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Introduced Wildlife of Oregon and Washington

Gary W. Witmer
USDA-APHIS-Wildlife Services, gary.w.witmer@usda.gov

Jeffrey C. Lewis

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Introduction

Each species of wildlife occurs as part of an ecosystem, interacting in many ways with other plant and animal species in that system as well as with the abiotic components such as soil, air, water, and other substrates. The array of wildlife species around the globe has been shaped by geological and climatological events as well as by eons of evolution and natural selection. Species have come and gone and those remaining have, in most cases, co-evolved or co-adapted with many other species so that relatively stable, and often complex, relationships exist. Usually, a great many niches have been carved out and occupied, creating a distinct flora and fauna in each region of the globe that is maintained under conditions of relative stability over time. Natural disturbances (wind, fire) and large-scale events (volcanic eruptions, drought) may occasionally alter that stability and the relationships between species, but an overall homeostatis "a return to the climatic community steady state" usually prevails. These and other concepts of biogeography have been discussed in detail.[31, 162]

Species we refer to as "native" or "indigenous" naturally occur in a particular area and have been there for a very long time. However, events can occur that bring individuals of a new species into a region where they come into contact with many species with which they are neither co-adapted nor co-evolved. In most cases, these newly arrived individuals soon succumb, but some may survive long enough to interact with, or disturb, normal relationships in the community. In a few cases, the newcomers may survive, reproduce, and become established in the ecosystem, permanently altering relationships among or between species. These newcomers are usually referred to as "introduced," "exotic," "non-native," or "non-indigenous." Species that are very successful at this are sometimes called "invasive" species. These species are often capable of spreading unchecked, increasing to high population levels, and comprising a significant portion of the total biota. In cases where the species has thrived in the new location for a relatively long period of time (in terms of human generations), they are considered "naturalized" and are essentially considered a regular part of the local flora and fauna (species complex).

In this chapter, we present information on wildlife introduced to Oregon and Washington. While other terms could be used, we will refer to these relatively new members of the fauna of Oregon and Washington as "introduced" species. Occasionally, the term "exotic" will be used, especially in the context of legal terminology, such as state or federal laws and regulations. We will not include species that are expanding their range on their own without the direct intervention of humans; examples of these species include the cattle egret and the barred owl. Also, we will not include the reintroduction or population augmentation of native species, although much of this activity is occurring in the Pacific Northwest for conservation and biodiversity purposes.

Additionally, we will only include introduced species of birds, mammals, amphibians, and reptiles. In additional to at least 125 species of vertebrates, it has been estimated that over 2,000 species of plants and over 1,100 species of invertebrates have been introduced into the U.S., along with 111 species of fish and over 50 plant pathogens.[116] There are many introduced species of plants, invertebrates, and fish that occur in the Pacific Northwest, and many are of major concern with regard to ecosystem integrity, natural resource management, crop protection, or human health and safety. Detailed discussions on the rapid and destructive spread of various noxious plant species that have been introduced to the Pacific Northwest have been presented by Peck,[120] Stein and Flack,[139] and Toney et al.[146] Most plant species introduced to the Pacific Northwest have been perennial forbs originating from Eurasia, although there has been a trend towards woody species introductions in more recent years.[146] It is ironic that many plant species were purposefully introduced for wildlife habitat enhancement.[130] Introduced invertebrate species and their impacts have been discussed,[68, 139] as well as introduced fish species and their impacts to aquatic systems.[30, 139]

In this chapter we will discuss why wildlife introductions occur; the benefits and problems associated with introductions; regulation of introductions; the introductions that have occurred in Oregon and Washington; the known or potential interactions between introduced species and native species; and the

management of introduced species. We will also include several case histories that characterize favorable and adverse aspects of wildlife introductions.

How Introductions Occur

Wildlife species can be introduced to new areas through a variety of mechanisms, both accidental and purposeful (Table 1). Accidental introductions can result from animals escaping captivity, as has occurred with fox, mink, monk parakeet (*Myiopsitta monachus*), various livestock species, and an array of wild ungulates such as fallow (*Dama dama*) and axis (*Axis axis*) deer. As stowaways on ships, trains or other vehicles, some rodent species (Norway rat, black rat, house mouse) and bird species (house sparrow) have achieved worldwide distribution. Finally, human alteration of habitats or native species ranges, after an initial introduction elsewhere, has resulted in the altered and often expanded range of number of species such as the opossum into regions of the country in which they did not historically occur.

Purposeful introductions have occurred for many reasons (Table 1). The desire to have bird species from the countries of their European heritage, hence aesthetics, led the Portland Song Bird Club to attempt many songbird introductions, including the starling.[46,76] Similarly, eastern gray and fox squirrels have been released in many urban/suburban areas of the west.[154]

Many "game" species, as well as some domestic livestock species, have been introduced to provide some combination of recreational hunting or economic benefit (fur, food, or clothing). These species include many species of upland game birds, turkeys (*Meleagris gallopavo*), foxes, eastern cottontail rabbits, nutria, and various species of deer. Domestic species have been released to provide a future source of food or transportation (pig, *Sus scrofa*; goat, *Capra hircus*; horse, *Equus caballus*; burro, *Equus asinus*).

In some cases, species were introduced to fill a perceived vacant niche, as with upland game birds, carnivores on islands, and herbivores on islands. In actuality, in some of those cases, the populations of native species occupying those niches had been greatly reduced by over-harvest or by human-induced changes in habitats or predator-prey relationships (e.g., many native grouse species). Carnivores (such as fox; mongoose, *Herpestes* spp.; European ferret, *Mustela putorius*; and domestic cat, *Felis catus*) have been introduced, especially on islands, to help control rodent or rabbit populations, many of which were also introduced accidentally or purposefully at an earlier date. This form of biological control has rarely, if ever, been successful in its intended purpose.

In some cases, animals kept in captivity were released because the owners no longer cared or could afford to maintain the animals, or because the economic incentive to raise the animals had declined, as with bullfrogs, nutria, mink, fox, exotic deer, "road-side zoo" animals, and some species of livestock. In a few cases, the animals released from captivity may have been rehabilitated animals or problem animals. Some persons may release animals from captivity on a whim: "what the heck, let's see what happens." This may have occurred with some parakeet/parrot species as well as with some reptile and amphibian species. Finally, persons have given animals (wild or domestic) away as gifts, which later escaped or were released and established free-ranging populations.

Table 1. Some reasons why wildlife introductions occur.

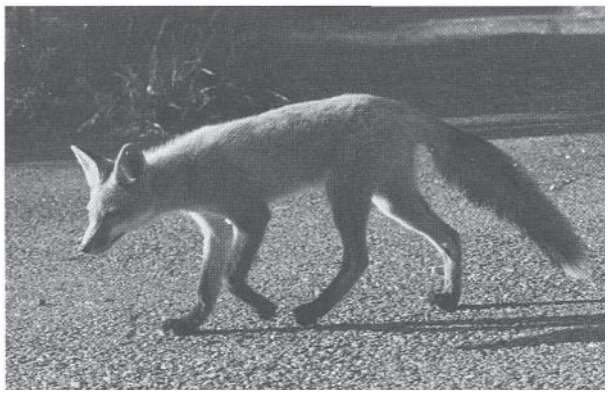
A. Accidental introductions
1. Escaped captivity
2. Stowaways
3. Expanded range of species after introduction elsewhere
B. Purposeful introductions
4. Aesthetics
5. Economics
6. Recreation
7. Source of food
8. Filling "vacant" niches
9. Biological control
10. Released from captive population
11. Release of rehabilitated or problem animals
12. Whimsy: "what the heck, let's see what happens"
13. Gifts

What Makes Introductions Succeed or Fail?

Most wildlife introductions, whether accidental or purposeful, fail to establish free-ranging and sustained populations.[59,163] There are many reasons why this is the most likely outcome of an introduction: inadequate numbers of animals, poor health or genetic quality of animals, predation, disease or parasites, inadequate habitat, competition with native species, poor planning, and others.[59,163]

On the other hand, certain characteristics of a species or population make it more likely to be successful at "invading" a new area and becoming established.[44,112] These include a large native range, high mobility, broad diet, short generation time, high genetic variability, gregariousness, larger size than most closely related species, few predators, association with humans, association with freshwater habitats, and ability to function under a wide range of physical conditions. Often these species are "habitat generalists" and have a "broad ecological amplitude."[44]

It is important to recognize that many factors are involved in the success or failure of a wildlife introduction. Even chance and timing play a role.[33] Disturbance of a site or community, often human-induced, may make the area more susceptible to invasion.[51,117,125] As such, it is difficult to predict whether or not a given introduction will succeed or fail.[129,136,137] There have been some efforts to construct predictive models of the likelihood of successful establishment of an introduced species.[136,137] Unfortunately, there is much to be learned in this area of ecology. In terms of regulation of wildlife introductions,



Red fox. (Photograph by Jeffrey C. Lewis)

this situation has historically resulted in an "innocent until proven guilty" attitude, and species introductions are not prohibited until it is known that they are likely to cause adverse effects; and once these occur, they may be impossible to reverse.

