BRANCHING OUT WITH A GENUS IDEA: THE NEED TO PRESERVE GENETIC BIODIVERSITY THROUGH PHYLOGENETIC METRICS IN CONSERVATION LAW DURING THE ANTHROPOCENE

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INTRODUCTION: KINGDOM

The United States is facing a critical moment in human history and the choices we make will determine the future we will collectively inhabit. Societally, we are still grappling with whether the science of climate change is real and whether humans are the cause of it.[1] In the meantime, species are

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dying off in all ecosystems at alarming levels.[2] The increase in overall extinction has drastically accelerated since the dawn of the Industrial Revolution and increased production of human-produced greenhouse gases.[3] While we are taking steps in the right direction to reduce greenhouse gas production, the reduction is not happening quickly enough to prevent a global warming and its ensuing effects on all species.[4] Currently, the way we conserve species focuses on populations that are already threatened—whose numbers are dangerously close to extinction.[5] We should be taking more proactive steps to assist species that are still abundant, so that they are capable of adapting through the Anthropocene.[6]

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work to make the world a little better. She would also like to thank Dani Walthall for howling at the moon and watching the meteors.

1. ANTHONY LEISEROWITZ ET AL., CLIMATE CHANGE IN THE AMERICAN MIND: APRIL 2019, 4–10 (Yale Univ. & George Mason Univ. 2019). While there has been an increase in U.S. public acknowledgement of climate change in the last decade, the percentage of U.S. voters who believe direct action needs to occur is still staggeringly low. As of 2021, only 66% of registered voters felt that the U.S. should be doing more to address climate change and that the reduction of greenhouse gas emissions was critical to climate change mitigation. *See* ANTHONY LEISEROWITZ ET AL., PUBLIC SUPPORT FOR INTERNATIONAL CLIMATE CHANGE: SEPT. 2021, 4 (Yale Univ. & George Mason Univ. 2021).

2. U.N. Report, *Nature's Dangerous Decline 'Unprecedented'; Species Extinction Rates 'Accelerating'* (May 6, 2019), https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report/#:~:text=The%20Report%20finds%20that%20around,20%25%2C%20mostly%20since%201900 [hereinafter *Nature's Dangerous Decline*]; IPBES, THE GLOBAL ASSESSMENT REP. ON BIODIVERSITY & ECOSYSTEM SERV. 26 (2019) [hereinafter IPBES].

3. *See* Rebecca Lindsey, *Climate Change: Atmospheric Carbon Dioxide*, NOAA (Aug. 14, 2020), https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide (graphically displaying the increase in atmospheric carbon dioxide since 1750); Bjorn Carey, *The Industrial Revolution of the Oceans Will Imperil Wildlife, Says Stanford Scientist*, STANFORD NEWS (Jan. 16, 2015), https://news.stanford.edu/2015/01/16/oceans-extinction-cycle-011615/#:~:text=Many%20scientists%20have%20identified%20the,other%20factors%20killed%20other%20animals (noting that scientists have determined the Industrial Revolution as the tipping point of species extinction rates).

4. *See Nature's Dangerous Decline*, *supra* note 2 (finding that of the five primary factors driving global species loss, climate change due to greenhouse gas emissions is on track to be the largest contributor); Charles Noyes, *5 Takeaways From the 2021 IPCC Report on Climate Change*, ONETREEPLANTED (Aug. 12, 2021), https://onetreeplanted.org/blogs/stories/5-takeaways-from-the-2021-ipcc-report-on-climate-change?utm_source=google-search&utm_medium=pdmr&utm_campaign={campaign}&utm_term=ipcc%20climate%20report%202021&gclid=Cj0KCQiAw9qOBhC-ARIsAG-rdn7fXLvi_XbGHx94UcUveDnLuEeCIjMGZZQa8xdwRhDtUZeOW4c-qcsaAqpUEALw_wcB (summarizing the major points of the 2021 Intergovernmental Panel on Climate Change (IPCC) Report, which found that humans have created climatological changes that are irreversible and certain projections of these changes are locked in, regardless of human action to decrease emissions).

5. *See* Lilian Sayuri Ouchi-Melo et al., *Integrating Phylogenetic and Functional Biodiversity Facets to Guide Conservation: A Case Study Using Anurans in a Global Biodiversity Hotspot*, 27 BIODIVERSITY & CONSERVATION 3247, 3257–60 (2018) [hereinafter Ouchi-Melo et al.] (pointing out the negative implications of focusing conservation solely on individual species and those in biodiverse hotspots).

6. The Anthropocene is defined as "the most recent period in Earth's history when human activity started to have a significant impact on the planet's climate and ecosystems." *Anthropocene*, NAT'L GEOGRAPHIC, https://www.nationalgeographic.org/encyclopedia/anthropocene/ (last visited Mar. 16, 2021).

Preserving species that currently have large genetic variance in their populations will allow them to evolve with the coming anthropogenic changes to habitat.[7] We must actively work to prevent genetic bottlenecking because it is critical to species adaptation and climate change mitigation.[8] Moving this concept further, the use of phylogenetic data[9] on *speciation* can serve to identify which species have the ability to evolve through the Anthropocene and which habitats should be the focus of conservation.[10] Congress should implement legal frameworks and protections to work alongside *best available* scientific data to create a proactive phylogenetic approach to conservation. It is upon us as policymakers, legislators, and legal advocates to make this happen.

This note asserts that the current legal protections afforded to non-human species in the United States are insufficient for preserving species diversity as we progress through the Anthropocene. Conservation law should focus on incorporating phylogenetics as a metric for preventative species population degradation. In Section I, this note addresses fundamental biology and the current scientific data regarding phylogenetics and species biodiversity to set the stage for why species preservation matters to human survival in the Anthropocene. Section II addresses the current structure of the federal Endangered Species Act (ESA) and its successes and failures as it relates to phylogenetics. After discussing the inadequacies of law and policy currently in place under the ESA, this note suggests measures to address and improve regulations that agencies can incorporate into a more approachable and boundaryless solution. In conclusion, this note reiterates those solutions proposed in the suggested, more comprehensive act—The Phylogenetic Preservation Act—while emphasizing why this measure is critical to all species adaptation through the Anthropocene.

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7. *See* Ary A. Hoffmann & Carla M. Srgò, *Climate Change and Evolutionary Adaptation*, 470 NATURE 479, 480–82 (2011) (discussing how genetic variation, climate change pressures, and adaptation relate to trait selection in species ability to evolve with the rate of climate change) [hereinafter Hoffmann].

8. *See Genetic Bottleneck*, NAT'L GEOGRAPHIC, https://www.nationalgeographic.org/media/genetic-bottleneck/ (last updated Mar. 8, 2019) [hereinafter *Genetic Bottleneck*] ("A genetic bottleneck occurs when a population is greatly reduced in size, limiting the genetic diversity of the species."); Martine Maron et al., *Climate-Induced Resource Bottlenecks Exacerbate Species Vulnerability: A Review*, 21 DIVERSITY & DISTRIB. 731, 731, 738 (2015) (noting that climate change and human-induced stressors exasperate resource and genetic bottlenecking) [hereinafter Maron et al.].

9. Phylogenetics refers to "the ancestral relatedness of groups of organisms, whether alive or extinct" and can be determined by the DNA sequencing of species. Omar Sultan Haque, *Phylogenetics,* BRITANNICA, https://www.britannica.com/science/phylogenetics (last visited Mar. 16, 2021).

10. Speciation is defined as "[t]he formation of new and distinct species in the course of evolution." John L. Gittleman, *Speciation,* BRITANNICA, https://www.britannica.com/science/speciation (last visited Mar. 16, 2021); *See* Rebecca J. Safran & Patrick Nosil, *Speciation: The Origin of New Species*, 3 NATURE EDUCATION KNOWLEDGE 10, 17 (2012) (breaking down the different ways in which speciation occurs).

I. BACKGROUND: PHYLUM

Biodiversity, as an overarching concept, refers to all the species within an ecosystem, their genetic variation, and how species interact with one another within their ecological web.[11] Biologists further break biodiversity down into genetic diversity, species diversity, and ecosystem diversity.[12] Genetic biodiversity refers to the variance of genetic material within an individual in a species.[13] Species biodiversity points to the number of individuals in the population capable of contributing variance to the genetic material within a species.[14] Finally, ecosystem biodiversity pans the lens out further by looking to: how diverse an actual ecosystem is; the quantity of individuals that exist within each species; and the number of species that coexist within the ecosystem.[15] Biodiversity is a critical means of determining the health of populations and ecosystems.[16] This notion is not new to the worlds of science and law.[17] Scientists, working alongside legislators, have begun to implement biodiversity metrics into law.[18] Phylogenetics, on the other hand, has not been utilized to its fullest extent to push conservation law to its next stage.[19]

To take conservation law's next step for the success of all species, agency decisionmakers and attorneys should understand that phylogenetics is many things. First, it is the evolutionary tree of species and how the genes contained within the individuals of those species allow for the genetic iteration of what

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11. *Biodiversity*, ECOLOGICAL SOC'Y OF AM. (Fall 1997), https://www.esa.org/wp-content/uploads/2012/12/biodiversity.pdf.

12. *Id.*

13. *Id.*

14. *Id.*

15. *Id.*

16. *See Biodiversity Critical to Maintaining Healthy Ecosystems*, U.S. GEOLOGICAL SURV. (Jan. 15, 2016), https://www.usgs.gov/center-news/biodiversity-critical-maintaining-healthy-ecosystems#:~:text=Researchers%20have%20found%20clear%20evidence,than%20those%20depleted%20of%20species (explaining an ecological study completed on five continents showing that "you cannot have sustainable, productive ecosystems without maintaining biodiversity in the landscape").

17. *What is Biodiversity?*, SLOW FOOD, https://www.essedra.com/biodiversity/biodiversity/#:~:text=The%20term%20%E2%80%9Cbiological%20diversity%E2%80%9D%20was,Kind%20of%20Country%20advocating%20conservation (last visited Apr. 11, 2022).

18. *See generally* Cyrille de Klemm & Clare Shine*, Biological Diversity Conservation and the Law: Legal Mechanisms for Conserving Species and Ecosystems*, 29 IUCN ENV'T L. CENTRE (1993) (documenting the development of U.S. and international law in species conservation).

19. *See id.*(showing that the basis for legal conservation theory is based in genetic biodiversity)*;* Sophia Franke et al., *Predicting Regional Hotspots of Phylogenetic Diversity Across Multiple Species Groups,* 26 DIVERSITY & DISTRIB. 1305, 1306 (2020) ("The protection of phylogenetic diversity has become a priority in conservation biology") [hereinafter Franke et al.]; Phylogenetics refers to the evolutionary history of how a species has evolved over time given the interplay of genetic material contained within its taxonomic tree. *See* Dr. Sanchari Sinha Dutta, *What is Phylogenetic Analysis?*, NEWS-MED. LIFE SCI. https://www.news-medical.net/health/What-is-Phylogenetic-Analysis.aspx (last updated Mar. 9, 2021).

a species is.[20] Second, phylogenetics is how the genetic code of closely related species interacts over generations, and the interplay between the evolutionary relationship of species.[21] Phylogenetics helps us answer evolutionary history and relationship questions—e.g., how much genetic overlap exists between the green and brown anole and where did their evolutionary history diverge to create two distinct species?[22] Phylogenetics helps us determine: (1) whether there is a possibility that these anoles will evolve with the constraints that the Anthropocene presents, and; (2) whether they will be able to reproduce with one another to assist the genus in surviving habitat and resource constraints.[23] Additionally, we must ask whether each species performs a distinct or supplementary role within its respective ecosystem.[24]

Biodiversity and phylogenetics overlap in the study of ecosystem health. At the surface level, both can point to deficiencies or strengths that exist within ecosystems and populations.[25] The critical difference between the two theories lies in how humans understand the world around them when attempting to conserve habitat, prevent species die-off, and create future species diversity.[26] Phylogenetics provides the ability to look at the micro-world within the macro-problem.[27] The push to use phylogenetics in

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20. *See* Douglas E. Soltis & Pamela S. Soltis, *The Role of Phylogenetics in Comparative Genetics,* 132 PLANT PHYSIOLOGY 1790, 1790–91 (2003) (noting that tracing phylogenetic relationships over time assists in the greater understanding of other scientific fields) [hereinafter Soltis]; Ouchi-Melo et al., *supra* note 5, at 3247–66 (using the Cerrado region of Brazil to show phylogenetic use as a successful means of ecosystem conservation).

