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THE ROLE OF HYBRIDIZATION AND THE UNITED STATES FISH AND WILDLIFE SERVICE BIOLOGISTS' DISCRETION IN THE IMPLEMENTATION OF THE ENDANGERED SPECIES ACT

Jennifer F. Lind-Riehl
Michigan Technological University

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THE ROLE OF HYBRIDIZATION AND THE UNITED STATES FISH AND WILDLIFE SERVICE BIOLOGISTS' DISCRETION IN THE IMPLEMENTATION OF THE ENDANGERED SPECIES ACT

By

Jennifer F. Lind-Riehl

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Department of Social Sciences

Thesis Advisor: *Audrey L. Mayer*

Committee Member: *Oliver Gailing*

Committee Member: *Adam Wellstead*

Department Chair: *Hugh Gorman*

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"To keep every cog and wheel is the first precaution of intelligent tinkering."

-Aldo Leopold (1953, P. 147)

Abstract

The Endangered Species Act (ESA) requires that the “best available scientific and commercial data” be used to enable the protection of critically imperiled species from extinction and preserve biodiversity. However, the ESA does not provide specific guidance on how to apply this mandate. In addition, the interpretation of scientific data can be uncertain and controversial, particularly regarding species delineation and hybridization issues. US Fish and Wildlife Service (FWS) field biologists must decide what the best science is and how to interpret and apply it in their recommendations. As a result, FWS field biologists often have considerable discretion when it comes to making recommendations for what species to list and how to recover them. My study has examined how FWS field biologists’ knowledge and beliefs about species concepts and hybridization may impact their discretion to use the best available science to protect and recover imperiled species. I used semi-structured interviews to help uncover how much discretion FWS field biologists believe they have, and their knowledge and beliefs about species concepts and hybridization related to ESA implementation. I found that they have a large amount of discretion to determine what the best available science is and how to interpret it. However, their recommendations are subjected to multiple levels of peer review and generally they defer to the scientific consensus on the taxonomic status of an organism. Hybridization was viewed primarily as a problem in the context of the ESA, which likely reflects the tumultuous history the FWS has had with this issue. However, FWS field biologists who had experience with hybridization issues were more likely to describe it as a complex evolutionary force with varied outcomes rather than wholly negative, as compared to those with little to no experience. Overall, resource limitations and “listing by litigation” impacted ESA implementation more than biologists’ knowledge and beliefs concerning species concepts and hybridization.

Introduction

The Endangered Species Act (ESA) is considered the "strongest American legal expression to date of environmental ethics" (Nash 1982, P. 175). The ESA grants federal environmental agencies significant latitude to use the best scientific knowledge available to protect and recover endangered or threatened species and their habitats. The US Fish and Wildlife Service (FWS) must keep up with the dynamic landscape of scientific advancements, and provide credible and consistent decisions in the eyes of the policy world. The field biologists on the ground working directly with these species thus have a great deal of discretion to determine the best scientific information available and how to interpret it with respect to the ESA. In turn, when the science available for a given species involves complex and controversial scientific topics, such as delineating species in the presence of hybridization, the views and knowledge of field biologists may also influence the agency's recommendations. While the conundrum of dealing with hybridization and species delineation issues in the context of the ESA has been discussed extensively within the scientific realm (Ellstrand et al. 2010; Gross 2005; Allendorf et al. 2001; Mallet 1995; Waples 1995; Mayr and O'Brien 1991), little attention has focused on what these situations look like from the perspective of the field biologists and policy implementation. Understanding of this dynamic will likely become more important as climate change is predicted to potentially increase the number of endangered species (Stevison 2008). It will also lead to range shifts and potential contact between closely related species that may result in increased interspecific hybridization (Doak and Morris 2010; Woodall et al. 2009). To address this gap, my work examined the discretion of field biologists when dealing with controversial scientific topics like hybridization and species concepts while implementing the ESA.

First I will discuss why hybridization and species concepts are controversial topics in the scientific world, and how that controversy has translated into serious implementation barriers for the ESA. I will then discuss what is meant by discretion from a policy perspective and why this discretion may be necessary for sound policy implementation. Following that I will introduce the rationale and methods behind my study. Finally I will describe the main outcomes of the interviews and conclude with a discussion of future policy implications.

Controversy in science: hybridization and species concepts

Hybridization occurs when two different species or subspecies reproduce. Hybridization can be artificial, e.g., when horses and donkeys are mated to produce mules. It can also occur naturally such as when different species of oaks interbreed in the wild (Curtu et al. 2007; Lind and Gailing 2013). Offspring that are produced through hybridization, natural or artificial, are called hybrids, and the hybridizing species are referred to as parental species. Although hybridization was previously thought to be uncommon and result in sterile or unviable offspring (e.g., mules), research over the past century has shown quite the opposite (Arnold 2004; Rieseberg et al. 2003; Schluter 2009). Hybrids can often reproduce successfully and the evolutionary results of this reproduction can be quite varied. Hybrids can be more or less robust than either parental species, typically as the result of different adaptations to environmental conditions (Arnold 1999). For example, crossbred dogs have a longer lifespan than purebred dogs (O'Neill et al. 2013). Hybrids can also do well in an intermediate or different habitat than either parental species, creating so-called hybrid zones between hybridizing species. California oak species have been shown to exhibit such hybrid zones as a result of environmental gradients (Dodd and Afzal-Rafii 2004). New species can result from successful hybrid offspring; sunflowers are a classic example of hybrid speciation, where three of 11 annual sunflower species are thought to be of hybrid origin (Rieseberg et al. 2003; Rieseberg 1997). Far from resulting in sterile or unviable offspring, hybridization provides a source of genetic recombination and diversity with evolutionary consequences.

As a result, new knowledge on the diverse evolutionarily consequences of hybridization has profoundly influenced how scientists define species. The concept of what divides organisms into different species (or hybrids between them) has evolved over time. The earliest classification of organisms into taxonomic groups was largely reliant upon morphological and behavioral characteristics. As the field of molecular biology (including genetics) emerged (Allendorf et al. 2010), scientists began to use genetic similarity as a measure of relatedness. Advancements in genetics has illustrated that evolutionary dynamics cannot always be directly observed at the macro-evolutionary or phenotypic scale alone. To this end dozens of species concepts have been proposed to explain these relationships. I will briefly cover a few of the most popular concepts.

The Biological Species Concept (BSC) was the earliest to emerge. It defines species as populations of organisms that interbreed with one another, but are reproductively isolated from other groups (Mayr 1942). The BSC remains the prevailing species theory today, even though it has not always been able to explain variations in natural systems (Mallet 1995). For example, extensive natural hybridization, like that which occurs between oaks or sunflowers (Curtu et al. 2007; Rieseberg et al. 2003), contradicts the BSC because interspecies breeding violates the reproductive isolation required by the concept. More recently, many other species concepts have been developed to account for hybridization and suggested as a replacement for the BSC; most prominent are the Ecological Species Concept and the Evolutionary Species Concept.

The Ecological Species Concept defines species by their local environmental adaptations that are maintained by selection despite interspecific gene flow (interbreeding between species) (Schluter 2009; Via 2009). This has been a popular explanation for why certain species such as oaks, sunflowers, and various fish species maintain their species identity despite often high levels of gene flow (Scotti-Saintagne et al 2004; Curtu et al. 2007; Kane and Rieseberg 2008; Schluter 2009). For example, two European white oak species display very homogenous genomes, with a few regions of high divergence thought to be involved in species specific adaptations to different soils (i.e., *Q. robur* grows on moist soils and *Q. petraea* grows on dry soils) (Scotti-Saintagne et al 2004).

The Evolutionary Species Concept emerged from systematic biology, or the science of diversity, and defines species as independent lineages resulting from various evolutionary and historical processes (e.g., mutation, genetic drift, natural selection, and vicariance) (Dimmick et al. 1999; Soltis and Gitzendanner 1998). While the Ecological Species Concept focuses on microhabitat adaptations between species, the Evolutionary Species Concept addresses within-species diversity as well. Since both of these concepts allow for gene flow between groups of organisms, they may better capture biodiversity and positively direct conservation efforts than the traditional BSC perspective (Mallet 1995; Dimmick et al. 1999; Soltis and Gitzendanner 1998). Nonetheless, no one species concept has unanimous support, although the BSC remains the most popular. This is likely due to the general trend in biological sciences to view organisms as part of an evolutionary continuum rather than discontinuous units (Mallet 2001). Mallet (1995 and 2001) has discussed at length how Darwin viewed "species" as continually evolving; the concept of a species is more for our convenience rather than an accurate reflection of reality.

The Endangered Species Act

The Endangered Species Act (ESA) was passed by Congress in 1973 (16 U.S.C. §§ 1531-1544, P.L. 93-205, 87 Stat. 884) in response to inadequate previous legislation (e.g., Endangered Species Preservation Act of 1966 (P.L. 89-669) and the 1969 Amendment (P. L. 91-135)) (Czech and Krausman, 2001). The main purpose of the

ESA is to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" (Section 2b). The ESA was written with the input of scientists and lawyers, allowing for the incorporation of a new set of principles and ideas and fostering the inclusion of science as the center of implementation decisions. The ESA is administered by the US Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS). The FWS is responsible for terrestrial and freshwater species, while the NMFS is responsible for marine species. The NMFS is part of the Commerce Department under the National Oceanic and Atmospheric Administration. I focused on the FWS for this study and will therefore only elaborate on this agency's structure. The FWS is part of the Department of the Interior (DOI) and is represented nationally by eight different regions, each with a regional office. Below the regional office, each state has at least one field office (Figure 1). Both regional and field offices employ a regional or field supervisor, administrator, and numerous field biologists. It is these field biologists that are the focus of my study. To understand how they fit within the structure of the organization, we can examine the ESA implementation process.

There are five major stages in the implementation of the ESA, all of which incorporate scientific information (Table 1). The FWS employs a process called a rule-making procedure that requires public commentary periods on proposed rules, such as listing or critical habitat designation, before they are officially adopted. The comments are taken into consideration before final decisions are made. These proposed and final rules are published in the Federal Register, which is a daily publication of administrative regulations for all federal agencies. This method is meant to create a higher level of agency transparency and public participation. Before those proposed rules are published in the Federal Register, a review process is conducted within the agency itself. Field biologists are generally responsible for researching and writing these rules (for proposed listing, designating critical habitat or recovery plans). However, these documents must be approved by the field supervisor, the regional supervisor and ultimately the Secretary at the headquarters level. Additionally, solicitors must also sign off on these rules to assure that they adhere to the legal boundaries of the ESA. Until more recently, this was done in a linear fashion. However, it is becoming more common for field biologists to communicate with and get feedback from field and regional supervisors, as well as solicitors, while they are writing their documents.

Implementation begins with listing a species as threatened or endangered, which can occur through two venues (Table 1, Stage 1). The first is the candidate conservation process where the FWS proposes species for listing (utilizing the best science available). The second method is through a petition process, where anyone can submit a petition to the Secretary of the DOI to list a species. Ultimately the Secretary of the DOI makes the decision to list a species, but the FWS puts together listing proposals and can directly impact the Secretary's decision through the information they provide. An "endangered" listing indicates that the species is in danger of extinction throughout all or a significant portion of its range, while "threatened" means is it likely to become endangered within the foreseeable future.

