra* note 57, at 502 (describing successful challenge to computer scoring system used by the Forest Service to support its wilderness recommendations because the model failed to supply the kind of site-specific analysis required by NEPA).

¹³² Michael A. Larson et al., *Linking Population Viability, Habitat Suitability, and Landscape Simulation Models for Conservation Planning*, 180 *ECOLOGICAL MODELING* 103, 104 (2004). The authors assert that “[m]ethods for habitat modeling based on landscape simulations and PVA modeling based on habitat quality are well developed, but no published study of which we are aware has effectively joined them in a single, comprehensive analysis.” *Id.* at 104.

¹³³ Brennan, *supra* note 31, at 432.

¹³⁴ Larson et al., *supra* note 132, at 114-15.

¹³⁵ 44 Fed. Reg. 53,928 (1979). The Secretary of Agriculture selected the Committee, which was comprised of experts from outside the Forest Service, with the assistance of the National Academy of Sciences. Wilkinson & Anderson, *supra* note 96, at 12 (listing the members of the Committee).

¹³⁶ 47 Fed. Reg. 43,026 (1982).

process,”¹³⁷ again after consulting with the Committee of Scientists. At the time the Forest Service adopted the 1982 regulations, scientific understanding of biodiversity was rudimentary. The prevailing view among scientists at the time apparently was that the number of species in an area provides an accurate representation of the area’s biodiversity.¹³⁸ The 1982 planning regulations required the agency to assess the impact of management actions on management indicator species because the Forest Service believed that population changes in these MIS provided a gauge on the impacts of management actions on other species as well.¹³⁹

The 1982 planning regulations required that each land use plan include monitoring and evaluation requirements that would provide a basis for a periodic determination of the effects of management practices.¹⁴⁰ The regulations also directed planners to manage fish and wildlife habitat to maintain “viable populations” of existing native and desired non-native vertebrate species. The regulations defined a “viable population” for these purposes as “one which has the estimated numbers and distribution of reproductive individuals to insure its continued existence is well distributed in the planning area.”¹⁴¹ To insure the maintenance of viable populations, the regulations required that land use plans provide sufficient habitat “to support, at least, a minimum number of reproductive individuals” and that the habitat be well distributed to permit those individuals to interact with others in the planning area.¹⁴²

The 1982 regulations required that vertebrate and invertebrate species in the planning area be “identified and selected as management indicator species” as a means of estimating the effects of alternative management actions on fish and wildlife populations.¹⁴³ The plan documents also had to explain the reasons for selecting those MIS. The regulations directed planning officials to select MIS “because their population changes are believed to indicate the effects of management activities.”¹⁴⁴ MIS were supposed to include representatives, where appropriate, of plant and animal species listed by federal or state agencies as endangered or threatened, species with special habitat needs that might be significantly influenced by management programs, species commonly hunted or fished, non-game species of special interest, and any additional plant or animal species “selected because their population changes are believed to indicate the effects of management activities on other species of selected major biological

¹³⁷ 47 Fed. Reg. 7678 (1982) (proposed rule).

¹³⁸ See Corbin, *supra* note 108, at 392. Corbin adds that, more recently: scientists [have] recognize[d] that biodiversity is far more than the simple sum total of species found within an arbitrarily defined geographic locale. For instance, biodiversity is currently seen within a hierarchical paradigm encompassing levels of biological organization from genes to ecosystems. In addition, each level of the hierarchy comprises compositional, structural, and functional elements.

Id.

¹³⁹ Anna M. Seidman & Douglas S. Burdin, *Forest Wildlife Management: A Legal Battleground for a Scientific Dilemma*, 20 NAT. RESOURCES & ENV’T 40, 41 (Fall 2005).

¹⁴⁰ 36 C.F.R. § 219.11(d) (2000).

¹⁴¹ 36 C.F.R. § 219.19 (2000).

¹⁴² *Id.*

¹⁴³ 36 C.F.R. § 219.19(a)(1) (2000).

¹⁴⁴ *Id.*

communities or on water quality.”¹⁴⁵ The regulations specified that, “[o]n the basis of available scientific information,” planners were to “estimate the effects of changes in vegetation type, timber age classes, community composition, rotation age, and year-long suitability of habitat related to mobility of management indicator species. Where appropriate, measures to mitigate adverse effects shall be prescribed.”¹⁴⁶

Finally, the regulations parroted but amplified the NFMA’s diversity mandate. They required that

forest planning provide for diversity of plant and animal communities and tree species consistent with the overall multiple-use objectives of the planning area. Such diversity shall be considered throughout the planning process. Inventories shall include quantitative data making possible the evaluation of diversity in terms of its prior and present condition. For each planning alternative, the interdisciplinary team shall consider how diversity will be affected by various mixes of resource outputs and uses, including proposed management practices.¹⁴⁷

The MIS approach to protecting biodiversity proceeds on the premise “that a single species can act as a bellwether for environmental change. According to this concept, the species is so closely tied to its environment that fluctuations in its population directly reflect environmental changes that impact other species as well.”¹⁴⁸ The approach was attractive to those engaged in forest planning because it avoided the need to engage in the much more burdensome task of monitoring and managing for all species found in a particular ecosystem.¹⁴⁹ It was a relatively sophisticated method of simulating the effects of management actions on diversity in that it allowed modelers to consider a variety of factors, including:

genetics, demographics, habitat needs, spatial distribution, inter-and intra-population dynamics, and environmental influences on the continued existence of a population. With such a broad scope of relevant factors, PVA is capable of incorporating many levels of the biodiversity hierarchy. Even more powerful is its ability to link those factors to population extinction probabilities. Once the critical factors in a population’s survival are hypothesized, land managers can estimate how many reproductive individuals are necessary to maintain a healthy population over a chosen period of time.¹⁵⁰

¹⁴⁵ *Id.*

¹⁴⁶ *Id.*

¹⁴⁷ 36 C.F.R. § 219.26 (2000).

¹⁴⁸ Corbin, *supra* note 108, at 397.

¹⁴⁹ As one commentator has noted:

The advantages are obvious. In an age of budgetary and personnel constraints, land management agencies like the Forest Service can not afford outlays of resources necessary to individually manage each species in an ecosystem. The ability to meet a seemingly impossible obligation to maintain viable populations of all wildlife by simply monitoring a handful of species is to move from the impossible to the probable.

Id.

¹⁵⁰ *Id.* at 396.

It soon became apparent, however, that the MIS approach to protecting biodiversity was not a panacea. Even though it is less resource-intensive than an approach based upon monitoring of all species within an ecosystem, it nevertheless requires the accumulation of large amounts of information, and sometimes that information is difficult to obtain. In addition, the extrapolation from the impacts of management actions on one or a selected small group of species to the effects of those actions on an entire ecosystem upon which the entire approach depends is fraught with uncertainty. This is particularly likely to be true if little is understood about the natural fluctuations of the MIS.¹⁵¹

These difficulties prompted the Forest Service to consider using the habitat-based rather than the population viability approach. Under this second approach, planners do not seek to keep track of the population numbers of the designated MIS. Instead, they assess the effects of management actions on the habitat of the MIS, based on the assumption that “the presence of adequate healthy habitat for a species would indicate the presence of viable populations of those species.”¹⁵² This “proxy-on-proxy” approach has been described as follows:

For this approach, the Forest Service designates the first proxy level by selecting several MISs that the Service believes will represent the needs of various types of wildlife that live throughout the forest and share the same habitat needs as the designated MISs. Each MIS acts as an indicator, or proxy, for many other species. The Forest Service does not inventory or monitor the population of each MIS, but instead designates certain types and quantities of habitat that it deems sufficient to maintain viable populations of the selected MISs. The Service then assesses the impact of a proposed management activity on the habitats and, consequently, on the populations of the MISs and the species that the MISs represent.¹⁵³

The benefit of the proxy-on-proxy simulation approach is that it avoids the need to do any population monitoring whatsoever. The agency can fulfill its responsibility to protect biodiversity through the planning process simply by assuming that if sufficient habitat acreage for the MIS (as defined by the agency’s scientists) remains following a particular management action such as a timber harvest, then a viable population of the MIS must necessarily also exist. Because the MIS is a surrogate for the other species present in the area affected, a viable population of MIS necessarily translates into plant

¹⁵¹ *Id.* at 397-98. Corbin asserts that:

It is simply naive, in an ecological sense, to assume that effects on one species will mirror those on all other species within an ecosystem. . . . Choosing an appropriate indicator species requires a detailed understanding of the species selected, how it reacts to changes in its habitat, and how the larger community reflects those changes. For most of the nation’s forest system, the detailed data required to select indicator species did not exist when NFMA was passed, and likely does not exist in an appreciably greater amount today.

Id.

¹⁵² Seidman & Burdin, *supra* note 139, at 41.

¹⁵³ *Id.*

and animal diversity sufficient to satisfy the NFMA planning provisions.¹⁵⁴ It may not even be necessary for the habitat to exist in any particular location or condition.¹⁵⁵

The courts have taken divergent approaches when faced with the question of whether the proxy-on-proxy simulation approach is consistent with the Forest Service's responsibility to provide for diversity of plant and animal communities.¹⁵⁶ The Ninth Circuit first addressed the validity of that approach in the *Inland Empire Public Lands Council* case.¹⁵⁷ The issue was whether the Forest Service complied with its regulations implementing the diversity requirement, and in particular, with the regulatory provision that dictated that fish and wildlife habitat be managed to maintain viable populations of vertebrate populations.¹⁵⁸ The environmental group plaintiffs contended that the agency violated the statutory diversity requirement and the viability regulation by failing to examine the population dynamics of MIS in old-growth forests in which timber harvests were scheduled. The Forest Service responded that its habitat viability analyses sufficed.¹⁵⁹ The court approved the agency's conclusion that a species would remain viable as long as the percentage of each type of habitat (such as nesting, feeding, or denning) remaining after the timber sales would be greater than required for the species to survive. According to the court, that assumption was "eminently reasonable"¹⁶⁰ and the Forest Service's analysis was sound because it used all of the scientific data then available.¹⁶¹

In subsequent cases, the Ninth Circuit has held that the Forest Service's approval of timber sales violated the 1982 regulations implementing the NFMA's diversity requirement because, even though the proxy-on-proxy approach is valid as a general proposition, the agency relied on habitat monitoring methodologies that were arbitrary and capricious.¹⁶² The court summarized its precedents concerning the legality of the

¹⁵⁴ The burdens on the agency of pursuing the proxy-on-proxy approach are particularly light if the agency has already collected habitat data in making timber inventories. See Corbin, *supra* note 108, at 401.

¹⁵⁵ Thus, Corbin asserts, "[d]isturbance, such as logging, is not precluded because its impact on the species will never be detected." *Id.*

¹⁵⁶ The courts also have addressed the validity of the Forest Service's use of models or surrogates in connection with other NFMA requirements concerning habitat for MIS. See, e.g., *Western Watersheds Project v. United States Forest Serv.*, 62 Env't Rep. Cas. (BNA) 1142 (D. Idaho 2006) (holding that the Forest Service acted improperly by using a model for estimating the effects of grazing in seeking to comply with NFMA regulation requiring that forest plans determine "the suitability and potential capability of [NFS] lands for producing forage for grazing animals and for providing habitat for [MIS]").

¹⁵⁷ *Inland Empire Pub. Lands Council v. United States Forest Serv.*, 88 F.3d 754 (9th Cir. 1996).

¹⁵⁸ 36 C.F.R. § 219.19 (1998).

¹⁵⁹ *Inland Empire Pub. Lands Council*, 88 F.3d at 759.

¹⁶⁰ *Id.* at 761.

¹⁶¹ *Id.* at 762.

¹⁶² *Earth Island Inst. v. United States Forest Serv.*, 442 F.3d 1147, 1175-76 (9th Cir. 2006) (finding that the Forest Service improperly relied on habitat analyses in lieu of population monitoring where there was no evidence that it consulted current or accurate field studies and failed to identify the methodology it used in determining what constitutes suitable habitat); *Idaho Sporting Cong., Inc. v. Rittenhouse*, 305 F.3d 957, 972-73 (9th Cir. 2002). See also *Env'tl. Prot. Info. Ctr. v. United States Forest Serv.*, 2007 WL 1417163, No. 05-17093 (9th Cir. May 9, 2007) (invalidating proxy-on-proxy analysis because the Forest Service neither analyzed acreage needed by MIS nor analyzed how much suitable acreage would remain in the project area after the project was completed); *Ecology Ctr., Inc. v. Austin*, 430 F.3d 1057, 1063-65 (9th Cir.