21. *See* Soltis, *supra* note 20, at 1790–1800 (analyzing the concept of phylogenetics in relation to various plant species as they coexist with other species in their ecosystems and how biologists can implement methodology to develop understanding of the evolutionary trees); Ouchi-Melo et al., *supra* note 5, at 3258 (discussing how the interplay between species richness in a geographical zone and phylogenetic diversity within a singular species can affect future evolutionary lineages).

22. The green anole is a species of lizard native to Florida. In the 1950's, the native Cuban brown anole was introduced to Florida and has since become an invasive species, largely outcompeting the green anole. Yoel Stuart, *Invasive Species Trigger Rapid Evolution for Lizards in Florida*, THE CONVERSATION (Nov. 4, 2014), https://theconversation.com/invasive-species-trigger-rapid-evolution-for-lizards-in-florida-33491. Scientists have analyzed the available genetic material found in both species to assess whether there is enough genetic overlap to produce a hybridized anole. *See generally* Dan G. Bock et al., *Changes in Selection Pressure Can Facilitate Hybridization During Biological Invasion in a Cuban Lizard*, 118 PNAS 1, 1–10 (2021), https://www.pnas.org/doi/pdf/10.1073/pnas.2108638118.

23. *See* Hoffmann, *supra* note 7, at 483–84 (noting that phylogenetic analyses can be a critical tool in species preservation as climate change progresses and habitat range and availability shift); Ouchi-Melo et al., *supra* note 5, at 3262 (discussing how conservation based solely on taxonomic classifications ignores the nuances of species preservation and that the inclusion of phylogenetics could lead to a more successful conservation method in future environmental changes).

24. Franke et al., *supra* note 19, at 1311.

25. Ouchi-Melo et al., *supra* note 5, at 3247–49.

26. *Id.*

27. Key to this analysis is looking at: which species contain a large variance in genetic material; how they coexist with other species (both genetically and in the roles they play); which species have the ability to bend their evolutionary trees back towards other closely-related species; and given the inevitable

conservation law is more than just looking towards preserving species that currently exist. Phylogenetics is a proactive means of ensuring that species have the genetic tool kit to evolve and speciate through increased constraints.[28]

When constraints or events (like habitat removal or decreased resource availability) occur—which significantly decrease the numbers of individuals within a population—genetic bottlenecking can take place.[29] Genetic bottlenecking occurs when a species loses a large portion of the individuals from their population.[30] The result is less variety in the genetic material available for the remaining species to exchange.[31] When individuals who contain beneficial DNA or evolutionarily advantageous gene variations die, those genes die too.[32] The end result is that the remaining individuals have less genetic material at their disposal to assist in adapting and evolving to newly presented challenges.[33] As climate change accelerates, these constraints and events become not only more frequent but also more severe.[34] The nearly nationwide wildfires and the quantity and size of hurricanes that have occurred in 2020 are prime examples of these effects.[35]

Now to the anthropocentric question, and thus the question that drives policy: why should we care? All species (humans included) are interdependent with one another.[36] It is not simply that we want variety in our flowers or enjoy watching videos of animals doing silly things; our ability

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Anthropogenic constraints they will face, which species are most genetically viable for this mode of preservation. *See* Marc W. Cadotte et al., *Phylogenetic Diversity Promotes Ecosystem Stability*, 93 ECOLOGY S223, S223–24, S230–31 (2012) (recognizing the interplay between phylogenetics and biodiversity in promoting a stable ecosystem) [hereinafter Cadotte et al.].

28. *See* Maron et al., *supra* note 8, at 732–33 (noting that the foreseeable increase of climate-based disruptions to habitats and resources will effect species success); Cadotte et al., *supra* note 27, at S230–31 (discussing that as the phylogenetic diversity in populations increases, so does the health of the ecosystem of which they are a part).

29. *See* Maron et al., *supra* note 8, at 732–35 (discussing the results of their study on climate-based disruptions to habitats and the resulting resource bottlenecking effects to species).

30. *Genetic Bottleneck, supra* note 8.

31. *Id.*

32. A well-known basic principle within the field of biology is that if there are no genes present in a species when they reproduce, those genes will not be passed along to offspring.

33. *See* Maron et al., *supra* note 8, at 737–38 (noting that as climate change accelerates resource bottlenecking, there is less genetic and phenotypic diversity for species to work with in adaptation).

34. Jeff Berardelli, *How Climate Change is Making Hurricanes More Dangerous*, YALE CLIMATE CONNECTIONS (July 8, 2019), https://yaleclimateconnections.org/2019/07/how-climate-change-is-making-hurricanes-more-dangerous/?gclid=EAIaIQobChMI0qr31eLI7AIVgTUrCh0vkA9-EAAYASAAEgLH5_D_BwE; IPCC, AR5 CLIMATE CHANGE SYNTHESIS REP. at 53, 73, 78 (2015) [hereinafter IPCC]; IPBES, *supra* note 2, at 51.

35. *See* Sarah Kaplan & Andrew Ba Tran, *More Than 40 Percent of Americans Live in Counties Hit by Climate Disasters in 2021*, WASH. POST (Jan. 5, 2022), https://www.washingtonpost.com/climate-environment/2022/01/05/climate-disasters-2021-fires/ (noting how extensive the climate changed related disasters were in 2021 alone).

36. Maria Neira, *Our Lives Depend on a Healthy Planet*, WORLD HEALTH ORG. (June 3, 2015), https://www.who.int/mediacentre/commentaries/healthy-planet/en/ [hereinafter Neira].

to breathe, eat, and have access to clean water is dependent on the species with which we share the planet.[37] From the microbes in the water, to the algae that cleans it, to the fish that feed on the algae, and the fish that feed on those fish, ecosystems can serve us when in balance or pollute us when out of control.[38] Both aquatically and terrestrially similar trophic relationships exist.[39] Each species has a role to play in the larger system, including among each other.[40] Species may be able to come and take the place of others in that trophic relationship but only up to a limit.[41] As climate change accelerates, these constraints and events become not only more frequent but also more severe.[42] Over time, that means humans lose the species they depend upon for our basic survival needs.[43]

Even with various technologies at our disposal, we cannot rely on these systems to design our solutions as the problems become apparent, although many have made that assertion.[44] On a small scale (relative to altering the DNA of all species on the planet), we have already engaged in this practice.[45]

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37. *Id.*

38. While ocean currents distribute nutrients through upwelling, whales move nutrients up and down coast lines through their migration. In simplistic terms, whales create food for all of the fish we so thoroughly enjoy. *See* Christopher E. Doughty et al., *Global Nutrient Transport in a World of Giants*, 113 PROC. NAT'L ACAD. SCI. U.S.A. 868, 869, 871 (2016) (reporting on the effects whales have on ocean nutrient distribution).

39. For example, the types of grasses contained in a prairie determine how much nitrogen that patch of earth takes in. Different varieties of plants in ecosystems determine our quality of air. *See* David W. Kicklighter, et al., *Future Nitrogen Availability And its Effect on Carbon Sequestration in Northern Eurasia*, 10 NATURE COMMC'N 3024 (2019) (discussing how human impacts on Eurasian ecosystems have shifted available nitrogen levels and therefore the amount of carbon sequestration amongst plants).

40. *See Ecological Interactions*, KHAN ACAD., https://www.khanacademy.org/science/high-school-biology/hs-ecology/hs-ecological-relationships/a/ecological-interactions (last visited Mar. 16, 2021) (explaining ecological concepts of how species interact with one another).

41. *Id.*

42. *See* IPBES, *supra* note 2, at 27–29 (discussing the human impacts on other species, and noting that some species' evolutionary cycle has increased because of constraints, but others have been greatly hindered).

43. *See* Neira, *supra* note 36; SARAH MATSUMOTO ET AL., CITIZENS' GUIDE TO THE ENDANGERED SPECIES ACT 8 (2003), https://earthjustice.org/sites/default/files/library/reports/Citizens_Guide_ESA.pdf (noting that we have nearly lost species that have critical medicinal properties such as cancer treatments) [hereinafter MATSUMOTO ET AL.].

44. *See e.g.,* Heidi Ledford, *CRISPR, the Disrupter*, 522 NATURE 22, 24 (2015) (reporting on the use of CRISPR gene editing technology for agriculture and ecosystems by disseminating the altered genetic codes of species into their larger populations over time); *see also e.g.,* Becky Mackelprang, *Can the Gene Editing Technology Known as Crispr Help Reduce Biodiversity Loss Worldwide?*, ENSIA (Sept. 13, 2019), https://ensia.com/features/crispr-biodiversity-coral-food-agriculture-invasive-species/#:~:text=In%20the%20short%20term%2C%20agriculture, United%20States%20in%20early%202019.&text=No%20single%20solution%20can%20save,solutions%20can%20cause%20more%20problems (breaking down the ways in which humans have been changing the genetics of other species in various ecosystems over time, and how CRISPR is the latest version of this solution to biodiversity loss due to climate change) [hereinafter Mackelprang].

45. Humans have been breeding other species based on the selectivity of genes since the advent of agriculture. The practice of genetically modifying organisms presents potential issues of limiting the

We have genetically modified organisms so that species with these adjusted genetic compositions meet our own needs.[46] Genetically engineered organisms (GEOs) are one specific type of this genetic modification.[47] But there are many unknowns to this practice.[48] Corn and soybeans are insidious examples of this genetic tailoring. We have spliced these GEO crops with bacterial genes to make them more resilient.[49] We do not yet know the long-term effects on cows, pigs, humans, etc. who consume bacterial genes regularly. We are also unaware of how these GEO species will reproduce or interact with their non-altered counterparts, if at all.[50] This lack of understanding about the consequences of a new scientific application implicates that we should use the precautionary principle.[51] This principle implies that we should hesitate, further review, and potentially resist introducing new processes or technologies with unknown consequences into the environment.[52] The more we alter the natural world around us, the more unforeseen consequences flow from these adjustments. We then start the process anew.[53]

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overall gene pool. We have based these breeding practices on the problems or pests we have seen in the past, but removal of these genes may hinder species success in dealing with future problems we have yet to encounter. *See* Mackelprang, *supra* note 44 (discussing the history of food diversity and human selected gene preservation in agriculture).

46. *Science and History of GMOs and Other Food Modification Processes*, FDA, https://www.fda.gov/food/agricultural-biotechnology/science-and-history-gmos-and-other-food-modification-processes (last visited Mar. 16, 2021).

47. *See* A. A. Snow et al., *Genetically Engineered Organisms and the Environment: Current Status and Recommendations*, 15 ECOLOGICAL APPLICATIONS 377, 378–79 (2015) (advising on the ways to monitor the effects of GEOs on the environment, other species, and agriculture as this technology moves forward).

48. *See* Theresa Philips, *Genetically Modified Organisms (GMOs): Transgenic Crops and Recombinant DNA Technology*, 1 NATURE EDUCATION 213 (2008) (pointing to the known and unknown effects of GMOs on crops, pollinators, economics, and human philosophical concerns) [hereinafter Philips]; Gabriel Rangel, *From Corgis to Corn: A Brief Look at the Long History of GMO Technology*, HARVARD U. (Aug. 2015), http://sitn.hms.harvard.edu/flash/2015/from-corgis-to-corn-a-brief-look-at-the-long-history-of-gmo-technology/ (illustrating the history of GMOs and GEOs along with where the technology is progressing as a food source).

49. Philips, *supra* note 48, at 213 (showing that soybeans are spliced with bacteria that makes them tolerant to the herbicide Roundup and corn in circulation is spliced with bacterial genes making them resistant to pests).

50. *See* Heather Landry, *Challenging Evolution: How GMO's Can Influence Genetic Diversity*, HARV. UNIV. (Aug. 10, 2015), https://sitn.hms.harvard.edu/flash/2015/challenging-evolution-how-gmos-can-influence-genetic-diversity/ (discussing whether genetically modified organisms can lead to decreased genetic diversity and looking at the genetic implications of GMO and non-GMO breeding).

