

## AGROFORESTRY

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**Fields of Study:** Biology; Botany; Ecology; Economics; Ecosystems; Energy; Environment; Environmentalism; Forestry; Horticulture; Life sciences; Plants and vegetation; Preservation; Public policy; Renewable resources; Wildlife conservation

### ABSTRACT

*Agroforestry is an agricultural practice in which conventional agriculture crops are grown among forested areas. The practice has been used since ancient times by Indigenous peoples worldwide and is seeing a resurgence of interest in the present as a sustainable practice utilizing the natural environment.*

### PRINCIPAL TERMS

*annual crops:* plant crops that complete their life cycle from seed to fruit on a yearly basis, such as grains and various flowers and herbs

*carbon cycle:* the natural cyclic process of the planet by which its carbon content is cycled through various forms and states such as carbon dioxide, carbonate minerals, and biological entities, without changing the overall carbon content of the planet

*carbon sequestration:* a condition in which atmospheric carbon, as carbon dioxide, is removed from the atmosphere and isolated from the natural carbon cycle of the planet for an indefinite period of time

*perennial crops:* plant crops that regrow year after year without the need for reseeding, such as trees and plants that regrow each year from an established root system

### BACKGROUND AND HISTORY

Agroforestry encompasses a broad range of land-use practices involving the integration of trees with annual crops. Though as old as agriculture itself, agroforestry has only recently attracted scientific attention. Many agroforestry practices have the

potential to contribute to climate change mitigation, adaptation, or both. A land-use system is defined as agroforestry if it includes at least one perennial species (generally a tree) and one crop species that interact on the same land. Usually, the role of the trees is to provide the crop with nutrients, shade, improved soil quality, physical support, or protection from wind, water, or pests. The goal is to achieve a net benefit as compared to growing the species in monocultures. The complementarity can be economic (e.g., income diversification) as well as biophysical. Agroforestry systems may also provide fuelwood, timber, fruit, and other products. However, when trees are grown solely for these purposes and are not intended to improve cropland, the practice is usually not considered agroforestry.

### AGROFORESTRY AND CLIMATE

Agroforestry trees can contribute to climate mitigation by sequestering carbon in their biomass, in the soil, and in wood products. Although agroforestry systems usually store less carbon per unit area than do conventional forests, they have the advantage of allowing the land to remain in use for the production of food or other crops. Additionally, a large total land area is suitable for agroforestry practices, implying a potential for large-scale carbon sequestration—similar in magnitude to that of reforestation, according to a 2000 estimate by the Intergovernmental Panel on Climate Change (IPCC). However, the distributed and diverse nature of agroforestry poses challenges for carbon accounting. Carbon sequestration alone is unlikely to drive the adoption of agroforestry, but it can provide a coincentive.

Agroforestry can also play a role in climate adaptation. Trees can moderate local microclimate, protecting crops by lowering temperatures and reducing soil evaporation. They can ameliorate drought by improving soil water-holding capacity. They can

(such as fires, pollution, poaching, increasing demands for recreational sites, and urban development).

In addition, the act provided that any decision concerning the use and development of these lands must be approved by the secretary of the interior to ensure that such development does not violate the mission of the refuge system. The act also provided guidelines for specific recreational uses of the public lands: controlled hunting and fishing as a way to manage game populations, photography, educational uses for students of all levels, and environmental education and scientific research. Finally, the act defined a protocol for the acquisition of new lands, either through donation or through government funding.

The National Wildlife Refuge System Administration Act did not satisfy everyone; under pressure from vested interests, Congress did not include farming, grazing, or oil and gas drilling among the activities restricted in wildlife refuges, for example (these activities were included in the 1997 National Wildlife Refuge System Improvement Act). The act accomplished a great deal, however, in creating the world's largest system of public lands designated as sanctuaries for plant life and wildlife.

—Joseph Dewey

#### Further Reading

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## PRESERVATION OF OLD-GROWTH FORESTS

**Fields of Study:** Advocacy; Agencies; Botany; Conservation; Ecology; Ecosystems; Energy; Environment; Environmentalism; Ethics; Forestry; Forests; Horticulture; Life sciences; Organizations; Plants; Policy; Protest; Renewable resources; Vegetation

#### ABSTRACT

*People involved in the timber industry generally view the large trees found in old-growth forests as a renewable source of fine lumber, but environmentalists argue for protection of these trees, asserting that they are part of ancient and unique ecosystems that can never be replaced.*

#### PRINCIPAL TERMS

- old-growth forests:* forests containing many trees that have never been harvested by loggers
- deforestation:* the loss of forestlands through encroachment by agriculture, industrial development, or unsustainable commercial forestry
- forest policy:* high-level governmental plans of action for managing the use of forests in a country
- hectare:* a unit of surface, or land, measure equal to 100 acres, or 10,000 square meters (equivalent to 2.471 acres)
- sustainability:* in 1987, the United Nations Brundtland Commission defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs”

#### BACKGROUND AND HISTORY

In the 1970s scientists began studying the uncut forests of the Pacific Northwest and the plants and animals that inhabit them. One of the first results of this research was the US Forest Service publication *Ecological Characteristics of Old-Growth Douglas-Fir For-*

ests (1981). In this report, biologist Jerry Franklin and his colleagues revealed that these forests are not just tangles of dead and dying trees; rather, they constitute unique, thriving ecosystems made up of living and dead trees, mammals, insects, and even fungi.

