40. Environmental Stress Effects

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Trees are long-lived plants that endure through many years of climatic changes. Some, such as the redwoods and Sequoias of the West Coast and the bristlecone pines of the high Sierras, are the oldest living things on earth. To survive through hundreds or even thousands of years of drought, freezing, blizzards, and high winds, trees must be somewhat resistant or adaptable to extreme climatic conditions. Because of this great longevity, people automatically attribute most tree injuries to attack by parasitic disease organisms. After all, how can a tree that has been growing in the same site for decades be injured by drought or freezing?

To comprehend the role of environmental stress in tree diseases, one must know how trees grow and what relationships exist between various plant parts and their surrounding environment. As a tree seedling becomes established in a site, the root system attains an increasingly delicate balance with the root environment or rhizosphere. Initially, roots may penetrate soil to a considerable depth; but as the tree approaches maturity, the bulk of the feeder root system on which the tree depends for water and nutrients concentrates throughout the upper layers of soil, often within a few cm of the surface depending upon soil type, tree species, and soil moisture. Because the surface layers of soils are more subject to variations in temperature, moisture, and aeration than deep layers, environmental stresses may have more injurious effects on large, mature trees than on younger, deeper-rooted saplings. For example, a woodlot of century-old white oaks may show symptoms of dieback and decline following a prolonged drought, while smaller trees retain enough vigor to recover once the stress is relieved.

Another important factor to consider in understanding tree diseases is that woody perennial plants resist the damaging effects of environmental stresses predominantly through the hardening or acclimation of tissues. Buds, living stem tissues, and, to some extent, roots enter dormancy in the fall and become increasingly resistant to freeze damage as days become shorter and temperatures drop below freezing. In some cases, trees subjected to mild drought early in the growing season will drought-harden and become more resistant to succeeding droughts of greater severity. Trees suffer more damage if they are not sufficiently hardened when stress conditions occur.

Two types of damage may result from environmental stresses: direct damage due to the injurious effects of stress on host cells, and indirect damage that involves attack of injured or weakened cells by plant parasites (figs. 40–1 to 40–4). Because trees, compared to succulent plants, are relatively resistant to stress and are able to harden under certain conditions, direct damage usually results only from rather severe levels of stress. However, even moderate stress levels can have pronounced effects on the susceptibility of trees to attack by disease parasites. When the susceptibility of a tree to parasitic attack increases as a result of unfavorable environmental factors, it is said to be "predisposed." The most common and effective predisposing environmental factors affecting trees are temperature and soil moisture.

Figure 40–1. Direct damage on cottonwood injured by a hard fall freeze.

High and Low Temperatures

Direct Damage:

High temperatures seldom cause significant damage to trees in the Great Plains. Succulent leaves and shoots may wither and blacken when exposed to unusually high temperatures but the damage is rarely permanent. Exposure of thin-barked stems to bright hot sun in winter may cause sunscald if bark tissues are killed to the cambium. Sunscald may also appear on tender bark of shaded branches that are suddenly exposed to bright sun following thinning or pruning operations. Stem tissues killed by sunscald are often invaded by fungi and boring insects. High temperatures usually combine with bright sun to increase water loss from foliage; consequently, damage associated with heat is more often due to water stress than heat stress per sé.

Low temperature injury to trees in the Great Plains is usually the result of exposure to subfreezing temperatures. Even very hardy tree species can be injured by freezing when an extended period of mild weather is followed by a sharp drop in temperature to near zero (fig. 40–5). Such extreme temperature changes are characteristic of the Great Plains, particularly in the fall before trees have become fully acclimated to low temperatures. In the spring, trees lose cold hardiness rapidly during warm weather and can be severely injured by a hard freeze. Symptoms of direct damage by freezing include bud kill, browning of evergreen foliage, dieback, frost collars at the base of trunks, frost cracks, and splitting of bark on frozen branches. A symptom often associated with freeze damage is prolific growth in spring of suckers on the trunk and branches of injured trees. Because the root systems of plants do not harden to temperatures much below freezing, root kill may occur during cold periods in the absence of an insulating cover of snow or leaf litter.

Figure 40–2. Indirect damage on drought-stressed honeylocust due to girdling cankers caused by *Nectria cinnabarina*.

Figure 40–3. *N. cinnabarina* canker of honeylocust.