Only scientific evidence can be used in this step, to prevent lack of protection for economic reasons. As of June 7, 2015, 1568 US species are officially listed as endangered or threatened, including 685 animals and 883 plants (http://ecos.fws.gov/tess_public/pub/boxScore.jsp).

Once a species is listed, the FWS must determine if there is critical habitat to be designated (Table 1, Stage 2). Critical habitat is a geographic area that is essential to the species' conservation as determined by the scientific evidence, but economic and any other relevant impacts must be accounted for. As of June 7, 2015, 704 endangered or threatened species have critical habitat designations (http://www.fws.gov/endangered/what-we-do/critical-habitats-faq.html).

After a species is listed and its critical habitat designated, the FWS is legally responsible for protecting the listed species by preventing the "take" of individuals (Table 1, Stage 3), where take means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct" (Section 3). At this point the FWS is now responsible for developing a recovery plan, which outlines what needs to be accomplished to restore that species to ecological health and meet the criteria for delisting (Table 1, Stage 4). These plans are developed with the input of relevant public and private agencies and institutions. As of June 7, 2015, 1155 of the 1519 listed species have active recovery plans (http://ecos.fws.gov/tess_public/pub/boxScore.jsp). There is also a "candidate list" for species that warrant listing, but are given a lower priority than other species for various reasons, including a lower magnitude and immediacy of threats or a lack of taxonomic distinctiveness. However, the FWS often works with local agencies and landowners to start conservation efforts for candidate species even before they enter the official listing process.

The ESA's best available science mandate

The Endangered Species Act (ESA) mandates that the best available science be used throughout the process from listing a species to designing recovery plans (ESA 16 U.S.C. §§ 1533(b), 1536(c), 1537(c)). It was meant to shield endangered species protection from political influence. However, this directive has been a source of controversy to this present day (Rosenberg 2015; Doremus 2010; Ch. 11, Scott 2006; Doremus 1997; Hill 1993). The FWS and NMFS must make definitive policy decisions using only scientific information, which is often uncertain and dynamic over time (Ch. 11, Scott 2006). For example, how to define species has been a source of continued debate and controversy in the scientific world ever since Darwin's theory of evolution squashed the idea that "species" are discrete static entities (Mayr 1982). For example, for both the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) and the western greater sage grouse (*Centrocercus urophasianus phaios*), the FWS reversed its decision on listing for the two organisms due to unclear and conflicting scientific evidence as to whether they were valid subspecies (Doremus 2010).

The ESA defines species to "[include] 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" (Section 3). While the ESA has undergone numerous amendments spanning the last 37 years, the definition for species has only changed once. In the 1978 Amendments (P.L. 95-632, 92 Stat. 3751), protection of populations of vertebrates was added, creating the distinct population segment (DPS) term (Section 3). At the time, this change was controversial, but Congress ultimately agreed that the FWS needed some flexibility in protecting populations and expected this to be used sparingly. However, the FWS did not use the DPS designation until nearly 20 years later (Alexander and Corn 2010). The DPS term only exists in the context of the ESA, thus science could not provide guidance on how to utilize such a designation in practice. Additionally the ESA did not provide a clear definition of what constituted a DPS. Consequently, when some Pacific salmon species (*Oncorhynchus spp.*) presented a situation where the DPS designation would benefit species conservation, a new controversy on how to define a DPS emerged. In 1991, a policy that defines a modified version of a DPS called an Evolutionary Significant Unit (ESU) was adopted by NMFS to apply to salmonid species (Fed Reg 61). The ESU delineates a population or group of populations that are “substantially” reproductively isolated from other conspecific populations, and represent an important component in the evolutionary legacy of the species (Waples 1991 and 1995). As a result of this policy, a modified joint policy between NMFS and FWS was drafted and accepted in 1994 that gave more guidance on how to interpret the DPS, based on discreetness and significance of a population that had more of a scientific basis (Alexander and Corn 2010). This was endorsed by the National Research Council in 1995 (Czech and Krausman 2001).

Hybridization and the ESA

Why is hybridization relevant when implementing the ESA and creating ESA policies? First, hybridization has been a controversial topic in the scientific community for decades, with some seeing hybridization as just evolutionary noise and others seeing it as a strong driver of evolution through adaptation and gene flow (Arnold 1997; Rieseberg 1995). The latter perspective has been gaining support from current research (see Fritz 2006; Rieseberg 2003; Schluter 2009). Since FWS field biologists are largely responsible for implementing the ESA, their understanding of hybridization as well as the policies they are obliged to follow directly impacts endangered and threatened species. For example, both the dusky seaside sparrow (*Ammodramus maritimus nigrescens*) and the Florida panther (*Puma concolor coryi*) suffered from small population sizes and inbreeding depression. However, the use of genetic restoration methods using females from a closely related species of the dusky seaside sparrow was denied because of the DOI's policy to not protect hybrids at that time. This led to the sparrow's extinction in 1987 (Walters 1992). That policy was revisited in the early 1990s, and in 1995 the Florida panther was allowed to be genetically rescued by female mountain lions from Texas, from a subspecies which shared a historical range with the Florida panther, with occasional incidents of hybridization. Many of the negative effects of inbreeding (e.g., kinked tails, sterile male cubs) disappeared and now the main threat to the Florida panther is habitat availability (Gross 2005).

Additionally, climate change may dramatically increase the number of endangered species, as distribution ranges of plants and animals may shift into areas that have been highly modified by human activity (Doak and Morris 2010; Woodall et al. 2009). Hybridization provides a route for adaptation and gene flow that could either help or hinder species in their survival during these challenging times (Stevison 2008). For example, hybridization can introduce new genetic variation that can increase the fitness of a species, as with the Florida panther. However, it can also potentially swamp out a species if the threatened species hybridizes with a more common species, diluting the more rare species' genetics over generations. This is potentially happening to the endangered Catalina Island mountain mahogany (*Cercocarpus traskiae*), which will be discussed in more detail later on.

In response to the challenge of preserving genetic diversity in the presence of hybridization, the DOI's Solicitor released three opinions on how to handle hybrids, collectively called the Hybrid Policy (Ch. 12, Scott 2006) (Table 2). The first opinion in 1977 protected hybrids because the Solicitor reasoned that the ESA supported the protection of any offspring of a listed species and necessarily included hybrid offspring. In response to this first opinion, the FWS expressed their concern that hybrids may further endanger already rare species since one of the possible outcomes of hybridization could be the loss of one parental species through genetic swamping (Hill 1993). This led to a second opinion by the Solicitor that revoked hybrid protection under the ESA and was reaffirmed in 1983. The opinion to exclude hybrids from protection was contested widely in the scientific community because of the potential loss of genetic diversity and thus adaptive potential of endangered or threatened species (Ch. 12, Scott 2006; Allendorf 2001; O'Brien and Mayr 1991). Additionally, a lawsuit by environmental groups was initiated when the FWS tried to delist the Eastern gray wolf (*Canis lupus*) population segment due to potential wolf-coyote hybrids. The federal court ruled in favor of the coalitions of environmental and animal welfare groups, stating that the FWS had misrepresented scientific information (Adkins Giese 2006). Finally, a genetic study on the hybrid origins of the red wolf (*C. rufus*), which the FWS had spent much time and money on restoring, was slated to be released in 1991 (Jenks and Wayne, 1992). Genetic evidence suggests that the red wolf is the result of hybridization between gray wolves and coyotes (*C. latrans*) and the timing of this hybrid speciation was likely during the last 2500 years (Reich et al. 1999). As a result, the FWS released a statement in 1990 which expressed a need to revisit the strict standards dealing with hybrids, because it was more appropriate to have this question resolved by current scientific knowledge rather than by a legal interpretation of the ESA. This left the agency without any policy on how to handle hybrids until 1996.

In 1996, a potential policy for protecting hybrids was developed and proposed by FWS and NMFS. The Intercross Policy was designed to provide guidelines for handling hybrids. This policy attempted to increase the ESA's flexibility and adaptability, allowing recovery plans to determine whether hybrids should be protected or not with the aid of scientific information. However, this policy did not address populations (instead it is worded in terms of individuals) or natural hybridization, and also relies on morphological characteristics to determine whether hybrid offspring more closely resemble the listed versus non-listed parent species. This policy was never formally adopted or withdrawn, and remains in limbo.

There are other ways that hybrids can be protected under the ESA. Chapter 12 of Volume II of the *Endangered Species Act at Thirty* states that the FWS unofficially protects hybrids of natural origin where the hybrid is a stable, self-sustaining species that originated through non-anthropogenic means. For example, the Pecos sunflower (*Helianthus paradoxus*) was still listed after research showed it was of hybrid origin, because it was also shown to be a stable, independent species (Lexer et al. 2003). Additionally, Section 4(e) allows for protection of species with a similarity of appearance to listed species, in order to prevent the accidental taking of a listed species because its appearance is indistinguishable from an unlisted species. This has been used by the FWS only seven times; for example all cougars are protected in Florida to ensure that a Florida panther is not killed by someone claiming it was another subspecies (Ch. 12, Scott 2006). Additionally, current recovery plans can now include a genetic recovery plan, which stresses the importance of genetic diversity (Ch. 12, Scott 2006; Waples 1995).

The progression in treatment of hybrids in the ESA reflects the changing opinions of the scientific community over the last 30 years. This new information has the potential to improve the success of conservation efforts in the long run, even if it complicates the implementation of the ESA in the short run. However, since there is no official policy to address hybridization issues at this time, FWS agent discretion may prove to be the most important aspect of whether the advancing scientific information used to further the goal of the ESA.

Street level bureaucracy and discretion in natural sciences

Examinations of public administration have often been top-down in nature, with the assumption that agency goals are automatically transformed into action at the local level (Kaufman 1960; Wilson 1989). This method can provide important information about how authority is delegated or discretion is controlled from the top levels. However, it does not help determine how those goals are advanced by those at the field level. Field level information can provide critical insight into which policies are working (or not working) and why. Herbert Kaufman conducted a study examining the US Forest Service (FS) in 1960 that did just that (Kaufman 1960). He asked the question, how are the goals set by the top officers transformed into the actions of the forest rangers? He reasoned that in order to understand how forest rangers did their job, one had to look at the agency from the forest ranger perspective; or in other words, from the bottom up. Kaufman's study set the stage for many others who began to look at public administration problems from this bottom-up approach. This approach to examining organizational function was given a more formalized name by Michael Lipsky, who developed the concept of "street-level bureaucracy" (Lipsky 1971; Lipsky 1980). He examined areas of government outside of the natural resources management, such as schools and social services. Street-level bureaucrats are civil servants who interact regularly with citizens and have broad discretion in how they interpret and execute their agency defined rules and guidelines, leading to considerable variability in policy implementation, such as police officers, teachers, and social workers. For example, based on personal perceptions of who needs more help combined with limited resources, a social worker may put more effort into helping one client over another (Riccucci 2005). Most street-level bureaucracy studies have focused on the above mentioned civil servants. They generally cite personal values and pressures from the bureaucratic structure, including limited resources and ambiguous job expectations, as influential on how these individuals carry out their jobs (Lymberly and Postle 2015; Ellis 2007; Evans and Harris 2004; Maynard-Moody and Musheno 2003; Riccucci 2005; Lewis and Glennerster 1996). As a result of this work policy changes have been made in some cases. Lewis and Glennerster (1996) examined the implementation of England's 1990 community care reforms that were meant to curtail too much social security spending and provide more clear legal entitlements for clients. This was in response to widely inconsistent practices due to the discretion of social workers in interpreting claims. Reduction in social worker discretion in how to meet client needs was accomplished through predefined eligibility criteria. Unfortunately, a new form of disparity was created due to the reduced resources; hence different strategies to meet client needs within the budgetary constraints arose, an issue that continues to this day (Lymberly and Postle 2015).