The lands usually referred to as old-growth forests are located primarily on the western slope of the Cascade Mountains in southeast Alaska, southern British Columbia in Canada, Washington, Oregon, and Northern California. The weather in these regions is wet and mild, ideal for the growth of trees such as Douglas fir, cedar, spruce, and hemlock. Some studies have shown that there is more biomass, including living matter and dead trees, per

hectare in these forests than anywhere else on earth. The trees in old-growth forests may be as tall as 90 meters (300 feet) with diameters of 3 meters (10 feet) or more and can live as long as one thousand years. The forest community grows and changes over time in such a forest, not reaching biological climax until the forest consists primarily of hemlock trees, which are able to sprout in the shade of the sun-loving Douglas fir.

One of the most important components of the old-growth forest is the large number of standing dead trees, or snags, and fallen trees, or logs, on the forest floor and in the streams. The fallen trees rot very slowly, often taking more than two hundred years to disappear completely. During this time,



*Old-growth European beech forest in Biogradska Gora National Park, Montenegro. Photo by Snežana Trifunovi?, via Wikimedia Commons.*

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## TROPICAL RAINFORESTS

**Fields of Study:** Agriculture; Biology; Botany; Conservation; Earth systems modeling; Ecology; Ecosystems; Environment: Environmentalism; Forestry; Forests; Horticulture; Life sciences; Plants; Politics; Renewable resources; Standards and practices; Vegetation; Water resources; Zoology

### ABSTRACT

*Tropical rainforests are forest biomes with an average rainfall between 67 inches (170 centimeters) and 400 inches (1,016 centimeters). The World Wide Fund for Nature (WWF) defines them as a type of tropical wet forest, tropical moist broad-leaf forest, or lowland equatorial evergreen rainforest. Tropical rainforests are found in the equatorial zone between the Tropics of Cancer and Capricorn, roughly between latitudes 28 degrees north or south of the equator, where the direct angle of the sun rays causes high rates of evaporation. As water vapor evaporates from the forests, it rises, cools, and falls about an eighth-inch per day, giving these forests their name. Average humidity is usually around 77 to 88 percent. Mean monthly tempera-*

*tures exceed 64 degrees F (18 degrees C) throughout the entire year. Tropical rainforests are found in five major geographical areas: Central and South America in the Amazon River Basin; Africa in the Zaire Basin; a small amount in West Africa and East Madagascar; in Indo-Malaysia on the west coast of India, Assam, southeast Asia; as well as New Guinea and Queensland, Australia.*

### PRINCIPAL TERMS

*biome:* a specific type of ecological community that is maintained in a relatively stable equilibrium and is characterized by specific environmental conditions and a distinctive group of flora and fauna

*canopy:* the upper reaches of a forest where the branches of individual trees meet and provide an overall shade from sunlight

*carbon sink:* plant growth, mineral formation, and synthetic activities that act to remove carbon dioxide and other carbon sources from the environment

*carbon sequestration:* a condition in which atmospheric carbon, as carbon dioxide, is removed from the atmosphere and isolated from the natural carbon cycle of the planet for an indefinite period of time

*ecosystem:* an ecological community functioning collectively as a unit with its environment

*habitat:* a place that is natural for the life and growth of an organism

*hectare:* a unit of surface, or land, measure equal to 100 acres, or 10,000 square meters (equivalent to 2.471 acres)

### BACKGROUND AND HISTORY

There are four main types of rainforest; lowland equatorial evergreen rainforest, moist deciduous and semievergreen seasonal forests, montane rainforests, and flooded forests. Lowland equatorial evergreen rainforests have high rainfall throughout the year. They form a belt around the equator of the globe, covering the Amazon Basin of South America, the Congo Basin of central Africa, Indonesia, and

New Guinea. Moist deciduous and semievergreen seasonal forests have high rainfall overall but have a distinct warm summer wet season and a cooler winter dry season. Some species of trees in this type of rainforest even drop their leaves during the winter dry season to conserve water. These forests make up parts of South America, Central America and the Caribbean, coastal west Africa, India, and Indochina. Montane rainforests are also sometimes called cloud forests because of their almost constant shroud of fog. These forests are found in cooler-climate mountain areas, depending on the latitude, between elevations of about 4,920 and 18,827 feet (1,500 and 3,300 meters). Flooded forests are caused by seasonal flooding of tropical rivers. There are seven types of flooded forests recognized in the Tambopata Reserve in Amazonian Peru alone.

