INVASIVE SPECIES IN THE NORTHWESTERN UNITED STATES: THREATS TO WILDLIFE, AND DEFENDERS OF WILDLIFE'S RECOMMENDATION FOR PREVENTION POLICIES

AIMEE DELACH

Defenders of Wildlife, 1130 17th Street NW, Washington, DC 20036; adelach@defenders.org

ABSTRACT—Invasive alien species have long been recognized as a leading threat to biological diversity, contributing to the decline of nearly half of the imperiled species in the United States for which threat information is available. This paper discusses some of the invasive species that threaten imperiled wildlife in the western United States, including endemic birds in San Francisco Bay, sage grouse, and grizzly bears. I present 3 examples of the difficulties inherent in balancing the need to close pathways of invasive species entry with maintaining active international and interstate trade (wood packing materials, ballast water, and the nursery trade) and I present Defenders of Wildlife's policy recommendations in these areas.

Key words: invasive species, impacts, pathways, prevention, policy

The proliferation of invasive species outside the boundaries of their indigenous ecosystems has long been recognized as a major source of anthropogenic damage to terrestrial (Elton 1958), aquatic (Lodge 2001), and estuarine and marine (Ruiz and others 1999; Fofonoff and others 2003) ecosystems. Loss, damage, and control costs associated with invasive species have most recently been estimated at $120 billion/year (Pimentel and others 2005), and new and emerging diseases such as Acquired Immune Deficiency Syndrome, West Nile encephalitis, Severe Acute Respiratory Syndrome, and various strains of influenza threaten human health (CDC 2002). One study, which investigated factors contributing to the imperilment of species listed or proposed for listing, under the United States Endangered Species Act (ESA) or designated as "imperiled", "critically imperiled", or "possibly extinct" by The Nature Conservancy and Natural Heritage programs, found that invasive species impact 49% of those imperiled species in the United States for which threat information was available, making invasives the nation's 2nd leading cause of species endangerment (Wilcove and others 2000) after habitat destruction and degradation (Wilson 1992, 2002).

An alien species can be defined as a species, or propagative material thereof, which did not historically occur in a given ecosystem (64 Federal Register 6183–6186). While many species are of unknown origin, it is estimated that 50,000 alien species have been introduced to the United States (Pimentel and others 2005). Many of these, including crop and livestock species, persist only where deliberately cultivated; many others fail to survive or to establish naturalized populations. However, a small but important subset of introduced species, such as hydrilla (*Hydrilla verticillata*), cheatgrass (*Bromus tectorum*), and European starlings (*Sturnus vulgaris*), become invasive. While it has been argued that the term "invasive species" should be used to describe dispersing alien species without respect to environmental or economic impact (Richardson and others 2000), I will utilize the definition and terminology promulgated in President Clinton's Executive Order 13112, which directed federal agencies to control and minimize the impacts of invasive species: "'Invasive species' means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health" (64 Federal Register 6183–6186). Population and ecosystem impacts by invasive species include disease, predation, competition, interference, hybridization, alteration of fire regimes, alteration of nutrient regimes, and alteration of hydrologic cycles (Mack and others 2000). Many of these factors are in play in the interactions between invasive species and native ecosystems in the northwestern United States.

Case Studies: Invasive Species Threats to Imperiled Wildlife

A number of exotic invasive species in the northwestern United States and northern California are negatively impacting wildlife species that have been proposed or listed as "threatened" or "endangered" under the ESA or have been designated as "imperiled", "critically imperiled", or "possibly extinct" by Natural Heritage programs, collectively referred to here as "imperiled species". I provide a sampling of the impacts of exotic invasive species to native wildlife in widely disparate ecosystem types in the western United States, and present Defenders of Wildlife's recommendations for policies that target closing pathways for invasive species entry.

Endemic Birds and Mammals in San Francisco Bay

The San Francisco Bay Estuary in California "supports the largest and most ecologically important expanses of tidal mudflats and salt marshes in the contiguous western United States" (CSCC and USFWS 2003, p 8). The estuary is characterized by unvegetated tidal flats at elevations below mean sea level and native Pacific cordgrass (*Spartina foliosa*) above mean sea level, with upper reaches dominated by pickleweed (*Salicornia virginica*), then halophytes like saltgrass (*Distichlis spicata*) and a variety of other species (CSCC and USFWS 2003). The tidal mudflat areas are an important feeding ground for migratory shorebirds and waterfowl, and the salt marshes support a number of endemic plant and animal species, including several that are listed under the ESA (CSCC and USFWS 2003). Prior to the mid-19th century, the marsh complex covered 732 km^2, but sedimentation from upstream mining, diking and filling, agriculture, and urban development have reduced the tidal marsh complex to 152 km^2 (USFWS 1984) and the tidal flats to $<$120 km^2 (CSCC and USFWS 2003). "Non-native invasive cordgrasses dominate greater than 500 acres of San Francisco Estuary mud flats and tidal marsh. . . and are spreading rapidly" (CSCC and USFWS 2003, p 8).

Spartina alterniflora is a perennial coastal cordgrass native to the east coast of the United States (Gleason and Cronquist 1991). In the early 1970s, the US Army Corps of Engineers introduced *S. alterniflora* into a pond at the Coyote Hills regional shoreline, and it was later introduced to San Bruno Slough (Grossinger and others 1998). *Spartina alterniflora* exhibits a larger growth form, higher stem density, and higher rate of lateral spread (Josselyn and others 1993), is less susceptible to wave action (Gleason and others 1979), and tolerates a wider range of salinities, sedimentation rates, and soil oxygen levels than its native western counterpart *S. foliosa* (CSCC and USFWS 2003). Combined, these characteristics enable *S. alterniflora* to form dense monotypic stands in tidal marsh and mud flat communities that once varied along a mean-sea-level gradient. Other invasive cordgrass forms in the estuary include: *Spartina densiflora*, a South American cordgrass that was introduced accidentally to Humboldt Bay, California, in the mid-19th century and transplanted to Corte Madera Creek in 1976, prior to recognition that it is an exotic invasive species (Grossinger and others 1998); English cordgrass (*S. angelica*); salt-meadow cordgrass (*S. patens*); and hybrids between *S. alterniflora* and *S. foliosa*.

Rare and endemic species that depend on the complex of native habitats in the San Francisco Bay estuary include the California clapper rail (*Rallus longirostris obsoletus*), the California black rail (*Laterallus jamaicensis coturniculus*), the California least tern (*Sterna albifrons browni*), the salt marsh harvest mouse (*Reithrodontomys raviventrus*), and 3 subspecies of song sparrow (*Melospiza melodia*). All of these species face habitat degradation due to the presence of invasive cordgrasses.

