The Nonnative Wildlife Invasion Prevention Act

The Science Behind H.R. 669

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Executive Summary

For the last two decades, there has been a substantial increase in the importation of nonnative wildlife species into the United States – roughly doubling in volume since 1991. This increase has been fueled by the growing demand for rare animal species as pets in conjunction with lowering barriers to international trade and travel that allow importers to deal directly and expeditiously with individual purchasers in the United States. For example, between 2000 and 2004, more than 2,200 non-native animal species were intentionally transported into the country. These species would not pose a significant problem if they remained in their owner's possession and control. Unfortunately, many escape or are deliberately released into regions of the country where they have the potential to establish a viable population and cause harm. As presciently observed in a 1991 report by the Congress Office of Technology Assessment: "Given the high U.S. rates of pet imports—estimated to be hundreds of thousands to millions of wild birds, aquarium fish, and reptiles annually—the potential for pet escapes and releases is great."[1]

The ecological damage caused by nonnative wildlife is well documented. Species native to the United States, in particular, have experienced large losses in the face of encroaching invasive wildlife. Competition, predation, and diseases carried by invasive wildlife are responsible for nearly half of the "threatened" or "endangered" species listings under the Endangered Species Act. For example, the Brown Tree Snake has had a devastating effect upon the bird and lizard populations on the tiny island of Guam. Recent estimates suggest that at least one thousand free-ranging Burmese Pythons, brought to Florida through the pet trade, now inhabit the Everglades and compete with the native alligator population for scarce resources. Although difficult to quantify, the economic consequences of this "biological pollution" have also been severe, with $114 billion expended in the United States each year to control the spread and remedy the damage caused by nonnative animals. In addition to this ecological and economic harm, nonnative wildlife are also potential vectors for the spread of deadly or debilitating pathogens to human populations. In fact, approximately three-quarters of human diseases are believed to be transmitted to humans by animals.

In the face of the evidence of past damage attributable to nonnative species and the predictions of increasing damage in the future, a strong regulatory solution is needed to prevent their continued spread throughout the country. The existing patchwork of federal and state laws that are potentially applicable to nonnative wildlife has proven to be inadequate to the task. This legislation is wholly reactive in that it only addresses the harm caused by an invasive species after the harm has already occurred. In doing so, the Lacey Act is in tune with the approach followed by a majority of our environmental laws, which is to attempt to remedy existing damage. What is needed is a proactive solution that prevents a nonnative species from becoming a problem in the first place.

H.R. 669, entitled the Nonnative Wildlife Invasion Prevention Act ("H.R. 669" or the "Act"), represents a clear shift from a reactive to a proactive policy in dealing with the rising tide of nonnative animal imports into the United States. In particular, the Act prevents the intentional introduction and establishment of nonnative animal species in the United States that will cause or

[1] OTA, 1993.

are likely to cause environmental and economic harm. This goal is achieved through a rigorous risk assessment process that considers a number of listed, nonexclusive factors. If a species is determined to be harmful under this process, it cannot be imported into the United States, transported between states, possessed, sold, purchased, bartered, released into the wild, or bred. Nonnative species that are found not to present harm or potential harm are included on a list of "approved" species. Significantly, nonnative species that are not included on this list are subject to the Act's prohibitions even if they have not yet been assessed – essentially creating a "guilty until proven innocent" scheme. The Act supports its prohibitions with strong civil and criminal penalties.

Given the strict prohibitions embodied in H.R. 699, it is critical that sound and widely accepted scientific principles be applied to the risk assessment process. In this regard, there are numerous scientific models that have been developed in the United States and in other nations battling nonnative species that can be used to predict whether a particular species will establish itself in the United States and cause harm. While any scientific model will involve some degree of uncertainty, achieving a reasonable degree of certainty should be all that is expected or required in making legally and scientifically defensible decisions whether to approve a nonnative species under the Act.

The likely and potential consequences of the Act's strict, proactive scheme to stakeholders should not be discounted. The exotic pet industry in particular has voiced concern about the potential impact to trade. With the guilty until proven innocent scheme, those involved in the pet trade will not be able to import or sell a nonnative animal until it has been assessed and approved – a process that may be subject to significant delay. This problem will only be compounded by the current lack of federal government resources and personnel to conduct the anticipated large volume of risk assessments.

Despite the uncertainties and potential burdens associated with the Act, it represents an innovative and necessary solution to the deepening crisis of biological pollution in the United States. The damages to native wildlife, habitats, agriculture, and watersheds caused by established nonnative species cannot be reversed, and the economic costs of controlling, containing, and eradicating their presence are mounting at an exponential rate. Proactive legislation is needed in order to limit the introduction of additional destructive pests.

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The Environmental Problem

Invasive animal species are non-native, introduced species that have deleterious effects on native environments, native wildlife, the economy and/or human health. The United States is the world leader in importation of non-native species (Jenkins et al. 2007). The potential for successful invasions of non-native species in the United States has grown with increasing global trade. As a result of both intentional and inadvertent introductions, it is estimated that approximately 7,000 non-native plant and animal species are already established in the United States (UCS 2009). Between 2000 and 2004 alone, 2,241 non-native animal species were intentionally transported into the country. Of these, 302 species have already been identified as significant risks, having the potential to cause harm (Jenkins 2007).

