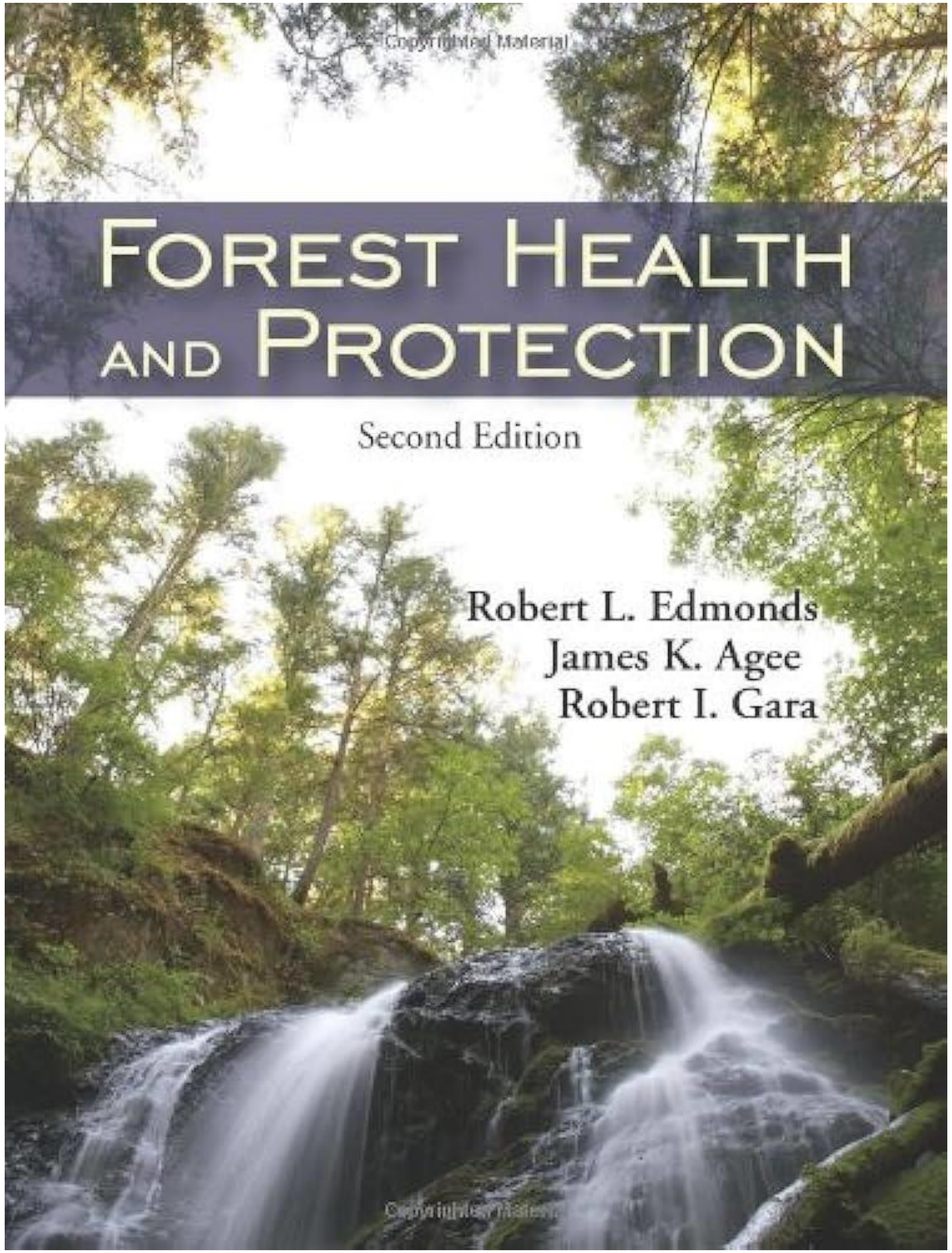

Course in Forest Protection
Master of Science Level
2023-2024

PhD. Dr. Zana Abubakr Ahmed Forest Ecophysiology

Introduction to Forest Diseases

- ✓ Organisms causing diseases occur naturally in forests, but until recently they were considered to be important only because of the losses they caused to forest productivity and timber volumes. New views of forest management, however, have forced us to examine the role of diseases in forest ecosystems, since disease-causing organisms play important roles in maintaining properly functioning ecosystems, particularly in providing wildlife habitat and biodiversity. On the other hand, introduced disease organisms can cause great ecological change in areas where trees have little natural resistance .All tree species suffer diseases, although some are more resistant than others. Some disease-causing organisms attack a wide variety of host species, while others have a very limited host range. Diseases thus can strongly influence forest succession by selectively killing certain species and not others. Improper management practices also can alter the role of native disease-causing organisms in forest ecosystems.

