FOREST HEALTH NOTE

May 1999

DEAD BRANCHES, DEAD TOPS, AND DEAD DOUGLAS-FIR TREES - THE INTERACTION OF WATER STRESS, INSECTS, AND DISEASE

INTRODUCTION

The sudden appearance of dead branches, dead tops, or dead Douglas-fir trees in late winter and spring can alarm anyone, especially tree growers. These symptoms have been unusually dramatic and widespread in 1999. This Forest Health Note discusses the probable causes and suggests ways to prevent damage.

SYMPTOMS OF DAMAGE

From late winter through spring or early summer, tree tops, lateral branches, or entire conifer trees may suddenly turn red (Figures 1-4). On some trees, close inspection of stems and branches may reveal dead, sunken patches of bark, called cankers. On young Douglas-fir, these dead areas are reddish-brown and contrast well with the gray/green color of healthy bark (Figures 5-10). Swellings and splits in the bark, tiny holes, and sawdust from boring insects also maybe visible (Figures 11-12). Many trees do not have cankers or visible indicators of insect activity.

The pattern of branch death on a tree often is very disorderly. Branches on only one side of the tree may die. On other trees, scattered branches in the mid-crown may die, while those above and below remain green. Dead branches may occur in the top only, the bottom only, or randomly throughout the crown. On some trees only the smallest branches die, while on others the entire top may turn red (Figures 13-15).

DISTRIBUTION OF DAMAGE

Damage occurs throughout the state and is most severe in urban areas, on the fringe of forested areas, and on shallow, rocky, or droughty soil types. Damage also appears on very wet or seasonally flooded sites. Trees growing near roads, ditches, pastures, or in areas of soil disturbance or abundant competing vegetation are most frequently affected. Damage to Douglas-fir is especially common on former grass or pasture lands, and on dry south aspects. Damage occurs much less frequently in the undisturbed forest than in fringe areas. During 1999, damage has been particularly noticeable in interior southwest Oregon (Rogue/Umpqua basin) and in the Willamette Valley.

TREE SPECIES AFFECTED

All conifers can be affected, but damage is most common in young Douglas-fir (usually less than about 30 years old). Drought-tolerant species such as Ponderosa pine are damaged less frequently than Douglas-fir or true fir. Douglas-fir generally does not tolerate extreme drought conditions or waterlogged soils as well as Ponderosa pine. Trees growing beyond their natural range or from non-local seed sources generally are at an increased risk of drought damage compared to locally adapted trees.

THE PRIMARY CAUSE - WATER STRESS

The primary cause of branch and tree death described in this note is water stress inside the tree, although other contributing factors may be involved. Water stress, which often is called drought stress or moisture stress, refers to a shortage of water inside the tree which results whenever water loss exceeds uptake long enough to cause plant damage or disturb physiological processes. It usually results from a lack of available soil moisture due to drought (drought is a period without rainfall that causes depletion of soil moisture and reduction in plant growth). The length of time without rainfall required to produce drought depends mostly on the water storage capacity of the soil and on the rate at which plants take up water through their roots and evaporate it through the foliage (the process is called evapotranspiration).

Water stress often affects groups of trees because they share common soil and environmental conditions that can affect the rate of evapotranspiration and the degree of water stress in trees. Because water storage capacity varies among soil types, water stress will develop in trees on some sites sooner than others under the same weather conditions. Trees exposed to full sunlight and free air movement tend to lose water faster than trees growing among other trees in a closed canopy. Sudden changes in the stand that expose the crown to wind greatly increase rate of water loss. Competing vegetation can intercept water from tree roots during periods of low rainfall. Soil compaction or disturbance can damage roots, alter drainage patterns, reduce aeration, and prevent water infiltration--all of which influence water uptake and tree water stress. Rooting habit and structure of the water conducting tracheids in the tree also play a role in susceptibility to water stress.

Trees respond to water stress in a number of ways. Low levels of water stress will reduce stem and root growth. As water stress increases, trees become increasingly susceptible to certain insects and diseases. Water stressed trees even attract certain bark beetles. Many of the tree's internal responses to water deficits occur without visible outward indicators of stress. Under severe drought conditions, water content may drop to a critical level where trees are irreversibly damaged and entire trees or just portions of the tree may die. Tops of trees and branch tips often die first because they are farthest from the water-absorbing roots. Roots and lower boles are last to die from moisture stress, and often remain living even though above-ground parts are dead (Figure 16).

In Oregon, water stress injury usually occurs in late summer or fall after trees have formed buds. Ample moisture and cool temperatures of winter improve the tree's water balance and prevent drying of needles. By late winter and spring, warm, dry conditions increase evapotranspiration and dead needles dry and turn red. Even though damage occurred in fall, it usually is not visible until late winter or spring of the following year. Examination of discolored branches and tops in late winter has shown little evidence of fungal pathogens or insects, probably because they were not active when the extreme water stress occurred (many of the bark and twig beetles fly in spring and early summer). However, by April of 1999, insect attacks and stem cankers have become obvious as these agents become active in warmer temperatures.