51. *See* David Kriebel et al., *The Precautionary Principle in Environmental Science*, 109 ENV'T HEALTH PERSP. 871, 871–75 (2001) (providing an overview of the precautionary principle, why it is important in the realm of science, and the implications of the uncertainty when utilizing new technology in the public realm).

52. *See id.* at 871–72 (illustrating how science and policy making should work within these bounds when attempting to solve environmental issues such as climate change).

53. *See id.* at 872–73 (providing case studies of when the precautionary principle is not used).

II. STATUTORY & REGULATORY ORDER

The ESA comes close to forcing agencies to work with nature rather than against it—but not close enough. Congress should integrate species-specific phylogenetic data into our current legal conservation framework and shift the lens towards making sure environmental management utilizes this metric. To create this more proactive measure, Congress could use the lessons we have learned under the ESA (evaluating the successes and failures of the Act's structure and implementation) to enact a Phylogenetic Preservation Act. Working alongside the scientific community, agencies can identify and list species that meet certain phylogenetic criteria. This will enable us to work towards protecting species and their habitats, like the way we do with endangered and threatened species.

A. The Endangered Species Act

The ESA is one of the most expansive means of protecting non-human species in the United States.[54] Its stated purpose is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved . . . . "[55] However, the ESA may not be able to live up to its intended goal. Species are losing individuals at acceleration rates faster than the ESA can provide adequate protections (due to both financial and procedural constraints).[56] While there have been many great successes on the endangered species front, threatened species vastly have remained listed.[57] The ESA has done some great work in preventing the

54. MATSUMOTO ET AL., *supra* note 43, at 4–5.

55. 16 U.S.C. § 1531(b) (2018); *See* H.R. Rep. No. 93–412, at 5 (1973) ("From the most narrow point of view, it is in the best interests of mankind to minimize the losses of genetic variations. The reason is simple: they are potential resources.").

56. *See e.g.*, Jacob Wallace, *NOAA to Protect 6K Square Miles of Coral Reef Habitat*, GREENWIRE (Nov. 30, 2020), https://stevens2.vermontlaw.edu:2073/greenwire/2020/11/30/stories/1063719477 (noting that it took a lawsuit filed in 2019 by the Center for Biological Diversity for five threatened coral species that were listed in 2014 to receive protections) [hereinafter Wallace]; *see also e.g.*, Liz Kimbrough, *No Endangered Listing For Monarch Butterflies as Western Count Hits Alarming Low,* MONGABAY (Dec. 16, 2020), https://news.mongabay.com/2020/12/no-endangered-listing-for-monarch-butterflies-as-western-count-hits-alarming-low/ (discussing that while the Western Monarch Butterfly is experiencing an alarmingly sharp decline in their population numbers, they will not be listed under the ESA as the resources to do so are lacking) [hereinafter Kimbrough]; Noah Greenwald et al., *Extinction and the U.S. Endangered Species Act,* 1 PEERJ 1, 5 (2019) (noting that as of 2019, there are over 500 species waiting to be listed by FWS and that the FWS currently takes approximately 12 years list a species) [hereinafter Greenwald].

57. There are still many species whose populations the scientific community considers threatened, but the Services has not listed as "threatened." *See The IUCN Redlist of Threatened Species*, IUCN, https://www.iucnredlist.org/ (last visited Mar. 16, 2021) (providing a regularly updated list and status update of species whose populations are considered threatened with extinction by the scientific community) [hereinafter *IUCN Redlist*]; Compare *As Scientists Warn of Biodiversity Crisis, Trump*

extinction of species that became listed, but this method of conservation is only kicking the proverbial bucket down the road. With climate change constraints increasing in frequency and magnitude, simply preventing the extinction of a species is not a long-term solution.[58] Even at its best, the hurdles that stand in the way of the ESA's success in achieving its intended purpose merely slow down a species' migration from a threatened to an endangered listing.[59]

The Fish & Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) [60] (collectively Services) are the primary agencies responsible for putting the intent of the ESA into action through listing and managing these species and their *critical habitats*.[61] The ESA defines *species* as "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."[62] The ESA enables agencies to list species as either *endangered* or *threatened* when their population numbers are nearing extinction.[63] A species is considered *endangered* if it is "in danger of extinction throughout all or a significant portion of [their] range . . . ."[64] Although, insects that are deemed pests cannot be given endangered listing protections.[65] A species can qualify as *threatened* if it is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of [their] range."[66] Each of these listed species can also be divided into Distinct Population Segments (DPS's).[67] A DPS designation

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Administration Guts Endangered Species Act, THE NATURAL RESOURCES DEFENSE COUNCIL (Aug. 12, 2019), https://www.nrdc.org/experts/nrdc/scientists-warn-biodiversity-crisis-trump-administration-guts-endangered-species-act (noting a success rate of saving 99% of listed species from extinction), *with* Louis Jacobson, *Only 1 Percent of Endangered Species List Have Been Taken Off List, Says Cynthia Lummis,* POLITIFACT (Sept. 3, 2013), https://www.politifact.com/factchecks/2013/sep/03/cynthia-lummis/endangered-species-act-percent-taken-off-list/#:~:text=September%203%2C%202013-,Only%201%20percent%20of%20endangered%20species%20list%20have%20been%20taken,falcon%20and%20the%20American%20alligator [hereinafter Jacobson].

58. *See* Greenwald et al., *supra* note 56, at 5–6 (finding that of the 97 listed species who have gone extinct, the population numbers were much too low for 55 of them for the ESA to have likely prevented extinction).

59. *Id.* (noting that the current number of species awaiting listing in combination with the extended time frame that FWS takes to provide protections to these species will likely result in more future extinctions).

60. *See, e.g.*, Deborah F. Buckman, *Construction and Application of Threatened Species Requirements Under Sec. (4a) and (b) of the Endangered Species Act of 1973, 16 U.S.C.A. § 1533(a) and (b),* 6 A.L.R. Fed. 3d Art. 2 (2015) (breaking down the issues presented with listing a species as threatened and discussing pivotal cases from the circuit courts).

61. Also known as National Oceanic & Atmospheric Administration (NOAA) Fisheries. *See id.*

62. 16 U.S.C. § 1532(16) (2018).

63. 50 C.F.R. § 402.01 (2002).

64. 16 U.S.C. § 1532(6) (2018).

65. 16 U.S.C. § 1532(6) (2018).

66. 16 U.S.C. § 1532(20) (2018).

67. *Little Known But Important Feature of the Endangered Species Act,* U.S. FISH & WILDLIFE SERV., https://www.fws.gov/pacific/news/grizzly/esafacts.htm (last visited Mar. 16, 2021).

separates segments of vertebrate species populations so that only part of a species can be listed, delisted, and managed at a more localized level, where threats to existence may differ.[68] A DPS designation allows the Services to manage listed vertebrate species geographically rather than taxonomically.[69] For example, the Grizzly Bear is listed as a threatened species and has six DPS's in the United States, which are each managed in relation to their needs.[70]

Once a species becomes listed, it is entitled to a panoply of federal protections under the ESA to prevent the species from becoming extinct.[71] The ESA provides each listed species with substantial legal protections that more abundant species are not afforded.[72] Key to these protections are: (1) the *critical habitat* designation; (2) the consultation requirement for every proposed federal action where the species is present; (3) the *take* prohibitions limiting harm to listed species; (4) the *recovery plan* used to revive the existing number in the species; and (5) the *monitoring* of the species once they have "recovered."[73] This note considers each in turn.

1. Listing

Congress has set out criteria for when and how the Services can place a species on either the endangered or threatened lists.[74] The Services each follow a five-factor analysis to determine whether a species should be listed.[75] These five factors are: "[1] the present or threatened destruction, modification, or curtailment of its habitat or range; [2] overutilization for commercial, recreational, scientific, or educational purposes; [3] disease or predation; [4] the inadequacy of existing regulatory mechanisms; or [5] other natural or manmade factors affecting its continued existence."[76] If any of

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68. *Id.*

69. *Id.*

70. *See Endangered Species|Mammals|Grizzly Bear*, U.S. FISH & WILDLIFE SERV., https://www.fws.gov/mountain-prairie/es/grizzlybear.php (discussing the state of Grizzly Bears and their management recovery plans in each of the six distinct population segments) (last visited Jan. 6, 2021).

71. U.S. FISH & WILDLIFE SERV., DELISTING A SPECIES 1–2 (Apr. 2011), https://www.fws.gov/endangered/esa-library/pdf/delisting.pdf [hereinafter FWS DELISTING]; *Listing Species Under the Endangered Species Act,* NOAA FISHERIES (June 2, 2020), https://www.fisheries.noaa.gov/national/endangered-species-conservation/listing-species-under-endangered-species-act [hereinafter NOAA *Listing*].

72. 16 U.S.C. § 1533 (2018); FWS DELISTING, *supra* note 71, at 1–2; NOAA *Listing, supra* note 71.

73. 16 U.S.C. § 1533 (2018); *See* MATSUMOTO ET AL., *supra* note 43, at 15–22, 32–33, 35–37 (relaying the fundamentals of pivotal provisions in the ESA).

74. 16 U.S.C. § 1533(a)(1) (2018); FWS DELISTING, *supra* note 71, at 1–2; NOAA *Listing, supra* note 71.

75. 16 U.S.C. § 1533(a)(1) (2018); FWS DELISTING, *supra* note 71, at 1–2; NOAA *Listing, supra* note 71.

76. 16 U.S.C. § 1533(a)(1)(A)–(E) (2018).

these factors present a danger to the existence of a species, the species must be listed.[77]

Looking at the five-factor analysis, numerous advocates have argued that many more species deserve listing due to the climate change impacts that have already occurred.[78] Two of these listing factors are becoming even more salient: "the present or threatened destruction, modification, or curtailment of its habitat or range," and "other natural or manmade factors affecting its continued existence."[79] With species that could potentially receive threatened listing protections, these two factors hinge on how the Services interpret the *foreseeable future*.[80] In 2019, Congress finally defined this term and reinforced the species-by-species assessments made by the Services.[81] While still theoretically dependent on the *best available science*, *foreseeable future* now means "*only* so far into the future that the Services can reasonably determine that both the future threats and the species' responses to those threats are likely."[82] However, this definition still leaves open much room for interpretation in light of climate change and species' ability to adapt with enough genetic variation in their populations. If the Services are simply looking at whether the species will foreseeably exist in the future, this does not account for whether they have enough genetic variance to adapt to climate and habitat changes that may accelerate faster than they can evolve. This definition of *foreseeability* should be reevaluated under the Phylogenetic Preservation Act.

2. Critical Habitats

Critical habitats are the geographical areas that threatened or endangered species occupy at the time of their listing that are deemed "essential to the conservation of the species" and "may require special management considerations or protection" to conserve the species.[83] Using the *best available* scientific data, critical habitats are supposed to provide the species with food, shelter, breeding grounds, and space for natural behavior.[84] The

77. *Id.*; FWS DELISTING, *supra* note 71, at 1–2; *See* NOAA *Listing, supra* note 71. (noting the five-factor analysis that the Services use when determining whether to delist a species under the ESA).

78. *See* CONG. RSCH. SERV., THE ENDANGERED SPECIES ACT AND CLIMATE CHANGE: SELECTED LEGAL ISSUES 4–7 (2019) (discussing the legal arguments used by advocates for ESA listing expansion due to climate change and the courts' interpretation of 'foreseeable future' scope in light of the five-factor listing criteria) [hereinafter CONG. RSCH. SERV.].

79. 16 U.S.C. § 1533(a)(1)(A), (E) (2018).

80. *See* 16 U.S.C. § 1533(b)(1)(B)(ii) (2018) ("[T]he Secretary shall give consideration to species which have been . . . identified as in danger of extinction or likely to become so within the foreseeable future . . . .").

81. CONG. RSCH. SERV., *supra* note 78, at 6–7.

82. 50 C.F.R. § 424 (2019) (emphasis added).

83. 16 U.S.C. § 1532(5)(A)–(B) (2018).

84. 16 U.S.C. § 1533(B)(2) (2018); MATSUMOTO ET AL., *supra* note 43, at 19–21.

ESA requires the Services to weigh these needs against the economic impact required to designate critical habitats.[85] The Services have discretion in their designation of critical habitats, so long as that choice does not lead to the extinction of the species.[86] However, these habitats do not necessarily extend to all the areas a listed species could occupy.[87] This presents a hiccup in the ESA as it comes into conflict with accelerated climate change.

