Hybridizing Law: A Policy for Hybridization Under the Endangered Species Act

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Summary

For centuries, hybridization was a poorly understood process thought to be a threat to endangered species. With the advent of genomic technologies, those views are starting to change; hybridization is now recognized as vital for the formation and continued persistence of many species. However, our current system of protection under the Endangered Species Act (ESA) fails to take many of the modern nuances of evolutionary biology into consideration. Despite calls for an explicit "hybrid policy" since the early 1990s, the U.S. Fish and Wildlife Service and National Marine Fisheries Service have instead chosen to apply a case-by-case approach with no guidance or overarching policy. With the new technologies, many species we are currently protecting could technically be unsuitable for protection based on a rigid interpretation of the ESA. A defined hybrid policy must be adopted, taking into consideration the twin aims of protecting genetic lineages and protecting ecosystems.

"This animal is not an endangered species. This animal is a hybrid and should be delisted immediately."[1] "They absolutely invented a species and called it endangered."[2] These were just a couple of the plethora of rebukes directed at the U.S. Fish and Wildlife Service (FWS) condemning the continued protection of the red wolf (*Canis lupus*) in light of recent findings. For decades, the taxonomic status of red wolves has been up in the air: is it a distinct species, a subspecies of gray wolves or coyotes, a recent hybrid population between gray wolves or coyotes, or some mix of all of these different hypotheses?[3] A 2016 genomic study seems to have answered this question once and for all: the red wolf is a population of hybrids formed, primarily since the 1800s, from gray wolves and coyotes.[4]

The red wolf has been one of the flagship species for protection under the Endangered Species Act (ESA), yet, as the aforementioned quotes hint, under the current implementation of the ESA, hybrids are not afforded protection. Is this just "a case of well-intentioned biologists going back several decades, trying to bring back a species they believed existed,"[5] suggesting the red wolf does not deserve continued protected status? Or, in spite of their hybrid status, does there exist significant biological justification to continue protecting red wolves, and other hybrids? These are the questions our policymakers and wildlife managers are forced to answer, despite a decided lack of legal guidance.

When the Human Genome Project was completed in 2003, few could imagine the widespread proliferation of these sequencing technologies just a decade later.[6] That first genome cost $2.7 billion dollars and nearly 15 years to complete; today, a genome can be sequenced for under $2,000 in days to weeks.[7] These drastic reductions in cost have driven all the major fields in biology to new heights, perhaps none more so than wildlife conservation.[8] Conservation genetics traditionally utilized just a few genes, yet,

1. Quote from Gary Mowad, a former Deputy Chief of Law Enforcement for the U.S. Fish and Wildlife Service (FWS), found in William LaJeunesse, *Feds Mull Whether to Remove Red Wolf From Endangered Species List*, Fox News, Sept. 22, 2016, http://www.foxnews.com/us/2016/09/22/feds-mull-whether-to-remove-red-wolf-from-endangered-species-list.html.
2. Quote from Scott Griffin from the group Citizens Science, found in LaJeunesse, *supra* note 1.
3. Steven M. Chambers et al., *An Account of the Taxonomy of North American Wolves From Morphological and Genetic Analyses*, 77 N. Am. Fauna 1 (2012).
4. 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*, 2 Sci. Advances e1501714 (2016).
5. Quote from Gary Mowad, found in LaJeunesse, *supra* note 1.
6. National Human Genome Research Institute, *The Cost of Sequencing a Human Genome*, https://www.genome.gov/sequencingcosts/ (last updated July 6, 2016).
7. *Id.*
8. Fred Allendorf et al., *Genomics and the Future of Conservation Genetics*, 11 Nature Revs. Genetics 697 (2010).

today, we can use millions of markers from throughout the genome.[9] This change in technology has ushered in a paradigm shift in evolutionary biology. Increasingly, biologists are coming to understand the dynamism of nature and the complexity of its systems. We can apply these novel techniques and our shifting understanding of evolution to answer age-old questions, such as the nature of hybridization and speciation.[10]

Hybridization, when individuals from one species or population interbreed with individuals from another species or population, has become recognized as a natural and, in many cases, vital process for evolution.[11] However, our laws on endangered species protection are found lacking in the face of modern biology.[12] There are no measures written into the ESA that explicitly offer protection to hybrids; the word hybrid, or its synonyms, were never included in this pivotal piece of legislation.[13] This potential lack of coverage for hybrids drew attention from scientists and academics as early as 1991,[14] yet to this day, a comprehensive policy on hybrids has never been adopted. In 1996, a rule, the so-called intercross policy, was proposed; however, it never became a final rule.[15] Yet, even this policy, if passed today, would be outdated and sorely in need of an upgrade. The ubiquity of genomic technologies has opened our eyes to the vast number of hybrids living amongst us, and without their proper protection, our ecosystems and wildlife will suffer.[16]

Part I of this Article will provide a crash course in the biology behind hybridization, taxonomy, and speciation, as well as explain why this biology is important to consider in the context of protecting wildlife. Part II will highlight the basics of the ESA and focus on the failure of the ESA to cover hybridization. In Part III, through an analysis of listing petitions in the *Federal Register*, I will examine how hybridization is being dealt with under the case-by-case framework currently in place. Part IV puts forth a more justifiable policy that better reflects our understanding of hybridization in an ecological sense, and Part V offers examples for how this new policy would be applied to current hybridization issues. Part VI projects the policy forward into the future, and Part VII concludes.

9. *Id.*
10. Benjamin M. Fitzpatrick et al., *Hybridization and the Species Problem in Conservation Genetics*, 61 Current Zoology 206 (2015).
11. *Id.*
12. Robert K. Wayne & H. Bradley Shaffer, *Hybridization and Endangered Species Protection in the Molecular Era*, 25 Molecular Ecology 2680 (2016).
13. Susan M. Haig & Fred W. Allendorf, *Hybrids and Policy*, *in* 2 The Endangered Species Act at Thirty: Conserving Biodiversity in Human-Dominated Landscapes 150 (J. Michael Scott et al. eds., Island Press 2006).
14. Stephen J. O'Brien & Ernst Mayr, *Bureaucratic Mischief: Recognizing Endangered Species and Subspecies*, 251 Science 1187 (1991).
15. Endangered and Threatened Wildlife and Plants: Proposed Policy and Proposed Rule on the Treatment of Intercrosses and Intercross Progeny (the Issue of "Hybridization"); Request for Public Comment, 61 Fed. Reg. 4710 (Feb. 7, 1996) (to be codified at 50 C.F.R. pt. 424) [hereinafter Intercross Policy].
16. Wayne & Shaffer, *supra* note 12.

I. Biology of Hybridization

A. *Defining Species Biologically*

To adequately preserve endangered species, there must be some method for determining what constitutes a species.[17] In a reality of finite resources and opposing world views, protecting any and all organisms is unfeasible and irresponsible; policymakers and wildlife managers must therefore decide what groups are in need of protection as well as what individuals qualify for membership in said group. The field of taxonomy is one of the oldest in history; humanity has been categorizing nature long before Linnaeus or even Aristotle tried to catalogue the natural world. Yet, the more we learn about biology, the more we are confounded by the realities of nature and evolution. Nothing is static, not even the species that walk the earth.

Few biologists doubt the veracity of the concept of species, yet defining the term is one of the great unanswered questions of evolutionary biology; to date, 26 prominent species concepts have arisen since Darwin.[18] Though a wide range of scientific, philosophical, or more esoteric differences separate them, Ernst Mayr's biological species concept (BSC) is the most widely accepted today.[19] Mayr postulated that a species was a population of organisms that could reproduce with each other yet were unable to successfully breed with other organisms from other populations.[20] This idea of reproductive isolation is still used today by many biologists, despite an obvious and ever-growing list of exceptions.[21] Chief among these exceptions is the issue of hybridization.[22]

B. *Biology of Hybridization*

Hybridization is the interbreeding of individuals from distinct genetic lineages.[23] In the most popular sense of the word, hybridization occurs at the species level, violating the BSC. However, biologists often use hybridization to describe interbreeding between subspecies or populations as well.[24] Additionally, introgression is the process where genetic material flows from one species into the other through hybridization.[25] Genomes become admixed when hybridization occurs between two groups and the genetic material persists through time and recombination.[26] Thus, a hybrid is an individual arising from this interbreeding.[27]

17. Richard Frankham et al., Introduction to Conservation Genetics (2d ed., Cambridge Univ. Press 2010).
18. Richard Frankham et al., *Implications of Different Species Concepts for Conserving Biodiversity*, 153 Biological Conservation 25 (2012).
19. *Id.*
20. Ernst Mayr, Systematics and the Origin of Species From the Viewpoint of a Zoologist (Columbia Univ. Press 1942).
21. James Mallet, *Hybridization as an Invasion of the Genome*, 20 Trends Ecology & Evolution 229 (2005).
22. *Id.*
23. Fred W. Allendorf et al., *The Problem With Hybrids: Setting Conservation Guidelines*, 16 Trends Ecology & Evolution 613 (2001).
24. *Id.*
25. *Id.*
26. *Id.*
27. *Id.*

Hybrids belong to both no species and two species at once: they are an admixture of genes from both of their parent species.[28] The concept of reproductive isolation breaks down in the face of hybridization.[29] Having two species produce viable offspring between them, on the face of it, violates this binary concept of reproductive isolation and the BSC.[30] Despite often being two distinct units—genetically, phenotypically, and ecologically discrete—these species are able to mix; the reproductive barrier between some species is at least semipermeable.[31] Ultimately, nature defies categorization.

