The Role of Scientific Uncertainty in Polar Bear Conservation Policy:

A Descriptive Analysis

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Abstract

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In recent years, the polar bear (*Ursus maritimus*) has become synonymous with the climate change movement. Prior to concerns over global warming, the biggest threat to polar bears was overharvest and trophy hunting. For decades, policies successfully mitigated population declines as a result of such stressors, but new and emerging threats have again put the species in peril. The impacts of climate change have motivated the five polar bear range states to revisit protective policies and yet no measures have been taken to address the drivers of climate change, which has been identified as the biggest threat facing polar bears. Scientific uncertainty is an integral component of both the scientific and policy processes. However, its misapplication can often compromise effective policy outcomes, as evidenced by polar bear conservation policy. An analysis

of the US Endangered Species Act and The Convention on International Trade in Endangered Species demonstrates that to achieve particular policy objectives, scientific uncertainty has been applied to manipulate policy intention, coerce inaction, and subvert precautionary responses to polar bear extinction. Understanding the influence that scientific uncertainty has on conservation policy can help identify weaknesses, as well as improve management and decision making strategies.

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Introduction

Polar bear *(Ursus maritimus)* conservation policy has been an international subject of interest since the mid-twentieth century. Divided into 19 subpopulations (13 of which reside in North America), polar bears are a shared resource between the United States, Canada, Russia, Denmark and Norway (see Figure 1), and thus the focal point of much attention. This has never been truer than over the last 20 years, when polar bears went from a somewhat mysterious creature of the North, to the poster species of the global climate change movement. Hunting polar bears has been regulated in certain parts of their range since the 1920s; the Russian Federation was the first state to ban hunting in any capacity, followed steadily by the remaining four states (Prestrud & Stirling 1994). These regulatory policies have resulted in over 15 pieces of legislation across the five nations. While early policies largely served their purposes of mitigating polar bear over harvest (and ultimately, extinction), more recent policies have not been as successful (Prestrud & Stirling 1994). Despite significant national and international effort, polar bears worldwide face imminent extinction as new threats to their survival illuminate the weaknesses of current conservation policies. Underscoring many of these weaknesses is the presence of scientific uncertainty.

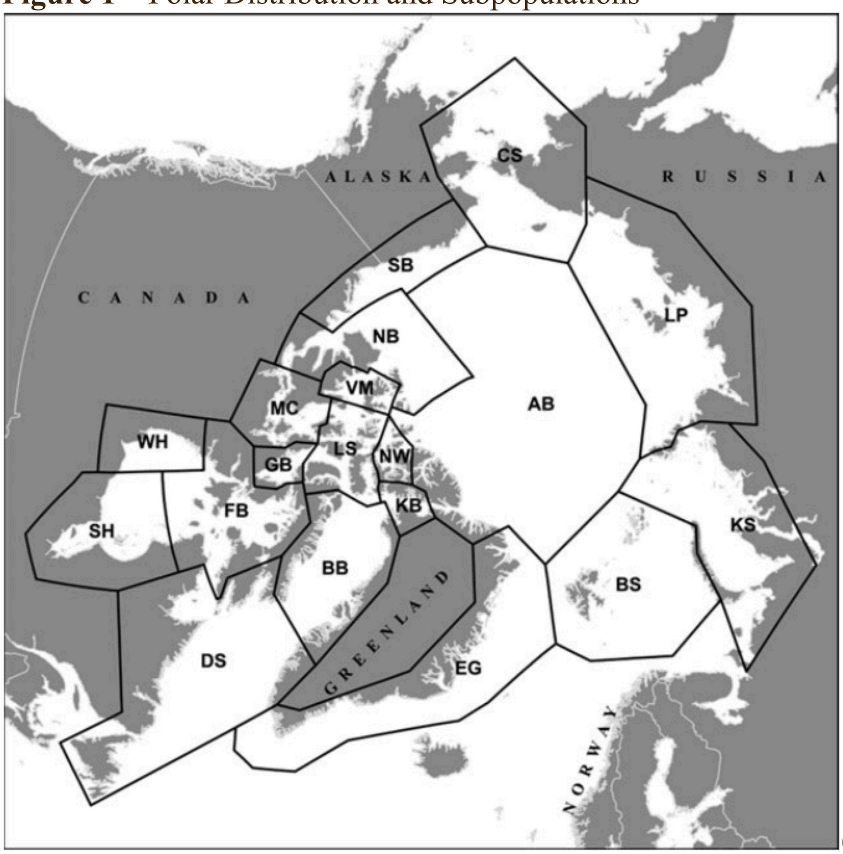
Though scientific uncertainty is not itself an instrument of duplicity, it can be used as a tool for pursuing certain political or economic outcomes (Costanza & Cornwell 1992). However, scientific uncertainty arises out of a lack of information rather than from a particular agenda. Due to the high degree of natural variability in the environment, research surrounding environmental issues and processes is frequently laden with uncertainty because so much in nature is subject to change and fluctuation (Hunter et al.

2010). Uncertainty can be reduced as financial investment and effort increase, but scientists are often limited in both of these areas. Uncertainty is not a deliberate creation, nor is it indicative of willful ignorance. Yet this interpretation has "shaped our scientific and political institutions" to treat it as such (Pahl-Wostl 1995; 196). This complicates natural resource management, which typically deals with uncertainty by taking a precautionary approach. This *better safe than sorry* rationale is often in conflict with industry and development interests, which argue for less restrictive intervention due to the uncertainty and lack of proof regarding imminent environmental harm. Based on this construction of scientific uncertainty, this thesis looks at the ways in which scientific uncertainty has been applied to polar bear conservation policy to manipulate policy intention, coerce inaction, and subvert precautionary responses to extinction.

This particular application of scientific uncertainty has led to a situation where existing policy is ineffectual at protecting polar bears from what has become their biggest threat, climate change. However this is not a problem exclusive to the arctic bears (Huntington 2009). The popularity and visibility of the polar bear only serves to represent the best studied out of a host of vulnerable arctic species that are facing similar issues due to a loss in sea ice (e.g. walruses, ringed and bearded seals, etc.) (Kovacs et al. 2011, Laidre et al. 2015, Huntington 2009). Additionally, other species (e.g. plankton, mollusks, bowhead whales, etc.) will be impacted by the byproducts of climate change like ocean acidification and temperature increases. Inadequate protection for polar bears and other subsistence resources will have a profound effect on Inuit communities that rely on these animals for their culture, nutrition, and income (Wenzel 2009, Sandell & Sandell 1996, Tyrell & Wenzel 2010). Furthermore, the impact that scientific uncertainty has on policy may potentially become more prevalent as a growing number of species face the adverse effects of climate change.

Understanding the role that scientific uncertainty plays in conservation policy will help establish a platform for the improvement of management through existing policies or for developing new policy. Once the weaknesses of existing policy have been identified and new threats defined, decision makers will have a launching pad from which to address the policy gaps. Scientists are motivated to reduce uncertainty with further inquiry, and perhaps understanding how uncertainty can be used to undermine policy will prompt continued collaboration and expansion of Arctic research. In this way, compounding and corroborating evidence of the fragility of Arctic species will reduce the overall lack of certainty and improve decision makers' abilities to enact sound policy.