The ESA requires that the Services designate critical habitats at the time they list, if feasible, but no longer than one year after the listing.[88] However, climate change is causing many species to migrate northward.[89] As a result, species that have been listed for decades may lose their habitat protections as they adapt to a changing planet. Even more so since critical habitats cannot extend into private property unless there are federal activities or finances associated with the land.[90]

Once a species' critical habitat is established, an agency must consult with the appropriate Service for any federal action that may affect the existence of the species.[91] This includes "any action authorized, funded or carried out by such agency . . . [that would] jeopardize [the species' existence or] adversely modif[y] [their habitat]."[92] As part of the consultation requirement, the Services must produce a biological opinion.[93] The biological opinion is used to assess whether the agency action may destroy or adversely modify the critical habitat or otherwise jeopardize the continued existence of the species.[94] Ordinarily, the Services only produce a biological opinion if the agency action determines that its action is likely to adversely affect a listed species.[95] To determine which listed species would be affected by the proposed action, the Services are required to use "the best scientific and commercial data available" in conducting the biological opinion.[96] If the

85. MATSUMOTO ET AL., *supra* note 43, at 20.
86. MATSUMOTO ET AL., *supra* note 43, at 21.
87. 16 U.S.C. § 1532(5)(C) (2018).
88. 16 U.S.C. § 1533(a)(3)(A), (b)(6)(C) (2018); Although legally required to designate critical habitats for listed species within one year, this doesn't always occur. In fact, there has been a backlog due to climate change that has required legal suit in order to enforce these ESA requirements. Five coral species listed in 2014 have just now starting to receive the protections thanks to the work of the Center for Biological Diversity. However, NMFS must still adhere to procedural requirements, like public comment periods, before concrete protections are in place. *See* Wallace, *supra* note 56.
89. *See* Craig Welch, *Half of All Species Are On The Move–And We're Feeling It*, NAT'L GEOGRAPHIC (Apr. 27, 2017), https://www.nationalgeographic.com/science/article/climate-change-species-migration-disease#close (discussing the observed pattern of species such as plants, insects, and fish shifting their range towards higher elevations and latitudes) [hereinafter Welch].
90. MATSUMOTO ET AL., *supra* note 43, at 21.
91. 16 U.S.C. § 1536(a)(2) (2018).
92. 16 U.S.C. § 1536(b) (2018).
93. 16 U.S.C. § 1536(a)(4) (2018).
94. 16 U.S.C. § 1536(a)(4) (2018).
95. 16 U.S.C. § 1536(a)(2) (2018).
96. 16 U.S.C. § 1536(c) (2018).

biological opinion finds that the agency action will jeopardize or adversely modify the critical habitat, the Services will then offer up a "reasonable and prudent alternative" to the proposed action.[97] The Services will "set forth the terms and conditions" to achieve this alternative as well as determine any incidental takes associated.[98]

3. No-Take Protections

The ESA entitles species to the *take* prohibition protections, but the prohibition differs for endangered and threatened species. For endangered species, § 9 prohibits the *take* of the species without a permit.[99] *Take* is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."[100] Notably, *harm* is defined as "an act which actually kills or injures fish or wildlife" and "includes any significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering."[101] *Harassing* a species is "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering."[102]

The ESA allows for incidental take permits (ITP) of species when the "taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity."[103] A non-federal project will only need an ITP if it results in *take*.[104] Listed plants are not subject to ITP because they are not given *take* protections under the ESA if the *take* occurs on private lands.[105] As it pertains to habitat modification, if a species is likely to be harmed (and therefore a *take* under the ESA), a permit is required.[106] *Harm* to a species occurs when habitat modification "actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding,

97. 16 U.S.C. § 1536(b)(3)(A) (2018).
98. 16 U.S.C. § 1536(b)(4) (2018).
99. 16 U.S.C. § 1538(a) (2018); 16 U.S.C. § 1539(a) (2018).
100. 16 U.S.C. § 1532(19) (2018).
101. 50 C.F.R. § 222.102 (2019).
102. 50 C.F.R. § 17.3 (2019).
103. 16 U.S.C. § 1539(a)(1)(B) (2018).
104. FWS, U.S. DEP'T OF INTERIOR, FWS/AES/067974, GUIDANCE ON TRIGGER FOR AN INCIDENTAL TAKE PERMIT UNDER SECTION 10(A)(1)(B) OF THE ENDANGERED SPECIES ACT WHERE OCCUPIED HABITAT OR POTENTIALLY OCCUPIED HABITAT IS BEING MODIFIED 2 (2018) [hereinafter FWS/AES/067974].
105. U.S. FISH & WILDLIFE SERV., ENDANGERED SPECIES LISTINGS: FREQUENTLY ASKED QUESTIONS 1 (2013), https://www.fws.gov/greatersagegrouse/factsheets/ESA%20Landowner%20Fact%20Sheet_080713.pdf [hereinafter FWS FAQ].
106. FWS/AES/067974, *supra* note 104, at 3–4.

feeding, or sheltering."[107] The Services also require an ITP when the harassing of a species may occur during habitat modification.[108] *Harass* is defined to pertain to "acts or omissions which are done intentionally or negligently."[109]

The crux of this *take* loophole is that in order to require an ITP when modifying the habitat of a listed species, the actor must anticipate that harm will be done.[110] The language requires that harm must be "reasonably certain to occur."[111] Additionally, the action must meet all three aspects of the harm definition to trigger an ITP requirement.[112] The habitat modification must be significant, must "significantly impair an essential behavior pattern," and must be "likely to result in the actual killing or injury of wildlife."[113] This all but eviscerates the intent of the ESA in preventing population decreases on non-federal property for threatened species not protected (or given limited protections) under the 4(d) rules.[114]

The 4(d) rule allows the respective managing Service to extend these same no-take protections to threatened species.[115] By default, the 4(d) rule applies § 9 protections to threatened species, but the rule gives the Services opt-out flexibility to apply some, or all, of the protections afforded to endangered species.[116] While FWS used to automatically apply § 9 protections to all threatened species with the option to decrease protections under 4(d) rules, NMFS has taken the inverse route.[117] Unfortunately, FWS has since adopted the opt-in policy of NMFS.[118]

FWS, charged with managing the bulk of listed species, had previously extended 4(d) *take* protections afforded to endangered species to threatened species unless specifically indicated otherwise.[119] The Trump Administration retracted this iteration of the ESA: "The U.S. Fish and Wildlife Service will

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107. 50 C.F.R. § 17.3 (2019).

108. FWS/AES/067974, *supra* note 104, at 2–3.

109. *Id.* at 3.

110. *Id.* at 4–5.

111. *Id.* at 2.

112. *Id.* at 4–5.

113. *Id.* at 4.

114. Prime examples include threatened plant species that may be critical for feeding pollinating insects and birds which they themselves may be listed as threatened or endangered. *See e.g.*, Karen Anderson, et al., *Endangered Pollinators and Their Habitats,* POLLINATOR P'SHIP, https://www.pollinator.org/shop/poster-2019 (last visited Mar. 16, 2021).

115. 16 U.S.C. § 1533(d) (2018).

116. YA-WEI LI, SECTION 4(D) RULES: THE PERIL AND THE PROMISE 2 (Defenders of Wildlife ESA Policy White Paper Series 2017), https://defenders.org/sites/default/files/publications/section-4d-rules-the-peril-and-the-promise-white-paper_0.pdf [hereinafter YA-WEI LI].

117. *Id.* at 3–4.

118. Press Release, U.S. Dep't of Interior, Trump Admin. Improves the Implementing Regul. of the Endangered Species Act (Aug. 13, 2019), https://www.doi.gov/pressreleases/endangered-species-act [hereinafter Trump Press Release].

119. YA-WEI LI, *supra* note 116, at 2–3; Trump Press Release *supra* note 118.

[now] craft species-specific 4(d) rules for each future threatened species determination as deemed necessary and advisable for the conservation of the species . . . ."[120] This opt-in shift, in combination with the other rollbacks, places threatened species in even more need of assistance to maintain genetic diversity.[121] It is worth noting that prior to 2019 and the Trump Administration environmental rollbacks, the Services listed species based "solely on the best scientific and commercial data available."[122] Now, with the addition of economic impacts as a metric for considering whether a listed species habitat is "critical" enough for the Services to protect it, the risk to threatened species has increased.[123]

4. Recovery Plans

The purpose of these ESA protections is to recover, not merely conserve, listed species to the point where the Services can delist them.[124] The ESA requires that the Services draft Recovery Plans for each species to provide objective, measurable criteria to achieve this result.[125] The Services base these criteria on the same five-factor analysis used in listing the species, and Recovery Plans are written when listings occur.[126] The Services draft unique Recovery Plans for each species (or DPS) which address the factors that prompted initial listings and posed a threat to the species' existence.[127] The ESA requires that these plans include "site-specific management actions" as

120. Jasmine Aguilera, *The Trump Administration's Changes to the Endangered Species Act Risks Pushing More Species to Extinction*, TIME (Aug. 14, 2019), https://time.com/5651168/trump-endangered-species-act/ [hereinafter Aguilera]; Trump Press Release, *supra* note 118.

121. On its face, it may seem advantageous to have a species-by-species 4(d) taking rule. However, prior to this Trump rollback, FWS applied an opt-out version for each species. The current iteration requires an opt-in standard, which makes it more challenging to apply the same protections to threatened species that endangered species receive. *See Legislative Attacks on the Endangered Species Act During the Trump Administration*, CTR. BIOLOGICAL DIVERSITY, https://www.biologicaldiversity.org/campaigns/esa_attacks/trumptable.html (last visited Mar. 16, 2020) (providing a complete interactive table of the rollbacks).

122. Approval for listing species or changing their status requires the approval of the Secretary of Commerce. This now requires the Services to consider economic factors when listing foreign species and designating critical habitats worthy of protection. 16 U.S.C. § 1533(a)–(b); Elly Pepper, *How Trump's ESA Rollbacks Will Affect Foreign Species*, NAT. RESOURCES DEF. COUNCIL (Aug. 21, 2019), https://www.nrdc.org/experts/elly-pepper/how-trumps-rollbacks-will-affect-foreign-species [hereinafter Pepper].

123. Aguilera, *supra* note 120.

124. 16 U.S.C. § 1533(f) (2018).

125. 16 U.S.C. § 1533(f)(1)(B)(ii) 2018).

126. NAT'L MARINE FISHERIES SERV. & U.S. FISH & WILDLIFE SERV., INTERIM ENDANGERED AND THREATENED RECOVERY PLANNING GUIDANCE 2.1-1, 3.1-1, 5.1-9, (2010), http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=8C395E222A4723DE7F33D1B379F48FDE?doi=10.1.1.225.554&rep=rep1&type=pdf [hereinafter NMFS & NOAA RECOVERY PLAN].

127. *Recovery of Species Under the Endangered Species Act*, NOAA FISHERIES (July 10, 2020), https://www.fisheries.noaa.gov/national/endangered-species-conservation/recovery-species-under-endangered-species-act [hereinafter NOAA *Recovery*].

well as estimates of the time and cost to get the species to the point of delisting.[128] Recovery Plans actions are not actually required to be implemented, but instead are guidance actions on how to lead a species to recovery.[129] The ESA does, however, require the Services to produce status updates every two years for listed species' plans.[130] The Services have occasionally created multi-species Recovery Plans when the critical habitats of certain species overlap.[131] Florida provides a good example of state-created multi-species recovery plans.[132] The Southern Florida Multi-Species Plan encompassed 68 listed species and focuses on "maintain[ing] biodiversity of natural communities."[133] This plan has been in place since 1999 and provides ample data regarding the effectiveness of grouping species management based on their geographical proximity.[134] Further, this plan could serve as a template for incorporating phylogenetics as a means of species recovery management.