Evolution is a gradual process, and there is an extended period where a population has diverged from the rest of its species but has not sufficiently differentiated itself to the point of reproductive isolation.[32] For vertebrates, it is exceedingly rare for species to differentiate themselves instantly; it can take millions of years for complete reproductive isolation to happen.[33] This intermediate zone is where subspecies and other subspecific taxonomic rankings exist, and it is where hybrids are able to form.[34] The process of speciation is on a continuous scale and drawing lines is inherently arbitrary.[35]

Like speciation, hybridization is yet another place where biologists and policymakers have used a discrete model to explain a continuous pattern of variation.[36] Hybridization can work to completely eradicate endangered taxa or it can create new species. Hybridization can decrease the fitness of a taxon or add novel adaptive variation. Sometimes it is anthropogenically induced, and other times, it is a natural feature of the environment that existed long before mankind. There is no one-size-fits-all approach.[37] The question of whether the process of hybridization is good or bad, beneficial or negative, can never truly be answered; hybridization is simply a process that can and will occur under the necessary conditions. Only after placing some aesthetic, ethical, environmental, or monetary value on an endangered or threatened taxon can scientists, lawmakers, and the general public analyze whether hybridization is having a beneficial or negative effect on said endangered taxon.

Hybridization thus proves inherently difficult to reconcile within a strict legal framework of species-based conservation.[38] The problems it poses for our current, rigid protection system will only continue to grow as a byproduct of the ubiquity of genomic sequencing techniques.[39] Detecting hybridization was traditionally one of the most difficult barriers to overcome when making management decisions about species protection.[40] Genomics, however, allows us to find and understand hybridization at the finest scale of resolution; thus, detecting hybridization is no longer a great hurdle.[41]

Genomics has allowed scientists to probe the depths of evolutionary history to its fullest extent; the more genomes we sequence, the more admixture we continue to find.[42] Wolves and coyotes,[43] brown bears and polar bears,[44] and even humans and our extinct ancestors all share significant portions of their genomes. Between 1% and 5% of any given human genome introgressed into our genomes from Neanderthals[45] or Denisovans.[46] Now that we know admixture is widespread and hybridization is both an important evolutionary process and a potential threat to species, the real problem is synthesizing what we know into a cohesive legal scheme under the umbrella of the ESA.[47]

II. The ESA and Hybridization

A. *ESA Overview*

The ESA, building on two earlier laws, is "the most comprehensive legislation for the preservation of endangered species ever enacted by any nation."[48] The U.S. Congress made its purpose explicitly clear: "to provide a means whereby the ecosystem upon which endangered species and threatened species depend may be conserved and to provide a program for the conservation of such species."[49] To make its intent unequivocal, Congress defined "conserve" as "to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer needed."[50] Congress felt that "these species of fish, wildlife, and plants are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people."[51]

To date, no legislation for the protection of biodiversity has caused as much controversy as the ESA.[52] When it first passed, however, there was little opposition to the Act, seemingly few disagreements on the U.S. House of Representatives or U.S. Senate floors, and even less fanfare

28. Mallet, *supra* note 21.
29. *Id*.
30. *Id*.
31. Richard G. Harrison & Eric L. Larson, *Hybridization, Introgression, and the Nature of Species Boundaries*, 105 J. Heredity 795 (2014).
32. Fitzpatrick et al., *supra* note 10.
33. *Id*.
34. Mallet, *supra* note 21.
35. Fitzpatrick et al., *supra* note 10.
36. *Id*.
37. *Id*.
38. Haig & Allendorf, *supra* note 13.
39. Wayne & Shaffer, *supra* note 12.
40. Haig & Allendorf, *supra* note 13.
41. Wayne & Shaffer, *supra* note 12.
42. *Id*.
43. Bridgett M. vonHoldt et al., *A Genome-Wide Perspective on the Evolutionary History of Enigmatic Wolf-Like Canids*, 21 Genome Res. 1294 (2011).
44. James A. Cahill et al., *Genomic Evidence of Geographically Widespread Effect of Gene Flow From Polar Bears Into Brown Bears*, 24 Molecular Ecology 1205 (2015).
45. Richard E. Green at al., *A Draft Sequence of the Neanderthal Genome*, 328 Science 710 (2010).
46. David Reich et al., *Genetic History of an Archaic Hominin Group From Denisova Cave in Siberia*, 468 Nature 1053 (2010).
47. Wayne & Shaffer, *supra* note 12.
48. Tennessee Valley Auth. v. Hill, 437 U.S. 153, 180, 8 ELR 20513 (1978).
49. 16 U.S.C. §1531(b) (1976).
50. *Id*. §1531(c) (1976).
51. *Id*. §1531(a)(3) (1976).
52. Mark W. Schwartz, *The Performance of the Endangered Species Act*, 39 Ann. Rev. Ecology, Evolution & Systematics 279, 280 (2008).

from the national media or scientific community.[53] Many of those voting on the Act supposedly did not fully comprehend the full power the ESA would have to halt and stall development.[54]

Though the ESA has been amended a number of times since 1973, the key provisions have remained on the books. Since 1988, however, "legislative gridlock and risk aversion on all political sides" has prevented further amendments.[55] Instead, it has fallen on FWS and the National Marine Fisheries Service (NMFS) to implement and, where necessary, promulgate rules interpreting the ESA.

B. *Defining Species Legally*

Perhaps the most overarching modern criticism of the ESA is that it assumes an overly simplistic and static view of nature.[56] This is especially true when looking at how the ESA decides what is to be protected.[57] The ESA as a document takes a somewhat fixed view of species, yet evolution does not make species-based conservation an easy task to consistently apply.[58] Though evolution was discussed during the drafting of the document, the final result still reads more natural historian than evolutionary biologist.

When first passed in 1973, the ESA defined a species as "any subspecies of fish or wildlife or plants or any other group or wildlife of the same species or smaller taxa in common spatial arrangement that interbreed when mature." This definition is in some ways obviously contradictory, such as equating a subspecies to a species, yet it does succeed in describing what should be protected, even if that unit of protection does not actually align with any biological definitions. The Act itself gives no definition of the terms "species" or "subspecies" as used within the definition of "species."

Instead, the basis for determinations of endangered or threatened species is to be made "solely on the basis of the best scientific and commercial data available . . . after conducting a review of the status of the species and after taking into account those efforts."[59] FWS has interpreted this as "considering all available data involving as many different classes of characters as possible" for determining taxonomy, with relevant characteristics including: "morphological, karyological (chromosomal), biochemical (including deoxyribonucleic acid (DNA) analysis and other molecular genetic techniques), physiological, behavioral, ecological, and biogeographic characters."[60]

The Administrative Procedure Act (APA) gives FWS and NMFS the authority to interpret the ESA, including how to interpret the definition of "species" within the loose framework Congress provided.[61] Thus, these interpretations, or rulemaking procedures, are subject to judicial review under the APA.[62] When determining the level of deference an agency should be afforded when interpreting statutory schemes, the U.S. Supreme Court devised a two-step test in *Chevron U.S.A. v. Natural Resources Defense Council, Inc.*[63] This *Chevron* deference is designed to allow agencies, not courts, to make policy decisions within their realm of delegated authority.[64] Deference is considered especially great when "reviewing technical matters within its area of expertise, particularly in its choice of scientific data and statistical methodology."[65] Overcoming this high level of deference is therefore exceedingly difficult for petitioners unhappy with FWS or NMFS interpretations of the ESA.[66]

Additionally, a court will not overturn agency action unless it determines that the action was "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law."[67] This arbitrary and capricious standard for review is a "narrow one" and the court "must consider whether the decision was based on a consideration of the relevant factors and whether there has been a clear error of judgment."[68]

C. *Distinct Population Segment*

In 1978, an amendment to the ESA tweaked the definition of species.[69] Today, it reads, "[T]he term species includes 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."[70] This amendment added the "distinct population segment" (DPS) as an additional unit that could be protected, removing the original "smaller taxa in common spatial arrangement."[71] Yet, Congress did not define what a DPS actually is, and it was left to the agency rulemaking process to define it. DPS has no biological meaning and was developed in the halls of Washington, not those of academia.[72] It was not until

53. Holly Doremus, *The Endangered Species Act: Static Law Meets Dynamic World*, 32 Wash. U. J.L. & Pol'y 175, 177 (2010).
54. *Id*.
55. *Id*.
56. *Id*.
57. *Id*.
58. Fitzpatrick et al., *supra* note 10.
59. 16 U.S.C. §1533(b)(1)(A) (1976).
60. Alabama-Tombigbee Rivers Coalition v. Kempthorne, 477 F.3d 1250, 1255, 37 ELR 20040 (11th Cir. 2007).
61. 5 U.S.C.A. §§500 et seq.
62. *Id.* §553.
63. 467 U.S. 837, 842-44, 14 ELR 20507 (1984).
64. Laurence Michael Bogert, *That's My Story and I'm Stickin' to It: Is the "Best Available" Science Any Available Science Under the Endangered Species Act?*, 31 Idaho L. Rev. 85 (1994).
65. Louisiana v. Verity, 853 F.2d 322, 329, 18 ELR 21351 (5th Cir. 1988).
66. Bogert, *supra* note 64.
67. 5 U.S.C.A. §706(2)(A).
68. Citizens to Pres. Overton Park, Inc. v. Volpe, 401 U.S. 402, 1 ELR 20110 (1971).
69. Endangered Species Act Amendments of 1978, Pub. L. No. 95-632, §2(5), 92 Stat. 3751 (codified as amended at 16 U.S.C. §1532).
70. 16 U.S.C. §1532.
71. *Id.*
72. The concept of DPS is modeled around the biological concept of evolutionarily significant units (ESU). The most commonly accepted definition of ESU today is: "substantially reproductively isolated from other conspecific population units, and [that] represents an important component in the evolutionary legacy of the species." *See* Robin Waples, *Evolutionarily Significant Units and the Conservation of Biological Diversity Under the Endangered Species Act*, 17 Am. Fisheries Soc'y Symp. 8 (1995); Oliver A. Ryder, *Species Conservation and Systematics: The Dilemma of Subspecies*, 1 Trends Ecology & Evolution 9 (1986).