As Kaufman proved 55 years ago, understanding how field level agents in natural resource management agencies accomplish the goals set forth by the agency is instrumental in dissecting policy effectiveness. Others have more recently examined various natural resource management agencies from the street-level bureaucrat perspective (Arnold 2014; Sandström, 2011; Sevä, 2013; Sevä and Jagers, 2013; Trusty and Cerveny 2012; Stern et al. 2010; Sabatier et al. 1995; Scholz et al. 1991). Many agents in environmental agencies perform functions that require them to interact with a client, such as environmental regulators inspecting and working with companies to reduce pollution, that allow them significant discretion despite specific laws and guidelines that govern their audits (Nielsen, 2006). The best studied environmental street-level bureaucrats are the FS professionals, starting with Kaufman's seminal work in 1960. He found that FS professionals' came close to meeting the goals set by higher officials and their decisions were generally upheld upon appeal (Kaufman 1960). At the time, most FS professionals had degrees in forestry (90%), creating a fairly uniform culture. Since then, biology and social sciences have taken over as the lead educational backgrounds of FS professionals. While his work is still relevant, others have since examined how FS professionals carry out their work within the context of Lipsky's street-level bureaucracy (Sabatier et al. 1995; Trusty and Cerveny 2012). For example, FS professionals are required to use natural and social sciences to develop environmental management plans, which leave them with a great deal of discretion with which to prioritize certain projects or advocate particular methods. Reflecting the educational background changes since Kaufman's study, Trusty and Cerveny (2012) found that these FS professionals often incorporated their own personal values into decisions on how to manage human activity in riparian areas. They found that these values were often tied to differences in educational background. Thus, there are some differences between social and environmental street-level bureaucrats. Environmental street-level bureaucrats often do not have face-to-face contact with their clients or stakeholders and they often have disparate educational backgrounds that may influence how they utilize their discretion (Sevä and Jagers, 2013).

The FWS field biologists in my study could be considered environmental street-level bureaucrats since they share many of the same characteristics as the well-studied FS professionals, particularly their level of discretion. The ESA states that species should be listed "solely on the basis of the best scientific and commercial data available" (Section 4b); commercial data refers to scientific data collected by the private sector (e.g., fisheries, fur, and timber industries) and allows for consideration of trade as a threat to a species survival (Doremus 1997). The legislation does not explicitly describe how science should be incorporated into implementation, nor does it specify which species concepts should be used or how hybridization should be handled (Carroll 1996; Waples 1995). Thus, the use of scientific information for ESA implementation relies upon the discretion of FWS agents. These individuals work with endangered or threatened species and relevant stakeholders at the field level, much like FS professionals work with landowners and other relevant parties to implement land management plans. Additionally, their decisions can impact the future of those species in their assessment and recommendations on how to best protect them, just as FS professionals' decisions direct public and sometimes private land management strategies. Collectively, their decisions impact policy implementation, potentially introducing considerable variability in policy implementation across agents and locales. FWS field biologists also face some of the same pressures as other street-level bureaucrats. The FWS suffers from chronic resource limitations and the ESA requires them to protect biodiversity using the best science available, while this science is continually evolving. In addition, they must meet this goal while also working with other local, state, and federal agencies tasked with their own directives. For hybridization issues in listing species or deciding among tactics to recover a listed species, the field biologists may have a high level of discretion due to the current lack of administrative direction.

Street-level bureaucrat discretion is often seen as negative. For example, social welfare systems have been extensively studied from the street-level bureaucracy perspective and social worker discretion has largely been viewed as perpetuating social inequities and as something to be curtailed (see Brodkin and Marston 2013). However, Evans and Harris (2004) have suggested that discretion by street-level bureaucrats may generally lie somewhere on a continuum of no discretion to complete discretion. They also posit that this discretion need not be purely negative in consequence, but could also have neutral or positive outcomes for policy goals and/or the clientele targeted by the policy. In line with this, environmental studies have also identified both positive and negative outcomes of street-level bureaucrat discretion as well as varying degrees of discretion (Nielsen, 2006; Sandström, 2011; Trusty and Cerveny 2012). Very little is currently known about the discretion of the biologists at the field level of ESA implementation. This is unfortunate because the

ESA provides the only law that explicitly protects biodiversity, and its "science only" mandate combined with uncertain scientific situations and concepts (i.e., hybridization and species definitions) leave its implementation largely in the hands of field biologists.

Thus, this study intends to illuminate the discretion of field biologists (as street-level bureaucrats) when using scientific information to make recommendations for protecting endangered and threatened species. Understanding the impact that current FWS field biologists' discretion has on ESA implementation may be particularly timely as Congress is currently trying to undermine the directive for using the "best science available" in the ESA (Rosenberg et al. 2015).

Research objectives

In my study I have investigated FWS field biologists' discretion and its influence on ESA implementation. Specifically, I will look at how species concepts and hybridization are interpreted by FWS field biologists and how their knowledge and beliefs about these concepts, combined with their professional discretion, impact ESA implementation. I used a qualitative data analysis methodology of semi-structured interviews. Policy analysis studies have frequently used qualitative methods (Turner 2010; Ritchie and Spencer 2002; Patton 1990). More specifically, street-level bureaucracy has also largely been studied using qualitative methods like semi-structured interviews (Evans 2011; Kim 2009). Semi-structured interviews consist of both open-ended and closed-ended questions. This method provides a general guide (interview questions) that ensures that the same basic information is obtained from all interviews. At the same time it also allows for flexibility in its semi-casual conversational nature to gather more information from each interviewee (Turner 2010).

Research design and methods

Interviewee selection

I identified endangered or threatened species with known hybridization or species delineation issues in the United States through a four step process. First, I used Google Scholar to search for published literature about the ESA and hybridization. I used these sources to identify a candidate list of species to target. Second, using the FWS website I searched for species with known hybridization issues and added any species not already on the candidate list. Third, I conducted two internet searches using several key word combinations, to determine which species on that list had available information on known or potential instances of hybridization. I performed the first search in Google using all possible combinations of the species' common name, scientific name, and the word "hybrid". I also did a secondary search by adding another phrase, "Federal Register", to capture information published by the FWS. I performed the second search in Google Scholar using the same combinations of key words as in the first search. I identified a total of 38 species from all FWS regions except Region 7 (Alaska) (Table 3). Fourth, using the FWS website I identified the lead field office for each species and the contact information for the field supervisor.

As per FWS protocol, I contacted the field supervisors to gain permission to speak with FWS field biologists as well as identify the best person to speak with about the species of interest. I initiated contact through a two-step process. First, I sent an email to the field supervisor. If there was no response by email, I made a follow-up phone call. Once I identified a candidate field biologist, I used the same contact method as for the field supervisors. If the first two contact attempts to either the field supervisor or the recommended field biologist resulted in no response, I made a third attempt to contact that individual by phone. I interviewed a total of 20 field biologists covering 25 of the original 38 species identified, as well as two additional species brought up by the interviewees. The interviews took place between September 2014 and March 2015.

Additionally I contacted administrators from the field, regional, and headquarters level (one from the Solicitor's Office and one from the Secretary's Office) through the same two-step process. However, I only garnered responses at the field and regional level. I used a snowball technique to try to identify a contact at the Solicitor and Secretary's Offices, but I received no responses after multiple attempts to contact those recommended individuals. I conducted two administrator interviews, a Recovery Branch Chief at the field level and an Assistant Regional Director.

Semi-structured interviews

Interview questions for both the field biologists and administrators progressed from a broad to a narrower perspective. For the field biologists, the first set of questions covered information about the field biologist's formal training, how they fit into the

FWS structure, whom they interacted with, and what level of discretion they believed they had. The second set focused on the interviewee's knowledge of species concepts and hybridization, as well as their experiences with hybridization or species delineation issues within the ESA (see Appendix A). For the administrators, I used three focus areas to develop the questions: personal background, how the organization functions (including questions about field biologist discretion), and how well the organization is functioning (including questions about how hybridization issues are handled within the context of the ESA) (see Appendix B). Interviews with field biologists were on average approximately 45 minutes long, with the shortest interview lasting 30 minutes and the longest interview lasting 1 hour and 30 minutes. Interviews with the two administrators were generally shorter, lasting between 20 and 40 minutes.

Data analysis

I audio-recorded and transcribed all 20 interviews and coded the 18 field biologist interviews (two interviews were conducted with two participants) using HyperResearch software. Coding is a process of placing and sorting data into categories and themes and is a common approach to analyzing interview data (Strauss and Corbin, 2007). I created the codebook using an iterative deductive-inductive process. First, I developed an initial set of codes to create categories and index the data (e.g., education level, years worked, position, experience with hybridization issues, awareness of hybrid policies) as well as specific themes (e.g., level of discretion, knowledge and opinions on species concepts, hybridization and conservation, organizational interactions, where scientific information comes from). Then, I developed additional codes throughout the coding process as I identified important patterns or themes that I did not consider originally (e.g., Section 7 and 10 implementation, hesitancy to talk about certain topics, limitations within the organization, sources of hybridization, areas of discretion) (refer to Appendix C for the complete code book). I chose this approach because it allows for discovery of information which influences the way hybridization issues are handled that is not quantifiable. This approach is becoming more common in studies that aim to uncover underlying influences impacting natural resource decision making, e.g., for forest management practices and conservation decisions (Beiling 2004; Schubert & Mayer 2012; Lind-Riehl et al. 2015). Once the coding was complete, I used frequency tabulations to gain a sense of what the overall trends were in terms of perceived discretion, views on hybridization, thoughts about hybrid policy, and other organizational functions. I then focused the qualitative analysis on the major themes related to how hybridization issues are handled within the ESA currently.

Since only two administrators were interviewed, I extracted important themes through manual reading of the transcripts. I identified a few major themes including: whether or not both administrators and field biologists expressed similar stories concerning field biologist discretion, and how hybridization issues are handled.

Results

All interviewees had a natural sciences background, which varied almost equally between bachelors, masters and doctoral degrees (Table 4). Most interviewees had been working with the FWS for somewhere between 10 and 20 years (Table 4). The interviews with field biologists revealed that they wield a great amount of discretion in two areas (Table 5). First, how they carry out the "detective work" to identify and assess data sources regarding a candidate species is completely up to them. Second, when field biologists are working with other agencies and institutions, they often have latitude to decide who might be best to collaborate or communicate with outside of the required interactions through Section 7 and 10 of the ESA. At the same time, they are directly accountable for their biological opinions and recommendations through peer review at multiple levels (e.g., field and regional levels, solicitors). Despite their ability to use the best information they can find, many also expressed distress over not being able to adequately protect species because of resource limitations (e.g., staff, funding, knowledge available for species) and political conflict (Table 5).