5. Monitoring

If a species meets the criteria for delisting or down-listing, the ESA still requires that the Services continue to monitor them.[135] Monitoring "shall" continue for no less than five years after delisting to ensure the threats that initially promoted listing will not continue to threaten the species.[136] For species that have been down-listed, monitoring entails the same actions and protections described above for threatened species.[137] Delisted-species monitoring entails the listing agency creating a monitoring plan that is also based on the five factors the agency used in the initial listing of the species.[138]

While the ESA does not require a formal plan, the Services have taken it upon themselves to draft plans for each delisted species as a means of

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128. *Id.*

129. *Id.*

130. 16 U.S.C. § 1533(f)(3) (2018).

131. NMFS & NOAA RECOVERY PLAN, *supra* note 126, at 1.1-1; NOAA *Recovery, supra* note 127.

132. *See generally*, *South Florida Multi-Species Recovery Plan*, U.S. FISH & WILDLIFE SERV. (May 3, 2019), https://www.fws.gov/verobeach/ListedSpeciesMSRP.html (providing an overview of the plan, all of the listed species included, and pertinent documents regarding recovery of the species) [hereinafter FWS *Florida*].

133. *Id.*

134. *See id.* (providing detailed information on all of the species managed under the South Florida MSRP).

135. 16 U.S.C. § 1533(g) (2018).

136. 16 U.S.C. § 1533(g)(1) (2018); Down-listing can occur when the Services reclassifies an endangered species as threatened. *See* FWS DELISTING, *supra* note 71, at 1 (providing an overview of how and when delisting and down-listing occurs).

137. FWS DELISTING, *supra* note 71, at 1.

138. FWS DELISTING, *supra* note 71, at 1–2.

individualized monitoring.[139] The Services recommend using the same monitoring methods and techniques used in the Recovery Plan so that there is consistency and baseline data from which to assess the species' success after delisting.[140] The Services do permit a deviation from this if the "historical sampling methods [used in the Recovery Plan] are inadequate . . . or if more effective or efficient monitoring methods are available . . . ."[141] However, if the updated monitoring methods and techniques require "more effort" than those methods originally used in the Recovery Plan, they are not to be implemented.[142] This is highly problematic because monitoring species to ensure they do not merit re-listing requires scientific methodology which, in and of itself, is evolving.[143] Monitoring may require "more effort" simply to retrain personnel on a new method of data collection or a new technology system. Integrating assessments that determine whether a species has enough genetic variability to survive future constraints will inevitably require "more effort" than retaining the original plan's status quo. This may no longer represent changing threats from climate change.

Given all these protections, the ESA's goal to prevent extinction has thus far worked.[144] In 2019, "only four species have been confirmed extinct with another twenty-two possibly extinct following protection."[145] The ESA began protecting species in 1973.[146] The planet, as we have known it, has been one of relative stability.[147] The ESA has worked within the confines of this stability despite human actions to thwart it with carbon emissions. But this model of protection will not remain sustainable in the Anthropocene.

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139. U.S. FISH & WILDLIFE SERV. & NAT'L MARINE FISHERIES SERV., POST-DELISTING MONITORING PLAN GUIDANCE UNDER THE ENDANGERED SPECIES ACT 1-1 (2008).

140. *Id.* at 2-1–2-2.

141. *Id.* at 2-2.

142. *Id.*

143. *See*, *e.g.*, Dorothy Leonard Barton &William A. Kraus, *Implementing New Technology,* HARV. BUS. REV. (Nov. 1985), https://hbr.org/1985/11/implementing-new-technology (discussing the financial, social, and implementation costs of adopting new technology).

144. *See* Greenwald et al., *supra* note 56, at 4–6 (noting that their findings indicate a 99% success rate of the ESA saving species from extinction).

145. Greenwald et al., *supra* note 56, at 1. However, on September 29, 2021, FWS released a press release announcing the proposal to declare 23 species extinct. FWS notes that "[w]hile protections were provided too late for these 23 species, the ESA has been successful at preventing the extinction of more than 99% of species listed." *See*, Brian Hires, *U.S. Fish and Wildlife Service Proposes Delisting 23 Species from Endangered Species Act Due to Extinction*, U.S. FISH & WILDLIFE SERV. (Sept. 29, 2021), https://www.fws.gov/news/ShowNews.cfm?_ID=37017.

146. Greenwald et al., *supra* note 56, at 1.

147. *See* DAVID ATTENBOROUGH, A LIFE ON OUR PLANET: MY WITNESS STATEMENT AND A VISION FOR THE FUTURE 20 (Grand Cent. Publ'g, 1st ed. 2020) (noting that we have most recently moved into the Anthropocene, but the geological period preceding this, the Holocene, has been the most climate stable periods of earth's history).

Currently, more species need protection than the Services' resources can protect.[148]

Most recently, the drastic decrease in western monarch butterfly populations brought this problem to the surface.[149] The FWS, while noting that the monarch (as well as other species) deserves ESA protections, stated that it will instead focus on those species most in need.[150] The FWS does not consider the western monarch butterfly sufficiently "threatened" to warrant listing, even though the species has a 68% chance of extinction within the next ten years and their population fell from 1.2 million in 1997 to less than 30,000 as of 2019.[151] This does not bode well for the many other species whose existence the United Nations has projected will experience drastic population declines in the coming years, if not full extinction.[152] If humans are to continue living on this planet, we will need to do more than just prevent the extinction of the species and ecosystems we depend on. We will need them to thrive. In order to thrive, all species will need genetic diversity in their populations to evolve and adapt through the effects we cannot mitigate in a changing climate.

B. The Phylogenetic Preservation Act: A Co-Conspirator to the ESA Family

The ESA has survived the test of time and spawned many state-ESA analogs.[153] While it has faults, this note does not suggest the ESA itself is facing extinction. Rather, it needs a partner to help it adapt. Learning from the extensive data on the ESA's efficacy in practice, Congress should develop a partner to supplement the areas in which the ESA is lacking. This note suggests the Phylogenetic Preservation Act (PPA). The PPA will take the structure of the ESA, modify it to incorporate phylogenetics as the *best available science*, and adjust some of the conservation inadequacies the ESA creates due to regulatory constraints. The PPA will look to the protections already in place under the ESA while redefining which species meet *threatened* or *endangered* listings. In continuing to drive home the necessity of proactive measures, we are approaching a point where species

148. *See* Kimbrough, *supra* note 56 (noting that the Services designate "warranted but precluded" status to species who should be listed under the ESA but will not receive protections due to insufficient resources to do so).

149. *See id.* (discussing that despite the drastic decrease in population, FWS will not list the Western Monarch Butterfly as there are species whose threats are more pressing).

150. *See id.* (relating statements made by the FWS when it chose to place the species in the "candidate" designation).

151. *See id.* (comparing the assessments made on the possible extinction of both the Eastern and Western Monarch species).

152. *See generally*, IPBES, *supra* note 2 (warning that more species are currently in risk of extinction than in any other period of human history); *Nature's Dangerous Decline*, *supra* note 2.

153. *See e.g.*, VT. STAT. ANN. tit. 10, § 123 (codifying Vermont's Endangered Species Act).

biodiversity, as a whole, is projected to take a nosedive.[154] Addressing the need to incorporate more than a singular perspective on species preservation, and to look at ecosystem interactions through genetics, is a mode of using the *best available* scientific and commercial data.[155] The PPA, working with the ESA, is one of the ways we can strive to avoid future ecosystem collapse.

1. Listing

In looking to use phylogenetics, ESA *threatened* species tend to have more genetic variability due to the quantity of individuals remaining.[156] *Threatened* species have a stronger ability to evolve with others who share similar genetic material in the evolutionary tree, making them more appropriate candidates for this theory of conservation.[157] That does not mean that the PPA should leave the heavy lifting of managing endangered species to the ESA. As climate changes, so will the geographical areas in which endangered species are located.[158] As species migrate away from their current geographic ecosystems, they will interact with other species in those new ecosystems that may assist them with future genetic variance.[159] The PPA will work to identify those species whose genetic material is *threatened* or *endangered* in the foreseeable future, using the *best available science*.

The ESA definition of *species* already allows for the consideration of phylogenetics when interpreted to use the *best available science*. *Species* is defined as "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."[160] Through using scientific analysis and modeling, we can determine which species are closely related, along with projections of future climate-induced migratory paths, to assess whether species have the potential to interbreed. The PPA would list a species as *genetically threatened* (GT) or *genetically endangered* (GE) based on many of the same listing factors enumerated in the ESA, but with a focus on threats

154. *See generally,* IPBES, *supra* note 2, at 13, 51 (warning of future biodiversity and ecosystems collapse unless global leaders take direct action); IPCC, *supra* note 34, at 2–16 (providing a full assessment of the status of worldwide biodiversity currently and future projections).

155. 16 U.S.C. § 1533(a)–(b) (2018).

156. *See* Ouchi-Melo et al., *supra* note 5, at 3247, 3248 (noting that prior methods of conserving species based on biodiversity "hotspots" and "taxonomic diversity" may not be the best way to protect ecosystems as more abundant species play key parts in contributing genetic material).

157. *See id.;* Maron et al., *supra* note 8, at 732–35 (discussing how species whose populations are already low have a much harder time succeeding when presented with new constraints like those produced by climate change).

158. *See* Welch, *supra* note 89 (noting that "[a]s the planet warms, species are shifting where, when, and how they thrive").

159. *See id.* (discussing that scientists have observed terrestrial species "moving an average of ten miles per decade, while marine species are moving four times faster").

160. 16 U.S.C. § 1532(16) (2018) (emphasis added).

to the genetic material contained within species.[161] The Services would apply language similar to that used under the ESA to determine whether a species is GT or GE. Under the ESA, a species can be listed as *endangered* if they are "in danger of extinction throughout all or a significant portion of its range . . . ."[162] A species can be listed as *threatened* if they are "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."[163] The PPA will use this same language but modify the statute to list a GE species as "a species that is in danger of extinction due to the isolation or extinction of genetic material." The PPA will list GT species as species which are "likely to become a genetically endangered species within the foreseeable future." This inclusive definition will look towards and apply which species have genetic and geographic overlap to qualify species who need protections as GT or GE.

The Services can achieve this by looking at the scientific data already collected on the phylogeny of species and comparing this data with those species currently listed as *threatened* under the ESA.[164] This data compilation would expand how the Services interpret the definition of *threatened* or *endangered*. Currently, an ESA species is listed as *threatened* on an individual taxonomic basis (or if a vertebrate, a DPS).[165] This perspective of conservation only looks at a particular species' population levels, rather than a prospective method of using evolution to expand and assist in *speciation*.[166] Under the lens of phylogenetics, the PPA's definition of a *threatened* species will encompass those species that are currently abundant in their populations but are the last remaining members of their genus. Under the ESA, these species would not qualify as *threatened* or *endangered* because their populations are not low enough, or they may not meet the five factors of listing.[167] But, as their habitats and access to food

161. 16 U.S.C. § 1533(a)(1) (2018).

162. 16 U.S.C. § 1532(6) (2018).

163. 16 U.S.C. § 1532(20) (2018).

164. TreeBASE, first launched in 1994, provides open-source database on the phylogeny of many species and works to collect and compare scientifically published work to link evolutionary trees. *See A Database of Phylogenetic Knowledge*, TREEBASE, https://treebase.org/treebase-web/about.html (last visited Mar. 16, 2021) [hereinafter TREEBASE].

165. Often, FWS and NOAA list species as "distinct population segment" (DPS) when they occupy large regions or are migratory. The Grizzly Bear is one such species that received a lot of contention when the Greater Yellowstone Ecosystem portion of their population was delisted from the ESA. This method of using DPS rather than a whole species may be beneficial in implementing phylogenetics. If only for the political and social push-back of ESA expansion on property rights. *See*, *e.g.*, Max Chaffetz, *Clarifying the Endangered Species Act's "Distinct Population Segment" Policy Through the Lens of Grizzly Bears*, GEO. L. REV. (Apr. 5, 2019), https://www.law.georgetown.edu/environmental-law-review/blog/clarifying-the-endangered-species-acts-distinct-population-segment-policy-through-the-lens-of-grizzly-bears/ (using the Grizzly Bear as a case study for the application of DPS under the ESA).

166. 16 U.S.C. § 1531 (2018).

167. 16 U.S.C. § 1531 (2018).

change, they may experience constraints that reach ESA listing standards.[168] The PPA is a preventative act which seeks to remedy this problem before the species requires ESA protections.