Following a drought, trees often are observed with one or more dead branches in various positions within the crown. Although secondary insects or disease could account for this, it could also result directly from moisture stress. Why would one branch and not another die on the same tree? A plausible explanation relates to the water conducting system of trees. If you injected colored water into a single tree root and traced its path upward, you would find that it follows a fairly narrow, often spiraling path upward into certain parts of a tree and not others. The system can be thought of as a network of microscopic tubes similar to a bundle of very small diameter drinking straws that begin at root tips and end in the foliage. Because of the variation in soil conditions (rocks, impervious layers, etc.) around a tree's root system, some roots may experience drought conditions sooner and more severely than others. The branch or branches connected to the roots growing in a localized poor situation will experience the most severe moisture stress and therefore may die sooner than other branches on the same tree. This oversimplifies water transport in a tree, but it's a useful model.

Water stress inside a tree also can result from excessive soil moisture. In waterlogged or flooded soils, Douglas-fir roots are deprived of oxygen and may be killed or damaged to the point that they can no longer take up water and nutrients efficiently. As the soil dries, the damaged root system cannot support the water needs of the top of the tree.

Low temperatures can cause water stress in several ways. Unusually low temperatures, especially following a warm period, can damage the sapwood and impair transport of water from roots to branches and foliage, causing them to dry out and die. Another type of water stress occurs most commonly in the Columbia River Gorge and is referred to as winter desiccation or winter drying. In this case, low temperatures (not necessarily below freezing) slow the soil water movement and uptake by roots. Very dry easterly winds and sunny weather can cause water loss to exceed uptake, inducing severe water stress. Damage usually is most prevalent on the east side (facing the prevailing dry winds) of trees and on trees growing in exposed locations. The damage occurs in winter, but symptoms (red-brown foliage) are most visible in early spring.

Water stress also induces loss of older foliage in the fall, immediately following a summer drought. This foliage loss (and occasionally branch death) is a drought-resistance mechanism in which the tree reduces the total surface area of the foliage and subsequently reduces the rate of water loss. It is most apparent in pines and cedar.

1998 WEATHER

The weather during 1998 certainly contributed to water stress in western Oregon trees. April and May were extremely wet months, with many rainfall records set in May. Many sites that were not especially wet under normal or dry conditions became waterlogged or flooded. Some sites were not obviously wet at the surface, but were waterlogged because of saturated or impermeable clay layers and rising water tables. This excess soil moisture can directly damage roots, predisposing trees to water stress when dry conditions return.

Following the wet spring in 1998, the period from the beginning of July through early October was extremely dry and temperatures were above average in much of western Oregon. During this period, precipitation in the Rogue/Umpqua basin and the Willamette Valley was far below normal. Along with the precipitation deficit, several high temperature records were set in August and September. It is very likely that the persistent low rainfall and periodic acute high temperatures caused extreme water stress in trees, especially on sites where other factors contribute to it.

Following periods of relatively warm temperatures that continued through November, unusually low temperatures occurred suddenly throughout the state during the week before Christmas. Even coastal areas experiences several consecutive days of below-freezing temperatures. For example, Tillamook had a low temperature of 10 F, Coquille had low temps below 16 F on four consecutive days, and Astoria had four consecutive days on which temperatures did not rise above freezing. Many areas in eastern Oregon had several days of temperatures below –10 F. The warm periods of November may have slowed the acclimation of trees to cold temperatures, rendering them particularly susceptible to damage from the low temperatures that followed.

IS IT SPREADING?

Probably not. Damage (tree death, dead branches, etc.) resulting from short periods of drought occurs first on trees least able to tolerate water stress. Trees on drought-prone soils or severely disturbed sites will show symptoms first, followed by trees in slightly better situations, and so on. It may appear as if damage is spreading, but it is not--the damage is occurring at different times and locations because of varying tree and soil conditions.

However, during prolonged periods of drought (several years) bark beetle populations can increase to levels where relatively healthy trees are attacked and killed. Such drought related outbreaks normally occur over a large geographic area.

WHAT CAN YOU DO ABOUT IT?

Once you see dead branches or dead trees, it's usually too late to prevent damage on the affected trees. Pruning dead branches or dead tops will reduce the hazard of falling branches and may limit the spread of pests to adjacent trees. However, before beginning any treatment, you should call your local State Forestry office, Extension office, or a consultant to get an accurate diagnosis of the cause. Do not assume that all damage is the result of drought or water stress. Specific treatments to prevent damage to other trees will depend on the diagnosis.

The single best strategy for preventing damage is to reduce stress on your trees. Most tree damage occurs on disturbed sites and is related to environmental stress which results from a combination of many factors including soil conditions, tree species, and weather extremes. It is unlikely that stress could be alleviated by altering just one or two of these factors. Improvement in tree vigor will most likely result from an accumulation of moderate improvements in many factors. Some suggested actions to improve tree health and reduce tree stress are as follows:

√ Prevent soil compaction caused by vehicle or animal traffic near trees. Livestock can compact surface soils and damage fine roots (most fine roots are within a foot of the soil surface). Clay soils are especially vulnerable to compaction.