Figure 1 – Polar Distribution and Subpopulations



(Derocher et al. 2013)

Scientific Uncertainty

Traditionally, uncertainty has been defined as "an event with an unknown probability" and in the field of environmental affairs, this encompasses many interactions between the natural and the human world (Costanza & Cornwell 1992; 13). This means that uncertainty is inevitable and unavoidable (Wilson 2002). Scientists accept it as a natural element of the scientific method and aim to reduce it through further inquiry, yet policy is often debilitated by it (Costanza & Cornwell 1992).

Scientific uncertainty is an unfortunate reality of both the scientific and the political processes, but a necessity nonetheless. If scientific uncertainty was ignored or if the policy process was not able to accept the inclusion of unknowns, there would be unmitigated consequences of persistent ignorance and ambiguity surrounding issues because data gaps would never be discussed and addressed (Wilson 2002). "Removing uncertainty from the public discussion can be expected to retard our ability to learn, risk the credibility of science and governance process on unproven theory, and most of all, diminish our long term ability to conserve the resource" (Wilson 2002; 332). Because of resource users' inability to show restraint when dealing with common pool resources, it has been argued that proper conservation is unattainable in a system with significant uncertainty where user input is heavily weighted. Tragedy of the commons literature dictates that users will deplete a resource until there is no more (Mitchell 2010). This is a *first come first served* mentality and is not conducive to conservative or precautionary approaches (Wilson 2002). So, while uncertainty can, and often does, lead to political inaction, failing to address it can give a false sense of sustainability and preclude conservation efforts.

There are four types of uncertainty: (1) ambiguity (lack of precision), (2) knowledge (incomplete understanding), (3) natural variability, and (4) ignorance (unknown unknowns) (Bostrom et al. 2015). As is evident by Table 1 (adapted from Bostrom et al. 2015), the problems facing polar bears encompass each type of uncertainty. The Arctic is a challenging, expensive place to study and the polar bear is an elusive animal. Couple this with the dynamics of climate science and it becomes clear that uncertainty is going to remain a persistent barrier to conservation policy. In other words, the question should not be how to eliminate uncertainty, but rather, how much uncertainty is acceptable and how to move forward with the existing uncertainty. This is a question that makes decision makers and stakeholders uncomfortable, and often leads to inaction. This is especially true in regards to extractive industries. These industries are powerful actors in the US political system, as well as other jurisdictions, and climate change mitigation threatens their continued growth. Imposing regulations will upset the status quo, and likely spark industry resistance due to the potential for their costs to increase and their profits to decrease (Gupta 2011).

Table 1 - Manifestations of Scientific Uncertainty

Types of Uncertainty	Examples in Polar Bear Conservation Policy	Solution
Ambiguity	Are reproduction rates declining as expected with habitat loss and nutritional stress	Collect more data to fill in deficiencies
Variability	How will distinct populations respond to regional differences in climate change impacts	Statistics to compare data across space
Knowledge	How best to discourage bears from human contact when they are stranded on shore and facing food scarcity	Develop a new theory or test
Ignorance	We do not know to what degree polar bears will utilize terrestrial habitat for essential behaviors as sea ice becomes less available	Learn from past failures

Consider the analogy of the envelope: science can define the parameters of the envelope as the limits to what is possible, but not what is possible within the envelope. The edges of the envelope are where the most certainty exists and that is where policymakers tend to adhere. The edges do not make up the entire picture, but because the interior is full of ambiguity or uncertainty over what else could happen, policymakers avoid it. To put polar bears into this context, consider the edges of the envelope to represent the limits of sustainable harvest. Policymakers linger close to this boundary, setting harvest quotas and mitigating human-bear interactions. This addresses direct takes, but ignores the inside of the envelope (e.g. climate change and emerging threats). This is where population dynamics, species adaptability, climate variability, and mitigation efforts exist. Such factors are hard to determine and concrete answers are not available, therefore policymakers avoid making decisions in these areas and adhere to what is easier to control – direct takes and monitoring population trends. (Analogy adapted from Costanza & Cornwell 1992)

Addressing the envelope's interior elements is complicated, requiring significant funding and effort, and the acceptance of unknowns. For these reasons, scientific uncertainty is often used as a political tool to undermine new policy, compromise existing policy, or simply to support passivity (Wilson 2002, Costanza & Cornwell 1992). It is not uncommon for uncertainty to justify inaction on difficult, contentious, or wicked problems, especially when a proposed policy interferes with extractive industries (Lee 1993). Because of this, concern and debate over scientific uncertainty runs rampant in discussions over polar bear conservation, which hinge on climate change and resource extraction.

Policy Introduction

Polar bear conservation is a multilateral effort that extends protections from the national level to multinational collaborations. Table 2 shows a list of regulatory agreements that actively seek to mitigate polar bear population declines and prevent extinction, and consists of both national legislation and international agreements. These agreements demonstrate the consistent commitment of arctic nations to the preservation of polar bears, and the collective understanding that the species is in danger, needs active management, and is representative of the fragility of the entire Arctic system.

Table 2 – Polar Bear Conservation Policies

Policy Name	**Year**	**Outcomes**	**Jurisdiction**
The Decree on Protection of Arctic Animals[44]	1956	Banned all polar bear hunting, including within aboriginal communities, with the exception of self-defense, live takes permitted for display	Russia
Marine Mammal Protection Act (MMPA)[56]	1972	Governs issuances of *take* (which is largely prohibited), banned sport hunting of polar bears in US jurisdiction but allowed for importation of Canadian trophies from designated populations*	United States
Endangered Species Act (ESA)[28]	1973	Provides protection of species at risk of extinction and their ecosystems, requires the development of recovery plans for listed species, requires designation of critical habitat with restricted uses, banned importation of sport trophies ○ Endangered: at risk for extinction throughout its range ○ Threatened: at risk of becoming endangered in the *foreseeable future* Polar bears are currently listed as *threatened*	United States

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)[14]	1973	Regulates international trade in endangered plants and animals o Appendix I: listing bans trade entirely o Appendix II: listing requires permits for export/import of species that could face endangerment from unregulated trade o Appendix III: species that are already subject to an outside trade regulation but whose managing body has requested extra support or cooperation from CITES Polar bears are currently listed under Appendix II	All Five Range States
International Agreement on the Conservation of Polar Bears and Their Habitat (the Agreement)[45]	1973	Requires all five range states to integrate best available science into the management plans of polar bears and take measures to conserve their habitat, however each state is allowed to implement its own interpretation of the Agreement o Norway – ban hunting polar bears under a rolling moratorium o Canada – restricted sport hunting practices	All Five Range States
Polar Bear Management Agreement for the Southern Beaufort Sea (the I-I Agreement)[41]	1988	Management agreement for shared Beaufort and Chukchi populations, protects dens, females and cubs, and stipulates the parameters for the harvest quota	United States and Canada
The Wildlife Act: *Polar Bear Defence Kill Regulations*[69, 100]	1999	Delineates the acceptable circumstances of killing a polar bear in self-defense and prohibits possessing a polar bear	Nunavut and Northwest Territories, Canada
Agreement of the Conservation and Management of the Alaska-Chukotka Polar Bear	2000	An expansion of the Agreement, broadens conservation efforts, establishes guidelines for collaboration, and stipulates the parameters for the harvest quota	United States and Russia