Definition of Disease and Types of Diseases

- ✓ Tree disease is defined as sustained physiological and/ or structural damage to tree tissues caused by biological agents (fungi, bacteria, viruses, phytoplasmas, nematodes, parasitic plants, and protozoans) or nonbiological agents (such as air pollution, etc.), ending sometimes in tree death. A third cause is a combination of abiotic and biotic stresses, such as freeze damage, predisposing trees to infection by canker or decay fungi. Examples of physiological damage are (1) impaired photosynthesis, which results in reduced food storage (e.g., starch) and reduced growth of shoots and roots, and (2) impaired water transport. An example of structural damage is decay. There are many definitions of disease and none is absolutely sacred. Disease also can be defined as a sustained impairment in function, structure, or form of an organism as provoked by biological, chemical, or physical factors of the environment.

A Brief History of Forest Pathology

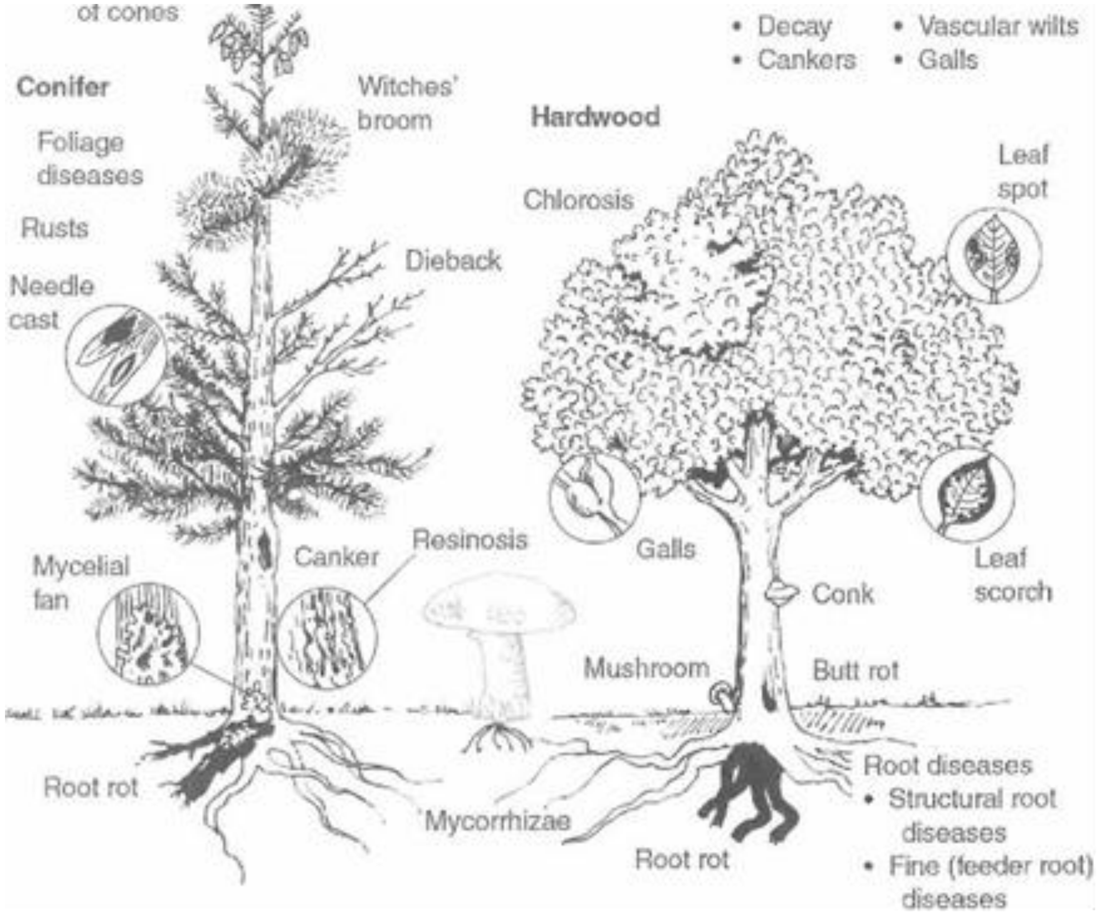

Figure 8.1
Classification of tree diseases by the part of the tree that is affected. (Source: From Callan and Funk, *Introduction to Forest Diseases*. © 1994 Natural Resources Canada, Canadian Forest Service. All rights reserved.)