1996 that FWS and NMFS promulgated a joint policy for recognition of DPS.[73]

Under this joint policy, DPS status is determined by: "(1) [the] [d]iscreteness of the population segment in relation to the remainder of the species to which it belongs; [and] (2) [t]he significance of the population segment to the species to which it belongs."[74] The joint policy offers two conditions that can be met for the discreteness element to be satisfied: the population is "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors" or it is "delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant."[75] Significance, on the other hand, can be demonstrated in four different ways: (1) persistence of the DPS in an ecological setting unusual or unique for the taxon; (2) loss of the DPS would result in a significant gap in the range of a taxon; (3) evidence that the DPS represents the only natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; or (4) the DPS differs markedly from other populations of the species in its genetic characteristics.[76] However, the policy also noted that "it is not possible to describe prospectively all the classes of information that might bear on the biological and ecological importance of a DPS."[77]

D. History of Hybrids Under the ESA

The way species are defined has significant effects on how hybrids are protected.[78] As stated above, hybrids are, by their very nature, impossible to classify in a traditional taxonomic scheme, making legal protection based around these traditional taxonomic schemes equally improbable. Hybridization was simply not on the drafters' minds in 1973.[79] Still, to this day, the ESA includes no mention of hybrids, even though much has changed in the associated science and the way the Act has been implemented.

The topic of hybrid protection under the ESA was first broached in a series of correspondence with the solicitor of the U.S. Department of the Interior (DOI), beginning in 1977.[80] Responding to a general inquiry by the Division of Law Enforcement of FWS, the solicitor reasoned that the ESA offered protection to hybrids.[81] The solicitor felt that hybrids fit within the statutory definition of "fish or wildlife": "any member of the animal kingdom, including without limitation any mammal, fish, bird, . . . amphibian, reptile, mollusk, crustacean, arthropod, or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof."[82] Offspring of a protected animal should be protected according to this piece of the statute.

Within one year, however, this policy was overturned and replaced.[83] Agency biologists from FWS were concerned about potential genetic swamping.[84] This led the solicitor to fear that common species might interbreed with purebred endangered species and negatively affect the gene pool or outcompete the endangered species, driving them out of their preferred niche and habitat.[85] On this basis, the solicitor argued that protecting hybrids was in fact incompatible with the conservation of endangered species.[86] The agency and the solicitor now believed hybrids were a threat to endangered species and protection of such hybrids would be detrimental.[87] This led to FWS, well into the 1990s, treating hybrids as threats to endangered species in all cases and affording hybrids no protection.

This new policy would be put to the test numerous times in the following years, most tragically with the dusky seaside sparrow (*Ammodramus maritimus nigrescens*) subspecies.[88] By 1981, the dusky seaside sparrow population had declined to five individuals, all males.[89] Biologists crossed these captured individuals with the morphologically similar Scott's seaside sparrow (*A. m. peninsulae*), and had planned to continue to backcross these hybrid sparrows with the pure dusky seaside sparrows before eventually reintroducing this population back into the wild.[90] While these hybrid sparrows would eventually look, even at the nuclear genome level, like their dusky ancestors, they would never regain the lost mitochondrial genome, as it is maternally inherited. Mitochondrial DNA was the main phylogenetic marker during this era, and a complete loss of the mitochondrial genome likely played a significant role in this decision.[91] The Office of the Solicitor, however, made it clear that these hybrids would not be considered dusky seaside sparrows, regardless of backcrosses, they would not be protected under the ESA, and federal funds could therefore not be used for the hybridization project.[92] The dusky seaside sparrow was declared extinct in 1987,

73. Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act, 61 Fed. Reg. 4722, 4722 (Feb. 7, 1996) [hereinafter Joint DPS Policy].
74. *Id*.
75. *Id*.
76. *Id*.
77. *Id*.
78. Haig & Allendorf, *supra* note 13.
79. Kevin D. Hill, *The Endangered Species Act: What Do We Mean by Species?*, 20 B.C. Envtl. Aff. L. Rev. 239, 243 (1993).
80. *Id*. at 243 (citing Memorandum from Assistant Solicitor, FWS, to the Chief, Division of Law Enforcement FSW (May 18, 1977) (on file with author)).
81. *Id*.
82. *Id*.
83. *Id*. at 243 (citing Memorandum from Assistant Solicitor, FWS, to Deputy Associate Director, Federal Assistance, FWS 1 (Aug. 2, 1977) (on file with author)).
84. *Id*.
85. *Id*.
86. *Id*.
87. *Id*.
88. Haig & Allendorf, *supra* note 13.
89. Frances C. James, *Miscegenation in the Dusky Seaside Sparrow?*, 30 BioScience 800 (1980).
90. *Id*.
91. *Id*.
92. Hill, *supra* note 79, at 243 (citing Memorandum from Assistant Solicitor, FWS, to Associate Director, Federal Assistance, FWS (May 6, 1981) (on file with author)).

the most notable casualty of the lack of a comprehensive hybrid policy.[93]

Also during this time period, the Office of the Solicitor determined that hybrids between two listed endangered species, in this case the gray wolf (*Canis lupus*) and the red wolf (*Canis rufus*), were still not deserving of protection. The solicitor reasoned that even though both were endangered, by hybridizing, the "genetic heritage" of the gray wolf and red wolf would not be conserved by protection of the hybrids because it would not protect the "pure genetic stock of the parents."[94]

The only place where hybridization was apparently tolerated during this time period was at the population level. Woodland caribou (*Rangifer tarandus caribou*) from the same subspecies but geographically isolated populations were used for population augmentation.[95] Essentially, this decision drew an arbitrary line between the subspecies and population level where hybridization would be allowed.

Unsurprisingly, this kind of draconian bright-line standard brought the ire of biologists who argued for a more science-informed, flexible "hybrid policy."[96] Stephen O'Brien and Mayr, two of the most prominent evolutionary biologists of the era, famously pointed out that two of the ESA's flagship species, the Florida panther (*Felis concolor coryi*), which had hybridized with a different puma subspecies from South America that escaped from a local zoo, and the red wolf, for which evidence was beginning to suggest an ancient hybrid origin, would not be protected under the current status quo.[97] In 1990, FWS noted a need to revisit its earlier position, as hybridization is "more properly a biological issue than a legal one."[98] In 1996, the agencies proposed the "intercross policy."[99]

In some aspects, this policy was a massive step forward in recognizing the role hybridization plays in the natural world; it recognized some of the varied roles hybridization has played historically, that some taxa may have come from hybrid origins, and that genetic rescue could, despite the hybridization it requires, be viable in extreme situations of low genetic diversity.[100] This policy determined that crosses between a listed taxon and an unlisted taxon will be protected under the ESA if the progeny "share the traits that characterize the taxon of the listed parent and the progeny more closely resemble the listed parent's taxon than an entity intermediate between it and the other known or suspected non-listed parental stock."[101] Additionally, it recognizes and offers protection to species of hybrid origins, as they are "self-sustaining, naturally occurring taxonomic species."[102]

Despite some progress from the days when the dusky seaside sparrow was allowed to go extinct, there were still substantial issues with this intercross policy, culminating in it never being adopted.[103] Too much focus is spent on identifying individuals as hybrids, essentially establishing a 75% similarity threshold. Additionally, the entire emphasis is based around hybrid individuals, not populations, and natural hybridization is not formally referenced. This policy has never made it through the end of the rulemaking process, and though it theoretically could still be finalized today, it seems increasingly unlikely.

FWS' stance on hybrids today is probably best laid out in the controversial case of the westslope cutthroat trout (WCT). As stated in a proposed rule:

> Understanding . . . the wide range of possible outcomes resulting from exchanges of genetic material between taxonomically distinct species . . . requires the Service to address these situations on a case-by-case basis. In some cases, introgressive hybridization may be considered a natural evolutionary process reflecting active speciation or simple gene exchange between naturally sympatric species. In other cases, hybridization may be threatening the continued existence of a taxon due to anthropogenic factors or natural environmental events. In many cases, introgressed populations may contain unique or appreciable portions of the genetic resources of an imperiled or listed species. . . . [T]he Service plans to carefully evaluate the long-term conservation implications for each taxon separately on a case-by-case basis where introgressive hybridization may have occurred. The Service shall perform these evaluations objectively based on the best scientific and commercial information available consistent with the intent and purpose of the Act.[104]

The WCT presented a significant challenge to hybrid management. Though more thorough accounts of the legal battles over this fish species abound, I will briefly recount it here.[105] The WCT readily hybridizes with rainbow trout that have been stocked into streams for the purpose of sport fishing.[106] FWS originally declined to list the WCT, determining that the species was widespread, despite the fact that the vast majority of populations suffered from significant introgression.[107] The courts struck this down, as