Potential Benefits and Adverse Effects of Introductions

A large number of introductions of plants and animals has already occurred, and continues to occur, in the United States.[116] Some past introductions have benefited the public for the reasons listed in Table 1. Consider, for example, domestic livestock and upland game birds. In Oregon, the introduction of ring-necked pheasant in 1881 resulted in large economic and recreational benefits—so much so, that captive-reared birds were soon being exported to many other states.[35] Upland game species (both bird and small mammal) continue to provide large revenues and extensive recreation to many states.[73]

There are many potential or realized ecological consequences of wildlife introductions (Table 2). To date, the most visible effects of introductions to Pacific Northwest ecosystems appear to be from plant and invertebrate species introductions, although overgrazing by domestic livestock has affected some dryland areas. We note that the effects of an introduced wildlife species, however, may take hundreds of years to become evident: the "blink of an eye" in ecological time. The effects can be to the physical environment, the flora, the fauna, and humans directly, or more often, to a combination of these ecosystem elements. Perhaps the most common effects are from herbivory, competition, or predation. However, many other types of effects can occur, such as hybridization with native species[133] and disease transmission.[52] Numerous examples of ecological effects were presented by MacDonald et al.[107] and Simberloff.[134] In some cases, a major disruption of the ecosystem can occur, but this has not yet been well documented from wildlife introductions in terrestrial ecosystems in Oregon and Washington, with the possible exceptions of San Juan Island (European rabbit),[28] Destruction Island (European rabbit),[6] and the Olympic Peninsula (mountain goat),[67] all in Washington. Major disruptions are most common on islands where rats,[165] carnivores,[164] or feral livestock[148] have been introduced. Erosion and community changes (species composition, abundances, biodiversity, and species loss) have occurred in these situations. On the North American mainland, similar effects have occurred in the Great Smoky Mountains National Park from the introduction of feral pigs.[10] Feral horses and burros have had substantial impacts on some southwestern ecosystems.[41] Species-specific examples of realized or (more often) potential ecological effects of wildlife introductions in Oregon and Washington are presented later in this chapter.

Table 2. Potential adverse ecological consequences of introduced wildlife species.

A. Effects on physical environment
1. Water quality, quantity
2. Soil compaction
3. Soil erosion
4. Nutrient balance

B. Effects on flora
5. Species composition
6. Species abundance
7. Vegetative structure
8. Plant succession
9. Species endangerment

C. Effects on fauna
10. Competition
    a. food
    b. habitats
    c. interference
11. Predation
12. Disease/parasite transmission
13. Hybridization
14. Species endangerment

D. Direct effects to humans
15. Disease/parasites to humans, livestock, pets
16. Crop damage
17. Structural damage
18. Livestock predation
19. Livestock forage competition
20. Human food consumption and contamination
21. Human safety
22. Aesthetics

E. Major ecosystem disruption or alteration
23. Combinations of the above effects

Regulation of Wildlife Introductions

The regulation, policies, and guidelines for wildlife introductions in the United States have had a long and convoluted history. A large number of governmental agencies—at federal, state, and local levels—have played roles; the net effect often being inconsistent, inadequate, or contradictory efforts among agencies, or policies that changed dramatically over time within an agency.[116, 131] There is a strong need for not only more regulation of species introductions, but also better coordination of

regulation across jurisdictional boundaries and governmental levels.[88, 116]

Regulations and practices have evolved from encouraging the importation and release of animals to improve agricultural resources, hunting opportunities, or local economies to restricting importations because of disease hazards, threats to agricultural resources or human health and safety, or potential disruption of natural ecosystems. As early as 1923, Taylor[142] discussed benefits, adverse effects, methods, and regulations for the introduction of upland game birds in the Pacific Northwest.

The U. S. Department of Interior's (USDI) Federal—State Cooperative Foreign Game Program of 1948 added an element of central authority at a time when the importation of game species into the United States was being strongly pursued. This program was guided by three objectives: to provide an ecological and life history data base to individuals or agencies, to discourage introductions when the data base suggested an introduction was unwise, and to fill vacant or understocked habitats with foreign species as an alternate course of action following appropriate testing and trial introductions.[128]

In 1966, the USDI published guidelines and recommendations for the importation of wildlife.[128] These guidelines incorporated eight conditions:

1. Critically determine that a need exists, with desirable ecological, recreational, and economic impacts.
2. A definite niche is available and unsuited for a native species.
3. Introductions should not be considered if they threaten the reduction or displacement of native populations; nor should existing or proposed land uses be in conflict with an exotic species transplant.
4. Introductions should be preceded by ecological studies of both the animal and the habitat proposed at the release site.
5. Disease relationships require special study as well as the steps assuring appropriate quarantine leading to disease-free stock.
6. Exotic species with close relatives in the United States should be avoided, to preclude hybridization with native wildlife.
7. Small-scale experiments and a thorough evaluation of these should precede larger introductions.
8. Before an exotic species is released, methods for controlling its abundance and expansion must be available.

These guidelines resulted in eight recommend-ations from the USDI. These were meant to apply to federal lands or federal actions and included: 1) no decisions until a full assessment is at hand, 2) no exotic species placed in national parks or lands devoted to the preservation of native biota, 3) no exotic species placed in the vicinity of rare or uncommon native species, 4) no exotic grazers placed on federal lands devoted to domestic grazers, 5) no exotic big game placed in areas devoted to intensive land uses, 6) no introductions on federal lands except under a permit and a commitment from the state wildlife agency, 7) treatment of exotics leaving federal land as trespassing livestock with the responsible party held liable, and 8) periodic review of public policy regarding exotic species.

The Wildlife Society published a policy statement on species introductions in 1975. This policy included the following three considerations:[91]

1. Support the introduction of exotic species only after competent scientists have thoroughly studied the situation and potential effects and quarantine requirements have been met.
2. Urge that no state, provincial, or national agency introduce an exotic species or permit such an introduction unless that species can be contained within its jurisdiction, or unless surrounding jurisdictions have sanctioned the introduction.
3. Exclude from the provisions of this policy the importation of exotic species by officially recognized scientific and educational organizations, and the institutional exchange of such species provided that the exotics are maintained in captivity at all times.

President Carter signed Executive Order 11987 in 1977. This document, in part, restricted federal agencies from introducing species to lands they administer, encouraged the prevention of introductions by other levels of government and by private citizens, and restricted federal support of introductions outside the United States.[128] These limitations applied unless either the Secretary of Interior or the Secretary of Agriculture determined that the introduction would not have an adverse effect on natural ecosystems.

An international position statement, containing policies and guidelines similar to those above, was developed and approved by the International Union for Conservation of Nature and Natural Resources (IUCN) in 1987.[116] The IUCN is an organization comprised of scientific experts and government officials involved in conservation around the world.

The concern about "invasive alien" species continues to generate activity by the federal government. On June 17, 1997, Vice President Gore directed the preparation of a strategy to combat the introduction and spread of non-native plants and animals in the United States that are causing great economic and ecological harm to the nation. A draft document has been prepared that reviews the situation, makes recommendations, and provides an action plan.[1] Based on the results of the Task Force, President Clinton signed an Executive Order on Invasive Species on February 3, 1999. Its goals are to prevent the introduction of invasive species, to provide for their control, and to minimize the economic, ecological, and human health impacts that they cause. It was estimated that invasive species cost the U.S. economy about $123 billion per year. The Order establishes Invasive Species Council assigned the task of setting up an Advisory Committee and preparing and implementing an Invasive Species Management Plan. The Plan will 1) detail and recommend performance-oriented goals and objectives,

2) review existing and prospective approaches and authorities, 3) identify pathways of introductions and ways to minimize risks of introduction, 4) identify research needs, 5) be science-based, 6) recommend and implement measures to reduce introductions and control those that have occurred, 7) identify requirements to achieve goals and objectives, and 8) evaluate and report on the success in achieving goals and objectives.

We have reviewed some of the long history of introduced wildlife concerns, policies, and recommendations. The groundwork has been set for a vigorous effort to reduce introductions and to manage existing introductions. It remains to be seen what level of success will be achieved towards this goal.

Current Federal and State Regulations

The two main federal agencies regulating wildlife species introductions in the United States are the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) and the USDI Fish and Wildlife Service (FWS).[116,131] A major function of APHIS is to protect United States agriculture (both plants and animals) from diseases or plant and animal "pests" that might gain access to the country or be transported between states. Border inspections, quarantines, disease testing, and eradication programs are some of its routine functions, and most of APHIS's pest exclusion occurs at ports of entry. APHIS does not expressly prohibit species-specific imports, but requires adequate quarantine and veterinarian inspection before such imports or transportations are allowed (9 CFR Ch. 1). The agency is particularly strict regarding hedgehogs (*Erinaceus* spp.) and the brush-tailed possum (*Trichosurus vulpecula*). A major concern of APHIS is to prevent the entry of Newcastle's disease, chlamydiosis, foot-and-mouth disease, rinderpest, bovine tuberculosis, and other communicable diseases of livestock and wildlife. APHIS is also active in management and research to prevent entry of the brown tree snake (*Boiga irregularis*) into Hawaii and the mainland United States.[17]

The FWS protects threatened and endangered species by, among other activities, restricting the importation and exportation of federally listed species under the Endangered Species Act and the Convention on International Trade in Endangered Species (CITES). Except under permit and various restrictions, the FWS expressly prohibits the importation and release of individuals, progeny, or eggs of many species of vertebrates into the United States, to protect national resources (50 CFR Ch. 1). These species include flying fox (*Pteropus* spp.), mongoose, European rabbit, wild dog (genus *Cuon*), multi-mammate rat (*Mastomys* spp.), raccoon dog (*Nyctereutes procyonoides*), starling, quelea (*Quelea qualea*), Java sparrow (*Padda oryzivora*), red-whiskered bul-bul (*Pycnonotus jocosus*), all species of amphibians, and all species of reptiles. Additionally, the importation and transportation of birds of the family *Psittacidae* (parrots, parakeets, macaws, etc.) are regulated by the U.S. Public Health Service because of disease hazards (42 CFR Parts 71 and 72).

Bullfrog. (Photograph by Jeffrey C. Lewis)

For many decades, many states, including Oregon and Washington, had few regulations regarding the importation or keeping of "exotic" wildlife or the protection of native biodiversity from exotics.[21,116] Many states in the late 1800s and early 1900s, including Oregon and Washington, encouraged—or were directly involved with—the propagation or release of many game species, including exotic species. These practices have largely been curtailed in recent decades, with notable exceptions such as with wild turkey and Sichuan pheasant, *P. c. suehschanensis*.[116] The Southeastern Cooperative Wildlife Disease Study provided a "model law" in 1988 to help guide states in regulating animal imports that addressed veterinary, humane, public safety, ecological, and other concerns.[116] It recommended a permit requirement for introduced species, that certain common domestic and naturalized species be exempt from the regulations, that criteria and a list be developed for "environmentally injurious animals," and that a technical advisory committee be formed to provide advice. Both Oregon and Washington legislatures and wildlife agencies have enacted detailed and specific regulations on the importation and keeping of introduced wildlife.