Population[32]			
Endangered Species Act[70]	2001	Designates polar bears as *vulnerable* and requires the development of a management plan, recovery plan, and critical habitat designation	Newfoundland and Labrador, Canada
Svalbard Environmental Protection Act, *Section 30*[46]	2001	Banned all polar bear hunting unless explicitly permitted	Svalbard, Norway
Species at Risk Act (SARA)[88]	2002	Prevent extinction of wildlife species, provide recovery plans for species at risk of extinction, develop federal management plans for species at risk of becoming threatened with extinction	Canada (Nationally Inclusive)
The Polar Bear Protection Act[70]	2003	Designates circumstances and guidelines for when polar bears can be removed from the wild	Manitoba, Canada
Protection and Hunting of Polar Bears[46]	2005	Provides management plans for harvested populations of polar bears and sets quotas, hunting and gear restrictions, and requires a double reporting system	Greenland
Endangered Species Act[70]	2007	Designated polar bears as a *species of special concern*, requiring the development of a management plan and regulates trade in endangered species paraphernalia	Ontario, Canada
Memorandum of Understanding between the Government of Canada, the Government of Nunavut, and the Government of Greenland for the Conservation and Management of Polar Bear Populations[29]	2009	Sets quotas for the shared polar bear population to ensure sustainable harvest and provides structure for management collaboration	Nunavut, Canada and Greenland
Circumpolar Action Plan[71]	2015	An extension of the Agreement; a platform for management and goal	All Five Range States

		collaboration, research standards, and knowledge transference. Does not make management provision	

(Some conservation efforts are meant to serve as a research platform, like the IUNC Red List of Threatened Species. Because these kinds of agreements have no regulatory capacity and are used to advise, they are not included in the table.)

The 1970s marked the beginning of polar bear conservation efforts on a large scale. By this time, it was evident that trophy hunting had severely depleted the species and something needed to be done if polar bears were to persist (Prestrud & Stirling 1994). Compounding this need was the understanding that Inuit communities needed healthy populations of marine mammals to maintain their lifestyle (Wenzel 2009).

Polar bear conservation really began as a multinational effort with the introduction of the Convention on International Trade in Endangered Species (CITES) and the International Agreement on the Conservation of Polar Bears and Their Habitat (the Agreement) in 1973. The five arctic states participate in the two agreements; both international agreements have been designed to make polar bear protection a priority while also giving each individual state sovereignty over specific management implementations. At that time, subsistence harvest of polar bears was also discussed. The range states wanted the polar bear population to rebound while simultaneously protecting native communities' use.

From there, a combination of bilateral agreements and national polices emerged. States started to come together to discuss the management of their shared polar bear populations, and within individual states, wildlife protection policies began to take shape at the national level (Fitzgerald 2013). Today each state has a national protection policy that specifically addresses the protection and management of polar bears. Around 2000, there also appeared to be a shift to more Inuit-centered policies. Legislation (or policies) in Canada and Greenland in particular feature strong community involvement and include traditional ecological knowledge (TEK) in their decision-making processes for Arctic resource management (Dowsley & Wenzel 2008, Peacock et al. 2011, Clark et al. 2008). More emphasis has been placed on Inuit input in US resource management as well, as indicated by the inclusion of stakeholder interests throughout the Endangered Species Act (ESA) process, and Russia is currently working to expand native rights to arctic marine resources (Peacock et al. 2011).

Despite the growing number of polar bear conservation policies, there remain persistent gaps and barriers to effective outcomes. Part of the problem with polar bear conservation policy is the inherent complexity of environmental issues (Lee 1993). This complexity is exacerbated by the fact that there is no imminent crisis (i.e. polar bears are not going to go extinct tomorrow), there is no definitive right answer (i.e. we cannot stop hunting or ban carbon emissions), and impacts (costs and benefits) of the problem are disproportionately diffused (i.e. Inuit communities have disproportionately incurred the cost of unabated emissions and increased restrictions on ecosystem services) (Lee 1993).

Climate change is unequivocally the biggest threat facing polar bears, and yet no agreement or legislation currently has the capacity to lessen its impacts. Many of the regulations (e.g. The Decree on Protection of Arctic Animals) lack enforcement, while even more lack funding (Reeves 2014). There are also huge data gaps. Of the 19 subpopulations, five have no data reported on them, another four have not been assessed in the last 2-3 decades, and half lack enough data to construct a population trend analysis (Laidre et at. 2015). These deficiencies greatly impede both policy and management because persistent unknowns distort policy goals and outcomes (e.g. the goal of The

Decree on Protection of Arctic Animals is to protect arctic species from population declines due to hunting but without data on population trends, such outcomes can never be assessed).

Lastly, pressures in the Arctic are not felt equally across space and time; this discrepancy also remains largely unaddressed. Polar bears in the most southern regions will experience ice-free summers before other populations and as a result will require more aggressive protective measures. Bears in the Russian Arctic are allegedly the target of unregulated and illegal poaching, therefore experience additional strain on population stability (Belikov & Boltunov 1998). Finally, Arctic pressures, which predominantly originate within industrialized areas, are hugely impactful on the native communities. Yet the decisions that are made in an effort to conserve polar bears do not address these drivers and do not require that the costs be shifted to those contributing most to climate changing carbon emissions. The Inuit endure the vast majority of the costs associated with Arctic conservation policies that address short-term drivers, unabated carbon emissions, and sea ice loss. Though their voice is being incorporated into policy more and more, nothing currently exists to address the inequity of climate change and its impacts.

Despite the apparent weaknesses in many of the listed laws and policies (The Decree on Protection of Arctic Animals, the Agreement, The Circumpolar Action Plan, etc.), some have not only withstood the test of time, but have also developed a reputation for success. The ESA and CITES are two such pieces of legislation. Based on this assessment, the ESA and CITES will be the focal policies for the remainder this paper for the following reasons: (1) both have been used in decisions that provide clear examples of the misapplication of scientific uncertainty; (2) the ESA and CITES are most relevant to the conservation of polar bears under US jurisdiction; (3) the ESA offers greater protections than the MMPA; (4) the US is typically considered a world leader in addressing environmental concerns, therefore US policies carry global pressure and should be exemplary, making the ESA a particularly important piece of legislation; and (5) both the ESA and CITES hinge on best available science, a construct that considers scientific uncertainty.

The Convention on International Trade in Endangered Species

CITES entered into force in 1975. This convention is comprised of 181 international states, including all five polar bear range states, and was designed to regulate both illegal and legal trade of wildlife in various states of population stability across international borders (CITES 1973). CITES is comprised of three appendices, which categorize the listed species according to their risk of extinction. Species are proposed for addition or deletion from the appendices at meetings of the Conference of the Parties (CoP). When reviewing petitions, the parties must decide under which Appendix to list a species or whether to amend a current Appendix listing. In either case, CITES operates under a framework specific to that species. This requires use of the best available science from either the CITES Science Committee, or research that has been collected in other arenas (CITES 2013c). The assumptions that underscore this framework are that abundance is an adequate indicator of population sustainability and that direct takes are the biggest threat to survival.

Under CITES, Appendix I species are those most vulnerable to extinction, affected by trade, and generally prohibited in the trade market (CITES 1973). This is followed by Appendix II, which includes species that could become threatened with extinction if trade is not well controlled, but which are not currently facing unmitigated pressures of trade (CITES 1973). Of least concern are species listed under Appendix III, which fall subject to an outside trade regulation but whose managing body has requested extra support or cooperation from CITES (CITES 1973).

For a species to be considered for an Appendix I listing, it must fit one of a list of biological criteria including, but not limited to: small or varying population size; restricted distribution and population declines as a result of habitat degradation, and observed or projected declines in the wild population due to habitat degradation; low recruitment; or specific vulnerabilities to natural or external factors (CITES 2013b). CITES operates under the finding that hunting and trade can exacerbate other stressors responsible for marked population declines (Scanion 2013). In the case of an Appendix I listing, CITES will prohibit trade of the species to reduce overall stress and preserve genetic diversity even if hunting and trade are not the primary drivers behind population declines (Scanion 2013).