93. Robert M. Zink & Herbert W. Kale, *Conservation Genetics of the Extinct Dusky Seaside Sparrow* Ammodramus Maritimus Nigrescens, 74 Biological Conservation 69 (1995).
94. Hill, *supra* note 79, at 243 (citing Memorandum from the Assistant Solicitor, FWS, to the Regional Solicitor, Northeast Region, FWS (Sept. 21, 1983) (on file with author)).
95. *Id*. at 243 (citing Memorandum from Assistant Solicitor, FWS, to Associate Director, Federal Assistance, FWS (Aug. 24, 1984) (on file with author)).
96. O'Brien & Mayr, *supra* note 14.
97. *Id*.
98. Intercross Policy, *supra* note 15 (citing Memorandum from Assistant Solicitor for Fish and Wildlife, U.S. Department of the Interior, to Director, FWS (Dec. 14, 1990)).
99. Intercross Policy, *supra* note 15.
100. *Id*.
101. *Id*.
102. *Id*.
103. Haig & Allendorf, *supra* note 13.
104. Endangered and Threatened Wildlife and Plants: Reconsidered Finding for an Amended Petition to List the Westslope Cutthroat Trout as Threatened Throughout Its Range, 68 Fed. Reg. 46989 (Aug. 7, 2003) (to be codified at 50 C.F.R. pt. 17) [hereinafter Reconsidered WCT Listing].
105. Fred W. Allendorf et al., *Intercrosses and the U.S. Endangered Species Act: Should Hybridized Populations Be Included as Westslope Cutthroat Trout?*, 18 Conservation Biology 1203 (2004).
106. Reconsidered WCT Listing, *supra* note 104.
107. 12-Month Finding for an Amended Petition to List the Westslope Cutthroat Trout as Threatened Throughout Its Range, 65 Fed. Reg. 20120

FWS did not adequately explain its reasoning for including hybrid populations.[108] Next, FWS changed the listing determination to include populations within the historic range of WCT that appeared morphologically to be WCT, as these were presumed to "express the behavioral, ecological, and life-history characteristics of WCT."[109] This time, the courts upheld this approach.[110] Today, introgression between the two species is still the major threat against the WCT, and continued research into mitigating this introgression is still occurring.[111]

III. Hybridization Under the ESA Today

Since the WCT decision, FWS has been more or less silent on the issue of hybridization: they have operated on a case-by-case basis. The biology community, however, has consistently railed against this non-policy, with calls for "flexible frameworks" and refusals of "one-size-fits-all approaches."[112] It has now been nearly two decades since the WCT decisions, and an empirical look at how the agencies treat hybrids today is important for any exercise in trying to develop a hybrid policy moving forward. Thus, I examined all of the petitions for listing and delisting in the *Federal Register* that mentioned hybrids or hybridization.[113] From these examples, we can draw a few conclusions about how hybridization is viewed during this era of case-by-case decisionmaking.

A. Hybridization as a Threat to Endangered Species

Hybridization can be particularly dangerous for endangered or threatened species,[114] and this was often noted by the agencies in the *Federal Register* as a key reason for listing. When a population is small, any migration in can have a significantly large effect; if you have a population of 10 individuals and one is a first-generation (F1) hybrid, 5% of your gene pool is now a different species.[115] When this migration comes in the form of introgression from some outside source, you can even have disproportionate effects, with heterosis[116] and outbreeding depression[117] at either extreme.[118] Hybridization occurring at sufficient frequency can lead to complete genetic assimilation, also known as genetic swamping or genomic extinction, where a rare taxon admixes with a more common taxon to the point where it is completely subsumed back into the more common taxon.[119] Rare and endangered taxa can thus easily be bred out of existence, solely represented by insignificant portions of the genome, with no "pure" individuals left on the landscape.[120]

These processes are often driven by anthropogenic factors, such as invasive species and habitat loss.[121] Threats of hybridization with an invasive species were involved in the proposed listing of the Sierra Nevada red fox (*Vulpes vulpes necator*)[122] and the Sonoran population of desert tortoise (*Gopherus agassizii*).[123] Though not explicitly stated, in these scenarios, hybrids would apparently not be protected. For Franciscan manzanita (*Arctostaphylos franciscana*), only individuals of known origin were to be protected, and the plethora of lines that have been cultivated for private or commercial uses were not to be protected based on concerns about hybridization.[124]

Threats of genetic swamping are not limited solely to invasive species, however. Hybridization from a natural, sympatric species was mentioned multiple times in listing petitions as a threat to endangered taxa such as the dusky sea snake (*Aipysurus fuscus*).[125] There have been

(Apr. 14, 2000) (to be codified at 50 C.F.R. pt. 17) [hereinafter WCT Amended Petition].

108. American Wildlands v. Norton, 193 F. Supp. 2d 244, 257, 32 ELR 20548 (D.D.C. 2002).
109. WCT Amended Petition, *supra* note 107.
110. American Wildlands v. Kempthorne, 530 F.3d 991, 38 ELR 20165 (D.C. Cir. 2008).
111. Ryan P. Kovach et al., *Dispersal and Selection Mediate Hybridization Between a Native and Invasive Species*, 282 Proc. Royal Soc'y Biological Sci. 2014.2454 (2015).
112. For a few most recent examples, see generally Wayne & Shaffer, *supra* note 12; Fitzpatrick et al., *supra* note 10; Raeyna N. Jackiw et al., *A Framework to Guide the Conservation of Species Hybrids Based on Ethical and Ecological Considerations*, 29 Conservation Biology 1040 (2015); Sarah Piett et al., *Characteristics for Evaluating the Conservation Value of Species Hybrids*, 24 Biodiversity & Conservation 1931 (2015); Astrid V. Stronen & Paul C. Paquet, *Perspectives on the Conservation of Wild Hybrids*, 167 Biological Conservation 390 (2013); Norman C. Ellstrand et al., *Got Hybridization? A Multidisciplinary Approach for Informing Science Policy*, 60 BioScience 384 (2010).
113. To do this, I searched through the *Federal Register* on Westlaw filtering for "hybrid" and "listing" and "endangered" or "threatened" after January 1, 2007.
114. Judith M. Rhymer & Daniel Simberloff, *Extinction by Hybridization and Introgression*, 27 Ann. Rev. Ecology & Systematics 83 (1996).
115. Frankham et al., *supra* note 17.
116. Heterosis, or hybrid vigor, occurs when the hybrid offspring has increased fitness relative to its parents and is the result of increasing genetic diversity, which is nearly always reduced in small populations through drift and inbreeding. This higher fitness will often ensure that these hybrids will proliferate by reproducing further, adding to the population admixture and further diluting the "pure" gene pool. *See generally* Rhymer & Simberloff, *supra* note 114.
117. Outbreeding depression can occur when two taxa that are too evolutionarily distant hybridize. While sterility, best demonstrated by mules, is one distinct possibility, hybrids between some species manage to still be fertile while showing a decrease in fitness, which, despite being selected against, may still proliferate, especially in small populations where the efficacy of selection is reduced. This decrease in fitness associated with outbreeding depression among hybrids is often due to the loss of locally adapted alleles. *See generally* Frankham et al., *supra* note 17.
118. Rhymer & Simberloff, *supra* note 114.
119. *Id*.
120. *Id*.
121. Allendorf et al., *supra* note 23.
122. Endangered and Threatened Wildlife and Plants: 12-Month Finding on a Petition to List Sierra Nevada Red Fox as an Endangered or Threatened Species, 80 Fed. Reg. 60990 (Oct. 8, 2015) (to be codified at 50 C.F.R. pt. 17).
123. Endangered and Threatened Wildlife and Plants: 12-Month Finding on a Petition to List the Sonoran Population of the Desert Tortoise as Endangered or Threatened, 75 Fed. Reg. 78094 (Dec. 14, 2010) (to be codified at 50 C.F.R. pt. 17).
124. Endangered and Threatened Wildlife and Plants: Determination of Endangered Status for *Arctostaphylos Franciscana* (Franciscan Manzanita) Throughout Its Range, 77 Fed. Reg. 54434 (Sept. 5, 2012) (to be codified at 50 C.F.R. pt. 17).
125. Endangered and Threatened Wildlife and Plants: 12-Month Finding for the Eastern Taiwan Strait Indo-Pacific Humpback Dolphin, Dusky Sea Snake, Banggai Cardinalfish, Harrisson's Dogfish, and Three Corals Under the Endangered Species Act, 79 Fed. Reg. 74954 (Dec. 16, 2014) (to be codified at 50 C.F.R. pts. 223-224).

similar issues with the wood bison (*Bison bison athabascae)* and plains bison (*B. b. bison*).[126] The wood bison was in 2012 downlisted from endangered to threatened, while the plains bison is not listed.[127] Introgression from the plains bison into the wood bison is considered a conservation issue, and "wood/plains bison hybrids . . . are not protected by the Act."[128] More recent studies, however, suggest that the two subspecies are likely invalid; any effect this may have on listing is unclear.[129] Fears of hybrid swarms[130] in a number of Hawaiian plants have been documented in listing notices.[131]

B. Natural Hybridization Is Tolerated

Somewhat surprisingly, given the historical hesitance of FWS and NMFS to acknowledge hybridization as a natural part of evolution, there were a large number of listing petitions that mention hybridization as an acceptable non-threat. This is consistent with our biological understanding of hybrid zones and natural introgression.[132] Natural introgression can be evolutionarily beneficial, moving advantageous genes between lineages, despite maintaining separate evolutionary trajectories.[133] When widespread species share portions of their ranges, natural hybrid zones can form, where both species and their hybrids are all naturally found.[134] These types of interactions are important pieces of these species' evolutionary histories.[135]

The Modoc sucker (*Catostomus microps*) was originally listed under the presumption that removal of barriers to gene flow was allowing anthropogenic-mediated hybridization with the Sacramento sucker (*Catostomus occidentalis*).[136] When further research illustrated that hybridization was actually natural and did not appear to be contributing to the loss of the Modoc sucker species, this information was used in its delisting.[137] Other examples include: Neches River rose-mallow (*Hibiscus dasycalyx*),[138] Yosemite toad (*Anaxyrus canorus*),[139] British Columbia DPS of the Queen Charlotte goshawk (*Accipiter gentilis laingi*),[140] and Morelet's crocodile (*Crocodylus moreletii*).[141]

Perhaps most interesting is the case of the eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*).[142] FWS notes that evidence of historic hybridization with western massasauga rattlesnakes (*S. c. tergeminus*) has been observed.[143] Additionally, during the notice-and-comment period for the listing of the eastern massasauga rattlesnake, FWS received a comment alerting them that populations in Iowa actually showed significant introgression, about 20%, from the western species.[144] A 2016 paper, with data supporting this commenter's assertions, argued that these Iowa populations should be listed as a separate DPS.[145] FWS decided that it will "consider the northeast Iowa individuals to be eastern massasauga rattlesnakes" because they are "comprised primarily of genetic markers of the eastern massasauga rattlesnake."[146] Whether this represents that FWS is willing to protect populations in hybrid zones where more than 50% of the genomic material is from the endangered taxon, or if it is merely a throwaway line meant to placate a single commenter, is unclear at this time.