Oregon Administrative Rules (OAR 635-056-0000 to -0150) prohibit the importation or keeping of numerous vertebrate species, including hedgehog, tri-colored squirrel (*Callosciurus* spp.), brush-tailed possum, bats of any species, mongoose, wild pig, chamois (*Rupicapra* spp.), non-domestic goat (*Capra* spp., except *C. hircus*), wildebeest (*Connochaetes* spp.), gazelles (*Procapra* spp.), capybara (*Hydrochaeris hydrochaeris*), prairie dogs (*Cynomys* spp.), any species of wild canid (except fox), Egyptian goose (*Alopochen aegyptiacus*), African clawed frog (*Xenopus* spp.), bullfrogs (*Pyxicephalus* spp.), alpine newt (*Triturus* spp.), brown tree snakes, snapping turtle (Chelydridae, all spp.), pond sliders (*Pseudemys* spp.), Chinese pond turtle (*Chinemys* spp.), pond turtle (*Chrysemys* spp.), painted turtle (*Chrysemys* spp.), map turtle (*Graptemys* spp.), North American (*Apalone* spp.) and African (*Trionyx spp.*) soft shell turtles, European pond turtle (*Emys orbicularis*), Blanding's turtle (*Emydoidea blandingii*), common mud turtle (*Kinosteron subrunum*),

common musk turtle (*K. odoratum*), and Asian pond turtle (*Mauremys* spp.). Many fish species are also prohibited. Exceptions, by permit, are made for zoos and research facilities if they are escape-proof and are staffed and equipped to provide adequate care. There is also a long list of domestic or otherwise exempt species, including dogs (*Canis familiaris*), cats, burros, horses, swine, European rabbits, ferrets, and parrots and parakeets (*Psittacidae*, all spp.). The State has specific requirements involving the sale, transportation, and holding of exotic animals, to help prevent escape of, or disease transmission by, introduced animals. There are strict reporting rules that apply when an introduced species escapes captivity.

Washington has similar laws (Chapter 77.08 RCW) and prohibits the importation or keeping of mute swan, mongoose, wild pig, collared peccary (*Tayassu tajacu*), and various species of exotic bovids and cervids. Many species of fish are also prohibited.

Much of the importation of introduced wildlife into the United States is because of the enormous pet industry.[116] About 23 percent of the vertebrate species of foreign origin that currently live in the wild in the United States were originally imported as cage birds or other wildlife pets.[116] There is a growing concern about the depletion of animals from exportation countries (hence the species listings in CITES, including its appendices), but also about the significant hazard that introduced species pose to native species, ecosystems, agriculture, and forestry.[1, 116, 124] It has even been speculated that the liberalization of international free trade may increase species introductions around the globe.[74] The probability of accidental release of non-native wildlife as well as disease transfer and other hazards can be reduced by the improvement of existing programs and the implementation of specific actions as presented by the Ad Hoc Federal Invasive Alien Species Task Force[1] and the Office of Technology Assessment.[116] Their recommendations include: acknowledge that the prevention of introductions is paramount, encourage governments to take an active role by establishing national and regional councils, develop new scientific expertise for dealing with introductions, develop a white-black-gray list to assist in regulating exotic species, develop a comprehensive program to prevent unintentional introductions by identifying major pathways and methods to interdict and reduce impacts, develop and implement an international regime for control and support cooperation through development assistance, develop a Web-based network of information, convene educational workshops, and consult with the United States Congress regarding new regulations and funding authority. The white-black-gray list would delineate species that are automatically allowed, never allowed, or allowed only after thorough investigation, respectively.

The implementation of adequate programs to prevent the accidental, or purposeful but prohibited, release of introduced diseases, plants, invertebrates, and vertebrates is especially important because of the difficulty and expense of eradication once an introduced species becomes dispersed and established.[36, 135] Furthermore, it is important to increase public awareness of the risks posed by wildlife introductions. A good public education program on this subject should lead not only to more public support for the prevention of future introductions and the management or eradication of past introductions (in terms of supporting appropriate legislation, management practices, and requisite budgets), but also for better public compliance with federal and state regulations.

Introduced Wildlife Species in Oregon and Washington

There have been a large number of wildlife introductions to Oregon and Washington, dating back to the 1700s (e.g., horses and burros). Most attempted introductions, whether accidental or purposeful, have failed. For example, Portland Bird Club attempted but failed between 1889 and 1907[46, 76] to introduce many species of songbirds, including Eurasian skylark, *Alauda arvensis*; wood lark, *Lullula arborea*; blackcap, *Sylvia atricapilla*; European robin, *Erithacus rubecula*; nightingale, *Luscinia megarhynchos*; Eurasian blackbird, *Turdus merula*; song thrush, *T. philomelos*; parrot crossbill, *Loxia pytyopsittacus*; Eurasian siskin, *Carduelis spinus*; Eurasian goldfinch, *C. carduelis*; linnet, *Acanthis cannabina*; Eurasian bullfinch, *Pyrrhula pyrrhula*; chaffinch, *Fringilla coelebs*; house sparrow, and European starling.

We have compiled a list of 42 wildlife species introductions to Oregon and Washington that have established free-ranging populations at least on a localized scale (Table 3).[7, 20, 27, 34, 37, 46, 54, 70, 75, 76, 94, 97, 98, 99, 104, 152] The information we provide on the 42 species includes common and scientific names, the date, and location of the introduction(s), the reason for the introduction, the current status and distribution (in general terms), and the country of origin (Table 3). We note that many of the species were introduced over a period of time and at several locations. The list includes 18 birds, 19 mammals, 3 reptiles, and 2 amphibians. About half (19 of 42) of the species listed have achieved widespread distribution in Oregon or Washington.

Most bird species were introduced for hunting or aesthetic purposes, although several arrived by range expansion after being introduced elsewhere. Many of the mammal introductions were escapees or animals released when no longer needed or economically valuable. Several were introduced for hunting or fur farming. The Old World rodents arrived as stowaways. Most amphibian and reptile introductions were for aesthetic, pet, or food purposes.

Additionally, there are many other non-native wildlife species that have been observed or reported in Oregon or Washington, but information on their occurrences is very limited and we cannot be sure whether or not those species are established (Table 4). We have included this species list because of the potential ecological consequences if they do become established and more widespread in distribution.

Table 3. Wildlife species introduced to Oregon or Washington.[7, 20, 27, 34, 37, 46, 54, 70, 75, 76, 94, 97, 98, 99, 104, 152]

Species	*Place/Date*	*Reason*	*Status*	*Origin*
Trumpeter swan, *Cygnus buccinator*	Harney Co. OR 1939-58; Spokane Co. WA 1963	aesthetics; hunting	very limited, small numbers in OR and WA	SE Alaska, NW Canada and somewhat south
Mute swan, *Cygnus olor*	Lincoln Co. OR 1950s; Deschutes Co. OR 1960s	aesthetics, escapees?	very limited, small numbers in OR and WA	Eurasia
American black duck, *Anas rubripes*	Snohomish Co. WA, date unknown	hunting	small localized popn in Puget Sound	E United States
Chukar, *Alectoris chukar*	Lake Co. OR 1951; Deschutes Co. OR 1952; Klamath Co. OR 1960s; E. WA 1930s	hunting, brood stock sale	scattered popns in E OR and E WA	Eurasia
Gray partridge, *Perdix perdix*	Linn Co. OR 1900; 23 counties OR 1913-14; Spokane Co. WA 1906; Columbia Co. WA 1908	hunting, brood stock sale	scattered popns NE OR and E WA	Eurasia
Ring-necked pheasant, *Phasianus colchicus*	Linn Co. OR 1881-82; Protection Is. WA 1883	hunting, brood stock sale	widespread, common	Eurasia
White-tailed ptarmigan, *Lagopus leucurus*	Wallowa Co. OR 1967-69	aesthetics?, hunting?	localized, small numbers in OR; native to WA	SE Alaska, W Canada into WA
Wild turkey, *Meleagris gallopavo*	OR 1899 (failed); many OR counties 1961-83; E. WA 1970s	hunting	widespread, moderate numbers in E OR and E WA; some on San Juan Is.	E United States, Southcentral United States
California quail, *Callipepla californica*	Thurston Co. WA 1857; many OR counties 1914	hunting, brood stock sale	widespread, common; native to S OR	SW United States just into OR
Scaled quail, *Callipepla squamata*	Yakima Co. WA 1913	hunting, brood stock sale, escapees	localized, small numbers; extirpated?	Southcentral United States
Northern bobwhite quail, *Colinus virginianus*	Walla Walla WA 1865 & 1920; Whidbey Is. WA 1871; Linn Co. OR 1882	hunting, brood stock sale	localized, small numbers	E United States
Mountain quail, *Oreortyx pictus*	W WA 1880	hunting, brood stock sale	localized in WA; native in OR	SW United States into SE WA
Rock dove, *Columba livia*	many OR counties <1900; W WA <1940	aesthetics, racing, messengers, then range expansion	widespread, common	Eurasia
Monk parakeet, *Myiopsitta monachus*	Multnomah Co. OR 1969	escapees	small numbers, Portland area; some in WA?	South America
Skylark, *Alauda arvensis*	Portland OR 1889 (failed?); Vanc. Is. BC 1903	aesthetics, then range expansion	small numbers on San Juan Is.	Eurasia
European starling, *Sturnus vulgaris*	Portland OR 1889 (failed); arr. on own 1940s OR & WA	aesthetics, then range expansion after introd. to E United States	widespread, common OR and WA	Eurasia
Crested mynah, *Acridotheres cristatellus*	Vancouver BC 1894	aesthetics, then range expansion	localized, small numbers in Seattle, Bellingham areas	SE Asia
House sparrow, *Passer domesticus*	Spokane Co. WA 1895; King Co. WA 1897; Portland OR 1889	aesthetics and insect control to E United States, range expansion	widespread, common OR and WA	Eurasia
Virginia opossum, *Didelphis virginiana*	Umatilla Co. OR 1910; WA <1941	aesthetics, pets escapees, fur trapping	locally common, esp. W WA, W OR & NE OR	E United States
Red fox, *Vulpes vulpes*	many places W WA by 1909, W OR by 1915	fox hunting, fur farming, escapees	widespread W OR & WA; less so in E OR & WA	Holarctic
European ferret, *Mustela putorius*	San Juan Is. WA	rabbit control	small population remains?	Europe