The ESA prohibits the listing of insects that are deemed pests and "would present an overwhelming and overriding risk to man."[169] This is especially problematic in agriculture because the threat to an insect's extinction hinges on the farming practices used at that moment in time.[170] We may find that an insect that has been nearly eradicated due to pesticides in fact contains critical medicinal properties or is key to pollinating a plant that an ESA-listed species depends on.[171] We may also find that after years of using land as monoculture, these insects are actually critical in reclaiming and restoring depleted soils.[172] Scientists have already warned of a coming worldwide insect species collapse.[173] To withhold protections from insects because they present issues to agriculture could lead us to unrecoverable ecosystem collapse. The PPA would protect insects based not only on their genetic variability but also their genetic relationship to other insects. The idea being that once protected, insects may mate and evolve with other species in their genus to prevent extinction in the future.

Unlike the ESA, the PPA would allow the listing of invertebrates as DPS.[174] The Services currently use a three-pronged analysis for determining if a species qualifies as a DPS.[175] The Services will ask: (1) how discrete the population is in relation to other members within its own species; (2) how significant the population is in relation to the species overall; and (3) whether that population of the species would require ESA listing if it were considered its own species.[176] Allowing invertebrates to qualify for DPS status would promote holistic species management. The PPA would use this same three-

168. *See* Welch, *supra* note 89 (noting that the Red Knot Chick and Alaskan Caribuo are already experiencing decreased in populations due to food shortages from being out of sync with other species in their habitats that they are dependent upon).

169. 16 U.S.C. § 1532(6) (2018).

170. *See* Simon Worrall, *Without Bugs, We Might All Be Dead,* NAT'L GEOGRAPHIC (Aug. 6, 2017), https://www.nationalgeographic.com/news/2017/08/insect-bug-medicine-food-macneal/ (noting that cockroaches are helping scientists understand antibiotic resistance because of the amount of time they spend in feces).

171. *See id.* (discussing the use of scorpion venom to identify tumors in the human brain).

172. *See* Andrew R. Moldenke, *Soil Arthropods*, USDA, https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053861#:~:text=They%20include%20insects%2C%20such%20as,to%20many%20different%20arthropod%20species (last visited Mar. 16, 2021) (discussing the roles of various insects in promoting soil health).

173. *See,* David L. Wagner, et al., *Insect Decline in the Anthropocene: Death by a Thousand Cuts*, 118 PNAS 2, 2 (finding that "climate change, habitat loss and degradation, and agriculture" were the leading causes of insect decline).

174. Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act, 61 C.F.R. § 4722 (1996).

175. 61 C.F.R. § 4722 (1996).

176. 61 C.F.R. § 4722 (1996).

prong analysis but enable expansion of DPS's to preserve and grow genetic variation among species. With insects in particular, this inclusion could prove critical because they play important roles in the success of other species.[177] A more localized and hands-on approach to invertebrate conservation would enable the Services to proactively preserve species.

To return to the western monarch butterfly, one of the impediments with the FWS not being able to list the species is that it did not qualify as a DPS.[178] Because they are invertebrates, the FWS classifies both the eastern and western monarch butterfly as one species.[179] Although their United States habitats do not overlap, population numbers and the recognized threats to their existence are viewed together.[180] This means that one cannot receive ESA protections until both need ESA protections. Applying this mode of DPS under the PPA would preempt this problem by listing and protecting the western monarch based on the genetic variance of its population, separate from that of the eastern monarch.[181]

As it currently stands, the *foreseeable future* requirement of listing a species does not itself rely on best[182] Under the ESA, the time frame in which species are considered *threatened* depends on how far in the future humans can reasonably predict likely threats.[183] This allows the Services to use a subjective standard—rather than a standard based on solely scientific analysis—to introduce the human-centric constraint of time. While the Trump administration created this definition, and it may change under

177. *See* Stuart Reynolds, *What Happens to the Natural World if All of the Insects Disappear?,* THE CONVERSATION (Feb. 18, 2019), https://theconversation.com/what-happens-to-the-natural-world-if-all-the-insects-disappear-111886 (discussing how insects form the basis of all trophic levels and that as insect populations decrease so do all of the species which depend on them for food, pollination, and processing organic matter).

178. Endangered and Threatened Wildlife and Plants; 12-Month Finding for the Monarch Butterfly, 85 Fed. Reg. 81813 (Dec. 17, 2020) (to be codified at 50 C.F.R § 17); 16 U.S.C. § 1532(16) (2018).

179. 16 U.S.C. § 1532(16) (2018).

180. It is worth noting that there has not been a finding of genetic variance amongst the eastern and western monarch butterflies. When they migrate south, they mate and exchange genetic data. *See* Carol Clark, *Butterfly Genomics, Emory Biologists Show How Monarchs Fly Differently But Meet Up and Mate*, EMORY UNIV., https://news.emory.edu/features/2020/07/esc-butterfly-genomics/index.html (last visited Mar. 16, 2021).

181. It is critical that since the Eastern and Western Monarch are able to mate, U.S. protections should work to protect the Western Monarch as its own distinct species. To not do so directly affects the populations and genetic variability within the Eastern population. *Id.*

182. The ESA's limitation of "foreseeable future" to only so far as humans can reasonably predict ignores much of the international scientific community's projections of future species die off at alarming levels. If the ESA took this scientific data into account, the Services would list many more U.S. species. *See IUCN Redlist, supra* note 57 (providing lists, data, and status reports of all species worldwide threatened with extinction).

183. 50 C.F.R. § 424 (2019).

Biden's initiative to address mitigation and adaptation to climate change,[184] the PPA would redefine this language by statute. However, even if future Administrations rectify some of this language, it is not good enough if it continues to use a near-sighted, anthropocentric lens.

The current anthropogenic definition of *foreseeable future* presents problems for the PPA.[185] The Services' use of *foreseeable future* should be based solely on the *best available science* (which would include international scientific analysis) and assess each species' genetic variability for success under the known effects of climate change. Scientists nearly unanimously agree that mass extinctions of species are in the foreseeable future even with the actions sought under the Paris Climate Accord.[186] In defining *foreseeable future*, the PPA should employ modeling of a species' current geographical ranges overlayed with their phylogenetic portfolio and apply known and projected changes to habitats as climate change accelerates. Modeling in this way would allow for a holistic analysis that can quickly and efficiently adjust to environmental changes. Scientists would still have to factor time frames into determining whether a species qualifies as GT or GE. Scientists can establish a baseline whereby identifying the potential risk for extinction of a species with no protections provides the initial control metric. From there, scientists can identify a probability rate to establish a threshold of how far in the future is too far to merit protections.[187] For example, if the PPA modeling of a species of mangrove without protections indicates that the mangroves face a 12% chance of extinction in the next 40 years, the PPA may hold off on extending protections and use its resources on more pressing threats.

Migratory species especially would benefit from GT listings. A threatened migratory species can have an expansive habitat and may not receive the protections needed except in United States territories where the

184. As of January 27, 2021, President Biden has already rolled back Trump Administration environmental policies and committed to preserving "30% of U.S. lands and coasts by 2030." *See* Sarah Gibbens, *The U.S. Commits to Tripling Its Protected Lands, Here's How it Could Be Done*, NAT'L GEOGRAPHIC (Jan. 27, 2021), https://www.nationalgeographic.com/environment/2021/01/biden-commits-to-30-by-2030-conservation-executive-orders/.

185. *See* 50 C.F.R. § 424 (2019) (defining "foreseeable future" to be "only so far into the future that the Services can reasonably determine that both the future threats and the species' responses to those threats are likely").

186. *U.N. Draft Plan Sets 2030 Target to Avert Earth's Sixth Mass Extinction*, THE GUARDIAN, https://www.theguardian.com/environment/2020/jan/13/un-draft-plan-sets-2030-target-to-avert-earths-sixth-mass-extinction-aoe (last updated Jan. 15, 2020) (noting that the goals of the Paris Accord are a "floor" not a "ceiling").

187. *See*, *e.g.*, Matthew J.R. Cowley, et al., *Habitat-Based Statistical Models for Predicting the Spatial Distribution of Butterflies and Day-Flying Moths in a Fragmented Landscape*, 37 J. APPLIED ECOLOGY 60, 60–72 (2000) (showing how the application of statistical modeling can be used to project and predict butterfly and moth habitat range).

FWS has designated their habitat as *critical*.[188] A practical example is the Golden-winged Warbler, which is listed as *threatened* under the ESA. The Golden-winged Warbler is a migratory bird whose path extends from Canada to the Northern portions of South America.[189] This bird has experienced a 66% population decrease in the last 50 years.[190] However, it has begun mating with the Blue-winged Warbler, producing a hybridized species.[191] Extending PPA GT protections to the Blue-winged Warbler and the hybridized species would preserve the evolutionary tree of these closely related species. This extension could potentially ensure that genetic variations within individual species persist, assisting all three species in surviving the Anthropocene.

2. Critical Habitats

While *critical habitats* are an important element of the ESA, that designation has its flaws. First, the ESA's critical habitat designation allows for the balance between the economic factors of designation and the needs of listed species.[192] Additionally, *critical habitats* cannot extend onto private property unless there is federal activity or funding associated with the property.[193] These limits have a basis in restricting government overreach and resource allocation. The PPA's extension of DPS designation to all species can help alleviate these flaws as they pertain to federal property by creating micro-critical habitats.

Under the PPA, the Services would be able to provide piecemealed critical habitat protections for species whose populations are segmented. This would entail identifying habitats where GT or GE species exist and providing protection to these habitats so that the species can continue to exist in them. However, this theory may present opportunities for potential abuse and decreased overall protection. A GT or GE species total habitat should not simply be an aggregate of a great many micro-critical habitats. To combat this, the PPA will require a baseline total critical habitat acreage for each species listed as GT or GE depending on their respective needs. This cumulative baseline will also incorporate metrics to limit how small each

188. The Trump Administration has further rolled back ESA protections for foreign species and international cooperation on species conservation. This could have even more dire effects on threatened migratory species. *See* Pepper, *supra* note 122.

189. *Golden-Winged Warbler,* AM. BIRD CONSERVANCY, https://abcbirds.org/bird/golden-winged-warbler/?gclid=Cj0KCQiAwf39BRCCARIsALXWET wc9KCeKnvzvhylmmNBW-QF0Jm8mL43_2xWBxMZYwhljrS609ErRjQaAkqKEALw_wcB (last visited Mar. 16, 2021).

190. *Id.*

191. *Id.*

192. MATSUMOTO ET AL., *supra* note 43, at 20–1.

193. *Id.* at 21.

micro-critical habitat can be. Each species' needs will be the same used in the ESA designation of critical habitat: food, shelter, breeding grounds, and space for natural behavior.[194] The PPA will focus on the goal of increasing or stabilizing genetic variation in the species when identifying these needs. Micro-critical habitats would allow for a more localized approach to species management because each service's field office can make management determinations as needed.

Under the ESA, this micro-critical habitat solution only assists species currently residing on federal lands.[195] While the United States owns and manages substantial quantities of public land, climate change will force some species off federal land onto private land.[196] To mitigate this problem, Congress could incorporate a grant program into the PPA to provide financial incentives for private property owners who opt-in to allocate portions of their land to preserve GT or GE species. The grant program should also include a provision that subsidizes private property within a buffer zone. A buffer zone would incorporate the overlap between the *critical habitat* for listed species under the ESA and the habitat of evolutionarily similar species listed under the PPA. Private property owners could select one of two grant program tiers: 1) lands specifically designated for GT or GE species, or 2) lands allotted as buffer zones. The PPA tiered system would allow for private property owners to decide how much governmental interaction and responsibility they want associated with their property. Additionally, the tiered system would allow the Services to invest constrained resources where they are most effective. The more financial investment the Services make on the property, the more constrained the private property owners use is of their land.

Currently, the Services and the Nature Conservancy have offered interactive mapping tools similar to Google maps.[197] These maps allow users to see exactly where a threatened or endangered species may exist.[198] The scientific community has published similar data on phylogenetics and has

194. *Id*. at 20.

195. 16 U.S.C. § 1533 (2018); *See Critical Habitat Under the Endangered Species Act,* U.S. FISH & WILDLIFE SERV., https://www.fws.gov/southeast/endangered-species-act/critical-habitat/ (last visited Mar. 16, 2021) (providing an overview of how critical habitats and private property relate to one another under the ESA) [hereinafter FWS *Critical Habitat*].