C. Hybrid Speciation

In a clear departure from the early rulings, FWS has accepted species of hybrid origin as acceptable for listing under the ESA. We now know that some species we consider distinct, such as the Clymene dolphin (*Stenella clymene*), formed through ancient or ancestral introgression between two separate species.[147] Though originally believed to be rare, hybrid speciation is being discovered across an increasing number of taxa.[148]

When pressed for the listing of reef-building coral species, NMFS "attempted to distinguish between a 'good species' that has a hybrid history—meaning it may display

126. Endangered and Threatened Wildlife and Plants: Reclassifying the Wood Bison Under the Endangered Species Act as Threatened Throughout Its Range, 77 Fed. Reg. 26191 (May 3, 2012) (to be codified at 50 C.F.R. pt. 17).
127. *Id.*
128. *Id.*
129. Matthew A. Cronin et al., *Genetic Variation and Differentiation of Bison (*Bison Bison*) Subspecies and Cattle (*Bos Taurus*) Breeds and Subspecies*, 104 J. Heredity 500 (2013).
130. A hybrid swarm is defined as "a population of individuals that all are hybrids by varying numbers of generations of backcrossing with parental types and mating among hybrids." *See* Allendorf et al., *supra* note 23.
131. Endangered and Threatened Wildlife and Plants: Determination of Endangered Species Status for 15 Species on Hawaii Island, 78 Fed. Reg. 64638; Endangered and Threatened Wildlife and Plants: Determination of Endangered Status for 38 Species on Molokai, Lanai, and Maui, 78 Fed. Reg. 32014 (May 28, 2013) (to be codified at 50 C.F.R. pt. 17).
132. Allendorf et al., *supra* note 23.
133. *Id.*
134. *Id.*
135. *Id.*
136. Endangered and Threatened Wildlife and Plants: Remove the Modoc Sucker From the Federal List of Endangered and Threatened Wildlife, 79 Fed. Reg. 8656 (Feb. 13, 2014) (to be codified at 50 C.F.R. pt. 17).
137. *Id.*
138. Endangered and Threatened Wildlife and Plants: Determination of Endangered Status for Texas Golden Gladecress and Threatened Status for Neches River Rose-Mallow, 78 Fed. Reg. 56026 (Sept. 11, 2013) (to be codified at 50 C.F.R. pt. 17).
139. Endangered and Threatened Wildlife and Plants: Endangered Status for the Sierra Nevada Yellow-Legged Frog and the Northern Distinct Population Segment of the Mountain Yellow-Legged Frog, and Threatened Status for the Yosemite Toad, 78 Fed. Reg. 24472 (Apr. 25, 2013) (to be codified at 50 C.F.R. pt. 17).
140. Endangered and Threatened Wildlife and Plants: Listing the British Columbia Distinct Population Segment of the Queen Charlotte Goshawk Under the Endangered Species Act, 77 Fed. Reg. 45870 (Aug. 1, 2012) (to be codified at 50 C.F.R. pt. 17).
141. Endangered and Threatened Wildlife and Plants: Final Rule to Remove the Morelet's Crocodile From the Federal List of Endangered and Threatened Wildlife, 77 Fed. Reg. 30820 (May 23, 2012) (to be codified at 50 C.F.R. pt. 17).
142. Endangered and Threatened Wildlife and Plants: Threatened Species Status for the Eastern Massasauga Rattlesnake, 81 Fed. Reg. 67193 (Sept. 30, 2016) (to be codified at 50 C.F.R. pt. 17) [hereinafter Massasauga Listing].
143. *Id.*
144. *Id.*
145. Michael G. Sovic et al., *Origin of a Cryptic Lineage in a Threatened Reptile Through Isolation and Historical Hybridization*, 117 Heredity 358 (2016).
146. *Id.*
147. Ana R. Amaral et al., *Hybrid Speciation in a Marine Mammal: The Clymene Dolphin (*Stenella Clymene*)*, 9 PLoS ONE e83645 (2014).
148. Richard Abbott et al., *Hybridization and Speciation*, 26 J. Evolutionary Biology 229 (2013).

genetic signatures of interbreeding and back-crossing in its evolutionary history—and a 'hybrid species' that is composed entirely of hybrid individuals."[149] Additionally, in a species complex of western chubs, the complex evolutionary history of multiple hybrid origins was considered and one species and one DPS within this complex were listed.[150] The Zuni bluehead sucker (*Catostomus discobolus jarrovii*) is another recently protected subspecies arising from ancestral hybridization.[151]

D. Denial of Protection Based on Hybrid Status

Strikingly, it seems only twice since the WCT has a petition been denied based on the hybrid status of the "species."[152] In 2005, one of these "hybrid species" of coral, *Acropora prolifera*, was denied protection, as it was entirely composed of morphologically distinct F1 hybrids.[153] More recently, in 2012, the sphinx date palm (*Phoenix dactylifera "Sphinx"*) was denied listing.[154] In a somewhat peculiar case, the sphinx date palm was determined to be a hybrid cultivar, a man-made taxon for horticulture that is unable to produce seeds and is perhaps most equivalent to a dog breed, not an endangered species.[155] Despite the peculiarities of this listing petition, it does provide some informative language as to how FWS views hybrid speciation:

> We acknowledge that hybridization is an important mechanism of plant speciation, as hybrids display new phenotypes and promote adaptive evolution. We also acknowledge that it is conceivable that over time, the sphinx date palm could become sufficiently reproductively isolated to accrue substantial genetic distinction from its parent species to become a species itself. At this time, however, Phoenix's grove of sphinx date palms is a collection of individuals which does not represent a cohesive population entity with an evolutionary lineage separate from its parent species.[156]

E. Genetic Rescue

Unsurprisingly, genetic rescue was not mentioned in any of the listing petitions; genetic rescue should be considered at the recovery planning phase, making it unlikely to appear in listing petitions.[157] By inducing hybridization in small and inbred populations, genetic diversity can be increased, effectively "rescuing" these populations.[158] This increase in genetic diversity can boost fitness by rapidly reversing inbreeding-induced phenotypes, halting, at least in the short term, the slide down the extinction vortex.[159] Additionally, genetic rescue is traditionally facilitated through anthropogenic actions, such as relocations and captive breeding programs.

Genetic rescue is the only scenario in which hybrids have the protection of the law based on an FWS and NMFS policy.[160] At the same time the policies for DPS and intercrosses were introduced, the Services put forth a policy for controlled propagation of species.[161] The policy states:

> Intercrossing will not be for use in controlled propagation programs unless recommended in an approved recovery plan; supported in an approved genetic management plan . . . ; implemented in a scientifically controlled and approved manner; and undertaken to compensate for loss of genetic viability in listed taxa that have been genetically isolated in the wild as a result of human activity.[162]

Genetic rescue has only been used once for an endangered taxon in the United States, with the Florida panther, when cougars from Texas (*P. c. cougar*) were brought in to reverse the negative effects of inbreeding.[163]

F. The Golden-Winged Warbler

The golden-winged warbler (*Vermivora chrysoptera*) is perhaps the best example of why there is still work to be done on a hybrid policy. In 2011, FWS posted a 90-day finding initiating a 12-month status review on listing the golden-winged warbler.[164] One of the main reasons for concern is hybridization with the blue-winged warbler (*Vermivora cyanoptera*), and conservation has been focused on minimizing these interactions.[165] The two readily hybridize