Species	*Place/Date*	*Reason*	*Status*	*Origin*
House cat, *Felis catus*	<1800	escapees, pest control	widespread, OR & WA?	Eurasia, Africa
Domestic dog, *Canis familiaris*	<1800	escapees	occasional occurrences	Eurasia
Burro, *Equus asinus*	E OR late 1700s	escapees or released when no longer needed	small population in SE OR	Africa
Horse, *Equus caballus*	E OR late 1700s	escapees or released when no longer needed	moderate population in SE OR	Asia
Feral pig, *Sus scrofa*	SW OR late 1800s; Skagit Co. WA 1981	hunting, escapees?	Very small, localized populations or extirpated	Eurasia
Axis deer, *Axis axis*	Pierce Co. WA >1980	aesthetics or escapees	small, localized population	India
Fallow deer, *Dama dama*	King Co. WA >1980	aesthetics or escapees	small, localized population	Europe
Mountain goat, *Oreamos americanus*	NE OR 1950 & Columbia Gorge OR 1969 (failed); Olympic Mtns. WA early 1900s	aesthetics, hunting	moderately abundant in Olympic mtns., native to N Cascade & Rocky Mtns.	Alaska to WA, Cascade and Rocky Mtns.
Eastern gray squirrel, Sciurus carolinensis	*King Co. WA 1925; W OR 1919*	aesthetics	localized, urban/suburban areas of W & NE OR and W WA	E United States
Fox squirrel, *Sciuris niger*	W OR & WA <1940; Baker Co. OR 1950s	aesthetics	localized, urban/suburban areas of E WA, W and NE OR	E United States
House mouse, *Mus musculus*	OR and WA late 1700s	stowaway, then range expansion	widespread, urban/suburban areas OR & WA	Europe
Norway rat, *Rattus norvegicus*	OR and WA <1850	stowaway, then range *expansion*	localized, urban/suburban *areas* OR & WA	Asia
Black rat, *Rattus rattus*	OR and WA <1800	stowaway, then range expansion	localized, urban/suburban areas OR & WA	Asia
Nutria, *Myocastor coypus*	King Co. WA 1930s; Lincoln and Tillamook Cos. OR 1937	fur farming, escapees, vegetation control?	localized, mostly W OR & WA	South America
European rabbit, *Oryctolagus cuniculus*	San Juan Co.. WA 1929; Destruction Is. WA 1970	aesthetics, hunting	Island populations persist, other localized populations in WA?	Europe
Eastern cottontail, *Sylvilagus floridanus*	Whitman Co. WA 1926; Linn and Benton Cos. OR 1940s	hunting	widespread, *locally* abundant	*E United States*
Bullfrog, *Rana catesbeiana*	many places OR & WA 1914 on	insect control, aesthetics, hunting, food, then range expansion	widespread, locally abundant	E and Central United States
Green frog, *Rana clamitans*	King, Stevens and Whatcom Cos. WA	aesthetics, hunting?	very localized, small populations	E. United States
Snapping turtle, *Chelydra serpentina*	many places W OR & W WA 1950s on	aesthetics, hunting?, pets, food	localized, small populations	E and Central United States
Red-eared slider turtle, *Trachemys scripta elegans*	many places OR and WA	aesthetics?, pets, escapees	Locally common in W and Central OR	SE United States
Plateau striped whiptail, *Cnemidophorus velox*	Jefferson Co. OR	aesthetics?	Localized, small population	SW United States

Habitat Use by Introduced Wildlife Species

All general habitat categories that occur in Oregon or Washington are used by at least one of the 42 introduced species, although few introduced species use alpine or marine habitats (Table 5). Only 12 of 42 (29%) introduced species are affiliated with only one general habitat category; most of those 12 species are restricted to freshwater/riparian systems. Most species (71%) can be considered habitat generalists, using several general habitat categories.

Human-disturbed areas (agriculture lands, urban/suburban areas) are used by a large number of the introduced wildlife species, 19 and 18 species, respectively (Table 5). This group of species includes most introduced upland game birds, songbirds, and mammals. Forests

Table 4. Other introduced wildlife species that have been occasionally observed or reported in Oregon or Washington.*

Birds	*Mammals*	*Amphibians/reptiles*
Domestic goose, *Anser cygnoides*	Wolf-dog hybrid, *Canis lupus x familiaris*	Eastern mud turtle, *Kinosternon subrubrum*
Egyptian goose, *Alopochen aegyptiacus*	Domestic cow, *Bos taurus*	Stinkpot, *Sternotherus odoratus*
Graylag goose, *Anser anser*	Domestic goat, *Capra hircus*	Painted turtle (non-natives), *Chrysemys picta*
Domestic mallards, *Anas platyrhynchos*	Domestic sheep, *Ovis aries*	Eastern box turtle, *Terrapene carolina*
Muscovy duck, *Cairina moschata*	Barbary sheep, *Ammotragus lervia*	Ornate box turtle, *Terrapene ornata*
Red-legged partridge, *Alectoris rufa*	Mouflon sheep, *Ovis musimon*	Malayan box turtle, *Cuora amboinensis*
Sichuan pheasant, *Phasianus colchicus suehschanensis*		Desert tortoise, *Gopherus agassizii*
		Texas tortoise, *Gopherus berlandieri*
Golden pheasant, *Chrysolophus pictus*		Gopher tortoise, *Gopherus polyphemus*
Peafowl, *Pavo cristatus*		Hermann's tortoise, *Testudo hermanni*
Guineafowl, *Numida meleagris*		Reeve's turtle, *Chinemys reevesi*
Psittacines (misc. Parrots, cockatoos, macaws)		Spiny softshell turtle, *Apalone spinifera*
		Florida softshell turtle, *Trionyx ferox*
		Big-headed turtle, *Platysternon megacephalum*
		Caiman, *Caiman crocodilus*

* Little is known about the status of most of these species; most probably do not comprise free-ranging, self-sustaining populations and have not expanded their range beyond the release site(s) in either state, however, these events could occur in the future.

Table 5. Use of general habitat categories by 42 wildlife species introduced to Oregon or Washington.

	No. (% of Group) of Species by General Habitat Category[a]						
Wildlife Group	*Forest*	*Shrub/grass*	*Agriculture*	*Urb/suburb*	*Freshw/rip*	*Marine*	*Alpine*
Birds (18 spp.)	8 (44%)	8 (44%)	11 (61%)	7 (39%)	4 (22%)	1 (6%)	1 (6%)
Mammals (19 spp.)	11 (58%)	4 (21%)	8 (42%)	11 (58%)	5 (26%)	0 (0%)	1 (5%)
Amphibians/reptiles (5 spp.)	1 (20%)	1 (20%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)
Total: (42 spp.)	20 (48%)	13 (31%)	19 (45%)	18 (43%)	14 (33%)	1 (2%)	2 (5%)

[a]Most species use more than one general habitat category.

(especially open, deciduous or mixed forests) are used by about half (48%) of the introduced species. Freshwater/riparian habitats are used by approximately equal numbers of introduced bird, mammal, and amphibian/reptile species groups, with all introduced reptiles and amphibians using those habitats. Shrub/grass habitats are used by introduced bird species and eastern cottontail rabbits, but especially upland game birds.

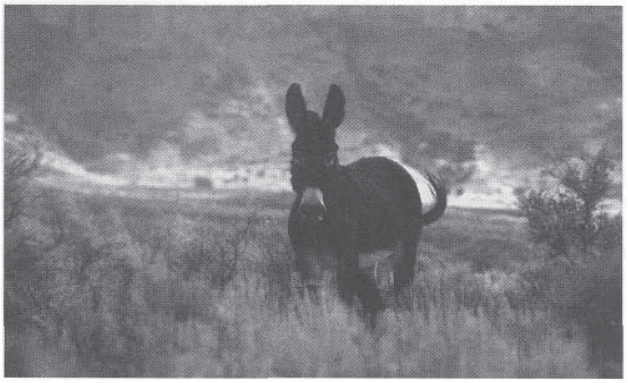
Specific habitat associations for many of the introduced wildlife species have not been well defined. Some insight for some species can be gained from Brown,[12] Guenther and Kucera[60] and Thomas.[144] That information, along with species-specific literature and expert opinion, has been used to complete the wildlife habitat matrixes of this book. These matrixes can be used, to some extent, to project the potential competition between native species and introduced species. For example, the introduced eastern gray and fox squirrels use oak woodlands as do native western gray squirrels; all three species use variously-aged forest stands and all use snags. White-tailed ptarmigans, introduced to Oregon, may compete with native blue and spruce grouse in the use of alpine meadows, subalpine fir habitats, and grass-forb dominated areas. On the other hand, there is little potential for competition between white-tailed ptarmigans and ruffed grouse. Competition may also occur between introduced upland game birds and native sage and sharp-tailed grouse; all of these species use shrub-steppe and sagebrush-steppe habitats, as well as grass-dominated areas and riparian areas. Most of these species use agricultural lands, too. Likewise, in some situations, the introduced eastern cottontail rabbit may compete with native rabbits (pygmy, and brush rabbits; Nuttall's cottontail) in grass/sedge meadows and alder bottomlands as well as riparian areas, agricultural lands, brushpiles (including downed woody materials), and burrows. For many introduced species, we do not know enough about what specific habitats they could use, given the opportunity and time for populations to occupy those habitats. For example, axis and fallow deer could potentially occupy many of the same habitats as the native black-tailed deer and the endangered Columbia white-tailed deer. Interested persons are referred to the matrixes for further investigation of potential habitat competition between native and introduced species.