Most field biologists rely on the current scientific consensus to inform them on taxonomic status and hybridization issues, which reflects the ESA's "best scientific information available" mandate (Table 5). However, work experience influences their opinions on whether hybridization issues can be complex with multiple outcomes, or a straightforward threat to a listed species (Tables 4 and 5). Despite this, all of the interviewees thought it was best to have a case-by-case approach to hybridization issues. Several also supported a "flexible" policy, where a basic guideline on how to approach a hybridization issue would be followed by a case-by-case approach to decide how to specifically deal with it (Table 5).

Field biologists as street-level bureaucrats

<u>Discretion of field biologists</u>

Discretion was most common in the information gathering step for listing a species or developing a recovery plan (Table 5). Field biologists are mandated to find all relevant scientific information useful to determine the status of the species (e.g., taxonomy, current populations and their distribution, current threats, severity of threats to the species continued existence). For example, this field supervisor described a field biologist’s ability to gather pertinent information in their own way.

“…She would use her own method to gather what information she needed to formulate her recommendation.”

This was mirrored by another field biologist’s statement about how he writes biological opinions and recommendations. In addition, he believes his supervisors support his autonomy in this particular part of his job and trust his recommendations.

“Nobody's every really told me the answer before I got to it. I do my literature review and research, you know, not primary research, but trying to figure out the information and make my assessment and you know, talk to the management, you know, the decisional team going up the line along the way and they may have questions, but generally it's my assessment.”

This discretion is believed to be necessary for these field biologists to do the job they have been hired to do.

"…In this business, both the listing and the recovery aspect are, you know, there's a lot of detective work. If you're not given discretion, you cannot do it. I mean you've got to be able to contact people, you've got to be able to ask questions, and you've got to be able to get out there and verify information that you've been given. If you don't have it, you can't do it."

There are real world consequences to the protection of endangered species, both large and small, as a result of this discretion. For example, this field biologist ended up writing a document which formed the basis of a joint policy between FWS and NMFS.

"…Before we could start all these status reviews...all these stocks were petitioned not as their own species but as distinct population segments [DPS]. So we had to figure out what were DPSs and are they threatened or endangered. So I ended up writing a scientific document that ended up forming the policy NMFS still uses for defining DPS of salmon."

In this situation, research method as well as interpretation of the DPS policy were both subject to discretion at the field biologist level, albeit peer reviewed by others in the FWS and NMFS. In another instance, several species of butterflies were protected due to a proactive field biologist.

"I mean, it's kind of hard to say what would happen if we didn't take action, but, you know, like with these butterflies, we initiated that listing action ourselves. And it's possible that we would have been eventually petitioned to list them, so… but like it in

that case, several years ago I decided to ask a bunch of experts what species we should be looking at. So if I hadn't done that, I guess it probably would have happened, but it probably would have happened a little more slowly."

A second area of discretion that was not specifically asked about was mentioned by several interviewees. Field biologists indicated that they had a lot of autonomy when collaborating with other agencies (e.g., federal, state, private, etc.) usually through Section 7 and 10 of the ESA (Table 5, collaboration). This field biologist illustrates a strong sense of autonomy when working with partners.

"So, we have discretion for certain things about like, working things out with landowners, or other federal agencies to protect endangered species through Section 7 consultation. There's a lot of discretion there, and I have that discretion and I feel like I have a lot of discretion there."

Section 7 specifies that all federal agencies must consult with the FWS when endangered species may be affected by their activities. Likewise, Section 10 similarly requires this of other groups including state and local governments, tribal groups, private entities and citizens. However, different groups may impact listed species in different locations and have different levels of information and ability to gather or share information on listed species. Additionally, the FWS can voluntarily work with outside entities if those partnerships will help further listed species conservation. Thus, whom the FWS will end up collaborating with may vary greatly and is often at the discretion of the field biologists. For example, this field biologist expresses how partnerships are a key component of how they set and accomplish goals for conserving species, for all stages from listing to recovery plans.

"Yeah, I'm given a pretty good bit of latitude to work with partners who identified, in the case of species that are listed, who identified the tasks that are most important to be doing in the way of recovery of that species and working with them to get them accomplished."

Most field biologists thought inter-agency communication was very good. This interviewee describes how this high level of communication helps ameliorate potential conflicts among the stakeholders involved in a listed species action.

"A huge piece of our work is working in kind of a proactive, most collaborative type fashion with an array of partners from tribes, to industry to private landowners to other local state federal governments... all of them have different mandates than ours. But at the same time have certain obligations to do good things for listed species or minimize their impact or prohibitions on take that they might be causing. And so, we have lots of different tools that we utilize to try to find that balance of working with other folks out there. And of course a lot of it comes down to relationships and kind of building partnerships and stakeholder groups and keeping people informed, and making transparent decisions; things like that, but I can't emphasize enough that every biologist in our office, and probably in our agency, on a very very regular basis are working constantly with other entities outside of our agency to find that common ground of doing as much as we can to promote

conservation while acknowledging all the other constraints that other people have out there across the landscape. Yeah, it's central to a lot of the work that we do."

Despite the seemingly high level of autonomy field biologists have, all interviewees were quick to also add that their work is peer reviewed at many levels. This field biologist describes how she uses her own method to gather information, but it must follow the ESA mandate and FWS policies and is subject to multiple reviews.

"However, all decisions must be based on the best available science, and follow Service policy and regulations. There is never a complete set of information available for any decision, so discretion is used to interpret the available information and formulate a decision document. An employee at any level of the organization must be able to provide a valid scientific and legal rationale for their decision to the higher levels of the organization."

While discretion at the information gathering stage is high for field biologists, as described by this interviewee, the actual decisions are made at a higher level. Communication between these levels is critical for the time sensitive nature of most listing and recovery plans. As such, field biologists' identified intra-agency communication as a key component of their daily activities.

"We're providing a recommendation and the actual decision doesn't get made until it reaches headquarters. Although we're trying to work very closely with those various layers [Solicitor's Office, Regional Office, Field Office], so there's no surprises at the end."

Administrators described the level of discretion the field biologists have in very similar terms as the field biologists themselves. An Assistant Regional Director expressed how heavily those at his level and above rely on the information the field biologists provide them to make final decisions.

"There's definitely a lot of discretion in terms of making recommendations. And that's where we have sometimes some conflicts because, as you would know, in the policy making process there are different levels and different aspects. So we rely on those field biologists and the field supervisors heavily in terms of providing us the best available information they can find… So I would just tell you the actual decision, who puts his or her signature on the documents doesn't happen at the field biologist level. But definitely we rely heavily on those pieces of information that come from the biologists."

This administrator emphasized the role of peer review in making sure field biologists make clear and rational arguments in their recommendations to counter potential bias.

"I think there is some discretion. Part of it is based on how our people dig for information and how that threats analysis is evaluated and weighed in relation to current conservation efforts. There's a little bit of flexibility, but it really needs to make sense in terms of how they got from point A to point B in that decision making process and there's so many people that weigh in along the way, that if something doesn't sound right we have plenty of opportunity to question it and reevaluate and make sure that we're moving forward with the a manner that consistent with the

information that's provided.”

This field level Recovery Branch Chief stated that field biologists had discretion during the data collection and interpretation stage to formulate recommendations. However, just as most of the interviewed field biologists stated, he also made a point to describe the system of checks and balances for the work of field biologists. However, consistent communication between the field and regional levels was cited as a way to keep what is going on at the field level more transparent.

“You know, we're now... we're trying that new approach where we actually work with our regional office as well as our headquarters, which is in Washington, and then a solicitor kind of at the same time. So that that biologist that's doing most of the work, they're not kind of left out to dry.”

Communication within the agency as well as with partners was highlighted as incredibly important by both administrators. The regional level administrator described how he makes a point to know who the field biologists are that he’s supervising and to be involved in what they are working on.

“Email and phone calls are the most common. However, we make a lot of effort to actually visit field offices and directly interact with the field biologists and not only to get to know them but also to see firsthand what projects they're working on on the ground. That personal connection is very critical.”

Policy complexity and political influence

Political conflict and policy were mentioned frequently as barriers to protecting listed species using the best available science. Political climate sometimes influenced how critical habitat for listed species was designated, as in this example of the Canada lynx (*Lynx canadensis*).

"One example is back when we worked on Canada lynx and there was a pretty well known political appointee in the previous administration who basically kind of came in at the last second and drastically altered the proposal. In that particular instance it became clear that it was... you know it would be handled way above our heads… it seemed like there were interest groups that were influencing you know the political appointees in Washington DC. I'm trying to remember how it all happened; I can't remember if we were sued, but that was eventually overturned. And we wound up with a designation of critical habitat that makes a fair amount of sense... from a biological perspective."

In other instances, economic motivations allowed for some stakeholders to exploit the uncertainty of the status of a listed species. For example, development pressures combined with uncertain taxonomic status made the coastal California gnatcatcher (*Polioptila californica californica*) a "lightning rod" for legal and political battles.

"Some of these things are listed under that subspecies rank and the gnatchcatcher is one… the California gnatcatcher lives in southern California and off the Baja California peninsula in the coastal sage scrub. The coastal sage scrub grows in the lower slopes and flatlands of coastal slopes of southern California. I think LA,

Orange county, San Diego; all these big urban areas. So there's a lot of development pressure to convert that habitat type and that was the primary reason for listing the species or was 20 years ago. And as a result of that listing and that development pressure there were a lot of people with real estate that wanted to develop it and now had to spend a lot of money to deal with an endangered species instead of doing what they want to do with their land. And so it became a lightning rod for this issue in the subspecies. And there's a long sordid history with the gnatcatcher in particular; we're dealing with a legacy of ornithological history and how subspecies were named and that meeting economic pressures with the gnatcatcher in particular."

As of December 31, 2014, the FWS has stated the delisting petition may be warranted. Whether the gnatcatcher remains listed will largely depend on how the FWS biologists, like this one, interpret the current scientific data on its taxonomic status.

Policy can also complicate protection of listed species when conflict arises over the interpretation of that policy, as in the case of the gray wolf. A field biologist commented on how difficult policy interpretation can be when dealing with the natural world.

"And our DPS policy, there's some subjective language in there that you have to interpret. Words like significant or markedly separate. And so you know, you're using your best judgment and your scientific background and your knowledge of the species... some of those policies fit certain species better than others and for instance

our DPS policy is a difficult one to fit wolves into because you're supposed to be drawing this boundary around animals in this area that are markedly separate from anything else. But wolves move long long long distances and so to try to fit these animals that have these capabilities of moving long distances into words like markedly separate... well, what does that mean? Is it totally separate or not really, occasionally, a wolf can travel 300 miles."

In the case of gray wolves, this issue of DPS designation led to decades long legal battles over whether the agency had applied this policy appropriately. This had less to do with the actual science and more with the value judgments made on how to apply the DPS policy.

Limited resources

Lack of funding was also mentioned by almost all interviewees as a limitation to adequately protecting endangered and threatened species. This interviewee describes how a relatively small budget makes it difficult to accomplish their job, in this case protecting the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis)*, which is in a similar situation to the now extinct Dusky seaside sparrow.