Impact of Diseases

- ✓ Diseases can have both negative and positive impacts on forests as shown in Box 8.1. Tree mortality results in a loss of harvestable volume unless trees can be salvaged. On the other hand, dead trees provide habitat for a variety of wildlife species, including woodpeckers, which search for the larvae of bark beetles and other insects . It may be preferable to leave dead trees for wildlife rather than salvage them, depending on management objectives for the land. If trees have cavities resulting from decay, they are commonly used by cavity-nesting birds and bats, but decay also results in a loss of wood volume. Logs on the forest floor can act as nurse logs for seedling establishment and provide habitat for small mammals.

Some Examples of Negative and Positive Impacts of Forest Diseases

Negative impacts are considered to be related to timber and economic losses; positive impacts are ecological, especially related to wildlife habitat. These impacts are largely defined by human values and are subject to change.

- Mortality: negative and positive
- Reduced growth: negative
- Decay of merchantable wood: negative and positive
- Reduction in pulp yield: negative
- Stain and reduced wood quality: negative
- Delayed regeneration: negative
- Inadequate stocking (low number of trees per hectare): negative and positive
- Site deterioration-buildup of pathogens: negative
- Change in forest structure and function (e.g., nutrient cycling): negative and positive
- Change in species composition and species succession: negative and positive
- Change in ecosystem biodiversity (generally increase biodiversity): positive
- Creation of wildlife habitat: positive

The Disease Triangle, Square, or Tetrahedron

- ✓ Plant pathologists have long recognized that diseases develop only in the presence of a pathogen and if environmental conditions are correct .This insight resulted in the development of the concept of the disease triangle, relating host, pathogen, and the environment .This concept was expanded to the disease square .where the environment was subdivided into the physical and biological environments, and the disease tetrahedron, where time influences the relationship between pathogens, hosts, and the environment .

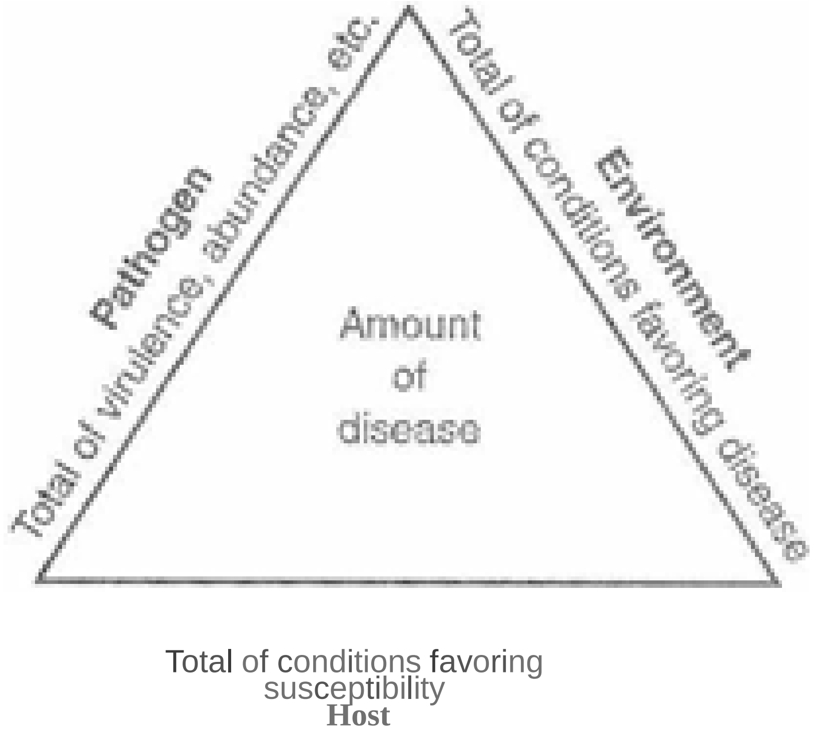

Figure 8.2
The disease triangle. (Source: From Agrios, G. N., *Plant Pathology,* 4th ed. © 1997 Elsevier.)