Ecological Consequences of Wildlife Introductions

It is very important to recognize the potential ecological consequences of wildlife introductions. While considerable effort and expense have been invested in dealing with introduced plants and insects in the Pacific Northwest, introduced wildlife also has caused, or has the potential to cause, substantial harm to Pacific Northwest ecosystems and agricultural resources (Table 2). There are many potential or realized ecological consequences for each of the 42 wildlife species introductions that have occurred in Oregon and Washington (Table 6).

Several points need to be emphasized. The code "NK" (none known) appears frequently in Table 6. With wildlife introductions, we are often presented with ecological "situations" with which we have little or no experience; hence, our predictive powers are very limited. Additionally, serious effects may occur long after the introductions. The rather cavalier attitude of the past ("let's do it and see what happens") is no longer acceptable, given the many legal mandates and policies for species and biodiversity protection, healthy ecosystem maintenance, and the protection of human health and agricultural resources. We must not only deal with existing introduction problems, but must strive to prevent future introductions that have significant potential for adverse consequences. Both require a greater ecological and managerial knowledge base than we now possess. On the other hand, great strides in agriculture, recreation, local economies, biological control of pests, and even in the medical profession, have been made as a result of species introductions. Obviously, a careful and deliberate analysis, on a case-by-case basis, must be made before proceeding with any wildlife introduction.

Introduced wildlife species have the potential for several, if not numerous, adverse ecological consequences (Table 6). Most introduced birds have the potential to adversely affect native birds, especially through forage and nest site competition. A classic example is the ability of starlings to usurp nest sites from wood ducks, bluebirds, woodpeckers of many species, and many other songbirds.[57, 155] Additionally, some hybridization problems exist; for example, black ducks hybridize with mallards,[133] some upland game species hybridize with native species[8] and eastern cottontail rabbits hybridize with the brush rabbit.[151] Avian diseases, such as avian tuberculosis, Newcastle's disease, salmonellosis, and chlamydiosis, can be transmitted to native species.[52] Members of the parrot family make popular pets, but they have the potential to spread avian tuberculosis, a disease transmissible to not only other wildlife, but to pets, livestock, and humans.[52] Congregations of introduced bird species such as house sparrows, rock doves, and starlings at roosts or feeding stations have produced significant disease hazards (e.g., histoplasmosis, ornithosis, salmonellosis).[52] Several of the introduced bird species (starling, house sparrow, rock dove, skylark, crested mynah, *Acridotheres cristatellus*) have a great potential to damage crops, contaminate foodstuffs, and cause aesthetic problems.[52, 55] Additionally, the introduced rodent species cause many types of structural damage to human dwellings, livestock facilities, and constructed features such as dikes, dams, levees, transmission lines, and irrigation systems.[69] Considerable effort is expended each year to reduce the negative effects of these species. On the other hand, the introduction of upland game birds may have increased the prey base for native predators, both avian and mammalian, as well as having provided recreation as intended.



Wild burro. (Photograph by Jeffrey C. Lewis)

Most introduced mammal species have the potential to adversely affect various species of native plants and animals, as well as humans and their resources, through herbivory or predation. Species such as red foxes, ferrets, and feral dogs and cats can inflict high levels of mortality on ground nesting birds and have been implicated in the endangerment of numerous species, such as snowy plovers, least terns (*Sterna antillarum*), and clapper rails (*Rallus longirostris*).[164] Similar results have been reported for introduced carnivores in Europe.[82] Feral or free-ranging cats kill large numbers of songbirds every year in urban/suburban settings.[25] Essentially, all introduced herbivorous mammals can cause plant damage and may even impede regeneration of some plant species. Usually the amount of damage is related to the density of introduced mammals; hence, existing small, introduced populations of axis and fallow deer are probably not causing significant impact to the native flora. On the other hand, high densities or concentrated use can cause substantial impacts on native flora, as occurs with European rabbits, mountain goats, and feral pigs, horses, and burros. In some cases, endangerment of native plant species may occur, as with herbivory by introduced mountain goats on the Olympic Peninsula.[67] Many of the introduced mammal species, especially carnivores and Old World rodents, have been implicated in the transmission of disease to native wildlife, livestock, pets, or humans; these diseases include rabies, plague, distemper, relapsing fever, and leptospirosis.[38]

Introduced amphibians and reptiles have been implicated in the decline of many native aquatic fauna through predation or competition.[29, 111] The introduced bullfrog is a classic example and will be considered in more detail in the case histories at the end of the chapter.

Table 6. Potential or realized ecological consequences of wildlife species introduced to Oregon or Washington.

Species	*Physical Environment*	*Flora*	*Fauna*	*Human*
Trumpeter swan, *Cygnus buccinator*	NK	NK	FC, NC, AB	AB
Mute swan, *Cygnus olor*	NK	NK	FC, NC, AB	AB
American black duck, *Anas rubripes*	NK	NK	H	NK
Chukar, *Alectoris chukar*	NK	NK	D, FC, NC, IP	CD
Gray partridge, *Perdix perdix*	NK	NK	D, FC, NC, IP	CD
Ring-necked pheasant, *Phasianus colchicus*	NK	NK	D, FC, NC, IP, H	CD
White-tailed ptarmigan, *Lagopus leucurus*	NK	NK	FC, NC, AB	NK
Wild turkey, *Meleagris gallopavo*	NK	PR	FC, IP	NK
California quail, *Callipepla californica*	NK	NK	D, FC, NC, IP, H	CD
Scaled quail, *Callipepla squamata*	NK	NK	D, FC, NC, IP, H	CD
Northern bobwhite quail, *Colinus virginianus*	NK	NK	D, FC, NC, IP, H	CD
Mountain quail, *Oreortyx pictus*	NK	NK	D, FC, NC, IP, H	CD
Rock dove, *Columba livia*	NK	NK	FC, NC, D	A, HD, CF
Monk parakeet, *Myiopsitta monachus*	NK	PD?	FC, NC, D	CD
Skylark, *Alauda arvensis*	NK	PD?	FC, NC, D?	CD?
European starling, *Sturnus vulgaris*	NK	PD?	FC, NC, D	CF, A, HD
Crested mynah, *Acridotheres cristatellus*	NK	PD?	FC, NC, D?	CF, A, HD?
House sparrow, *Passer domesticus*	NK	PD?	PC, FC, NC, D	CF, A, HD
Virginia opossum, *Didelphis virginiana*	NK	NK	P, D	A, HD
Red fox, *Vulpes vulpes*	NK	PD?	P, PC, E, H, D	CD, LP, HD
European ferret, *Mustela putorius*	NK	NK	P, E, H?, D?	AB, HD?
House cat, *Felis catus*	NK	NK	P, PC, E, H?, D	HD
Domestic dog, *Canis familiaris*	NK	NK	P, PC, E, H, D	AB, LP, HD
Burro, *Equus asinus*	S, W	PD, E	FC, D	LC, HD
Horse, *Equus caballus*	S, W	PD, E	FC, D	LC, HD
Feral pig, *Sus scrofa*	S, W	PD, PR	FC, D, IP	AB, LC
Axis deer, *Axis axis*	NK	PD, PR	H?, D?	NK
Fallow deer, *Dama dama*	NK	PD, PR	H?, D?	NK
Mountain goat, *Oreamos americanus*	S	PD, PR, E	FC, IP	NK
Eastern gray squirrel, *Sciurus carolinensis*	NK	PD, PR	FC, NC, AB, D	SD
Fox squirrel, *Sciuris niger*	NK	PD, PR	FC, NC, AB, D	SD
House mouse, *Mus musculus*	NK	NK	FC?, D	HD, A, CF, SD
Norway rat, *Rattus norvegicus*	NK	NK	FC?, D	HD, A, CF, SD
Black rat, *Rattus rattus*	NK	PD?	FC?, D	HD, A, CF, SD
Nutria, *Myocastor coypus*	S, W	PD, PR	FC?, D	HD, SD
European rabbit, *Oryctolagus cuniculus*	S	PD, PR, E	FC, NC?, D, IP?	CD, LC, HD
Eastern cottontail, *Sylvilagus floridanus*	NK	PD, PR?, E?	FC, NC?, D, IP	CD, LC, HD
Bullfrog, *Rana catesbeiana*	NK	NK	PC, P, E	NK
Green frog, *Rana clamitans*	NK	NK	PC, P?, E?	NK
Snapping turtle, *Chelydra serpentina*	NK	NK	PC, P, E?, AB, D	AB
Red-eared slider turtle, *Trachemys scripta*	NK	PD?	P?, PC?, FC?, D, AB	NK
Plateau striped whiptail, *Cnemidophorus velox*	NK	NK	PC?	NK

A=aesthetics, AB=aggressive behavior, CD=crop damage, CF=contamination of foods, D=disease/parasites, E=species endangerment, FC=forage competition, H=hybridization, HD=human/livestock/pet disease/parasites, IP=increase prey base, LC=livestock forage competition, LP=livestock predation, NC=nest competition, NK=none known, P=predation, PC=prey competition, PD=plant damage, PR=plant regeneration, S=soil erosion, SD=structural damage, W=water quality/quantity.

