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MANAGING THE ANTHROPOCENE: GENETIC ENGINEERING, DE-EXTINCTION, AND THE UNCERTAIN FUTURE OF ECOSYSTEM MANAGEMENT

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> *Where an animal or plant from one part of the world appears in another, some might use the language of invasion, of a native ecosystem despoiled and rendered lesser by newcomers. Frequently, this is an appeal to nostalgia, to the landscape known in childhood, contrasted with the altered, often depleted world of today. It brings with it an implication that what* was *was right and what* is *is wrong.*
>
> *What is important in conserving an ecosystem is conserving the functions, the connections between organisms that form a complete, interacting whole. In reality, species do move, and the notion of 'native' species is inevitably arbitrary, often tied into national identity.*[1]

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1. THOMAS HALLIDAY, OTHERLANDS: A JOURNEY THROUGH EARTH'S EXTINCT WORLDS 67 (2022).

I. INTRODUCTION

In June 2022, the latest film addition to the late novelist Michael Crichton's *Jurassic Park* franchise, *Jurassic World: Dominion*, exposed audiences to an interesting and terrifying proposition: humans living alongside genetically engineered "dinosaurs," sometimes harmoniously, sometimes tragically.[2] Formerly contained to islands off the coast of Costa Rica—with a short-lived exception of a *Tyrannosaurus rex*'s romp through San Diego—dinosaurs once again roam the continents. The implications of this escape are more thoroughly explored in a video game created by Frontier Developments, released in November 2021, called *Jurassic World Evolution 2*. The game's campaign has players "lead the efforts of the [U.S. Fish and Wildlife Service] to control, conserve, and contain wild dinosaurs now rampaging across" the United States.[3]

The *Jurassic Park* franchise is, of course, fantastical, even despite Crichton's detailed and extensive postulations in the original novel from the late 1980s. We are no closer today to "resurrecting" dinosaurs or other pre-Holocene animals for two simple reasons: the fossilization process destroys DNA,[4] and even frozen or otherwise preserved DNA cannot survive without severe protein degradation for thousands of years, let

2. *See* JURASSIC WORLD: DOMINION (Universal Pictures 2022).

3. *Overview*, JURASSIC WORLD EVOLUTION 2, https://www.jurassicworldevolution2.com/overview (last visited Mar. 20, 2023); *Jurassic World Evolution 2*, STEAM, https://store.steampowered.com/app/1244460/Jurassic_World_Evolution_2/ (last visited Mar. 20, 2023).

4. Alisa Harvey, *Could We Build a Real-Life Jurassic Park?*, LIVE SCI. (May 14, 2021), https://www.livescience.com/could-we-build-jurassic-park-dinosaurs.html.

alone millions.[5] Further, because "[t]he study of modern ecosystems and the interactions of species and their environment is one based on the huge numbers of intertwined pressures that are exerted in all manner of directions that are constantly changing,"[6] it may be a Sisyphean task to uncover the ecology and behavior of species that have been long extinct. Moreover,

> watching numerous individuals 24 hours a day for a year . . . would still not be sufficient to work out all the nuances of their behavior in response to changes in humidity or temperature, or the scent of a predator, or why they avoid some plants on one day and devour them a week later.[7]

This has not stopped interested individuals with the capital to do so from trying. At least two biotech companies, Revive & Restore[8] and Colossal Biosciences,[9] have explored the possibility of reviving the woolly mammoth, a species that went functionally extinct over 10,000 years ago at the end of the latest ice age.[10] Despite the significant time difference between the extinctions of the non-avian dinosaurs and the woolly mammoth—over 60 million years[11]—the latter presents much the same problems as the former for the reasons stated above.

But the idea of "resurrecting" extinct species is not limited to bringing into the modern era species that have not existed for thousands or millions of years. The mapping of DNA from extant species has led some to call for efforts to produce members of species that have been extinct for less than a century. Such is the case, for example, of the University of Western Australia's researchers whose recent breakthrough in mapping the numbat's DNA has led other scientists to speculate that their successful decoding could aid efforts to de-extinct the thylacine—better

5. *How Close Are We to Being Able to Reconstruct the DNA of Long-Extinct Creatures—Dinosaurs, for Instance?*, SCI. AM. (Oct. 21, 1999), https://www.scientificamerican.com/article/how-close-are-we-to-being/.

6. DAVID HONE, THE FUTURE OF DINOSAURS: WHAT WE DON'T KNOW, WHAT WE CAN, AND WHAT WE'LL NEVER KNOW 201 (2022).

7. *Id.* at 189.

8. *Woolly Mammoth Revival*, REVIVE & RESTORE, https://reviverestore.org/projects/woolly-mammoth/ (last visited Mar. 20, 2023).

9. *The Mammoth*, COLOSSAL LABORATORIES & BIOSCIENCES, https://colossal.com/mammoth/ (last visited Mar. 20, 2023).

10. Orlando Jenkinson, *Wooly Mammoth De-Extinction Scientist Reveals Plan to Create 'Arctic Elephant'*, NEWSWEEK (Jan. 31, 2022, 10:20 AM), https://www.newsweek.com/wooly-mammoth-de-extinction-scientist-plan-create-arctic-elephant-1674509.

11. *End of an Era*, AM. MUSEUM OF NAT. HIST., https://www.amnh.org/exhibitions/dinosaurs-ancient-fossils/extinction/end-of-an-era (last visited Mar. 20, 2023).

known as the Tasmanian tiger—which went extinct in the 1930s.[12] Likewise, Revive & Restore is attempting to restore the passenger pigeon, which went extinct to its prior habitat in the eastern United States in the early twentieth century, where it was previously endemic.[13] More realistically, these breakthroughs in DNA mapping are not intended to de-extinct species, even those that have only recently disappeared from the planet's catalog of fauna. Instead, scientists hope to bolster the numbers of extant species with the intention to aid reproduction, boosting the number of offspring in captivity and, ideally, in the wild.[14]

Such efforts have become more prescient as the reality of climate change has brought to fore concerns that the Endangered Species Act ("ESA") is not currently able to account for the changes to habitat, subsequent migration of species, and consequently inevitable extinction of species that climate change will bring.[15] This has become especially evident since the Supreme Court's unanimous ruling in *Weyerhaeuser Co. v. U.S. Fish & Wildlife Service*,[16] limiting the federal government's ability to protect, as a critical habitat for listed species, geographic areas that are not currently occupied by those species,[17] despite the ongoing reality that human development likely degraded that habitat in the first instance.

The federal government's statutory approach to ecosystem management is not adequate to respond to accelerating ecological changes. In its current application, ecosystem management regimes spread too few resources among too many species and deemphasize the role of human activity in both causing and potentially remedying these changes. Although de-extinction is not imminent, its application to these regimes highlights concerns with existing statutory frameworks. In Parts III and IV, this Note will provide an overview and key criticisms of the

12. *Numbat Breakthrough Fuels Thylacine Dream*, SHEPPARTON NEWS (Feb. 8, 2022) [hereinafter *Numbat Breakthrough*], https://www.sheppnews.com.au/national/numbat-breakthrough-fuels-thylacine-dream/.

13. *Passenger Pigeon Project*, REVIVE & RESTORE, https://reviverestore.org/about-the-passenger-pigeon/ (last visited Mar. 20, 2023).

14. *Numbat Breakthrough*, *supra* note 12.

15. *See* Alisha Falberg, *The Pricelessness of Biodiversity: Using the Endangered Species Act to Help Combat Extinction and Climate Change*, 33 UCLA J. ENV'T L. & POL'Y 136, 136, 155 (2015) (arguing that amending § 1533's requirements for critical habitat, recovery, and monitoring are "the most effective and efficient way to save biodiversity and species from climate change").

16. 139 S. Ct. 361 (2018).

17. Jeffrey S. Knighton, Jr., *Critical Decisions: The Challenge of Defining Critical Habitat Under the Endangered Species Act*, 9 LA. STATE U. J. ENERGY L. & RES. 563, 565 (2021).

Endangered Species Act and key invasive species management laws to describe the federal government's approach to ecosystem management in the new context of climate change. In Part V, this Note will explore the applicability of these statutes to the introduction of genetically engineered and de-extinct species to demonstrate how current ecosystem management approaches can be modified to account for the drastic effects of accelerating climate change. This Note will conclude by providing policy recommendations for updating the federal government's ecosystem management approach through the Endangered Species Act to allow for more holistic, ecosystem-based management rather than disparate, species-specific regimes. Such an approach would deemphasize the need to protect all species at risk of extinction and instead prioritize species whose survival is absolutely necessary to support an ecosystem. It would also require the acceptance that active human management to a "new natural" is necessary, encouraging the introduction and use of genetically engineered and de-extinct species whose benefits outweigh potential adverse impacts.

II. ANTHROPOGENIC ECOLOGICAL CHANGE

Human-driven ecological change is nothing new. Humans have directly altered their own habitats for eons; sedentarism requires the clearing of land for agriculture and infrastructure, infrastructure requires the extraction of natural resources like wood and minerals. All of this requires the alteration of land that comprises many species' ecosystems. However, since the dawn of industrialism, human-driven ecological change has taken on a new, indirect form: the emission of greenhouse gasses—the byproducts of burning natural fuels like coal, oil, and gas to generate electricity and power homes and machines—has caused the Earth to warm by 1.1º Celsius since 1880, with the majority of that warming occurring since 1975.[18]

Humanity's development has directly affected species and their ecosystems, and that same development has had significant indirect effects, largely through the accidental introduction of invasive species[19] and, more worryingly, climate change. The Intergovernmental Panel on Climate Change ("IPCC"), the United Nations panel responsible for researching climate change, has documented the phenomena's effects,

18. *World of Change: Global Temperatures*, NAT'L AERONAUTICS & SPACE ADMIN., https://earthobservatory.nasa.gov/world-of-change/global-temperatures (last visited Mar. 20, 2023).

19. Invasive species and their effects on natural species and their habitats will be explored in Part IV of this Note.

both observed and projected, on species and their ecosystems. Climate change "has caused substantial damages, and increasingly irreversible losses, in terrestrial, freshwater and coastal and open ocean marine ecosystems," and the "extent and magnitude" of these impacts are "larger than estimated in previous assessments."[20] These effects are "becoming increasingly complex and more difficult to manage" as they occur simultaneously and cascade across regions.[21]

Specifically, the IPCC has noted several significant effects on species and their habitats. According to its most recent report, a "high proportion of species is vulnerable to climate change."[22] Biodiversity loss is not limited to animal species. As climates warm, temperate ecosystems are being pushed further poleward away from the equator, and half of the world's species "have shifted polewards" and to higher elevations as their habitats have warmed beyond usual temperatures.[23] This same heating, sometimes manifesting in extreme heat events, has led to "[h]undreds of local losses of species" and "mass mortality events on land and in the ocean."[24] The destruction of habitat by warming climate—in addition to direct destruction via pollution or clearing—will further place animal species at risk. The IPCC estimates that after 2040, 3 to 14% of terrestrial species will "*likely* face very high risk of extinction" at only 1.5º Celsius of warming, with the higher estimate increasing to 18% at 2º Celsius, 29% at 3º Celsius, 39% at 4º Celsius, and 48% at 5º Celsius.[25] Marine species face even higher likelihood of extinction.[26] Already, the globe has experienced significant biodiversity loss due to climate change. Since 1980, extinctions have occurred at over 1,000 times the background rate,[27] and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services concluded in its 2019 biodiversity survey that around one million of the planet's estimated eight million species are currently at risk of extinction in the foreseeable future.[28]

20. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2022: IMPACTS, ADAPTATION AND VULNERABILITY: SUMMARY FOR POLICYMAKERS, SPM-8 (2022) [hereinafter IPCC 2022 Report], https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FinalDraft_FullReport.pdf.