The California clapper rail historically ranged from Humboldt to San Luis Obispo counties, California (USFWS 1984), but is currently found only in the San Francisco and San Pablo Bays (CSCC and USFWS 2003); the subspecies has been federally listed as endangered under the ESA since 1970 (35 Federal Register 16047). They forage primarily in areas with small tidal creeks and "generally avoid uniform marsh plains lacking tidal creeks" such as the stands formed by *S. alterniflora* invasion (CSCC and USFWS 2003). The California clapper rail also has been negatively impacted by predation from another introduced species, the red fox (*Vulpes vulpes*), and will utilize invasive cordgrasses for cover during extreme high tides when other vegetation is submerged (CSCC and USFWS 2003).

The California black rail, which is listed as endangered under state but not federal law, also is associated with mixed pickleweed vegetation. Like the California clapper rail, it utilizes tidal creeks for foraging, requires available cover during high tides, and does not utilize *S. alterniflora* for breeding (CSCC and USFWS 2003).

Spartina alterniflora impacts Alameda song sparrows (*Melospiza melodia pusillula*), a California Species of Special Concern, both directly and indirectly. The species generally nests in the upper reaches of marshes, but will nest in *Spartina* on mudflats, where the nests are more likely to be washed away by tidal action (Nordby and Beissinger 2002). *Spartina alterniflora* also provides habitat for marsh wrens (*Cistothorus palustris*), which are expanding their range in the Bay and demonstrating competitive interactions with the endemic sparrow (Nordby and Beissinger 2002; Nordby and others 2003).

The salt marsh harvest mouse is endemic to the San Francisco Bay area (USFWS 1984), and was federally listed as Endangered at the same time as the California clapper rail (35 Federal Register 16047). The harvest mouse populations are dependent on pickleweed and terrestrial grasses adjacent to the tidal marshes and they do not utilize cordgrass (CSCC and USFWS 2003).

Sage Grouse

Greater sage grouse (*Centrocercus urophasianus*) once ranged through much of the west in 13 states and 3 adjacent Canadian provinces (Schroeder and others 2004), but populations have declined at an overall rate of 2.0%/year from 1965 to 2003, and only about 56% of potential pre-settlement distribution is currently occupied (Connelly and others 2004). Three petitions to list the sage grouse as threatened or endangered under the ESA were filed in 2002 and 2003, but the US Fish and Wildlife Service made a determination on 12 January 2005 that protection of the sage grouse under the ESA was not warranted (70 Federal Register 2244–2282). Consequently, in the United States, sage grouse management is undertaken at the state level, while much of the species' habitat on public lands is managed federally, particularly by the Bureau of Land Management (Connelly and others 2004). In Canada, where the species is listed under the Species at Risk Act, management is undertaken cooperatively by the federal and provincial governments (Connelly and others 2004).

Sage grouse decline can be attributed to many factors, as summarized by Braun (1998): habitat loss due to agriculture, mining and energy development, suburban and rural development, roads, and reservoirs; habitat fragmentation by fences, power lines, and sagebrush control treatments; habitat degradation from grazing, sagebrush control via mechanical and chemical means, and altered fire regimes; and natural factors including drought, predation, and hunting. The threats to sage grouse and their habitat also include invasive species, particularly cheat grass and West Nile Virus.

Sage grouse are considered obligates of sagebrush (*Artemesia* spp.) habitats (Braun and others 1976) and these habitats are diminished. Sage grouse require a large, connected landscape of habitats that vary in relative cover of sagebrush, grasses, and forbs for their lekking, nesting, brood-rearing, and autumn and winter feeding activities (Connelly and others 2004; Stinson and others 2004). In one study, occupied areas were characterized by 57% shrub-steppe habitat, compared to 42.3% shrub-steppe habitat in unoccupied range (Schroeder and others 2000). Connelly and others (2004) estimate that about 55% of the 500,000 km^2 of historical sagebrush community types remains in sagebrush habitat. Agricultural and urban land use encompasses 13% and 1%, respectively, of the remainder. Of the historical sage habitat, 31% has been converted to other vegetative cover, including areas dominated by invasive alien species (Connelly and others 2004). Cheatgrass and medusahead (*Taeniatherum caput-medusae*) are 2 of the most important invaders of arid and more mesic sagebrush communities, respectively (Connelly and others 2004). Cheatgrass was probably introduced as a contaminant in grain imports (Novak and Mack 2001) and spread through much of the intermountain west by the 1920s (Mack 1981), aided by livestock trampling of microbiotic soil crusts, which left bare ground more susceptible to cheatgrass invasion (Rosentreter 1995). Cheatgrass, in turn, promotes "larger, earlier and more frequent fires" due to its dense, continuous ground cover and summertime drought dormancy, as well as increased erosion potential following fires (West 1999). Cheatgrass invasion shortened the fire-return interval in the intermountain west from 20–100 y to as little as 5 y, reducing or eliminating fire-sensitive sagebrush from large parts of its range (Pyke 1999). Cheatgrass and other Eurasian annuals now dominate or significantly cover 70,000 km^2 of public lands in Washington, Oregon, Idaho, Nevada, and Utah (Connelly and others 2004). In Washington, for instance, roughly half of the original sagebrush habitat remains, but much of this does not meet the breeding requirements of sage grouse, because it has <10% sagebrush cover or bunchgrasses have been replaced by cheat grass and other invasive species (Stinson and others 2004).

West Nile virus (WNV), another exotic invasive species, is emerging as a potential threat to sage grouse populations. First described in Uganda in 1937, WNV was introduced to the United States in 1999 (CDC 2005a) and has since caused human, animal, or avian infection in every state except Washington, Alaska and Hawaii (CDC 2005b). Sage grouse mortality from WNV was 1st observed on 24 July 2003, prompting monitoring of radio-tagged sage grouse in 4 populations in Alberta, Montana, and Wyoming (Naugle and others 2004). Naugle and colleagues found that 18 of the 22 recovered testable carcasses were positive for WNV. They also found that survival in WNV areas was 26% lower than in their WNV-free control site and was 25% lower than the average survival for those areas from 1998 to 2002, prior to WNV emergence. Equally troubling, they found "no live sage-grouse seropositive for neutralizing antibodies against WNV;" in other words, "no evidence that sage-grouse are able to survive WNV infection and develop immunity". The authors conclude that "The spread of WNV represents a significant new stressor on sage-grouse and probably other at-risk species" (Naugle and others 2004).