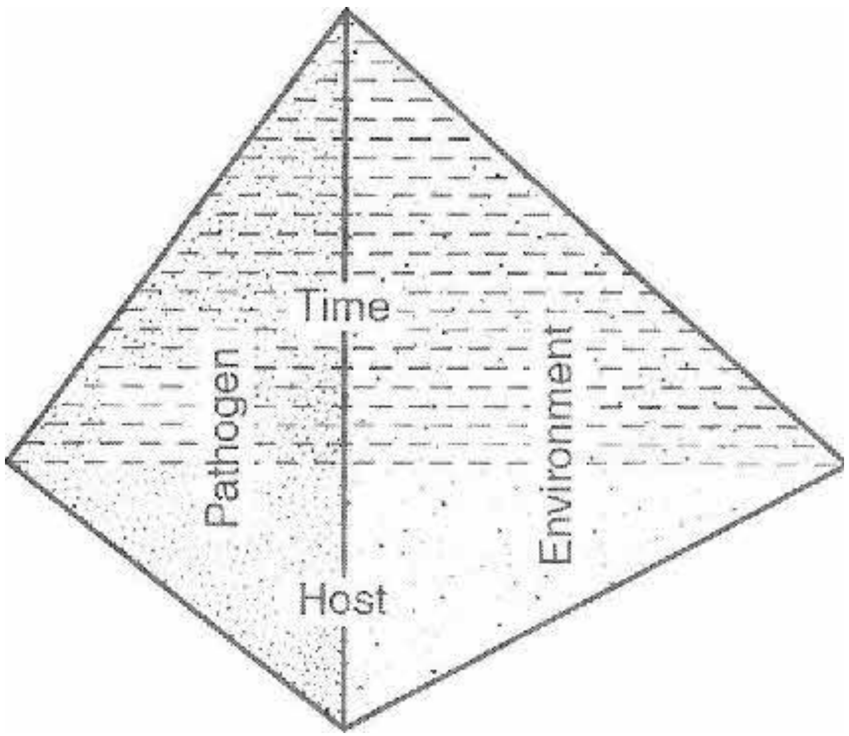

Figure 8.3
The disease tetrahedron. (Source: From Agrios, G. N., *Plant Pathology,* 5th ed., © 2005 by Academic Press.)

The Concept of Pathogens, Parasites, Saprophytes, and Symbiotic Relationships

- ✓ A pathogen is an organism that causes disease; a **parasite** is an organism that grows on or within another living species and derives part of its food from it .Pathogenic organisms can be autotrophic (deriving energy from photosynthesis, such as mistletoes) or heterotrophic (deriving energy from organic substrates, such as fungi). Heterotrophic organisms can be classified along a continuum including **obligate saprophytes, facultative parasites, facultative saprophytes, and obligate parasites**. Obligate parasites, such as the rust fungi and powdery mildews, must live on living hosts. Facultative saprophytes are mostly parasites but have the faculty to live on dead organic matter, like some root disease organisms. Facultative parasites are mostly saprophytes but have the faculty to live on living trees, such as wood decay fungi in living trees. Obligate saprophytes must gain their food from dead organic matter like decay fungi that only occur on dead logs.

Signs and Symptoms of Disease

Typical Signs of Pathogens and Host Symptoms

Signs (indicating presence of disease-causing organism)

Fungi

Fruiting bodies: mushrooms, conks, etc. Mycelial fans, ectotrophic hyphae, setal hyphae Rhizomorphs (resembling roots)

Spores: chlamydospores, conidia

Bacteria

Ooze or slime

Parasitic plants: presence of plants growing from tree branches Nematodes: presence of nematodes protruding from roots .