21. *Id.* at SPM-18.

22. *Id.* at SPM-11.

23. *Id.* at SPM-8.

24. *Id.*

25. *Id.* at SPM-14.

26. *See id.*

27. Malcolm L. McCallum, *Vertebrate Biodiversity Losses Point to a Sixth Mass Extinction*, 24 BIODIVERSITY & CONSERVATION 2497, 2515 (2015).

28. INTERGOVERNMENTAL SCIENCE-POLICY PLATFORM ON BIODIVERSITY AND ECOSYSTEM SERVICES, GLOBAL ASSESSMENT REPORT ON BIODIVERSITY AND ECOSYSTEM

The IPCC has suggested potential approaches to mitigating climate change's most severe effects on natural ecosystems that would both conserve and restore ecosystems to a "near-natural" state and help to prevent global warming from reaching or exceeding 1.5º Celsius.[29] "Near-natural" does not assume a *totally* natural composition. Indeed, the IPCC calls for "targeted management to adapt to *unavoidable* impacts of climate change" alongside traditional conservation, protection, and restoration management approaches.[30] Implicit in this definition is a recognition that these ecosystems are no longer natural. This type of approach, as part of Ecosystem-based Adaption,[31] utilizes human technology to restore and protect ecosystems by, for example, developing and planting hardier trees with which to populate natural forests to increase the forests' resilience.[32] The benefits of this type of approach are significant: even restoring just 30% of lands converted for farming could prevent "over 70% of projected extinctions of mammals, birds and amphibians."[33] In sum, this approach requires human intervention and involvement in "natural" ecosystems to foster adaptation and resilience to climate change and mitigate its overall effects. These approaches are themselves resource-intensive; they are also necessary to prevent what some are already referring to as Earth's sixth extinction.[34]

SERVICES: SUMMARY FOR POLICYMAKERS 12, 24 (2019), https://doi.org/10.5281/zenodo.3553579.

29. *See* IPCC 2022 Report, *supra* note 20, at SPM-13, 2-105.

30. *Id.* at SPM-24 (emphasis added).

31. Ecosystem-based Adaptation is defined as "the use of biodiversity and . . . ecosystems to buffer communities against the adverse effects of climate change, including climate extremes and variability." *See* Christine Wamsler et al., *Operationalizing Ecosystem-Based Adaptation: Harnessing Ecosystem Services to Buffer Communities Against Climate Change*, 21 ECOLOGY & SOC'Y 1, 1 (2016).

32. *See* IPCC 2022 Report, *supra* note 20, at SPM-24; *see also* Jonathan M. Adams et al., *The Case for Genetic Engineering of Native and Landscape Trees Against Introduced Pests and Diseases*, 16 CONSERVATION BIOLOGY 874, 876 (2002) [hereinafter *Case for Genetic Engineering*].

33. *Tackling Climate Change and Biodiversity Loss Together*, U.N. ENV'T PROGRAMME WORLD CONSERVATION MONITORING CTR., https://www.unep-wcmc.org/en/news/tackling-climate-change-and-biodiversity-loss-together (last visited Mar. 20, 2023).

34. Earth has experienced many extinction events, but scientists regularly refer to "the Big Five," the largest mass extinction events of multicellular animal life. *See* McCallum, *supra* note 27, at 2498–500; *see also* Simon Beard, *Catastrophic Failure of Earth's Global Systems Led to the Extinction of the Dinosaurs—We May Yet Go the Same Way*, PHYS.ORG (March 29, 2019), https://phys.org/news/2019-03-catastrophic-failure-earth-global-extinction.html. The most recent of these five is the Cretaceous-Paleogene (K-Pg) extinction that killed the non-avian dinosaurs—and 75% of all species—between 65 and 66 million years ago. *See* McCallum, *supra* note 27, at 2499. The current wave of extinctions, caused by human activity rather than natural calamity, is referred to interchangeably as the sixth extinction, the Holocene mass extinction, and the Anthropocene mass extinction. *See, e.g.*, Gerardo Ceballos & Paul R. Ehrlich, *The Misunderstood Sixth Mass Extinction*,

In order to implement these approaches, the government needs to "broaden, rather than restrict, the scope" of the ESA so that its tools may be used to respond more effectively to the effects of climate change.[35] This Note proposes broadening the scope of the ESA and invasive species management regimes to allow for the introduction of genetically engineered and de-extinct species to restore and fortify ecosystems against climate change by bolstering extant populations, providing food sources for extant natural species, and, in some dramatic cases, replacing totally or functionally extinct species necessary to the ecosystem's overall health. This Note will describe the key provisions of the ESA and invasive species management statutes that can and should be broadened to allow for the introduction of genetically engineered and de-extinct species to combat climate change.

III. THE ENDANGERED SPECIES ACT

The Endangered Species Act[36] is implemented by the United States Fish and Wildlife Service ("USFWS") in the Department of the Interior and the National Marine Fisheries Service ("NMFS") in the Department of Commerce (collectively "the Agency").[37] The ESA provides the Secretaries of Interior and Commerce (collectively "the Secretary") the authority to regulate for the conservation of flora and fauna as a "program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions" created for this purpose.[38] The ESA defines "conservation" as the use of "all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act

360 SCIENCE 1080, 1080 (2022) ("[S]cientists also agree that Earth is now suffering the sixth mass extinction."); *see also* Ron Wagler, *The Anthropocene Mass Extinction: An Emerging Curriculum Theme for Science Educators*, 73 AM. BIOLOGY TCHR. 78 (2011) (describing the causes and context of the "Anthropocene Mass Extinction"); *see also* Daisy Hernandez, *The Earth's Sixth Mass Extinction is Accelerating*, POPULAR MECHANICS (June 3, 2020), https://www.popularmechanics.com/science/animals/a32743456/rapid- mass-extinction/ ("The Holocene extinction is the sixth mass extinction event.").

35. Isabella Kendrick, *Critical Habitat Designations Under the Endangered Species Act in an Era of Climate Crisi*s, 121 COLUM. L. REV. 81, 99 (2021).

36. Endangered Species Act of 1973, 16 U.S.C. §§ 1531–1544.

37. Brian Gray et al., *Implementing Ecosystem-Based Management*, 31 DUKE ENV'T L. & POL'Y F. 215, 251 (2021). The USFWS is responsible for regulating freshwater and terrestrial species, while NMFS regulates saltwater and anadromous species. *Id.* Absent this context or unless otherwise specified, references hereinafter to "the Agency" are to either USFWS or NMFS acting pursuant to the ESA.

38. 16 U.S.C. § 1531(b).

are no longer necessary."[39] While the ESA itself specifies only conservation, federal courts have interpreted "conservation" within the meaning of the Act to include a species' survival at minimum and ultimately its recovery.[40] Indeed, scholars have noted that the ESA's definition of conservation—such that the protection afforded by the ESA is no longer necessary—in conjunction with 16 U.S.C. § 1533(f)'s requirements that the government develop "recovery plans," indicates that recovery is "arguably the main goal of the ESA."[41]

The ESA's goals conflict with both the realities of land use and the threats of climate change. From private development to resource extraction, both private actors and the government—whether via the state or federal government—contribute to diminution of the species, directly by take or indirectly by environmental degradation, that necessitates a species' listing under the ESA. Human activity has further exacerbated climate change, which has demonstrably threatened species and their ecosystems. To determine those conflicts and threats and how to mitigate them, the ESA requires the Secretary to (1) determine whether a species should be (a) listed as endangered, (b) listed as threatened, or (c) not necessary for listing;[42] (2) designate critical habitat for the listed species;[43] (3) establish a recovery plan for the listed species;[44] and (4) continue to monitor the species if it meets the goals set by the Agency and is properly delisted.[45] This Note will describe each of these provisions and consider recent interpretations and criticisms of the ESA in the context of climate change before demonstrating how genetically engineered species can fit into the statute's framework to allow for more flexible, recovery-oriented management.

A. Listing

First, under section 4 of the ESA, the Secretary is required to consider species of flora and fauna for listing.[46] Any individual can file a

39. *Id.* § 1532(3).
40. *See, e.g.*, Sierra Club v. U.S. Fish & Wildlife Serv., 245 F.3d 434, 441–42 (5th Cir. 2001) (examining the statute's provisions for critical habitat designation and recovery plans to find that "[t]he ESA's definition of 'conservation'" is "a much broader concept than mere survival" and "speaks to the recovery of a threatened or endangered species").
41. *See* Falberg, *supra* note 15, at 160, 182–83.
42. § 1533(a)(1).
43. *Id.* § 1533(a)(3)(A)–(B).
44. *Id.* § 1533(f).
45. *Id.* § 1533(g).
46. *See id.* § 1533(a)(1).

petition for the consideration of listing a species,[47] and the Secretary has up to ninety days to determine whether that petition is warranted, unwarranted, or warranted but precluded by other Agency priorities.[48] If the Secretary determines that the petition is warranted, the Secretary must then determine from a purely scientific perspective whether the species meets the proper criteria for listing.[49] The Secretary considers: (a) "the present or threatened destruction, modification, or curtailment" of the species' "habitat or range"; (b) whether the species has been "overutiliz[ed] for commercial, recreational, scientific, or educational purposes"; (c) the effects on the species of "disease or predation"; (d) whether "existing regulatory mechanisms" to protect the species are adequate or inadequate; and (e) "other natural or human-driven factors affecting [the species'] continued existence."[50] In making this determination, the Secretary may only consider "the best scientific and commercial data" and whether "any State or foreign nation, or any political subdivision [thereof]" has moved to protect the target species.[51] Depending on these criteria, the Secretary may either choose to list the species as endangered or threatened, or to not list the species at all.[52]

The definitions of endangered and threatened species reflect the purpose of the ESA as preventing the extinction of particular species. If a species is listed as "endangered," then it is "in danger of extinction throughout all or a significant portion of its range."[53] If a species is listed as "threatened," then it is likely to be in danger of extinction "within the foreseeable future throughout all or a significant portion of its range."[54] These definitions likewise recognize the key role that habitat—and the threats to that habitat—plays not only in a species' conservation, but in the level of risk the species faces. In sum, listing is the first stage of the government's process for protecting the most at-risk species by

47. *See* Administrative Procedure Act, 5 U.S.C. § 553(e). While the individual right to petition comes from the Administrative Procedure Act, the ESA provides a citizen-suit provision allowing any interested individual to compel the Secretary of Interior to perform nondiscretionary duties required by § 1533, including listing and critical habitat designation but not the implementation of recovery plans. 16 U.S.C. § 1540(g).