Forest Service's reliance on the proxy-on-proxy approach as follows: the agency could satisfy the diversity requirement by assessing the impact of particular management actions such as timber harvests on habitat "only where both the Forest Service's knowledge of what quality and quantity of habitat is necessary to support the species and the Forest Service's method for measuring the existing amount of that habitat are reasonably reliable and accurate."¹⁶³

Other courts refused to allow the Forest Service to rely on the proxy-on-proxy approach at all. In *Sierra Club v. Martin*, for example, the Eleventh Circuit concluded that habitat analysis did not comply with the requirement of the 1982 regulations that the Forest Service monitor population trends of MIS and their relationships to habitat changes.¹⁶⁴ The court held that the agency's approval of timber sales was arbitrary and capricious because it failed to gather quantitative data on MIS and use that data to measure the impact of habitat changes on the forest's diversity.¹⁶⁵ Other courts agreed

2005) (holding that the Forest Service violated the diversity mandate by assuming that commercial thinning and prescribed burning activities in old-growth forests would be beneficial to old-growth dependent species on the basis of an unverified hypothesis).

¹⁶³ *Native Ecosystems Council v. United States Forest Serv.*, 428 F.3d 1233, 1250 (9th Cir. 2005). *See also* *Envtl. Prot. Info. Ctr. v. United States Forest Serv.*, 2007 WL 1417163, at *10, No. 05-17093 (9th Cir. May 9, 2007) (stating that 'we have previously endorsed the practice [of using habitat as a proxy for population] absent some indication in the record that USFS's underlying methodology is flawed'); *Cascadia Wildlands Project v. United States Forest Serv.*, 386 F. Supp. 2d 1149, 1163 (D. Or. 2005) (stating that "if the methodology used for evaluating the effect of a plan on MIS populations is reasonably accurate, there is no absolute requirement that the Forest Service conduct population counts of MIS when analyzing management alternatives"); *League of Wilderness Defenders—Blue Mountain Biodiversity Project v. Bosworth*, 383 F. Supp. 2d 1285, 1303 (D. Or. 2005) (stating that, "[i]n the Ninth Circuit, . . . habitat analysis as a proxy for monitoring population trends is sufficient under the 1982 regulations where the methodology utilized by the Forest Service is sound"). In a case involving alleged noncompliance with the monitoring requirements of a NFMA forest plan, the court stated that the reliability of habitat capability models "may be jeopardized in either of two ways: If either 'monitoring were not taking place, or if the on-going monitoring reveals that the [habitat capability model] is not meeting expectations,' then the Forest Service cannot rely on the surrogate methodology of the model." *Envtl. Prot. Info. Ctr. v. Blackwell*, 389 F. Supp. 2d 1174, 1213 (N.D. Cal. 2004) (quoting *Gifford Pinchot Task Force v. United States Fish and Wildlife Serv.*, 378 F.3d 1059, 1068 (9th Cir. 2004)). The court in *Gifford Pinchot* held that the Forest Service may use changes in habitat to assess whether an agency's actions would violate the prohibition on jeopardizing species listed under the ESA if it "'reasonably ensures'" that the proxy results mirror reality." *Gifford Pinchot*, 378 F.3d at 1066 (quoting *Idaho Sporting Cong., Inc. v. Rittenhouse*, 305 F.3d 957, 972-73 (9th Cir. 2002)).

¹⁶⁴ *Sierra Club v. Martin*, 168 F.3d 1, 7 & n.10 (11th Cir. 1999) The 1982 regulations provided that "[p]opulation trends of the [MIS] will be monitored and relationships to habitat changes will be determined. *Id.* at 5 (quoting 36 C.F.R. § 219.19).

¹⁶⁵ *Id.* at 7. The Forest Service lacked population data for half of the MIS in the forest in which the sales had been proposed. A federal district court later interpreted *Martin* as allowing the Forest Service to rely on estimating procedures such as sampling or surveys to satisfy MIS data collection requirements. In particular, it concluded that the Forest Service may rely on sampling data for fish MIS, numerical survey data for vertebrate MIS, and descriptive reports for plant MIS. *Forest Conservation Council v. Jacobs*, 374 F. Supp. 2d 1187, 1203-04 (N.D. Ga. 2005), *rev'd on other grounds sub nom.* *Ouachita Watch League v. Jacobs*, 463 F.3d 1163 (11th Cir. 2006).

with the Eleventh Circuit that the 1982 regulations did not permit the Forest Service to substitute habitat information for actual, quantitative population data.¹⁶⁶

c. The 2000 Planning Regulations

The Forest Service adopted the first substantial revisions to the 1982 planning rules in November 2000, just three months before the end of the Clinton Administration.¹⁶⁷ Those regulations never went into effect, however. Acting at least in part in response to concerns over the 2000 regulations expressed by the Society of American Foresters,¹⁶⁸ the Department of Agriculture first extended by one year the effective date of the 2000 regulations¹⁶⁹ and then delayed compliance until the promulgation of a new final planning rule.¹⁷⁰

The 2000 regulations required that each LRMP “contain a practicable, effective, and efficient monitoring strategy to evaluate sustainability in the plan area” and that the strategy “require monitoring of appropriate plan decisions and characteristics of sustainability.”¹⁷¹ In particular, the regulations required monitoring of both ecosystem and species diversity. With respect to the former, the regulations required evaluation of “the status and trend of selected physical and biological characteristics of ecosystem diversity” and documentation of “the reasons for selection of characteristics to be

¹⁶⁶ *E.g.*, *Utah Envtl. Cong. v. Bosworth*, 372 F.3d 1219, 1225-27 (10th Cir. 2004). *See also* *Utah Envtl. Cong. v. Bosworth*, 439 F.3d 1184, 1191 (10th Cir. 2006); *Utah Envtl. Cong. v. Zieroth*, 190 F. Supp. 2d 1265, 1271-72 (Utah 2002) (holding that Forest Service regulations require collection of quantitative data on populations to measure the impact of habitat changes on forest diversity and that habitat data may not be used as a proxy); *Forest Guardians v. United States Forest Serv.*, 180 F. Supp. 2d 1273, 1281 (D.N.M. 2001) (holding that the Forest Service’s regulations require that it collect population data, not just habitat trend data, for MIS).

The 10th Circuit also held, however, that the agency need not develop forest-wide data if it can determine the viability of the MIS at issue without a forest-wide survey but that it must engage in good faith efforts to confirm the presence or absence of MIS. *Utah Envtl. Cong.*, 372 F.3d at 1230. In an earlier case, the 10th Circuit held that the diversity regulations did not require the Forest Service to collect population data or make data-based population viability assessments in the absence of any evidence that MIS existed in the affected area. *Colorado Envtl. Coalition v. Dombeck*, 185 F.3d 1162, 1170 (10th Cir. 1999). *Cf.* *Utah Envtl. Cong. v. Troyer*, 479 F.3d 1269, 1286 (10th Cir. 2007) (confirming that although the 1982 regulations required quantitative population data, “we otherwise imposed no specific requirements on the type of data that must be collected,” and upholding the Forest Service’s conclusion that the available population data were scientifically useful).

¹⁶⁷ National Forest System Land and Resource Management Planning, 65 Fed. Reg. 67,514 (Nov. 9, 2000).

¹⁶⁸ The Society for American Foresters is “the national scientific and educational organization representing the forestry profession in the United States.” Society of American Foresters, *Mission Statement*, available at <http://www.safnet.org/who/whoweare.cfm>.

¹⁶⁹ National Forest System Land and Resource Management Planning; Extension of Deadline Compliance; Interim Final Rule, 66 Fed. Reg. 27,552 (May 17, 2001) (asserting that the agency was not prepared to fully implement the rule nationwide).

¹⁷⁰ National Forest System Land and Resource Management Planning; Extension of Deadline Compliance; Interim Final Rule, 67 Fed. Reg. 35,341 (May 20, 2002). For discussion of the Bush Administration’s delays in implementing the 2000 planning regulations, see Alyson Flournoy et al., *In Name Only: How the Bush Administration’s National Forest Planning Rule Frees the Forest Service from Mandatory Standards and Public Accountability*, Center for Progressive Reform White Paper 508 (June 2005), at 5-6, available at http://www.progressiveregulation.org/articles/Forests_508.pdf.

¹⁷¹ 36 C.F.R. § 219.11 (2001).

monitored, monitoring objectives, methodology, and designate critical values that will prompt reviews of plan decisions.”¹⁷² Monitoring of species diversity had to evaluate “focal species”¹⁷³ and selected “species-at-risk.”¹⁷⁴

The 2000 regulations required monitoring of ecological conditions, but did not generally require population monitoring. The regulations, however, specified that a particular plan’s monitoring strategy “may require population monitoring for some focal species and some species-at-risk,” which could be accomplished by methods such as population occurrence and presence/absence data, sampling population characteristics, using population indices to track relative population trends, or inferring population status from ecological conditions.¹⁷⁵ Planning officials were to decide whether to monitor populations, and if so to select the methods for doing so, based on factors that included the degree of risk to the species, the degree to which particular species characteristics lend themselves to monitoring, the reasons for listing a species as a focal species or species-at-risk, and the strength of association between ecological conditions and population dynamics. The regulations stated that population trend monitoring “is often appropriate in those cases where risk to species viability is high and population characteristics cannot be reliably inferred from ecological conditions.”¹⁷⁶ Any document authorizing site-specific action also had to describe required monitoring and evaluation.¹⁷⁷ Monitoring methods could be changed to reflect new information without the need to amend or revise the applicable LRMP.¹⁷⁸

The regulations designated the first priority for NFMA planning and management to be the maintenance or restoration of ecological sustainability of the national forests.¹⁷⁹ The Forest Service regarded both ecosystem and species diversity as components of ecological sustainability.¹⁸⁰ Ecosystem diversity included several characteristics,

¹⁷² 36 C.F.R. § 219.11(a)(1)(i) (2001).

¹⁷³ The regulations defined focal species as follows:

Focal species are *surrogate measures* used in the evaluation of ecological sustainability, including species and ecosystem diversity. The key characteristic of a focal species is that its status and trend provide insights to the integrity of the larger ecological system to which it belongs.

Individual species, or groups of species that use habitat in similar ways or which perform similar ecological functions, may be identified as focal species. Focal species serve an umbrella function in terms of encompassing habitats needed for many other species, play a key role in maintaining community structure or processes, are sensitive to the changes likely to occur in the area, or otherwise serve as an indicator of ecological sustainability. *Certain focal species may be used as surrogates to represent ecological conditions that provide for viability of some other species, rather than directly representing the population dynamics of those other species.*

36 C.F.R. § 219.36 (2001) (emphasis added).

¹⁷⁴ Species at risk were defined as “[f]ederally listed endangered, threatened, candidate, and proposed species and other species for which loss of viability, including reduction in distribution or abundance, is a concern within the plan area. Other species-at-risk may include sensitive species and state listed species. A species-at-risk also may be selected as a focal species.” 36 C.F.R. § 219.36 (2001).

¹⁷⁵ 36 C.F.R. § 219.11(a)(1)(ii)(B) (2001).

¹⁷⁶ 36 C.F.R. § 219.11(a)(1)(ii)(C) (2001).

¹⁷⁷ 36 C.F.R. § 219.11(b) (2001).

¹⁷⁸ 36 C.F.R. § 219.11(c) (2001).

¹⁷⁹ 36 C.F.R. § 219.2 (2001).