"We operate on budgets that are miniscule compared to what the Army Corps of Engineers... you know a million dollars is chump change to them; that's a contingency on a project that they just write into... it could be inflation of a million dollars or two that you just have to write in as a contingency as part of this project.

A million dollars or two for us would you know... would pretty much tell us everything we need to know about Cape Sable seaside sparrows."

Many also felt that they could not adequately protect existing species, let alone newly listed species given the shrinking support (and consequently personnel) available for the FWS. As one field biologist stated:

"You know listing doesn't necessarily bring money, doesn't necessarily bring research."

Another field biologist describes how things have changed over the past decade or so and how it has impacted endangered and threatened species conservation actions.

"The bottom line is we're spread incredibly thin and we're still doing an amazing amount of work for the limited staff and budgets we have, but there's a price to be paid. And there's a lot of recovery out there on the ground that's not happening because of the constrained budget that our agency is operating under."

Administrators also brought up some of the same limitations to implementing the ESA as the field biologists. However, they also emphasized how much they valued the field biologists for the hard work they did with the resources available.

"Yeah, well, given the resources, in terms of money and people, we are pretty small agency relatively speaking. And we have a lot of... way more needs than resources, so I'll say that we're doing the best we can with the resources we have. And our people, you know, those field biologists out there, they do long long hours. They

don't work 40 hours a week, they probably work 50 or 60 hours a week. So, I say given the resources we have, definitely we're doing the best we can to implement and conserve the species."

Even though both administrators thought they were doing the best work they could, there was a desire for improved resource availability. This field level administrator expresses his desire to improve the efforts they already make to recover species, but knows that little improvement is possible without more staff and funding.

"I wish that we had more time and more effort to follow up more with partners, to follow up more with those we've already done work with, to better evaluate implementation. I wish we had more opportunity to fund more on the ground recovery work that would be separate from Section 7. And we get opportunities through Section 6; you get some opportunities from our recovery funds through the regional grant programs. But we still need more and it comes down to money and having more staff."

Science and the ESA

<u>Species concepts</u>

When asked what the main goal of the ESA meant to them, most biologists considered conservation to be about the species, largely because that is the focus the ESA and its policies. Additionally, most of them also discussed the importance of resiliency for these species and their habitats, since the goal of the ESA is to help species recover.

When trying to define a species, the BSC was mentioned by over half of the interviewees (Table 5). However, more often than not they tended to go with what the current scientific consensus is for the taxonomic status of a particular species. Even if there was some controversy surrounding that definition, the generally accepted taxonomic status is what they would follow, as evidenced by these two field biologists' responses.

"I define a species as it's generally presented to me in terms of its conservation status. Whether we're petitioned or whether I identify the species that's a potential candidate and then pursue it. I basically rely upon... must rely upon the best available information and that's generally the current taxonomic status. You know as it's published, as it's accepted... you know it's not always agreed upon."

"I guess for a species where there is some controversy or argument in the scientific community about whether it's a legitimate species or not, I would defer to the literature. If it's published and recognized as such, even if there's some controversy, I will accept that it's a unique entity and treat it as such."

Both field biologists expressed how much they rely on the scientific consensus regarding the current taxonomic status of the candidate species. Furthermore, the relatively recent role of genetics in defining species was recognized, as displayed by this field biologist's description of how he thinks species are defined.

"More and more that's being done not just on a morphological basis, but on genetics as well incorporating ecology also. So, we're certainly finding ourselves in a

position where's there's a lot more cryptic biodiversity or cryptic taxa that are being recognized, but that's the reality of what the biology and the scientists is telling us… they're an important tool that we have in identifying what our conservation units ought to be."

This of course can lead to more "cryptic taxa" complicating their ability to assess the taxonomic status of "species". This field biologist describes how they deal with taxonomic uncertainty of a species within the scientific literature available.

"When there is a dispute in the scientific literature, we try to determine which viewpoint has the most support in the scientific community, and meets the criteria of the ESA."

Hybridization

As the scientific community learns more about organismal relationships, gene flow and hybridization have been identified as important evolutionary forces. When asked, most of the field biologists were aware of this changing emphasis, but they often referred to it as a bad situation within the context of the ESA. This newer genetic information complicates the task of protecting the species. Some felt it may jeopardize the endangered or threatened species through genetic swamping. This field biologist in particular immediately expressed that concern when asked about hybridization.

"I get nervous because... I get worried, because in the endangered species world, typically when we start talking about hybridization it's a threat. We usually view it as

a threat because it means that a more common species is overtaking a listed species or it's maybe not that degree of concern, but is a concern because it's breeding and hybridizing with a listed species and so could potentially... the genetics of the listed species are getting diluted and/or the listed species could disappear, it's potentially then outcompeting the listed species."

At the same time, it clearly was recognized as a natural event by many of those same biologists. This biologist begins by stating that hybridization can have real evolutionary consequences that could be good, but that in the context of the ESA it is usually a threat.

"I think hybridization is something that's going on out there. And it can potentially be a source of new species arising. However, for the purposes of the ESA, we tend to view hybridization as a threat because of its potential to cause the appropriation of the species or loss of the species due to introgression and outbreeding depression and things of that nature."

In general, the less work experience a field biologist had with unclear species boundaries and hybridization events, either within the ESA or outside of it, the less likely they were to emphasize current scientific consensus. Some of that experience was gained through education as well. However, there were no clear divisions within the educational backgrounds of interviewees on this issue. This field biologist has been working with species that have both natural and unnatural hybridization occurring, as well as unclear species boundaries, and clearly sees that its role can be varied and complex.

"I think it's a potentially important method of gene exchange and gene diversity to them... can be potentially helpful in adaptation and thus future speciation through time. So it's an important natural event when it occurs at natural rates."

Since he has a wide array of experience with different hybridization outcomes, he recognizes its potential evolutionary consequences regardless of whether they are labeled good or bad. Unlike that field biologist, this one has had no experiences working with listed species that have hybridization issues. As a result he sees it as a threat to listed species.

"In general I view it as in most cases a disruptive process that can threaten species."

His knowledge is limited to what he has likely been exposed to within the FWS. Since the current prevailing view of hybridization is largely negative within the Ecological Services division of the FWS, he also largely views it as a threat to the species he works with.

Despite these differences, all of the field biologists acknowledged that hybridization events originating from human activities were different from natural hybridization events. This field biologist explains how he approaches natural versus anthropogenic hybridization events differently.

"I might only call it a threat if it's something that's obviously kind of human induced. So I guess, that would be my one bias; is this hybridization something that we can clearly point to a human cause for? You know, like one good example is introducing brook trout into the range of bull trout in the west. I know there's some [natural] hybridization that is going on... like with prairie bush clover, it hybridizes with round headed bush clover and it doesn't... it seems like that only happens in some places, but not in all places. And so I don't think we would call it a threat at this point."

He feels that human-induced hybridization is more likely to lead to a species' demise, while naturally hybridizing species may only hybridize in certain areas of their range, causing no threat to either species. Another field biologist underscored the importance of hybridization as an evolutionary force with complex outcomes, stating that human-caused hybridization events are the ones that create issues.

"I think it plays a huge role in speciation and natural selection. It presents as much opportunity as it does problem. Hybridization is only a problem because of human intervention."

Hybrid policy

Of the 18 interviewees, 12 were either unaware or unsure of the history of the FWS Hybrid Policy and its current status (Table 4). Those who stated that they had no experience working with species with hybridization or species delineation issues were also not aware of the FWS hybrid policies (Table 4). Those who had experience working with hybridization issues generally used available scientific resources to assess whether it was or could be a threat to candidate or listed species. However, when asked how they would like to see hybridization issues handled within the FWS, most field biologists preferred a case-by-case approach or a case-by-case approach with some official guiding policy on how to approach a hybridization issue (a flexible hybrid policy). This field biologist provides his own experiences with listed species to justify why a case-by-case approach not only works well, but is necessary to make the best conservation decisions for listed species.

"I think it's got to be case-by-case. Pallid sturgeon is a perfect example of why. There is hybridization occurring, there is introgression occurring, but as far as we can tell it's completely natural. And to me the best option from a conservation point of view is to let nature take its course. If this was a... if shovel-nose sturgeon had been introduced into the Mississippi River that was the source of hybridization, an introduced species, I think you've got a real threat. Something that's happening very rapidly and that can overwhelm the native species... You must consider the options: you can keep it from spreading, you can isolate it, and you can in some very rare cases even control it. So I think it's just got to be case-by-case."

Many also recognized value in having some guidelines when legal issues arise out of these situations, as expressed by this field biologist.

"I think it would be good to have general guidance as to how and when to deal with the hybridization issue. I think it's problematic from the legal point of view. OK, you have species X mates with species Y and you end up with something else, and it's not

X and X is the listed species and Y isn't. You know, so what do you do with it. From a legal point of view it's definitely on shaky ground. There's not much to do within the ESA that would give us much to stand on to do anything for those hybrids… Is it a problem and if so, then what do we do about it is going to be something that's a case-by-case basis. Is it a problem, well that may be case-by-case to, but I think we need to have some sort of guideline set that it isn't totally arbitrary."

In the eyes of this field biologist supporting a "flexible policy", it provides a compromise. It would still provide the field biologists with discretion to use science to best decide how to protect the listed species when hybridization issues are a part of the assessment. At the same time it would standardize the method they use to get to that point.

Administrators expressed similar views to the biologists supporting a case-by-case or flexible policy option over the historically rigid policies put forth. Both felt that a hybrid policy that was flexible would be the most useful, as described by the regional level administrator.

"I think a policy on the process of how to deal with that… I would love to be able to see something like that. And maybe again going back to having an independent entity that can provide advice to the agency. I'm thinking just randomly here: National Science Foundation, the Smithsonian Institution; they really don't have an agenda, you know, and their credibility level is extremely high. There might be some other organizations out there, but off the top of my head, they're coming to mind."

The Assistant Regional Director supported having guidelines to direct how to go about addressing hybridization issues. This may reflect concern over how the field biologists are currently dealing with this issue without any consistent guidance.

"I would hope that the biologist would bring [hybridization or species delineation issues] forward so that we can talk about it in house to figure out what the potential ramifications of that are and then talk to the species experts or those that are more familiar with any genetic work that has been done, which we could then make an informed decision."

If there were guidelines on whom to consult or how to systematically address the issue, this field level administrator would be more comfortable knowing that the right decision was being made in those cases.

Discussion

Field biologists as street-level bureaucrats

Field biologists exercise a great deal of discretion during the data collection and interpretation phases for listing and recovery plan recommendations. This is partially due to the vague nature of their mandate to use the best science available, as well as the equally vague definition of what constitutes a unit of protection under the ESA. Others have noted that this vague mandate, combined with unclear scientific information (i.e., hybridization or species status), has lead to inconsistent decisions and consequent legal battles over the years (Ellstrand 2010; Doremus 1997 and 2010; Gross 2005: Hill 1993). To describe just one recent example, some populations of westslope cutthroat trout (*Oncorhynchus clarki lewisi*) have known introgression from non-native trout species that is considered to be a threat to the species' fitness (Muhlfeld et al 2009; Campton and Kaeding 2005). In the FWS's determination they included all populations, even introgressed ones, in their population estimates, and concluded that the species was sufficiently abundant and did not qualify for listing. A federal district court struck this down on the grounds that they had not adequately justified their inclusion of hybrid populations. As a result, the FWS used morphological characters to assess what populations to include and determined that they still did not warrant listing. This decision was upheld by the federal district court (Doremus 2010). Basically this means that some hybrids and introgressed forms will inevitably exist in the included populations, since morphological identification has been shown to be less accurate that genetic identification (Weigel et al. 2002).