48. § 1533(b)(3)(A).

49. *Id.* § 1533(b)(1)(A).

50. *Id.* § 1533(a)(1)(A)–(E).

51. *Id.* § 1533 (b)(1).

52. *See id.* § 1533(a)(1); *id.* § 1533(b)(1)(A).

53. *Id.* § 1532(6). This excludes "species of the Class Insecta" the Secretary determines are pests "whose protection . . . would present an overwhelming and overriding risk to man." *Id.*

54. *See id.* § 1532(20).

determining not only the threats facing that species and its habitat but also the feasibility of protecting the species.[55]

B. Critical Habitat Designation

Section 4 of the ESA also requires the Secretary, within one year of listing, to designate habitat that is critical to the species' conservation.[56] The statute defines "critical habitat" in two parts based on the species' geographic range at the time it is listed.[57] Geographical areas within the species' current range can be designated critical habitat if on those areas are found "those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection. . . ."[58] Under the second critical habitat definition, the Secretary is given broad discretion to determine that "specific areas outside" the species' range at the time of listing "are essential for the conservation of the species" and may be designated critical habitat.[59]

The ESA provides to the Secretary broad discretion in designating critical habitat for a listed species despite designation being an apparent requirement. In determining whether an identified habitat may be designated or revised as critical, the Secretary shall consider only "the best scientific data available[,] the economic impact, the impact on national security, and any other relevant impact, of specifying any particular area as critical habitat."[60] The Secretary may still choose to exclude the area from designation if "the benefits of such exclusion outweigh the benefits" of designation, unless "based on the best scientific and commercial data available" the Secretary finds that the failure to designate will result in the listed species' extinction.[61]

Critical habitat designation has two purposes. First, it identifies an area in which the management of a species can be concentrated.[62] Second, it requires any federal government activity to consult with either USFWS or NMFS to determine whether the activity will adversely impact the

55. *See* Dale D. Goble, *The Endangered Species Act: What We Talk About When We Talk About Recovery*, 49 NAT. RES. J. 1, 3–5 (2009).
56. § 1533(a)(3)(A).
57. *Id.* § 1532(5)(A).
58. *Id.* § 1532(5)(A)(i).
59. *Id.* § 1532(5)(A)(ii).
60. *Id.* § 1533(b)(2).
61. *Id.*
62. *See* Chris Wilson, Weyerhaeuser v. U.S. Fish and Wildlife Service*: Swirling Uncertainty Around the Definition of Habitat*, 47 ECOLOGY L.Q. 761, 762 (2020).

listed species.[63] It also serves to warn both public and private actors of the presence of listed species.[64]

However, critical habitat designation is often controversial, as it limits the types of activities permitted within the area and can increase cost burdens of conducting permitted activities.[65] Because designation is often litigated, it is one of the foremost areas of legal development for ecosystem management regimes and particularly for the ESA.[66] While listing species has been largely uncontroversial until fairly recently—with the exception of the kerfuffle surrounding the USFWS's choice not to list the Greater sage-grouse, citing amelioration through other means[67]—designation often invokes litigation by concerned parties to limit the area to be designated or to enjoin the designation altogether.[68] One recent case, *Weyerhaeuser Co. v. U.S. Fish and Wildlife Service*,[69] had significant implications for critical habitat designation and signaled wider attempts to reign in the federal government's ability to enforce the ESA—particularly through designation—as it is currently written. An examination of this case will demonstrate how current definitions of critical terms in the ESA can be read to include genetically engineered and de-extinct species, which will be discussed in Part IV of this Note.

Along with several private landowners, Weyerhaeuser Company, a real estate investment trust and timber company, challenged USFWS's designating a parcel of land in Louisiana as critical habitat.[70] The USFWS designated this area as critical habitat for the dusky gopher frog, an endangered species that was listed in 2001.[71] Though indigenous to the lower coastal area of the Gulf Coast states of Louisiana, Mississippi, and Alabama, the dusky gopher frog has not been found in Alabama since

63. *See id.* at 763.
64. Kendrick, *supra* note 35, at 92.
65. YA-WEI LI, WHEN DOES CRITICAL HABITAT DESIGNATION BENEFIT SPECIES RECOVERY? 2 (2020), https://www.thecgo.org/wp-content/uploads/2020/10/When-Does-Critical-Habitat-Designation-Benefit-Species-Recovery.pdf.
66. *See* Regulations for Listing Endangered and Threatened Species and Designating Critical Habitat, 87 Fed. Reg. 37757, 37760 (June 24, 2022) (codified at 50 C.F.R. § 424.02 (2022)).
67. *Greater Sage-Grouse*, BUREAU LAND MGMT., https://www.blm.gov/programs/fish-and-wildlife/sage-grouse (last visited Mar. 20, 2023); *see also* Jeremy T. Bruskotter et al., *Support for the U.S. Endangered Species Act over Time and Space: Controversial Species Do Not Weaken Public Support for Protective Legislation*, CONSERVATION LETTERS, Nov./Dec. 2018, at 1, 5–7.
68. *See* Kendrick, *supra* note 35, at 93–96.
69. 139 S. Ct. 361 (2018).
70. *Id.* at 366–67.
71. DUSKY GOPHER FROG RECOVERY TEAM, U.S. FISH & WILDLIFE SERV., DUSKY GOPHER FROG (RANA SEVOSA) RECOVERY PLAN 16–17 (2015), https://ecos.fws.gov/docs/recovery_plan/2015_07_16_Final%20RP_R_sevosa_08212015%20(1).pdf.

1922 or in Louisiana since the mid-1960s.[72] The dusky gopher frog breeds at sites characterized by seasonal, isolated ponds requiring substantial winter rains, and individuals of the species spend the majority of their lives underground in forests with an open canopy and abundant ground cover.[73]

The USFWS proposed an area in Louisiana, dubbed Unit 1, as a potential critical habitat area for the dusky gopher frog due to its "rare, high-quality breeding ponds and its distance from existing frog population [that] made it essential for the conservation of the species" in accordance with § 1532(5)(A)(ii).[74] Weyerhaeuser challenged the designation, claiming that because the area did not currently support conservation of the dusky gopher frog, and because even the USFWS had "no reasonable basis to believe that it will do so at any point in the foreseeable future," the "unoccupied land cannot rationally be designated as 'essential for the conservation of [a] species'" to be a critical habitat.[75]

Because the area did not contain all the physical or biological features necessary for the species' conservation, it did not meet the standards required under the ESA for designating the area as unoccupied critical habitat.[76] The plaintiffs argued that the designation of potential habitat was too speculative and beyond the intent of § 1533(a)(ii).[77] For these reasons, the plaintiff-petitioners argued that USFWS's attempted designation was an improperly broad interpretation of the ESA that would extend the ESA's reach to *developed* land, raising the potential for exorbitant takings claims against the government consequent to critical habitat designations.[78]

The United States Supreme Court sided with the petitioners insofar as holding "[o]nly the 'habitat' of endangered species is eligible for designation as critical habitat."[79] Adopting petitioners' plain reading of the statute, the Court rejected the USFWS's argument that the statute's definition of "critical habitat" is separate and distinct from any underlying definition of "habitat."[80] The Court did not reach petitioner's argument that unoccupied areas without primary constituent elements

72. *Id.* at 1–2.

73. *Id.* at 8.

74. *Weyerhaeuser*, 139 S. Ct. at 366.

75. Joint Brief of the Appellants at 36–37, Markle Ints., LLC v. U.S. Fish and Wildlife Serv., 827 F.3d 452 (5th Cir. 2016) (No. 14-31008) (alteration in original) (citing 16 U.S.C. § 1532(5)(A)(ii)).

76. *See Weyerhaeuser*, 139 S. Ct. at 368–69; Wilson, *supra* note 62, at 761.

77. *See* Brief for Petitioner at 22–25, Weyerhaeuser Co. v. U.S. Fish & Wildlife Serv., 139 S. Ct. 361 (2018) (No. 17-71).

78. *See id.* at 32–34.

79. *Weyerhaeuser*, 139 S. Ct. at 368.

80. *Id.*

were not "essential for the conservation of the species" and thus ineligible for critical habitat designation,[81] preserving USFWS's ability to designate unoccupied areas as critical habitat.[82] However, the Court remanded to the lower courts to "interpret the term 'habitat' in Section 4(a)(3)(A)(i)."[83] The parties ultimately settled, denying the Fifth Circuit the opportunity to consider the definition of "habitat" and leaving the matter unresolved.[84]

Mindful of the Supreme Court's ruling in *Weyerhaeuser*, USFWS and NMFS published to the Federal Register a final rule in December 2020 defining habitat, "[f]or the purposes of designating critical habitat only, [as] the abiotic and biotic setting that currently or periodically contains the resources and conditions necessary to support one or more life processes of a species."[85] The final rule also changed how economic and national security concerns were evaluated, increased the number of exclusions the Secretary may consider when designating critical habitat, and provided the Secretary the opportunity to consider additional exclusions at any time during the designation process.[86] However, USFWS, under the Biden Administration, proposed to rescind this rule on October 27, 2021, less than one year after this post-*Weyerhaeuser* definition was promulgated.[87]

C. Recovery Plans and Delisting

Section 4(f) states that the Secretary "shall develop and implement" recovery plans for listed species,[88] prioritizing species that would "most likely . . . benefit" from such plans or are or will be at risk of conflict with other projects or economic activity.[89] Despite this apparent mandate, the Secretary may elect to forego a recovery plan if "he finds that such a plan will not promote the conservation of the species."[90] Courts have repeatedly held that section 4(f) grants the Secretary broad discretion in

81. *Id.* at 369 n.2.
82. Wilson, *supra* note 62, at 765.
83. *Weyerhaeuser*, 139 S. Ct. at 369.
84. Wilson, *supra* note 62, at 765.
85. Regulations for Listing Endangered and Threatened Species and Designating Critical Habitat, 85 Fed. Reg. 81411, 81421 (Dec. 16, 2020) (codified at 50 C.F.R. § 424.02 (2021)).
86. Laura Bies, *USFWS Plans to Rescind Key Critical Habitat Rules*, WILDLIFE SOC'Y (Nov. 2, 2021), https://wildlife.org/usfws-plans-to-rescind-key-critical-habitat-rules/.
87. Regulations for Designating Critical Habitat, 86 Fed. Reg. 59346, 59346 (proposed Oct. 27, 2021) (to be codified at 50 C.F.R. § 424.02).
88. 16 U.S.C. § 1533(f)(1).
89. *Id.* § 1533(f)(1)(A).
90. *Id.* § 1533(f)(1).