196. *See* CONG. RSCH. SERV., R42346, FEDERAL LAND OWNERSHIP: OVERVIEW AND DATA (2020) (stating that "[t]he federal government owns roughly 640 million acres, about 28% of the 2.27 billion acres of land in the United States").

197. *Science & Data Maps*, NOAA FISHERIES, https://www.fisheries.noaa.gov/resources/maps (last visited Mar. 16, 2021) [hereinafter NOAA *Maps*]; *Coastal Resilience Mapping Portal*, NATURE CONSERVANCY, https://maps.coastalresilience.org/ (last visited Mar. 16, 2021) [hereinafter NATURE *Maps*]; *Conservation Planning Atlas*, U.S. FISH & WILDLIFE SERV., https://www.fws.gov/southeast/conservation-tools/conservation-planning-atlas/ (last visited Mar. 16, 2021) [hereinafter FWS *Atlas*].

198. NOAA *Maps, supra* note 197; NATURE *Maps, supra* note 197; FWS *Atlas, supra* note 197.

made this information open source.[199] The technology exists. The Services should implement strategic analysis, comparing a GT or GE species habitat range with that of other species that are most closely genetically related. Using the overlay of these two data sets can more effectively create the total protected habitat of species to reflect what species actually need to survive. Using scientific modeling and grant programs, these buffer zones would create financial incentives for private property owners. Private property owners who choose to participate would receive additional funding on a preservation scale, where the funding increases as the level of agreed-to protections increase. This would allow autonomy and multi-use of private property while financially supporting owners in their conservation efforts.

All of these proposed PPA programs implicate a large expense on behalf of the taxpayers. The Services already experience financial constraints, limiting their ability to fully implement the ESA.[200] The PPA proposes adding yet another statute onto the Services' proverbial plate. Implementing the PPA will require hiring personnel, training and paying for new modeling systems, subsidies to private property owners, and providing boots on the ground enforcement of subsidy agreements. None of these proposals will be cheap. However, the alternatives are much more costly.[201] The loss of biodiversity on this planet affects all aspects of human survival.[202] As the loss accelerates, so may the financial costs.[203] Investing in proactive measures now may help to slow down these future expenses and identify gaps in conservation.

The western monarch butterfly pulls all of this together in a real-world example. Monarchs "cannot survive without milkweed."[204] Monarchs lay

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199. *See*, *e.g.*, Ralph Pethica et al., *TreeVector: Scalable, Interactive, Phylogenetic Trees for the Web*, PLOSONE, Jan. 2010; *see also e.g.*, Andrew F. Magee et al., *The Dawn of Open Access to Phylogenetic Data,* PLOSONE, Oct. 2014 at 1; TREEBASE, *supra* note 164.

200. *See*, *e.g.*, Robert Gordon, *"Whatever the Cost" of the Endangered Species Act, It's Huge,* COMPETITIVE ENTER. INST. (Aug. 20, 2018), https://cei.org/studies/whatever-the-cost-of-the-endangered-species-act-its-huge/ (providing examples and breakdowns of how much money the FWS spends to administer the ESA) [hereinafter Gordon].

201. OECD, BIODIVERSITY: FINANCE AND THE ECONOMIC AND BUSINESS CASE FOR ACTION 26–7 (May 2019), https://www.oecd.org/environment/resources/biodiversity/G7-report-Biodiversity-Finance-and-the-Economic-and-Business-Case-for-Action.pdf (finding that between 1997 and 2011, the global cost of species biodiversity loss was "$4-$20 trillion per year in ecosystem services owing to land-cover change," $20 billion annually due to inadequate ocean management, and $6.3-$10.6 trillion per year because of land degradation) [hereinafter OECD].

202. *See Biodiversity and Health,* WORLD HEALTH ORG. (June 3, 2015), https://www.who.int/news-room/fact-sheets/detail/biodiversity-and-health (breaking down just some of the ways that loss of species biodiversity impacts global human existence).

203. *See* OECD, *supra* note 201, at 26 ("Failure to address biodiversity loss is (and will continue to be) costly.").

204. *Create Habitat for Monarchs,* MONARCH JOINT VENTURE, https://monarchjointventure.org/get-involved/create-habitat-for-monarchs#:~:text=Monarchs%20cannot%20survive%20without%20milkweed,milkweed%20to%20lay%20their%20eggs (last visited Mar. 16, 2021).

their eggs in milkweed and as their caterpillars grow, they rely on it as a food source.[205] Milkweed is native to the United States and there are 115 known species within the genus of milkweed.[206] On the west coast, the common milkweed is only found in Oregon.[207] As mentioned earlier, the western monarch does not qualify as a listed species under the ESA.[208] Under the PPA, the western monarch would qualify as a DPS, distinct from the eastern monarch population. The PPA would enable the FWS to designate a buffer zone where the monarch's migratory path overlaps with areas where milkweed currently grows. Once established, private property owners could participate in the PPA's grant programs by planting native species of milkweed on their land.

Two critical hindrances to this grant program are private property and federal government entanglement. Because the federal government will be paying private property owners, the grant program may implicate other federal acts.[209] For example, ESA critical habitat protections do not ordinarily extend to species on private property unless there is a *federal nexus* between the private property and the federal government.[210] This *federal nexus* can be established when federal funds are attached to the property.[211] PPA federal funding to private lands would also make owners subject to the ITP requirements for any *take* of plants on their property.[212] This could deter owners from wanting to participate in the PPA. The PPA will address this and relieve private owners of any additional responsibility for federal regulations outside of PPA grant program monitoring. While there is a governmental benefit from this federal entanglement in private property, the need to proactively prevent ecosystem failure through species conservation should outweigh these larger federal benefits.

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205. *Id.*

206. David Taylor, *Common Milkweed (Asclepias syriaca L.)*, https://www.fs.fed.us/wildflowers/plant-of-the-week/asclepias_syriaca.shtml (last visited Mar. 16, 2021).

207. *Asclepias syriaca L. Common Milkweed*, USDA, https://plants.usda.gov/core/profile?symbol=ASSY (last visited Mar. 16, 2021).

208. Endangered and Threatened Wildlife and Plants; 12-Month Finding for the Monarch Butterfly, 85 Fed. Reg. 81813 (Dec. 17, 2020) (to be codified at 50 C.F.R § 17); 16 U.S.C. § 1532(16) (2018).

209. For example, under the ESA, this could subject private property owners to "critical habitat" designations on their lands. *See* FWS *Critical Habitat, supra* note 195 (noting that "critical habitat designations do not affect by private landowners if there is no federal 'nexus'").

210. *Id.*

211. *Id.*

212. FWS FAQ, *supra* note 105, at 1.

3. No-Take Protections

The *take* provision of § 9 presents plenty of issues in attempting to incorporate phylogenetics.[213] By expanding protections to species within an ESA listed species' phylogeny, the breadth of the *take* provision could step on some private property and industry toes.[214] With the quantity of species that the Services would list under the PPA, Congress would be hesitant to replicate the same protections given to ESA-listed species in favor of GT or GE species. Extending the ESA's *take* protections to PPA species would heavily burden private property owners. Under the ESA, all *take* is prohibited without a permit, but a permit is only required for non-federal projects that could lead to *incidental take*.[215] This is inadequate to affect real *take* protections.

Incorporating the tiered system of private property opt-in and the buffer zone theory into the PPA could fix some of these inadequacies. The buffer zone theory (advanced above) requires incorporating provisions to address no-take protections, creating either exemptions or permits depending on whether the GT or GE *take* occurs on federal or non-federal land.[216] The PPA would place an annual cap on the *take* of GT or GE species on federal property. Each GT or GE species would have their own unique permissible federal *take* limit. With private property, it would be a stretch to apply this same cap unless the land was already involved in the PPA grant program. Permissible *takes* through the ITP require knowledge that actions will lead to the *take* of a species.[217] Requiring private property owners to be on notice of all the GT or GE species on their land would be too heavy of a burden.

Under the ESA, threatened species may have lower levels of *take* protections under the Services' application of 4(d) rules.[218] The PPA would apply these same 4(d) rules to that GT and GE have some no-take protections

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213. "In general, Section 9 of the ESA prohibits persons from importing, exporting, transporting, or selling endangered species of fish, wildlife, and plants in interstate or foreign commerce. It is also illegal to "take" an endangered fish or wildlife species or possess taken species. Take means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect," or an attempt to do the same. It is unlawful to import or export endangered plant species from the United States, or to remove, possess or maliciously damage or destroy such species on federal land or any other area in knowing violation of a state law or regulation." ERIN H. WARD, CONG. RSCH. SERV., IF11241, THE LEGAL FRAMEWORK OF THE ENDANGERED SPECIES ACT (ESA) (2019) [hereinafter IF11241].

214. *See* MATSUMOTO ET AL., *supra* note 43, at 44–52 (discussing the political challenges facing many portions of the ESA).

215. 16 U.S.C. § 1538(a) (2018); 16 U.S.C. § 1539(a) (2018); FWS/AES/067974, *supra* note 104, at 2.

216. Using the permissible taking language in Rule 4(d) could possibly assist with this. Allowing each Agency on a species-by-species basis to determine which taking permits and how lenient they are, could get over this hurdle. *See* YA-WEI LI, *supra* note 116, at 2–3 (discussing how rule 4(d) and rule 9 interact within the "take" provision of the ESA in regards to different agency implementation).

217. FWS/AES/067974, *supra* note 104, at 2.

218. 16 U.S.C. § 1533(d); YA-WEI LI, *supra* note 116, at 3–4.

but not to the same extent as endangered species under § 9. This plan maintains the localized attention and management goals of PPA listed species. A federal project will be subject to the same biological opinions required under the ESA if a *take* of a GT or GE species might occur in the process. This would additionally serve to increase knowledge and data points for the PPA database to track where species are located and the quantity of individuals in their populations.

One of the biggest issues of the § 9 no-take prohibition is that it does not apply to ESA-listed plants on private property.[219] An ITP is not required when the *take* of a plant occurs on private lands.[220] This has cumulative effects on other species who rely on plants for food, shelter, and breeding.[221] Given the huge variance in phylogenetic relationships and reproduction rates, this could lead to many lost genetic variations in climate-change-susceptible regions like coastal zones.[222] For example, private property containing threatened plant species of mangroves could critically impact carbon sequestration.[223] Mangroves can sequester six to eight tons of carbon per hectare from the atmosphere annually.[224] In addition to the potential lost genetic variance, loss of mangroves can magnify the accumulation of carbon in the atmosphere. It is worth noting, however, that some of these species may fall under other federal protections outside of the ESA when located on private property.[225]

The PPA grant program will address the issues present with plant species on private land. One means of achieving more genetic variability in plants on private property is to offer incentives to protect and grow GT and GE plants. The PPA grant program may provide the most viable method to protect species on private lands. The PPA could tier the grant system and make

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219. FWS FAQ, *supra* note 105, at 1.

220. *Id.*

221. While all species rely on plants for food, whether directly or indirectly, one prime example is pollinators such as bumblebees. *See* Nancy Ostiguy, *Pests and Pollinators,* NATURE EDUC. KNOWLEDGE (2011), https://www.nature.com/scitable/knowledge/library/pests-and-pollinators-23564436/ (discussing the inter-reliance of pollinators and plants).

222. *See* 16 U.S.C. § 1538(a)(2) (2018) (providing some protections against harm to listed plants, but not to the extent that Sec. 9 "take" prohibitions provide).

223. *See Human Activities Such as Dredging and Careless Boating Are Threatening South Florida's Mangroves and Seagrass,* FLA. KEYS NAT'L MARINE SANCTUARY, https://floridakeys.noaa.gov/plants/msthreats.html#:~:text=Human%20activities%20such%20as%20dredging,South%20Florida's%20mangroves%20and%20seagrass&text=In%20the%20Florida%20Keys%2C%20human,have%20been%20destroyed%20for%20development (last visited Mar. 16, 2021) (noting that in the last seventy years, 60% of mangroves have been lost to development in Monroe County, Fl. alone).

224. *See About Blue Carbon*, BLUE CARBON INITIATIVE, https://www.thebluecarboninitiative.org/about-blue-carbon (last visited Mar. 16, 2021) (noting that these rates of carbon sequestration can be up to four times that of a "mature tropical forest").