The polar bear is currently listed under Appendix II, which stipulates that it can be traded on the international market provided "it is legal, sustainable, and traceable…and is not detrimental to the survival of the species in the wild" (Scanion 2013). Appendix II listings are reserved for species that would likely fall under the Appendix I criteria and/or the wild population is at risk of falling below sustainable levels without intervention and regulation of trade (CITES 2013b). Nearly all of the animals listed under CITES have an Appendix II listing; a petition to uplist to Appendix l requires the compilation of population assessments, threats and cumulative impacts, management plans, and the impacts of trade (CITES 2013a). All of this must be done using the best available science and data.

Participation in CITES is voluntary; CITES treats states and their people as environmental stewards of their own wildlife (Scanion 2013). They do not regulate domestic trade of any species, regardless of its Appendix status (CITES 1973). Should states choose to engage in international trade of a given species, CITES will regulate it, but states are also able to enforce their own, more restrictive regulations as they see fit (CITES 1973). For example, Canada is able to sell and exchange polar bear goods both internationally and within their own borders. And in fact, 80% of the polar bear pieces that arrive in the international market originate from Canada (Scanion 2013). In stark contrast, however, CITES prohibits polar bear products from the US from entering the international market while the ESA and MMPA prohibit trade within the country (IUNC 2009).

As with most treaties, laws, and policies, CITES is not without its weaknesses. Securing an uplisting is an arduous process that often is not successful (CITES 2013a). The review committee relies on the use of best available science, but due to varying definitions of what is "best," this can (and has) resulted in selective use of the science to better suit particular political agendas (Heazle 2004, Parsons & Cornick 2011). There are no specific sources of funding to pursue CITES goals, meaning it is the individual state's responsibility to fund monitoring programs (Reeves 2014). As a result, CITES has been difficult to enforce in some areas and completely ineffectual in others (Reeves 2014). While CITES permits an Appendix I listing on the basis of habitat loss, it offers no recourse or protection against further habitat degradation. Lastly, CITES does not regulate domestic trade in any capacity, which is a missed opportunity for protecting species at risk of extinction as a result of the trade market (CITES 2013b).

The Endangered Species Act

The ESA is a federal statute devised to protect plants, animals, and insects from extinction by designating them as either threatened or endangered. The ESA was passed in 1973 under President Richard Nixon, with support across congressional party lines (Clark 2013). This was a necessary law, and the Supreme Court solidified its importance when it declared that it was the intention of Congress "to halt and reverse the trend toward species extinction, whatever the cost" (*TVA v. Hill* 1978). This landmark case propelled the ESA forward and established its reputation as "the pit-bull" of environmental legislation.

The objectives of the ESA are pursued through a five step process: (1) using best available science to decide if a species warrants listing under the ESA; (2) develop a recovery plan; (3) designate critical habitat as habitat essential to the survival of a species given its current range and future range needs; (4) ensure that federal actions do not jeopardize a species' long term survival or cause adverse modification to critical habitat; and (5) issue exemptions and permits where appropriate (Seney et al. 2013, 16 U.S.C. 1536). When deciding whether to list a species, the implementing agencies designated under the Act, NOAA and the USFWS, consider the following criteria:

> *"…the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization…; disease or predation; the inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its continued existence" (16 U.S.C. 1533(a)(1)(A-E)).*

Once listed, the ESA protects plants, animals, and insects from harm, loosely defined to include a spectrum of offenses from harassment to significant habitat modification (Morath 2008). The ESA also offers special provisions for threatened species through the 4(d) rule, which allows listing agencies to either lessen or strengthen protections already afforded by the ESA, depending on the conservation needs (Lundquist et al. 2012).

Throughout the listing process, natural resource agencies tasked with implementing the ESA are required to make decisions based on the "best available scientific and commercial information" (16 U.S.C. 1536). This is an important stipulation because it requires the collection of scientific data in each progressive phase. However, it does not require particularly complete or targeted collection of data, leaving ample room for uncertainty. This is to say that although scientific research ensues, the collection process is restricted by time and money, may still be subject to industry pressures, and there is no definitive parameter delineating when enough research has been gathered. This requirement has been especially critical in the polar bear listing process as reliable studies are needed to link anthropogenic factors with climate change, which leads to sea ice loss, and threatens ice dependent species with extinction (Morath 2008, 73 FR 28212). Without strong scientific evidence linking anthropogenic factors to environmental degradation, polar bears would not have been listed.

Despite its influence, the ESA has notable weaknesses, including those related directly to the act's effectiveness. Critics of the ESA have pointed out the legislation's lack of teeth and have called for "action to be taken now to further unlock the ESA's immense conservation potential" (Clark 2013; 330). Recovery plans are the single most important tool for guiding conservation strategies at the local, regional, and national level

(Povilitis & Suckling 2010). This is especially true in reference to climate change because the recovery plan dictates acceptable levels of habitat degradation. However, no recovery plan currently stipulates how to combat loss of habitat due to climate change (Povilitis & Suckling 2010). The polar bear in particular faces climate change as "the single largest threat to the bear's survival and the reason it was placed on the endangered species list" yet it remains largely unaddressed in the ESA recovery plan (CBD 2013).

The process of designating critical habitat requires review of economic impacts of the policy, and while this protects industry and stakeholder interests, it can compromise conservation efforts (Kubasek & Silverman 2014). As will be discussed later, economic pressure can be significant and ultimately halt conservation progress. Additionally, there are inherent challenges in environmental valuation; how much is a polar bear worth, and who decides? Other problems that continue to persist beyond the ESA's influence include species decline due to climate change, land conservation, invasive species, as well as a general lack of funding toward recovery (Kubasek & Silverman 2014).

Polar Bear Demographics

To understand the impacts of scientific uncertainty on polar bear conservation policy, it is important to have a contextual understanding of polar bears and issues endangering their survival. Polar bears are one of ten endemic Arctic marine mammals and have evolved to become an ice dependent species (Laidre et at. 2015). Ice cover and body condition have been positively linked, and indicator populations have shown increased nutritional stress in correlation with sea ice loss (Regehr et al. 2007, Derocher et al. 2004, Molnar et al. 2010). When sea ice is insufficient, polar bears have to expend considerably more energy in search of prey and appropriate denning sites (Parsons &

Cornick 2011). The reallocation of this energy takes its toll, causing "reduced physical condition, reduced reproductive success, or increased mortality," ultimately catalyzing further declines in the population (Parsons & Cornick 2011; 729). Furthermore, the bears need a substantial amount of energy to reproduce and require significant fat stores to prevent reproduction from ceasing (Regehr et al. 2007, Derocher et al. 2013).

The issues facing polar bears are drastic in consequence and promise to only become more severe as long as greenhouse gas emissions remain unabated (Amstrup et al. 2009). Excess carbon dioxide is responsible for up to 70% of greenhouse gases, and carbon emissions continue to rise, increasing over 13% between 2008-2013 (CBD 2013). This has a disproportionate effect on the Arctic because of a positive feedback loop known as the albedo effect. Sea ice reflects up to 90% of the sun's warming rays away from the earth's surface (Garrison 2005). In contrast, the dark ocean surface can absorb over 90% of the sun's warmth (Garrison 2005). This accelerates sea ice loss because as more ocean surface becomes exposed, the potential grows for increases in ocean temperature, exacerbating sea ice loss.