English (house) sparrow. (Photograph by Jeffrey C. Lewis)

Certain introduced species have the potential for substantial ecosystem disruption, the final and highly significant category in Table 2. Of the 42 wildlife species already introduced into Oregon or Washington, we would include feral livestock (pigs, horses, burros), mountain goats (in areas where they are not native), nutria, and European rabbits in this category. Other species (such as the Old World rodents) cause substantial ecological disruption in tropical ecosystems, but are not as damaging to temperate ecosystems. Major ecosystem disruption can occur when these species seriously impact the physical environment (soil parameters, erosion, water quantity and quality), achieve relatively high densities, exert heavy grazing pressure, or successfully compete with native fauna. Mountain goat impacts on the Olympic Peninsula and the difficulties of resolution have been described,[18, 67] and so have impacts and management of feral horse and burro.[19, 41, 98] Feral pigs have been studied extensively around the world because of their very significant impacts to ecosystems.[10, 98] The pros and cons of nutria introductions in the Pacific Northwest and elsewhere have also been discussed.[89, 93, 98] Similar discussions for European rabbits were presented as well.[6, 28, 63, 98] Because of the significant potential for ecological disruption by these species, there have been extensive efforts to eradicate them after introduction, especially from islands, and most are banned from import at the federal or state level.

Management of Introduced Wildlife Species

It is better to prevent the introduction of an unwanted species rather than deal with the management or attempted eradication of the species once it becomes established.[36, 135] On the other hand, many introduced wildlife species (upland birds, cottontail rabbits, nutria, red fox) are managed as "game" species by state wildlife agencies, using traditional methods of harvestable wildlife management. Usually, a harvest license is required; seasons, bag limits, methods of take, and other regulation are set each year; and, in some cases, populations and harvests are monitored.

There are many wildlife management methods available to assist us in the management of "undesirable" introduced wildlife species (Table 7). These physical, mechanical, chemical, biological, and cultural methods are used to reduce the carrying capacity of the area for the species, to reduce population density, or to keep animals out of certain areas. Reduction of populations by lethal means may only provide a temporary "fix" unless habitats can be modified to reduce their carrying capacity for the introduced species.[149] On the other hand, commercial exploitation or bounties on introduced wildlife has been used in some situations as a way to keep population levels down while generating local income.[22, 118] Pathogenic agents are rarely used to control vertebrate populations because of the need for specificity, start-up costs and potential hazards, although efforts continue in Australia.[114] Often a variety of methods are employed, as in an integrated pest management (IPM) approach.[13, 17, 118, 165] If a new species is released in the area, it is important to restrict its spread as soon as possible.[9] Research is underway on chemosensory and reproductive inhibition devices that may provide valuable tools in the future management of introduced species.[48]

Eradication of an introduced species is often the management goal, but is difficult to achieve.[9, 24, 127] Nonetheless, eradication has been achieved in some places, especially on islands.[127, 148, 165] An entirely different philosophy is to "let nature take its course" and assume that eventually introduced species will drop out on their own, will fit in satisfactorily, or will result in a worldwide homogenization of the planet's flora and fauna. While this may be the ultimate fate of the global flora and fauna, we, as resource managers and concerned citizens, should not take such a defeatist attitude.[88]

Table 7. Examples of methods for the management of introduced wildlife species by category.

Cultural/Habitat	*Physical*	*Chemical*	*Biological*	*Other*
Crop selection	Barriers	Repellents	Predators	Bounties
Cover reduction	Traps	Toxicants	Disease/Parasites	Insurance
Water removal	Electrocution	Reproductive inhibition	Resistant plants	Harvest
Sanitation	Flooding	Aversive conditioning	Lethal genes	Acclimation
Buffer crops	Shooting/Frightening devices	Tranquilizers, other drugs	Biosonics	Acceptance

In most cases, an integrated management approach will be required to control most introduced species, using a problem assessment, action plan, several methods, and monitoring. Adequate surveillance and control at the point of origin are important. Additionally, adequate budgets, public support, and access to private lands will be essential to the successful management or eradication of most introduced wildlife species.[9, 36, 165] Using introduced rodents as an example; Witmer et al.[164, 165] discussed the many considerations of introduced species management and eradication.

There are many socio-political, economic, and ecological issues associated with introduced species.[88, 143] Realizing this, and involving the appropriate and interested parties in the decision-making process, will be essential to the successful resolution of current and future wildlife introductions.

Case Histories

We conclude this chapter with several case histories of wildlife introductions in Oregon and Washington. As we have mentioned, some introductions can be considered "positive" while many are considered "negative" for a number of reasons. In reality, most introductions have the potential for both positive and negative effects. Only time and our concerted efforts will determine the future status of native and introduced wildlife species and of ecosystems in Oregon and Washington. In many cases, we will continue to live with these naturalized species.

1. Ring-necked Pheasant

History, Distribution, and Status. Ring-necked pheasants are native from the Caucasus Mountains of Eurasia through Southeast Asia to Northern Japan where they are closely associated with river valleys, bamboo stands, and agricultural lands. They have been widely introduced throughout the world, primarily for upland game hunting, but also for viewing.[99, 104] Substantial revenues have been generated for state wildlife agencies and for local economies from upland game seasons.[73] The first successful introduction to the United States occurred in 1882 when Owen Denney, an Oregon attorney and judge, had 28 birds from China delivered to Portland.[138] He began breeding the birds, and they did so well that he was soon shipping them to other parts of Oregon, into Washington in about 1883, and, eventually, to other states. The first pheasant hunting in the United States occurred in Oregon in 1891. In 1911, the State of Oregon opened the first large-scale, state-operated game bird farm.[95] The facility in the Willamette Valley achieved peak production in 1950 when over 70,000 pheasants were reared and released. The State of Washington followed with the development of extensive game bird farms.[142] It has been estimated that about 100,000 pheasants were harvested in Washington in 1922,[142] and that number tripled by 1950.[95] More recently, however, many of the rearing facilities have been shut down because of increased costs, low survival rate of pen-reared birds, and other problems.[32] Interestingly, this situation has resulted in attempts to introduce another subspecies, the Sichuan pheasant, that is better adapted to wooded or shrubby habitats.[138] Pheasants are currently widespread in Oregon and Washington. The natural history of the pheasant in the United States and the Pacific Northwest has been recounted.[2, 99, 104, 138]

Ecological Implications. Although the introduction of pheasants and other upland game birds (see Table 3) has largely been considered positive, they are not without some adverse ecological effects. Concerns were expressed as early as 1923 in Washington that pheasants may damage crops (sprouting corn, potatoes) and gardens.[142] They compete for food and nest sites with native grouse species, especially because they are more adaptable and tolerant of disturbed landscapes and because they may be released in large numbers on a regular basis.[138, 150, 159] Their aggressive behavior can displace other birds. Nest parasitism with blue grouse, ruffed grouse, and other upland game bird species has been reported.[83, 132, 142, 150, 158, 159]

There is the potential for hybridization between pheasants, native grouse, and other upland game bird species,[8, 78] but the extent and seriousness of this effect is not known. The potential transfer of diseases, such as avian tuberculosis, to other bird species and even humans, pets, and livestock has been noted.[52]

Management and Research Needs. In Oregon and Washington, pheasants are classified as upland game birds and are managed with season lengths and bag limits to regulate the number of harvested birds. During most years, female pheasants have been protected from harvest to increase recruitment. Wild bird populations have been supplemented with pen-reared birds to increase harvest, although the use of this strategy has greatly declined. There have often been state and federal efforts to encourage agricultural crop producers to manage their lands for the benefit of pheasants and other upland game species. The Conservation Reserve Program is an example of one such program. Activities involve establishing or maintaining areas of woody or herbaceous vegetation; in drier areas, water sources ("guzzlers") may be provided.

It is likely that pheasants will be a less significant element of the Oregon and Washington introduced avifauna in the future. There are many reasons for this, including long-term declines in wild populations, the reduced emphasis on pen-rearing and release of birds, human encroachment on pheasant habitats, clean farming practices, and an increased interest in improving conditions for native upland game bird species. That being said, there is still substantial interest in this naturalized member of the Pacific Northwest fauna, and a wish to assure that its regional presence will continue.

2. European Starling

History, Distribution, and Status. The European starling is a palearctic species that originally ranged throughout Europe and east to Lake Baikal, Siberia, and the Middle East.[99] It has since become naturalized, via numerous introductions, to most of North America, South Africa, Australia, and New Zealand.[99] Starlings were purposefully

and successfully introduced to Central Park, New York City, in 1890-91, although the Portland Songbird Club attempted an introduction in Portland, Oregon, in 1889 that failed.[77] The species range expansion in North America is nothing less than amazing, reaching Mexico in the 1940s and Alaska in the 1970s.[16, 85] While numbers of starlings appear to have stabilized over much of North America, they are now one of the most numerous bird species in North America.[16] The species was introduced for aesthetic purposes, to bring a little of the Old World to the New World. Starlings first appeared in Oregon and Washington in 1943.[77] They are now abundant throughout most of Oregon and Washington, especially in urban/suburban and agricultural settings. The natural history of the species has been described.[16, 49, 104]

Ecological Implications. Few benefits have been attributed to the introduction of starlings in North America. Cabe[16] noted, however, that much basic research on avian biology has been done using starlings. Starlings have also been attributed with high levels of insect consumption, may be hunted, and may provide food for humans in some situations.[49] Finally, starlings occur in highly disturbed settings that might otherwise have few birds present.

Feare[49] reviewed the many adverse effects of starlings, including plant damage; food and nest competition with native bird species; disease and parasite transfer to wildlife, livestock, pets, and humans; fruit consumption and damage; livestock food consumption and contamination; aircraft strikes; and aesthetic problems (droppings, odors, noise). Much of the concern about ecological effects of starlings seems to involve their highly competitive ability to usurp nest cavities (both natural and man-made) and thus contribute to the declines in populations of native cavity nesters. Adverse effects have been noted for bluebirds,[39, 122] purple martins,[11] tree swallows,[122] northern flickers,[72] various species of woodpeckers,[71, 84, 147, 156] and various cavity nesting duck species.[50, 57, 105] Not only is it difficult for these species to find and hold nest cavities in the presence of starlings, but starlings may also parasitize the nests of other species by destroying eggs or hatchlings.[50, 57, 122] Brush[15] noted, however, that significant cavity competition probably only occurs where natural cavities are very limited.

