Conservation and Environmentalism
An Encyclopedia

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to another is not always an isolated sequence as suggested above. A given species population can occupy more than one trophic level according to the source of the food energy consumed. Some carnivores prey on both herbivores and other carnivores that are at different levels in the food chain. Foxes, for example, feed on mice and rabbits, both are herbivores, and they also feed on raccoons and birds, which are both herbivores and carnivores. Actually, when hungry, foxes sometimes will feed on berries and other plant material and thus, in a limited way, are omnivores. This interlocking pattern of feeding is referred to as the food web rather than food chain. Humans feed on both plant and animal material, and therefore are omnivores. Humans are thus both low in the food chain when eating grains and high in the food chain when eating fish and beef.

The number of trophic levels in the food chain is often limited to four or five because of the rapid dissipation of energy in the food chain. For example, when one organism eats another, approximately 90 percent of the chemical energy consumed is dissipated as heat energy, and therefore only 10 percent is passed on in the form of living weight to the next level in the food chain. By this process, the biomass of organisms higher in the food chain is lower than that of organisms lower in the food chain.

The rapid decline in food availability for organisms high in the food chain can be illustrated with a pasture. The forage grasses and forbs in a hectare may produce about three tons of biomass per year. Only 300 kilograms (kg) of this biomass is available to the second level in the food chain after the herbivores have fed on the pasture forage. This declines theoretically to thirty, then three, and finally to only 0.3 kg at the fifth trophic level. If the decline in amount of biomass available to each succeeding level of the food chain is graphed it appears as a pyramid with the plants forming the base of the pyramid.

A complicating factor in investigating food chains is the different rates of metabolism in various organisms. For example, in an aquatic ecosystem, the plant community often consists of phytoplankton or microscopic plants. These small plants may have a high rate of metabolism and thus their standing biomass may be relatively small compared with the fishes that are feeding on them. When expressed in biomass, this aquatic system may not show a nice pyramid as was mentioned earlier for the pasture. Instead, the plant biomass for the aquatic system may be relatively small compared to the biomass of the fishes. However, in terms of total energy flow this food system is similar to the pasture. The phytoplankton, because of their high rate of metabolism, supply approximately ten times the amount of energy that is present in the fish feeding on them. In fact, energy flow pyramids give the most accurate assessment of the roles of organisms at the various trophic levels.

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Further Readings

See also BIOACCUMULATION; KEYSTONE SPECIES; WEB OF LIFE

Forest Fires and Conservation
Large and recurrent lightning-caused fires are widespread in conifer forests and pine or oak savannas worldwide. The general rule is that 95 percent of the area burned is due to 5 percent of the fires. In other words a few large fires burn most of the area. These large fires generally recur in any given locality at fifty- to 200-year intervals.

Studies indicate that weather plays a key role in determining the fire regime of different forests. The fire recurrence period is determined by the frequency of an ignition source which has been preceded by a period of warm dry weather. There are generally ample ignition sources as indicated by the large number of fires that occur in most years in forested regions. However, the area burned in a typical fire is usually small because the fuel moisture is not low enough to allow the rapid spread of fire. In occasional years anomalous high pressure weather systems persist over a large area for extended periods, resulting in extreme fuel drying conditions. In such years very large areas are burned. Two recent years with these conditions occurred in Canada, for example, in 1981 when 5.4 million hectares of forest burned and in 1989 when 7.6 million hectares burned. This compares to an average annual area burned in Canada over the past fifty years of approximately 1 million hectares.

Despite the intuitive expectation that fuels are as important as weather the mechanisms that determine forest fire behavior indicate that variation in fuel variables can change fire behavior only 100 times while variation in
weather variables can cause a change of 1,000 times. Furthermore forest fires are largely propagated by fine dead fuels; therefore, large tree trunks have little influence on the spread of fires.

In using prescribed fires ecologists and resource managers first define the desired ecological effects and then couple those to the appropriate fire regime. Fire regimes are characterized by fire intensity, duff consumption, fire frequency (interval between fires), and size and pattern of burns, each of which produces particular ecological effects. The prescription in prescribed fires is the explicit statement of both the fire regime and the ecological effects.

Fire Intensity
Fire intensity is the heat output kilowatts per meter (kW/m) from the flaming front. It is related by a simple equation to flame length which is readily measured. The greater the fire intensity (greater flame length), the more likely a tree will be killed, either by scorching the canopy leaves or by killing the cambium around the base of the tree.

Duff Consumption
Duff consumption is the percentage of the duff layer consumed by the fire. The duff layer is the partially decomposed organic horizon above the surface of the mineral soil but not including the litter that lies on top of the duff. The ecological effects of duff consumption include mortality of plants rooted in the duff (a large number of herbaceous plants) and of dormant seeds. Furthermore duff removal exposes mineral soil which is the best germination surface for most forest trees.

Interval between Fires
The interval between fires will determine whether trees have had enough time to reach reproductive maturity. If fires come too short an interval tree species can be eliminated from the forest because they will not yet be producing seeds.