Damages

Economic damages caused by invasive species are difficult to quantify, as long-term scientific studies have not been conducted. However, best estimates indicate that non-native plant and animal species cause $137 billion in economic damage annually. Of that total, $114 billion is attributable to exotic animal species and their impact on crops, forestry, and other economic sectors. Crop pests alone account for $14 billion in losses, damages, and control costs. (Pimental et al. 2005). If importation of non-native species remains unchecked, those numbers are likely to rise.

Damage by invasive species is not limited to economic loss. Invasive species have decimated populations of native species, spread disease to humans, destroyed native habitats, and significantly impeded the function of entire ecosystems. Endangered and threatened species are particularly at risk; at least 400 species been listed under the Endangered Species Act may be threatened by increased competition, disease risk or predation by invasive species (Pimental 2005). By way of example, the endangered native Anastasia Island beach mouse (*Peromyscus polionotus phasma*) must compete for food resources with introduced, non-native house mice (*Mus musculus*) (USFWS 1993; Moulton and Sanderson 1999). In Guam, 13 of 22 endemic bird species became extinct as a result of the introduction of the non-native Brown Tree Snake (*Boiga irregularis*). Prior to the introduction of the snake, the birds were not subject to any native predators on the island (Rodda and Savidge 2007).

Non-native invasive species can carry new diseases into the country, as well as serve as hosts to existing diseases that otherwise did not have an appropriate vector. The monkeypox virus is a prime example of a disease that is transmitted to humans by non-native wildlife (Guarner et al. 2004). This virus is similar to smallpox and was introduced by Gambian giant pet rats. Similarly, avian influenza, H5N1, is thought to have traveled throughout the world through legal and illegal trade of infected pet birds, as well as through migratory bird flight. The virus causes rapid and severe flu symptoms, and can be fatal in humans (Jenkins 2007).

The Process of Invasion

Understanding the process of invasion is key to understanding the extent of the threat posed by non-native animal species. If a non-native species is to become invasive, it generally first progresses through three stages: importation, introduction, and establishment (Figure 1). Without human influence, non-native species often die en route; only approximately 10 percent survive at each stage of the process (Williamson & Fitter 1996; Williamson 1999). Thus, without human intervention, of all non-native species introduced to the United States, only 0.1 percent are likely to become invasive (Williamson & Fitter 1996). Humans, however, increase the number of non-native species entering the United States and alleviate some of the threats to survival during transport, thereby increasing substantially the chances that non-native species will become invasive (Williamson & Fitter 1996; Moyle & Michael 2006). The transition percentages noted here can vary; other research found a 50 percent success rate at each stage of the invasion process (Jeschke and Strayer, 2005).

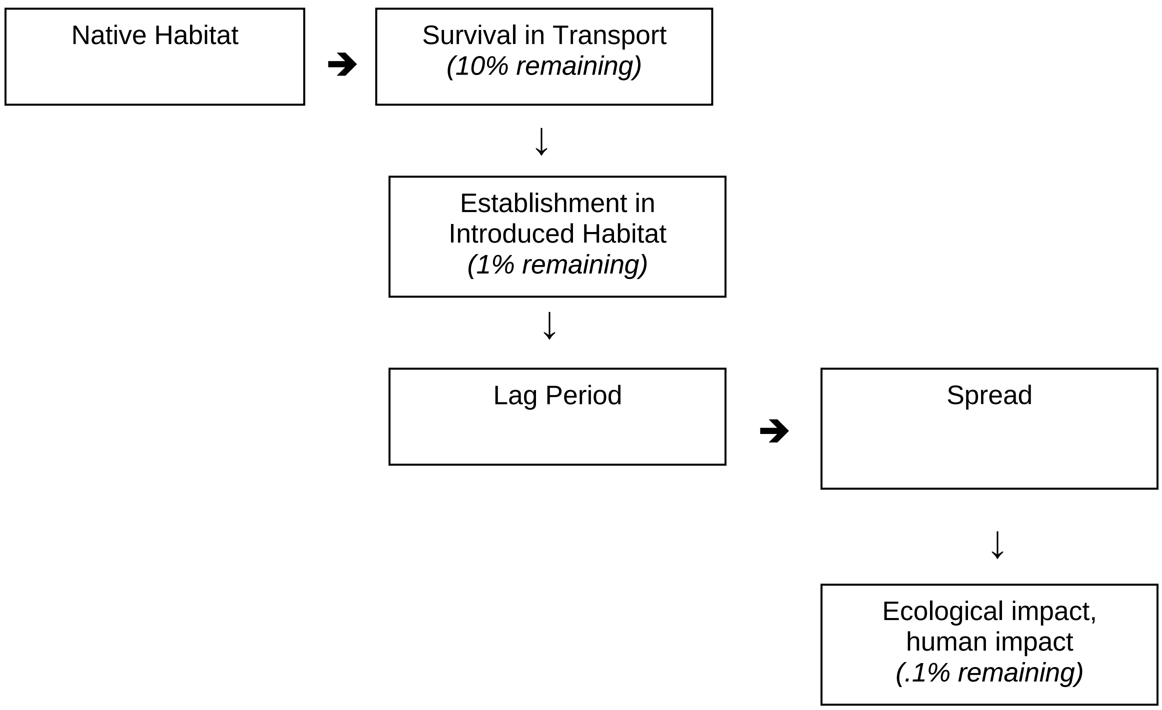

Figure 1: Steps in the invasion process (adapted from Sakai et al, 2001).