Grizzly Bear

Grizzly bears (*Ursus arctos horribilis*) historically ranged throughout most the contiguous United States west of the Mississippi River (Servheen 1990). The species has been extirpated from most of this range and currently a total of 800 to 1000 bears persist in 5 ecoregions—Greater Yellowstone in Wyoming, Idaho, and Montana; northern Continental Divide and Cabinet-Yaak in Montana; the Selkirk in Idaho; and the North Cascades in Washington, with potential for a population in the Bitterroot ecoregion in Idaho (USFWS 1993; Mattson and Merrill 2002). Grizzly populations in all 5 ecoregions are currently listed as Threatened under the ESA; however, the US Fish and Wildlife Service on 2 March 2000 released a Draft Conservation Strategy that presents a management plan for the grizzly bear in the Yellowstone ecosystem following recovery and delisting of the Yellowstone population (65 Federal Register 11340), and a delisting proposal for Yellowstone grizzly was released on 17 November 2005 (70 Federal Register 69854-69884).

Grizzly bear extirpation and range contraction in the contiguous United States from 1850 to 1970 has been correlated to human presence and to the presence of foods that apparently brought grizzlies into contact with humans, particularly bison (*Bos bison*), salmon (*Oncorrhynchus* spp.), and piñon (*Pinus edulis*) from 1850 to 1970 and cattle from 1920 to 1970 (Mattson and Merrill 2002). Conversely, "grizzly bears survived well" where their range overlapped with that of the whitebark pine (*Pinus albicaulis*) (Mattson and Merrill 2002), probably because its high-elevation, low human-density habitat draws bears to remote areas where their chances of fatal interaction with humans is lower (Mattson and others 2001). Whitebark pine seeds are highly nutritious, containing 52% fat, 21% carbohydrate, 21% protein, 3% ash, and 3% water (Lanner and Gilbert 1994). They are 1 of the most important food sources for grizzlies in Yellowstone from mid-August through mid-November, with over-wintered cached seeds also being important the following May and June (Mattson and others 1991).

Whitebark pine is currently under threat through much of its range due to an exotic invasive fungus, the white pine blister rust (*Cronartium ribicola* J. C. Fisch. ex Rabenh). The fungus is a heteroecious stem rust with a life cycle dependent on *Ribes* (currant and gooseberry) shrubs and 5-needled *Pinus* (subgenus *Strobus*). Native to Asia, white pine blister rust was introduced into the United States in the early 1900s and into British Columbia in 1910, and it has since spread from there to Washington, Idaho, Montana, Wyoming, Oregon, and California (Scharpf 1993). Historically, control efforts focused on *Ribes* eradication, with a mechanical and chemical control effort that lasted 40 y and removed an estimated 500 million *Ribes* plants (Neuenschwander and others 1999). Ultimately, however, this proved ineffective, due to the distance of spore travel and the vast area affected (Monnig and Byler 1992; Maloy 1997). Nor have chemical controls for the fungus proved effective (Maloy 1997). For this reason the mortality from this disease has been extremely high: infection rate among whitebark pine has been 51% to 100% in Washington, northern Idaho, and western Montana, and 20% to 50% in central Idaho, Oregon, and northern California (Kendall and Keane 2001). Mortality among infected whitebark pine ranges from 51% to 100% in northern and eastern Washington, northern Idaho, and northwestern Montana, and 20% to 50% in southern and western Washington and northern Oregon (Kendall and Keane 2001). Current management mainly involves finding and propagating naturally disease-resistant white pine species, although this work is farther ahead in commercially valuable species like sugar pine and western white pine than it is in whitebark pine (Kegley and others 2004).

To date, infection and mortality of whitebark pine by the blister rust has been lower in the greater Yellowstone ecosystem than elsewhere in the Northwest, with infection rates of about 5% and mortality among infected trees of 7% (Kendall 1999). However, it is expected that climate change will hasten whitebark pine decline in Yellowstone in coming years by facilitating the spread of the fungus, as well as by shrinking the subalpine range of whitebark pine and promoting more frequent and intense forest fires (Koteen 2002). Mattson and Merrill (2002) predict that "virtually all the whitebark pine in [the greater Yellowstone ecosystem] is projected to be lost" and they suggest that "The apparent robustness of Yellowstone's grizzly bear range is contingent on the presence of abundant whitebark pine. Such vulnerability emphasizes the need for concern over the loss of this food and argues for the inadvisability of removing any legal protections for this population."

A 2nd important food source of grizzly bears is also under threat from invasive species. Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) are native to Yellowstone Lake and spawn in spring in many of the lake's tributary streams (Gresswell 1995) where in shallow water they are highly available to predation by grizzly bears (Reinhart and Mattson 1990). Cutthroat trout have a high protein and lipid content and are utilized by grizzlies from early May to mid-August, with peak use in June and July (Mattson and others 1991); these are important times for post-hibernation weight gain and lactation in females with cubs. Cutthroat trout now face competition from lake trout (*Salvelinus namycush*), which were apparently illegally introduced to Yellowstone Lake as early as 1989 and probably numbered in the tens of thousands by 1995 (Keading and others 1995). Lake trout, the 3rd largest member of the Salmonid family (Behnke 2002), threaten the native cutthroat trout by competition for macroinvertebrates and by predation upon the cutthroat trout themselves (Keading and others 1995). Lake trout availability to grizzly bears and other terrestrial predators is significantly lower than for Yellowstone cutthroat trout because the former spawn in the lake rather than in tributary streams (Behnke 2002); therefore, exclusion or significant decline in cutthroat trout due to the presence of invasive lake trout could threaten that important food source of grizzly bears. Despite removal of over 56,000 lake trout since 1995, cutthroat trout populations have continued to trend downward (Bigelow and others 2003). A second likely contributing factor in cutthroat trout decline is another exotic species, the parasite *Myxobolus cerebralis*, which causes potentially fatal whirling disease in salmonids (Gilbert and Granath 2003) and was 1st detected in Yellowstone Lake in 1998 (Mahony and Hudson 2000).

DEFENDERS OF WILDLIFE'S POLICY RECOMMENDATIONS TO PREVENT FURTHER INVASIVE SPECIES INTRODUCTIONS

Reducing adverse effects of invasive species requires the development of policies aimed at forestalling their entry to new areas. Both governments and environmental advocacy groups are working towards this goal. For example, as an advocacy organization with a policy and education focus, Defenders of Wildlife has emphasized in its invasive species policies the prevention of further invasive species entry and establishment. Our efforts at the US federal level have been aimed at complementing and strengthening existing federal policies. President Clinton's Executive Order 13112 in 1999 (64 Federal Register 6183–6186) ordered federal agencies "to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause" and formed the National Invasive Species Council (NISC) to implement the order. The NISC consists of representatives from the Departments of Interior, Agriculture, Commerce, State, Transportation, Defense, Homeland Security, Treasury, Health and Human Services, the Environmental Protection Agency, the National Aeronautics and Space Administration, the Office of the US Trade Representative, and the US Agency of International Development. Executive Order 13112 also established an Invasive Species Advisory Committee consisting of various stakeholders from states, tribes, universities, industries, and non-governmental organizations (NISC, undated).