¹⁸⁰ 36 C.F.R. § 219.20(a)(1) (2001).

including major vegetation types, water resources, soil resources, air resources, and focal species that provide “insights to the larger ecological systems with which they are associated.”¹⁸¹ Species diversity was defined in terms of species characteristics that included “the number, distribution, and geographic ranges of plant and animal species, including *focal species and species-at-risk that serve as surrogate measures of species diversity*. Species-at-risk and focal species must be identified for the plan area.”¹⁸²

Planners had to evaluate ecological sustainability by describing the current status of both ecosystem and species diversity, risks to ecological sustainability, the cumulative effects of human and natural disturbances, and the contributions of NFS lands to the ecological sustainability of all lands within the area being analyzed.¹⁸³ The evaluation of ecosystem diversity had to include “[i]nformation about focal species that provide insights to the integrity of the larger ecological system to which they belong.”¹⁸⁴ The evaluation of species diversity had to include, “as appropriate,” assessments of the risks to species viability and the identification of ecological conditions needed to maintain species viability over time. Individual species assessments for the viability of any endangered, threatened, or candidate species under the ESA were mandatory, while for all other species, the regulations authorized a variety of evaluative approaches, including “individual species assessments and assessments of *focal species or other indicators used as surrogates* in the evaluation of ecological conditions needed to maintain species viability.”¹⁸⁵

The regulations required that plan decisions that would affect ecological sustainability be based on the evaluations of ecosystem and species diversity. Plan decisions affecting ecosystem diversity had to provide for maintenance or restoration of the characteristics of ecosystem composition and structure within the range of variability expected under natural disturbance regimes. Where definition of the range of variability was impractical, plan decisions had to “provide for measurable progress toward maintaining or restoring ecosystem diversity,” based on independently peer-reviewed scientific methods other than the expected range of variability to maintain or restore ecosystem diversity.¹⁸⁶ Plan decisions affecting species diversity had to “provide for ecological conditions that the responsible official determines provide a high likelihood that those conditions are capable of supporting over time the viability of native and desired non-native species well distributed throughout their ranges within the plan area.”¹⁸⁷

¹⁸¹ 36 C.F.R. § 219.20(a)(1)(i) (2001).

¹⁸² 36 C.F.R. § 219.20(a)(1)(ii) (2001) (emphasis added).

¹⁸³ 36 C.F.R. § 219.20(a)(2) (2001).

¹⁸⁴ 36 C.F.R. § 219.20(a)(2)(i)(A) (2001). The agency also had to describe the effects of human activity on ecosystem diversity. *Id.* § 219.20(a)(2)(i)(E).

¹⁸⁵ 36 C.F.R. § 219.20(a)(2)(ii) (2001) (emphasis added). The regulations provided that, with the exception of species listed under the ESA, assessments of functional, taxonomic, or habitat groups rather than individual species “may be appropriate” for species groups that contain many species. *Id.*

¹⁸⁶ 36 C.F.R. § 219.20(b)(1) (2001).

¹⁸⁷ 36 C.F.R. § 219.20(b)(2)(i) (2001).

The planning regulations issued during the Clinton Administration thus set as the first priority of the NFMA planning process the maintenance or restoration of ecological sustainability. The regulations appeared to treat ecosystem and species diversity as equally important components of ecological sustainability. Planning officials had to conduct evaluations of both kinds of diversity, and plan decisions had to protect both kinds of diversity. Every LRMP had to include a monitoring strategy to evaluate sustainability in the plan area. The 2000 regulations replaced the concept of the MIS with two new surrogate measures of both components of ecological sustainability, focal species and species-at-risk. Both focal species and species at risk had to be evaluated as part of the process of monitoring species diversity. In addition, the regulations included focal species as one of the characteristics of ecosystem diversity because such species provide insights into the condition of the larger ecosystem of which they are a part.

The regulations did not mandate population monitoring of affected species in all cases. They recognized, however, that population monitoring might be necessary for focal species and species-at-risk through any of several illustrative methodologies, based on factors such as the degree of risk being experienced by the species, the degree to which the species lend themselves to population monitoring, and the strength of the association between ecological conditions and population dynamics. The regulations declared population monitoring to be particularly appropriate in situations marked by high risk to species viability and inability to infer reliable population characteristics from ecological conditions. In short, the 2000 regulations continued to rely heavily on the effects of management actions on designated species as surrogates for the ability to maintain plant and animal diversity in the national forests.

d. The 2005 Planning Regulations

Based on its conclusion that the 2000 planning regulations were difficult to implement and failed to clarify the “programmatic nature” of land and resource management planning,¹⁸⁸ the Forest Service completely scrapped the 2000 regulations and replaced them with a new set of regulations in 2005.¹⁸⁹ The Forest Service, which adopted the new regulations without convening a Committee of Scientists,¹⁹⁰ characterized the 2005 regulations as “a paradigm shift in land management planning.”¹⁹¹ For one thing, although the 2005 regulations nominally retain sustainability as the overall goal of the NFMA planning process,¹⁹² the regulations deemphasize the ecological component of sustainability by declaring sustainability to be composed of three “interrelated and interdependent” components: social, economic, and ecological

¹⁸⁸ National Forest System Land and Resource Management Planning; Proposed Rule, 67 Fed. Reg. 72,770, 72,770-71 (Dec. 6, 2002).

¹⁸⁹ National Forest System Land and Resource Management Planning; Final Rule, 70 Fed. Reg. 1023 (Jan. 5, 2005).

¹⁹⁰ See Flournoy et al., *supra* note 170, at 7.

¹⁹¹ 70 Fed. Reg. at 1024. Representative Tom Udall of New Mexico called the 2005 regulations “a radical overhaul of forest policy.” Flournoy et al., *supra* note 170, at 7 (quoting Juliet Eilperin, *New Rules Issued for National Forests; Some Environmental Protections Eased*, THE WASHINGTON POST, Dec. 24, 2004, at A1).

¹⁹² 36 C.F.R. § 219.10 (2006).

sustainability.¹⁹³ Included among the changes in approach reflected in the 2005 regulations was a shift away from assessment of species diversity to assessment of ecosystem diversity as a means of implementing the NFMA's diversity requirement. In particular, the 2005 regulations abandoned the approaches reflected in both the 1982 and 2000 regulations for monitoring the effect of management actions on species selected on the basis of their capacity to serve as surrogates for the diversity of plant and animal species in the affected planning area as a whole.

The 2005 regulations state that the overall goal of the ecological element of sustainability is "to provide a framework to contribute to sustaining native ecological systems by providing ecological conditions to support diversity of native plant and animal species in the plan area."¹⁹⁴ Achieving this goal "will satisfy the statutory requirement to provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives."¹⁹⁵ Unlike the 2000 regulations, the 2005 regulations declare ecosystem diversity to be the "primary means by which a plan contributes to sustaining ecological systems" and LRMPs therefore "must establish a framework to provide the characteristics of ecosystem diversity in the plan area."¹⁹⁶ The plan must include additional measures to protect species diversity only if planning officials determine that the plan provisions designed to protect ecosystem diversity are insufficient to provide appropriate ecological conditions for specific endangered or threatened species, species-of-concern, or species-of-interest.¹⁹⁷ It is within that broad framework that the 2005

¹⁹³ 70 Fed. Reg. at 1028. See also 36 C.F.R. § 219.10 (2006) (stating that "sustainability, for any unit of the National Forest System, has three interrelated and interdependent elements: social, economic, and ecological," and that a LRMP "can contribute to sustainability by creating a framework to guide on-the-ground management of projects and activities," but cannot itself ensure sustainability). For discussion of the shift in emphasis away from ecological sustainability, see Flournoy et al., *supra* note 170, at 9-11; Robert L. Glicksman, *Traveling in Opposite Directions: Roadless Area Management Under the Clinton and Bush Administrations*, 34 ENVTL. L. 1143, 1172-76, 1204-07 (2004).

¹⁹⁴ 36 C.F.R. § 219.10(a) (2006).

¹⁹⁵ 36 C.F.R. § 219.10(a) (2006).

¹⁹⁶ 36 C.F.R. § 219.10(a)(1) (2006). The Forest Service now defines ecosystem diversity as "the variety and relative extent of ecosystem types including their composition, structure, and processes." Forest Service Handbook (FSH) 1909.12, § 43.1. Agency officials are to evaluate ecosystem diversity by identifying selected ecosystem characteristics, assessing their natural variation under historic disturbance regimes, and comparing that to existing and projected future conditions. *Id.* § 43.1.1. Compare the following definition of ecosystem diversity:

The concept of "ecosystem diversity" refers to the variety of biological communities and their physical settings and can be used to associate species with their required habitat. This association between habitat and ecosystem diversity is possible because a species' habitat is selected from the ecosystems available to that species (i.e., habitat is a subset of ecosystems for a specific species).

Seidman & Burdin, *supra* note 139, at 42.

¹⁹⁷ 36 C.F.R. § 219.10(a)(2) (2006). "Species-of-concern" are those species for which their continued existence is a concern and listing under the ESA may occur. *Id.* § 219.16. "Species-of-interest" are species for which the responsible planning official determines that management actions may be necessary or desirable to achieve ecological or other multiple use objectives. *Id.* The Forest Service directives will describe "a systematic, scientifically credible, and efficient approach, using existing information, to identify species-of-concern and species-of-interest." 70 Fed. Reg. at 1048. See also FSH 1909.12, §§ 43.22b-43.2c (defining species-of-concern as "species for which the Responsible Official determines management actions may be necessary to prevent listing under [ESA]" and species-of-interest as "species

regulations address the responsibility of planning officials to rely on the “best available science” and to take steps to protect the diversity of plant and animal species.

(1) The Use of the Best Available Science

The 2005 NFMA planning regulations state that agency planning officials “must take into account the best available science.”¹⁹⁸ The agency’s position is that it is impossible to provide a substantive definition of the “best available science”¹⁹⁹ in a regulation or directive.²⁰⁰ As a result, the agency’s approach to describing its responsibility to take the best available science into account is process-based. The 2005 regulations, amplified by agency directives,²⁰¹ describe a four-step discovery process that, when followed, is supposed to insure that planners satisfy the requirement that the best available science be taken into account and that it will properly influence plan components.²⁰² For purposes of the planning regulations, “taking into account the best available science” requires planning officials to (1) document how the best available science was taken into account in the planning process, (2-3) evaluate and disclose substantial scientific uncertainties and substantial risks associated with plan components based on that science, and (4) document that the agency appropriately interpreted and applied the science.²⁰³ This process of evaluation and disclosure of uncertainty and risk

for which the Responsible Official determines that management actions may be necessary or desirable to achieve ecological or other multiple-use objectives”).

¹⁹⁸ 36 C.F.R. § 219.11(a) (2006).

¹⁹⁹ The agency has taken a stab at defining the term science, however. According to the Forest Service Manual (FSM),

[s]cience refers to knowledge, information, concepts, methods, and theories based on organized systems of facts learned from study, observation, and experience. Science is brought into the planning process through evaluations, other information gathering, and syntheses. The application of science in planning provides the Responsible Official with knowledge, methods, and expert review in order to inform the planning process.

FSM 1921.8.

²⁰⁰ *Cf.* The Ecology Ctr. v. United States Forest Serv., 451 F.3d 1183, 1194 n.4 (10th Cir. 2006) (stating that “we have not found, nor have the parties cited, any cases that define ‘best available science’ in today’s context”).

²⁰¹ “The Forest Service directives consist of the Forest Service Manual (FSM) and the Forest Service Handbook (FSH), which contain the agency’s policies, practices, and procedures and serve as the primary basis for the internal management and control of programs and administrative direction to Forest Service employees. The directives for all agency programs are set out on the World Wide Web/Internet at <http://www.fs.fed.us/im/directives>.” National Forest System Land Management Planning Directives; Notice, 71 Fed. Reg. 5124, 5124 (Jan. 31, 2006).

²⁰² 71 Fed. Reg. at 5130.

²⁰³ 36 C.F.R. § 219.11(a) (2006). The FSM provides a slightly different description of the four-step process:

The Responsible Official shall demonstrate that the best available science (36 CFR 219.11) is taken into account during the planning process by using appropriate procedures including: 1. Timely and comprehensive gathering of peer-reviewed and other quality-controlled literature, studies, or reports related to the planning issues. 2. Assessing the information for pertinence based on objectivity, utility, relevance, and integrity. 3. Synthesizing the pertinent information for application in the planning process. 4. Based on assumptions and professional judgment, applying the best available science synthesis to the planning process, including developing plan components and evaluating plan outcomes.