Indirect Damage:

High temperatures alone seldom lead to indirect damage by parasites on trees unless tissues are killed or severely injured. In fact, during hot weather foliar diseases, which require prolonged periods of moisture films on leaf surfaces for infection, are usually less of a problem. However, high temperature combined with high moisture when succulent tissues are present may result in increased damage by fungi and bacteria that cause blights. A more significant effect of high temperature in indirect damage involves increased drought stress usually associated with hot, dry weather.

Low temperatures can be quite effective in predisposing trees to attack by parasites. Although direct damage may result from freezing of plant tissue, the indirect effects of freezing are far more common. Outbreaks of canker diseases, collar rots, and diebacks because of attack by fungal and bacterial parasites are symptoms of indirect damage. The fact that freezing can predispose trees to parasitic attack at levels too moderate to cause direct damage means that the appearance of disease damage may be the only outward sign of freezing stress.

High and Low Soil Moisture

Direct Damage:

High soil moisture or flooding over a prolonged period can cause significant damage to tree roots. Although tree species vary in their sensitivity to changes in soil moisture, all tree roots require adequate aeration (a constant exchange of gases in the rhizosphere). When excess moisture blocks or reduces soil porosity for an extended period and creates anaerobic conditions, toxic metabolites accumulate in roots and cause damage. Flooding of tree roots also results in a reduction of water and nutrient uptake; consequently, affected trees may wilt or become chlorotic. Other symptoms associated with high soil moisture or "wet feet" are enlarged lenticels near the base of the main stem on saplings and the

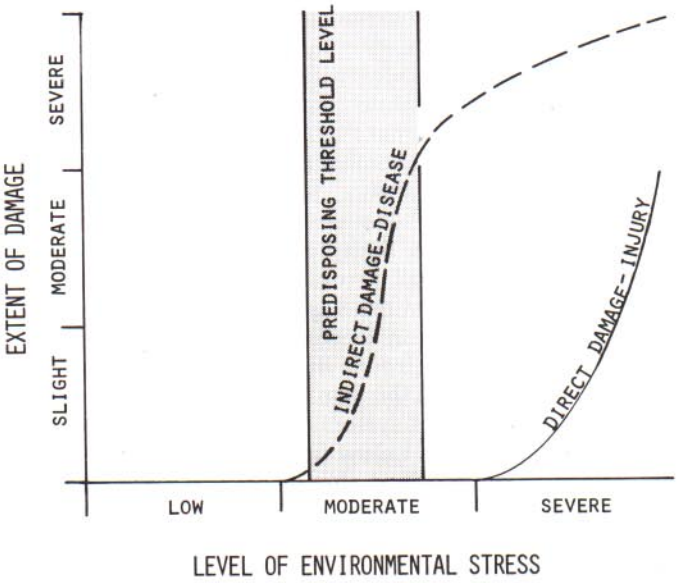

Figure 40–4. Relation of stress level to extent of damage.

formation of new roots near the soil surface where better aeration occurs. When a tree produces very shallow new roots and the older, deeper roots become blackened, high soil moisture is likely the cause of damage.

Low soil moisture or drought is a very common environmental stress in the Great Plains. Trees may be damaged directly by a severe seasonal drought, or damage may be cumulative over several consecutive years of below normal rainfall. Most trees injured directly by drought exhibit wilting symptoms, often accompanied by leaf drop, and may eventually die back from the branch tips. Necrosis of interveinal tissues and/or leaf margins, a condition known as "scorch," is often a symptom of drought damage. Drought and flooding both result in a reduction in root absorptive capacity and aboveground symptoms may be quite similar.

Indirect Damage:

High soil moisture effects on susceptibility of trees to parasitic attack have not received much attention from researchers. However, outbreaks of stem cankers and declines have been observed following prolonged periods of standing water or several consecutive years of abnormally heavy rainfall.

Low soil moisture or drought, in contrast, has been the subject of considerable research relating environmental stress to attack by parasites. Boring insects and bark beetles are attracted to drought-stressed trees and many stem canker fungi attack trees predisposed by drought. The level and duration of drought stress required for predisposition may be sufficiently moderate that no visible signs of stress appear, except for increased attack by parasites.

