I.45 Managing ecosystem effects in an era of rapid climate change

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Abstract

Climate change is exerting significant pressure on ecosystems. Without management strategies that impede harmful invasions and help vulnerable resources adapt, biodiversity and ecological function will likely decline. However, governing processes are too often insufficiently adaptive, and many resource laws are not designed primarily to facilitate biodiversity or promote ecological health. Many laws are primarily directed at promoting consumptive use; others on promoting historical fidelity; still others on limiting human management. Global climate change causes these various conservation goals to be increasingly at odds with each other and with promoting biodiversity. Except in rare circumstances when decline in ecological health is deemed an acceptable trade-off for historical fidelity, non-intervention, and/or human consumption or development, natural resources laws must be better adapted to accommodate change not only through adaptive management measures that integrate flexibility into regulatory processes, but also by promoting substantive goals that emphasize ecological health.

Keywords

Biodiversity, ecosystems, ecological health, endangered species, native, invasive, exotic, wildlife, assisted migration, wildlife corridors, public lands, wilderness

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I.45.1 Introduction

Many existing legal provisions affecting the management of ecological resources, particularly in the United States and European Union, are not designed primarily to promote ecological health, whether measured by the ecosystem's organization (i.e., number and diversity of components and their interactions), vigour (i.e., energy and productivity), and/or resilience (i.e., ability to 'bounce back' from perturbation and handle stress).[1] Various provisions are directed predominantly at promoting consumptive use, only secondarily emphasizing sustainability. Other 'historical preservation' regulations focus chiefly on promoting historical fidelity. Still other legal provisions emphasize limiting or preventing human management and favour 'wild' or 'natural' over human-assisted movement.

As climate change places increasing pressure on flora and fauna to shift their range or risk extinction, these various conservation goals are increasingly at odds with each other, as well as with promoting ecological health and biodiversity. In light of the disruption and gravity of ecological harms projected to be caused by global climate change, this chapter asserts that substantial declines in ecological health will rarely be an acceptable trade-off for goals oriented toward consumption, historical fidelity, or non-intervention. Accordingly, natural resources laws must be adapted to better accommodate change not only through adaptive measures that integrate flexibility into the regulatory process, but also by primarily emphasizing biodiversity and/or ecological health.

I.45.2 Existing and projected ecological effects

Extensive data substantiates that anthropogenic climate change already has exerted significant pressure and harm to wildlife, vegetation and ecological processes throughout the globe.[2] Increases in temperature have already driven species to shift their ranges, primarily towards the poles and higher altitudes,[3] as well as phenological changes.[4] The Intergovernmental Panel on Climate Change and scholars also have identified ecosystem disturbances (such as drought and fire), range contractions, and mortality as a result of climate change.[5]

Considerable evidence suggests that global climate changes will have increasingly severe effects over the next several decades.[6] Global climate change threatens to move many ecosystems outside their historical variability[7] extraordinarily quickly.[8] Changes in temperature are occurring very rapidly, requiring species to move long distances and ultimately shift their distribution quickly to adapt and survive.[9]

These changes are expected to affect and often harm existing biodiversity. First, climate change is projected to lead to the proliferation of some invasive species that may decrease biodiversity or ecological productivity.[10] It is also expected to constrain the abundance and/or distribution of many species or otherwise adversely impact ecosystem function. Some species may be stranded[11] or react in ways that are incompatible with

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1 Rapport (2009) 27–29.
2 Field et al, 'Summary for Policymakers' (2014).
3 Field et al, 'Climate Change 2014' (2014) 295–96.
4 ibid 292; Melillo et al (2014) 201.
5 Hoegh-Guldberg et al (2008) 345; Field et al, 'Climate Change 2014' (2014) 300; Field et al, 'Summary for Policymakers' (2014) 4.
6 Field et al, 'Summary for Policymakers' (2014) 14–19, 23.
7 Rahel et al (2008) 557; Field et al, 'Summary for Policymakers' (2014) 4.
8 Schneider et al (1992) 53.
9 Field et al, 'Climate Change 2014' (2014) 274.
10 ibid 288–89.
11 Gitay et al (2002) 22.