One of the NISC's 1st duties was the creation of a National Invasive Species Management Plan, which included "a review of existing and prospective approaches and authorities for preventing the introduction and spread of invasive species, including those for identifying pathways by which invasive species are introduced and for minimizing the risk of introductions via those pathways, and shall identify research needs and recommend measures to minimize the risk that introductions will occur." In 2002 the stakeholders' advisory committee formed a Screening Task Team and a Pathways Task Team to examine and reduce the risks of introductions via the various intentional and unintentional pathways (Campbell and Kriesch 2003).

The pathways identified by the Pathways Task Team fall into 3 categories. Transportation-related pathways include air, aquatic, and land transport vessels (airplane landing gear, hull fouling, ballast water containers and packing materials, solid wood packing material, tourism, travel, and shipping). Living Industry pathways include foods, the pet and aquarium trades, bait industry, livestock and other animals, and the trade in whole plants, seeds, and plant parts. Finally, Miscellaneous pathways include connected waterways, minimally processed plant and animal products (hides, trophies, feathers, logs, firewood, mulch, and straw), and ecosystem disturbances (rights of way, clearing, and damming) (Campbell and Kriesch 2003). Advocacy groups, including Defenders of Wildlife, have been active in efforts to tighten several of these pathways to reduce the threat of invasive species entry. In each of these cases, federal authorities have struggled to balance the need for increased protection from invasive species with the priorities for maintaining active international and interstate trade.

Wood Imports

In 2004, the United States imported 1.75 million m^3 of softwood logs, 55 million m^3 of softwood lumber, 300,000 m^3 of hardwood logs, and 1.5 million m^3 of temperate hardwood lumber (USDA FAS 2005), as well as large quantities of minimally processed wood such as railroad ties and wood chips. Furthermore, roughly 52% of maritime shipments and 9% of air shipments, involving 250 different commodities, are accompanied by solid wood packing material in the form of pallets, crates, spools, and dunnage (USDA APHIS-FS 2000). Wood imports are vectors for many pests, including Asian long-horned beetle, chestnut blight, Dutch elm disease, Formosan subterranean termite, gypsy moth, pine shoot beetle, and smaller Japanese cedar long-horned beetle (USDA APHIS-FS 2000). Wood packaging alone accounted for an average of 402 interceptions per year representing 156 taxa from 1996–98 (USDA APHIS-FS 2000).

The USDA Animal and Plant Health Inspection Service (APHIS), recognized that due to high volume of imports and difficulties in detecting organisms, inspection is "inadequate" as a mitigation measure for the pest risk associated with solid wood packing material (USDA APHIS-FS 2000), and proposed in 2003 to adopt the international phytosanitary standard for wood packaging material as set forth in the International Plant Protection Convention Guidelines (68 Federal Register 27480–91). These guidelines require that wood packaging material be either "heat treated to achieve a minimum wood core temperature of 56°C for a minimum of 30 minutes," or "fumigated with methyl bromide in an enclosed area for at least

16 hours," followed by the marking of each treated piece with a "legible and permanent mark".

These regulations were a step forward in that they signaled an effort to comprehensively address a pest pathway and a move away from reliance on inspections. However, several advocacy groups, including Defenders of Wildlife, raised concerns about the proposed rule in comments to the agency (Defenders of Wildlife, unpublished comments, available upon request from author). First, methyl bromide is an ozone-depleting substance slated for phaseout under the Montreal Protocol, and as the cheaper alternative, would likely be used more widely than heat treatment. A large increase in the use of methyl bromide could potentially ensue, as was recognized in USDA's environmental impact statement on wood packing material treatment (USDA MRP-APHIS 2003). Second, effectiveness of both treatments is questionable especially if wood diameter is large, a problem also recognized by APHIS in its environmental impact statement. Third, once the wood is marked, it can be reused without further treatment and without consideration of the possibility of re-infestation. Defenders of Wildlife and other commenters recommended phasing out solid wood packing material in favor of "Alternative materials include processed fiberboards and particleboards constructed from chipped wood, as well as non-wood materials like metal, plastic and fiberglass, and inflatable bags for dunnage."

Despite these questions about the effectiveness and adverse consequences, APHIS adopted the international guidelines, which will be fully phased in by July 2006, in part on the rationale that "adopting them would simplify and standardize trade requirements" (69 Federal Register 55719–330). The agency also concurred with shipping industry comments that alternative packaging materials pose extra expense, add weight to shipments and are harder to dispose of than wood packing material. This case exemplifies the difficulty in balancing maximum protection with other economic interests.

Ballast Water

Ballast is material taken on by ships that are not carrying cargo in order to maintain stability and buoyancy. Ballast water is generally taken on in 1 port when a ship empties and is discharged at another port when the ship is filled with cargo. An estimated 70 million metric tons of ballast water is discharged into US waters annually (Ruiz and others 2001), and at least 7000 species are transported daily via ballast water (Carlton 1999). A variety of techniques are available to close this pathway, including ballast water exchange, filtration, hydrocyclone, and treatment with ultraviolet radiation, heat, or chemicals, though these treatments vary in cost, effectiveness, and availability (Pacific Ballast Water Group, undated).

In 1990, in its 1st legislative attempt to address the ballast water pathway, the United States enacted the Nonindigenous Aquatic Nuisance Prevention and Control Act (Public Law 101–646), which required that ships entering the Great Lakes after operating outside the United States' "exclusive economic zone" (200 nautical miles) exchange ballast water on the high seas or treat it to kill organisms. The bill also established a task force and helped to promote state and regional aquatic nuisance planning efforts. The 1990 law was reauthorized in 1996 as the National Invasive Species Act (Public Law 104–332). Ballast exchange remained mandatory for the Great Lakes, while ships in other areas were asked to meet voluntary guidelines. The bill threatened that the standards would become mandatory if they were not adequate, although standards for determining this were never defined. The bill also authorized research into treatment and containment technologies. The bill did not address organisms on the hulls of ships, voluntary imports of potentially invasive organisms, or ballast guidelines for ships operating within the exclusive economic zone.

Attempts to reauthorize the National Invasive Species Act failed in the 107th and 108th Congress, and the bill was introduced in April 2005 in the 109th Congress. Given the gaps in the law, specifically the voluntary nature of its guidelines for outside of the Great Lakes region, state authorities have stepped in to regulate ballast-water release under state water quality and wildlife laws (Pacific Ballast Water Group, undated). Furthermore, in response to a lawsuit brought by Northwest Environmental Advocates, the Ocean Conservancy, and others, a District Court judge recently ordered the Environmental Protection Agency to repeal a regulation that exempted ships' ballast water from federal Clean Water Act regulations. The ruling means that the Agency will have to require ships operating in waters that are impaired by the presence of invasive species to obtain National Pollutant Discharge Elimination Systems permits (USDC—NDC 2005).