149. Endangered and Threatened Wildlife and Plants: Proposed Listing Determinations for 82 Reef-Building Coral Species; Proposed Reclassification of *Acropora Palmata* and *Acropora Cervicornis* From Threatened to Endangered, 77 Fed. Reg. 73220 (Dec. 7, 2012) (to be codified at 50 C.F.R. pts. 223-224); Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal to List 66 Reef-Building Coral Species and to Reclassify Elkhorn and Staghorn Corals, 79 Fed. Reg. 53852 (Sept. 10, 2014) (to be codified at 50 C.F.R. pt. 223).
150. Endangered and Threatened Wildlife and Plants: Threatened Species Status for the Headwater Chub and a Distinct Population Segment of the Roundtail Chub, 80 Fed. Reg. 60754 (Oct. 7, 2015) (to be codified at 50 C.F.R. pt. 17).
151. Endangered and Threatened Wildlife and Plants: 6-Month Extension of Final Determination for the Proposed Listing of the Zuni Bluehead Sucker as an Endangered Species, 79 Fed. Reg. 1615 (Jan. 9, 2014) (to be codified at 50 C.F.R. pt. 17).
152. This is based solely on listing petitions in the *Federal Register*.
153. Endangered and Threatened Species; Proposed Threatened Status for Elkhorn Coral and Staghorn Coral, 70 Fed. Reg. 24359 (May 9, 2005) (to be codified at 50 C.F.R. pt. 223).
154. Endangered and Threatened Wildlife and Plants: 90-Day Finding on a Petition to List *Phoenix Dactylifera "Sphinx"* (Sphinx Date Palm), 77 Fed. Reg. 71757 (Dec. 4, 2012) (to be codified at 50 C.F.R. pt. 17).
155. *Id.*
156. *Id.*
157. Andrew R. Whiteley et al., *Genetic Rescue to the Rescue*, 30 Trends Ecology & Evolution 42 (2014).
158. *Id.*
159. *Id.*
160. Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act, 65 Fed. Reg. 56916 (Sept. 20, 2000) [hereinafter Controlled Propagation Policy].
161. Press Release, Fish and Wildlife Service Issues Scientific Policy Guidelines (Feb. 15, 1995), https://www.fws.gov/mountain-prairie/pressrel/96-14.html.
162. Controlled Propagation Policy, *supra* note 160.
163. Warren E. Johnson et al., *Genetic Restoration of the Florida Panther*, 329 Science 1641 (2010).
164. Endangered and Threatened Wildlife and Plants: 90-Day Finding on a Petition to List the Golden-Winged Warbler as Endangered or Threatened, 76 Fed. Reg. 31920 (June 2, 2011) (to be codified at 50 C.F.R. pt. 17).
165. *Id.*

to form fertile offspring.[166] The F1 hybrids are known as Brewster's warblers and possess dominant traits for plumage, in Mendelian fashion.[167] These Brewster's warblers can then backcross with either parent taxon to form Lawrence's warblers, which display the recessive plumage traits.[168] These were once considered separate species, but have been recognized as merely F1 and F2 hybrids since the 1870s.[169] It was commonly held that the decline and hybridization between the two species was caused by recent anthropogenic habitat modification through the creation and abandonment of farmlands, which created new breeding habitat to bridge the gap between ranges.[170]

To date, no final ruling has been passed on the golden-winged warbler, but a recent scientific study is set to throw the entire endeavor into chaos. The study, using the entire genomes of both species and their hybrids, found that the two "species" are 99.97% alike genetically, with only six regions of the genome displaying significant differences between species.[171] Of these six genes, five were directly involved in the phenotypic differences in plumage, while the last was of unclear function.[172] This evidence could easily be interpreted to mean these two species should in fact be one. However, the disproportionate divergence on the Z chromosome is likely attributed to gene accumulation due to a reproductive barrier between the species; further, the mitochondrial lineage supports a divergence of 1.3 million years and the demographic modeling supporting historic, ancestral hybridization.[173]

Under the current policies, it is unclear how FWS will eventually treat the golden-winged warbler for listing purposes; that lack of clarity and reproducibility is a problem. On one hand, FWS could use its discretion to continue recognizing the two as separate species, as the most recent research failed to make bold claims about taxonomy, and only offer protection to the golden-winged phenotypes. Even if FWS decides to lump the two together into one species, the golden-winged populations could be listed as a DPS with a somewhat loose interpretation of the requirements. To be listed as a DPS, it must be significant and discrete. To my knowledge, there has never been an attempt by FWS to list any hybrid populations as a DPS.

For this one to be a DPS, it would need to prove discreteness as being "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors."[174] An argument could be made that physiological and ecological differences between the two taxa are enough, despite regular hybridization, and the fact that they have maintained themselves as separate lineages despite regular introgression suggests discreteness. Significance would be more difficult to prove as the population would need to differ "markedly from other populations of the species in its genetic characteristics."[175] A 99.97% genomic similarity would be difficult to argue for significance.[176] However, those six genomic regions demonstrate adaptive variation and the mitochondrial lineages are as different as other closely related species.[177]

Despite all individuals being the product of multiple introgression and separation events, the hybrid intermediates would likely not be protected under this scheme. These hybrid individuals are seemingly important for continued gene flow between species, as they often cross and backcross regularly.[178] Under the current version of the ESA, there is not an effective way to carry out the recommendation of "focusing on managing the genetic and phenotypic diversity within the warbler complex as a whole."[179]

G. *Case-by-Case Summary*

Despite the case-by-case framework currently instituted, a few general rules can be gleaned from these cases. Taxa arising from ancestral hybridization can be protected, and this seems to extend to taxa that merely have signals of ancient introgression within their genome at low levels. Natural hybridization is at least tolerated in a number of cases, though it is unclear if these natural hybrids are protected or not. One possible "unofficial" guideline would be the 50% threshold for hybrids in a natural hybrid zone.[180] Other times, hybridization is looked upon negatively, especially if the species are invasive. When the species are not invasive, but hybridization with a naturally sympatric species occurs to the detriment of the endangered taxon, this hybridization is looked upon negatively. Lastly, in spite of the seemingly restrictive hybrid policy of the 1980s and 1990s, very few taxa have actually been denied listing on the basis of hybridization.

IV. Proposed Hybrid Policy

A. *Calls for a Policy*

Despite the progress that has been made during this case-by-case time frame, there is still a clear and pressing need for a more defined policy. FWS and NMFS have, in the past, recognized that a case-by-case determination for listing is not wholly effective; when they passed the joint DPS policy, the Services "believe[d] that the Act will be best administered if there is a general policy framework governing the recognition of DPS's that can be disseminated and understood by the affected public," thus reject-

166. Frank B. Gill, *Blue-Winged Warblers (*Vermivora Pinus*) Versus Golden-Winged Warblers* (V. Chrysoptera), 121 Auk 1014 (2004).
167. *Id.*
168. *Id.*
169. *Id.*
170. David A. Buehler et al., *Status and Conservation Priorities of Golden-Winged Warbler* (Vermivora Chrysoptera) *in North America*, 124 Auk 1439 (2007).
171. David P.L. Toews et al., *Plumage Genes and Little Else Distinguish the Genomes of Hybridizing Warblers*, 26 Current Biology 2313 (2016).
172. *Id.*
173. *Id.*
174. Joint DPS Policy, *supra* note 73.
175. *Id.*
176. Toews et al., *supra* note 171.
177. *Id.*
178. *Id.*
179. *Id.*
180. Massasauga Listing, *supra* note 142.

ing calls for maintenance of the status quo.[181] As most commentators have argued, a flexible policy is needed to apply to the wide range of scenarios involving endangered species and hybrids.[182]

As such, there have been constant calls from within the scientific literature for a policy, and apparently many FWS agents agree.[183] The current system puts far too much discretion in the hands of the agency biologists without giving them the guidance on how to use their discretion.[184] Negative views of hybridization still largely permeate through FWS and the agency biologists feel the process is currently too ambiguous.[185] FWS biologists are receptive to clear consensus in the literature when it comes to hybridization; however, these same biologists see a need for more guidance on hybridization-based situations.[186]

B. Two-Factor Hybrid Policy Test

When they set forth the DPS policy, FWS and NMFS stated that "the Services understand the Act to support interrelated goals of conserving genetic resources and maintaining natural systems and biodiversity over a representative portion of their historic occurrence."[187] Any hybrid policy would likewise need to strike that balance of preserving distinct evolutionary lineages, especially the potential to adapt, and protecting the ecosystem for these and other species. Thus, at its simplest, the decision of whether or not to protect hybrids should be made based on a simple two-factor test: will protecting hybrids benefit the continued persistence of the endangered taxon, and will protecting hybrids benefit the ecosystem as a whole? If protecting hybrids will benefit the endangered species by protecting the unique genetic lineages or the environment as a whole, that supports protection of hybrids; likewise, if protecting hybrids will harm the endangered taxon or the other organisms in its ecosystem, then that goes against protection of hybrids.

If these two factors are at odds, then the protection of genetic lineages should be given more weight. The genetic lineage factor is weighed more heavily than the ecosystem factor because the ESA is, at its core, a species-based conservation plan. The intent of Congress is clear; the ESA was developed to protect endangered or threatened species and the habitat they rely on.[188] The provisions for protecting habitat, such as the critical habitat designation, are designed to benefit the individual endangered taxon, and the benefits to the ecosystem as a whole are merely a side product. The best available science standard would be applied here, as well. Ultimately, this standard would be the most consistent with the original intent of the ESA, still maintain the flexibility of the case-by-case procedure, and give agency personnel and interested citizens some direction when attempting to understand these issues.

C. Beneficial for Endangered Taxa

The first part of the test focuses on whether protecting hybrids will likely benefit endangered taxa. To preserve unique genetic lineages, a hybrid policy should focus on the evolutionary processes that formed the taxa we see today, and are continuing to drive the lineage moving forward. As such, a general distinction between natural hybridization and anthropogenic-induced hybridization is important.[189] Natural hybridization is part of the evolutionary history of these species and it is to be expected. The current case-by-case policy has consistently offered protection to hybrid species and any new framework would simply codify that.

Additionally, while natural hybridization was occasionally recognized as good or neutral in the petitions for listing, these hybrids were not given protection under the law. Sympatric species and hybrid zones deserve protection and should be protected at the complex level in these scenarios.[190] Setting up boundaries for protection within broad hybrid zones is difficult and gets back to setting some sort of genomic composition threshold.[191] Fifty percent has been suggested both in the literature[192] and by FWS in the *Federal Register*,[193] and is ultimately as good a threshold as any other. This protection of natural introgression is a clear place where this new policy would have an effect versus the current case-by-case model.