Another discretion issue is the distinct population segment (DPS) policy. Field biologists are being asked to apply the best available science, but DPS is a policy creation and does not exist in the scientific world. This became an issue when the NMFS was trying to identify conservable units of Pacific salmon species since they have large ranges, substantial local variation, and reproductive isolation (Waples 1991 and 1995). Neither the DPS policy nor the subspecies categories were readily applicable given the taxonomic assessment of the species in the scientific literature. However, fish systematic biologists recognized the significant adaptive variation present in these salmon populations (Doremus 2010). In response to this the NMFS developed a guideline to interpret the DPS policy and eventually a joint policy between the FWS and NMFS to better define what qualifies as a DPS was formulated (described in detail in "The ESA's best available science mandate" section) (Waples 1991 and 1995). Wolves have also posed a problem for the application of the DPS policy (Alexander and Corn 2010). As one interviewee mentioned:

"There's some subjective language in [our DPS policy] that you have to interpret. Words like 'significant or markedly separate'. And so you know, you're using your best judgment and your scientific background and your knowledge of the species... some of those policies fit certain species better than others and for instance our DPS policy is a difficult one to fit wolves into because you're supposed to be drawing this boundary around animals in this area that are 'markedly separate' from anything else. But wolves move long long long distances and so to try to fit these animals that have these capabilities of moving long distances into words like 'markedly separate'... well, what does that mean? Is it totally separate or not really, occasionally... a wolf can travel 300 miles."

Other natural resource management sectors (e.g., forest land management, fisheries) have looked at implementation issues from this perspective and have seen similar results (Crewett 2015; Sevä, 2013; Sevä and Jagers, 2013; Uprety 2013; Trusty and Cerveny 2012; Sandström, 2011). For example, an institutional analysis of community-based pasture management in Kyrgyzstan showed that simplification of implementation rules at the street-level had resulted in reduced community participation in community pastureland management. This was attributed to a poor fit of the policy to what was actually happening on the ground (Crewett 2015).

Almost all of the interviewees mentioned funding as the biggest limitation to doing their job to the best of their ability. Those who did not mention funding directly felt that lack of scientific data for a species and inability to get that information (i.e., no funds to contract or do the needed research) as a major limitation. In 2002, the United States General Accounting Office (GAO) released a report on how funds are allocated within the FWS for ESA implementation. They found that the FWS is unable to tackle their backlog of listing activities from litigation, court orders, and settlements because of a funding cap on these activities that has been in place since 1998 (USGAO 2002). Furthermore, Greenwald et al. (2013) found that the number of species listings fluctuate with politics and litigation. This seems to be a common issue in natural resource management. Uprety (2013) uncovered that foresters in Nepal struggled to implement community forestry services due to inadequate resources.

Species concepts, hybridization and the ESA

Field biologists with work or educational experience dealing with tenuous species delineations and hybridization situations had a more open view of the potential benefits of hybridization. However the culture of the FWS still reflects a bias against hybridization, typically considering it a threat. This bias is likely a result of the many complications that hybridization has created for species protection under the ESA. The red wolf provides a prime example as it had a lot of FWS resources dedicated to its conservation (Hinton et al. 2013). Thus, when a genetic study came out describing the likely hybrid origin of the species in addition to current hybridization with coyotes occurring (Reich et al. 1999), there was a public outcry over continuing to protect and maintain captive breeding programs for the red wolf (Hinton et al. 2013). Another reason hybridization events with listed species have been typically tumultuous is because many of the situations FWS field biologists deal with involve anthropogenically caused or initiated hybridization due to invasive species or habitat loss. For example, the Catalina Island mountain mahogany (*Cercocarpus traskiae*), an island endemic, was decimated by livestock grazing. There is currently one population of the tree species in existence and it was discovered that some of the seedlings are likely hybrids between the listed species and the more common species, birch-leaf mountain mahogany (*Cercocarpus betuloides*) (Simberloff 2000). Various listed trout species have also been impacted by hybridization with trout species introduced for recreational fishing, often resulting in reduced fitness of the native endangered species (Table 3; Muhlfeld 2009; Rieman 2006).

However, ESA hybridization issues have not always resulted in conflict. For example, the threatened prairie bush clover (*Lespedeza leptostachya*) has been shown to hybridize with a more common species, but only in a limited hybrid zone (Fant et al. 2010). As a result, the FWS does not consider this natural hybridization a threat to the species. While these cases are not uncommon, I had to prod the interviewees for these examples. The more controversial and problematic examples (e.g., red wolves, salmon, Florida panther) were what came to mind without prompting. Finally, even without an official policy excluding hybrids anymore, species may lose protection because of hybridization issues. The Arizona agave (*Agave arizonica)* is an example of a species that was delisted because it was discovered that it was a recent and sporadic hybrid of two other more common agave species (Fed Reg. 70). However if hybridization plays an important role in adaptation and speciation, this recent hybrid could be the result of environmental adaptation or the early stages of hybrid speciation. Climate change may also increase hybridization events and change the importance and magnitude of these interactions (Ellstrand et al. 2010). Another example involves the pallid sturgeon (*Scaphirhynchus albus*), which naturally hybridizes with the more common shovelnose sturgeon (*S. platorynchus*). Originally the hybridization was thought to be anthropogenically caused, until research showed that it was natural and likely a result of an incomplete divergence between the two closely related species (Allendorf 2001). In other words, it could be argued that these two species are really one species far along in the process of diverging into two species. However, the pallid sturgeon retains its protection under the ESA and FWS has shifted its focus to addressing the habitat loss threatening the pallid sturgeon. Given these two examples, do we want to preclude the creation of biodiversity because it's in a more diverged stage of speciation versus a situation where it is potentially just beginning? How do we determine which cases are worth saving and which are not? These are all questions that FWS field biologists must answer to be sure they are working towards the main goal of the ESA.

Policy Implications

In general, field biologists believe they are using the best available scientific information they can obtain for use in listing, critical habitat, and recovery plan recommendations. However, the process for deciding what the best available information is remains largely discretionary. This in turn impacts how hybridization and species delineation issues are handled, which has real world consequences for the protection of endangered species. For example, difficulties in interpreting what constitutes a DPS led to the creation of a policy first within the NMFS followed by a joint policy between NMFS and FWS still in use today (Doremus 2010). In other cases species have been delisted (e.g., Arizona agave) or remained listed (e.g., pallid sturgeon) because of the interpretation of scientific information. Shifts in policy on how to handle hybridization between listed species and non-listed species due to scientific information forbade the use of genetic restoration in the case of the dusky seaside sparrow (now extinct), but allowed it for the Florida panther (increased population numbers and health).

The use of the best available science as the guiding policy for protecting endangered and threatened species has been discussed extensively over the decades (Sullivan et al. 2006; Czech and Krausman 1998; Doremus 1997, 2010; Hill 1992). The common thread has always been a discussion of whether it really provides the best solution for protecting endangered species. In other words, can science be used to implement a policy effectively? FWS field biologists often have to make value judgments that have very little to do with science (Czech and Krausman 1998). For example, the scientific debate over whether the coastal California gnatcatcher is a legitimate subspecies has put its listing status under intense economic pressure (MacCormack and Maley 2015; Zink et al 2013; Cronin 1997). While the species cannot be delisted without scientific evidence that it is recovered, its taxonomic uncertainty may allow undue influences to affect this decision (Zink 2013; McCormack 2015). This is a product of how the ESA was written.

As postulated by Vucetich et al. (2006), many of the directives in the ESA are normative statements, even though they require the use of empirical methods to prove them. For example, a species can be considered endangered or threatened if it is at risk for extinction throughout all or a significant portion of its range. This describes a determination of acceptable and unacceptable risk. However, science does not provide this type of assessment (whether a risk is "acceptable") and can only state whether a species is more or less at risk. As with the gnatchcatcher, its taxonomic status may be in question, but a lack of evidence for distinctiveness is not support for delisting from a scientific perspective. This aspect of science and its inherent uncertainty can lead to varied interpretations of science influenced by political and policy pressure. For example, indications that the red wolf might be of hybrid origin led to a fierce debate over whether it should continue to be listed (Hinton 2013; Allendorf 2001). There was a legitimate debate over the uncertainty in the science concerning when and how the hybridization had happened. However the pressure to delist the red wolf was a result of the public's generally negative attitude toward conserving carnivores. A great deal of effort and money has been put forth to recover the red wolf, meaning that the FWS had a stake in continuing to keep the species listed. In addition, the scientific community strongly supported continued protection for the red wolf. Similarly, an examination of factors influencing FS professional decisions during the late 1980s showed that they were also impacted by political pressures. The most important influences were local stakeholders (e.g., environmental/wildlife groups and other agencies) and maintenance of existing timber harvest levels (Sabatier et al. 1995).

There are a myriad of situations where hybridization or species delineation issue are present and the FWS field biologists have provided diverse responses. Thus it may become necessary to provide some more specific guidance on how to approach these situations to generate some consistency in response (and potentially limit political influence). My study uncovered a generally negative view of hybridization when listed species were involved, which may hinder the protection of some organisms with uncertain taxonomy, but which still contribute to overall biodiversity (i.e., Arizona agave, red wolf, California gnatcatcher, Catalina Island Mountain mahogany). However, a policy may not be necessary to change this organizational view and prevent further tragedies like the Dusky seaside sparrow. Many of the interviewed field biologists already expressed an understanding of the complexity and potential advantages of hybridization, something they have learned through experience. In another study looking at use of rapid wetland assessment tools by state agents, Arnold (2014) found that agents are more likely to use new methods they have been exposed to through their experiences on the job (i.e., people they work with and activities they perform). Additionally, the evolution of rigid hybrid policies to a case-by-case assessment based on the best available science has allowed for a flexible response, and has shown that the FWS is capable of adapting to changing scientific trends (albeit slowly). Finally, as the FWS brings in new employees whose education reflects the changing views on the importance of hybridization as an evolutionarily important force for adaptation and genetic diversity, hybridization's negative connotation in the agency may dwindle.

What will be more challenging is to assess how to deal with outside influences co-opting these scientific uncertainties for their own interests (Wilson 1989), like what is currently happening with the California gnatcatcher. It will be imperative to include the input of those from the social, policy and legal realms as well as those in the natural sciences when faced with the vague directives of the ESA for listing and recovery. As we can see with the red wolf and coastal California gnatcatcher examples, science alone cannot sufficiently answer questions that have inherent policy and legal aspects to them. As suggested by Vucetich et al. (2006), the "best science available" mandate doesn't have to limit scientists' ability to make value judgments on what constitutes threatened or endangered status. However, the science should be used to specify whether a particular species meets those normatively determined conditions to be considered endangered or threatened. Even if the question of what the "best available science" means could be resolved (whether it needs to be remains highly debatable), we will still have to address a fundamental problem with ESA implementation. A large amount of the discretion exercised by field biologists will still occur in response to the limited resources (particularly funds and personnel) and ever increasing pressures from regulatory time limits and litigation (which usually result from strained resources and policy interpretation, not the application of science) (NRC 1995). We may have to decide as a society how much we value conservation of biodiversity and be prepared to admit a lack of commitment, rather than lambast an underfunded and overtaxed agency for not meeting their goals.