determining whether to implement recovery plans.[91] Just as the decision whether and how to list requires risk assessment, so too does the Secretary's decision whether and which listed species require recovery plans.[92]

In developing its recovery plans, which are divided into general plans for a species and specific on-the-ground plans for the species in specific areas, the USFWS considers a species' resiliency, redundancy, and representation.[93] These three factors, comprising USFWS's Species Status Assessment ("SSA"), characterize "a species' ability to sustain populations in the wild over time based on the best scientific understanding of current and future abundance and distribution within the species' ecological settings."[94] The higher level recovery plan must incorporate (1) a description of "site-specific management actions," (2) "objective, measurable criteria" that would determine when a species has recovered sufficiently to be delisted, and (3) time and cost estimates to bring the species to recovery.[95] USFWS includes this information in the SSA.[96] The SSA further identifies the primary threats facing a species, and it is imported to the species' higher level recovery plan,[97] which must go through notice-and-comment rulemaking.[98] On-the-ground activities are implemented as part of USFWS's Recovery Implementation Strategy ("RIS"), a "short-term, more flexible operational document focused on how, when, and with whom the recovery actions will be implemented."[99] The USFWS prefers RISs in part because they streamline the process of implementing recovery plans by avoiding the need to amend higher level recovery plans, a process that can take years.[100]

Delisting a species requires an analysis of the threats facing a listed species using the same five factors identified for listing the species under section 4(a).[101] Such a determination can be made following review of a civilian petition or at the Secretary's discretion as part of the five-year

91. Eric Helmy, *Teeth for a Paper Tiger: Redressing the Deficiencies of the Recovery Provisions of the Endangered Species Act*, 30 ENV'T L. 843, 853–54 (2000).
92. Goble, *supra* note 55, at 3–5.
93. *Species Status Assessment*, U.S. FISH & WILDLIFE SERV., https://www.fws.gov/project/species-status-assessment (last visited Mar. 20, 2023).
94. *Id.*
95. § 1533(f)(1)(B)(i)–(iii).
96. *Id.*
97. *Recovery Planning and Implementation,* U.S. FISH & WILDLIFE SERV., https://www.fws.gov/project/recovery-planning-and-implementation (last visited Mar. 20, 2023); *see* § 1533(a)(1); § 1533(f)(1)(B)(i)–(iii).
98. *See* § 1533(b)(3)(B)(i)–(ii); *id.* § 1533(b)(5)(A)(ii).
99. *Recovery Planning and Implementation*, *supra* note 97.
100. *See id.*
101. § 1533(a)(1); *id.* § 1533(c)(2)(B)(i).

review of all listed species.[102] Species may be delisted because the Secretary determines the species has recovered, the species has been rendered extinct, or because new information renders the decision to list the species erroneous.[103] When a species is delisted because it has recovered or because a new threat analysis has supplanted the prior one, section 4(g) still requires the Secretary to work with the relevant states to monitor the species for "not less than five years" to determine if the species shall maintain its recovered status or will require re-listing.[104]

D. The Endangered Species Act Cannot Respond Adequately to Climate Change

Despite general consensus that the Endangered Species Act is the most successful conservation legislation, scholars have critiqued the Act as conflicting in its implied purpose and stated purpose, unwieldy and inflexible, and prone to backlogs. Critics have concentrated on the ESA's listing, critical habitat designation, and recovery provisions. Because the ESA is the primary means by which the U.S. federal government can tackle biodiversity loss due to climate change,[105] these criticisms are especially poignant entering the third decade of the twenty-first century. In Parts VI and VII of this Note, these criticisms will highlight how genetically engineered and de-extinct species could and could not currently fit into ecosystem management regimes under the ESA and serve as the basis for overall policy recommendations and changes to the ESA.

Depending on the interpretation of the ESA's mandate, the Act can only respond to and mitigate climate change related harm rather than foster resilience or reverse that harm. Despite common interpretations that the ESA mandates recovery, scholars point to section 4(f)'s granting the Secretary broad discretion in implementing recovery plans to argue that the statute does not, with USFWS and NMFS prioritizing "survival" over recovery as the minimum standard.[106]

Whereas courts have interpreted discretion in critical habitat designation,[107] scholars have noted that the Secretary has even greater

102. *Id.* § 1533(a)(3)(A); *id.* § 1533(c)(2)(A).
103. *See National Downlisting and Delisting Workplan*, U.S. FISH & WILDLIFE SERV., https://www.fws.gov/project/national-downlisting-and-delisting-workplan (last visited Mar. 20, 2023).
104. § 1533(g).
105. Kendrick, *supra* note 35, at 101.
106. Justin Berchiolli, *Stewarding Species: How the Endangered Species Act Must Improve*, 10 U.C. IRVINE L. REV. 1079, 1081–83 (2020).
107. *See supra* Section III.B.

discretion in deciding whether and which listed species require a recovery plan. Primarily, as Eric Helmy notes, critical habitat designation operates on statutorily imposed deadlines; there are no deadlines for implementing recovery plans.[108] Despite the propriety of granting wide discretion to the Secretary to decide which listed species are most in need of recovery plans, the "temporal accountability deficiency" adversely affects the extant populations of other listed species.[109] Because recovery plans in particular have no rigid deadlines, extant but depleted populations "suffer disproportionately severe impacts from the action of selective forces over time" as no recovery plan is implemented to mitigate these risks and pressures.[110] Especially as climate change manifests in simultaneous and cascading events like heat waves, drought, and wildfires, the failure to implement recovery plans exposes species to even greater risk than as already expected when the species were listed.

The Supreme Court's decision in *Weyerhaeuser* brought to light an apparent conflict between the common understanding of the ESA's purpose of conservation and the statute's stated purpose of restoration.[111] The USFWS's need to actively manage some areas of critical habitat that do not presently support a listed species speaks to the Agency's discretion to implement recovery plans. However, by limiting a species' critical habitat to where it currently exists, the ESA would only protect the species' survival based, at least in theory, on its extant at the time of listing.[112] This latter interpretation would severely limit the Agency's ability to recover a species by precluding the Agency's consideration of a species' projected needs, such as establishing new migration corridors or even responding to other mitigation measures.[113] Likewise, the Agency would be unable to effectively respond to climate change and human encroachment when designating a species' critical habitat, potentially dooming the species to extinction by forcing it into an area that is unable to support recovery.[114] The 2020 rule's narrow definition of habitat intensified recommendations to update the ESA to provide greater flexibility to address ecological dynamism, especially in response to growing concerns about climate change.[115] Such recommendations long

108. § 1533(b)(3)(D); Helmy, *supra* note 91, at 846.
109. Helmy, *supra* note 91, at 846–47.
110. *Id.* at 846.
111. Kendrick, *supra* note 35, at 110–11.
112. *See id.* at 103–04, 106.
113. *Id.* at 110–11.
114. *See id.*
115. *See id.* at 84–85; *see also* Wilson, *supra* note 62, at 767–68.

preceded *Weyerhaeuser*,[116] and they will likely continue as the USFWS proposes recovery plans that do not sufficiently address these threats.

This same deficiency extends to the listing process: because listing is a complex process and thus time-consuming, the multiplying effects of climate change will accelerate harm to candidate species and their habitats. The parameters for assessing the extinction risks facing candidate species are imprecisely defined and focus more on qualitative issues than quantitative data.[117] Even so, the listing process's focus on evaluating threats "obscure[s] the inherent risk analysis that the [ESA] requires."[118] Dale Goble has argued that these parameters, while assisting the Secretary's determination of the qualitative risks a listed species faces, do not satisfactorily address the ethical acceptability of allowing a species to go extinct, the statute's underlying assessment.[119]

Other commentators note the practical problems of listing. The USFWS and NMFS routinely face substantial backlogs of species that they have determined may warrant listing.[120] In 2018, for example, over 500 species were awaiting review.[121] Because listing is a multi-step process—from petition to protection determination—that relies on the best scientific data available at each stage, a species that may warrant protection may be rendered functionally extinct by the time protection is extended.[122] At least forty-two species have gone extinct while protection was being considered.[123] While a listed species' survival, if not recovery, is at minimum the ESA's mandate, climate change and encroaching human development have added pressure to already strained populations.[124] Fifty-four species have been delisted due to recovery and fifty-six have been down-listed from endangered to threatened, and the USFWS drew attention in September 2021 when it proposed in the Federal Register to delist twenty-three species that had been rendered extinct.[125] Like the dusky gopher frog, several of the species had not been

116. *See, e.g.*, J.B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future*, 88 B.U. L. REV. 1, 2, 32–42 (1990) (analyzing the USFWS's ability and discretion to respond to climate change under the ESA).

117. Goble, *supra* note 55, at 7–9.

118. *Id.* at 8.

119. *Id.* at 14–15.

120. Noah Greenwald et al., *Extinction and the U.S. Endangered Species Act*, PEERJ, Apr. 22, 2019, at 1, 5.

121. *Id.* at 5.

122. *See, e.g.*, *id.* (stating that seventy-one species went extinct while under consideration for listing).

123. *Id.*

124. *See* Berchiolli, *supra* note 106, at 1095.

125. Rich Mckay & Kanishka Singh, *U.S. to Declare 23 Species, Including Ivory-Billed Woodpecker, Officially Extinct*, REUTERS (Sept. 29, 2021, 8:57 PM), https://

seen for decades, including, in two cases, since before the ESA's passage in 1973.[126] Scholars cite such reasons to argue that the ESA's recovery mandates "fail to adequately protect" species "whose absence decreases biodiversity by reducing critical interactions among species" by prioritizing other, potentially more charismatic species.[127]

Ultimately, these criticisms highlight how the ESA, a fifty-year-old statute, is not currently able to meet the demands of a rapidly warming planet. Amendments to the statute would allow for holistic ecosystem management regimes, including approaches that could allow for the use of genetically engineered and de-extinct species to promote ecosystem health. However, both the ESA and invasive species management statutes create barriers to the use of non-natural species. These will be explored in Parts IV and V, with recommendations to reduce or eliminate these barriers in Part VI.

IV. INVASIVE SPECIES MANAGEMENT

Even if the Endangered Species Act posed no barrier to the protection of genetically engineered or de-extinct species, invasive species management statutes still would present significant hurdles to their introduction, protection, or use in wider ecosystem management regimes. This Part will identify the practical consequences and threats of invasive species, the federal government's attempts to control or eliminate them, and legal scholars' critiques of these attempts. The applicability of invasive species management statutes to genetically engineered and de-extinct species will be explored in Part V.

A. *Practical Consequences of Invasive Species*

In recent decades, the United States has combated a particular scourge in freshwater ecosystems: zebra and quagga mussels.[128] Only the size of a fingernail, the mussel went undetected within the holds of international vessels traveling from eastern Europe—where the mussel is native[129]—and were discharged with ballast water into the waters of

www.reuters.com/world/us/us-declare-23-species-including-ivory-billed-woodpecker-extinct-ap-2021-09-29/.