Reauthorization of ballast water regulations will have to balance locally led attempts for stricter regulation with international pressure for regulations that are standardized but not necessarily the most stringent. In February 2004, the International Maritime Organization, which is the United Nations agency that sets agreements for shipping safety and pollution reduction, adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments. However the convention has not yet been ratified by member states. The agreement sets a ballast discharge performance standard, but it offers less than optimal protection from invasive species because the timeline is long (2016) and because in the interim ships would be required to do no more than 3 volumes exchange, even if such an exchange purges less than 95% of the ballast water. It also is weak with respect to ballast treatment in near-shore shipments. The other main weakness of this agreement is that it has an open-ended review process for adopting treatment technologies, which could significantly delay adoption of new ballast water treatments (Cangelosi 2004). Nonetheless, the Senate has marked up the Ballast Water Management Act of 2005 (S. 363), a bill that would adopt measures that closely conform to the international standard.

A bipartisan group of senators introduced a more comprehensive approach to aquatic invasive species management on 13 April 2005. Their National Aquatic Invasive Species Act of 2005 (S. 770), requires that by 2011, all existing ships must treat ballast water with the "best performing treatment technology" and reduces viable biological material by 99%. New vessels are held to 99.9% reduction standards. In the interim, the bill requires that ships entering all ports in the United States must exchange ballast using a complete empty and refill or a flow-through that replaces at least 95% of ballast water. The bill also requires ships operating exclusively within the "exclusive economic zone" to comply with ballast provisions by 2011. The newly introduced bill also directs the National Invasive Species Council to identify and manage other high-priority introduction pathways, mandates the establishment of guidelines for intentional introductions, and contains early detection, rapid response, research, and coordination components.

Of the 2 competing ballast water bills, at least 7 environmental and conservation groups with interest in invasive species issues are supporting S. 770 (NECIS 2005). The Shipping Industry Ballast Water Coalition is on record as supporting the standards set by the international convention (Cox 2004) and has publicly supported the Ballast Water Management Act of 2005 (S. 363), with the caveat that the bill should be amended to loosen the performance standard, in order to conform more exactly with the international convention (Metcalf 2005).

Nursery Trade

Importation of living plants, rootstock, and seeds intended for planting has increased dramatically over the past 10 y. USDA estimates, for instance, that the volume of imports of grass, crop, and garden seeds doubled to 332,538 metric tons between 1995 and 2002 (69 Federal Register 71738). Plants and propagative materials imported for both food and non-food purposes involve 3 separate subpathways for invasive species entry: plant itself is invasive, "hitchhikers" enter on the plant or plant parts, or invasives exist within the growing medium associated with the plant (Campbell and Kriesch 2003). Horticultural imports that have become invasive species include Porcelainberry (*Ampelopsis brevipedunculata*) (Young, undated), Russian-olive (*Elaeagnus angustifolia*) (Muzika and Swearingen, undated), Princess tree (*Paulownia tomentosa*) (Williams 1983), and many others. *Phytophthora ramorum*, the pathogen that causes sudden oak death (Rizzo and others 2002), has been found widely on nursery stock, prompting quarantines of potential host species (7 Code of Federal Regulations 301.92, 68 Federal Register 6834). The golden nematode (*Globodera rostochiensis*), a pest of potato plants, is an example of a pest found on soil associated with the tubers (Marks and Brodie 1998).

The Animal and Plant Health and Inspection

Service (APHIS) has signaled its intent to revise its rules regarding the importation of nursery stock in an advance notice of proposed rulemaking published on 10 December 2004 (69 Federal Register 2004). In this document, APHIS estimates that species from "2,000 genera are being imported or have been imported in the past. Most of the taxa of plants for planting currently being imported have not been thoroughly studied to determine whether their importation presents a risk of introducing a quarantine pest into the United States. We typically rely on inspection at a Federal plant inspection station or port of entry to mitigate the risks of pest introduction associated with the importation of these taxa." Unfortunately, since the transfer of most of APHIS's Plant Protection and Quarantine inspectors to the Department of Homeland Security in 2003, the number of agricultural inspections at many border crossings, airports, and ports has declined even as cargo volume has increased, and interceptions of potential quarantine pests have also declined, potentially indicating "a decline in the quality of inspections or a switch to less effective methods" (GAO 2005). Within its public notice, APHIS recognizes that inspection "may not always provide an adequate level of protection against quarantine pests" (69 Federal Register 2004).

Defenders of Wildlife submitted the following comments on the agency's proposal to update its rules regarding the nursery trade:

1. The rule should be developed within the context of a clearly articulated national level of protection, and thereby acceptable levels of risk. This would make the US policy more transparent with respect to international trade rules. Such a policy statement would codify the commitment level of APHIS and other relevant agencies to preventing introductions that impact agriculture, the environment and human health, and provide a fundamental rationale for achieving parity in the strength of our regulations across the spectrum of invasive species threats.
2. The rule must address all 3 pathways—invasiveness of the plant itself, quarantine pests associated with the plant, and quarantine pests associated with the growing medium.
3. In its decision-making process, the agency should give equal weight to protection of natural ecosystems as it does to its historic mission of protecting agriculture, rangeland, and timber resources.
4. Neither visual inspection nor methyl bromide fumigation is a viable solution to the problem of hitchhikers. The agency should move to clean-stock measures that are more effective for reducing associated pest risk.
5. With respect to plant weediness, Defenders of Wildlife recommends a multi-tiered listing approach, preferably one that covers all taxa not currently prohibited from importation, allowed for importation under specific restrictions, or allowed for import under general restrictions. Under such an approach, taxa would be listed without regard to whether they are already traded in significant amounts. Risk evaluations on greylisted taxa could then proceed based on requests and information submitted by potential importers.
6. With respect to proposed re-evaluation of taxa whose importation is currently prohibited, Defenders does not recommend revisiting this issue while taxa that have not yet been evaluated are being imported for introduction and planting in the United States on a large scale.

As this process moves forward, Defenders of Wildlife will monitor whether APHIS chooses the most protective path or the path that is most conducive to free and open trade and easy entry for invasive species.

CONCLUSIONS

Invasive species have well-documented detrimental impacts to economic interests, human health, and ecosystems and wildlife, including a number of imperiled species. Stringent prevention policies, based on closing pathways of entry by invasive species, are vital to protect terrestrial, marine, and aquatic resources from future invasive species threats. However, fully protective measures can conflict with trade promotion priorities, leading to continued potential for invasive species entry.