FSM 1921.81.

is designed to “provide a crosscheck for appropriate interpretation of science and help[] clarify the limitations of the information base for the plan.”²⁰⁴ Planners may meet these requirements by using independent peer review, a science advisory board, or “other review methods to evaluate the consideration of science in the planning process.”²⁰⁵ According to the Forest Service, this four-step process “represents the state-of-the art for science review for natural resource management.”²⁰⁶

Agency planning officials must conduct substantive reviews of the best available science applied during the planning process. The review process must include, at a minimum, an assessment of the scientific credibility of (1) the methods selected and applied to evaluate a plan’s components; (2) information gathered and applied for these evaluations; and (3) synthesis, interpretation, and inferences drawn from these evaluations.²⁰⁷ These review procedures are described more fully in the Forest Service Handbook (FSH). The purpose of the reviews, according to the FSH, “is to enhance and maximize the quality and credibility of plans and planning evaluations” and “review how the best available science was taken into account, not to add to the body of scientific knowledge.”²⁰⁸ A science review, as described in the FSH, should address four main questions:

1. Has applicable and available scientific information been considered?
2. Has scientific information been interpreted reasonably and accurately?
3. Are the uncertainties associated with the scientific information acknowledged and documented?
4. Have the relevant trends of social, economic, and ecological resources . . . , including risks and uncertainties, been identified and documented?²⁰⁹

The Forest Service has explained in the Forest Service Manual (FSM)²¹⁰ that the “best available science” may be uncertain due to evolving understandings of social, economic, and ecological processes and conditions. The sources of uncertainty identified by the agency include incomplete or conflicting scientific information; assumptions, interpretation, and extrapolation of information; and predictions of future trends or conditions. The Manual concedes that some level of uncertainty will continue to exist even if planning officials comply with their responsibility to take into account the best available science. It accordingly requires that they evaluate substantial uncertainty in the

²⁰⁴ 70 Fed. Reg. at 1027.

²⁰⁵ 36 C.F.R. § 219.11(b) (2006).

²⁰⁶ 71 Fed. Reg. at 5130.

²⁰⁷ FSM 1921.85.

²⁰⁸ FSH 1909.12, § 41.1 (also stating that “[s]cience reviews allow [planners] to document that the best available science was taken into account in the planning process” and that “[r]eviews should be conducted in a timely and expeditious manner to provide useful feedback”).

²⁰⁹ FSH 1909.12, § 41.1.

²¹⁰ The Forest Service has described the FSM, which form part of the agency’s “directives,” as a document that “contains legal authorities, objectives, policies, responsibilities, instructions, and guidance needed on a continuing basis by Forest Service line officers and primary staff to plan and execute programs and activities, while the FSH is generally the principal source of specialized guidance and instruction for carrying out the policies, objectives, and responsibilities contained in the FSM.” National Forest System Land Management Planning Directives; Notice, 71 Fed. Reg. 5124, 5124 (Jan. 31, 2006).

best available science by identifying its sources and assessing how it affects the planning process.²¹¹

The “best available science mandate” of the 2005 planning regulations is a watered-down version of the proposed planning rules issued by the Forest Service in 2002. Those rules would have required that agency planning decisions “be consistent with” the best available science, rather than that planners merely “take into account” the best available science. The Forest Service stated in the preamble to the final regulations that, despite the change in language, “[t]he actual process for taking into account science in planning has not changed from the 2002 proposed rule.”²¹² The agency added, however, that science is “only one aspect of decisionmaking” (albeit a “significant source of information”) and that public input, competing use demands, budget projections,²¹³ and “many other factors” are also relevant to planning decisions.²¹⁴

This open-ended recitation of potentially relevant factors provides ample room for political factors to override science as the basis for planning decisions without an acknowledgment by the agency of the actual basis for its decision. At a minimum, the failure to specify what these “other factors” might be, and how they are supposed to be weighted in comparison to science and other factors in the decisionmaking process, is likely to hinder the transparency of the planning process and make it more difficult for interested persons to provide meaningful input. The agency’s decision to shift much of the detailed description of the planning process requirements from regulations published in the Code of Federal Regulations to the lesser known agency “directives” (which include the Forest Service Manual and the Forest Service Handbook) may exacerbate these difficulties.²¹⁵

²¹¹ FSM 1921.82. *See also id.* 1921.84 (requiring that planning officials disclose “evaluations of substantial uncertainty and risk in the plan set of documents” and that the disclosure of uncertainty “include the evidence for and controversy regarding key assumptions that influence planning outcomes.”).

²¹² 70 Fed. Reg. at 1027. The agency also asserted that the 2005 regulations “retain[] the emphasis in the 2002 proposed rule on the consideration of science in planning, on documenting how science was interpreted and applied, and on evaluating the associated risks and uncertainties of using that science.” *Id.* at 1048.

²¹³ According to the FSM, “[c]ost should be considered in the decision of how to apply the best available science in the planning effort.” FSM 1921.81.

²¹⁴ 70 Fed. Reg. at 1027. *See also id.* at 1048 (explaining that “[t]he words ‘consistent with’ ha[ve] been replaced by ‘take into account’ because this term better expresses that formal science is just one source of information for the Responsible Official and only one aspect of decisionmaking”).

²¹⁵ The Forest Service stated in the preamble to the 2005 regulations that:

The final rule does not include many of the specific analytical processes and requirements set out in the 2002 proposed rule. Appropriate processes will be included in the Forest Service directives. The Department believes it is more appropriate to put specific procedural analytical requirements in the Forest Service directives rather than in the rule itself so that the analytical procedures can be changed more rapidly if new and better techniques emerge. As for other portions of the Forest Service directives, public notice and comment is required where there is substantial public interest or controversy.

70 Fed. Reg. at 1028. The agency also defended this shift on the ground that the “directives can be more extensive and can be more easily changed as the agency learns how to improve its analytic processes and as new scientific concepts and new technological capabilities become available.” *Id.* at 1029.

(2) Protection of Diversity

One of the most fundamental alterations that the 2005 NFMA planning regulations make in the approaches reflected in the 1982 and 2000 regulations relates to the manner in which they require the Forest Service to monitor, assess,²¹⁶ and protect biodiversity. The Forest Service explained in the preamble to the 2005 regulations that, thirty years after the adoption of the NFMA, the concepts of biological diversity at different spatial and temporal scales (including genetic, species, structural, and functional diversity) have been substantially refined. The complexity of the concept of biological diversity, according to the agency, requires “a corresponding complicated array of concepts, measures, and values from several scientific disciplines.”²¹⁷ The Forest Service settled as its foundational principle that “maintenance of the diversity of plant and animal communities starts with an ecosystem approach,” which seeks to “provide a framework for maintaining and restoring ecosystem conditions necessary to conserve most species.”²¹⁸ The more effective a plan is in protecting ecosystem diversity, “the less need there is for species-specific analysis.”²¹⁹ Accordingly, it is only when Forest Service planners determine that the ecosystem approach fails to provide an adequate framework for maintaining and restoring conditions to support species listed under the ESA, species-of-concern, and species-of-interest that the plan must include additional provisions for those species.²²⁰ LRMPs should provide “measures for accounting for progress toward ecosystem and species diversity goals. . . . Progress toward desired conditions and objectives will be monitored and the results made available to the public. The adaptive monitoring and feedback process will help maintain and improve diversity.”²²¹

²¹⁶ “In the most general sense, ecological risk assessment involves estimating the likelihood that an identified hazard will have a negative effect, and estimating the ecological consequences of that negative effect.” GARY K. MEFFE ET AL., *PRINCIPLES OF CONSERVATION BIOLOGY* 376 (2d ed. 1997).

²¹⁷ 70 Fed. Reg. at 1028.

²¹⁸ *Id.* See also *id.* at 1047-48 (stating that the “ecosystem diversity framework provides an essential ecological context and identifies the unique contributions that lands can make to the three elements of sustainability”).

²¹⁹ *Id.* at 1048.

²²⁰ *Id.* at 1028. See also 71 Fed. Reg. at 5137 (stating that the 2005 planning rule “stipulates that the species diversity approach is to be used when the components set up through ecosystem diversity need to be supplemented to provide appropriate ecological conditions for listed species, species-of-concern, and species-of-interest”); FSH 1909.12, § 43.25 (stating that “[a]s a rule, provisions in plan components for conservation of species should focus first on providing appropriate amounts and distribution of suitable habitat throughout the plan area over time,” and that “[o]nly where a broad-scale ecosystem diversity framework will not provide appropriate ecological conditions for listed species, species-of-concern, and species-of-interest, should small spatial scales be considered or analyzed”). The Forest Service characterized its approach as “a complementary ecosystem and species diversity approach for ecological sustainability.” 70 Fed. Reg. at 1029.

A 2006 report issued by the H. John Heinz Center for Science, Economics and the Environment identified ten key information gaps that prevent effective reporting on key indicators of the condition and use of U.S. ecosystems. The ten data gaps related to both species and ecosystem health. See THE H. JOHN HEINZ CENTER FOR SCIENCE, ECONOMICS AND THE ENVIRONMENT, *FILLING THE GAPS: PRIORITY DATA NEEDS AND KEY MANAGEMENT CHALLENGES FOR NATIONAL REPORTING ON ECOSYSTEM CONDITION* 21 (May 2006), available at <http://www.heinzctr.org/publications.shtml>.

²²¹ 70 Fed. Reg. at 1028. See also Seidman & Burdin, *supra* note 139, at 43 (stating that the 2005 regulations “recognize that the planning process should include monitoring of progress toward ecosystem and species diversity”).

In marked contrast to the 1982 regulations²²² and the 2002 proposed regulations,²²³ the 2005 planning regulations do not require that the Forest Service provide for viable populations of plant and animal species. The Forest Service provided three principal explanations for this omission. First, the agency concluded based on experience “that ensuring species viability is not always possible” due to problems such as species-specific distribution problems, declines in species due to factors beyond the agency’s control, or the inability of available land to support species.²²⁴ Second, NFS units contain “very large” numbers of recognized species, and the Forest Service found it “clearly impractical” to analyze all those species. Further, previous attempts to analyze the full suite of species via groups, surrogates, and representatives have had mixed success in practice.”²²⁵ Third, the agency’s past focus on the viability requirement diverted attention and resources away from an ecosystem-based approach to land management, which the Forest Service now considers to be “the most efficient and effective way to manage for the broadest range of species with the limited resources available for the task.”²²⁶

Similarly, the 2005 planning regulations do not impose any requirements that LRMPs dictate population monitoring. The Forest Service explained that population data are difficult to obtain and evaluate due to factors beyond the agency’s control that affect populations.

The Department believes that it is best to focus the agency’s monitoring program on habitat on NFS land where the agency can adjust management to meet the needs of certain species. Desired conditions are often a focus of the monitoring program. The agency will identify species-of-concern and species-of-interest. . . . Where ecological conditions for these species are identified as desired conditions, the habitat could be monitored to assist in avoiding future listing of these species.²²⁷

The regulations do not prohibit population monitoring, and the agency may require it in as-yet undefined “appropriate” circumstances.²²⁸ But Forest Service directives issued after the 2005 planning regulations take the position that, “[f]or most species, the only practicable quantitative evaluation is assessment of habitat conditions.”²²⁹

²²² 36 C.F.R. § 219.19 (2000). *See supra* notes 141-42 and accompanying text.

²²³ *See* 70 Fed. Reg. at 1029 (describing Option 1 of the proposed rule).

²²⁴ *Id.*

²²⁵ *Id.*

²²⁶ *Id.* In issuing the directives that elaborate on the 2005 planning regulations, the Forest Service explained that, although “[t]he viability standard will no longer be used,” Forest Service directives will continue to require that planners identify listed species, species-of-concern, and species-of-interest; collect available data and information for those species, including population data; develop management direction for the species; and assess the effects of management actions. 71 Fed. Reg. at 5138.

²²⁷ 70 Fed. Reg. at 1029.