Additional Information

Rust and mildew fungi, viruses, mycoplasmas, and nematodes are obligate parasites that cause damage predominantly on vigorous trees, as do facultative fungi and bacteria that blight soft tissues. The opposite is true of most facultative parasites, which include many of the fungi and bacteria attacking stems and roots of trees. These organisms usually cause increasing amounts of damage as trees become stressed. Some are aggressive pathogens on vigorous trees but cause even more damage if trees become weakened. Others, including many stem canker and dieback fungi and bacteria and several root rot fungi, are nonaggressive parasites that normally grow saprophytically on dead and dying plant parts. If trees become stressed beyond a predisposing threshold level, they attack weakened tissue and cause damage. For example, it is quite common to find stem cankers forming around a branch stub, wound, or dead bud (fig.40–3) where the pathogen has been growing as a saprophyte.

Perhaps the greatest problem in identifying the causes of both parasitic and nonparasitic tree diseases is the long delay that often occurs between the cause of a disease problem and the appearance of damage symptoms. Damage from a hard fall freeze may not be apparent until well into the next growing season, particularly if the damage involves attack by parasites. Disease symptoms may continue to appear throughout the summer. Drought damage also may not be apparent for months or even years after the drought has ended. Large trees injured by drought may decline slowly over several years with increasing attack by disease organisms and boring insects. Accurate weather records are often of great help in the diagnosis of tree problems.

Many other factors such as nutrient deficiencies, herbicides and toxic pollutants, soil compaction, storm damage, and defoliation, alone or in combination with drought or freezing, may result in direct or indirect damage to trees. Most stresses weaken the entire tree, and the type of damage that appears may depend upon what parasites are present and what parts of the plant they attack. The main exception is freezing stress. Only tissues subjected to injurious temperatures are damaged; those insulated by snow cover or other temperature barriers remain healthy and resistant to parasites. Also, older wood tissues are more sensitive than bark and cambium to freezing stress in winter. The condition known as "blackheart" in trees is a result of freeze-damaged wood becoming susceptible to attack by fungi present deep in the wood.

Prevention of Stress-Related Damage

It is usually impossible and almost always impractical to prevent environmental stresses in forest trees. Shade and ornamental trees, however, have high per unit value and may warrant considerable time, effort, and money for their protection. Because direct damage usually occurs only if trees are severely stressed, even minimal maintenance in the form of watering, pruning, and fertilizing may afford protection from nonparasitic damage. Hardy trees, particularly species and varieties selected for disease resistance, when planted into well drained

Figure 40–5. Winter burn on Scots pine in a planting in North Dakota.

fertile soil, are much less subject to nonparasitic and parasitic damage than those planted on marginal sites. Practices that favor plant vigor and the development of a proper shoot/root ratio should be employed. However, those that delay hardening or promote succulent growth at the wrong time, such as pruning or shearing before plants enter dormancy and applying high nitrogen fertilizer in late summer, invite stress damage and should be discouraged.

Treatment of Stress-Damaged Trees

As long as the tree remains stressed beyond a threshold level for infection, which may be relatively moderate stress, parasites may continue to cause damage. Therefore restoration of vigor is of prime importance in preventing further damage. If a tree is not killed by stress, it will begin to recover and heal once the stress is relieved. Dead or severely injured branches should be removed as soon as possible, since these tissues may be attacked by parasites that can cause further damage on weakened stems. In addition, disease organisms can remain viable for weeks or months in woody tissue even after healing has occurred and may resume activity and spread to healthy tissue if the tree is again predisposed by stress. Infected plant parts should, therefore, be removed and destroyed. Wound dressings are now seldom recommended because recent studies have shown that they do not aid in healing and may in fact provide conditions conducive to infection.

Many of the parasites that attack stressed trees are referred to as "secondary organisms," implying that they are not the cause of damage. Yet trees will often recover from predisposing stress without injury if these parasites are not present. Indirect damage from stress is therefore a combination of physical and biological factors. Most fungal and bacterial pathogens of trees are wound parasites that do not penetrate intact plant surfaces. During wet weather they produce large masses of infective spores or cells in diseased tissues that easily spread to fresh wounds on healthy plants. Diseased plant parts should be removed and destroyed only during dry weather to eliminate the sources of further infections, and tools and equipment should be cleaned and disinfected regularly.

Selected References

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