LITERATURE CITED

BEHNKE RJ. 2002. Trout and salmon of North America. New York, NY: The Free Press. 359 p.

BIGELOW PE, KOEL TM, MAHONY D, ERTEL B, ROWDEN B, OLLIFF ST. 2003. Protection of native Yellowstone cutthroat trout in Yellowstone Lake. Yellowstone National Park, WY: USDI National Park Service. Technical Report NPS/NRWRD/NRTR-2003/314. 12 p. Available at: http://www.nps.gov/yell/planvisit/todo/fishing/nrppfish.pdf. Accessed 30 January 2006.

BRAUN CE. 1998. Sage grouse declines in western North America: What are the problems? Proceedings of the Western Association of State Fish and Wildlife Agencies 78:139–156.

BRAUN CE, BAKER MF, ENG RL, GASHWILER JS, SCHROEDER MH. 1976. Conservation committee report on the effects of alteration of sagebrush communities on the associated avifauna. Wilson Bulletin 88:165–171.

[CSCC AND USFWS] CALIFORNIA STATE COASTAL CONSERVANCY, UNITED STATES FISH AND WILDLIFE SERVICE. 2003. San Francisco Estuary invasive *Spartina* project: spartina control program. Vol I: Final programmatic environmental impact statement/environmental impact report. State Clearinghouse #2001042058. 454 p. Available at: http://www.spartina.org/Spartina_Final_EIR/Spartina_Final_EIR.pdf. Accessed 15 August 2005.

CAMPBELL F, KRIESCH P. 2003. Invasive Species Pathway Team: final report. 25 p. Available at: http://www.invasivespecies.gov/council/pathways.doc. Accessed 4 April 2005.

CANGELOSI A. 2004. Invasive species: global treaty not enough. NE-MW Economic Review (Spring): 8–11.

CARLTON JT. 1999. The scale and ecological consequences of biological invasions in the world's oceans. In: Sandlund OT, Schei PJ, Viken Å, editors. Invasive species and biodiversity management. Dordrecht, Netherlands: Kluwer Academic Publishers. p 195–212.

[CDC] CENTERS FOR DISEASE CONTROL AND PREVENTION. 2002. Protecting the nation's health in an era of globalization: CDC's global infectious disease strategy. 76 p. Available at: http://www.cdc.gov/globalidplan/global_id_plan.pdf. Accessed 4 March 2005.

[CDC] CENTERS FOR DISEASE CONTROL AND PREVENTION. 2005a. West Nile virus background. Available at: http://www.cdc.gov/ncidod/dvbid/westnile/background.htm. Accessed 30 March 2005.

[CDC] CENTERS FOR DISEASE CONTROL AND PREVENTION. 2005b. 2004 West Nile virus activity in the United States. Available at: http://www.cdc.gov/ncidod/dvbid/westnile/surv&control04Maps.htm. Accessed 30 March 2005.

CONNELLY JW, KNICK ST, SCHROEDER MA, STIVER SJ. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats. Cheyenne, WY: Western Association of Fish and Wildlife Agencies. 610 p.

COX JJ. 2004. Testimony of Joseph J. Cox on behalf of the Shipping Industry Ballast Water Coalition regarding "Ballast water management: new international standards and National Invasive Species Act Reauthorization" Before the Coast Guard and Maritime Transportation and Water Resources and Environment Subcommittees of the House Transportation and Infrastructure Committee. March 25. Available at: http://www.nemw.org/BW-Coalition-3-25-Testimony.pdf. Accessed 14 April 2005.

ELTON CS. 1958. The ecology of invasions by animals and plants. Chicago, IL: University of Chicago Press edition, 2000. 196 p.

FOFONOFF PW, RUIZ GM, STEVES B, CARLTON JT. 2003. In ships or on ships? Mechanisms of transfer and invasion for nonnative species to the coasts of North America. In: Ruiz GM, Carlton JT, editors. Invasive species: vectors and management strategies. Washington, DC: Island Press. p 152–182.

[GAO] GOVERNMENT ACCOUNTABILITY OFFICE. 2005. Homeland security: Much is being done to protect agriculture from a terrorist attack, but important challenges remain. GAO-05-214. 95 p. Available at: http://www.gao.gov/new.items/d05214.pdf. Accessed 13 April 2005.

GILBERT MA, GRANATH WO JR. 2003. Whirling disease of salmonid fish: Life cycle, biology and disease. Journal of Parasitology 89:658–667.

GLEASON HA, CRONQUIST A. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. 2nd ed. Bronx, NY: New York Botanical Garden. 910 p.

GLEASON ML, ELMER DA, FISHER JS. 1979. Effects of stem density upon sediment retention by salt marsh cord grass, *Spartina alterniflora* Loisel. Estuaries 2:271–273.

GRESSWELL RE. 1995. Yellowstone cutthroat trout. In: Young MK, editor. Conservation assessment for inland cutthroat trout. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-256. 61 p.

GROSSINGER R, ALEXANDER J, COHEN AN, COLLINS JN. 1998. Introduced tidal marsh plants in the San Francisco Estuary: regional distribution and priorities for control. Richmond, CA: San Francisco Estuary Institute. 52 p. Available at: http://www.sfei.org/ecoatlas/Plants/docs/images/intrtmar.pdf. Accessed 30 January 2006.

JOSSELYN M, LARSSON B, FIORILLO A. 1993. An ecological comparison of an introduced marsh plant, *Spartina alterniflora,* with its native congener, *Spartina foliosa,* in San Francisco Bay. A gaps in knowledge research program, San Francisco Bay estuary project. Tiburon, CA: Romberg Tiburon Centers, San Francisco State University. 47 p.

KEADING LR, BOLTZ GD, CARTY GD. 1995. Lake trout discovered in Yellowstone Lake. In: Varley JD, Schullery P, editors. The Yellowstone Lake crisis: confronting a lake trout invasion. A report to the director of the National Park Service. Yellowstone National Park, WY: Yellowstone Center for Resources. p 4–11. Available at: http://www.nps.gov/yell/publications/pdfs/laketrout2.pdf. Accessed 30 January 2006.

KEGLEY A, SNIEZKO RA, DANCHOK R, DANIELSON J, LONG S. 2004. Influence of inoculum source and density on white pine blister rust infection of whitebark pine: early results. In: Geils BW, compiler. Proceedings of the 51st western international forest disease work conference; 18 to 22 August 2003 at Grants Pass, OR. Flagstaff, AZ: USDA Forest Service, Rocky Mountain Research Station. 1 p (poster). Available at: http://www.fs.fed.us/r6/dorena/documents/publications/pub088.pdf. Accessed 30 January 2006.