²²⁸ *Id.*

²²⁹ FSH 1909.12, § 43.26. *See also* Seidman & Burdin, *supra* note 139, at 43 (stating that, “[i]nstead of wasting valuable agency resources on the impractical task of attempting to inventory all species or even

More specifically, the 2005 regulations scrap both the MIS monitoring requirements imposed by the 1982 regulations and eliminate the provisions of the 2000 regulations relating to focal species.²³⁰ In response to comments on the proposed rule suggesting that the final rule impose survey and monitoring requirements for MIS or focal species, the Forest Service explained that it chose not to require MIS monitoring because “recent scientific evidence identified flaws in the MIS concept.”²³¹ According to the agency, that evidence refuted the notion that population trends for certain species could serve as surrogates for other species.²³²

The Forest Service also rejected the concept of focal species initially proposed by the Committee of Scientists and adopted in the 2000 planning regulations based on its conclusion that that concept “is untested and it would not be prudent to potentially make the same mistake with focal species as was made with MIS in the 1982 planning rule.”²³³ The agency conceded, however, that the premise that focal species can serve “as indicators of the ecological conditions may have merit” and stated that Forest Service directives might use focal species “as a tool to identify monitoring approaches to assess progress towards achieving the desired condition articulated in a plan.”²³⁴

The Forest Service directives issued subsequent to the 2005 planning regulations state that it is important to identify species listed under the ESA, species-of-concern, and species-of-interest that are present in the plan area and gather existing information about them. One directive provides:

representative indicator species, the Service has recognized that healthy and diverse ecosystems are the best indicator of healthy wildlife populations”).

²³⁰ The regulations contain special provisions applicable to NFS units governed by plans developed under the 1982 planning rules. Planning officials may meet MIS obligations by considering data and analysis related to habitat, unless the plan specifically requires population monitoring or population surveys. 36 C.F.R. § 219.14(f) (2006); 70 Fed. Reg. at 1052. The Forest Service explained:

Providing explicitly for MIS monitoring flexibility will allow for monitoring of habitat conditions as a surrogate for population trend data. It is appropriate for a range of methods to be available to estimate, or approximate, population trends for MIS. The Responsible Official will determine which monitoring method or combination of monitoring methods to use for a given MIS.

Id. Even when planning officials decide to conduct actual population monitoring for MIS, the preamble to the 2005 regulations expresses a preference for using a sampling program instead of a total enumeration.

Id. See *Navajo Nation v. U.S. Forest Serv.*, 408 F. Supp. 2d 866, 881 (D. Ariz. 2006) (confirming that, under § 219.14(f), the Forest Service has “the option to utilize habitat data as to any obligation regarding MIS”), *aff’d in part, rev’d in part on other grounds, and remanded*, 479 F.3d 1024 (9th Cir. 2007).

²³¹ 70 Fed. Reg. at 1048. The Forest Service added:

Other tools can often be useful and more appropriate in predicting the effects of projects that implement a land management plan (such as examining the effect of proposed activities on the habitat of specific species); using information identified, obtained, or developed through a variety of methods (such as assessments, analysis, and monitoring results); or using information obtained from other sources (such as State fish and wildlife agencies and organizations like The Nature Conservancy).

Id. at 1052.

²³² *Id.* at 1048 (stating that through time, it “was found not to be the case” that “population trends for certain species that were monitored could represent trends for other species”).

²³³ *Id.*

²³⁴ *Id.*

However, in many cases it will be impractical to consider each species individually in the planning process. Therefore, the Responsible Official may identify a manageable subset of species on which to focus species conservation measures and evaluation in the plan, plan amendment, or plan revision. For this purpose, *species groups and/or surrogate species may be used as an evaluation and analysis tool* to improve planning efficiency and for development of plan components. When groups of species have been identified, *one or more species within each group may be selected to serve as surrogates for the ecological condition for other species in the group, or surrogate species may be selected based on other concepts such as umbrella species, keystone species, ecological indicators, and so forth.* If species groups and/or surrogate species are used, clearly describe the process for identifying groups or surrogates including critical assumptions and the uncertainty of conclusions. Explain why assumptions are reasonable and why the degree of uncertainty is acceptable. Identification and use of surrogate species is strictly an analysis and evaluation tool that may be used to improve planning.²³⁵

Even when surrogates are used in the manner described in the directive, however, “[t]here are no monitoring or inventory requirements for surrogate species.”²³⁶ Before it issued the final directives that expand upon the 2005 planning regulations, the Forest Service was urged by commenters to identify criteria for identifying surrogate species and to describe how this tool will be used in the forest planning process. The Agency’s response was simply that, “[a]s with any other approach used in NFMA planning, species grouping and the selection of surrogates must take into account the best available science and applicable portions of the Data Quality Act (44 U.S.C. 3516). An approach that does not satisfy these criteria would not be used.”²³⁷

In short, the 2005 planning regulations as well as the directives subsequently issued by the Forest Service neither “anticipate gathering population data for developing a plan,” specify the types of data needed to implement LRMPs, nor prescribe any requirements for monitoring of any resource. Instead, “[t]he types and amount of data needed will be determined by [planning officials] *taking into account best available science.*”²³⁸ In deciding what resources to monitor and in selecting the methods for doing so, the agency has indicated that it intends to afford priority to circumstances that present “a high degree of uncertainty associated with management assumptions.”²³⁹

(3) Evaluation of the 2005 Planning Regulations

²³⁵ FSH 1909.12, § 43.24. The directive also explains that “one or more species within each macrohabitat group may be selected as surrogates if they can be demonstrated to represent the ecological conditions for all species in the group” and that “[i]f the needs of surrogate species are met, then most needs of other species within the habitat group should also be met.” *Id.*

²³⁶ *Id.*

²³⁷ 71 Fed. Reg. at 5141.

²³⁸ *Id.* at 5137 (emphasis added).

²³⁹ *Id.* (quoting FSH 1909.12, § 12.1).

The 2005 planning regulations depart from the rules that governed NFMA planning from 1982 to 2000 and from the 2000 planning rules, had they ever gone into effect, in several significant ways relevant to the implementation of the NFMA's diversity requirement. First, the regulations provide equal emphasis on the social, economic, and ecological components of sustainability, whereas the 2000 regulations clearly identified restoration and maintenance of ecological sustainability as the preeminent goal of the NFMA planning process.

Second, they represent a marked shift from a mandate that planning officials assess the consequences of management actions at both the ecosystem and species levels. Although the 2005 regulations do not ignore species diversity, the default rule is that protection of ecosystem diversity will serve as an adequate mechanism for protecting species diversity as well. Planning officials must adopt mechanisms to provide specific protection for species-of-concern or species-of-interest only if they conclude that particular conditions in the planning area make it impossible for protection of ecosystem diversity to also achieve the goal of species diversity.

Third, the 2005 regulations eliminate the viability requirement contained in the 1982 regulations. According to the Forest Service, the species viability requirement diverted the agency's attention away from the more important task of protecting diversity at the ecosystem level. In addition, it was burdensome for planners to monitor the effect of management actions on a large number of species, and the effort resulted in "mixed success" at any rate. As two observers have indicated, the 2005 planning regulations reflect the Forest Service's attempt

to resolve the habitat-based versus population-based wildlife management dilemma by abandoning the "species viability" approach and by selecting the goal of maintaining or enhancing ecosystem diversity as "the primary means by which a [forest] plan contributes to sustaining ecological systems" to provide for diversity of plant and animal communities. The agency asserts that the more effectively it maintains the ecosystem, the less it will need to analyze and plan at the "species level of ecological organization."²⁴⁰

It is not clear, however, whether the 2005 planning regulations install sufficient monitoring or evaluation requirements to provide a meaningful check in the context of particular decisions on the accuracy of the agency's assumption that protection of diversity at the ecosystem level will suffice to insure the protection of species-level diversity as well.²⁴¹

²⁴⁰ Seidman & Burdin, *supra* note 139, at 42.

²⁴¹ See Jeffrey Rudd, *The Forest Service's Epistemic Judgments: Enhancing Transparency to Ensure "New Knowledge" Informs Agency Decision-Making Processes*, XXII *TEMPLE ENVTL. L. & TECH. J.* 145, 198 (2004) (asserting that "[i]n the absence of an assessment of species diversity, the agency will be unable to determine whether ecosystem level diversity provides the degree of species diversity protection necessary to maintain a sustainable ecological system" and urging the Forest Service to "conduct species level analysis in order to conclude that the ecosystem level plan complies with NFMA's species diversity requirements").

Fourth, consistent with the Forest Service's focus on ecosystem as opposed to species diversity, the 2005 regulations eliminate the requirement that planning officials engage in population monitoring of any kind, although they permit such monitoring to be conducted under individual plans. The regulations abandon the concept of MIS, characterizing it as a "flawed" method for using limited information to predict the consequences of management actions on the forest as a whole. The regulations also back away from the designation of focal species, which were an important component of the 2000 regulations, because the Forest Service deems the concept to be untested and imprudent.

The 2005 regulations, however, do not abandon the technique of using surrogate components of the resources in the plan area to simulate the effect of management actions on the broader ecosystem. On the one hand, the Forest Service justified throwing out the use of MIS on the ground that recent scientific evidence refuted the premise that population trends for individual species can serve as surrogates for the trends of other species.²⁴² On the other hand, because it is impractical to consider each species individually in the planning process, the Forest Service directives permit planners to identify a "manageable subset of species on which to focus conservation measures and evaluation in the plan" and to use species groups or surrogate species as evaluative and analytical tools.²⁴³ It is not clear why the Forest Service believes that such techniques will provide useful information, even assuming that the agency provides forthright descriptions of the uncertainties involved in the selection of the surrogates,²⁴⁴ if the premise that tracking population trends for surrogate species can simulate trends for the ecosystem in which they live has been found "not to be the case."²⁴⁵

A particularly troublesome component of the new approach to reliance on surrogates is the statement contained in Forest Service directives that, in selecting surrogates, Forest Service personnel must take into account not only the best available science, but also "applicable portions of the Data Quality Act" (also known as the Information Quality Act (IQA)). That statute requires that all federal agencies comply with guidelines issued by the Office of Management and Budget to ensure and maximize "the quality, objectivity, utility, and integrity of information (including statistical information) disseminated by federal agencies."²⁴⁶ The IQA has served as a tool by which those opposed to the imposition of environmental protection measures have sought to delay implementation of those measures and to censor information with which they disagree or which they would rather not be disseminated because of its potential to put their activities in a bad light. The IQA has become a basis for challenging agency efforts to protect the public health and the environment by casting decisions made despite the

²⁴² See 70 Fed. Reg. at 1048.

²⁴³ FSH 1909.12, § 43.24.

²⁴⁴ One observer, however, has expressed a fear that due to "[t]he inherent limitations in the process of producing scientific knowledge[,] . . . Forest Service administrators will justify as "scientific" claims that mask the level of uncertainty recognized by the broader scientific community." Rudd, *supra* note 241, at 165.

²⁴⁵ 70 Fed. Reg. at 1048.

²⁴⁶ Pub. L. No. 106-554, § 515, 114 Stat. 2763, 2763A-153 (codified at 44 U.S.C. § 3516 note).

existence of scientific uncertainty as decisions based on “bad science.”²⁴⁷ Scientific uncertainty is a pervasive attribute of environmental regulation, and its existence does not necessarily reflect unsubstantiated decisions or decisions based on unsound science.²⁴⁸ The incorporation of IQA procedures into the NFMA process for protecting biodiversity appears to be a prescription for imposing shackles on efforts by the Forest Service to use the planning process to impose new constraints on resource extraction activities or other uses with the potential to interfere with the restoration or protection of biodiversity.²⁴⁹

Moreover, the Forest Service has not abandoned the use of surrogates as predictors of the effects of management actions on biodiversity. Rather, it has redefined the surrogate. Instead of assessing the impact of management actions on individual or focal species to determine whether the actions will frustrate the statutory requirements of protecting plant and animal diversity, the Forest Service has chosen in most cases to proceed on the basis of the assumption that assessing the impact of management actions on species habitat, and taking measures to protect that habitat, will enable planners to comply with the NFMA mandate that plant and animal diversity be protected through the planning process. The Forest Service has thus resorted to the proxy-on-proxy approach it began using under the 1982 regulations when it concluded that the monitoring of MIS was too burdensome. The substitution of the proxy-on-proxy approach for the MIS-based approach is problematic. Despite ongoing debate over how to define a species,²⁵⁰ it may be even more difficult for scientists to agree on the definition of an ecosystem and on how to measure its vitality.²⁵¹ The more abstract the measurement chosen to represent

²⁴⁷ Sidney A. Shapiro et al., *Ossifying Ossification: Why the Information Quality Act Should Not Provide for Judicial Review*, Center for Progressive Reform White Paper 601 (Feb. 2006), at 2-3, available at http://www.progressivereform.org/articles/CPR_IQA_601.pdf.