126. *See id.*

127. Berchiolli, *supra* note 106, at 1086–87.

128. Sam Libby, *Zebra Mussels Emerge as a Growing Threat*, N.Y. TIMES (Aug. 26, 2001), https://www.nytimes.com/2001/08/26/nyregion/zebra-mussels-emerge-as-a-growing-threat.html.

129. Mark Hoddle, *Quagga & Zebra Mussels*, CTR. FOR INVASIVE SPECIES RSCH., https://cisr.ucr.edu/invasive-species/quagga-zebra-mussels (last visited Mar. 20, 2023).

the Great Lakes.[130] Since its discovery in Lake St. Clair in June 1988,[131] the zebra mussel has spread to most freshwater ecosystems in the northeastern United States and Canada and throughout the Mississippi River Basin, and it has even been found in Texas, Colorado, Utah, Nevada, and California.[132]

The zebra mussel has a three-fold effect on freshwater environments. First, it bonds to indigenous mussel species to which it is distantly related, ultimately destroying them and their habitat.[133] Second, it filters particulate matter that increases water clarity and light penetration, leading to algal blooms that deprive the ecosystem of oxygen and kill off local wildlife.[134] Third, because these mussels spread quickly and adhere to almost any surface, they often clog water intake structures for essential infrastructure like power plants and water treatment facilities; encrust on boats, buoys, and docks; and, because they are sharp, cause bodily injury to any unwitting traveler unfortunate to tread upon them.[135]

In the decades since the quagga and zebra mussels' discovery in U.S. waters, their dominance over their new ecosystems has served as a wake-up call for scientists, policymakers,[136] and legal scholars.[137] The introduction and spread of invasive species "is correlated with" environmental degradation, biodiversity loss, and "numerous less obvious impacts related to economic loss, crime and national security, and public health and safety."[138] In the event that a zebra and quagga mussel infestation occurs in the Columbia River, experts estimate that

130. *Id.*

131. Libby, *supra* note 128.

132. *What Are Zebra Mussels and Why Should We Care About Them?*, U.S. GEOLOGICAL SURV., https://www.usgs.gov/faqs/what-are-zebra-mussels-and-why-should-we-care-about-them#publications (last visited Mar. 20, 2023).

133. Hoddle, *supra* note 129.

134. *Id.*

135. *Id.*

136. *See generally* Stephanie R. Januchowski-Hartley et al., *The Need for Spatially Explicit Quantification of Benefits in Invasive-Species Management*, 32 CONSERVATION BIOLOGY 287 (2018) (overviewing various international approaches to invasive species management and highlighting the need for "spatial asset" analysis within popular cost-benefits analyses).

137. *See, e.g.*, Rachel White & Stephanie Showalter Otts, *Preventing the Spread of Zebra and Quagga Mussels: The Role of the Lacey Act*, 3 ARIZ. J. ENV'T L. & POL'Y 85, 86–87 (2013) (analyzing "the limits of the Lacey Act as a tool for preventing the spread of invasive zebra and quagga mussels").

138. Jane Cynthia Graham, *Snakes on a Plain, or in a Wetland: Fighting Back Invasive Nonnative Animals—Proposing a Federal Comprehensive Invasive Nonnative Animal Species Statute*, 25 TUL. ENV'T L.J. 19, 24 (2011).

maintaining hydroelectric facilities would cost $64 million annually,[139] while the Great Lakes states spend roughly $300 million to $500 million per year to remove these mussels from infrastructure.[140] The U.S. Geological Survey has estimated that the "[m]ore than 6,500" invasive species in the United States "cause more than 100 billion dollars in damage" per year.[141] These damages take the form of outcompeting local species, causing food webs to collapse, destroying natural habitats, encouraging illicit wildlife trafficking, and harming humans via unfamiliar and dangerous characteristics.[142]

Invasive species pose significant threats not only to native wildlife and plants but also to human interests, including economic development and infrastructural integrity. These species "can negatively impact ecosystem processes, decrease native species abundance and richness, minimize overall genetic diversity, disturb the structure of natural communities, and can pose a direct threat to imperiled native species."[143] Indeed, the introduction of invasive species—often caused by human activity—is likely one of the "top direct drivers of global biodiversity loss."[144] Climate change will exacerbate the spread of invasive species as biome shifts alter "the occurrence, abundance and life histories of native species" and thus "decrease biotic resistance."[145] In other words, climate change's effects on biological communities can create niches for invasive species to fill and, finding little resistance to their propagation, eventually overrun.

The lack of comprehensive invasive species management legislation in the face of expanding invasive species led President William Clinton to promulgate Executive Order 13112 on February 3, 1999.[146] The Executive Order distinguishes between "alien species" and "invasive species." An "alien species" is any species that "with respect to a particular ecosystem, is not native to that ecosystem."[147] An invasive

139. Travis Warziniack et al., *Economics of Invasive Species*, *in* INVASIVE SPECIES IN FORESTS AND RANGELANDS OF THE UNITED STATES 305, 305 (Therese M. Poland et al. eds., 2021).

140. *Id.*; *see also* Hoddle, *supra* note 129.

141. Wetland & Aquatic Rsch. Ctr., *What Is an Invasive Species?*, U.S. GEOLOGICAL SURV. (Feb. 23, 2021), https://www.usgs.gov/news/invasive-species-science-warc.

142. Graham, *supra* note 138, at 24–28.

143. Damian C. Adams et al., *Federal Invasive Alien Species Policy: Incremental Approaches and the Promise of Comprehensive Reform*, 23 DRAKE J. AGRIC. L. 291, 293 (2018).

144. *Id.* at 293–94.

145. Regan Early et al., *Global Threats from Invasive Alien Species in the Twenty-First Century and National Response Capacities*, NATURE COMMC'NS, Aug. 2016, at 1, 6.

146. Exec. Order No. 13,112, 64 Fed. Reg. 6183, 6183 (1999).

147. *Id.* § 1(a).

species is any "alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health."[148]

The Executive Order primarily requires "all federal agencies [to] coordinate a response to the threats posed by [invasive alien species]."[149] To accomplish this coordinated approach to invasive species management, the Executive Order established the National Invasive Species Council ("NISC") to oversee the thirty-five agencies authorized to regulate invasive species.[150] The NISC has no legal authority to compel agency action; it may recommend actions to federal agencies, states, and territorial and tribal governments.[151] However, the NISC manages coordination between these organizations, providing an overarching management plan for which "activities are to be evaluated against eighty-seven performance targets."[152]

Prior to the promulgation of Executive Order 13112, the Lacey Act[153] was the primary statutory mechanism supporting the prevention and management of invasive species. The Lacey Act criminalizes the "import, export, transport, [sale], recei[pt], acqui[sition], or purchase of any fish or wildlife or plant taken, possessed, transported, or sold in violation of any law, treaty, or regulation."[154] It lists injurious species—including the zebra and quagga mussels—the transportation of which into or through the United States requires permits from USFWS, and authorizes USFWS to add injurious species to this cumulative list.[155] The USFWS considers a variety of factors when determining whether a species should be listed as injurious, including (1) the species' ability to survive and propagate in the wild; (2) the species' impacts on (a) habitats, (b) species listed under the ESA, and (c) human beings and resource-based industries; and (3) the ability to control and eradicate the species.[156] The USFWS also considers mitigatory measures to prevent the species' listing and economic analyses to determine potential impacts of the listing.[157]

While the U.S. Congress has passed other federal statutes to manage invasive species, legal scholars have derided the federal government's

148. *Id.* § 1(f).
149. Adams et al., *supra* note 143, at 302–03.
150. *Id.*
151. Sophie Riley, *Peak Coordinating Bodies and Invasive Alien Species: Is the Whole Worth More Than the Sum of Its Parts?*, 35 LOY. L.A. INT'L & COMP. L. REV. 453, 470–71 (2013).
152. *Id.* at 471.
153. Lacey Act, 16 U.S.C. §§ 3371–3378 (2008).
154. *Id.* § 3372(a)(1).
155. 18 U.S.C. § 42; *see* Graham, *supra* note 138, at 38.
156. *See* KRISTINA ALEXANDER, CONG. RSCH. SERV., INJURIOUS SPECIES LISTINGS UNDER THE LACEY ACT: A LEGAL BRIEFING 23–24 (2013).
157. Graham, *supra* note 138, at 37.

piecemeal, often reactive approach to invasive species management since the passage of the Lacey Act in 1900.[158] Jane Cynthia Graham notes that of the two "main federal invasive species laws," the Lacey Act and Executive Order 13,112, the former is reactive and "lack[s] cost recovery and incentive tools" and the latter "does not have the force of law."[159]

Scholars, such as Graham, have criticized the Lacey Act's "dirty list" as reactive and ineffective to address the spread of dangerous invasive species.[160] First, listing is governed by a notice-and-comment rulemaking process that coincides with an analysis under the National Environmental Protection Act ("NEPA") that together can take anywhere between fourteen months and seven years.[161] Second, listing may come too late to prevent damage to native species and their habitats because USFWS may not have sufficient scientific information to list a species as injurious prior to its introduction to the United States.[162]

The NISC is insufficient to bridge the gap left by Congress's failure to provide comprehensive invasive species management legislation. Commentators point to the NISC's lack of authority to issue legally binding mandates even to its member agencies.[163] Because it lacks rulemaking authority, it "relies heavily on the reliability of state based programs."[164] But because states are left with the burden to manage invasive species, state statutes are often reactive to specific circumstances rather than proactive in providing wider guidance in managing invasive species.[165] The NISC is further affected by budgetary limitations because it does not have a legislative appropriation.[166] Finally, because the NISC has no statutory basis, oversight is provided only under NEPA, and because invasive species management "scenarios are murky, at best," accountability remains elusive.[167]

Without comprehensive invasive species management legislation, the federal government will be unable to react to problems associated with climate change. Further, the complex web of federal and state

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158. William K. Norvell III, Note, *America's Invaders: The Nile Monitor and the Ineffectiveness of the Reactive Response to Invasive Species*, 22 ANIMAL L. 397, 402 (2016).
159. Graham, *supra* note 138, at 34.
160. *Id.* at 38.
161. Susan D. Jewell & Pam L. Fuller, *The Unsung Success of Injurious Wildlife Listing Under the Lacey Act*, 12 MGMT. BIOLOGICAL INVASIONS 527, 530 (2021).
162. Graham, *supra* note 138, at 38; *cf.* Jewell & Fuller, *supra* note 161, at 531 ("Some of these papers . . . ignored the substantial number of species listed before they were introduced and that remained absent from the United States.").
163. Adams et al., *supra* note 143, at 319; *see also* Norvell, *supra* note 158, at 409–10.
164. Norvell, *supra* note 158, at 409.
165. *Id.* at 407–09.
166. *Id.* at 410.
167. Adams et al., *supra* note 143, at 319–20.

legislation that is often circumstance-specific and contradictory complicates the introduction and use of non-native species to sustain habitats and promote the recovery of species listed under the ESA.

