

# Threats to Biodiversity: A Case Study of Hawaiian Birds

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## Background Reading

What is biodiversity? Defining biodiversity is a difficult and complex task that depends on the level of analysis used to categorize a region. At the ecosystem level, biodiversity may be defined as the number of biomes in a given region. Biomes are large ecosystems that are characterized by vegetation, precipitation gradients, moisture gradients, elevation, and latitude. At the organism level, biodiversity is the number of species in a given area. This would include not only the number of species, but also the number of populations of each species in a given area as well as information about the size of these populations. A third definition of biodiversity is based on genetic diversity. Genetic diversity refers either to the number of alleles in a given population or to the number of rare alleles present in the population.

Yet another way to conceptualize biodiversity is to think of it as evenness. Evenness can be applied at multiple levels of analysis (biomes, species, or alleles). For example, evenness may consider the number of species in a given area relative to the total number in that area. A region with five species found in equal abundances is more diverse than a region with five species where only one of those species is abundant and the other four species are encountered less often. Because biodiversity is defined in different ways and at different levels in biology, monitoring the biodiversity of a particular region can be a difficult task. The integration of all levels of analysis leads to complex and often conflicting descriptors of biodiversity.

Regardless of how biodiversity is defined, there is little question that it is declining. Though most of the public's attention is focused on a few charismatic endangered species, such as the Northern spotted owl, the gray wolf, and the giant panda, these are only a minuscule fraction of the number of species that are threatened, endangered, or already extinct. The North Carolina Natural Heritage Program, an affiliate of The Nature Conservancy, the world's premier data collector on biodiversity, is tracking the populations of one bird, two salamander, four fish, seven mollusk, six insect, and 35 plant species in Durham County, North Carolina, alone. Not all of these species are in immediate danger of going totally extinct. In fact, only two plants, the smooth coneflower and Michaux's sumac, are federally protected as "Endangered Species." Some of these species are rare in North Carolina but common elsewhere. However, the process of extinction begins with the extirpation of local populations, and it usually happens without our knowledge.

Biodiversity is threatened by disruptions to the natural ecosystem that limit the resources needed by an organism (e.g., light, water, food, or space) or alter how that organism interacts with other organisms (e.g., competition and predation). Two phenomena that create these types of disruptions include the establishment of **exotic**, or **introduced species**, and **habitat fragmentation**. The establishment of introduced species threatens indigenous biota. Introduced species are brought to an area either intentionally or by accident and are not part of the native ecosystem. Although most introduced species fail to survive in a new habitat, some actually

thrive and can out-compete native species, prey on native species, transmit exotic diseases, facilitate the spread of native diseases, hybridize with natives, and alter habitats. Some of these effects are observed with the salt cedar, a tree that derives its name from the fact that it concentrates salts in its leaves. This drought-tolerant tree was introduced into the western United States in the early part of the last century to control erosion. It spread rapidly, and now many streams, particularly in the southwest, are lined with nothing but salt cedar. The leaf litter causes the soil to become too saline for native cottonwood and willow seedlings to establish. Given that the native vegetation along southwestern rivers and streams is possibly the most productive habitat for breeding birds in North America, it is not surprising that bird populations have been affected, including the endangered southwestern willow flycatcher and Bell's vireo (cowbirds are also a problem for these species).

Along with introduced species, habitat fragmentation may disturb native ecosystems. When people alter natural areas, for example, through agriculture or urban sprawl, the habitats needed to sustain native species are often eliminated. The remaining natural areas are left isolated. This process is referred to as habitat fragmentation. This problem is one of the major concerns of conservation biologists. With habitat fragmentation, the direct loss of suitable habitat is not the only problem. Other, less obvious effects can also be important. For example, breaking up large populations into smaller ones that cannot remain self-sustaining may result in loss of genetic exchange among different populations, or increased edge effects. In the take-home exercise, you'll learn how the introduction of ungulates such as cattle, goats, or pigs by humans has led to habitat fragmentation.

But why should humans worry about introduced species, habitat fragmentation, or even extinction? Practically speaking, numerous species fulfill crucial ecological roles in our biosphere by recycling nutrients, producing oxygen, or pollinating plants, while other species are actual or potential natural resources that can be used for crops, fibers, and medicine. Reservoirs of genes for disease resistance can be found in the wild relatives of crop plants or domestic livestock. When the value of biodiversity is assessed in terms of ecology and resources, its importance to human health, the economy, social justice, and national security can be appreciated.

In this assignment you will examine the biodiversity crisis using the Hawaiian Islands as a case study. This archipelago is geographically diverse in size, elevation, and habitat type and is historically rich in biodiversity. Hawaii's flora and fauna is an example of how isolation can lead to adaptive radiation (the emergence, from a common ancestor, of numerous species to fill underused niches). This has produced many very specialized species, most of which are endemic, meaning they are found nowhere else on Earth. However, these species are particularly vulnerable to the effects of introduced species, habitat loss and fragmentation. To put the magnitude of the problem in perspective, the Hawaii Natural Heritage Program tracks 30 vertebrates, 102 invertebrates, and 515 plants that are considered to be "critically imperiled globally" (1-5 occurrences and/or fewer than 1,000 individuals remaining, or more abundant but facing extremely serious threats range-wide) or "imperiled globally" (6-20 occurrences and/or 1,000-3,000 individuals remaining, or more abundant but facing serious threats range-wide). For comparison, in New Jersey, which is approximately the size of Hawaii, the Natural Heritage Program tracks 3 vertebrates, 14 invertebrates, and 21 plants that are "critically imperiled

globally" or "imperiled globally." We will attempt to understand some of the reasons why, over the last several centuries, there has been a massive decline in Hawaii's biodiversity.

### References:

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## Assignment:

Examine the data presented in Table 1, and answer the questions

**Table 1. Status of native birds breeding in the Hawaiian Islands.**

Group	Species Known to Have Existed	Current Species	Endangered or Threatened Species	Number of Extinct Species
Seabirds	22+	22	2	
Herons	1	1	0	
Ibises	2	0	-	
Waterfowl	11	3	3	
Hawks	3	1	1	
Rails	11	2	2	
Stilts	1	1	1	
Owls	4	1	0	
Crows	3	1	1	
Honeyeaters	6	2	2	
Old World Flycatchers	1	1	0	
Old World Warblers	1	1	1	
Hawaiian Thrushes	6	3	2	
Honeycreepers	45	20	9	
Totals	117+	59	24	

Table 1 modified from Scott, J.M., C.B. Kepler, C. van Riper III, and S.I. Fefer. (1988). Conservation of Hawaii's vanishing avifauna. *Bioscience* 38(4):238-253.

1. One factor that leads to a decline in biodiversity is the introduction of non-native species. However, most species that are introduced to an area do not become established. What are some characteristics of species that might make them more likely to thrive in a new habitat?

2. Several species of large rats arrived to Hawaii as stowaways on ships. These rats live in a variety of habitats and eat a variety of foods, both plants and animals. Speculate about how these introduced rats could directly and indirectly affect native bird species.

3. Researchers hypothesize that several factors may affect the extent of predation by rats on birds. These factors include bird size, nesting site, and the amount of time young spend in the nest (duration of egg incubation and nestling period). Formulate a hypothesis about how one of these factors might affect predation.