ecologically linked species;[12] others with slow dispersal rates may be unable to keep up with the rate of climate change.[13] Some species will be unable to shift their range because there is no alternative suitable habitat or bridge to adequate ecological conditions.[14] Other less direct stressors include increased susceptibility to predation or disease,[15] increased competition from arriving species,[16] and even human adaptations that damage habitat.[17]

These impediments to range shifts are compounded by existing anthropogenic barriers such as highways, urban areas and monoculture,[18] as well as past habitat loss, over-exploitation, invasive species and disease.[19] Ultimately, absent intensive and direct human strategies to mitigate and evade these various stressors, climate change is expected to increase the risk of extinction, loss of genetic diversity, and the vitality and productivity of many biological communities,[20] even in the unlikely event of immediate and massive reduction in greenhouse gas emissions.[21]

I.45.3 Potential adaptation strategies

To minimize harms to biodiversity and ecological function, climate change generates great urgency for the use of a broad range of management strategies that focus on the dual challenges of assisting vulnerable species in adapting to climatic changes while impeding the dispersal of harmful species. In the context of protecting ecological resources, more modest alternatives include strategies that remain closely tied to maintaining past or current ecological conditions, and/or passive strategies that seek to promote ecological resilience without direct human intervention. For example, managers may attend to the preservation and even genetic enhancement of vulnerable genotypes, species and communities to improve climate robustness of populations within existing geographic range.[22] Similarly, to buttress ecological resilience some call for increased reliance on conventional conservation tools such as the reduction of other stressors,[23] restoration of past habitat,[24] the designation of new reserve areas,[25] or even ex situ conservation practices (such as storage of egg/sperm/seed).[26]

However, as landscape-scale changes in climatic conditions combine with natural and human-induced dispersal barriers to significantly limit the capacity of biota to adapt,

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12 ibid 12; Ruhl (2008) 23–24.
13 Trakhtenbrot et al (2005) 174; Field et al, 'Climate Change 2014' (2014) 275.
14 Root et al (2007) 93; Ruhl (2008) 4.
15 Solomon et al (2007) 13–14.
16 ibid 16–17.
17 ibid 3–4, 42–43; Ruhl (2008) 24–26.
18 Marris (2008) 113; Field et al, 'Climate Change 2014' (2014) 275.
19 Pyke (2004) 178; Field et al, 'Climate Change 2014' (2014) 274–75.
20 Field et al, 'Summary for Policymakers' (2014) 13–15.
21 Backlund et al (2008) 5.
22 Hoegh-Guldberg et al (2008) 345; Kareiva et al (2008) 2; Thomas et al (2013).
23 Field et al, 'Summary for Policymakers' (2014) 14.
24 Kareiva et al (2008) 20–21; Claisse et al (2013); Field et al, 'Climate Change 2014' (2014) 324.
25 Hannah et al (2007) 135; Lopoukhine et al (2012); Field et al, 'Climate Change 2014' (2014) 324.
26 Hoegh-Guldberg et al (2008) 345; Pritchard et al (2012); Field et al, 'Climate Change 2014' (2014) 326.

promoting biodiversity and ecological function may require direct interventions that are expressly directed at actively promoting ecological change. Examples include the creation of wildlife migration corridors focused on increasing the potential future routes for biota to migrate,[27] the active development of new replicate ecosystems or habitat[28] to accommodate 'natural' species movement, the active protection of organisms in preserves if they are able to arrive without assistance;[29] or manipulation of disturbance regimes such as fires or floods.[30] The most interventionist strategies would include species translocation to areas the species has never previously inhabited.[31] These more active and future-oriented protocols would be a significant departure from conventional natural resource laws.

I.45.4 Legal frameworks premised on non-intervention, historical fidelity, or consumption

Unfortunately, as currently designed and/or implemented, many legal provisions governing the management of ecological resources in the US and EU are not particularly suited for maximizing ecological health in light of climatic change. Many resource management laws do not directly seek to maximize future ecological health. For public lands laws, the emphasis often is at best secondarily on sustainability, with laws premised on or seeking to promote as primary objectives consumptive use, historical fidelity, and/or minimizing human management. Invasive species regulations focus heavily on whether species were present historically and/or moved without human involvement. Finally, even laws that seek to minimize harm to rare species are typically premised on and structured for promoting historical conditions rather than future ecological health.