Successful establishment is dependent upon whether the overall number of incoming individuals is sufficient to found a viable breeding population in the new habitat (Kolar 2001; Sakai 2001). A lag period generally follows before the species begins to spread. Even after having successfully established itself and spread, a non-native species is not considered "invasive" unless it causes economic or ecological harm (Cox 2005).

The factors that play a role in whether an introduced species will become established and invasive can be divided into two categories: the characteristics of the species themselves and the conditions of the environment to which they are introduced. Successful invaders generally have certain characteristics, including (1) early sexual maturity; (2) a high reproductive output (the ability to reproduce frequently and produce many offspring during each reproductive cycle); (3) the ability to thrive in diverse environments; (4) high dispersal ability; (5) a history of successful invasion elsewhere; and (6) the ability to readily adapt to new environments (Holway 1999; Sakai et al 2001). Habitat conditions that are particularly conducive to invasion by non-native species include (1) areas of frequent or intense disturbance (often anthropogenic in nature); (2)

lack of native, competing predators; (3) presence of naïve or vulnerable native prey; (4) favorable climatic conditions; and (5) abundant resources (Sakai et al 2001). Even if a species has appropriate characteristics and habitat conditions are favorable, invasion will not always result.

Why Action Is Needed

Government action is needed in order to mitigate the damage to natural and agricultural ecosystems. Current laws governing non-native species do not regulate or significantly restrict the importation of potentially invasive animals (Jenkins 2007). Accordingly, an invasive species could be introduced at any time and proliferate unchecked until it causes such significant harm that the government feels obligated to act. The Lacey Act is the primary federal legislation employed to regulate the introduction of non-native wildlife species. The Act is, however, outdated and cumbersome. Under the Lacey Act, assessment and listing of new invasive species can take up to seven years. The Act is also primarily reactive, generally addressing invasive species only after they have already established and caused extensive damage. Invasive species would be best controlled, however, by identifying species which pose threats prior to their introduction and taking action to prevent invasion (Miller 2003). The following case studies serve as key examples of why comprehensive legislation is needed to prevent potentially dangerous species from entering the country.

Case Study No.1: The Small Indian Mongoose (*Herpestes javanicus*)

The Small Indian Mongoose is a prolific invasive species. It is so prolific, in fact, that it has been designated as one of the International Union for Conservation of Nature's (IUCN) "World's 100 Worst Invasive Alien Species" (Yamadai 2004). In order to control rat infestations on plantations, mongooses were imported in the late 1800s from Calcutta to Puerto Rico, Hawaii, and the U.S. Virgin Islands (Simberloff 2000). For a number of interconnected reasons, it has since established as harmful invasive species on these islands.

In its native territory, the Small Indian Mongoose is sympatric (shares the same range) with the Indian Grey Mongoose (*H. edwardsii*,) and has overlapping range with other species with which it competes for prey (Simberloff 2000). Also in its native range, it was the prey to a number of animals, including jackals, bears, martins, and several cats. In Hawai'i, Puerto Rico, and the U.S. Virgin Islands, its only significant predators are feral cats and dogs, leaving populations less vulnerable to predation. The Small Indian Mongoose is versatile both in terms of habitats it can occupy and the food it consumes. It can survive in virtually all mid-latitude habitats other than urban areas and forest, where food supplies are limited (Pimentel 1955). In Hawai'i, for example, mongooses eat a wide variety of animals and plants, such as crab, fish, insects, birds and fruit. These characteristics strengthen its ability to establish in nonnative environments (Simberloff 2000). Further, the wildlife native to most islands where mongooses have been introduced has evolved in the absence of predatory mammals, and as a result they have not developed the defense mechanisms to protect against predation (Yamadai 2004).

For these reasons, the Small Indian Mongoose was able to successfully expand its population in Hawai'i, Puerto Rico, and the U.S. Virgin Islands. However, the effectiveness of this species as a pest control method has in fact declined over time, with some varieties of rat being less susceptible to predation (Pimentel 2000). Regardless, mongoose populations have remained large and preyed heavily on some native species, caused amphibian and wild bird extinctions, preyed on domesticated chickens, and functioned as a reservoir and a vector for diseases such as rabies and leptospirosis (Hays 2007).

<u>Case Study No. 2</u>*:* Nutria (*Myocastor coypus*)

Nutria are semi-aquatic rodents with rat-like features (Nutria Workshop 2002). In 1899, they were first intentionally introduced into North America from South America for their fur. However, when nutria farming largely collapsed in the 1940s, some ranchers released their nutria or failed to recapture those that escaped (Evans 1970). State and federal agencies and individuals also transported nutria into many states for the purpose of controlling undesirable vegetation and enhancing trapping opportunities (Nutria Workshop 2002). This proved to be a grave mistake because of certain nutria characteristics.