Many scientists believe that polar bears are simply too reliant on sea ice to survive ice-free summers (Parsons & Cornick 2011). One of the bleakest predictions came from the Center for Conservation Biology, which forecasted that "more than two-thirds of the world's polar bears, including all the bears in Alaska, will be gone by 2050" and could be entirely extinct by 2100 (2013; 2). This is directly related to a warming Arctic and subsequent declines in sea ice. Polar bears depend on sea ice for hunting, feeding on seals (their primary food source), finding mates, breeding, making long-distance movements, accessing terrestrial maternity denning areas and sometimes even maternity denning itself, as well as rearing cubs (Regeher et al. 2007,Derocher et al. 2004, Derocher et al. 2013, Kovacs et al. 2011, CBD 2013, Stirling & Derocher 2012). Female polar bears exhibit site fidelity when choosing den locations, returning to the same sites year after year, and may decide to terminate the pregnancy if and when appropriate sites are not located (Amstrup & Gardner 1994, Derocher et al. 1992). Reduced concentrations of sea ice have been directly linked to declines in two subpopulations, though population trends suggest that eight in total are in decline (Regehr et al. 2010, Parsons & Cornick 2011). This is a noticeable change since the 2005 status report, at which time only five populations were in decline (Parsons & Cornick 2011). This estimation however could be an underrepresentation as seven other populations are listed as "data deficient," (CBD 2013, Parsons & Cornick 2011).

Several populations presently suffer from the adverse impacts of climate change. Resident US bears of the Beaufort Sea are forced to swim increasingly great distances to find stable ice platforms, or to reach land when ice is in recession (Pagano et al. 2012, Hunter et al. 2010). This causes exhaustion and consumes precious energy (Monnett & Gleason 2006). It also increases diminished recruitment as cubs are incapable of swimming the long distances and face the threat of drowning or abandonment (Durner et al. 2011). Bears in the Western Hudson Bay have experienced reduced body condition, reproduction, and overall survival since marked declines in sea ice (CBD 2013, Regehr et al. 2007).

Without sufficient sea ice, many populations of bears are constrained to land for substantial amounts of time, during which time they are subsisting off fat reserves (Cherry et al. 2009, Morath 2008). This displacement not only limits what polar bears hunt, but greatly restricts the amount of time they have in which to build up healthy fat reserves (Wiig et al. 2008, Cherry et al. 2009). This can be especially problematic for females who fast for up to eight months in order to find appropriate denning sites, give birth, and care for cubs during the harshest winter months (Stirling & Derocher 2012, Meek 2011). Female body condition is particularly important considering the high correlation between fat stores prior to denning and cub survival (the higher percentage of maternal fat, the higher chance cubs had of surviving their first year) (Robinson et al. 2012, Atkinson & Ramsay 1995). Conversely, prime males are larger and more adept hunters (Stirling & Derocher 2012). They have the ability to threaten other bears away from food sources, and are able to hunt without the added pressure of keeping noisy and wandering cubs safe (Stirling & Derocher 2012). This reduces their overall vulnerability but does not improve recruitment or long-term population sustainability.

Research also shows that foraging for other food sources (e.g. berries, bird eggs, etc.) is inefficient and can end up draining starving bears of valuable energy for little nutritional benefit (Hobson et al. 2009, Rockwell & Gormezano 2009, Fitzgerald 2013). Nutritional stress often drives bears into inhabited areas in search of food, putting them at risk of mortality by humans and/or reinforcing undesirable behaviors where bears associate communities with their next meal (Derocher et al. 2013, Stirling & Parkinson 2006). The probability of intraspecies predation from food scarcity also increases the longer bears are forced to stay ashore in close proximity to one another (Stirling & Derocher 2012). Events that negatively impact recruitment can be attributed to slower recovery as well, since high cub mortality lessens the number of bears that will ever reach sexual maturity and reproduce.

Relying on polar bears' natural ability to adapt may not be conducive to their conservation either. Research suggests that polar bear adaptation is a slow process (Derocher et al. 2004). This is not only supported by general biological indicators such as their long lifespan, late sexual maturity and extended period between litters, but from an evolutionary perspective, it has taken polar bears between 150,000 - 600,000 years to adapt to their current state (Peacock et al. 2010). The rate at which the climate is changing now outpaces anything in Earth's history, and certainly outpaces the ability of polar bears to adapt, who will soon have no suitable habitats in which to relocate, regardless of adaptive capacity (Peacock et al. 2010, Parsons & Cornick 2011, Ragen et al. 2008). Additionally, it is important to bear in mind that the genetic effect of consistently removing the most robust males from a population over a long period of time through trophy hunting may have also reduced the polar bears' adaptive capacity (Parson & Cornick 2011, Taylor et al. 2008). Climate change can also exacerbate non-climate stressors such as pollution or over harvesting and negatively affect a species' adaptive capacity (Seney et al. 2013). For example, an ice-free Arctic will open up the region to oil and gas development, exposing the region and its inhabitants to contamination from spills and harassment from marine and land-based operations.

While climate change is undoubtedly the most pressing threat facing polar bears, ultimately it is just one of many emerging threats. Increased accessibility into the Arctic will allow for more traffic and thus potential for disruptions in behavior, as well as pollution transference. Open ocean circulation enables the transference of pollutants from industrialized areas to penetrate deeper into the Arctic where they get deposited among lower trophic level food sources, leading to unhealthy levels of bioaccumulation in polar bears (Sonne 2010, Roginko & LaMourie 1992). Growing Arctic tourism will also likely have a negative impact on polar bears. More vehicles will certainly cause environmental and behavioral disturbances. This could compromise a bear's ability to hunt and avoidance will be energetically costly. Furthermore, continued exposure to humans and vehicles could arguably desensitize the bears and dull the instinct to avoid human contact. In an environment already prone to bear encounters, activities and behaviors that encourage human-bear interactions are likely to result in a growing number of polar bear shootings.

Polar Bears and the Subsistence System

The ramifications of emerging threats and ineffective polar bear conservation policy are not limited to the polar bear alone because Inuit communities and arctic marine mammals, like the polar bear, are inextricably connected. Historically, accessibility to reliable sources of marine mammals helped to determine where native communities settled (Boas 1888). Today, the same arctic resources, know locally as the "real food," remain central to the subsistence system (i.e. "the hunting and harvesting of the traditional food") (Wenzel 2009; 89). The importance of subsistence resources has created deep social constructs that encompass not only material production, but also community relationships, reinforced by the giving and sharing of provisions (Ford et al. 2006, Wenzel 2009, Sandell & Sandell 1996). Food is the focal point around which kinship and security are expressed. In this way, the risks to Inuit communities from climate change are much greater than food availability alone.

The very fabric of Inuit culture is threatened by the deterioration of the Arctic environment. Polar bears and seals are especially important for Greenlandic communities and in warm years that yield poor ice condition and extent, the haul of these two species has been significantly reduced (Vibe 1967). To some extent, the nutritional value of seals and polar bears can be substituted with arctic cetaceans, however this exchange does not compensate for the loss of hides and pelts (Wenzel 2009). Declines in material resources negatively impacts trading, which decreases the Inuit's ability to maintain, and repair the equipment needed for increasingly long hunting journeys (Wenzel 2009). Additionally, polar bear sport hunting is a primary source of revenue for the Canadian Inuit, and is viewed as an expression and utilization of "traditional skills" (Tyrelle & Wenzel 2010). Without subsistence resources to meet Inuit's nutritional needs, money will need to be exchanged for imported goods, however money cannot be reliably sourced without income generated by material resource products (e.g. pelts, trophy pieces, handicrafts) (Wenzel 2009).