KENDALL KC. 1999. Whitebark pine communities. USGS Northern Rocky Mountains Science Center. Available at: http://www.nrmsc.usgs.gov/research/whitebar.htm. Accessed 16 March 2005.

KENDALL KC, KEANE RE. 2001. Whitebark pine decline: infection, mortality, and population trends. In: Tomback DF, Arno SF, Keane RE, editors. Whitebark pine communities: ecology and restoration. Washington, DC: Island Press. p 221–242.

KOTEEN L. 2002. Climate change, whitebark pine and grizzly bears in the greater Yellowstone ecosystem In: Schneider SH, Root TL, editors. Wildlife responses to climate change: North American case studies. Washington, DC: Island Press. p 343–414.

LANNER RM, GILBERT BK. 1994. Nutritive value of whitebark pine seeds and the question of their variable dormancy. In: Schmidt WC, Holtmeier FK, editors. Proceedings—international workshop on subalpine stone pines and their environment: the status of our knowledge, 5 to11 September 1992 at St. Moritz, Switzerland. Ogden, UT: USDA Forest Service, Intermountain Research Station. General Technical Report INT-GRT-309. p 206–211.

LODGE DM. 2001. Lakes. In: Chapin FS III, Sala OE, Huber-Sannwald E, editors. Global biodiversity in a changing environment: scenarios for the 21st century. New York, NY: Springer-Verlag. p 277–313.

MACK RN. 1981. Invasion of *Bromus tectorum* L. into western North America: an ecological chronicle. Agro Ecosystems 7:145–165.

MACK RN, SIMBERLOFF D, LONSDALE WM, EVANS H, CLOUT M, BAZZAZ FA. 2000. Biotic invasions: causes, epidemiology, global consequences and control. Ecological Applications 10:689–710.

MAHONY D, HUDSON C. 2000. Distribution of Myxobolus cerebralis in Yellowstone cutthroat trout Oncorhynchus clarki bouvieri in Yellowstone Lake and tributaries. Project completion report for the period June 1999 to May 2000. Yellowstone National Park, WY: National Park Service Aquatic Resources Center. 10 p. Available at: http://whirlingdisease.montana.edu/biblio/pdfs/Mahony_99–00.pdf. Accessed 30 January 2006.

MALOY OC. 1997. White pine blister rust control in North America: a case history. Annual Review of Phytopathology 35:87–109.

MARKS RJ, BRODIE BB. 1998. Potato cyst nematodes: biology, distribution, and control. New York, NY: Cab International. 408 p.

MATTSON DJ, BLANCHARD BM, KNIGHT RR. 1991. Food habits of Yellowstone grizzly bears, 1977–87. Canadian Journal of Zoology 69:1619–1629.

MATTSON DJ, KENDALL KC, REINHART DP. 2001. Whitebark pine, grizzly bears and red squirrels. In: Tomback DF, Arno SF, Keane RE, editors. Whitebark pine communities: ecology and restoration. Washington, DC: Island Press. p 121–136.

MATTSON DJ, MERRILL T. 2002. Extirpations of grizzly bears in the contiguous United States, 1850–2000. Conservation Biology 16:1123–1136.

METCALF KJ. 2005. Testimony of Ms. Kathy Metcalf, Director of Maritime Affairs, Chamber of Shipping of America, on behalf of The Shipping Industry Ballast Water Coalition before the Ocean Policy Study Subcommittee of the Senate Committee on Commerce, Science and Transportation. 15 June 2005. Available at: http://commerce.senate.gov/hearings/testimony.cfm?id=1543&wit_id=4336. Accessed 15 August 2005.

MONNIG E, BYLER J. 1992. Forest health and ecological integrity in the Northern Rockies. Missoula, MT: USDA Forest Service. Report FPM 92–7. 18 p.

MUZIKA R, SWEARINGEN JM. Undated. Russian-olive. Plant Conservation Alliance fact sheet. National Park Service. Available at: http://www.nps.gov/plants/alien/fact/elan1.htm. Accessed 11 April 2005.

NAUGLE DE, ALDRIDGE CL, WALKER BL, CORNISH TE, MOYNAHAN BJ, HOLLORAN MJ,BROWN K, JOHNSON GD, SCHMIDTMANN ET, MAYER RT, KATO CY, MATCHETT MR, CHRISTIANSEN TJ, COOK WE, CREEKMORE T, FALISE RD, RINKES ET, BOYCE MS. 2004. West Nile virus: pending crisis for greater sage-grouse. Ecology Letters 7:704–713. Available at: http://www.forestry.umt.edu/personnel/Faculty/dnaugle/ele_631.pdf. Accessed 30 March 2005.

[NECIS] NATIONAL ENVIRONMENTAL COALITION ON INVASIVE SPECIES. 2005. Letter to Senate. 3 p. Available at: http://www.necis.net/necis/files/naisa_060605.pdf. Accessed 16 August 2005.

[NISC] NATIONAL INVASIVE SPECIES COUNCIL. Undated. Invasivespecies.gov: a gateway to federal and state invasive species activities and programs. http://www.invasivespecies.gov/council/whatis.shtml. Accessed 18 April 2005.

NEUENSCHWANDER LF, BYLER JW, HARVEY AE, MCDONALD GI, ORTIZ DS, OSBORNE HL, SNYDER GC, ZACK A. 1999. White pine in the American West: a vanishing species-can we save it? Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. General Technical Report RMRS-GTR-35. 20 p.

NORDBY JC, BEISSINGER S. 2002. The impact of an invasive Atlantic cordgrass (*Spartina alterniflora*) on San Francisco Bay song sparrow populations: direct and indirect influences. Vertebrates of tidal marshes symposium, 24 to 26 October 2002 at Patuxent, MD. Laurel, MD: Smithsonian Institution. 44 p. Available at: http://nationalzoo.si.edu/ConservationandScience/MigratoryBirds/Research/Symposia/Vertebrates_of_Tidal_Marshes/atm_program.pdf. Accessed 30 January 2006.

NORDBY JC, COHEN AN, BEISSINGER S. 2003. Impact of an invasive Atlantic cordgrass on bird populations in San Francisco Bay salt marshes. 17th meeting of the Society for Conservation Biology, 28 June to 2 July 2003, at Duluth, MN. 209 p. Available at: http://www.conbio.org/scb/activities/meetings/2003/website/book.pdf. Accessed 30 January 2006.

NOVAK SJ, MACK RN. 2001. Tracing plant introduction and spread: genetic evidence from *Bromus tectorum* (cheatgrass). Bioscience 51:114–122.

PACIFIC BALLAST WATER GROUP. Undated. Working draft report and recommendations. 54 p. Available at: http://www.clr.pdx.edu/projects/ballast_water/pbwg/docs/pbwg_report.pdf. Accessed 7 April 2005.