I.45.4.1 Invasive species laws

Invasive species management laws are designed to protect favoured pre-existing (typically designated as native or natural) species from the ostensible harms of exotic species. To be sure, limitations on the proliferation or movement of organisms that are likely to cause significant harm to valuable ecosystems or human systems make significant sense. Yet some such laws rely on simplistic divisions between native and exotic species as well as introduced and natural movement. In the context of the ecological pressures from global climatic changes, some laws serve to overly inhibit or prevent the movement (and in particular the intentional introduction) of species as an adaptation strategy for combating extinction or overcoming human-induced dispersal barriers.

Some laws categorically seek to prevent the arrival of a species if it was not historically present, without regard to its potential ecological harms or benefits. For example, the United States' National Invasive Species Act of 1996, which seeks to prevent the unintentional introduction and dispersal of nonindigenous species into the United States, defines 'nonindigenous species' as 'any species or other viable biological material that

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[27] Williams et al (2005) 1064; Romportl et al (2013); Field et al, 'Climate Change 2014' (2014) 325–26.
[28] Julius et al (2008) 2; Mawdsley et al (2009) 1082–83.
[29] Hoegh-Guldberg et al (2008) 345.
[30] Field et al, 'Summary for Policymakers' (2014) 14.
[31] Camacho (2010); Field et al, 'Climate Change 2014' (2014) 325.

enters an ecosystem beyond its historic range, including any such organism transferred from one country into another'.[32] Other authorities restrict or manage species if merely deemed exotic.[33] England and Wales' Wildlife and Countryside Act 1981 prohibits releasing or allowing 'to escape into the wild any animal which . . . is of a kind which is not ordinarily resident in and is not a regular visitor to Great Britain in a wild state'.[34] Laws seeking to categorically prevent the migration or introduction of any non-native species would necessarily make any species movements into new areas that could promote biodiversity or ecological function difficult.

More commonly, jurisdictions deem a species as native (and thus not subject to invasive species management) if it arrived 'naturally', i.e., without human intervention. For instance, United States Executive Order 13,112, which binds all federal agencies, defines a 'native' species as a species that 'other than as the result of an introduction, historically occurred or currently occurs in that ecosystem',[35] while an 'introduction' is an 'intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity'.[36] The European Union's recently enacted invasive species law similarly excludes from management 'species changing their natural range without human intervention, in response to changing ecological conditions and climate change'.[37] For many of these laws, it is not even clear whether species movements that result from anthropogenic climate change would qualify as natural movement or a product of human intervention (i.e., as an 'unintentional . . . dissemination . . . as a result of human activity').[38] Jurisdictions like the European Union that categorizes climate change-induced movements as natural may unfortunately allow migrations that cause substantial harm. On the other hand, those laws that consider climate change-induced movements (or indeed *any* intentional introductions) to be categorically harmful may impede movements that promote ecological function.

It should be noted that many invasive species laws do require that a species be deemed not only exotic but also harmful (to human and/or ecological systems) before being subject to control or eradication measures.[39] The European Union's recent invasive species law, for instance, seeks to regulate only exotic species that have significant adverse impact on biodiversity.[40] Such laws or policies are certainly less likely to restrict beneficial migrations. However, some authorities that adopt that approach for migrations nonetheless categorically prohibit *introductions* of non-native species, without any additional demonstration of harm.[41] By focusing on maintaining pre-existing biota – without

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32 16 USC § 4702(11) (2012).

33 Arizona State Parks Policy and Procedures, Natural Resource Management § 3(G)(8) (2009); Cal Dep't of Parks & Recreation.

34 Wildlife and Countryside Act 1981, s 14(1).

35 Exec Order No 13,112 (3 Feb 1999).

36 ibid.

37 Regulation 1143/2014, OJ 317/35, Art 2 § 2(a).

38 *Michigan v US Army Corps of Eng'rs* 667 F 3d 765, 771–72 (7th Cir 2011).

39 Exec Order No 13,112 (3 Feb 1999); Plant Protection Act § 7702(10) (2006); Lacey Act § 42(a) (2000).

40 Regulation 1143/2014, OJ 317/35, Art 4 § 3(c).

41 US Forest Serv (2007); FWS Refuge Manual §§ 7–8.6(B), 8.7; US Dep't of the Interior Bureau of Land Mgmt (2014).

an analysis of their continued compatibility with changing conditions – and/or limiting human involvement in ecological change – without considering the potential benefits of such interventions – these types of provisions fail to track the possible risks and benefits of potentially crucial climate change adaptation strategies.