Symptoms: plant response

Necrosis: death of tissues or cells
Decay: decomposition of wood cells in roots and stem-sap, white and brown rots
Cankers: death of cambium cells (target, diffuse, with ooze, mechanical)
Leaf diseases: death of localized areas of cells-defoliation
Vascular wilts: death and plugging of parenchyma cells in branches, stems, and roots
Blights or diebacks: sudden death of all or part of tree
Hypertrophy: overgrowth of tissues
Witches' -brooms: proliferation of adventitious buds Galls: overgrowths on stems and branches
Leaf blisters: localized enlargements, puckering
Atrophy: lack of growth or failure of development Dwarfing
General, interveinal, or marginal chlorosis
Physiological and other responses :
Resin flow on stems and roots Chlorosis
Reddening
Excess cone crops

Resistance to Diseases

- ✓ Forest pathogens pose serious threats to tree survival, but the probability of death of anyone tree on an annual basis is relatively low .Resistance to pathogens varies from susceptible to tolerant to immune, where resistance is the ability of a tree to exclude or overcome the effect of a pathogen. A tolerant species can sustain the effects of a pathogen without dying or suffering serious injury or growth loss, whereas immune species are not affected. Trees have evolved both constitutive and inducible defense systems that deter or exclude pathogens chemically or physically .Constitutive defenses are present before infection by pathogens, such as resin ducts, physical barriers, or phenolic chemicals. These defenses can be compromised and subsequent resistance involves induced chemical resistance, including hypersensitive response and localized induced resistance. The inducible system may include secondary resins, additional phenolics, phytoalexins (low molecular weight antimicrobial compounds), and lytic enzymes like chitinases that can degrade fungal cell walls. Induced resistance occurs when the host plant is stimulated. Stimulations can include pathogens, nonpathogenic microbes, host-incompatible pathogen races, and chemicals.

Linkages between Diseases, Insects, Fire, and Wind

Diseases, insects, fire, and wind are strongly linked in ecosystems. Insects and diseases interact directly and indirectly . Many insects, particularly bark beetles and weevils, disperse the spores of vascular wilt fungi that cause Dutch elm disease, oak wilt, and black stain root disease. Indirect effects involve bark beetle attacks on trees that are weakened by root diseases, such as Armillaria root disease. Defoliating insects, like the gypsy moth, may weaken deciduous hardwoods, especially oaks, to the point where they are susceptible to Armillaria. bark beetles spread pine wood nematodes that cause a wilt disease.

Interactions between fire, insects, and diseases are strongest in areas where fire frequency and moisture stress is high, such as the conifer ecosystems. Fire scars at the base of stems provide entry points for decay fungi, especially in areas where fire frequencies are low and fires are intense in the productive cool temperate rainforests .On the other hand, fire has been suggested as a treatment for root diseases caused by Armillaria spp. and *Cylindrocladium clavatum*. Scolytid beetles also may attack fire-damaged trees.

Finally, wind can cause trees damaged by fire, insects, and pathogens to fall, creating fuel for future fires. Wind also creates wounds through branch and top breakage, resulting in entry points for fungi and insects.

Abiotic (Non biological) and Animal-Caused Injuries

- ✓ Abiotic or nonbiological factors, like extremes of temperature and moisture, lack of soil oxygen, air pollution, herbicides, nutrient deficiencies, elemental toxicities, salt, and lack or excess of light, can cause injuries and effects that resemble those caused by biological agents like fungi .Abiotic injuries also may make trees more susceptible to infection by fungi. The effects of mechanical injuries and fire also should be considered, although these act differently than the other factors and may not be considered as agents of disease because they occur in a discrete period of time. Likewise, extremes of temperature may not be considered as disease agents, although they certainly affect tree health. Animal injuries (e.g., bear damage) may resemble disease, so we also will consider this type of injury here.

The Pattern of Abiotic Injuries

- ✓ Abiotic injuries and effects can usually be distinguished from those caused by biotic agents. Diseases caused by pathogens tend to be more random, whereas abiotic injuries are mostly uniform or more nonrandom, but not always. As mentioned in chapter 8, some diseases caused by biological agents may have nonrandom symptom patterns (e.g., casting of needles of only one age on a conifer and aggregated mortality in a root rot "pocket"). An example of a systematic pattern caused by an abiotic agent is injury at the edges and between the veins of beech leaves caused by high sulfur dioxide (S02) concentrations in the atmosphere .Very cold temperatures also can cause necrosis at the tips and/ or edges of leaves and needles .This contrasts with hardwood foliage diseases, which typically have more random infection patterns .At the landscape level, cold-temperature injuries usually are related to cold air drainage patterns and may occur along valley bottoms .