Anthropogenic-induced hybridization possesses a wider range of issues and outcomes; it is not as simple as natural being good and human-mediated being bad.[194] Genetic rescue is a vital, if underused, tool in the wildlife manager's toolbox.[195] Captive breeding with hybrids or release of a population into the range of an endangered population with the goal of hybridization for genetic rescue should result in the protection of hybrids. Additionally, when hybrid populations are all that exist, then they should be protected to maintain what remains of the genetic lineage.[196] Hybridization that increases fitness and ecological plasticity in the form of adaptive variation without swamping the taxon should be protected; these benefits to fitness need to be long-term and not simply the effects of heterosis in F1 individuals.[197]

When genetic swamping and extinction through introgression from invasive species, or even natural species with no history of introgression, are a threat to conservation, these hybrids should not be protected and active removal

181. Joint DPS Policy, *supra* note 73.
182. Jackiw et al., *supra* note 112.
183. Jennifer F. Lind-Riehl et al., *Hybridization, Agency Discretion, and Implementation of the U.S. Endangered Species Act*, 30 Conservation Biology 1288 (2016).
184. *Id.*
185. *Id.*
186. *Id.*
187. Joint DPS Policy, *supra* note 73.
188. 16 U.S.C. §1531(b) (1976).
189. Jackiw et al., *supra* note 112.
190. *Id.*
191. Wayne & Shaffer, *supra* note 12.
192. *Id.*
193. Massasauga Listing, *supra* note 142.
194. Jackiw et al., *supra* note 112.
195. Whiteley et al., *supra* note 160.
196. Jackiw et al., *supra* note 112.
197. *Id.*

should be a conservation goal.[198] Sterile hybrid offspring that outcompete the natural taxa should be removed and left unprotected.[199] Additionally, when hybridization negatively affects fitness or reduces the ability of populations to adapt, either through outbreeding depression or another method, these hybrids should not be protected.[200] Selection is expected to prevent these hybrids from proliferating in the long term, but in small populations or when other pressures, such as dispersal, are strong enough, the efficacy of selection is decreased.[201]

In other cases, anthropogenic-induced hybridization can be considered effectively neutral, thus allowing for the second prong of the test to be determinative. When hybridization is occurring at low levels and often accompanied by backcrossing, then it can be considered effectively neutral.[202] In these cases, habitat modifications to favor the natural taxa over invasive species and hybrids should be undertaken if available to change the selective forces driving the hybridization process.[203] When the hybridization is being favored due to anthropogenic habitat modifications that are essentially permanent, then the place of these hybrids in the ecosystem—the second prong of the test—should be the deciding factor.[204]

To sum up the first factor, hybridization is beneficial to the endangered taxon when it is a natural event occurring throughout its genetic history (including both hybrid species and natural hybrid zones), when it is effecting a genetic rescue or restoration, or when it adds adaptive or genetic diversity to the parent taxon without subsuming it. Hybridization can be considered more or less neutral for the endangered taxon in the case of low levels of anthropogenic-induced introgression. Hybridization is detrimental to the endangered taxon when it threatens genetic swamping or when hybrids threaten the native taxa through competition.

D. Beneficial for the Ecosystem

The current view of hybridization taken by FWS does a far greater job of preserving "unique" genetics, occasionally at the expense of maintaining natural systems and biodiversity. Preserving unique lineages is important, and hybridization is often a threat to unique lineages; however, preserving ecosystem functions can ultimately be just as important.[205] Ecological authenticity or equivalency is the idea that sometimes hybrids are equivalent with pure individuals in terms of ecological roles and community interactions, and in these situations, preservation of these populations and individuals is important.[206] This idea of ecological authenticity is often lost in the species-specific model of conservation the ESA supports.[207] Moving away from a system of species protection to one of ecosystem-based protection has been proffered before and debated far more extensively than I will here.[208] However, it does not always have to be one or the other, and, in the case of hybrids, we should adopt the idea of ecological authenticity.

When hybrids are ecologically authentic, then ultimately their presence is beneficial. Removal of these hybrids would cause a loss of ecosystem functionality, and therefore they should be protected. It is more beneficial to protect hybrids with similar functions and community interactions, even though they are not genetically pure, than to remove or unprotect these hybrids at the expense of the ecosystem as a whole.[209] However, if hybrids are interacting negatively with other species (through competition, predation, etc.), then they are unauthentic and should be removed and unprotected.[210] Studying the ecological authenticity of hybrid populations is a relatively new field, and further research is needed to make these distinctions for many taxa.[211]

V. Application of the Two-Factor Hybrid Test

This section will apply the two-factor hybrid test to a few recent examples: the golden-winged warbler, the red wolf, the California tiger salamander, and the WCT.

A. Golden-Winged Warbler

Looking back at the golden-winged warbler, application of the two-factor test supports protection of these hybrids. Protection of the hybrids between the two warbler species would be beneficial to the golden-winged warbler. The genomes of these birds demonstrated that the hybridization was both modern and ancestral; additionally, the best available evidence shows that anthropogenic habitat modification is likely not driving the introgression.[212] Despite the 99.97% introgression, the two species seem stable and have persisted throughout time in some hybridization

198. *Id*.
199. Issues with sterile hybrids need to be addressed in a hybrid policy; however, none were observed in my search of the *Federal Register*. When the F1 hybrids are infertile yet cause a negative effect on their parent taxa through competition, loss of breeding opportunity, or other ecological effects, hybridization resulting in sterile offspring can still be a problem for endangered species. Competition with sterile hybrids is believed to be a fairly uncommon issue, again making it unsurprising that it was not observed in a search of the *Federal Register*.
200. Jackiw et al., *supra* note 112.
201. Kovach et al., *supra* note 111.
202. Jackiw et al., *supra* note 112.
203. Wayne & Shaffer, *supra* note 12.
204. *Id*.
205. Fitzpatrick et al., *supra* note 10.
206. Benjamin M. Fitzpatrick et al., *Rapid Spread of Invasive Genes Into a Threatened Native Species*, 107 Proc. Nat'l Acad. Sci. 3606 (2010).
207. Wayne & Shaffer, *supra* note 12.
208. *See generally* Mark L. Shaffer et al., *Proactive Habitat Conservation*, *in* 1 The Endangered Species Act at Thirty: Renewing the Conservation Promise (Dale D. Goble et al. eds., Island Press 2006); Jacqueline Lesley Brown, *Preserving Species: The Endangered Species Act Versus Ecosystem Management Regime, Ecological and Political Considerations, and Recommendations for Reform*, 12 J. Envtl. L. & Litig. 151 (1997).
209. Christopher A. Searcy et al., *Ecological Equivalency as a Tool for Endangered Species Management*, 26 Ecological Applications 94 (2016).
210. Wayne & Shaffer, *supra* note 12.
211. *Id*.
212. Toews et al., *supra* note 171.

equilibrium, so genetic swamping is not a concern.[213] Since all of these factors point to hybridization being beneficial to the species, the hybrids should be protected across the hybrid zones.

B. *Red Wolf*

Canids have been the bane of taxonomists for decades, especially the highly contentious red wolf. The red wolf, at one point or another, has been considered its own species, a subspecies of gray wolf, a hybrid species derived ancestrally from wolves and coyotes (*Canis latrans*), or a recent hybrid driven by the extirpation of the gray wolf across the southeastern United States.[214] A new study seems to have finally answered that question once and for all in favor of the recent hybridization hypothesis.[215]

By sequencing nearly 30 genomes from gray wolves, red wolves, coyotes, dogs, and the equally contentious eastern wolf (*Canis lycaon*), scientists have determined that the red wolf and the eastern wolf were not species at all; they were highly admixed hybrid populations of gray wolves and coyotes.[216] The red wolves sequenced ranged from 9% to 20% gray wolf ancestry with the rest coming entirely from coyotes.[217] All evidence points to this being a recent hybridization event.[218] Red wolves likely began to form when gray wolves were hunted to extinction in the southeastern United States in the 19th century; lone wolves began to interbreed regularly with coyotes as other wolves were so few in number.[219]

The red wolf has been on the endangered species list prior to even the ESA, and since 1980, it has been extinct in the wild.[220] An extensive captive breeding and release program has been ongoing with varying levels of success since that time. Twice DOI was sued for delisting the red wolf and denied the petition at the 90-day stage based on the best available science of the time.[221] Yet, this new study could pose a more substantial threat to the continued protection of the red wolf, as this time the science is as comprehensive and clear as it has ever been.

FWS has remained adamant that it will continue to protect this "species." Steve Guertin, the director of policy for FWS, stated in front of Congress that: "We believe there is enough scientific evidence that the red wolf has been treated as and will continue to be treated as a separate species. That's based on genetics, behavioral, taxonomic and other criteria."[222] Additionally, in the wake of this discovery, a U.S. Geological Survey workshop was held on the continued listing of the red wolf.[223] Generally, the scientists and legal scholars in attendance believed the red wolf was still a listable entry, though there was no consensus on whether it is a full species, subspecies, or DPS.[224] Members of the recovery team were split, with some believing the red wolf still met listing criteria and others believing it should be delisted.[225]

Continued listing of this species under the current framework is more uncertain, in my opinion. If the Services continue to list it as a separate species, a legal challenge under the APA citing the listing as arbitrary and capricious could succeed. FWS is tasked with using the best available science to make the determination, and continued reliance on less comprehensive methods and experiments would be arbitrary and capricious.[226] However, FWS does have considerable latitude when determining what is and is not a species or subspecies and tends to take a more holistic look than the biological community.

Listing red wolves as a DPS would be an interesting and unprecedented strategy. First, they would have to be officially determined as a DPS of either wolves or coyotes, with potentially different consequences. A population of hybrid individuals has never before been listed as a DPS; to be a valid DPS, the population has to be both discrete and significant. Discreteness seems the easier of the two, as the red wolf is readily distinguishable from both gray wolves and coyotes morphologically; thus, there are "physical, physiological, ecological, or behavioral factors" between the other canids and red wolves. For significance, the best argument might be that the population differs markedly from other populations of the species in its genetic character. As a hybrid, it differs significantly from both coyotes and gray wolves. However, this would be a subversion of the intent of the significance factor, and seems like a stretch. A well-defined hybrid policy is needed to resolve the situation.