Inuit communities have demonstrated some elasticity in response to resource availability, and modern provisions have helped to further bridge deficiencies of this nature (Ford et al. 2006). However, the Inuit are likely to experience resistance from conservationists in industrialized nations should they try to substitute one arctic resource for another (Wenzel 2009). History has shown that divisive issues regarding animal conservation have had a powerful impact on native communities. From the controversy over the Canadian harp seal hunt, to the setting or reduction in quotas as a result of polar bear population declines, and total bans on subsistence uses of certain species, the Inuit have repeatedly endured the costs of wildlife degradation and conservation policy (Lynge

1992, Peacock et al. 2011, Collings 1997). As the effects of climate change on other arctic species becomes more salient, the Inuit are likely to experience this pressure once again because "concern for the well-being of one species can translate into opposition to the Inuit subsistence use of another" (Wenzel 2009; 96).

Discussion of Results

In order to explore conservation policy gaps and overall failures as a result of how scientific uncertainty has been incorporated into the policy process, a literature review was conducted pertaining to polar bear conservation policy and the challenges inherent in existing laws and regulations. This research has led to a better understanding of the role that scientific uncertainty plays in the polar bear protection policy process. For political feasibility and management adaptability purposes, most policies have gaps. This is certainly true of polar bear conservation policy. The trouble with the persistent prevalence of scientific uncertainty is that it can be used to exacerbate these gaps, fracturing the policies and reducing their effectiveness, especially regarding the policy aims, political response, and protective measures.

Manipulate Policy Intention

One attempt to evade an expressed policy objective occurred in 2013 during the process of designating critical habitat as required by the ESA. Designating critical habitat is a proactive approach to conservation (Sanchirico et al. 2012). The ESA listing decision is reactive to threats, but designating critical habitat is anticipatory and offers higher protection in certain areas as a strategy for mitigating adverse impacts before they cause further harm. However, the plan also requires input from both the resource managers and the resource users when considering what areas to designate and how to assess the trade offs of conservative efforts versus the status quo (Sanchirico et al. 2012). This process weights economic benefit heavily and often economics and environmental protection have misaligned goals.

In 2013, a federal court ruling in the state of Alaska, denied the US Fish and Wildlife Services' (FWS) proposal for polar bear critical habitat designation (*AOGA v. Salazar* 2013). FWS planned to designate over 187,000 miles of northern Alaska, including both areas that currently act as habitat and anticipatory range expansions due to climate change (75 FR 76086). The governor of Alaska referred to this plan as an "effort to kill jobs and economic development" and an encroachment of the state's rights (Rooks 2013). Evidence of the attention given to economic impacts was clear in the ruling as well, which stated that the designation did not allow "for growth and much needed economic development [and that it] went too far and was too extensive" (*AOGA v. Salazar* 2013; 49). To support this ruling, the court looked to uncertainties surrounding specific denning locations, feeding platforms, and traversed routes. Highlighting gaps in these data, the court ruled that the FWS did not sufficiently prove the necessity and functionality of the proposed critical habitat.

However unpopular the designation might have been, choosing not to designate critical habitat is in conflict with ESA objectives of protecting a species and the habitat "essential to its survival" (16 U.S.C. 1536). The science clearly states that polar bears are losing their habitat faster than they will be able to adapt. Similarly, recovery plans are designed to address the primary threats facing imperiled species. However, there are currently no recovery plans, including the polar bear's, that provide specific conservation strategies in response to likely climate scenarios (Seney et al. 2013). Climate change models are widely used to project future scenarios and yet none have been incorporated into the recovery of vulnerable species (Molnar et al. 2010). The ESA is more flexible today than when *TVA v. Hill* (1978) ruled to protect a species, "whatever the cost," yet by ignoring climate change in these plans, and relying on uncertainty over the urgency of critical habitat, this original intention of the ESA had not delivered upon (Bryant 2009).

There are also examples of decision makers attempting to manipulate a policy objective with scientific uncertainty when reviewing the intersection between polar bear protection and CITES. The United States sought to take an unorthodox approach for a CITES amendment in both 2010 and 2013 by proposing that the polar bear be uplisted to CITES Appendix I in an effort to strengthen protection for the bears on an international scale. Listing the polar bears under Appendix I would ban all international trade of their products, but would not affect hunting for subsistence or domestic trade (CITES 1973, Parsons & Cornick 2011). The United States had already addressed the international trade of polar bear contraband domestically through the MMPA, but the high amount of bear paraphernalia that continued to cross other international borders led to US concern over population decreases due to persistent, legal trophy hunting in Canada (Parsons & Cornick 2011, CITES 2013c). To achieve their goal, the US relied on uncertainties over how "utilization and trade" may exacerbate other stressors related to climate change and the loss of sea ice (CITES 2013b; 2). Citing uncertainties over adaptability, climate scenarios, and cumulative impacts, they sought the uplisting for precautionary measures, stating it was "necessary to ensure that primary commercial trade does not compound the threats posed to the species by loss of habitat" (CITES 2013b; 2).

Though the US was attempting to increase the protection for polar bears, and provide additional conservation capabilities through CITES, it was not in keeping with CITES objectives of international trade regulation (Tyrrell & Clark 2014). Despite polar bear products appearing on the market, it had been well documented by that time that polar bears had recovered from unsustainable hunting practices and over harvest. Polar bears are also no longer part of a commercial hunt, but rather a subsistence industry that participates in a quota system and legally trades pieces across international borders. Because of this, an Appendix I listing might have stopped trade but it arguably would not reduce the numbers of polar bears harvested annually. Climate change is the primary threat facing the bears now. While severe population declines are projected, uplisting the bears under CITES would not have helped mitigate such declines, as CITES is neither an avenue for habitat protection nor emissions regulations (Hunter et al. 2010, Tyrrell & Clark 2014). The final decision declared that the polar bear did not fit the criteria for an uplisting, and while biological data may not support this assertion, the decision is in keeping with the CITES objective of regulating international trade (CITES 2013c).

Coerce Inaction

Building off of the previous section, the case for how scientific uncertainty has been used as one excuse for justifying inaction begins to take shape. Though the decision to refuse the petition to uplist was warranted from a policy objective perspective, the biological criteria does illustrate a failure to act. The convention states that for amendment of appendices to occur, just one of several biological criteria need to be met, including that the species faces projected declines due to habitat loss (CITES 2013b).

Despite substantial scientific evidence that "predicted a 66% decline [in polar bear population numbers over the next 45 years], which would qualify as a "marked decline" according to the CITES guidelines", the parties refused the petition each time it was presented (Parsons & Cornick 2011; 730). Though the move would likely not offer the polar bear any more protection from hunting, which is CITES main platform, that was not the reason cited by the parties for the petition denial. Rather than point this distinction out, the Science Committee referenced uncertainties over the science. Continuing to use the best available science when making management decisions is critical (Seney et al. 2013). In both petition attempts, the parties declined to use the most recent, comprehensive collection of research, which had been gathered by United States' scientists as the body of evidence supporting the proposal to list polar bears under the ESA, because it contradicted other literature (Parsons & Cornick 2011). In this case, the combined forces of inconsistencies in the literature and the failure to reconcile the competing conclusions led to uncertainties and propelled inaction instead of a precautionary response.