PIMENTEL D, ZUNIGA R, MORRISON D. 2005. Update on the environmental and economic costs associated with alien invasive species in the United States. Ecological Economics 52:273–288.

PYKE DA. 1999. Invasive exotic plants in the sagebrush ecosystems of the Intermountain West. In: Entwhistle PG, Debolt AM, Kaltenecker JH, Steenhof K, compilers. Proceedings: sagebrush steppe ecosystems symposium. USDI BLM Publication No. BLM/ID/PT-001001+1150. p 43–62.

REINHART DP, MATTSON DJ. 1990. Bear use of cutthroat trout spawning streams in Yellowstone National Park. International Conference on Bear Research and Management 8:343–350.

RICHARDSON DM, PYSEK P, REJMANEK M, BARBOUR MG, PANETTA FD, WEST CJ. 2000. Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distributions 6:93–107.

RIZZO DM, GARBELOTTO M, DAVIDSON JM, SLAUGHTER GW, KOIKE ST. 2002. *Phytophthora ramorum* as the cause of extensive mortality of *Quercus* spp. and *Lithocarpus densiflorus* in California. Plant Disease 86: 205–214.

ROSENTRETER R. 1995. Lichens of the Columbia River Basin. USDI Bureau of Land Management Idaho State Office report. 54 p. Available at: http://www.icbemp.gov/science/rosentre.pdf. Accessed 30 March 2005.

RUIZ GM, FOFONOFF P, HINES AH. 1999. Non-indigenous species as stressors in estuarine and marine communities: assessing invasion impacts and interactions. Limnology and Oceanography 44:950–972.

RUIZ GM, MILLER AW, LION K, STEVES B, ARNWINE A, COLLINETTI E, WELLS E. 2001. Status and trends of ballast water management in the United States: first biennial report of the National Ballast Information Clearinghouse. Edgewater, MD: Smithsonian Environmental Research Center. 45p. Available at: http://invasions.si.edu/nbic/reports/NABSBienRpt1.pdf. Accessed 7 April 05.

SCHARPF RF (technical coordinator). 1993. Diseases of Pacific Coast conifers. Washington, DC: USDA Forest Service. Handbook 521. 199 p.

SCHROEDER MA, ALDRIDGE CL, APA AD, BOHNE JR, BRAUN CE, BUNNELL SD, CONNELLY JW, DIEBERT PA, GARDNER SC, HILLIARD MA, KOBRIGER GD, MCCARTHY CW. 2004. Distribution of sage grouse in North America. Condor 106:363–376.

SCHROEDER MA, HAYES DW, LIVINGSTON MF, STREAM LE, JACOBSON JE, PIERCE, DJ. 2000. Changes in the distribution and abundance of sage grouse in Washington. Northwestern Naturalist 81:104–112.

SERVHEEN C. 1990. The status and conservation of the bears of the world. International Conference on Bear Research and Management 2:297–302.

STINSON DW, HAYS DW, SCHROEDER MA. 2004. Washington State recovery plan for the greater sage-grouse. Olympia, WA: Washington Department of Fish and Wildlife. 109 p. Available at: http://wdfw.wa.gov/wlm/diversty/soc/recovery/sage_grouse/final_sage_grouse_recovery.pdf. Accessed 30 March 2005.

[USDA APHIS-FS] USDA ANIMAL AND PLANT HEALTH INSPECTION SERVICE AND FOREST SERVICE. 2000. Draft pest risk assessment for importation of solid wood packing materials into the United States. Washington, DC: USDA APHIS. 275 p.

[USDA MRP-APHIS] USDA MARKETING AND REGULATORY PROGRAMS AND ANIMAL AND PLANT HEALTH INSPECTION SERVICE. 2003. Importation of solid wood packing material. Final environmental impact statement. 251 p. Available at: http://www.aphis.usda.gov/ppq/enviro_docs/pdf_files/swpmfeis.pdf. Accessed 8 April 2005.

[USDA FAS] USDA FOOD AND AGRICULTURE SERVICE. 2005. Production, supply and distribution official statistics. Online database. Available at: http://www.fas.usda.gov/psd/complete_files/default.asp. Accessed 8 April 2005.

[USDC—DNC] US DISTRICT COURT –NORTHERN DISTRICT OF CALIFORNIA. 2005. Northwest Environmental Advocates, the Ocean Conservancy, and Waterkeepers of Northern California and its projects, Center for Marine Conservation and San Francisco Baykeeper and Deltakeeper v. United States Environmental Protection Agency. Order granting plaintiff's motion for summary judgment; denying defendant's motion for summary judgment. March 30. Available at: http://www.pwsrcac.org/documents/other/Order%20Granting%20SJ%203–30–05.pdf. Accessed 7 April 2005.

[USFWS] UNITED STATES FISH AND WILDLIFE SERVICE. 1984. Salt marsh harvest mouse and California clapper rail recovery plan. Portland, OR: USDI Fish and Wildlife Service. 154 p. Available at: http://ecos.fws.gov/docs/recovery_plans/1984/841116.pdf. Accessed 18 March 2005.

[USFWS] UNITED STATES FISH AND WILDLIFE SERVICE. 1993. Grizzly bear recovery plan. Missoula, MT: USDI Fish and Wildlife Service. 181 p. Available at: http://ecos.fws.gov/docs/recovery_plans/1993/930910.pdf. Accessed 14 March 2005.

WEST NE. 1999. Synecology and disturbance regimes of sagebrush steppe ecosystems. In: Entwhistle PG, Debolt AM, Kaltenecker JH, Steenhof K, compilers. Proceedings: sagebrush steppe ecosystems symposium. USDI Bureau of Land Management. Publication No. BLM/ID/PT-001001+1150. p15–26.

WILCOVE DS, ROTHSTEIN D, DUBOW J, PHILIPS A, LOSOS E. 2000. Leading threats to biodiversity: what's imperiling US species. In: Stein BA, Kutner LS, Adams JS, editors. Precious heritage: the status of biodiversity in the United States. New York, NY: Oxford University Press. p 238–254.

WILLIAMS CE. 1983. The exotic empress tree, *Paulownia tomentosa*: an invasive pest of forests. Natural Areas Journal 13:221–222

WILSON EO. 1992. The diversity of life. Cambridge, MA: Belknap Press. 424 p.

WILSON EO. 2002. The future of life. New York, NY: Alfred A Knopf. 256 p.

YOUNG J. undated. Porcelainberry. Plant Conservation Alliance fact sheet. USDI National Park Service. Available at: http://www.nps.gov/plants/alien/fact/ambr1.htm. Accessed 11 April 2005.