It is estimated that more than half of all plant and animal species are found in tropical rainforests, and there are likely millions of species yet to be discov-

ered. Many of these species are, or could be, important sources of food and medicine. Tropical rainforests produce about 40 percent of the Earth's oxygen and sequester carbon from the atmosphere, which helps to mediate climate change. However, due to heavy logging and clearing for agriculture throughout the twentieth century, tropical rainforests now cover only about 7 percent of the Earth's land surface. They are threatened globally by deforestation and fragmentation for agriculture and urbanization, mining, drilling, invasive species, and climate change.

### **MAKEUP OF TROPICAL RAINFORESTS**

Tropical rainforests are typically made up of four layers or zones typified by the structure of the vegetation. These different zones form habitats for a variety of animal species. Though this stratification is not always clear-cut, these four layers are generally found at different heights in the forest: starting at



*Photo via iStock/yusnizam. [Used under license.]*

keet, Vanuatu mountain pigeon, peregrine falcon, Vanuatu flycatcher, and golden whistler. Populations of these species vary widely, in part due to the cyclonic nature of the weather. Large population crashes are noted after severe storm activity, yet rapid recoveries tend to occur during intervening years.

### THE FUTURE OF THE RAINFORESTS

As an island nation, Vanuatu is severely threatened by rising sea levels caused by global climate change. Since 1993, sea levels have risen by an average of 6 millimeters per year (0.24 inches) per year. At the same time, the island has also been negatively impacted by extreme weather. In response, Vanuatu's government proposed the creation of a loss-and-damage fund that would both proactively combat climate change while remedying the effects it has already had on the nation. The proposed fund would carry a \$178 million price tag by 2030. It would include commitments to end the use of fossil fuels, greatly reduce emissions, and provide money to repair damage and reimburse losses caused by climate change.

—Robert C. Whitmore

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## WASATCH AND UINTA MONTANE FORESTS

**Fields of Study:** Animal husbandry; Botany; Conservation; Ecology; Ecosystems; Energy; Environment; Environmentalism; Ethics; Forestry; Forests; Geography; Geology; Horticulture; Life sciences; Mineral resources; Plants; Public policy; Renewable resources; Silviculture; Standards and practices; Vegetation; Water resources; Zoology

### ABSTRACT

*The coniferous montane forests of the Wasatch and Uinta mountain ranges are valuable resources threatened by wildfires, beetle infestation, and invasive plant species.*

### PRINCIPAL TERMS

- biome:* a specific type of ecological community that is maintained in a relatively stable equilibrium and is characterized by specific environmental conditions and a distinctive group of flora and fauna
- coniferous:* any tree that bears cones, and usually thrives year-round
- habitat:* a place that is natural for the life and growth of an organism
- montane:* an ecosystem contained within or including mountainous regions.

### BACKGROUND AND HISTORY

At the eastern edge of the Great Basin in the western United States, the Wasatch and Uinta Mountain ranges begin their dramatic ascent to elevations over 12,000 feet (3,600 meters). Beneath their peaks lies a deep green conifer forest, part of a unique ecoregion that stretches from the far corner of southwestern Wyoming to the Colorado plateau in southern Utah. The Wasatch and Uinta Montane Forests biome includes both the Wasatch Mountains, which form the backdrop for the Ogden, Salt Lake City, and Provo, Utah metropolitan areas, and the

Uintas, the highest east-west oriented range in the contiguous United States.

Though inaccessibility and conservation efforts have preserved pockets of undisturbed habitat throughout the region, most of the area has been impacted over the years by logging, mining, live-stock grazing, and recreational use. As a consequence, forest plant communities have been compromised, resulting in degradation of plant and animal habitat.

One hundred miles east of Salt Lake City, the treeless peaks of the Uinta Mountains rise 11,000-13,500 feet (3,400-4,100 meters) into rarified air. Consisting of quartzite, shale, and slate,

these broad, flat monoliths are the products of 70 million years of geological uplift and glaciation.

The Wasatch and Uintas are bordered by the Great Basin Desert to the west, and because they are also in the rain shadow of the Sierra Nevada range—much further to the west—they are more arid than the rest of the Rockies. They receive less than 20 inches (50 centimeters) of precipitation per year. The higher peaks, however, receive a great deal of dry snow.

### PRINCIPAL PLANT LIFE

Different species of conifers grow depending on varying soil types—in this case, either limestone or



*Coniferous forest with Kings Peak in the background, Uinta Mountains. Photo by Hkw2 at the English-language Wikipedia, via Wikimedia Commons.*