B. The Endangered Species Act and Invasive Species Management

The Endangered Species Act, as we have seen, seeks to "provide a program for the conservation of" listed species and the ecosystems upon which they depend.[168] However, the ESA does not directly address invasive species. Instead, Executive Order 13112 cites the ESA—among several other statutes—as granting the executive branch the authority to manage invasive species.[169] Invasive species pose two potential threats under the ESA: direct threats to the listed species by killing—or "taking"—members of the listed species, and indirect threats to the listed species by destroying or adversely affecting their habitat.[170] Because section 7 of the ESA requires USFWS and NMFS to consult with agencies or organizations whose federally supported activities may adversely modify or destroy a listed species' habitat,[171] these action agencies should include in their consultations invasive species management plans should an invasive species be present in the area. Section 9 of the ESA likewise prohibits any agency action from the "take" of a listed species.[172] These requirements pose issues for the introduction of genetically engineered or de-extinct species to habitats, which may be considered alien or invasive alien species. Part VI of this Note will include policy recommendations to rectify these issues.

V. GENETIC ENGINEERING AND DE-EXTINCTION WITHIN ECOSYSTEM MANAGEMENT

Genetic engineering and de-extinction are some of the tools that may be used to combat climate change. Particularly in the context of keystone species—a species that "holds the [ecological] system in check and preferentially consumes species that would otherwise dominate the system"[173]—genetic engineering and de-extinction may restore to a

168. 16 U.S.C. § 1531(b).
169. Exec. Order No. 13,112, 64 Fed. Reg. 6183, 6183 (1999).
170. Adams et al., *supra* note 143, at 298.
171. § 1536(a)(2).
172. *Id.* § 1538(a)(1)(B).
173. Ann Garibaldi & Nancy Turner, *Cultural Keystone Species: Implications for Ecological Conservation and Restoration*, 9 ECOLOGY & SOC'Y, Dec. 2004, at 1, 2. Since Robert Paine coined the term in the 1960s, scientists have critiqued its ambiguity and chosen instead to modify it to allow for circumstance-specific application. *Id.*

habitat a critical component that has been rendered functionally or totally extinct due, in part, to climate change. However, because genetically engineered species are inherently non-natural, their use in ecosystem management must overcome some barriers within the ESA and invasive species management. This Part will explore some of those barriers and demonstrate how genetically engineered and de-extinct species do and do not fit within these regimes. In Part VI, this Note will recommend policy changes to encourage the use of genetic engineering in ecosystem management to combat climate change.

A. *De-Extinction: Its Background, Benefits, and Caveats*

De-extinction is a new phenomenon that has yet to achieve actual success, but genetic engineering at large has been otherwise used with great success in recent decades and will be integral in any de-extinction process. There are two primary methods of genetic engineering: Recombinant DNA ("rDNA") technology and CRISPR-Cas9 genome-editing technology ("CRISPR"). Recombinant DNA technologies have proven useful since the 1980s, after the Food and Drug Administration approved a recombinant insulin called Humulin offered by the pharmaceutical company Eli Lilly.[174] CRISPR is a much newer technique, demonstrating gene-editing success in late 2017.[175] Commentators note the widespread potential applications of each.[176] These applications—both potential and realized—have included the conservation of species.

Recombinant DNA remains an important biotechnology for conservation purposes. For example, a wildlife conservation organization promoting biotechnologies, Revive & Restore, is working to receive FDA approval of Recombinant factor C ("rFC"), a synthetic alternative to Limulus amebocyte lysate ("LAL") that has been available in Europe since 2016.[177] An important clotting agent for testing the sterility of vaccines, drugs, and other products, LAL is derived exclusively from the amebocyte found in in the horseshoe crab's blood, due in part to the

174. *Recombinant Drugs*, SMITHSONIAN, https://www.si.edu/spotlight/birth-of-biotech/recombinant-drugs (last visited Mar. 20, 2023).

175. Aparna Vidyasagar & Nicoletta Lanese, *What Is CRISPR?*, LIVE SCI. (May 13, 2022), https://www.livescience.com/58790-crispr-explained.html.

176. *Id.*; *see also Recombinant Drugs*, *supra* note 174.

177. *The Horseshoe Crab Project*, REVIVE & RESTORE, https://reviverestore.org/horseshoe-crab/about/ (last visited Mar. 20, 2023); Sarah Zhang, *The Last Days of the Blue-Blood Harvest*, ATLANTIC (May 9, 2018), https://www.theatlantic.com/science/archive/2018/05/blood-in-the-water/559229/.

species' ancient roots.[178] While blood can be harvested and the horseshoe crab returned alive to the water, roughly 10–15% of the subjects die from the letting.[179] Although it is not a listed species in the United States, the horseshoe crab is a carefully managed species.[180] While the species is notable for having changed very little in the 350 million years of its existence, it is also plays a key role in shoreside ecosystems by providing food—its eggs—for fish and migratory birds.[181] One such bird, the rufa red knot (*Calidris canutus rufa*), has been listed by USFWS as threatened since 2014, with commercial fishing of the horseshoe crab included as one of the threats facing the red knot's continued survival.[182] Despite management plans for the species to maintain sustainability in the face of pharmaceutical exploitation, conservationists have supported efforts to create synthetic alternatives. In 2018, the Horseshoe Crab Recovery Coalition endorsed rFC "as a sustainable alternative to LAL," arguing that decreasing dependence on horseshoe crab blood will "help restore horseshoe crabs to ecological carrying capacity and the recovery of threatened shorebird populations and sport fish."[183]

While genetically engineering a *product* to eliminate the need for its natural counterpart is vastly different from introducing into an environment an engineered animal, the effects can be similar. Just as reducing the need to harvest horseshoe crabs benefits the red knot, so could the introduction of genetically engineered—or even de-extinct—organisms benefit at-risk species and habitats. For example, some conservation biologists have called for using genetic engineering "to add resistance genes to trees for reintroduction to native forests" to combat insects and blights.[184] In other cases, the extinction of a species may leave

178. *See Horseshoe Crabs: Managing a Resource for Birds, Bait, and Blood*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. FISHERIES (July 31, 2018), https://www.fisheries.noaa.gov/feature-story/horseshoe-crabs-managing-resource-birds-bait-and-blood.

179. *Id.*

180. The Atlantic States Marine Fisheries Commission ("ASMFC") coordinates the harvesting of horseshoe crabs along the Atlantic coast, limiting the total harvestable number in the Delaware Bay region alone to 500,000 male and zero female horseshoe crabs per season. *Horseshoe Crab*, ATL. STATES MARINE FISHERIES COMM'N [hereinafter *Horseshoe Crab*, ATL. STATES], http://www.asmfc.org/species/horseshoe-crab (last visited Mar. 20, 2023); *see also Horseshoe Crab*, DEF. WILDLIFE, https://defenders.org/wildlife/horseshoe-crab (last visited Mar. 20, 2023).

181. *Horseshoe Crab*, ATL. STATES, *supra* note 180.

182. Threatened Species Status for the Rufa Red Knot, 79 Fed. Reg. 73706, 73706–07 (Dec. 11, 2014) (codified at 50 C.F.R. § 17.11(h)).

183. HORSESHOE CRAB RECOVERY COAL., USE OF RECOMBINANT FACTOR C (RFC) IN BACTERIAL ENDOTOXIN TESTING: TRANSITION FROM LIMULUS AMEBOCYTE LYSATE (LAL) 1 (2021), https://hscrabrecovery.org/wp-content/uploads/2021/07/rFC-fact-sheet-7_21.pdf.

184. *Case for Genetic Engineering*, *supra* note 32, at 876.

unfilled a niche that other species have difficulty filling. This is particularly true for a keystone species.[185] As Taylor Waters notes, the reintroduction of the passenger pigeon, a known carrier of tree nuts, would "stabilize the gaping ecological hole" their extinction left in North American "disturbance regimes of tree reproduction."[186] This concept of introducing a "revived species into the habitat of which it previously was a constituent might be considered a form of re-wilding or restoration ecology," which are viable management regimes.[187] In some cases, then, introducing a de-extinct species may fit into another species' recovery plan if not the de-extinct species' own.

On the other hand, genetically engineered organisms may pose problems similar to those acknowledged by scholars of invasive species management. As John Charles Kunich notes, "[p]lants, animals, and microorganisms are genetically engineered to give them certain advantages, and among those advantages are resistance to herbicides, insecticides, natural pests, unfavorable weather conditions, and other impediments to naturally occurring organisms" including "faster growth rates, increased productivity and reproductive potential, larger size, and other advantages."[188] These artificially created traits may give genetically engineered species "enormous advantages over native life forms" such that the indigenous species will find themselves outcompeted.[189] This risk could come to fruition in three ways: escape of the modified species and direct competition with natural species, deliberate cross-breeding between the modified species and genetically similar natural species, or cross-breeding between modified and natural species incidental to escape.[190] The descendants of this intermingling may likewise demonstrate advantages known to the modified species and even develop advantages of their own.[191]

De-extinction and genetic engineering implicate practical issues, as well. Reintroducing a de-extinct species poses significant administrative issues, from organizing the research and production of individuals of the species to managing its introduction to its now nonnative environment.[192]

185. *See* Garibaldi & Turner, *supra* note 173.

186. Taylor Waters, *Passenger Pigeons: The De-Extinction and Reintroduction of a Bird*, 15 J. ANIMAL & NAT. RES. L. 19, 36 (2019).

187. Alejandro E. Camacho, *Going the Way of the Dodo: De-Extinction, Dualisms, and Reforming Conservation*, 92 WASH. U. L. REV. 849, 857 (2015).

188. John Charles Kunich, *Mother Frankenstein, Doctor Nature, and the Environmental Law of Genetic Engineering*, 74 S. CAL. L. REV. 807, 818 (2001).

189. *Id.*

190. *See id.* at 818–20.

191. *Id.* at 821–22.

192. Camacho, *supra* note 187, at 858–60.

For example, the introduction of a de-extinct species to its former habitat may disrupt the ecosystem that has evolved in its absence, including other listed species.[193] Underlying each of these practical concerns is the overall cost-effectiveness of the undertaking.[194] While the costs of de-extinction are high in part because of the risks associated with it,[195] genetic engineering is not prohibitively expensive and has become more widely available.[196] Nevertheless, conservationists worry that a focus on de-extinction will draw resources away from other listed species[197]—a phenomenon that already occurs.[198] Indeed, critiques of the ESA point to the government's "insufficient and highly disproportionate" costs associated with species' recovery plans,[199] to which adding de-extinction would only balloon. The availability of de-extinction technology may discourage conservation of listed species in the first place, undermining extant conservation practices in favor of an attractive, technological marvel.[200]

Genetically engineered and de-extinct species fall somewhere between the extremes of deserving protection and requiring containment or eradication. Like species listed under the ESA, de-extinct species are, by definition, at risk of extinction: if not for human intervention, a de-extinct species would remain nonexistent.[201] But like an invasive species, a de-extinct species would be introduced to an ecosystem very dissimilar to the one it left.[202] While the passenger pigeon[203]and the dodo[204] have not been missing from the planet for very long, the woolly mammoth has

193. *Id.*

194. *Id.* at 859, 861.