Nutria occupy semi-aquatic habitats, which includes swamps and marshes and along the shores of rivers and lakes. They feed on many terrestrial and aquatic green plants and occasionally consume grains (Whitaker 1988). Their feeding habits are extremely destructive to marsh vegetation because their foraging activity destroys vegetative root mat. This so-called "eat out" loosens a plant's hold on the soil, which then becomes more vulnerable to erosion. These "eat-outs" can transform a productive wetland into a barren mud flat (Nutria Workshop 2002).

The destructive foraging habits of the nutria are compounded by their rapid population expansion. Nutria reach sexual maturity at about four to six months of age and reproduce throughout the year, typically having two to three litters annually (Brown 1975; Willner et al. 1979). They also have an aggressive nature and will displace native animals such as beavers and muskrats. Threatened by few predators (other than humans), nutria have experienced a population boom in certain areas of the country. For example, in Dorchester County, Maryland, the nutria population was estimated to have expanded on a 10,000 acre parcel of land from less than 150 in 1968 to 35,000 to 50,000 in 2002 (Nutria Workshop 2002).

<u>Case Study No. 3</u>*:* Golden apple snail (*Pomacea canaliculata*)

The golden apple snail is native to South America, but recently invaded South Asia and may now be in the process of invading North America (Naylor 1996; Cowie 2002; Carlsson, Bronmark, & Hansson 2004; Carlsson & Lacoursiere 2005; Du et al 2007). It was first introduced to Taiwan from Argentina around 1980 as a potential high-protein food source (Naylor 1996; Cowie, 2002; Carlsson & Lacoursiere 2005). Aquaculturists, either intentionally or inadvertently, allowed the molluscs to escape into irrigation channels, wetlands, and rice paddies (Naylor 1996; Carlsson & Lacoursiere 2005). More recent introductions resulted from floods, weed control, transport of contaminated soil, transport of contaminated vegetables, and the pet industry (Naylor 1996; Cowie 2002). The golden apple snail recently reached Hawai'i, Guam, California, and the southern United States. It is currently a major taro crop pest in Hawai'i (Cowie 2002; Carlsson, Bronmark, & Hansson 2004; Du et al 2007).

By feeding on submerged or floating vegetation, including rice, taro, lotus, wild rice, water chestnut, and water cress, the golden apple snail has significantly altered natural habitats and damaged agricultural crops in South Asia (Naylor 1996; Cowie 2002; Carlsson, Bronmark, & Hansson 2004; Carlsson & Lacoursiere 2005). In natural wetlands, the snail kills the plants responsible for water purification, leading to increased pollution and algal blooms (Carlsson & Lacoursiere 2005). By destroying populations of wild rice, the golden apple snail could contribute to the loss of genetic diversity (Naylor 1996). The golden apple snail has also been linked to the decline of native apple snails in the Philippines (Du et al 2007).

The golden apple snail is a successful invader because it possesses many weed-like characteristics. First, the snail matures and reproduces rapidly; each female matures within two months after hatching and lays up to 8,700 eggs every year for up to three years, leading to exponential population growth rates (Naylor 1996; Cox & Moore 2005; Du et al 2007). Secondly, the golden apple snail is highly adaptable: although it is a freshwater mollusk, this snail can also live in both low oxygen and drought conditions, allowing it to survive disturbances that native snails may not (Naylor 1996; Du et al 2007). Finally, the snail is capable of occupying previously unoccupied niches. It prefers plants most native snails avoid and tends to invade simplified ecosystems with little diversity, including many agricultural areas (Naylor 1996; Callaway & Aschehoug 2000; Kennedy et al 2002; Carlsson & Lacoursiere 2005).

The snail enjoys further advantages in that it was introduced into habitats suitable for invasion. It invades habitats similar to its native range (Naylor 1996), but that lack natural enemies and other constraints to growth. In South America, the snail exists at low densities due to both predation and the seasonal cold periods (Carlsson et al. 2004; Carlsson & Lacoursiere 2005). The mollusk's introduced ranges—particularly South Asia—lack predators, cold weather, disease, and competition, all of which could contribute to the rapid increase in snail densities (Callaway & Aschehoug 2000; Keane & Crawley 2002; Du et al. 2007).

The Proposed Solution: H.R. 669, The Nonnative Wildlife Invasion Prevention Act

The Non-Native Wildlife Prevention Invasion Prevention Act is based on the precautionary principle. Its goal is to prevent the intentional introduction of nonnative invasive species in order to preserve biodiversity and ecosystem functions, minimize economic damages from pests and pathogens, and reduce harm to human health and native species. The bill seeks to accomplish this through a risk assessment process based upon the consideration of several explicit factors, including identification of the species and its native range and the likelihood that the organism will establish and cause harm to wildlife resources in the United States.

All non-native wildlife species proposed for importation into the United States must be assessed and determined to be non-injurious prior to entrance. As defined by this bill, an injurious species is one that will cause or is likely to cause economic and environmental harm or harm to other animal species' health or human health. If the US Fish and Wildlife Service (FWS) concludes, on the basis of the risk assessment process, that a proposed species would be injurious, the non-native species will not be allowed into the United States (Bill H.R. 669). On the basis of this risk assessment process, the Secretary of the Interior places a particular nonnative species on either of two lists: the list of approved species that are not subject to the protections imposed by the bill or the list of unapproved species that may not be imported into the United States or sold, bred, or relocated across state or national boundaries. Significantly, these prohibitions not only apply to species on the unapproved list, but also extend to all nonnative species that the Secretary has not explicitly approved. The prohibitions imposed by the bill are enforced through the imposition of civil and criminal penalties.