Size and Pattern of Burns
Sizes and shapes of burns are very important in determining the regeneration pattern of forests. Most seeds effectively disperse to a distance of about four times the height of the parent tree; therefore large burns without surviving seed trees could have regeneration problems. Fortunately most large fires contain numerous patches of surviving trees and therefore the dispersal distances to any part of the burn are not generally great. A few species such as jack pine (Pinus banksiana) and lodgepole pine (Pinus contorta) have cones which require heat to open and consequently have aerial seed banks that survive the fire.

At one time conservationists thought fires were destructive to natural ecosystems. However, by the 1970s, fire was recognized as a natural part of ecosystems to be used along with other forest management techniques. The scientific knowledge of fires has only developed in the past forty years. Consequently for most ecosystems there is still a limited understanding of the relationship between fire behavior and its ecological effects. In addition incorporation of this scientific understanding of fires has been slow as illustrated by the persisting ideas of the widespread distribution of old-growth forests in North America in pre-settlement times and of the effectiveness of fire suppression.

It is a common belief that, at the onset of European occupation, North America was covered largely by old-growth primeval forests. However ecologists have found by studying natural disturbances such as fires that forests over 400 years old made up less than 20 percent of the natural landscape, in many cases less than 5 percent.

Another common belief is that fire suppression has been effective in decreasing the frequency and intensity of forest fires. Although fire suppression has been reasonably successful in grassland/savanna vegetation and in isolated blocks of forest it is now clear that there are limitations to fire control in large areas of continuous forest. In such areas fire suppression is only effective in years when fuel moisture conditions are high enough that the area burned by fires would not be large, even in the absence of suppression. The large area burned in the decade of the 1980s has enforced the understanding that weather, and not fuels, determines fire behavior and hence the size of fires. Weather affects large areas (thousands of square kilometers at a time) allowing large numbers of fires to ignite and spread rapidly under very dry conditions. Under such conditions the only economically reasonable approach is for firefighters to focus on public safety and values at risk.

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Further Readings


See also Foresty; History of; Landscape Ecology; Old Growth Forests

Forest Fragmentation and Bird Habitats
Fragmentation of forests by human or natural causes decreases forest-interior habitats or “core areas” (i.e., forest areas over 100 meters from an edge) and increases forest edge. The size, shape, and age of a forest fragment, as well as the forest structure all affect the amount of core area available for forest-interior birds. Increasing forest fragmentation on breeding grounds generally leads to reduced population abundance, reduced pairing and nesting success of forest-interior birds, and increased abundance of forest-edge species. Although larger forest fragments may harbor a high abundance of forest-interior birds, nesting success is often significantly lower than that of birds in continuous forests.

Forest-interior species are often absent in small forest patches, despite the presence of forest areas large enough for many territories. The biogeography model of true islands is often invoked to explain the low abundance of such species in isolated forest patches. When species extinctions—through emigration and mortality—are not sufficiently counterbalanced by immigration or reproduction species abundance in isolated forest patches declines. Rates of immigration can be affected by distance from continuous forest and the amount of forest habitat available nearby. In contrast the abundance of forest-edge species appears more closely tied to vegetation complexity than to forest size.

Neotropical migrants appear particularly vulnerable to forest fragmentation on their North American breeding grounds. Many of these species nest on or near the ground and use open-cup rather than cavity nests. Open-cup nests are especially prone to nest predation and brood parasitism. Brood parasitism, the practice of birds laying their eggs in the nests of other birds, is a significant threat in some regions of North America, as cowbird species expand their ranges. Predator and parasite numbers often are higher near forest edges, resulting in increased nest losses for forest birds near edges. Because they migrate earlier and arrive later than residents and short-distance migrants, neotropical migrants are less apt to renest and, therefore, less able to recover from nest losses. Return rates of territorial adults to smaller forests are often lower than those in contiguous forests. Although minimum forest size for species presence has been estimated for many species little is known about minimum forest size necessary to maintain self-sustaining populations. Moreover minimum size may vary with habitat quality and landscape attributes.

Nearly half of all neotropical migrants breeding in North American forests winter in tropical forests. Fragmentation on the wintering grounds also reduces abundance and survivorship for such forest specialists. Tropical and subtropical forests harbor many forest-specialist species. Forest endemics such as the harpy eagle, resplendent quetzal, woodcreepers, and tropical antbirds are particularly vulnerable to deforestation. Frugivorous species may require an extensive continuous forest to locate ephemeral food. Some species are restricted to forest of a certain altitude, such as the blue bird of paradise of New Guinea. As tropical forests are converted to agriculture, harvested, and developed populations of both wintering migrants and resident tropical forest species decline. Although second-growth forest patches and hedgerows provide habitat for some forest-specialists in many regions forest habitat is scarce.

Fragmentation may diminish the overall habitat quality compared to similar areas in larger forests. Changes in microclimate, sunlight, and vegetation may intensify seasonal and annual weather cycles, reduce insect abundance, and affect the food availability for insectivorous birds. This, in turn, may result in larger forest bird territories in small forests. Edge species are often more aggressive and may compete with interior species for limited resources.

Composition of the surrounding habitat influences the type and extent of fragmentation effects on forest-interior birds. Suburban and agricultural edges, for example, attract different predator communities. The distance of the fragment from a contiguous forest and the degree of isolation from other woodlots is known to affect colonization and impact mating success and abundance. A higher proportion of forested to open area surrounding a fragment can mod-