195. *Id.* at 861. Colossal, a biotech and genetics company seeking to "resurrect" the woolly mammoth by combining its DNA with that of the elephant, made the news in September 2021 when it raised $15 million to fund the endeavor. Ian Sample, *Firm Raises $15m to Bring Back Woolly Mammoth from Extinction*, GUARDIAN (Sept. 13, 2021, 10:00 AM), https://www.theguardian.com/science/2021/sep/13/firm-bring-back-woolly-mammoth-from-extinction.

196. For example, creating a short RNA template using CRISPR can cost less than $100. *See* Mark Shwartz, *Target, Delete, Repair*, STAN. MED., Winter 2018, at 20, 24.

197. Camacho, *supra* note 187, at 861.

198. Between 1989 and 1991, only 1.8% of all listed species received 54% of federal conservation funding. Liana N. Joseph et al., *Optimal Allocation of Resources Among Threatened Species: A Project Prioritization Protocol*, 23 CONSERVATION BIOLOGY 328, 328–29 (2009).

199. Leah R. Gerber, *Conservation Triage or Injurious Neglect in Endangered Species Recovery*, 113 PROC. NAT'L ACAD. SCI. 3563, 3563 (2016).

200. Camacho, *supra* note 187, at 861.

201. *Id.* at 863–64.

202. *Id.*

203. The last passenger pigeon died in 1914. Waters, *supra* note 186, at 20.

204. The dodo went extinct by 1700 as a result of human interaction. Camacho, *supra* note 187, at 851.

not shared contiguous habitat with humans or other species native to North America for at least 4,000 years.[205] The reintroduction of these species could pose substantial risks not only to listed species, but also to protected habitats.

B. De-Extinct Species in the Endangered Species Act

The Endangered Species Act does not facially consider de-extinct species, and it would be difficult to argue that drafters in 1973 considered the possibility that genetic technology would advance enough to make de-extinction possible. Nevertheless, de-extinct and genetically engineered species do fit into the ESA in several ways: a textual interpretation of the statute can lead to the inclusion of non-natural species under the Act's definition of species, in its stated purpose, and, arguably, within the implementation of recovery plans.

De-extinct and genetically engineered species may qualify as species worthy of protection according to the ESA's definitions. Section 2 acknowledges that extinct and endangered species have "esthetic, ecological, educational, historical, recreational, and scientific value" worthy of protection.[206] Further, the ESA's definition of "species"—"any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature"[207]—is sufficiently broad to include de-extinct and genetically engineered species that are capable of successful reproduction.[208] Logically, a species that was once endangered, rendered extinct, and restored to existence through de-extinction would still have "esthetic, ecological, educational, historical, recreational, and scientific value."[209] Because only species qualifying as keystone species would be considered for resurrection, those species would necessarily have ecological value as they provide some greater benefit to their ecosystem as a whole.

On the other hand, scholars note that a strict originalist approach to statutory interpretation would bar de-extinct species from protection under the ESA.[210] Although it exists in a variety of flavors, originalism requires an evaluation of a statute's text based on either the drafters'

205. Jenkinson, *supra* note 10.
206. 16 U.S.C. § 1531(a)(3).
207. *Id.* § 1532(16).
208. Jonas J. Monast, *Governing Extinction in the Era of Gene Editing*, 97 N.C. L. REV. 1329, 1356 (2019).
209. § 1531(a)(3).
210. Norman F. Carlin et al., *How to Permit Your Mammoth: Some Legal Implications of "De-Extinction"*, 33 STAN. ENV'T L.J. 3, 21 (2013).

intent[211] or the "original public meaning," identifying what a "reasonable speaker of English would have understood the words of the text to mean at the time of its enactment."[212] Under this approach, it is likely that de-extinct species do not fit within the scope of the ESA's definition of species or its greater purpose to protect such species. Indeed, de-extinction was not on the horizon when Congress passed the ESA in 1973. It was only in 1963 that chemist Linus Pauling and biologist Emile Zuckerkandl coined the term "paleogenetics" to describe what has become the study of the past through preserved genetic material,[213] and only after the first successful DNA extraction from an extinct animal—the quagga, a cousin of the zebra—in 1984 that the field gained widespread attention.[214] When the success of the quagga was announced, the American Society of Biological Chemists noted that "the possibility of actually bringing ancient species back to life is extremely remote."[215] Under the originalist approach, then, it is virtually impossible to say that either the drafters or the public anticipated the ESA's text to leave room for de-extinct species.

While de-extinct species do fit into some current statutory text, they do not comport with all of it. Some commentators have pointed out that the ESA does not protect species that have been determined to be extinct,[216] and that this presents a barrier to the post-delisting protection of species. The discovery of "Lazarus species"—species previously thought or determined to be extinct—still may implicate the protections of the ESA.[217] A species that is rediscovered may be successfully petitioned for listing. However, if that species was previously delisted, the basis for that decision would support a decision not to re-list the species, as the Lazarus species may not be sufficient in number to propagate. On the other hand, the decision to delist the species may itself be erroneous, withdrawing protection from a listed species prematurely and exposing it to greater risk.[218]

211. Joseph S. Diedrich, *A Jurist's Language of Interpretation*, WIS. LAW., Aug. 2020, at 36, 38.

212. *Id.* at 39 (quoting Randy E. Barnett, *The Gravitational Force of Originalism*, 82 FORDHAM L. REV. 411, 415 (2013)).

213. Marianne Sommer, *History in the Gene: Negotiations Between Molecular and Organismal Anthropology*, 41 J. HIST. BIOLOGY 473, 491 n.43 (2008).

214. Harold M. Schmeck, Jr., *Scientists Clone Bits of Genes Taken from Extinct Animal*, N.Y. TIMES, June 5, 1984, at A1.

215. *Id.*

216. Erin Okuno, *Frankenstein's Mammoth: Anticipating the Global Legal Framework for De-Extinction*, 43 ECOLOGY L.Q. 581, 587 (2016).

217. *Id.* at 588.

218. *Id.* at 587.

Further, section 4(e) allows the Secretary discretion in treating a non-listed species as endangered or threatened if it "closely resembles in appearance, at the point in question," a listed species such that "substantial difficulty" would result from attempting to differentiate the two species, this difficulty would contribute to the threat facing the listed species, and treatment of the unlisted species would "substantially facilitate the enforcement and further policy of" the ESA.[219] Because de-extinct species—such as the proposed wooly mammoth[220] or the passenger pigeon[221]—are likely to be genetic derivatives of extant species, scholars have indicated that without strict measures to segregate these populations, it is possible that intermingling could lead to natural hybridization, creating entirely new species bereft of protection.[222] These hybridizations may be considered "acceptable non- threat[s]" and even contribute to the restoration of ecological communities.[223]

The USFWS does provide for the designation of listed species that have been or will be released into "suitable natural habitat outside the species' current natural range."[224] These "experimental populations" may be released either within its "probable historical range" or outside that range if the Director determines that the species' primary habitat "has been unsuitably and irreversibly altered or destroyed."[225] The release must be necessary to "further the conservation of the species."[226] The USFWS must consider (1) any adverse effects on extant populations due to removal for introduction elsewhere; (2) the likelihood that the experimental population will become established and self-sustaining; (3) whether establishing the experimental population will support recovery of the species; and (4) the extent to which the experimental population will be affected by federal, state, or private activities "within or adjacent to" the introduction area.[227] The determination does not consider economic factors, considering only the best scientific and commercial evidence.[228]

219. 16 U.S.C. § 1533(e)(A)–(C).
220. Jenkinson, *supra* note 10.
221. Waters, *supra* note 186, at 20.
222. John A. Erwin, *Hybridizing Law: A Policy for Hybridization Under the Endangered Species Act*, 47 ENV'T L. REP. NEWS & ANALYSIS 10615, 10623 (2017).
223. *Id.* at 10622.
224. 50 C.F.R. § 17.81(a) (2022).
225. *Id.*
226. *Id.* § 17.81(b).
227. *Id.* § 17.81(b)(1)–(4).
228. *Id.* § 17.81(c).

The definition of "experimental populations" is neutral to genetically engineered and de-extinct species, but the regulation may function to exclude them. The regulation specifies that an experimental population must be of an "endangered or threatened species," signaling that the species must be listed.[229] Because the ESA's definition of "species"[230] and its stated purpose to protect aesthetically, ecologically, educationally, historically, recreationally, and scientifically valuable species[231] do not textually discriminate against de-extinct or genetically engineered species, the barriers to listing such a species lie instead in the determination of the species' risk of extinction, which is ostensibly high. However, because the species would not naturally face current threats in the wild and any such threats would be conjectural, the determination of whether to list the species may lean against listing. This is especially true if the resurrected species is considered distinct from the original extinct species because it has been engineered using the genes of other species, as will the passenger pigeon.[232] On the other hand, the resurrection of recent species may arguably swing in favor of listing as the risks of extinction are more readily apparent, having caused the species' death in the first place.

Others have argued that the ESA can merely be updated to include an "extinct list" composed of Lazarus species and resurrected species that are still in danger of extinction.[233] Arguing, similarly to others, that the ESA's criteria for delisting is often binary, with extinction becoming more likely than recovery, Taylor Waters recommends adding an additional "extinct" category to listed species in order to make some room for the potentiality—or, in the case of the passenger pigeon, the inevitability[234]—that some recently extinct species will return.

However, the reintroduction of a species on the "extinct list" may still pose problems with invasive species statutes. As Waters notes, "[the passenger pigeon] might be considered invasive and thus illegal to release in many states [because] it will not have a natural home range, lest it is granted its historical range or at least a portion of it."[235] The species' historical range—measured from the period preceding industrialization[236]—may have been long destroyed. If it were instead considered an entirely new species, "then it could not have any historical

229. *Id.* § 17.81(a).
230. *See* 16 U.S.C. § 1532(16).
231. *Id.* § 1531(a)(3).
232. Waters, *supra* note 186, at 20; *see also* Camacho, *supra* note 187, at 852–53.
233. Waters, *supra* note 186, at 22.
234. *Passenger Pigeon Project*, *supra* note 13.
235. Waters, *supra* note 186, at 35.
236. Camacho, *supra* note 187, at 874–75.