²⁴⁸ Sidney A. Shapiro, *The Data Quality Appropriations Ride: New Procedures and Information Disclosure*, Center for Progressive Reform Perspective (2005) (arguing that there is a “crucial distinction between incomplete data and poor quality data”), available at <http://www.progressivereform.org/perspectives/dataQuality.cfm>.

²⁴⁹ Cf. Sidney A. Shapiro, *OMB's Dubious Peer Review Procedures*, 34 ENVTL. L. REP. (ENVTL. L. INST.) 10064 (2004) (arguing that the IQA creates a procedural apparatus that is likely to stifle the government’s efforts to provide useful information to the public about their safety and health risks and about risks to the environment). See generally Stephen M. Johnson, *Junking the ‘Junk Science’ Law: Reforming the Information Quality Act*, 58 ADMIN. L. REV. 37 (2006); Sidney A. Shapiro, *The Information Quality Act and Environmental Protection: The Perils of Reform by Appropriations Rider*, 28 WM. & MARY ENVTL. L. & POL’Y REV. 339 (2004); Sidney A. Shapiro, *The Case Against the IQA*, 22 ENVTL. F. # 4 (July/August 2005), at 26; Michelle V. Lacko, Comment, *The Data Quality Act: Prologue to A Farce or A Tragedy?*, 53 EMORY L.J. 305 (2004).

²⁵⁰ J. B. Ruhl, *The Battle Over Endangered Species Act Methodology*, 34 ENVTL. L. 555, 576 n.57 (2004) (“The scientific consensus on ‘species’ ... is that no complete consensus exists and that different definitions suit different purposes.”) (quoting Blake Hood, *Transgenic Salmon and the Definition of “Species” Under the Endangered Species Act*, 18 J. LAND USE & ENVTL. L. 75, 78 (2002)); Anna L. George & Richard L. Mayden, *Species Concepts and the Endangered Species Act: How A Valid Biological Definition of Species Enhances the Legal Protection of Biodiversity*, 45 NAT. RESOURCES J. 369, 369 (2005) (stating that “[t]here is no single accepted definition of a ‘species’ in the natural sciences”).

²⁵¹ Susan Harrison, *Biodiversity and Wilderness: The Need for Systematic Protection of Biological Diversity*, 25 J. LAND, RESOURCES, & ENVTL. L. 53, 56 (2005) (“Academic ecology is full of unresolved debates, however, over the degree to which communities or ecosystems are real entities with objectively definable boundaries and in what ways their functional properties depend on their component species.”). Cf. Kristin Carden, *Bridging the Divide: The Role of Science in Species Conservation Law*, 30 HARV.

plant and animal diversity within a forest, the more likely it is that agencies can base management decisions on undisclosed value judgments rather than falsifiable scientific hypotheses. The status of the habitat of an MIS appears less concrete than a specification of the rise or fall in MIS populations.

Fifth, the regulations introduce the concept of planning based upon a vague, process-based “best available science” mandate. The regulations require that planners identify scientific uncertainty and how it might affect planning decisions. Although the 2002 proposed regulations would have required planners to base their decisions on the best available science, the final regulations only require that the agency “take into account” the best available science, and the Forest Service has acknowledged that science provides only one of many factors upon which it will make its planning decisions. There is nothing inherently wrong with a process-based approach to the protection of biodiversity. There is also merit, as discussed below,²⁵² to the idea that the Forest Service maintain flexibility in its efforts to protect biodiversity so that it can respond quickly and effectively to changes in the state of scientific knowledge. Both the use of a procedure-based definition of diversity and the movement into agency directives of most of the detailed prescriptions, substantive and procedural, for protecting biodiversity in the NFMA planning process, are designed to achieve that freedom to respond to circumstances as they develop.

The Forest Service Manual and the Forest Service Handbook are likely to be less accessible than agency regulations, however, and some people interested in Forest Service management may not even know about them.²⁵³ If the agency’s decisions are being guided by standards and procedures shielded from public view, efforts to provide meaningful input into Forest Service planning decisions may be frustrated.²⁵⁴ That result seems contrary to the spirit if not the letter of what the statute demands of the agency. It requires the Forest Service to “provide for public participation” in the development of LRMPs²⁵⁵ and provides that, in exercising his or her authority under the NFMA, the Secretary of Agriculture establish procedures to give the public adequate notice of and opportunity to comment on the formulation of standards and criteria applicable to Forest Service programs.²⁵⁶ It is hard enough for interested members of the public to provide informed and useful input when the issues are as technical as they typically are in determining the appropriate framework for approving management actions involving forest lands and resources. It is harder still for such persons to play the role Congress envisioned for them if the decisions are governed by criteria that are not readily available.

ENVTL. L. REV. 165, 216 (2006) (asserting that, “even given unlimited time, the complex, diverse, and dynamic nature of ecosystems does not lend itself to our full understanding”).

²⁵² See *infra* notes 281-7 and accompanying text.

²⁵³ The directives are accessible through the Forest Service’s official website, at <http://www.fs.fed.us/im/directives>.

²⁵⁴ Cf. Rudd, *supra* note 241, at 164 (asserting that “the regulations shield from view the scientific process of knowledge production and its relationship to the Service’s responsibility to honor that process”).

²⁵⁵ 16 U.S.C. § 1604(d).

²⁵⁶ 16 U.S.C. § 1612(a).

The barriers to informed participation in Forest Service planning efforts may even reduce the utility of input from the scientific community outside the agency, particularly in light of the possibility that the agency may not be receptive to interpretations of the “available” science that conflict with their own.²⁵⁷ The Forest Service did not even convene a Committee of Scientists before promulgating the 2005 regulations, in contrast to the practices followed in the development of both the 1982 and 2000 planning regulations,²⁵⁸ and in apparent violation of the NFMA’s requirement that the agency convene and solicit input from a Committee as part of the process of implementing the planning process.²⁵⁹

Far more worrisome than the accessibility of these directives, however, is their legal status. Although the courts have reacted differently when asked to characterize the status of Forest Service directives, some cases support the conclusion that the FSM and the FSH lack the force and effect of law, are not binding upon the agency, and cannot be enforced by private litigants in suits against the Forest Service. The Ninth Circuit, for example, concluded that the FSM “does not rise to the status of a regulation” and evidently need not be followed by the agency.²⁶⁰ The courts have reached similar results in assessing the status of the FSH.²⁶¹ If the Forest Service directives do not bind the agency in its NFMA planning decisions, the 2005 regulations have moved in the direction of vesting in the agency relatively unconstrained discretion in deciding how to implement the NFMA’s diversity mandate, particularly given the vagueness and brevity (compared to the 1982 and 2000 planning regulations) of the regulations themselves concerning what the agency is required to do to restore and maintain plant and animal diversity. This

²⁵⁷ Rudd charges that

one of the fundamental problems with the Forest Service’s reliance upon “science” to justify its management decisions [is that the] present institutional relationship between the Forest Service and the remainder of the scientific community fails to ensure “equality of intellectual authority among qualified practitioners.” The Forest Service’s choice of a “scientific” claim, theory, or technique over a conflicting knowledge claim results from an epistemic judgment about the relative values of the competing claims to address the problem at hand. The Service is not required to support its judgment with direct appeal to the broader scientific community’s views concerning the knowledge claims’ soundness.

Rudd, *supra* note 241, at 179.

²⁵⁸ See Flournoy et al., *supra* note 170, at 3, 4 (describing the input provided by the Committees convened prior to issuance of the 1982 and 2000 regulations).

²⁵⁹ 16 U.S.C. § 1604(h)(1) provides that, in carrying out the purposes of § 1604(g), which requires the Secretary of Agriculture to promulgate regulations governing the planning process, the Secretary “shall appoint a committee of scientists who are not officers or employees of the Forest Service.”

²⁶⁰ *Hi-Ridge Lumber Co. v. United States*, 443 F.2d 452, 454-55 (9th Cir. 1971). See also *Big Meadows Grazing Ass’n v. United States*, 344 F.3d 940, 945 (9th Cir. 2003); *Sw. Ctr. for Biological Diversity v. United States Forest Serv.*, 100 F.3d 1443, 1450 (9th Cir. 1996); *Hage v. United States*, 51 Fed. Cl. 570, 585 (2002) (stating that agency manuals lack “the force of law”).

²⁶¹ See, e.g., *Loggerhead Turtle v. County Council*, 148 F.3d 1231, 1243 n.11 (11th Cir. 1998). See also *W. Radio Serv. Co. v. Espy*, 79 F.3d 896 (9th Cir. 1996) (concluding that neither the FSM nor the FSH has the independent force and effect of law because they are not substantive in nature, are not promulgated in accordance with the procedures specified in the Administrative Procedure Act, and are not issued pursuant to an independent grant of congressional authority); *City of Williams v. Dombeck*, 151 F. Supp. 2d 9, 22 (D.D.C. 2001) (concluding that neither the FSM nor the FSH is mandatory because they were never published in the Code of Federal Regulations).

move toward decreased accountability is regrettable.²⁶² Finally, the directives provide little solace in that they state at one point that the agency's assessment of ecosystem diversity should "inform" planning decisions, rather than that the assessment will determine, or even play a significant role in determining, the outcome of the planning process.²⁶³

The degree to which the 2005 planning regulations conform to or deviate from the NFMA's dictate that LRMPs be developed in a manner that provides for the diversity of plant and animal communities probably will be decided in the crucible of litigation. The regulations did not settle the controversy over whether the statute mandates a species-based protection effort or allows the Forest Service to focus on habitat maintenance. Likewise, the policy debate has not been stilled.²⁶⁴ Environmental groups have sued the Forest Service, challenging the validity of the 2005 regulations on both substantive and procedural grounds.²⁶⁵ In the first round of litigation, a federal district court in California enjoined implementation of the 2005 regulations and remanded to the agency.²⁶⁶ The court instructed the Forest Service to comply with notice and comment rulemaking procedures set forth in the Administrative Procedure Act, the environmental assessment requirements of NEPA, and the consultation requirements of the ESA, all of which the agency contravened in issuing the regulations.²⁶⁷ The court did not address the substantive validity of the regulations, including the provisions bearing on the Forest Service's responsibility under the NFMA to protect plant and animal diversity.

IV. A GENERIC SET OF CRITERIA FOR MANAGING BOUNDED RATIONALITY AND SCIENTIFIC UNCERTAINTY THROUGH MODELING AND THE USE OF SURROGATES

The controversy over the Forest Service's evolving approaches to fulfilling its responsibility under the NFMA to protect biodiversity provides an opportunity to assess what a regulatory program for making science-based decisions in the face of scientific uncertainty should look like. This part of the article argues that such a regulatory program should be realistic, collaborative, transparent, and flexible, and should install mechanisms for insuring that the agency responsible for implementing the program may be held accountable.

The necessity of making environmental and natural resource management policy decisions despite the presence of considerable scientific uncertainty about the need for and effects of such decisions will not disappear any time soon. As the stakes of waiting

²⁶² See *infra* notes 298-303 for a discussion of the importance of agency accountability in the use of models or other surrogate simulations.

²⁶³ FSH 1909.12, § 43.1.

²⁶⁴ See Seidman & Burdin, *supra* note 136, at 44 (asserting that the 2005 regulations "appear to have simply fanned the flames of the controversy over forest wildlife management strategies").

²⁶⁵ The claims raised by the plaintiffs include allegations that the Forest Service violated applicable notice and comment rulemaking requirements, improperly failed to include adequate decisionmaking standards regarding wildlife protection, failed to support its decision to "abandon" the species viability requirement, and violated NEPA by refusing to prepare an environmental impact statement on the regulations. See *id.*

²⁶⁶ *Citizens for Better Forestry v. U.S. Dep't of Agric.*, 481 F. Supp. 2d 1059 (N.D. Cal. 2007).