I.45.4.2 Public lands laws

Similarly, some laws governing the management of public lands – which make up a major part of conservation lands – inhibit the migration or introduction of potentially valuable species from other jurisdictions. Importantly, some public land laws that make the primary aim of the regime the continued consumption or use of one or several ecosystem services (such as timber, grazing, recreation, watershed or wildlife) do provide for the possibility of strategies that accommodate changing climatic conditions. Though often focused on sustained resource yield, some such regimes do implicitly or explicitly allow for passive or active adjustments to such resources in furtherance of the sustainability of the ecosystem service(s). For example, the United States Forest Service (USFS) must manage the 193 million acres of National Forests in a manner that 'provide[s] for multiple use and sustained yield of the products and services obtained therefrom',[42] and is provided 'sufficient latitude for periodic adjustments in use to conform to changing needs and conditions'.[43] Management plans must 'provide for diversity of plant and animal communities',[44] and the USFS interprets its planning mandate to 'promote the ecological integrity' of these lands 'that provide a range of social, economic, and ecological benefits for the present and into the future'.[45] Other laws such as the Federal Land Policy and Management Act of 1976[46] (which governs the US Bureau of Land Management's (BLM) management of the nearly 248 million acres of public lands) provides a less robust recognition of the need to 'provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions'.[47]

However, other land management regulations focus principally on promoting historical fidelity and resistance to ecological change. For instance, in the United States in the 52 million acres of designated National Parks,[48] the National Park Service (NPS) has long interpreted the National Park Service Organic Act[49] to require it to focus on protecting historical conditions and pre-existing biota.[50] As such, the NPS regularly concentrates on active steps to resist change and promote or restore pre-existing ecological conditions.[51] New Zealand's National Parks Act 1980 provides that 'national parks . . .

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42 National Forest Management Act § 1604(e)1 (2006). The statute identifies recreation, range, timber, watershed, wildlife and fish, and wilderness as relevant multiple uses. ibid.

43 Multiple-Use Sustained-Yield Act § 531(a) (1960).

44 National Forest Management Act § 1604(g)(3)(B) (2006).

45 36 CFR § 219.1(c) (2014).

46 43 USC §§ 1701–1785 (2006).

47 43 USC § 1702(c) (2006).

48 US Census Bureau (2012).

49 16 USC § 1.

50 US Nat'l Park Serv Management Policies §§ 4.1, 4.4.1 (2006).

51 ibid §§ 4.4.2.2, 4.4.2.5, 4.4.2.3, 4.4.1.2.

shall be preserved as far as possible in their natural state'[52] and that generally 'the native plants and animals of the parks shall as far as possible be preserved and the introduced plants and animals shall as far as possible be exterminated'.[53] Such objectives would impede or preclude active measures that seek to promote ecological health in changing climate by departing from prior ecological conditions.

Finally, some legal regimes or particular provisions promote non-intervention as a fundamental goal of public land management, making active measures such as human-assisted movement to promote ecological health in response to climate change difficult if not impossible. For instance, Lithuania's Forestry Law makes non-intervention the core goal for Class 1 forests, which include 'State reserves, national parks, as well as reserves and forest reserve plots situated on biosphere monitoring territories'.[54] In the United States, the primary statutory example of this is the Wilderness Act of 1964,[55] which sets as the primary goal for managing 109 million acres of land[56] their preservation as 'wilderness', defined in part as 'an area where the earth and its community of life are untrammelled by man . . . retaining its primeval character and influence . . . which . . . generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable'.[57] Though some level of management is anticipated, particularly 'in the control of fire, insects, and diseases',[58] such areas are generally expected to be subject to minimal management,[59] and any active measures must be in service of the statutory mandate of preserving wilderness character or pre-existing natural conditions.[60] In the context of climate change, such mandates could allow for migrations deemed 'natural' that cause harm to ecological health on such lands. They also likely prohibit translocations as a climate adaptation strategy, even if such introductions promote biodiversity, because they are artefactual.[61]