Injuries Caused by Temperature Extremes

- ✓ Very high or very low temperatures can cause plant injuries. High-temperature injuries include heat defoliation, sugar exudation, and pole blight, which is exhibited as resin flow in pole-sized western white pine .Sunscald also is common. For example, young Douglas-fir trees are very susceptible to sunscald after thinning .Hardwood trees also are susceptible to sunscald. In the northern hemisphere most damage is in the south and southwest quadrants of stems where radiation loads are highest. Young trees are particularly sensitive because of their thin bark. Thinned and pruned trees may be more extensively damaged than thinned trees alone because the cambium is damaged. In ornamental plantings young trees growing close to south-facing are particularly sensitive to high-temperature injuries because of reradiation from the walls.

- ✓ Low-temperature injuries fall into two categories: frost injuries and winter damage .Both early and late frosts can cause extensive damage. Early frosts in autumn cause injury because tree tissues are not hardened off and buds may not be set. Young trees, particularly seedlings in open areas or in frost pockets, are more susceptible than older trees. Late frosts occurring after budburst cause extensive damage because new tissues are very susceptible. Vertical frost cracks can occur along the stem of susceptible species due to differential swelling and shrinkage of tissues .The mechanism of freeze damage is not completely understood. Plants have natural frost protection because water in the cell vacuole contains solutes that depress the freezing point of water below O°C .In intercellular spaces freezing draws water from cells, increasing concentrations of solutes within cells, which further reduces the freezing point and protects the plant. Very rapid freezing, however, may not allow water to move out of the cells quickly enough, causing ice formation in intracellular spaces and membrane rupture. Intracellular freezing usually is lethal, but plants often recover from intercellular freezing. Exposed wood in frost cracks also is susceptible to infection by spores of wood decay fungi.

Low and High Moisture and Low Soil Oxygen

Extremely dry conditions commonly cause drought distress symptoms in trees including wilting, loss of foliage, dead branches, and even tree death . Drought stress also causes trees to be more susceptible to root diseases and bark beetles. In areas where rainfall is unreliable, drought stress is common. Fire suppression in this region has resulted in increased tree density, which has exacerbated drought symptoms during times of low rainfall. Winter drying and leaf scorch also can be considered to be drought symptoms. Leaf scorch occurs either due to prolonged drought or to roots that are diseased and exposed to a continuous warm wind. Scorched conifers have needles with dead tips or drooping needles .

Excesses of moisture or flooding can cause tree stress and wilting symptoms and death .Soils may go anaerobic, placing the roots under oxygen stress. Douglas-fir trees treated with biosolids (sewage sludge) in Washington State developed oxygen stress and defoliated in areas where the water table was shallow and biosolids effectively sealed the soil surface. Root weevils attacked the weakened trees, resulting in considerable mortality.

Global change

Trees are very responsive to environmental conditions, and the current distribution of tree species is largely determined by climate. In recent years there has been great concern that human activities are causing global warming due to anthropogenic activities, such as fossil fuel burning, increasing atmospheric carbon dioxide (C02) concentrations (IPCC 2007). Carbon dioxide is a greenhouse gas that traps longwave radiation in the atmosphere. Atmospheric CO2 has increased from about 275 ppm in the 1850s to over 380 ppm today. In addition, other greenhouse gases like nitrous oxides (N0x)' chlorofluorocarbons, and methane (CH4) are increasing. Chlorofluorocarbons reduce stratospheric ozone (03), allowing more radiation to reach the earth's surface, further contributing to warming. Global temperatures are predicted to rise 1.5°C to 3.5°C over the next 100 years with greater increases at higher than lower latitudes.

Global warming is also expected to influence precipitation patterns, and some computer models predict a decrease in summer moisture over middle and high latitudes. Such a change may cause these areas to be drier and have longer growing seasons. Global change has occurred in the past, but the rate of change caused by recent human activities is thought to be more rapid than natural rates of change. This has great implications for trees and tree mortality ,since trees adapt to change slowly because of their long generation times. Regional warming and related increases in water deficits are likely causing the widespread increase in tree mortality rates .