Additionally, there are examples of scientific uncertainty leading to inaction when reviewing polar bear conservation in relation to the ESA. Though a reputable piece of legislation, the ESA only works when applied directly to the key threats facing the species, and in the case of the polar bears, it has not been (CBD 2013). To effectively protect the polar bears from further depletion the ESA would need to explicitly be used to address climate change. This is not entirely outside of the ESA's capacity, were it not for the enactment of the 4(d) rule (discussed in more detail later) (Kuhn 2010). This understanding has led to a battle over if and how the ESA should address climate change, wherein several examples of inaction have ensued.

Intentionally vague language in the ESA like "foreseeable future" and "significant portion of its range" are heavily reliant on best available science and accurate forecasts. This is especially true of habitat that is vulnerable to climate change (McClure 2013). It is difficult to make sound determinations when there is a persistent level of uncertainty in the available science, as this means that a certain level of the process will always be subject to interpretation. But in the case of critical habitat, decision makers chose inaction rather than incorporating the implications of scientific uncertainty. Similarly, scientific uncertainty over actual climate change impacts and population declines were discussed as reasons not to list polar bears under the ESA. While this attempt to maintain the legislative status quo of no ESA listing was unsuccessful, it remains substantial evidence of how scientific uncertainty has been used to justify inaction.

In order for polar bears to be listed under the ESA, evidence needs to be collected to confirm that climate change is occurring, will continue to occur, is adversely affecting the bears, and most importantly, the link between global warming and anthropogenic causes needs to be made (Morath 2008). A series of reports were compiled in 2007 to delineate the side effects of climate change as sea level rise, ocean acidification, melting permafrost, shrinking sea ice, heat extremes, and intensifying storms (Morath 2008). Furthermore, the IPCC concluded that global warming was "very likely" human induced (IPCC 2007). Since then, the IPCC has confirmed that climate warming is "extremely likely" the result of anthropogenic activities (IPCC 2014). This level of certainty over the anthropogenic causes of climate change was critical for the listing because it satisfied the requirement of 'harm' that earned the polar bear protection under the ESA (Morath 2008). However, there was significant push back because of concerns over existing uncertainty.

FWS addressed many of these concerns in its final ruling, which determined that polar bears fit the criteria for a threatened listing under the ESA (73 FR 28212). FWS identified that stakeholders were primarily worried about evidence regarding (1) the possibility of ice loss being caused by natural variability, rather than climate change; (2) uncertainty over climate change projections and scenarios; and (3) current population numbers did not warrant the listing (seemingly regardless of the population trends) (73 FR 28212). Despite climate change already being identified by the IPCC as anthropogenically driven, with high confidence intervals for climate scenarios in the foreseeable future, some stakeholders still hoped to dismiss the listing petition and do nothing on the grounds of scientific uncertainty (IPCC 2007, 73 FR 28212).

Once listed, questions came to light over whether the ESA was equipped to address climate change, or if climate change could even be cited as a reason for species decline. The Secretary of the Interior, Dirk Kempthorne, agreed that polar bears were indeed facing definitive habitat loss but that the "whole aspect of climate change is beyond the scope of the Endangered Species Act" (Morath 2008; 24). Still, proponents of the listing held fast to the hope that since climate change was undisputedly identified as the primary threat against polar bear survival, the ESA could provide an avenue through which to regulate climate change and carbon emissions (Morath 2008). This came in the form of the 4(d) rule, which can be implemented to include special management considerations for threatened species to further strengthen conservation efforts and keep the species from becoming endangered (FWS 2013).

In the case of polar bears, the 4(d) rule was an opportunity to regulate the loss of polar bears as a result of climate change impacts (FWS 2013). The administration, however, saw this attempt as an overreach of the ESA's capacity and enacted a rule that would preclude the ESA listing from prompting emission reductions and evoking additional actions against climate change impacts that result in the incidental take of polar bears (CBD 2013). The reason cited for this decision was that science had not yet "established a causal connection between specific emissions and incidental take of polar bear[s]," despite widespread agreement among scientists that anthropogenic-induced warming is what is causing loss of sea ice (FWS 2013b; 3, IPCC 2007). This resulted in inaction around emission reductions, and in turn, promulgated less effective US polar bear conservation policy.

Revisiting the critical habitat designation decision, one can see again how inaction was supported with scientific uncertainty. One of the primary reasons the critical habitat plan was denied was for insufficient evidence that the terrestrial portion of the designation was in fact necessary for maternity denning (*AOGA v. Salazar* 2013). The court made a similar claim regarding lack of proof around the use of specific locations on the Barrier Islands to access denning and feeding sites (*AOGA v. Salazar* 2013). FWS maintained that not only had it proven the presence of polar bear dens throughout the habitat, but that since females often travel vast distances in search of den sites, and distribution can make tracking the location of such sites difficult, the area was not only necessary but may well be inadequate (Joling 2015). Additionally, given the bears' frequent use of the islands, as well as their vast distribution and range relative to the size of the islands, it would have been insufficient to designate only part of the islands as habitat (Amstrup & Gardner 1994). Still, Judge Beistline ruled that FWS failed to sufficiently prove that the habitat provided access to the coast and had minimal human contact, both of which were requirements of essential critical habitat as outlined by the ESA (*AOGA v. Salazar* 2013). However, by virtue of the fact the denning sites do exist throughout the proposed area, it should have been inherently evident that there is in fact access to the coast. Regardless of the actual evidence at hand, the court used limited (albeit conclusive) science as an excuse for abolishing the entire critical habitat plan and protecting private and governmental interests.

Interestingly, in a recent turn of events involving the same case, a different application of scientific uncertainty was used to overturn the final decision in *AOGA v. Salazar* (2013). In early 2016 , the federal Court of Appeals ruled to uphold FWS' original critical habitat plan on the grounds that polar bears need unmolested area to travel to and from denning and feeding sites (*AOGA v Jewell* 2016). Based on the distribution and range of the polar bear, the appellate court also concluded that FWS did not create a plan that was too extensive or arbitrary. Though specific denning sites were not present in every part of the listed range, the court ruled that FWS used the best available science to determine that the area as a whole is critical to the survival of the species, especially given the likely needs of future range shifts (*AOGA v Jewell* 2016).

In stark contrast to the lower court, the court of appeals referred to natural variability (one type of uncertainty) as a precise reason for upholding the designation (Remillard 2016). The court reasoned that due to the high level of fluctuation that occurs in the arctic environment, the scope of critical habitat should be broadly defined, out of necessity (Remillard 2016). The path that a bear takes from the ice to a denning site may not be accessible the following year, so all of the surrounding area must also be free of disturbances to give the bears the best opportunity to traverse safely. Though outcomes may vary across time, the example of the critical habitat designation highlights how the role that scientific uncertainty plays throughout the policy development and implementation processes is significant.

Subvert Precautionary Responses to Extinction

As the polar bear example demonstrates, scientific uncertainty can be used as a tool to protect and further political agendas (Heazle 2004). Unfortunately, when this happens, it is often at the expense of precautionary action. The precautionary principle is widely used in environmental management, but is not itself, legally binding (Weiss 2007). CITES and the ESA are each built on a precautionary platform, however, this approach is not absolute and does not equate to an entirely preventative response under all circumstances. In addition, the flexibility built into the structure of both the ESA and CITES for political feasibility purposes, can occasionally result in the failure to achieve a policy goal (e.g. adequate protections for polar bears). To this point, when reviewing the responses to polar bear conservation under CITES and the ESA, there appear to be several examples of policy gaps and uncertainties that lead to failures in precautionary action.