I.45.4.3 Endangered and protected species laws

Though international and national endangered species conservation laws have been useful stopgap tools for protecting rare species where they have historically existed, they were not designed to promote ecological health in contexts of landscape-scale climatic change. Most international and national regulatory regimes focus on listing and permitting processes that restrict or prohibit human activity that directly harms rare species. For example, the United States' Endangered Species Act (ESA)[62] prohibits

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52 National Parks Act 1980, 17 December 1980, Public Act 1980 No 66, part 1 sec 4(2)(a) (New Zealand).
53 ibid sec 4(2)(b).
54 Forestry Law, 22 November 1994, No I-671, art 4 (Lithuania).
55 16 USC §§ 1131–36.
56 Wilderness.net.
57 16 USC § 1131(c) (2006).
58 16 USC § 1133(d)(1) (2006).
59 *Wilderness Soc'y v US Fish & Wildlife Serv* 353 F 3d 1051, 1067 (9th Cir 2003) (en banc).
60 *Wilderness Watch, Inc v US Fish & Wildlife Serv* 629 F 3d 1024, 1033 (9th Cir 2010); *Izaak Walton League of Am, Inc v Kimbell* 516 F Supp 2d 982 (D Minn 2007).
61 Camacho (2010).
62 16 USC §§ 1531–1544 (2012).

any 'take' of a listed fish or wildlife species,[63] defined very broadly to include 'harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct'.[64] Similarly, the Convention on International Trade in Endangered Species of Wild Fauna and Flora provides 'particularly strict regulation' for the 'trade' – defined in Article I(c) as 'export, re-export, import and introduction from the sea' – of specimens of species that are 'threatened with extinction'.[65] Such trade may be permitted only in exceptional circumstances, and permits for import or introduction may only be granted if 'the specimen is not to be used for primarily commercial purposes'.[66]

These laws focus on restricting human activities that directly encroach on pre-existing habitat, not for the affirmative protection or recovery of those vulnerable species, particularly on private lands.[67] Many such laws are also primarily based on a static conception of nature that focuses on promoting the preservation of existing species in their historical or existing habitat range.[68] As such, they may be unconcerned with, or even inhibit, the full integration of those species into new areas, even if such species would benefit ecological function. Various American states, for example, expressly refuse to afford protections under their endangered species laws to species deemed to be non-native.[69]

Similarly, the European Union's Habitat Directive makes a fundamental distinction between human-induced and 'natural' movement. It seeks to protect listed wildlife in their natural range, which regulatory guidance states includes circumstances '[w]hen a species or habitat spreads on its own to a new area/territory or when a species has been re-introduced into its former natural range'.[70] However, the Guidance also specifically excludes from protection 'individuals or feral populations of an animal species introduced deliberately or accidentally by man to locations where they have never occurred naturally, or where they would not have spread to naturally in the foreseeable future'.[71] Such restrictions will inhibit assisted migration adaptation strategies that seek to reduce harm to ecological health.

The US ESA allows for reintroduction of any endangered species through a permitting process for 'experimental populations',[72] but imposes restrictions on such active conservation measures that would impede climate change adaptation strate-

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[63] 16 USC § 1538(a)(1)(B).
[64] 16 USC § 1532(19).
[65] CITES, art II(1), 3 Mar 1973.
[66] ibid art III(3), (5). The European Union's Habitats Directive Article 12(1), and the Convention on the Conservation of Migratory Species of Wild Animals Article III ¶ 5, similarly prohibit the take (or deliberate disturbance or destruction) of listed species and habitat.
[67] The ESA does include affirmative obligations for agencies to engage in recovery planning (16 USC § 1533(f)(1)), but even then such plans are merely aspirational and unenforceable (Goble (2010) 83–85).
[68] Camacho (2009).
[69] Ariz Rev Stat Ann § 17–296 (2014); Fla Stat Ann § 379.2291 (West 2014); NC Gen Stat § 113–331(2) (2014); Nev Rev Stat Ann § 503.584(2)(a) (West 2014).
[70] European Union (2007) 11.
[71] ibid.
[72] 16 USC § 1539(j) (2012).