H.R. 669 does not set forth a standard operating procedure for the risk assessment process. However, the bill does stipulate that the process be based on sound science and incorporates several factors when assessing risk. Specifically, the risk assessment process should (1) identify the organism to the species level; (2) identify the native range of the species; (3) determine whether the species has proven to be injurious in ecosystems that are similar to those in the United States; (4) assess the likelihood that environmental conditions suitable for the establishment of the species exist in the United States; (5) determine the likelihood of establishment and/or spread in the United States; (6) assess the likelihood that the species would prove to be injurious with regard to wildlife resources, rare or threatened native species, or habitats or ecosystems; and (7) determine the likelihood that pathogenic or parasitic species may accompany the proposed species (Bill H.R. 669).

Within this framework, H.R. 669 does provide for some degree of flexibility. Under this bill, animals owned prior to the enactment, non-native invasive species that are too widespread to control, and non-native domesticated animals such as cats and dogs will be exempt from these restrictions. The bill also exempts federal agencies from liability for importing and transporting non-native species for their own use. Finally, H.R. 669 includes a permitting option for scientific research, medical, accredited zoological or aquarium display purposes, or for educational purposes that are specifically reviewed, approved, and verified by the FWS (Bill H.R. 669).

The Science of the Proposed Solution

Risk Assessment

Despite decades of research, predicting whether a particular species is likely to be a successful invader remains difficult, primarily because sufficient information is often not available to assess the characteristics of the invading species, the manner in which it interacts with its habitat, and its impact on native species (Williamson 1999). Moreover, statistical and biological variation confounds the prediction process. Each invasive species is affected by a different suite of variables, making predicting via models even more challenging (Williamson 1999).

Efforts to develop accurate, quantitative, analytic, and systematic methods of predicting invasive species success are underway (Parker and Reichard 1998, as cited in Williamson 1999). As it stands, the most consistent way to predict whether a non-native species will become invasive is whether it has successfully invaded similar regions. However, even this indicator can be unreliable: for instance, the zebra mussel (*Dreissena polymorpha*) is responsible for large-scale economic and ecologic in the United States, but it is innocuous in Europe (Williamson 1999).

H.R. 669 sets forth a number of factors that must be considered when assessing the risk that an incoming non-native species will become invasive. These factors applied in the risk assessment process, can be divided into two categories (1) the likelihood that the species will invade; and (2) the likelihood that the species will cause harm. In this regard, H.R. 669 ties in well with ongoing research modeling techniques that serve, in essence, as an early warning system to predict the probability that an exotic species will become a successful invader.

To quantitatively and accurately predict an exotic species' likelihood of successful invasion, researchers must identify key characteristics of the species, and compare the ecological characteristics of the species' native habitat with other habitats. For example, "climate-matching" based on the ecological niche concept, predicts whether a species can survive in a geographic area outside its historic range based on the similarity of the ecological conditions present in the species' native habitat. By identifying populations of a species in its native range and using environmental data to define a niche, analysts attempt to identify regions outside the historic range that would be suitable to the establishment of the species (Peterson & Vieglais 2001; Peterson 2003).

H.R. 669's risk assessment process is similar to that of invasive species legislation in other countries. New Zealand's 1996 Hazardous Substances and New Organisms Act (HSNO), for example, similarly addresses intentional importations. Researchers tasked with carrying out the risk assessment apply mathematical models, which incorporate factors such as climate-matching and diet preference of a species, to predict the impact that a species might have if it is introduced. The assumptions that go into these models, however, are subjective, and are often founded upon the opinions and perceptions of the experts, analysts and decision-makers. As a result, quantitative analyses are not necessarily any more objective or precise than that of a qualitative assessment (Biosecurity 2006).

Australia also has invasive species legislation in place. The well-developed risk analysis techniques applied in Australia's legislation model the likelihood of establishment and spread of key threat species. Using this technique, Australian officials predicted the likelihood that the black rat (*Rattus rattus*), a highly destructive predator in neighboring New Zealand, might become established and spread in Australia. Based on a comparison of ecological attributes in Australian habitats to those of other countries in which the black rat is established, officials developed a prediction model that indicated that most of Australia is at high risk of invasion (Figure 2).