²⁶⁷ *Id.* at 1110-01.

until all of the “necessary” information is available get higher in resolving issues such as how to combat global climate change, the need to make expeditious but informed decisions before the decisionmaker has eliminated doubt only grows stronger.²⁶⁸ Agencies responsible for restraining the potentially harmful activities of industrial and governmental polluters and for acting as stewards of publicly owned resources, and the legislatures that delegate decisionmaking authority to such agencies, therefore must avoid falling into the trap of believing that there is “an” optimal answer to a particular environmental policy problem, and that if we wait long enough, science will provide us with the information necessary to ascertain what that answer is and then allow us to put it into effect. Uncertainty can easily be used, and unfortunately has been in many environmental policy debates in the past, as “an excuse for inactivity, citing that ‘more research is needed before a sound decision is made.’”²⁶⁹ Bounded rationality is here to stay. The task at hand is not eliminating it, but reducing it to manageable proportions through research and the use of simulation techniques, such as modeling, so that reasonably informed judgments can be made about the relative merits of the competing alternative policy choices.

Environmental agencies will continue to rely on models (like the dose-response assessment models that permit extrapolation of animal test data on toxic chemicals down to the levels of likely human exposure, or the identification of MIS or focal species to serve as surrogates for the effect of the management alternatives being considered on the larger ecosystem of which they are a part) to help them close the data gaps they face in making policy judgments. In doing so, they should be careful not to cordon themselves off from those who might provide useful input on the potential flaws in their modeling exercises and on the availability of alternative means of managing bounded rationality.²⁷⁰ Agencies can isolate themselves either by making their decisions in secret, without

²⁶⁸ See Rose, *supra* note 1, at 294 (arguing that, “more than ever, policymakers cannot wait until scientific evidence is conclusive; instead, they often have to make up their minds while the data is still tentative”).

²⁶⁹ Eric Wolanski et al., *Mud, Marine Snow and Coral Reefs*, 91 AMERICAN SCIENTIST 44 (Jan. 1, 2003), 2003 WLNR 13226176. The authors, who made this comment in discussing ecosystem models, assert that “the major impediment at this point appears to be political will.” *Id.* Cf. *Natural Res. Def. Council, Inc. v. Evans*, 364 F. Supp. 2d 1083, 1131-32 (N.D. Cal. 2003) (criticizing agency subject to mandate to make decisions based on the “best available science” for characterizing new study as “junk science” as a pretext for ignoring it), *appeal dismissed sub nom. Oceana, Inc. v. Gutierrez*, 457 F.3d 904 (9th Cir. 2006). Cf. *Earth Island Inst. v. Hogarth*, 484 F.3d 1123, 1134-35 (9th Cir. 2007) (concluding that agency’s finding that yellowfin tuna fishery was not having an adverse impact on dolphin populations, which was supposed to be based solely on the best available science under the Marine Mammal Protection Act, and was couched in those terms, was instead improperly influenced by international political concerns).

²⁷⁰ According to a critic of the 2005 planning regulations:

Although models may serve an important instrumental purpose, and “case studies may provide the best approach to applied ecology,” both approaches are subject to the influence of bias and assumption. Theoretical models’ assumptions risk the loss of specific knowledge about a particular ecosystem or species in an attempt to demonstrate “exceptionless laws.” Case-studies’ background assumptions may sacrifice general knowledge transferable across study areas in favor of detailed, local knowledge claims.

Rudd, *supra* note 241, at 207. See generally ORRIN H. PILKEY & LINDA PILKEY-JARVIS, USELESS ARITHMETIC: WHY ENVIRONMENTAL SCIENTISTS CAN’T PREDICT THE FUTURE (2007) (contending that mathematical models used to make scientific determinations yield results that depart from reality due to factors such as erroneous assumptions and the reluctance to check predictions against natural outcomes).

soliciting the views of knowledgeable experts and lay persons, or by framing the debate in terms that are so technical that the world of potentially useful contributors becomes extremely small.

By combating this tendency and welcoming rather than dreading the possibility that other experts have insights not yet developed by agency scientists, the agency provides itself with an opportunity to reduce the level of uncertainty surrounding its decision. Indeed, the “best available science” standard contained in the 2005 regulations is fully consistent with the idea that agencies should reach out for expert advice if it is interpreted as imposing on the agency an affirmative obligation to make reasonable efforts (but not efforts so onerous as to cripple the agency’s ability to act within a reasonable time frame) to supplement the existing knowledge base.²⁷¹

There is some evidence that at least one court has begun to adopt a similar approach in assessing the Forest Service’s compliance with the 2005 regulations. In an NFMA-based challenge to the validity of a logging project governed by the “best available science” mandate, the Tenth Circuit reversed the district court’s finding that the Forest Service complied with the statute and regulations and remanded to the district court with instructions to vacate the Forest Service’s approval of the project.²⁷² The Forest Service asserted that it followed the best available science, contending that it has the discretion to decide what constitutes the best available science.²⁷³ The court rejected that claim, however, concluding instead that the 2005 regulations “underscore that the ‘best available science’ is *not* just whatever the Forest Service finds on the shelf.”²⁷⁴ The court was troubled by the Forest Service’s selective reliance on a 1992 Forest Service report and in particular its contention that the court was obliged to defer to the agency’s expertise whenever its conclusions differed from those in the report.²⁷⁵ The court invalidated the logging project because, on the record before it, it was unable to determine whether the Forest Service satisfied the best available science mandate. It suggested that, on remand, the Forest Service look to the practice of agencies governed by other statutes (including the ESA, the Safe Drinking Water Act, and the Magnuson-Stevens Fishery and Conservation and Management Act) that require agencies to base their decisions on the best available science. The court read the cases and regulations interpreting those other statutes as clearly absolving the Forest Service of the need to collect new data, but as requiring that it “seek out and collect all existing scientific evidence relevant to the decision” and prohibiting it from ignoring existing data.²⁷⁶

²⁷¹ See *supra* note 34 and accompanying text (discussing the possibility that Congress imposes “best available science” mandates as a means of requiring such affirmative, information-gathering efforts); Doremus, *Best Available Science Mandate*, *supra* note 34, at 30-31 (urging both agencies and courts to “return to the earlier interpretation that section 7 [of the ESA] imposes an obligation on the action agency to provide any reasonably obtainable information”).

²⁷² *The Ecology Ctr. v. United States Forest Serv.*, 451 F.3d 1183 (10th Cir. 2006).

²⁷³ *Id.* at 1193.

²⁷⁴ *Id.*

²⁷⁵ *Id.*

²⁷⁶ *Id.* at 1194-95 n.4 (quoting *Heartwood, Inc. v. United States Forest Serv.*, 380 F.3d 428, 436 (8th Cir. 2004)).

Notably, it also established that “*the best available politics does not equate to the best available science.*”²⁷⁷

The Tenth Circuit subsequently invalidated timber sales in two additional cases based on the Forest Service’s noncompliance with the best available science mandate. In one case, the court concluded that the agency provided no evidence that it used the best available science in approving the project.²⁷⁸ In the other, the court found it “obvious” that the agency did not satisfy its obligations to base approval of the logging project on the best available scientific evidence and rejected the district court’s conclusion that the error was harmless due to the agency’s reliance on other available data.²⁷⁹ The administrative record contained no indication that the Forest Service ever considered its best available science obligations before approving the timber sales.²⁸⁰ These precedents may presage a refusal on the part of the courts to rubber-stamp the Forest Service’s findings on whether individual projects were properly based on the best available science.

The fear that agency scientists will close themselves off from the potentially conflicting views of experts on the outside is apparently a legitimate one in the context of decisionmaking to preserve biodiversity. According to one account, “[o]ver the last 50 years, it appears that sections of the wildlife discipline have developed a certain subculture that is not inclined to release strategic wildlife and habitat data on which decisions are based.”²⁸¹ The NFMA provides at least two concrete mechanisms for combating any tendency of agency scientists to cut themselves off from potentially dissenting views. First, as indicated above, the statute requires the Secretary of Agriculture to convene and seek input from a Committee of Scientists when the Forest Service embarks on the process of amending the planning regulations.²⁸² Second, the statute requires that, in providing for public participation in the planning for and management of the national forests, the Secretary “shall establish and consult such advisory boards as he deems necessary to secure full information and advice on the execution of his responsibilities.”²⁸³ Those boards must reflect a cross-section of groups interested in planning and management decisions governing the use and enjoyment of the national forests.²⁸⁴ The Forest Service should scrupulously follow these solicitation requirements, and other environmental and natural resource management agencies should likewise create or take advantage of procedures that allow them to collaborate with experts outside the agency before deciding how to narrow the relevant data gaps that seem to pose obstacles to informed policy judgments. As one critic of the 2005 planning regulations has argued:

²⁷⁷ *Id.* at 1194 n.4 (quoting *Midwater Trawlers Co-Op. v. Dep’t of Commerce*, 282 F.3d 710, 720 (9th Cir. 2002)).

²⁷⁸ *Utah Env’tl. Cong. V. Richmond*, 483 F.3d 1127, 1135-37 (10th Cir. 2007).

²⁷⁹ *Id.* at 1287. Interestingly, the court noted that the Forest Service “relied solely on MIS-based analysis in approving these three projects.” *Id.*

²⁸⁰ *Id.* at 1288.

²⁸¹ Huetmann, *supra* note 65, at 470.

²⁸² 16 U.S.C. § 1604(h)(1).

²⁸³ 16 U.S.C. § 1612(b).

²⁸⁴ *Id.*

The objectivity of the science-based judgments required by the “best available science” regulation will only be established through interactive discourse between the agency and the broader scientific community; i.e., through the process of “transformative criticism.” Scientific “consistency checks” will limit the introduction of arbitrary or subjective preferences undermining the scientific knowledge production process and its reasonable impact on Forest Service planning decisions.²⁸⁵

He adds that “the influence of bias and authoritarian tendencies will only be prevented by transparent and collaborative decision-making processes.”²⁸⁶

Agencies making science-based decisions in the face of bounded rationality must reach out to more than just the scientific experts, however. Although scientific information is no doubt essential to an agency’s ability to make resource allocation decisions such as the ones at issue in the NFMA planning process, these decisions “cannot be divorced from underlying value-based considerations, including related political, economic, social, and aesthetic judgments,” especially when, as is often the case, scientific debate precludes the technical experts from settling upon a single, right answer.²⁸⁷ The solicitation of input from all interested members of the public, including but not limited to those subject to environmental regulation and those seeking permission to use public resources, is essential to the making of informed judgments on those extra-scientific questions.

Unless the agency explains its options in terms accessible to non-experts, it cannot hope to receive useful input on questions such as whether to monitor wildlife habitat through the use of a model that extrapolates from the effects of a decision on a single species to the effects of that decision on all species, or instead to focus on the effects of the decision on the habitat of a species or group of species. Moreover, the agency should make efforts to distinguish between the scientific and non-scientific components of the relevant decision of whether and how to use a model or other simulation technique.²⁸⁸ Part of the agency’s full disclosure efforts ought to involve explaining the limits of the modeling approach being considered and describing the assumptions built into the model, and the policy judgments upon which those assumptions rest.²⁸⁹

²⁸⁵ Rudd, *supra* note 241, at 186. In particular, Rudd argues that the Forest Service must “(1) develop standards for reviewing relevant claims produced by the broader scientific community, and (2) design collaborative processes involving non-agency scientists to establish through transformative criticism the credibility of the agency’s science-based positions.” *Id.* at 186-87.

²⁸⁶ *Id.* at 187.

²⁸⁷ Keiter, *supra* note 111, at 324. See also Holly Doremus, *Natural Resource Management in the Bush Administration*, 32 *ECOLOGICAL L.Q.* 249, 299-303 (2005).

²⁸⁸ See, e.g., Doremus, *Listing Decisions*, *supra* note 31, at 1130-31 (arguing that, “[i]nstead of remaining hidden, the non-scientific elements of the listing decision should be consigned to a more openly political process,” and that “[s]uch a process would permit the airing of all relevant viewpoints, provide a forum to educate the public concerning the range of benefits provided by species, and ultimately provide a more solid political foundation for conservation policy”).