The precautionary principle is a basic *better safe than sorry* approach to problems (Heazle 2004). The UN explains the parameters of a precautionary approach as, "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (UN 1992). UNESCO offers a similar definition, but incorporates language surrounding morality and equity (Weiss 2007). They declare that the precautionary principle be applied to avoid "morally unacceptable harm that is scientifically plausible but uncertain" for situations that could result in *inequitable* outcomes and *human rights* violations (Weiss 2007; 33). The precautionary principle also dictates that in a situation where a value judgment must be made in order to assign risk error (costs and benefits cannot be assessed for alternative outcomes due to high uncertainty), the error should favor the environment (Bodansky 1991, Aldred 2013). In other words, costs should be incurred to avoid harm, even if the degree of harm is uncertain.

Since conservation policies serve to mitigate irreparable damage, they are often inherently precautionary. However, by promoting inaction and manipulating policy intention, decision makers end up subverting precautionary action and weakening policy effects. The 4(d) rule eliminated the potential for addressing the threat of climate change through the ESA, and the polar bear lacked designated critical habitat until very recently, all due to how scientific uncertainty was used to support political agendas. The petition to amend the polar bear's CITES Appendix was also a failed opportunity to act proactively. Despite the ESA and CITES having precautionary objectives, these actions were not preventative and have done nothing to further conservation efforts for the polar bear.

Both the ESA and CITES also incorporate the use of best available science, but in each of these instances, the need for more concrete science before action could be taken was cited. It should be noted that there is always the ability for improvements in science and data collection as long as there is money to support it (Bodansky 1991). This construct illustrates the vagueness in phrases like *best available science* because there is no clear boundary for when this definition has been reached. This means that there is also no definitive time when action should be taken. Relying on nebulous parameters of ill-defined terms does little to promote precautionary action. The threat of polar bear extinction will also have profound human rights impacts, a consequence that is typically overlooked but in direct conflict with precautionary ideology. In this way, scientific uncertainty not only manipulates policy intention and fosters inaction, but through these constructs also presents barriers to precautionary responses.

Recommendations & Conclusion

Recommendations Moving Forward

A first attempt at correcting some of the inefficiencies in polar bear conservation policy could be to strengthen current efforts within existing policy. The ESA could be given more power to address climate change, and uplisting the polar bear across policy platforms would highlight the severity of the climate change crisis. Policies that are not currently legally binding could be given enforcement capacity. Quotas could be required in all jurisdictions. Sport hunting could be banned, tourism regulated under ESA protections, and the 4(d) rule could be reassessed. Finally, cumulative impact assessments (CIAs) could be implemented to establish congruence across managing agencies and consolidate information regarding risks associated with human activity.

To better maintain precautionary ideology, science should aim to research the worst-case scenario rather than reduce uncertainty (Costanza & Cornwell 1992). In this way, the aforementioned envelope would be restructured with the parameters signifying the very limits of what is acceptable and the interior of the envelope being varying degrees of outcomes. Since scientific uncertainty is unavoidable, this would allow for the reallocation of research efforts toward prevention and mitigation, ultimately improving anticipatory responses to problems.

Then again, perhaps it is time to introduce entirely new conservation techniques and strategies. Climate vulnerability assessments could be a valuable addition to conservation efforts. These would involve climate specialists and species experts to frame analyses of species-specific data collection in a way that uniquely considers their vulnerability and adaptive capacity regarding climate change, and to develop indicators for risk of exposure and sensitivity. Expanding comanagement between scientists and managers "to implement conservation actions in ways that reduce uncertainty and allow management approaches to be altered as necessary" would help move management toward an adaptive management style and involve more stakeholders (McClure 2013; 1231).

Integrating a social-ecological systems (SES) approach could also be beneficial since the bears play such an intimate role in social constructs. In this approach, the policy and the ecosystem are viewed as dynamic, and resilience is applied to both the viability of the polar bear population and the ability of the Inuit to maintain a sustainable harvest (Meek 2011). SES also considers fast and slow drivers that affect polar bear recovery (Meek 2011). The fast drivers are the physical takings and spatial distribution of the bears. The slow drivers are the policy implementations, climate change, habitat degradation and encroaching industry. This ultimately allows for a holistic inclusion of threats.

Zero-sum management has the potential to be especially effective because it requires that existing industry lessen their impact before they are able to expand, essentially keeping the impact within the parameters of its current footprint. A less aggressive option could be through CIAs. CIAs are meant to address all anthropogenic impacts that adversely affect a given species in a specific area to the point of limiting their recovery. This is a complicated process that involves considering the collective impact of all current and proposed human activity before moving forward with a new action (Wright & Kyhn 2014). Comprehensive CIAs could ultimately reduce negative impacts such as stress responses of the animal or environment, fitness consequences, and likelihood of increased direct or indirect takes. This can be done by compiling information from environmental impact assessments, marine spatial planning, ecosystem-based management plans, and population consequences of disturbance, and employing tools such as management cycles, cross company collaboration, and zero-sum management techniques (Wright & Kyhn 2014).

Conclusion

On average, the Arctic is warming twice as fast as the rest of the globe, which is contributing to record lows in sea ice extent and snow cover (CBD 2013). This also causes permafrost, which is an efficient carbon sink, to melt, releasing CO2 into the atmosphere. All of this has led to the National Oceanic and Atmospheric Administration (NOAA) projecting ice free summers in the Arctic occurring as early as 2020, but almost certainly by 2050 (CBD 2013). When this happens, it will be profoundly devastating for all ice dependent species and the communities that rely on them.

Maintaining the momentum that has surrounded polar bear protection is critical for the future of the Arctic because of what this species has come to represent. Though polar bear extinction is a legitimate concern in its own right, in the context of pressing Arctic issues, the polar bear serves as the portrayal of the danger posed to all Arctic marine mammals. Ten Arctic marine mammals are ice dependent and will likely face extinction with the loss of sea ice (Laidre et al. 2015). Those that are able to adapt to ice free summers will face other pressures, including food scarcity and dietary variation, changes in predator/prey relationships, range shifts, and increases in pollution, traffic, noise, and human contact, all of which create the potential for stress and harm.

Native hunters use the ice as a platform for harvesting precious resources. Disruptions and variations in sea ice coverage restrict hunting seasons, create unpredictability in seasonal migrations, and can yield harvest of animals with poorer body condition (Pearce et al. 2010, Marz & Medina 2013). Animals in poor health have usually burned through their fat reserves, which have high concentrations of fat-soluble contaminants that stay sequestered until metabolized (Regehr et al. 2007, Sonne 2010). Other toxins, like mercury, are not stored in the lipids and synergistically these contaminants afford polar bears the highest body burdens of toxins among arctic species (Letcher et al. 2009). This elicits toxic transference up the food chain to subsistence communities that harvest polar bears and other marine predators (Bjerregaard et al. 2001, Sonne 2010). Exposure to these kinds of chemicals is known to have adverse effects on the hosts, though the impacts are not yet well understood in human beings (Letcher et al. 2009, Sonne 2010).

Most of these issues however have not garnered the attention and visibility that polar bears have received. In this way, this charismatic megafauna has come to represent the Arctic community as a whole. Protections for polar bears will not only protect other species by extension, but also have the potential to motivate and initiate protective policies for the entire region.

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