When applying this proposed hybrid policy, red wolves would continue to be protected as hybrids of gray wolves. In an ideal world, gray wolves would be reintroduced into the Southeast; "red wolves" as a taxon would no longer exist, but hybrids between gray wolves and coyotes would be protected until gray wolves themselves no longer needed protection.[227] However, this scenario is borderline impossible for a number of reasons. Gray wolves are not going to be reintroduced in the Southeast anytime soon, and it could be centuries, if ever, that the population expands back from the West into the East.

More importantly, the habitat to support gray wolves in the Southeast is gone and will likely never come back.[228] The same processes that are driving gray wolf hybridiza-

213. *Id*.
214. Chambers et al., *supra* note 3.
215. vonHoldt et al., *supra* note 4.
216. *Id*.
217. *Id*.
218. *Id*.
219. *Id*.
220. Endangered Species, 32 Fed. Reg. 4001 (Mar. 11, 1967).
221. Endangered and Threatened Wildlife and Plants: Finding on a Petition to Delist the Red Wolf (*Canis Rufus*), 57 Fed. Reg. 1246 (Jan. 13, 1992) (to be codified at 50 C.F.R. pt. 17); Endangered and Threatened Wildlife and Plants: 90-Day Finding for a Petition to Delist the Red Wolf, 62 Fed. Reg. 64799 (Dec. 9, 1997) (to be codified at 50 C.F.R. pt. 17).
222. LaJeunesse, *supra* note 1.
223. Group Solutions, Inc., Red Wolf Recovery Team Recommendations (2016), *available at* https://www.fws.gov/redwolf/docs/red-wolf-recovery-team-recommendations-facilitated-by-group-solutions-inc.pdf.
224. *Id*.
225. *Id*.
226. Trout Unlimited v. Lohn, 645 F. Supp. 2d 929 (D. Or. 2007).
227. Wayne & Shaffer, *supra* note 12.
228. *Id*.

tion in the Great Lakes and northeastern United States likely drove the red wolf into formation.[229] This new, more urbanized habitat seems to select for an intermediate-sized canid, needing less land than a wolf, but larger than a coyote to allow for feeding on the overabundance of deer, suggesting introgression from the coyote into the gray wolf may be adaptive in this specific case.[230] These red wolves fit the bill ecologically. Thus, they meet the criteria for protection, as they are the last remnants of gray wolves in this region, the introgression is adding adaptive variation, and they are ecologically beneficial.

Red wolves should continue to be protected and bred in captivity as a DPS of the gray wolf. While the population is so small, the red wolves should continue to be kept from further hybridization with coyotes. Selection is less effective in small populations and the increase in admixture from coyotes will persist until the population grows large enough that selection can work to maintain the red wolf form. Once their numbers are sufficient, hybridization back with coyotes should be protected until such time as the red wolf no longer needs federal protection.

C. California Tiger Salamander

This rule would see protection for a subset of hybrids between the endangered California tiger salamander (*Ambystoma californiense*) and the invasive barred tiger salamander (*Ambystoma mavortium*), while the other set of hybrids would not be protected. The barred tiger salamander was released into California in the 1950s to be used in stock ponds for fish bait.[231] However, today, about one-fourth of the California tiger salamander's range is occupied by "full hybrids" that consist of nearly 70% barred tiger salamander genes.[232] Additionally, a different one-fourth of the range has seen introgression of only 4% of the examined genome, in the form of three genes, forming these "super-invasive hybrids."[233] Genetic swamping is a concern, especially in the case of the "full hybrids," and hybridization appears to be a major cause of decline in these species.[234] Thus, protection should not be offered to these hybrids.

However, the low-level introgression from the super-invasive genes poses a different quandary. Overall, the introgression, though sizeable in the proportion of the species' range, is fairly negligible at 4%.[235] When only a few genes are affected in the long term, genetic swamping is not a concern. Thus, in this case, the second question of ecological equivalency comes into play. Unlike the full hybrids or the barred tiger salamander, these super-invasive hybrids fulfill the same role in the community, at least at the pivotal larval stage, and are ecologically equivalent to the best of our scientific knowledge.[236] Thus, as these super-invasive hybrids are ecological surrogates, they should be protected.

D. The WCT

Based on this ruling, the hybrids between the WCT and the rainbow trout would not be protected. Genetic swamping is occurring and total genomic extinction is a possibility.[237] Additionally, admixed individuals are being selected against and are overall less fit.[238] This increase in hybridization is happening in spite of selection, and is driven by high dispersal rates of hybrids and invasive rainbow trout, not some increased fitness attributed to admixture.[239] Not protecting hybrids is the correct implementation of the rule, and the heavily hybridized populations should not be weighted the same as unmixed WCT populations when determining whether the species is threatened or endangered across its range.

VI. Looking Forward

A. Dealing With a Changing Base of Knowledge

Ultimately, the policy suggested in this Article is not the definitive answer for dealing with protection of endangered species and hybrids, but it would signal a significant step forward from the scattershot case-by-case policy in place today. Yet, just as species are not static entities, the laws that protect them must evolve and change.[240] As highlighted above, determining what the proper unit is for conservation is a problem even more vexing than hybridization.[241]

New genomic techniques are changing the way biologists are answering this question as well. For the first time, we are finally able to examine adaptive variation at the genomic level, and this is changing the way biologists view conservation units.[242] The legal view of species and subspecies is far too rigid, mired in a 19th-century mindset of categorization. A holistic view, moving away from rigid taxonomy, is needed. Protecting hybrids for ecological reasons can begin this march away from Victorian halls into the labs of the 21st century, but it must not stop there.

B. Dealing With a Changing Climate

The need for such a scheme has never been greater. Climate change is set to drive the issue of hybridization to the next level.[243] Key to the survival of biodiversity in light of the

229. vonHoldt et al., *supra* note 4.
230. *Id.*
231. Fitzpatrick et al., *supra* note 206.
232. *Id.*
233. *Id.*
234. *Id.*
235. *Id.*
236. Searcy et al., *supra* note 209.
237. Kovach et al., *supra* note 111.
238. *Id.*
239. *Id.*
240. Doremus, *supra* note 53.
241. Frankham et al., *supra* note 18.
242. W. Chris Funk et al., *Harnessing Genomics for Delineating Conservation Units*, 27 Trends Ecology & Evolution 489 (2012).
243. Ary Hoffmann et al., *A Framework for Incorporating Evolutionary Genomics Into Biodiversity Conservation and Management*, 2 Climate Change Responses (2015).

rapidly changing climate is the ability to adapt.[244] High genetic diversity is the most predictive sign of how well a population or species will react to changing environmental conditions.[245] By mixing two previously distinct groups, hybrid populations generally have higher genetic diversity than their parent taxa.[246]

Additionally, hybridization can allow beneficial alleles that are being selected for by the changing climate to spread to other groups.[247] New hybrid zones will be forming, as some species migrate poleward in search of a familiar environment.[248] Species that have been out of contact for significant portions of evolutionary time could come back together and begin to hybridize.[249] Inevitably, some of these interactions will see endangered taxa hybridizing with their more common relatives. These new hybrid interactions are, by definition, the result of anthropogenic modifications of the environment, and thus should only be protected where these hybrids are beneficial to the ecosystem as a whole.

Enforced hybridization and assisted migration will likely become increasingly required.[250] Many researchers argue that these kinds of genetic rescue are going to be pivotal for facilitating the maintenance of biodiversity in the face of an environment changing far faster than most taxa, especially those with small populations, will be able to evolve.[251] While conservation-minded assisted migration and genetic rescue are seemingly protected through the "experimental population" clause[252] and the controlled propagation of species policy,[253] there is no policy in place to deal with these novel hybrid zones that climate change will create between endangered and non-threatened taxa. Tough questions will be posed when the niche an endangered species inhabits ceases to exist due to climate change, and they begin hybridizing into extinction with a taxon that has moved into their region as a result of a warming climate. Despite these challenges, the two-factor test presented here provides necessary groundwork for the protection of hybrids that can be modified and expanded based on changing environments and a better understanding of our natural world.

VII. Conclusion

For now, a new hybrid policy is needed. Academic scientists believe so,[254] agency biologists believe so,[255] and even many legal scholars believe so.[256] Genomics has provided us with information previously unobtainable and we are now able to answer formerly unanswerable questions.[257] With the new information available about the red wolf, golden-winged warbler, and other species, now is the time to finally make the step forward to formally recognizing protection of hybrids in a biologically informed manner.

The current case-by-case strategy is steeped in murkiness and leads to conflict and litigation over whether a group is hybrid. The policy presented here shifts that battleground from "Is it a hybrid?" to "What effect is hybridization having on the endangered taxa and the environment?" This policy places stakeholders from all walks of life onto the same platform to discuss hybridization and endangered species protection.

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244. *Id.*
245. Frankham et al., *supra* note 17.
246. *Id.*
247. Hoffmann et al., *supra* note 243.
248. *Id.*
249. *Id.*
250. *Id.*
251. *Id.*
252. 16 U.S.C. §1539(j)(2)(A).
253. Controlled Propagation Policy, *supra* note 160.
254. *See supra* note 115.
255. Lind-Riehl et al., *supra* note 183.
256. *See generally* Hill, *supra* note 79; Doremus, *supra* note 53; Oliver Frey, *When Science and the Statute Don't Provide an Answer: Hybrid Species and the ESA*, 26 Duke Envtl. L. & Pol'y F. 181 (2015).
257. Wayne & Shaffer, *supra* note 12.