²⁸⁹ Larson et al., *supra*, note 132, at 116, argue that “[t]he validity of habitat suitability models may be questionable, and the direct effects of variation in habitat suitability on wildlife vital rates are often

In addition to being realistic, collaborative, and transparent, any decisionmaking process that relies on models or similar simulation techniques to mitigate the difficulty that bounded rationality imposes on agency decisionmakers should be flexible. Because, by definition, the situations in which models are used involve scientific uncertainty, the existing body of relevant knowledge is likely to change over time. It makes no sense, therefore, to create an approach to addressing bounded rationality that is set in concrete. Rather, what is needed is a decisionmaking process that allows the agency to adjust its approach to conform to new information.²⁹⁰

One means of providing such flexibility (although some have characterized it as a “trendy” one) is adaptive management.²⁹¹ As Brad Karkkainen has explained:

The argument for adaptive management proceeds from the recognition that conventional environmental regulation and natural resource management operate piecemeal, attempting to fraction ecological complexes into smaller, putatively manageable components, and parceling out management responsibilities among mission specific agencies and programs.²⁹²

unknown. It is important, therefore, that model users evaluate these uncertainties and make them explicit, so model results can be interpreted appropriately.” See also Fine & Owen, *supra* note 6, at 971 (contending that “[a] public participant cannot effectively scrutinize a model-based decision without having some understanding of the uncertainties involved, and both modelers and planners therefore ought to be explicit and comprehensive in their discussions of uncertainty”); Kann & Weyant, *supra* note 39, at 29 (urging modelers to lay out assumptions inherent in different models explicitly and be more explicit about the level of confidence they have in model outputs). Fine and Owen add that “[a] modeling prediction unqualified by disclosure of known, or knowable, sources of error is fundamentally deceptive. It conveys a level of certainty that does not exist, hides real risks, and fails to explain key information that ought to be factored into policy choices and decisions. Without such information, public debate may be pointless.” *Id.* at 972.

²⁹⁰ See, e.g., Tarlock, *supra* note 5, at 153 (urging the use of decisionmaking processes that “allow mid-course corrections”); Doremus, *Constitutive Law*, *supra* note 1, at 375-76 (supporting “sufficient flexibility to permit [the agency] to respond to new information, changed conditions, and the progressively sharper conflicts that will inevitably characterize environmental problems”). Jamison E. Colburn, *The Indignity of Federal Wildlife Habitat Law*, 57 ALA. L. REV. 417, 498 (2005), argues that federal wildlife habitat laws are not well suited in their current form to adapt to changing circumstances and to learning in light of experience and that “[a] more reflexive and pragmatic model is needed if we are to preserve much of the habitat our wildlife require.” For discussion of a variety of pragmatic approaches to environmental regulation and natural resource management that respond to the need for agencies to make decisions despite scientific uncertainty, see SHAPIRO & GLICKSMAN, *supra* note 21, at 147-77.

²⁹¹ Bosselman, *supra* note 107, at 496-97. On adaptive management, see generally J.B. Ruhl, *Regulation by Adaptive Management — Is It Possible?*, 7 MINN. J.L. SCI. & TECH. 21 (2005); J.B. Ruhl, *Taking Adaptive Management Seriously: A Case Study of the Endangered Species Act*, 52 U. KAN. L. REV. 1249 (2004); J.B. Ruhl, *Is the Endangered Species Act Eco-Pragmatic?*, 87 MINN. L. REV. 885 (2003); J.B. Ruhl, *Thinking of Environmental Law as a Complex Adaptive System: How to Clean Up the Environment by Making A Mess of Environmental Law*, 34 HOUS. L. REV. 933 (1997); Bradley C. Karkkainen, *Panarchy and Adaptive Change: Around the Loop and Back Again*, 7 MINN. J.L. SCI. & TECH. 59 (2005).

²⁹² Bradley C. Karkkainen, *Adaptive Ecosystem Management and Regulatory Penalty Defaults: Towards A Bounded Pragmatism*, 87 MINN. L. REV. 943, 945-46 (2003).

Conservation ecologists, among others, have supported the iterative approach reflected in an adaptive management-based decisionmaking regime, based on the recognition that the policy approaches developed to deal with questions such as how to protect plant and wildlife diversity are “inescapably provisional and experimental, subject to subsequent modification in response to new learning and changing conditions.”²⁹³ The idea is to use feedback from experience with the approach initially selected to “pragmatically and continuously adjust both ends and means in light of experience and learning.”²⁹⁴ The need for flexibility is particularly acute in the context of land and resource planning, which is designed to provide an ongoing framework for resource allocation decisions given that the state of the resources being managed is continuously in flux.²⁹⁵

The NFMA envisions precisely this sort of flexible, iterative management process. It requires that the Forest Service’s regulations for developing LRMPs “insure research on and (based on continuous monitoring and assessment in the field) evaluation of the effects of each management system to the end that it will not produce substantial and permanent impairment of the productivity of the land.”²⁹⁶ The provisions of the directives that implement the portions of the 2005 planning regulations which deal with protection of biodiversity fare relatively well when judged under this criterion. The FSH, for example, states that “[d]evelopment of plan components for ecosystem diversity and species diversity may be an iterative process”²⁹⁷ (although it would have been better to state that the process *should* or *must* be iterative). The FSH also provides that such an iterative process “may suggest the need for refinement of a proposed plan . . . that would then require additional analysis.”²⁹⁸

An agency’s use of modeling or simulation techniques to facilitate its ability to make decisions in the face of scientific uncertainty must insure that the agency remains accountable for its choices. Unless the agency is accountable for its decisions, the normative suggestions for decisionmaking in the face of scientific uncertainty discussed above will not amount to much. The substantive output of agency modeling

²⁹³ *Id.* at 943.

²⁹⁴ *Id.* See also Bradley C. Karkkainen, *Toward A Smarter NEPA: Monitoring and Managing Government’s Environmental Performance*, 102 COLUM. L. REV. 903, 907-08 (2002) [cited hereinafter as Karkkainen, *Toward A Smarter NEPA*] (contending that a shift “in the focus of information production from the uncertain and speculative realm of comprehensive ex ante prediction to the pragmatic empiricism of observation, measurement, and verification” through the use of management tools such as those that employ digital technologies “enable systematic error detection and correction, early identification of unforeseen circumstances, and ongoing advances in our understanding of complex natural systems”; as a result, decisionmaking can be situated “on a firmer pragmatic and empirically grounded footing, and expand the decisionmaker’s capacity to learn and to adjust decisions over time”).

²⁹⁵ *Cf.* Bosselman, *supra* note 107, at 496-97 (stating that “organizations learned from practical experience that simple extrapolations of history and cadres of professional planners failed to lead to innovation, adaptation to change, or even survival”); Karkkainen, *Toward A Smarter NEPA*, *supra* note 294, at 965 (arguing that “efforts at ecosystem management emphasize the need for experimentation and dynamic adjustment in response to new learning”); Rudd, *supra* note 241, at 167 (contending that “[t]he varying degrees of uncertainty characterizing the explanation and prediction of natural phenomena highlight the importance of continually evaluating models and theories in light of new evidence”).

²⁹⁶ 16 U.S.C. § 1604(g)(3)(C).

²⁹⁷ FSH 1909.12, § 43.26.

²⁹⁸ *Id.*

efforts is not likely to improve, for example, if the agency engages in a collaborative and transparent information-gathering and analytical process, only to blithely ignore the input it has received by reaching a predetermined result. Accountability can take one of several forms.²⁹⁹ Congress has mechanisms, such as legislative oversight hearings and budgeting decisions, by which it can seek to avert or reverse agency decisions that frustrate legislative intent. It is unlikely, however, that Forest Service decisions concerning the formulation and application of models for assessing the impact of agency-approved management actions on biodiversity will surface on the legislative radar screen.

Realistically, accountability for agency decisions involving modeling or related simulation techniques to fill scientific data gaps probably depends on meaningful judicial review. The courts have shown the inclination and the capacity, despite the technical nature of the questions involved, to overturn decisions in which environmental agencies applied a model that bore “no rational relationship to the reality it purport[ed] to represent.”³⁰⁰ The courts traditionally adopted an extremely deferential posture to the review of Forest Service decisions, however, particularly when the agency made the challenged decisions under multiple use, sustained yield statutes such as the NFMA.³⁰¹ In one case involving an attack on Forest Service planning decisions, for example, the court required the plaintiffs to demonstrate that “there is virtually no evidence in the record to support the agency’s methodology.”³⁰²

Reviewing courts have the capacity to play a more useful function in holding agencies accountable for science-based decisions than that.³⁰³ At a minimum, the courts must insist that agencies seeking to fill gaps in scientific knowledge through modeling-type exercises abide strictly by whatever procedural devices Congress has chosen to impose upon them to facilitate transparent decisionmaking that is informed by input received through a process that allowed meaningful public participation. Beyond that, the courts must require that the agencies provide explanations for their decisions that reveal the assumptions upon which their models proceeded, as well as descriptions of the remaining scientific uncertainties and how they affected the agency’s choices. Finally, the courts should vacate or remand agency decisions in which the agency’s explanation fails to demonstrate that the model used is an appropriate one for dealing with the particular data gaps the agency is trying to fill or that a relevant model has been

²⁹⁹ “Accountability can be roughly defined as the ability of one actor to demand an explanation or justification of another actor for its actions and to reward or punish that second actor on the basis of its performance or its explanation.” Edward Rubin, *The Myth of Accountability and the Anti-Democratic Impulse*, 103 MICH. L. REV. 2073, 2073 (2005).

³⁰⁰ *Columbia Falls Aluminum Co. v. EPA*, 139 F.3d 914, 923 (D.C. Cir. 1998) (quoting *American Iron & Steel Inst. v. EPA*, 115 F.3d 979, 1005 (D.C. Cir. 1997)). See also *supra* notes 85-91 and accompanying text.

³⁰¹ See 3 COGGINS & GLICKSMAN, *supra* note 96, at § 16:5 (stating that “administrative decisions authorized under multiple use, sustained yield statutes are at present almost unreviewable, even for abuse of discretion”).

³⁰² *Oregon Natural Res. Council v. Lowe*, 836 F. Supp. 2d 727, 732 (D. Or. 1993).

³⁰³ See Rudd, *supra* note 241, at 149 (arguing that “[t]raditional judicial deference to the Forest Service’s decision-making processes on scientific issues is insufficient to ensure that scientific claims are fairly evaluated”).

misapplied.³⁰⁴ There is some preliminary evidence in the early decisions reviewing the Forest Service's application of the 2005 planning regulations that the courts may be willing to undertake each of those tasks.³⁰⁵

Finally, environmental and natural resource management agencies should take the position that when scientific uncertainty hinders their ability to predict the nature of the impact of their decisions on the public health or on the health of sustainable public natural resources such as those found in the national forests, despite reliance on modeling and evaluation of surrogate trends, the burden of justifying any activity that poses threats to those resources should be allocated to those who support agency approval of those activities.³⁰⁶ The potential for pollution or public natural resource development to impose irreparable harm should not be ignored or minimized simply because the nature of the effects of those activities is as of yet unascertainable. Requiring those supporting agency actions with potentially damaging environmental effects to bear that burden is consistent with the thrust of much of the federal environmental and natural resource management legislation under which these decisions are made, which was adopted in large part to control speculative risks to health and the environment.³⁰⁷

³⁰⁴ Rudd also suggests that courts supplement the administrative record by calling witnesses and impaneling experts to evaluate agency science-based decisions. *See id.* at 149, 216-21.

³⁰⁵ *See supra* notes 272-80 and accompanying text.

³⁰⁶ *See, e.g.*, A NEW PROGRESSIVE AGENDA FOR PUBLIC HEALTH AND THE ENVIRONMENT: A PROJECT OF THE CENTER FOR PROGRESSIVE REGULATION 124 (Christopher H. Schroeder & Rena Steinzor eds., 2005) (stating that “[w]here uncertainty exists, the proponent of the potentially degrading activity should bear the burden of proving that the activity will not cause unacceptable adverse impacts”).

³⁰⁷ *See GLICKSMAN ET AL.*, *supra* note 26, at 750-51; *Ctr. for Biological Diversity v. Bureau of Land Mgmt.*, 422 F. Supp. 2d 1115, 1135 (N.D. Cal. 2006) (quoting *Conner v. Burford*, 848 F.2d 1441, 1454 (9th Cir. 1988) (quoting H.R. Conf. Rep. No. 96-697(1978), *reprinted in* 1979 U.S.C.C.A.N. 2572, 2576)) (stating that, to the extent there is any scientific uncertainty as to what constitutes the “best available scientific information” for purposes of § 7(a)(2) of the ESA, 16 U.S.C. § 1536(a)(2), Congress intended that the FWS, in issuing biological opinions under the ESA, “give the benefit of the doubt to the species”).