. . . range."[237] Because it is therefore non-native, the species will be subject to scrutiny as an invasive species, and because it may compete with or take other species and habitat, it will be barred from introduction under the Lacey Act.[238]

Instead, de-extinct species may more suitably constitute a part of a holistic, ecosystem-based approach to conservation and recovery under the ESA. As some scholars have noted, the ESA implies that a holistic approach to species management is not only allowed but also encouraged.[239] Section 1531(b) specifies that the ESA's purpose is "to provide a means whereby the *ecosystems* upon which [listed species] depend may be conserved."[240] A de-extinct species could be introduced when its cumulative effect would be to benefit an ecosystem, such as by eradicating invasive species or filling a niche left open by another species' destruction.[241] For example, the reintroduction of the passenger pigeon or its facsimile may aid the reseeding of trees in North America while also providing extant predatory species with prey.

The holistic model does not on its own present a perfect, one-size-fits-all approach to ecosystem management, however. As Alejandro E. Camacho of the University of California, Irvine, has noted, our regulatory framework relies on a duality between humanity and nature, and this duality often inhibits regulatory ability to promote ecosystem health.[242] Wildlife management statutes are often "erroneously premised on ecological stasis" that promotes dualistic thinking wherein "exotic" species—such as de-extinct species—are subjected to control or elimination strategies.[243] Native species, on the other hand, are "treated as *per se* beneficial," regardless of whether the native species is compatible with the current or projected status of the ecosystem or its management plans.[244] The focus on minimizing human involvement, despite the ESA's mandate to promote ecosystem health, would likely lead to a de-extinct species' being obstructed from introduction "even if [it] might promote ecological function in a particular area."[245] Holistic ecosystem management plans would need to account for the underlying

237. *Id.*
238. 16 U.S.C. § 3372(a)(1).
239. Gray et al., *supra* note 37, at 253–54.
240. § 1531(b) (emphasis added).
241. *See* Monast, *supra* note 208, at 1355–56.
242. *See* Camacho, *supra* note 187, at 893–97 (arguing that a risk-based adaptive ecosystem management approach to conservation would largely avoid regulatory issues stemming from strict definitions of ecosystems).
243. *Id.* at 892.
244. *Id.*
245. *Id.*

ethical or utilitarian analysis of whether a particular native species, regardless of its being threatened with extinction, should be protected when other non-native species, including de-extinct species, may be more ecologically beneficial.[246]

VI. RECOMMENDATIONS

As explored above, the Endangered Species Act does not fully fit with the conflicting mandates of invasive species management statutes, nor does it alone effectively respond to the challenges posed by climate change and human encroachment due to its complicated framework. The introduction of genetically engineered and de-extinct species may aid fostering ecosystem adaptation and resilience to climate change by, for example, replacing now extinct keystone species. While de-extinct species may be afforded some protections under the ESA, invasive species management statutes may frustrate the reintroduction of de-extinct species, both pure and hybridized. Amending the ESA and other statutes or otherwise legislating to allow for the reintroduction of de-extinct species would shift current management practices to prioritize restoring whole ecosystems instead of conserving particular species within those ecosystems.

The federal government's approach to wildlife management does not adequately account for the necessity of human involvement. While wider legislative reform would best serve the purpose of placing holistic ecosystem management at the center of wildlife management regimes, this is unlikely to occur. Instead, this Note proposes amendments to the ESA and its regulations to promote holistic ecosystem management practices. These practices would consequently deemphasize the need to protect all species at risk of extinction, instead reinforcing the statute's allowance for the explicit prioritization of species whose survival is necessary to support an entire ecosystem. This would likewise allow for the introduction of genetically engineered and de-extinct species whose benefits outweigh their adverse impact. These proposed changes include adding a separate list for experimental non-natural species that would simultaneously offer protection from invasive species management statutes, redefining "habitat" to include potentially habitable areas for a listed species, and explicitly defining the ESA's mandate as one of promoting recovery.

Engineered species and organisms will require special protection under both the ESA and invasive species statutes. Commentators who

246. *See* Goble, *supra* note 55, at 14–15.

have acknowledged the potential benefits of introducing de-extinct species to habitats that no longer resemble their historical ranges have noted the legal impracticalities implicated by introducing a "non-native" or exotic species to a "native" environment. Waters notes that introducing the passenger pigeon to its historical range—despite its being extinct for less than a century—poses the issue that it may be considered invasive.[247] Executive Order 13112 prevents the introduction to any particular habitat of a non-native species whose "introduction does or is likely to cause economic or environmental harm or harm to human health."[248] While an "extinct list" would extend protections to species that have been delisted due to extinction, its application would be too narrow to allow for the introduction of de-extinct species. As previously discussed, realistically, a de-extinct species will be closer to a facsimile of the species created through a mixing of the extinct species' genes with those of a living relative.[249] Because these are not the *same* species that was delisted, they will be functionally excluded from protection.

The legislative addition to the ESA of an "experimental list" would more beneficially allow for the protection of de-extinct species. This experimental list would differentiate between experimental *populations* of listed species and experimental *species*, defined as "species genetically engineered for the purpose of restoring habitat or promoting the recovery of a listed species." An "experimental species list" would therefore be focused on the experimental species' overall benefits, creating a carveout from invasive species definitions. Unlike a species listed as threatened or endangered, an experimental species would be contingent on a listed species' recovery plan, not the species' independent risk of extinction. This risk assessment would consider both the best scientific and commercial data and economic feasibility.

Altering the definition of "habitat" would remove some of the textual barriers posed by listing criteria and invasive species statutes while simultaneously resolving the conflict raised by *Weyerhaeuser*. The need for an updated definition of habitat is evidenced by the Supreme Court's ruling in *Weyerhaeuser* and the executive branch's repeated promulgation of new rules defining the word. The Trump administration's definition of "habitat"— "the abiotic and biotic setting that currently or periodically contains the resources and conditions

247. Waters, *supra* note 186, at 35.
248. Exec. Order No. 13,112, 64 Fed. Reg. 6183, 6183–84 (1999).
249. Camacho, *supra* note 187, at 852–53.

necessary to support one or more life processes of a species"[250]—further restricted the Secretary's ability to designate areas as critical habitat to only those places that are currently or periodically habitable.[251]

Defining habitat to include *potentially* habitable areas would have a significant effect on wildlife management. Habitat could be defined as "the abiotic and biotic setting that contains, once contained, or could be reasonably altered to contain the resources and conditions necessary to support a target species." Additional criteria would be required to avoid claims that the statute is ambiguous or that the Agency's interpretation of the statute in defining habitat to include potentially habitable areas is unreasonable. Such criteria could include whether (1) the potential habitat was formerly capable of supporting the species prior to human development or the species' elimination in the area; (2) the potential habitat is similar to the target species' former habitat; (3) the potential habitat can be reasonably altered to support the species; (4) the potential habitat is necessary, in the Secretary's discretion, for the recovery of the species; (5) the recovery of this species would have a great effect on the stabilization or recovery of another species; and (6) the potential habitat's alteration to suit the species would adversely affect other listed species greater than the failure to alter the potential habitat.

These criteria also limit the discretion of the Secretary to introduce entirely alien species while encouraging active management of an ecosystem. The first factor specifies that the area was "formerly capable of supporting the species prior to . . . the species' elimination in the area," implying that the species was once able to and did inhabit the area. For species that did not inhabit the area at issue, this can be weighed against the following five factors. Defining potential habitat to include areas that are similar to a species' former habitat allows the Secretary the discretion to implement recovery plans that would see the species imported to a "foreign" environment. However, by limiting this importation to "necessity" under the fourth factor, species would not simply be dropped into new environments that share superficial similarities with their natural habitat. Moreover, that necessity can be weighed toward or against the target species' potential beneficial effect on the ecosystem as a whole as measured by its impact on other listed species.

Nor does this definition of habitat including potential habitat conflict with the ESA's definition of critical habitat or the process of critical habitat designation. Indeed, redefining "habitat" in this way may assist

250. Regulations for Listing Endangered and Threatened Species and Designating Critical Habitat, 85 Fed. Reg. 81411, 81421 (Dec. 16, 2020) (codified as 50 C.F.R. § 424.02 (2021)).

251. Kendrick, *supra* note 35, at 112.

in critical habitat designation. Section 3(5)(A)(i)'s definition of critical habitat emphasizes the presence at the time the species is listed of "those physical or biological features" necessary to the species' conservation that may require management of their own accord.[252] The proposed definition of "habitat" complies with this portion of section 3(5)(A), as the three-part definition notes the habitat "contains" those features necessary to support the species. Further, the proposed definition's providing for potential habitat complies with section 3(5)(A)(ii)'s allowing the Secretary to designate as critical habitat specific areas outside the listed species' occupied geographical area so long as those areas are, at the Secretary's determination, "essential for the conservation of the species."[253] The proposed definition provides a scientific basis for such a discretionary decision, as the habitat outside the current geographical range either "once contained, or could be reasonably altered to contain" the features necessary to support the species. Section 3(5)(C) still limits the Secretary's discretion to designate the whole of the potentially inhabitable geographic area, and it would further encourage the prioritization of specific areas that could be rehabilitated to better suit the target species in a contained manner.[254] This could incentivize targeted critical habitats that are geographically contiguous, potentially reducing the need for fragmented critical habitats and ensuring that resources are allocated more efficiently.

With the updated definition of habitat to include potential habitat as well as its effects on critical habitat designation, recovery plans can take more active roles in managing a listed species' ecosystem. The new definition, including both potential habitat and an expanded interpretation of historical range, would contribute to a de-extinct species' listing as experimental. Further, a more expansive definition of habitat in conjunction with the analysis of the experimental species' effect within a larger recovery plan would create a carveout for relevant invasive species statutes. This would afford the experimental species an added protection necessary within the larger scope of the government's ecosystem restoration efforts, and it may even bolster its protections when compared to other species petitioned for listing.

In sum, these recommendations would require systemic changes to the federal government's conservation efforts. Choosing to prioritize certain species, though less charismatic, while allowing for the extinction of other species would be publicly controversial. However, by allowing for active management to respond to the threats of climate change and

252. 16 U.S.C. § 1532(5)(A)(i).
253. *Id.* § 1532(5)(A)(ii).
254. *Id.* § 1532(5)(C).

human encroachments these new laws would seek to preserve biodiversity in the present and promote biodiversity through human intervention in the future.

VII. CONCLUSION

The reality of the threats facing the planet's species has only grown more concrete since the Endangered Species Act's adoption in 1973. While political pushback has become more concentrated in recent years, the public generally supports expansion of the federal government's management of species to protect against climate change-driven ecological change and human development of habitat areas. To respond to these wishes, the federal government's wider wildlife management approaches will need to change to look more holistically at ecosystems as they currently exist and as they will likely change in coming decades. Lacking more overarching legislation dedicated to protecting the environment, the ESA, the keystone federal conservation statute, will have to be updated to allow for greater discretion in defining these ecosystems and the species that comprise them while maintaining some deadlines to avoid substantial backlogs. Likewise, invasive species management statutes will need to be amended to allow for engineered species to fill ecological niches deemed necessary to promote the sustainability and recovery of protected ecosystems.