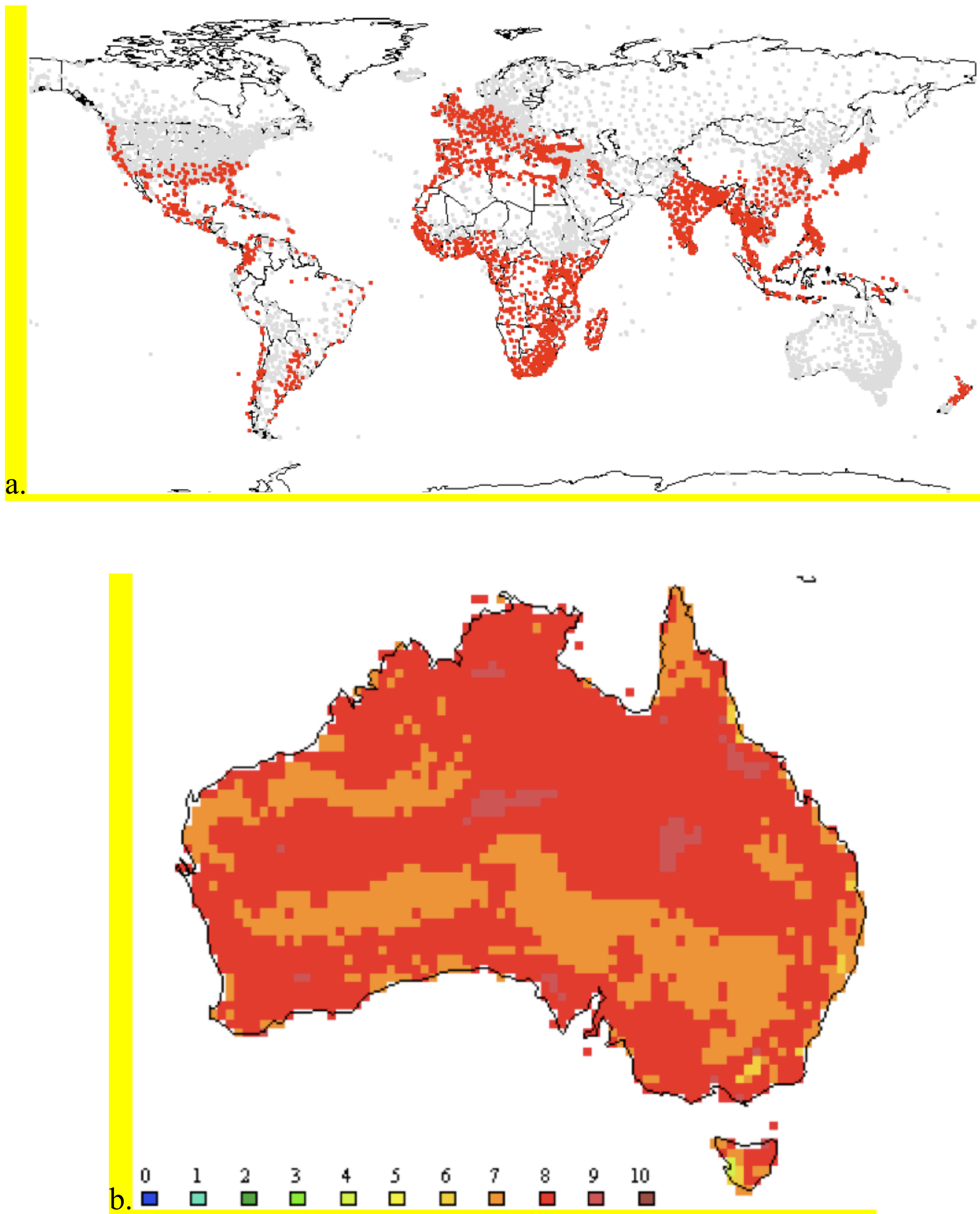

Figure 2: (a): Current global distribution of *Rattus rattus*; (b): Model of potential distribution of *Rattus rattus* in Australia. The legend represents areas of likely spread, with 10 representing areas with the highest likelihood of successful invasion.

H.R. 669's risk assessment process includes factors aimed to predict the likelihood that a species will cause harm once established. Assessment of a non-native species' potential impact is difficult in that it requires a full understanding of the species' place in its native food web and its interspecies relationships, including competition, predation, and mutualism (Grosholz & Ruiz, 1996). For example, invasive green crabs were found to reduce the abundance of bivalve mollusks. This reduction could impact not only the native mollusks but also native shorebirds that feed on them (Grosholz and Ruiz 1996). A species' impact can also be predicted by considering the abundance of the invader, ecological role of the invader, ecological composition of the invaded community, and consistency of impacts in previously invaded habitats (Ricciardi, 1998).

Measuring the Success of the Nonnative Wildlife Invasion Prevention Act

The success of H.R. 669 should be measured by the number of new invasive species established and the amount of damage they have caused after H.R. 669 is enacted. This seemingly straightforward metric is complicated by a number of factors. Perhaps the most significant of these is that an unknown period of time will need to elapse before effective measurement can even begin. Measuring the success of the desired outcome, therefore, will be a time-consuming process; it will most likely take years, if not decades, to know whether the bill is working. To monitor the short-term success of the Act, measuring its implementation may also be useful.

Scientific Indicators of Success

The primary measure of success will be the number of invasive species established after the approved and unapproved lists are published. Figure 3 shows the cumulative number of nonnative invasive fish species in the United States over time, including both intentionally and unintentionally introduced species. According to a 1993 report of the U.S. Congress Office of Technology Assessment (OTA), between 4 and 19 percent of nonnative species are highly invasive. Further, the number of intentionally and unintentionally introduced species that are harmful is roughly equal. For example, 35 out of 76 species of intentionally introduced fish species were found to be harmful, versus 10 out of 26 unintentionally introduced fish species (OTA 1993). If H.R. 669 is successful, we would expect the proportion of harmful nonnative species to decline over time.