225. The Coastal Zone Management Act employs three federal programs that work alongside of states and local governments to acquire or procure easements on private land for coastal conservation. *See Coastal Zone Management Act*, NOAA, https://coast.noaa.gov/czm/act/ (last visited Mar. 16, 2021).

funding dependent on the number of species of plants and area of land designated for conservation. For example, in areas with limited open space, like urban landscapes, residential homeowners could receive a $100 per year supplement to plant milkweed in their yard.

4. Recovery Plans

Recovery Plans based on the listing factors of the ESA work to prevent a species from going extinct by addressing the threats that face them.[226] Although these factors are still present for GT and GE species, they are not the best means of conserving genetic variability. Using the five-factor analysis as the sole metric used to determine whether a PPA-listed species met "recovery" would induce ramifications. The results would conflict with not only private property rights, but also the Services' resource allocation. The PPA focuses on genetic variability and the interplay between phylogenetic relationships. Given the nature of this mode of listing, PPA-listed species will be more extensive than ESA-listed species. Constraining PPA recovery plans to the ESA listing factors in light of climate change is an unworkable solution. This could lead to the PPA being overly broad—which is not a feasible conservation tool. This is most notable on federal lands where implementing the PPA would require vast acreage, impacting timber and mineral leasing, as well as recreational use on public land.

Recovery Plans under the PPA should focus on genetic variability within phylogenetically related species. The Services can achieve this by mapping the phylogenetic lineage of species, overlaying this on topographical maps, and creating a database housing this information. Mathematical modeling can use algorithms to help the Services assess and list species as *threatened* or *endangered* in relation to the genus' overall genetic pool. The PPA's inclusion and utilization of DPS's would allow the Services to create malleable Recovery Plans to fit each species' needs—even more so on public land, as it would prevent blanket protections and plans for GT and GE species.

The United States' gray wolf provides a good illustration of this problem.[227] The FWS has divided the gray wolf into three DPS's that are deemed separate and distinct from other populations of wolves in the United

226. 16 U.S.C. § 1533(a), (f) (2018).

227. *See The Fight for Northern Rocky Gray Wolves*, EARTHJUSTICE, https://earthjustice.org/features/campaigns/wolves-in-danger-timeline-milestones (last visited Mar. 16, 2021) (documenting the history of the legal protections and disputes over the gray wolf listing) [hereinafter *Gray Wolves*].

States.[228] The species overall has experienced drastic reductions in their populations due to overhunting, habitat loss, and other human induced constraints.[229] Over time, the northern Rocky Mountain gray wolf DPS population numbers have increased due to their afforded protections.[230] However, the genetic lineage is widely debated.[231] Scientists question whether each individual of the species is actually a member of that distinct species.[232] There has been data collected to suggest that they are breeding within their evolutionary tree; that they are utilizing phylogenetic avenues of adaptation.[233] The genetic data suggests that there are genetic overlaps between the wolves contained in each of the discrete DPS's.[234] If this is true, then the success of the recovery plan for the western gray wolf is dependent upon the population of those phylogenetic peers. However, the PPA would be unable to extend a buffer zone with the same protections given to the gray wolf in its recovery plan. This will be a non-starter for cattle ranchers in their habitat area unless they willingly selected to be a part of the PPA grant program.[235]

One solution that Florida and Hawaii have attempted is a multi-species recovery plan.[236] This concept is based not on phylogenetics, but rather on habitat overlap.[237] While taxonomy is still a part of the analysis, the viability

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228. *See Gray Wolf (Canus lupus)*, U.S. FISH & WILDLIFE SERV., https://www.fws.gov/home/wolfrecovery/ (last updated Nov. 6, 2020) (describing a brief history of the gray wolf under the ESA and providing further information about the Northern Rocky Mountain DPS, the Western Great Lakes DPS, and the Mexican Wolf DPS).

229. Mark Hofberg, *Why Delisting Gray Wolves From the Endangered Species Act Would Spell Trouble for the Species-And Our Shared Ecosystems*, IFAW (Mar. 27, 2019), https://www.ifaw.org/journal/why-delisting-gray-wolves-from-the-endangered-species-act-would-spell-trouble-for-the-species-and-our-shared-ecosystems?gclid=CjwKCAiA5IL-BRAzEiwA0lcWYhQNHj7V2-_sT565TNjMECe39JUAOi9R7F9NIfZrKJx44-pQBPyb6BoCKzoQAvD_BwE [hereinafter Hofberg].

230. *Id.*

231. *See* Bridgett M. vonHoldt et al., *Whole Genome Sequence Analysis Shows That Two Endemic Species of North American Wolf Are Admixtures of the Coyote and Gray Wolf*, 7 SCIENCE ADVANCES (2016) (discussing the results of their genetic sequencing of the eastern wolves and the fallacy to delist the western gray wolf).

232. *Id.*

233. *Id.*

234. *Id.* (noting that the alleles present in each of the wolf DPSs show the potential of interbreeding amongst wolves and that the tracing of coyote alleles present in wolf samples may provide further information about how long it has been since the individuals of each DPS produced offspring).

235. Wolves are apex predators and cattle ranchers have been pushing back against the take provision afforded to the gray wolf when it was listed due to the economic loss the wolf imposes on their herds. *See* Hofberg, *supra* note 229; *Gray Wolves*, *supra* note 227.

236. *See* FWS *Florida*, *supra* note 132; DRAFT REVISED RECOVERY PLAN FOR HAWAIIAN FOREST BIRDS, U.S. FISH & WILDLIFE SERV. ii–447 (Region 1, Portland, OR., 2003), https://www.fws.gov/pacific/ecoservices/endangered/recovery/documents/hawaiiforestbirdsdraftrevisedrecoveryplan.pdf. [hereinafter FOREST BIRDS FWS].

237. *See* FOREST BIRDS FWS, *supra* note 236, at viii–ix (explaining that all but two of the birds included in the plan share the same habitat regions).

of cooperative adaptation based on genes is not part of the analysis.[238] Each of these state plans could serve as test models. Modeling can look to the success rates and data collected from these plans and determine their applicability in other states or regions. Working within § 6 of the ESA, states would most likely have to provide § 10 permits for the *take* or *harm* of unlisted species whose listed counterparts are genetically intertwined.[239]

5. Monitoring

Monitoring ESA-listed species ensures that after the Services delists or down-lists an ESA species, they are still a successful and viable species whose level of protection meets their needs.[240] With climate change accelerating, it is not feasible to have a monitoring program for GT or GE species that mimics that of the ESA. The threats that GT and GE species face will be in constant flux with many shifting variables due to anthropogenic climate change, land use degradation, etc.

The PPA should instead use a database monitoring system that incorporates boots on the ground observations and citizen reporting. The database and modeling systems should work to identify not only which species currently face threats, but also which ones are subject to genetic decline that will affect the phylogenetic tree of their relatives. This monitoring program should begin at the onset of the PPA and continue to expand throughout each species' existence.[241] Because the PPA works to integrate the genetic pool of all phylogenetically related species into conservation, the down-listing or delisting of a species does not preclude the need to continually monitor them. Even if one member of the genus is not in need of PPA listing at one point in time, they may require those protections in the future based on the population or migration of other members of the genus. This model of monitoring will require extensive resources from the Services—especially at the onset of implementing the PPA. This will be expensive, but again, the cost of doing nothing to prevent species collapse will be much more expensive.[242]

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238. *See* FWS *Florida*, *supra* note 132 (showing the breakdown of the multi-species plan based on taxonomy).

239. *See* IF11241, *supra* note 213 (outlining the ways in which the sections of the ESA interact with each other).

240. 16 U.S.C. § 1533(g) (2018).

241. The choice to use the term 'existence' reflects the reality that not all GT or GE listed species will survive the Anthropocene.

242. *See* OECD, *supra* note 201, at 26–27 (providing a breakdown of known costs from species biodiversity loss from 1997 to 2011).

A GENUS CONCLUSION

Climate change is accelerating.[243] Congress has failed to take necessary actions and address the drastic steps needed in the face of this critical issue.[244] The ESA can provide a potential framework to introduce phylogenetics into conservation law. As it stands, the ESA has succeeded in preventing the extinction of the vast majority of those species fortunate enough to be listed.[245] However, when a species' population numbers are low enough to warrant listing, the genetic variation left within those populations may not be nearly enough to survive the Anthropocene.[246] The Services that administer the ESA already face resource constraints in the ability to list species and provide adequate protection to already listed species.[247] A new statute, such as the PPA, would proactively address the preservation of populations that have wide genetic variation within their evolutionary tree. Alongside providing a more proactive protection scheme, it would also provide additional funding and resources to meet this objective. The PPA has the potential to provide a federally funded, localized, and science-based approach to conservation law.

On a planetary scale, we are running out of time to technologically design our way out of our problems. [248] A more simplistic solution, both economically (relative to the costs incurred from cumulative ecosystem collapse) and temporally, is to work with nature to assist species in evolving through the damage we have already created for them.[249] There are certain consequences of our actions that cannot—and will not—be halted or changed in time.[250] The Amazon Rain Forest, the lungs of our planet, has a low chance

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243. IPCC, *supra* note 34, at 2–16.

244. The Biden Administration, thus far, has placed a strong emphasis on combating climate change and addressing adaptation and mitigation in response to the damage already done. However, the ability of Congress to take the hard initiative of implementing large scale response to species degradation is yet to be seen and may not be seen. *See* Jennifer Ludden, *Biden Will Face Major Limits to His Ambitious Climate Plans*, NAT'L PUB. RADIO (Nov. 8, 2020), https://www.npr.org/2020/11/08/932160547/biden-will-face-major-limits-to-his-ambitious-climate-plans (discussing the hurdles that lay ahead for Biden's climate initiative).

245. Jacobson, *supra* note 57.

246. *See* Hoffmann, *supra* note 7, at 480–82 (discussing how genetic variation, climate change pressures, and adaptation relate to trait selection in species ability to evolve with the rate of climate change).

247. In 2016 alone, it cost FWS and NMFS about $1.5 billion dollars to administer the ESA when factoring in the consultation work done with other agencies. *See* Gordon, *supra* note 200.

248. *See generally* IPCC, *supra* note 34 (showing just how many actions we collectively need to make in order to avert the worst-case scenarios of climate change and the amount of time we have to do so).

249. *See generally* IPCC, *supra* note 34 (discussing a multitude of various challenges we face and making nature-based suggestions on how to prevent some of the worst effects of climate change).

250. *See generally* IPCC, *supra* note 34 (finding that certain effects from the carbon we have emitted into the atmosphere have been locked in as climate consequences).

of surviving as we wait for legal protections to be implemented.[251] Carbon emissions are projected to exceed the Paris Agreement's recommended parts per million in order to keep the planet below a warming of 2ºC.[252] In the meantime, those within the legal field should be working alongside scientists to create proactive frameworks, not just reactionary ones.[253] The problems we will collectively face downstream will require all hands on deck. One critical aspect of this puzzle is to provide species with all the tools possible to ensure that they can evolve and adapt through these problems as we attempt to solve them.

251. Matt Sandy & Sebastian Liste, *The Amazon Rainforest is Nearly Gone. We Went to the Frontline to See if it Could be Saved*, TIME (Sept. 12, 2019), https://pulitzercenter.org/reporting/amazon-rainforest-nearly-gone-we-went-front-lines-see-if-it-could-be-saved.

252. Nicola Jones, *How the World Passed a Carbon Threshold and Why it Matters*, YALE SCH. ENV'T (Jan. 26, 2017), https://e360.yale.edu/features/how-the-world-passed-a-carbon-threshold-400ppm-and-why-it-matters (noting that while we have globally exceeded the recommended 400 ppm carbon threshold of the Paris Agreement, an unlikely drastic reduction in emissions could still prevent a 2ºC warming).

253. *See* Matthew Metz, *7 Ways Lawyers Can Join the Fight to Curb Climate Change*, A.B.A. J. (Feb. 27, 2020), https://www.abajournal.com/voice/article/7-ways-lawyers-can-join-the-fight-to-curb-climate-change (advocating for lawyers to use their skillsets to work on behalf of all of the problems we face with climate change).