√ Avoid direct damage to trees and roots by grazing animals or by machinery.

√ Reduce competing vegetation.

√ Irrigate landscape trees during dry weather (apply water slowly over many hours so it penetrates to tree roots or use irrigation wands that penetrate soil).

√ Do not alter drainage patterns (ditches, ponds, pipes, etc.) near established trees.

√ Apply mulch to help maintain soil moisture (a three-inch thick organic mulch is best).

√ Plant trees that are well suited for the site, i.e., use local seed sources and species that are well-adapted to your soil types. On sites where Douglas-fir mortality is occurring it may be advisable to plant ponderosa pine or hardwoods. Check with your local service forester or extension agent for advice.

√ Prune infected branches and burn them to reduce the spread of some canker diseases and insects.

√ Promptly harvest dead or dying trees and split the wood or remove the bark to prevent a buildup of bark beetle populations.

√ Do not fertilize during drought conditions. Fertilization stimulates foliage production and can increase a tree's water requirements.

SECONDARY AGENTS - INSECTS AND DISEASES

Healthy vigorous trees can usually resist attacks of insects and disease by producing defensive chemical compounds. Tree stress, especially water stress, can reduce production of these compounds and decrease the tree's ability to withstand pest attacks. In general, trees experiencing water stress are more susceptible to pests than unstressed trees.

Insects

Populations of insects that attack weakened Douglas-fir trees can be expected to build up during and following drought years or other events that cause water stress in trees. Trees infested by bark beetles or flathead borers often require a year before dieback symptoms are visible. Contact your local Forestry department, Extension office, or a consultant for specific information about insect pest management. The most common insects in stressed or damaged Douglas-fir include:

Insect	*Damage*
Douglas-fir twig weevil	Kills twigs and small branches (Figures 17-18)
Douglas-fir engraver beetle	Kills patches of the stem; may cause branch or top kill (Figure 19)

Insect	*Damage*
Flathead wood borer	Infests the entire tree, the top, or individual branches
Roundhead wood borer	Infests the branch collar area and main bole
Douglas-fir beetle	Can kill large diameter (8” diameter or greater) trees
Twig beetles	Kill individual branches (Figure 20)

Diseases

Several canker-causing fungi can infect and kill stems and branches of conifers. Cankers are most visible in late winter and early spring when the infected portion of bark becomes sunken and discolored (Figures 5-10). These fungi are weak pathogens that usually damage only trees under stress (in fact, many canker fungi cannot kill stems unless another stress factor is present). As a result, canker disease occurrence usually increases one to two years after drought or cold weather injury. If severe drought occurs in any year, expect an increase in canker diseases for at least the following one or two years.

Several other diseases (root diseases, foliage disease, etc.) can kill or damage trees. If you have dead or damaged trees, contact your local Forestry department, Extension office, or a consultant to have the problem diagnosed. It's essential to know what the problem is before you attempt to do anything about it.

THE OUTLOOK

If dry weather and drought conditions develop in 1999, expect continued above-average occurrence of branch dieback and top kill for at least two more years. Incidence of attacks by bark beetles and diseases will also remain above average.

The tree damage described in this note appears to be the direct or indirect consequence of environmental stresses resulting from extreme weather conditions and soil/site characteristics. It happened before during the late 1950’s, the 1970’s, and from 1987 to 1990, and it likely will happen again. In the meantime, we should be preparing our trees and soils for the next period of weather extremes.

Figure 1: Dead branches caused by water stress in Douglas-fir, May.

Figure 2: Dying Douglas-fir trees on the edge of a young plantation growing on a droughty site, February.

Figure 3: Mature Douglas-fir trees dying from water stress resulting from severe soil compaction, June.

Figure 4: Tops and branches of Douglas-fir dying from water stress, June.

Figure 5: Reddish brown sunken canker on shoot of young Douglas-fir, caused by a fungus.

Figure 6: Elongate canker (brown area) on stem of Douglas-fir, caused by a fungus.

Figure 7: Bark cut away from canker to show dead tissue inside.

Figure 8: Small sunken canker showing dead tissue beneath bark.

Figure 9: Tip of Douglas-fir shoot showing slight shrinkage as result of canker.

Figure 10: Same shoot as shown in Figure 9, bark cut away.

Figure 11: Swelling of Douglas-fir twig caused by twig weevil.

Figure 12: Small hole in Douglas-fir branch caused by twig weevil.

Figure 13: Branch tips of
Douglas-fir killed by twig

Figure 14: Cluster of dead branches
resulting from water stress.

Figure 15: Dead tops of Douglas-fir
resulting from water stress and low
temperature injury.

Figure 16: Cut-away bark of dying
douglas-fir showing dead inner bark of
lower trunk, with live root system below.

Figure 17: Swelling of Douglas-fir twig
caused by twig weevil.

Figure 18: Section through Douglas-fir twig
showing tunnel created by twig weevil.

Figure 19: Dead patch of bark peeled back to show tunnels of Douglas-fir engraver beetle.

Figure 20: Tunnels of twig beetles beneath bark of water-stressed Douglas-fir.