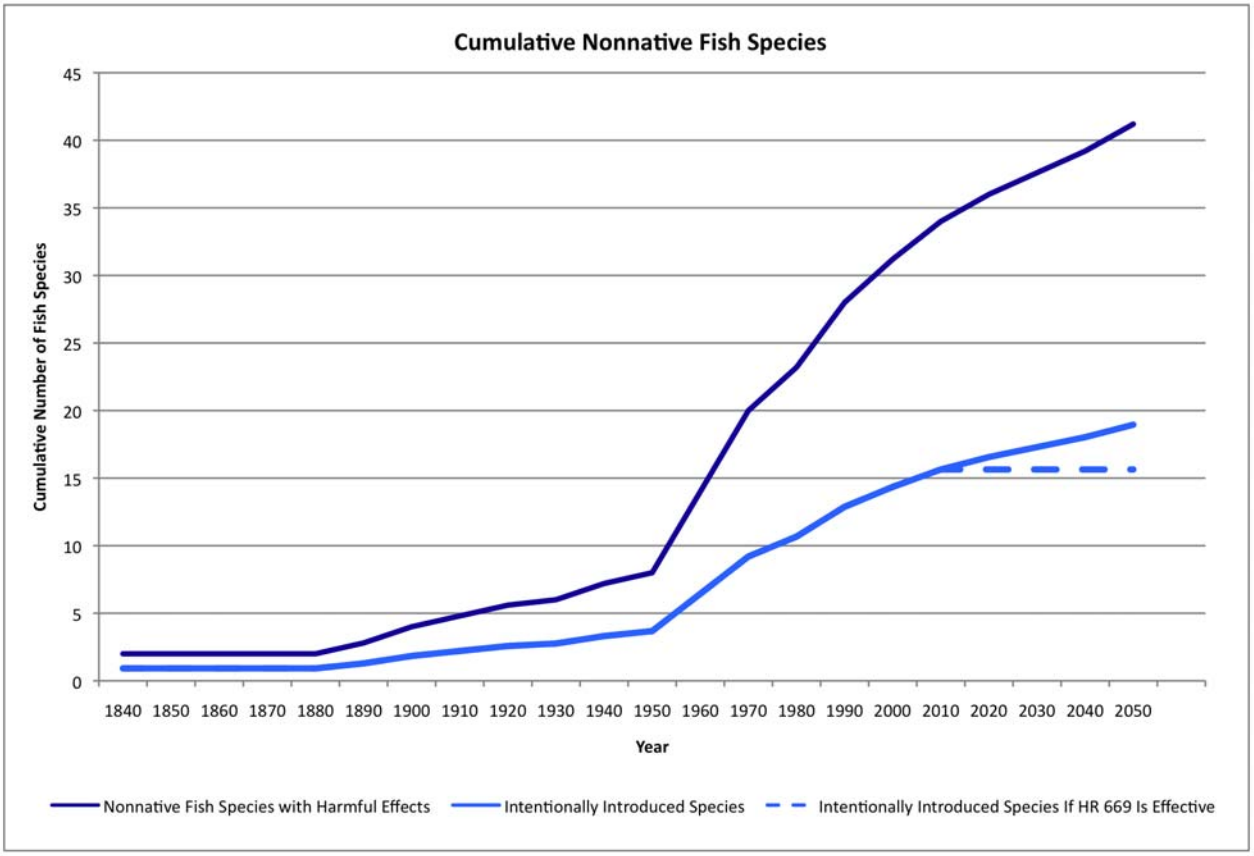

Figure 3. Adapted from OTS, 1993. Figures through 1990 are actual; figures after 1990 are projected for illustration purposes. Hypothetically, the line showing intentionally introduced nonnative invasive fish species should flatten after the H.R. 669 is implemented. The difference between the desired outcome of H.R. 669 and the status quo is shown in green.

A second measure of success is the magnitude of economic or health costs which are spared by restricting the introduction of a particular species. For example, extensive studies have been done on the economic damages of nonnative fish in the United States. As of 2006, 138 nonnative fish species found in the United States. Control costs and economic damages come to approximately $1 to $5.7 billion annually (Lovell et al. 2006). While economic damages due to already established species will not be affected by the passage of H.R. 669, we should see a decline in economic damages from new invasions. The additional costs to human health as a result of invasive species should also decline.

A third metric for measuring the success of H.R. 669 is the magnitude of decline or loss of ecosystem function and biodiversity as a result of invasive species. Historically, data on the damages of nonnative species has been skewed toward direct market effects and control costs paid for by the government (OTA 1993). One measure of biodiversity loss that is commonly used is the number of endangered or threatened species in a region. As of 1991, the listing of 41 indigenous species as endangered or threatened was considered to be a direct result of impacts from nonnative species. The focus on endangered species, however, tends to underestimate the environmental harm of nonnative species, because they create harm in a variety of ways (OTA

1993). Nonetheless, a decline in the rate of species newly endangered or threatened as a result of nonnative species invasions would be a clear indicator of success of H.R. 669.