Caveats and Outlook

This study is the first of its kind to look at the discretion of FWS field biologists involved in ESA implementation. However, it does have some limitations.

First, there was a high level of consistency between administrators and field biologists on matters of field level discretion and how to handle hybridization and species delineation issues. However I was only able to speak with administrators at the field and regional level, which field biologists also identified as the levels they have the closest relationship with. This may mean that individuals at a higher level in the organization, e.g., in the Headquarters in Washington D.C., may not have the same views on these issues.

Second, I was only able to speak with 20 field biologists, of which four did not have experience with hybridization issues. A larger, more balanced sample of field biologists with and without experience with hybridization issues may better elucidate differences (or lack thereof) in perception. This could potentially be accomplished through a survey using the initial data from this study to design it, a common practice in social inquiry (King et al. 1994).

Third, there are differences in how NMFS and FWS are structured, which impacts how they implement the ESA. For example, when listing a species the NMFS field biologists create a stand-alone scientific document as part of the status review that does not have recommendations in it. The FWS field biologists write both the scientific document and the recommendations together. However both FWS and NMFS biologists do not make the final decision on whether to list a species; a decision is made at the headquarters level after passing through the regional level. Given the structural differences between the NMFS and FWS, it may be beneficial to also examine how those differences may impact ESA implementation. This could be done in a similar manner to a recent comparison of the United States ESA and Canada's Species at Risk Act (SARA). Waples et al. (2013) provided an assessment of how science and policy impact species listing, finding that each law had strengths that the other law could benefit from to further biodiversity conservation. This could be complemented by a more in-depth study of street-level bureaucrats as they apply the best available science mandate to ESA implementation, for both the FWS and NMFS.

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Table 1 Major Implementation Stages of the ESA

Stage	Action	Information Utilized
1	Listing of the species as threatened or endangered	Scientific only
2	Designating the species' critical habitat	Scientific and economic
3	Providing immediate protection and prohibiting jeopardizing activities	Scientific and economic
4	Developing and implementing a recovery plan	Scientific and economic
5	Delisting the species after restoration	Scientific only

Table 2 Timeline of hybrid opinions given by the Solicitor of the Department of Interior

Year	Opinion	Description
1977	Protect hybrids	Opinion protects hybrid offspring of threatened or endangered species
1977	Do not protect hybrids	Opinion excludes hybrid offspring of endangered or threatened species from protection
1983	Do not protect hybrids	The 1977 opinion is reaffirmed
1990	Withdrew the 1983 opinion	No replacement policy was put forth, leaving the question of whether hybrids or hybrid offspring were eligible for protection unanswered
1996	Proposed Intercross Policy (never officially adopted)	FWS and NMFS proposed policy that would allow protection of hybrids which resemble their listed parent species
2000	Controlled Propagation Policy	Allows FWS and NMFS to allow more latitude for utilizing genetic rescue methods if deemed necessary

Table 3 Study species

Species	Listing Status (as of 07/01/2015)	Organism type	Hybridization Issue
Canis lupus	endangered (northern Rocky Mountains DPS, WA DPS)	mammal	DPS designation and taxonomic status due to ongoing hybridization with coyotes
Canis rufus	endangered	mammal	Taxonomic status and contemporary hybridization with coyotes
Lynx canadensis	threatened	mammal	Hybridization with bobcats
Puma concolor	endangered	mammal	Genetic rescue project
Zapus hudsonius preblei	threatened	mammal	Taxonomic status
Ammodramus maritimus mirabilis	endangered	bird	Taxonomic status; candidate for genetic rescue
Ammodramus maritimus nigrescens	extinct	bird	Controversial genetic rescue project
Polioptila californica	threatened	bird	Taxonomic status
Sterna antillarum	endangered	bird	Taxonomic status
Strix occidentalis caurina	threatened	bird	Hybridization with barred owl
Chionactis occipitalis klauberi	candidate for listing	reptile	Taxonomic status
Etheostoma osburni	petitioned for listing	fish	Hybridization with the variegate darter
Oncorhynchus clarki lewisi	not listed	fish	Hybridization with introduced rainbow trout
Oncorhynchus gilae	threatened	fish	Hybridization with introduced rainbow trout
Oncorhynchus mykiss	endangered	fish	Hybridization with hatchery fish; taxonomic status
Oncorhynchus spp.	endangered	fish	Taxonomic status
Salvelinus confluentus	threatened	fish	Hybridization with introduced brook trout
Scaphirhynchus albus	endangered	fish	Hybridization with shovelnose sturgeon
Agave arizonica	Delisted (erroneous data)	plant	Hybrid between two species
Castilleja levisecta	threatened	plant	Contemporary hybridization with a closely related species
Cercocarpus traskiae	endangered	plant	Hybridization with introduced species
Purshia subintegra	endangered	plant	Of hybrid origin
Echinacea tennesseensis	Delisted (recovered)	plant	Artificial hybridization with purple coneflower
Helenium virginicum	threatened	plant	Hybridization with other species
Lespedeza leptostachya	threatened	plant	Contemporary hybridization with a closely relates species
Sedum integrifolium spp. leedyi	threatened	plant	Taxonomic status
Sisyrinchium sarmentosum	candidate for listing	plant	Contemporary hybridization with a closely related species

Table 4 Demographics of field biologist interviewees

Education Level	**BS**	**MS**	**PhD**
	6	8	5
Educational Background	**Natural sciences**	**Policy sciences**	
	18	0	
Years Worked[a]	**<10 years**	**10-20 years**	**>20 years**
	3	11	4
Position	**Field biologist**	**Field level manager**	**Other**
	8	11	1
Experience[b]	**Yes**	**No**	
	16	4	
Aware of policy[c]	**Yes**	**No**	**Unsure**
	8	7	5

[a] Refers to the number of years worked in the Ecological Services division of Fish and Wildlife Service
[b] Refers to whether or not the interviewee had any direct experiences working with species that presented hybridization or species delineation issues
[c] Refers to whether or not the interviewee is aware of the hybrid policy history and current state of how hybridization issues are handled by the FWS

Table 5 Average frequency of codes across all 18 field biologist interviews related to street-level bureaucracy characteristics and perception of species and hybridization concepts (see Appendix C for code definitions)

Street-level bureaucracy								
Discretion	No	Some	Yes	Biological Opinions & Recommendations	Data Collection	Collaboration	Implementation	Policy Interpretation
	1	11	13	27	19	10	2	10
Policy Complexity	Policy							
	29							
Political Influence	Political conflict							
	40							
Limited Resources	Communicating	Funding	Knowledge	Staff	Time			
	2	14	15	12	5			
Science & ESA								
Species Concepts	BSC	Consensus	ESA defined	ESC	PSC	Systematics		
	10	22	20	0	1	3		
Hybridization	Good	Bad	Neutral	Complex	Anthropogenic	Natural		
	12`	21	10	22	23	25		
Hybridization cont.	Adaptation	Fitness	Invasive	Similarity of appearance	Speciation	Swamping		
	14	26	7	5	11	23		
Hybrid Policy	Case-by-case	Flexible hybrid policy	Hybrid policy					
	12	7	1					

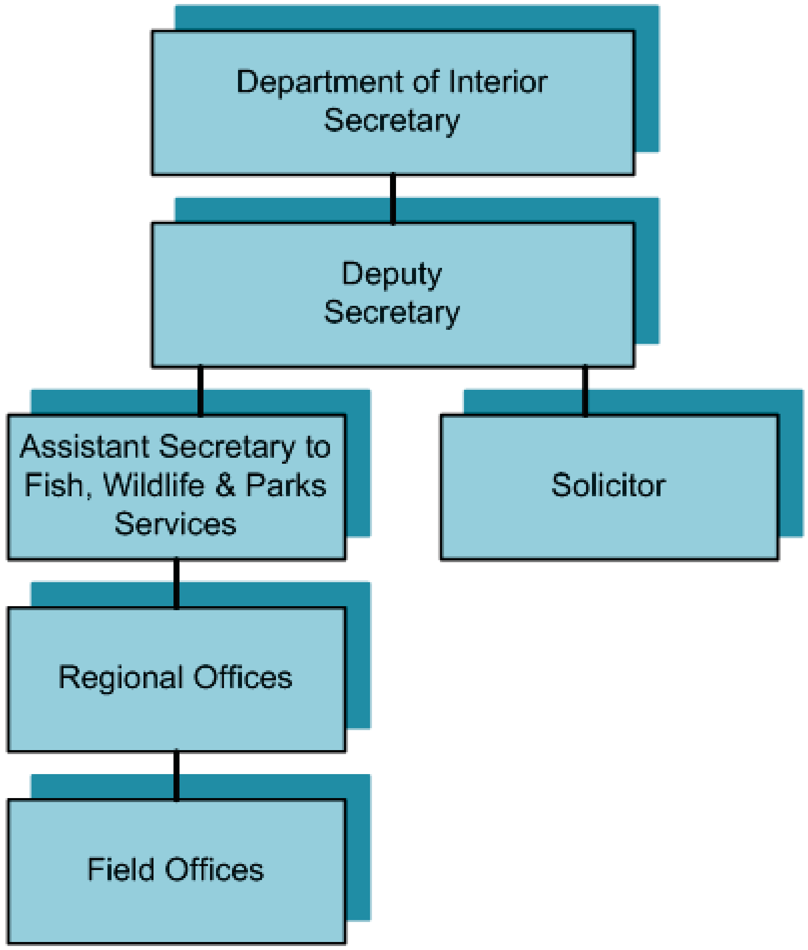

Figure 1 Organizational chart for the agency responsible for implementing the Endangered Species Act

Appendix A

Interview Questions for Biologists

A. Discretion of FWS biologists in decision making (general understanding of their job, how it fits in the organization and their sense of personal discretion)

  a. Can you tell me a little about yourself and how you got involved in this work?

  b. Which aspects of the implementation of the Endangered Species Act (ESA) are you involved in/help with? (Probing/Follow-up: Listing, designation of critical habitat, designing and implementing recovery plans, and/or delisting, Section 7 or 10?)

  c. What is the relationship between your office and the Solicitor's office (or the FWS for other agencies/institutions)? The Department of Interior Secretary's offices?

  d. Do you ever work with persons in the Solicitor's office (e.g., lawyers) about legal issues that arise while implementing the ESA?

  e. How often do the DOI and FWS consult or cooperate with outside agencies or other institutions to implement the ESA? (This could be flipped to ask those from other agencies how often they work with the FWS/DOI)

  f. When making listing decisions, where do you get the supporting information? (Probing/Follow-up: Do you work with any universities or other agencies?) or How do you help with providing information for listing decisions?

  g. Do you think you have personal discretion in making decisions about protecting endangered or threatened species? Or Are there aspects or duties in your job that require or allow for discretion on your part? (Probing/Follow-up: If so, could you describe the situation? What was the end result?)

h. Do you think like there are job constraints or resource limitations that make it difficult to make the decisions you would like to make to best protect endangered or threatened species?

i. Have you had any experiences with ESA (or other relevant) policy conflicting with recommendations provided by scientific evidence for protecting species? (Probing/Follow-up: Could you describe the situation? How was it resolved?)

j. Have you had any experiences recommendations provided by scientific evidence for protecting species conflict with other groups (e.g. governmental, private, public, etc.)