Economic losses and damage to planted crops (corn, winter wheat), fruits (grapes, peaches, blueberries, strawberries, figs, apples, and cherries) and livestock feedlots have been described,[49, 80] as well as the disease problems caused by starlings.[49, 52, 80] Constantin and Floyd[26] discussed the hazards of starlings and other birds at airports. Typically, starling problems are quite localized.

Management and Research Needs. The manage-ment of starlings is problematic at best because of their exceptional ability to exploit human-altered landscapes.[49] Many methods are used to reduce starling numbers, the damage they cause, or to disperse aggregations. These include attempts at exclusion from buildings, ledges, and trees; cultural and habitat modifications that reduce food, water, and roost availability; the use of frightening devices based on chemicals, sounds, or objects; the use of repellents and sticky substances; the use of toxicants; shooting; and trapping, with or without live bird decoys.[80] Although some of these methods have been moderately successful for a while, most are of limited effectiveness and must be repeated on a regular and long-term basis.[16, 49] The difficulty of dealing with starlings at high density roosts has been documented by Glahn et al.[56] In all likelihood, a combination of methods and the alteration of crop and livestock production practices would be most likely to provide damage reduction or population reduction.[49]

Starlings are here to stay and can be expected to continue to impact some native bird species. We need to better understand the interactions of starlings with food sources, habitats, and other species and with the control measures that we employ. We also need to develop more effective damage management methods; research is underway on avian repellents and on immunocontraception. There has been some effort to develop specific methods to reduce the ability of starlings to usurp nest sites from other species; Grabill[57] attempted to increase wood duck nesting success by placing starling nest boxes near wood duck nest boxes. He relied on the agonistic behavior of starlings during nesting to keep other starlings from using the wood duck nest boxes. Fielder et al.[50] reduced starling use of wood duck nest boxes by covering the opening from the end of the wood duck nesting season until just before the initiation of the next wood duck nesting season. Lumsden[105] and McGilvrey and Uhler[109] also presented designs to reduce nest box use by starlings. Knowledge of starling flocking behavior was instrumental in the development of Avitrol, a chemical frightening agent. A few birds are allowed to feed on treated bait. They become sick, fly erratically, and give warning cries that frighten other starlings from the area.[80] Most starlings ingesting Avitrol will eventually die; therefore, the chemical must be used carefully to minimize secondary poisoning hazards.[66] Geis[53] noted that starling and house sparrow numbers could be kept at lower densities by the careful design of urban structures; latticework on apartment buildings, for example, was very attractive to starlings and house sparrows. These examples illustrate the value of a thorough knowledge of the biology and ecology, including behavior, of a species to assist in resolving conflicts.

3. Nutria

History, Distribution, and Status. The nutria is a large semi-aquatic rodent native to South America, which has been introduced into a number of areas in North America since the 1930s. Oregon and Washington are among 15 or more states with feral nutria populations.[161] Nutrias were first brought to the Northwest in the 1930s in the expectation that nutria farming would become a lucrative endeavor.[61, 89, 94] Inflated breeding stock prices, poor reproduction, large farming expenses, and little economic return for nutria pelts (~$1.00 per pelt) resulted in the collapse of an industry whose boom was short-lived.[47, 87,

[89, 161] More than 600 nutria farms existed in Oregon from the 1930s to the 1950s,[89] and a number of farms existed in Washington at this time.[61, 93] Flooding and storms damaged holding structures and allowed some nutrias to escape from fur farms, however, farmers often released their stock when farming became uneconomical. By the 1940s, nutrias had been captured by trappers or collected on both sides of the Cascades in Oregon and Washington, but most nutrias were found in the Puget Sound area, the Willamette Valley, along coastal Oregon rivers, and along the Columbia River.[70, 79, 89, 93, 108] Only the Yakima River drainage in southcentral Washington supports substantial numbers east of the Cascade Mountains.

The nutria is an unclassified wildlife species in Oregon and Washington, and it can be harvested in unlimited numbers at any time of the year. The records indicate fluctuating harvest levels of nutrias, which may reflect fluctuating pelt prices[152] rather than fluctuating population densities. Nutria harvest data also indicate a relatively stable population, in that nutrias are consistently captured in the same counties (i.e., nutrias do not appear to be spreading to previously unoccupied counties in appreciable numbers). Short-term stability, however, does not necessarily mean that all habitats suitable for nutrias have been colonized or that a range expansion will not occur in the future. The natural history of the nutria has been described in detail.[47, 87, 161]

Ecological Implications. Through foraging, nutrias can denude expanses of vegetation, eliminating vegetative structure.[87, 157] While nutrias are generally opportunistic vegetarians, Wentz[157] found that broadleaf arrowhead (*Saggittaria latifolia*) and smartweed (*Polygonum* spp.) were selected by nutrias in Oregon, and these plants may be locally reduced or extirpated by foraging nutrias. Nutrias construct resting and feeding platforms of compacted vegetation in wet areas, form trails between these platforms through vegetation, and also create grooming areas, dens, and runs or slides at the water's edge.[47, 87] These activities can significantly impact vegetative communities.[87, 157] The clearing of vegetation by nutrias may alter plant succession, and convert marsh ecosystems to more open-water environments.

In Louisiana, increasing nutria harvests in the mid-1900s coincided with decreasing muskrat harvests.[87] The apparent decline in the muskrat population could have been the result of many factors, but the nutria irruption was considered among the most significant. Apparent declines in muskrat numbers have also been observed in areas where nutrias are abundant on the Finley National Wildlife Refuge in western Oregon (H. Brunkal, U. S. Fish and Wildlife Service, pers. comm.). Alteration of the vegetative community would be expected to have a significant influence on native fauna, especially sensitive amphibians and species that have niches similar to the nutria (e.g., muskrat, some waterfowl). Unfortunately, little information is available on the direct or indirect impacts of nutrias on other fauna.

Nutrias cause direct and indirect impacts to humans by their foraging and burrowing activities, which result in damage to agriculture, drainage systems, earthen structures (dikes, levees, embankments), and vegetative communities.[47, 89, 96] Burrowing can disintegrate and weaken these structures, and may cause them to fail.[96, 161] Ironically, nutrias were introduced in some areas to help control marsh vegetation.[47] Kuhn and Peloquin[89] reported nutria damage to agricultural crops in the Willamette Valley and estimated losses of thousands of dollars per year. Humans, livestock and pets are vulnerable to a number of diseases and parasites carried by nutrias, including equine encephalomyelitis, leptospirosis, hemorragic septicemia, paratyphoid, salmonellosis, giardiasis, tapeworms, and liver flukes.[96, 161] The aggressive behavior of nutria also poses a hazard to pets that approach them too closely (J. Tabor, Washington Department of Fish and Wildlife, pers. comm.).

Personnel with the USDA Wildlife Services and state wildlife officers respond to nutria damage complaints. Although a number of damage prevention and control methods exist for nutrias,[96] commercial trapping appears to be the most common method used in Oregon and Washington. Some trappers have certainly benefited from the introduction of nutrias, although the monetary benefits appear limited as nutria pelts are not highly valued for fur.[152] Low pelt prices offer little incentive to most trappers and consequently, commercial trapping may be limited as a management tool for nutria populations. Conversely, control of pest nutria can be a source of income for some trappers and pest control professionals.

Management and Research Needs. Trapping and localized control efforts have been used to manage nutria populations since they were first introduced, and these techniques will likely continue to provide for nutria management in the future. Trapping records indicate a relative stable nutria population in the Pacific Northwest. Until new information indicates that nutria impacts are particularly severe to certain species, ecological communities, or geographic areas, it is unlikely that current management methods will be altered or replaced. Lobbying efforts to ban trapping or outcries for nutria eradication could alter the status quo, but these do not appear to be immediate issues in Oregon or Washington. With the exception of research by Peloquin[121] on growth and reproduction and Wentz[157] on nutria density and impacts to marsh vegetation, little study of the nutria has been conducted in the Pacific Northwest, and none has been published from Washington. Future research should focus on how the nutria's alteration of aquatic environments and its physical presence (i.e., potential competition and disease transmission) could impact sensitive fauna and vegetative communities. This research may also prompt study into alternative management techniques for nutrias.

4. Red Fox

History, Distribution, and Status. Native to North America, Europe, Asia, and northern Africa,[103] the red fox has the largest geographic range of any terrestrial carnivore with the possible exception of the domestic cat.

European red foxes were introduced to the East Coast in the 1600s and 1700s[23, 126] and Australia in the mid 1800s[106] for fox hunting; actions that confused the taxonomy of red foxes in eastern North America and greatly expanded the range of the red fox. Non-native red foxes were brought to Oregon and Washington in the early 1900s for fur farming[40] and fox hunting or trapping.[4, 108, 160] In the 1910s, the fur industry was rapidly spreading west across the continent, when choice breeding stock and pelts from red foxes (predominantly the silver phase foxes) were sold for thousands of dollars.[40] By 1915, the first fox farms were established in Oregon and Washington.[40] Many introductions occurred when foxes were released or escaped from farms[3, 4, 40] or evaded hounds and hunters, forming free-roaming populations of non-native red foxes in both states. More recent introductions of red foxes in North America have included the release of pet foxes, the illegal release of farm foxes by animal rights activists, and the translocation of non-native foxes into previously unoccupied areas by pet owners, wildlife rehabilitators, and animal control officials.[102]

Non-native red foxes occur throughout many of the lowland areas in western Oregon and Washington[4, 5] and in several disjunct populations in eastern Oregon and Washington. The distribution of non-native red foxes has largely been determined as those areas where red foxes occur outside the historical ranges of native Cascade (*V. v. cascadensis*) and Rocky Mountain red foxes (*V. v. macroura*).[4, 5, 7, 62] The Cascade red fox historically occurred in the high-elevation meadows and parklands of the Cascade Range, whereas the Rocky Mountain red fox occupied similar habitats in northeastern Washington, and in the Blue and Wallowa Mountains.[7, 37, 62] Because relatively little information is available on the locations and operation of fox farms, especially in Oregon, and because there are no known means of visually distinguishing native from non-native red foxes, it is not known if introductions have occurred within the ranges of the native red foxes.