Finally, an indirect measure of success would be the amount of damages avoided in the United States as determined by comparison with the impacts that newly restricted taxa have on other countries. For example, the brown hare (*Lepus capensis*), introduced in New Zealand as a game-species and now pervasive throughout the islands, causes significant impact to agricultural areas, eating crops, pasture, and tree seedlings. The hare's wide geographic spread and high reproductive rate mean it can have a significant negative impact on a country's economy (Bomford et al. 1995; Braysher 2000). Because the brown hare was expected to inflict similar damages in Australia, it is prohibited there and thus has caused no economic damages.

Challenges of Measurements

Counting the number of new invasive species and the damages they have caused will be challenging for a number of reasons. First, the territory covered is large, and each region will require monitoring, a task that Fish and Wildlife Services (FWS)—already tasked with conducting risk assessments, inspecting shipments, and enforcing H.R. 669—will unlikely be able to do. Therefore, monitoring new invasive species will most likely be left to other government agencies at the federal and local levels and academic researchers. To accommodate this diversity of information, a centralized system for recording invasive species and their origin may need to be created in order to effectively measure the outcome of H.R. 669.

Given that the Act deals only with intentionally introduced nonnative species, it is probable that invasions will still occur in the United States. Counting the number of new invasive species will be complicated, because considerable effort may be required to determine the origin of some species. It may be difficult to distinguish between newly introduced non-native animals and the progeny of non-native animals that are already present in the US.

A third challenge is the amount of time that will elapse between implementation of the bill and when reasonable measures of effectiveness can begin. There is lag time between when a species is introduced and when it becomes invasive; this amount of time can be anywhere from four years to over a decade (OTA 1993). It is likely to take several years before any agency can determine whether restrictions or approvals were applied appropriately. Clearly, monitoring will need to be ongoing, so that if a species on the approved list is found to be invasive, the list can be amended and action taken to remove the species from the environment before its eradication becomes impossible.

Administrative Measures of Success

Implementation monitoring would address the following questions:

- How many import applications has Fish and Wildlife Services received?
- How long does it take to complete the risk assessment?
- How many species have been placed on the approved list versus the unapproved list?

- Are the funds available sufficient to conduct risk assessments?

The number of species evaluated during the initial 36-month period in which the FWS must publish the lists, would likely be the first indicator of success if H.R. 669 is passed. The FWS cites lack of funding for conducting the risk assessment as one of the key problems of H.R. 669 (Fraser, 2009). An essential question will be whether the FWS can conduct risk assessments for all species applications with the amount of funding allocated.

The length of time between when an application is submitted and when the species is placed on a list should also be measured. During this time period, FWS would need to conduct the risk assessment, publish the initial finding, and allow for public comment and then revision, as necessary (Bill H.R. 669). Gary Fraser of the FWS cites the need for a streamlined process of risk evaluation as a major problem of the bill (2009).

The Lacey Act: A Comparison

While the list of injurious species under the Lacey Act is almost certain to be much shorter than the unapproved list under H.R. 669, a recent study assessing the effectiveness of the Lacey Act is useful for informing how a monitoring program under H.R. 669 may work. To determine whether the Lacey Act prevents the establishment or spread of invasive species, Fowler and colleagues (2007) first had to determine whether the taxa on the injurious list were found in the United States prior to listing. This task proved to be difficult, as no central database exists that tracks nonnative species in the United States, when they arrived, or through what mechanism they were introduced. The scientists therefore relied on three separate databases, as well as historical documents, to determine whether the taxa on the injurious list were found in the United States (Fowler et al. 2007). In order to quickly assess whether H.R. 669 is accomplishing its goal, thorough recordkeeping would be essential.

Of the twenty-four individual species, genera, or families currently listed as injurious under the Lacey Act, only seven were found not to be in the continental United States prior to listing, and, somewhat remarkably, none have become established since. While it is tempting to interpret this finding as evidence of the absolute effectiveness of an unapproved list, whether there is a causal relationship between being listed under the Lacey Act and the lack of establishment of the listed species is unclear. Other factors, such as low commercial potential or unsuitable conditions for establishment, may have precluded establishment without the proscription of the Lacey Act (Fowler et al. 2007). This complication demonstrates the inherent uncertainty of the unapproved list. Because it is impossible to know with 100 percent certainty that a particular species would be invasive if allowed into the United States, it will also be difficult to ascertain whether a species on the unapproved list is correctly categorized. Thus, even if careful documentation and monitoring takes place, outcome measurements will necessarily be uncertain.

Conclusion

The United States is home to a rich web of native flora and fauna that combine to create diverse ecosystems. These natural resources provide not only direct economic benefits, but also recreational opportunities and ecosystem services that are less quantifiable but immensely valuable. Human health is also closely tied to the state of our environment. The invasion of non-native species threatens these important natural resources and human health. However, the legislation currently in place is woefully inadequate in addressing these threats. H.R. 669 presents an innovative, proactive solution that prevents the introduction and establishment of nonnative species that have the potential to cause harm. The Act will likely be difficult to implement because of the large number of nonnative wildlife species currently in trade domestically and internationally and the lack of available resources to identify and control them. Establishing the metrics needed to assess the effectiveness of the Act may also be difficult. Despite these potential hurdles, H.R. 669 provides wildlife managers with a powerful tool with which to defend our nation's natural resources and protect human health from nonnative invasive species.

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