gies like assisted migration. Any reintroduced populations must be kept wholly separate geographically from,[73] and are provided less conservation protection than, non-introduced populations.[74] Moreover, though reintroductions are allowed, introductions outside of a species' historical habitat range are prohibited except in 'the extreme case that the primary habitat of the species has been unsuitably and irreversibly altered or destroyed'.[75] The regulation establishing this requirement emphasizes that this exception is intended to be incredibly rare; to allow 'the transplantation of listed species to non-native habitat [would] abandon[] the statutory directive to conserve species in native ecosystems'.[76] As a result, in practice the US Fish and Wildlife Service (FWS) has only allowed non-native introductions in two cases, and even these situations were intended to only be temporary translocations.[77] Such legal frameworks are consequently ill-fitted for providing a comprehensive framework for the migration and especially intentional translocation of rare species as an adaptation strategy for preparing for or managing the effects of climate change.

I.45.5 Inelastic management processes

In addition to relying on legal provisions that heavily focus on non-intervention and/or historical fidelity, most regulatory processes managing biodiversity are not sufficiently nimble at adjusting to changing conditions or new information.[78] Laws that rely on static, front-end approaches, such as environmental assessment and cost-benefit analysis, thwart efforts to adjust regulation and 'move toward ecological resilience strategies when variability is on the rise and prediction is unreliable'.[79] Elevated uncertainty for resource management from climate change further exacerbates the limited adaptive capacity of natural resource laws and institutions.[80] Policymakers and scholars have urged greater reliance on scenario planning[81] and information infrastructures that promote iterative learning.[82]

Furthermore, many scholars and officials promote increased use of adaptive management as an adaptation strategy, relying on incremental policy and decision adjustments under a framework in which altering course if conditions warrant is an essential ingredient.[83] However, adaptive management does have implementation and opportunity costs,[84] and is most appropriate when there are information gaps, good prospects for learning and opportunities for adjustment in the regulatory process.[85] Otherwise, less

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73 16 USC § 1539(j); 50 CFR § 17.80(a).
74 16 USC § 1539(j)(2)C); 50 CFR 17.83(a), (b).
75 50 CFR § 17.81(a) (2013).
76 Endangered and Threatened Wildlife and Plants; Experimental Populations, 49 Fed Reg 33,885, 33,890 (27 Aug 1984).
77 Camacho (2010) 203.
78 Camacho (2009).
79 ibid 36–40; Ruhl (2011).
80 Ruhl (2008) 15; Camacho (2009) 12–15.
81 Carpenter et al (2005).
82 Camacho (2009) 1; The White House Council on Envtl. Quality (16 March 2010).
83 Tompkins and Adger (2004); Scott et al (2008); Camacho and Beard (2014).
84 Biber (2013).
85 Doremus et al (2011).

rigorous and costly alternatives such as contingency planning[86] may still incentivize iterative planning and periodic adjustments.[87]

I.45.6 Conclusion

Conventional resource management objectives that prioritize resource use, non-intervention and preservation of historical conditions are increasingly at odds with each other, as well as with promoting ecological health.[88] Protected areas will be unable to maximize yield and keep biota where they were without substantial intervention. More importantly, persistent emphasis on those objectives should not come at the expense of long-term biodiversity. Though there often may be economic, cultural and recreational benefits to promoting resource productivity, historical preservation, and/or wilderness, climate change necessitates the adjustment of resource management policies and regulations to give primacy to promoting biodiversity, articulated through the protection of specific ecological processes.[89] Moreover, management institutions can better accommodate change through the measures that integrate principled flexibility and learning into the regulatory process.

Of course, recognizing the need to adjust the laws and processes governing biodiversity is only the initial step. Neither ecology nor law have begun to grapple with the most difficult challenges of managing ecosystems in a changing climate. Considerable further research and public deliberation is essential on how to assess ecological health and compare competing claims of value in a dynamic world less tethered to non-intervention or historical fidelity.[90] Similarly, legal scholarship can aid in exploring how, the extent to which, and the variety of circumstances when laws should be adjusted to better prioritize and promote ecological health while accommodating other resource goals.

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[86] Macey (2013) (discussing use of contingency planning to accommodate data gaps in environmental law).

[87] Camacho (2011) 1449.

[88] Camacho (2011).

[89] Camacho (2009).

[90] ibid 245–52.

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