Red foxes are considered a furbearing species in Oregon and a furbearing game animal in Washington with no administrative distinctions made between native and non-native red foxes. Red foxes can be trapped in most areas of Oregon during a regulated season. In Washington, red foxes can be trapped during a regulated season except in Whatcom, Skagit, and Island Counties, and a portion of Cowlitz County. Because market prices strongly influence the harvest of most furbearer species, harvest data are not a good indication of fox population trends. While little information is available on population trends, there are no indications that fox populations in either state are increasing or decreasing dramatically. The natural history of the red fox has been described in detail.[103, 106, 141, 152, 153]

Ecological Implications. With the exception of excavating holes for dens and prey items, and leaving some uneaten prey remains scattered about, red foxes probably have little effect on their physical environment. Non-native red foxes feed on a variety of fruit-producing plants.[100] They also eat leafy vegetation, some of which may be ingested incidentally with other foods. Foxes may be important seed dispersers of both native and non-native plants. Den-site excavation and other digging could minimally disrupt flora, but would also expose a medium for seed germination.

Red foxes commonly prey on insects, earthworms, small- to medium-sized birds and mammals, and herpetofauna; predation on crustaceans and fish and the use of carrion has also been documented.[64, 100, 103] Red foxes are noted predators of species valued by humans as pets,[64] livestock,[58, 115] game birds and mammals,[45, 160] and endangered species.[164] Conservation of the snowy plover in Oregon and Washington could be hindered by red foxes should they become established near nesting colonies along the coast, as has happened in California. Interference with the reproductive behavior of native fauna, especially ground-nesting birds, can be significant.[166] Aubry[4, 5] suggested that non-native red foxes might not be physiologically or behaviorally capable of surviving in high-elevation habitats. However, an introduction of non-native red foxes within the historical ranges of native red foxes could result in resource competition, interbreeding and disease transmission.[5, 101] It is unknown if interbreeding with non-native foxes would reduce the fitness of native red fox populations. The transmission of diseases, including sarcoptic mange, rabies, canine distemper, parvovirus, and leptospirosis, is a threat that red foxes pose to other mammals.[103] Additionally, resource competition,[81] disease transmission, and interbreeding[145] would be expected to negatively affect native kit foxes should red foxes become established in southeastern Oregon.

Foxes may negatively impact humans in several ways, including livestock depredation, crop damage, disease transmission to humans and their pets, and predation or injury of pets. More indirectly, non-native red foxes may negatively impact humans by affecting species valued by the public (e.g., game or protected species). Positive impacts to the public include recreational and economical opportunities of trapping, hunting, and fur farming, and the recreational opportunities of feeding and watching wild foxes, along with the enjoyment from having foxes as pets; the latter is strongly discouraged by wildlife professionals.

Management and Research Needs. Relatively little is known about the populations of non-native red foxes in Oregon and Washington. Non-native red foxes provide additional harvest opportunities for trappers, and management in this regard comprises season restrictions and harvest regulations. Management has also involved communication with the public about occasional livestock kills and concerns about fox predation on domestic cats. Damage prevention and control methods for red foxes were reviewed by Phillips and Schmidt.[123] The wide distribution of red foxes in western Oregon and Washington reflects the potential for disease transmission to pets, livestock, other wildlife, and humans, with rabies being of particular concern. Research on non-native red foxes to determine distribution and densities, identify

disease prevalence, and characterize food habits is needed to better understand populations and potential impacts in Oregon and Washington.

5. Bullfrog

History, Distribution, and Status. Bullfrogs are native to North America east of the Rocky Mountains; however, their range has greatly expanded due to introductions by humans in western North America, South America, Europe, and Asia.[14] Bullfrogs were first introduced into the Northwest in the early 1900s to provide food (i.e., frog legs), opportunities for frog hunting, and stock for frog farms.[92, 140] Being the largest frog in North America, bullfrog legs were a highly prized food, and frog farming to supply the demand for bullfrog legs was undertaken but rarely succeeded.[14] Lampman[92] states that bullfrogs from Idaho were first brought to eastern Oregon in 1914, and subsequent introductions in western Oregon in 1921 involved releasing additional Idaho bullfrogs and bullfrogs from the previously introduced populations in eastern Oregon. Nussbaum et al.[113] reported the release of 18 bullfrogs in the Grant's Pass area in 1931 and that bullfrogs were soon well established in the upper Rogue River Valley. In Washington, Dvornich et al.[43] reported the first specimens collected in the 1930s, which suggests that the first successful introductions occurred in the 1920s and early 1930s.

Bullfrogs are largely aquatic and occur in lower-elevation freshwater habitats on both sides of the Cascades in Oregon and Washington and along much of the Columbia River.[97] Within this range, the bullfrog has become widely established and locally abundant because it is a capable colonizer of a wide variety of habitats and a prolific breeder.[14] They are classified as a game fish in Oregon and as a game species in Washington; however, these classifications may soon change in both states. Fishing or hunting license (in Oregon and Washington, respectively) is required to harvest bullfrogs and there are season restrictions, but no bag limits. Bullfrogs may still be expanding their range as suitable habitats are colonized by invading or introduced individuals. Humans continue to introduce bullfrogs into new, previously unoccupied areas. Water-garden and pond stores in Vancouver and Portland recently sold bullfrog tadpoles from California and North Carolina (at $3.00 per tadpole) to individuals interested in stocking their ponds with bullfrogs (selling or possessing live bullfrogs is illegal in Washington without a permit). Also, some summer festivals include a frog-jumping contest where captured frogs (often bullfrogs) may be released after the contest into previously unoccupied habitats. The natural history of bullfrogs has been described in detail.[14, 113]

Ecological Implications. Both tadpoles and adults feed on vegetation,[14, 113] although plant consumption by adults is likely the result of incidental ingestion while capturing a prey item. Consumption of vegetation by bullfrog tadpoles could constitute an impact on local flora and a significant indirect impact on native species that use this flora for food or cover,[90] but this consumption could make a substantial contribution to nutrient cycling in aquatic ecosystems.

Much of the literature on the bullfrog in western North America has been concerned with the effect of bullfrog predation on native fauna, especially other ranids.[42, 65, 86, 111] Kupferberg[90] demonstrated that bullfrogs negatively affected the growth of developing yellow-legged frogs by outcompeting them for food resources. Although many reports have implicated the bullfrog as a major cause of declines in some native species, Hayes and Jennings[65] argued that this has not been clearly proven and a number of other factors may be at work, such as predation by introduced fish, habitat alteration, commercial exploitation, and the effects of toxicants. However, until proven otherwise, it may be wise to consider bullfrog predation and competition as detrimental to a number of vulnerable, sensitive, or listed species in Oregon and Washington, including the Oregon spotted frog, leopard frog, red-legged frog, foothill yellow-legged frog, and western pond turtle. Bullfrog predation on hatchling western pond turtles has prompted management efforts to protect remaining populations in Oregon and Washington. Management efforts involve collecting hatchling turtles from western pond turtle nests and placing them in captivity until they are too large to be eaten by bullfrogs (R. Goggans, Oregon Department of Fish and Wildlife, and K. Slavens, Washington Department of Fish and Wildlife, pers. comm.). These efforts, which started in the early 1990s in Oregon and Washington, have been successful at recruiting young turtles into resident populations, and some female recruits from the first "head-started" cohorts are expected to be large enough to breed in 1999.

Bullfrogs are beneficial to some people as a source of food, sport, and economic gain. Universities and schools have created a significant demand for bullfrogs for use in classroom and laboratory study. Others simply enjoy the sound of bullfrogs or stock them for the pleasure of having bullfrogs on their property; the latter is strongly discouraged by wildlife professionals.

Bullfrog predation on and competition with native species are impacts that cause concern among many people. This concern may prompt a modification of the legal status of the bullfrog to allow for more effective bullfrog management and protection of native species vulnerable to bullfrog predation and competition.

Management and Research Needs. The predation and competition threats posed by bullfrogs to native species have prompted consideration of bullfrog eradication in some localized areas. Removing egg masses, killing adults, or promoting harvests of bullfrogs may act to reduce their impacts on native species. However, their local abundance, widespread distribution, ability to disperse and recolonize habitats, and the tendency for people to transplant bullfrogs, makes eradication difficult at best.[110] Perpetual bullfrog control may be required where management is important to protect or restore native species. Research efforts that determine the degree to which bullfrogs threaten native species, relative to other causes of species

decline, will help us focus our management actions on the most critical problems. Research into ways of controlling or eradicating bullfrogs without harming native species would also be valuable.[110] Studies that focus on single species or communities that may be impacted by bullfrog presence should also focus on obtaining data to credibly address the impacts of bullfrogs.

Conclusions

At least 42 introduced species of wildlife (birds, mammals, amphibians, reptiles) occur in Oregon and Washington. Introductions have occurred for many reasons, both accidental and purposeful. Some have greatly contributed to outdoor recreation, local economies, and state wildlife agency revenues, while others have had adverse ecological consequences through direct or indirect mechanisms (e.g., resource competition, displacement, predation, hybridization, and disease transmission). Economic losses to human-valued resources and public health hazards have been documented. There has been more stringent regulation of introduced species at the federal and state levels in recent years, in part due to the increased concern about potential harm to native flora and fauna. Options for resource managers include prevention of entry, eradication, and management after dispersal and establishment; the first is perhaps the most practical, while the latter is the most commonly employed option. Eradication is difficult and expensive in most situations. More surveillance and control at the point of origin is needed. A sustained effort, using a variety of methods and the principles of integrated pest management, is needed to limit adverse effects. Each situation must be assessed on a species- and site-specific basis. New methods are needed to improve the monitoring and management of introduced wildlife.

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