B. Species Concepts, Hybridization and ESA

a. The goal of the ESA is to "protect and recover imperiled species and the ecosystems upon which they depend" or "prevent the extinction of native and foreign animals and plants by providing measures to help alleviate the loss of species and their habitats." What does this mean to you? What do you envision conservation to mean? (Probing/Follow-up: Does it mean to restore a historical status? Does is imply restoring the ability to adapt or be resilient?)

b. How do you define a species? ((Probing/Follow-up: Are species best defined by the biological species concept, ecological species concept, or another concept?

c. Would your definition of a species be different depending on the organism? (Probing/Follow-up: Would you consider species distinctions to be different for plants and animals?)

d. Do you use this definition when writing supporting documents for species listings?

e. How would you define "hybridization"?

f. What role do you think hybridization plays in nature? How do you think it could impact conservation of biodiversity? From your experience? (Probing/Follow-up: Why do you think it is positive, negative, or neutral?)

g. What do you see as the possible consequences of hybridization when specifically looking at how it could affect a particular species and its conservation? (Probing/Follow-up: In the short-term? In the long-term?)

h. What species have you worked with during the process of listing, designating critical habitat, recovery planning, or delisting that have presented issues concerning hybridization? (Probing/Follow-up: If so, what were these issues? Can ask this for more than one species if applicable.)

How do you think hybridization issues should be handled? (Probing/Follow-up: What types of management recommendations are made to address this issue? Is there an official policy for dealing with situations involving hybridization?)

Appendix B

Interview Questions for Administrators

Focus: Garner information on how administrators perceive the level of their own discretion and that are available to FWS biologists to make decisions from the listing to the recovery plan design process and what the current institutional policies are on species concepts and hybridization.

A. Personal background (educational background, how they got into their current job, etc.)
    a. Can you tell me about your background in policy and how you got involved in your current position? How long in position? Any formal training in policy?
       Find out what they do in their job in addition to implementation
    b. Which aspects of the implementation (define implementation if they aren't sure) of the Endangered Species Act (ESA) are you involved in? (Probing/Follow-up: What tasks do you perform?)

B. Organization (how does the organization function)
    a. How well do you think that your agency's mission is being followed? (Probing/Follow-up: Can you think of any examples of tasks that are not central to the mission that may not have adequate resources?)
    b. How are others in your office involved in the implementation of the ESA?
    c. How does your office interact with the Department of Interior Secretary's office?
    d. How is does your office interact with FWS biologists working in the field to implement the ESA?
    e. Do you think that ESA implementation is mostly governed by the ESA and/or other related laws (e.g., state/local level)? Do you think that there is some flexibility in implementing the ESA?
    f. How much discretion do FWS biologists have in making listing, critical habitat, and recovery plan decision making?

C. Assessment (how well is the organization is working)
    a. Do you think that your agency is meeting the goals of its mission currently?
    b. Are there specific tasks that you think currently have inadequate resources?
    c. How do you decide if resources are inadequate? (Probing/Follow-up: Do you have a formal process for staff to request more resources?)

d. How do you handle inadequate resource issues?
i. Does the Department of Interior currently have a policy on how hybrids are treated under the ESA? (Probing/Follow-up: Is this policy official or unofficial?)
j. How do you think hybridization issues should be handled? (Probing/Follow-up: Should they be dealt with on a case-by-case basis? Should the field biologists have complete discretion?)
k. Do you feel that the current resources are sufficient to handle hybridization issues? (Probing/Follow-up: What resources do you feel are inadequate? How would you like to see them resolved/changed?)

Appendix C

CODE BOOK

Introduction

This document is the final version of the project codebook describing the codes and their hierarchical organization, used to determine patterns within the interview data.

Codes and Descriptions (in alphabetical order)

Group A: Identifiers

[code name]

Educational Background

Natural sciences

Policy sciences

DESCRIPTION: The type of educational background an interviewee has. Natural sciences could include botany, forestry, wildlife biology, conservation biology, ecology or taxonomy. Policy sciences could include political science, economics, policy, environmental policy.

Education Level

BS

MS

PhD

Years worked

DESCRIPTION: The level of education attained by the interviewee.

Position

Field Biologist

Field Level Administrator

NMFS Biologist

Regional Level Administrator

DESCRIPTION: The current position in the Fish and Wildlife Service or the National Marine Fisheries Service the interviewee holds.

Group B: Science

Biological Species Concept (BSC)

DESCRIPTION: When the Biological Species Concept is used to define what a species is.

Conservation

Damage control

Just to keep species and their ecosystems from becoming more endangered or threatened

Ecosystems

A focus on improving or protecting ecosystems so that the species consequently do better

Historical range

To return the species status to its historical range

Humans

conservation must include humans as part of the equation or is necessary because of human changes to the landscape

Not historical range

mentions historical range, but in a way of stating what conservation is not

Resilience

Focus on bringing the populations to a self sufficient viable point

Species

The focus is on the species, such as to keep them from going extinct

Threats

Focus on eliminating threats

DESCRIPTION: The meaning of conservation is discussed. There are several subcodes that could apply and all of them relate to how conservation is viewed. The purpose or meaning of conservation could be focused on a particular goal such as restoration of the historical range of a species or making sure the species has resilience and adaptive capabilities, being species or ecosystem centric, or identifying and eliminating threats or just doing post hoc damage control.

Experience

DESCRIPTION: The interviewee has had experience with hybridization or species delineation issues.

Hybridization

Bad

Complex

Good

Neutral

DESCRIPTION: Hybridization is discussed. The subcodes will be used to identify in what way hybridization issues are discussed, including a positive (good), negative (bad), or neutral context as well as being identified as a complex process.

Hybridization Outcomes

Adaptation

Fitness

affects fitness to either increase or decrease it for a given species

Invasive

Similarity of appearance

Speciation

Swamping

loss of species or genetic variation due to hybridization

DESCRIPTION: Interviewees cite different outcomes that have or could result from hybridization occurring. Potential outcomes include genetic swamping and eventual loss of one species, transfer of adaptive genes from one species to another, the creation of a new species, invasion of a habitat by a non-native or invasive species, loss of a species due to take because of similar appearance to a closely related species where there is also gene flow between the two species or impact on fitness of parental or hybrid populations.

Hybridization Sources

Anthropogenic

Natural

DESCRIPTION: Interviewees view the causes of hybridization to be entirely natural, anthropogenic, or a combination of both depending on the situation.

Organism

Bird

Fish

Invertebrate

Mammal

Plant

Reptile/Amphibian

DESCRIPTION: When the interviewee mentions a particular species in an example in the discussion about species delineation or hybridization issues the category of species is tracked.

No experience

DESCRIPTION: The interviewee has not had experience with hybridization or species delineation issues.

Species concepts

Consensus

Interviewee mentions that they go with whatever the scientific community's consensus is on what defines a species given a particular organism

ESA defined

Ecological Species Concept (ESC)

Other

Other species concepts or ideas that provide a different or more flexible version of the BSC

Phylogenetic Species Concept (PSC)

Systematics

systematics is the science of diversity relevant when ESUs are mentioned

DESCRIPTION: When other species concepts are used to define what a species is such as the ESC, PSC, systematics, or other variations or combinations of species definitions.

Group C: Policy

Areas of discretion

Biological opinions

Collaboration

Data Collection

Collecting information and interpreting what's important and/or what it means

Implementation

discretion in how the details of a plan are carried out

Policy Interpretation

Recommendations

DESCRIPTION: The interviewee identifies what areas of their job they have discretion in including writing biological opinions for listing or Section 7 consultations, perceptions of their recommendations by higher authorities, collaboration with other organizations, and how they collect data.

Aware

DESCRIPTION: The interviewee is aware of at least one hybrid policy including the unofficial one, the likeness policy or the policy history.

Case-by-case

DESCRIPTION: Interviewee believes hybridization issues should be handled on a case-by-case basis.

Communication

- Field office
- FWS HQ
- NMFS HQ
- Other government agencies
    - Federal and/or state
- Regional office
- Secretary
    - Anyone in the Secretary's Office in the Department of Interior
- Solicitors
    - Anyone at either the headquarters office or the regional offices at either FWS or NMFS

DESCRIPTION: The interviewee communicates with different levels of the Fish and Wildlife organization including the field, regional, and headquarters (Secretary) levels as well as solicitors and other governmental agencies at both the federal and state levels.

Discretion

No

Some

Yes

DESCRIPTION: The interviewee expresses that they have discretion, do not have discretion or have some discretion in how they carry out their job.

ESA Implementation

Critical Habitat

Delisting

could include downlisting as well

Listing

Recovery

Section 7

formal consultation with other federal agencies

Section 10

formal consultation and permit approval with other state and local level agencies as well as tribal and private entities

DESCRIPTION: Describes what steps of ESA implementation the interviewee is involved in

Flexible hybrid policy

DESCRIPTION: Interviewee believes there should be a policy in place to handle hybridization issues, but it should be general and allow case-by-case flexibility.

Hesitant

Complexity

topic is complex and is unsure how to answer

Legal issues

does not want to discuss because of the sensitive legal issues involved

No expertise

Does not have experience and doesn't feel comfortable discussing

Politics

does not want to discuss because of the sensitive political issues involved

DESCRIPTION: Interviewee displays discomfort talking about a particular topic that could include legal or political issues as well as topics outside their professional expertise.

Hybrid policy

DESCRIPTION: Interviewee believes hybridization issues should be subject to a specific policy for reference on how to handle them.

Limitations

Communicating

Funding

Knowledge

Policy

When the actually policy or how offices prioritize tasks because of time limits imposed by policies and legal issues

Political conflict

This could include internal political conflict as well as conflict with other organizations FWS works with such as state, local, and tribal governments and private entities

Staff

Time

DESCRIPTION: Limitations involve issues that prevent the interviewees from doing what they think is best for the species they are working with and could include lack of money, staff, time, knowledge about the species, limits placed on them due to political situations and/or policies in place.

Organizations work with

Academic institutions

Citizens

Federal government agencies

Local government

NGOs

Private organizations

State government agencies

Tribal groups

DESCRIPTION: When interviewees mention groups that they either work with or get information from, the subcodes will define what those groups are

Not aware

DESCRIPTION: The interviewee is not aware of the hybrid policies.

Scientific information

Academic research

collaboration or communication with researches at academic institutions or species experts

Contract research

work done with USGS or other contracted entities such as state and local governments, university researchers, and private entities

Grey literature

Government or NGOs research documents that are not published in peer reviewed journals; databases

Published literature

Literature published in peer reviewed journals

Research

Internally conducted research

DESCRIPTION: What the sources of scientific information used in biological opinions and recommendations made for listing, recovery, critical habitat, etc.