

Bacterial Wetwood and Slime Flux (Plate 185)

Wetwood, a water-soaked condition of wood, occurs in trunks, roots, and branches of many kinds of trees. In some trees, notably elms and poplars, bacteria are consistently associated with the condition and apparently cause it. Water-soaked wood with large numbers of bacteria (bacterial wetwood) is dead, usually discolored, and contains fatty acids that give it a sour or rancid odor.

Foliage in the tops of trees severely affected by bacterial wetwood sometimes wilts, and branches may die back. Usually, however, wetwood in landscape trees is unimportant except for the disfiguring appearance of vertical light or dark streaks where liquid seeps out of cracks or wounds and runs down the bark. In the wood, the sour liquid is colorless to brown and may contain up to 109 bacteria per milliliter. It darkens on exposure to air. On the plant surface, the liquid supports growth of many other kinds of bacteria, yeasts, and filamentous fungi that give it a slimy texture and an often fetid color and odor. This foul brew, which may bubble at a wound, is called slime flux or wetwood slime. Wetwood slime is distinct from the white or "alcoholic" flux that marks sites where microorganisms infect shallow wounds in the bark and cambial region (see Plate 78). Alcoholic flux is nearly colorless and acidic, often gives off a pleasant fermentative odor, and persists only a short time in summer.

Wetwood is most important in forest trees that are cut for lumber. Abnormal color and moisture cause lumber to be devalued. In hemlock and oak, affected wood tends to crack along or perpendicular to the growth rings. Poplar wetwood is inferior to normal wood in crushing strength and toughness. Such weakness is attributed to the enzymatic degradation by wetwood bacteria of part of the binding substance between cells. In the standing tree this is thought to promote cracks caused by bending action, differential expansion along temperature gradients, and freezing and expansion of water within the degraded part of the cell wall. The wet zones are more rigid than normal wood when frozen. Often a log with wetwood has no evident defect until lumber sawn from it cracks during kiln drying. Even when no cracks develop, wetwood dries only about one-third to one-half as fast as normal wood and requires twice as much energy.

In normal sapwood and heartwood of most trees, bacteria are scarce and fungi essentially absent while the wood is young. These organisms eventually enter through assorted wounds above and below soil line, even in young seedlings or cuttings. Wetwood, however, does not immediately or automatically follow bacterial entry. Typically it develops in wood several years old where organisms may have been present in small numbers, inactive during the years of greatest physiological activity of living wood cells.

Not all wetwood is caused by bacteria. Wet zones in pine wood are nearly devoid of organisms. In grand fir, wetwood may form before bacteria invade.

Bacterial wetwood in comparison with normal sapwood or heartwood has higher mineral content and specific gravity, less oxygen and more carbon dioxide, often contains methane, and has elevated gas pressure. It is usually malodorous and discolored and is often more alkaline by as much as 1 pH unit. Water content varies from near normal (e.g., in white fir) to twice the norm (in elm and cottonwood). In one analysis, liquid from elm wetwood contained 3, 8, and 11 times as much calcium, magnesium, and potassium, respectively, as sap of healthy sapwood. These differences together with elevated carbonate content are sufficient to account for elevated pH and for movement of

water along an osmotic gradient from normal wood into the wetwood zone. Alternate (but less satisfactory) explanations for wetwood involve inward movement of water from external sources such as branch stubs wet by rain. Gas pressure up to 0.7 kg . cm⁻² is common in wetwood. Extremes to 4.2 kg . cm⁻² have been detected in elms. Internal pressure causes liquid to seep from wounds and cracks. The gas in bacterial wetwood typically consists of 45-60% methane, 07% oxygen (often none), 6-16% carbon dioxide, 23-34% nitrogen, and about 1 % hydrogen. Air in normal wood contains about 19% oxygen, 75% nitrogen, and up to 5% carbon dioxide. Methane and hydrogen are produced by certain bacteria under anaerobic conditions and are never found in normal wood. The nearly anaerobic nature of wetwood prevents decay by fungi.

Wetwood liquid under pressure sometimes spreads to outer sapwood, where in elms and poplars it may cause gray-brown streaks and bands extending into small branches and twigs. These streaks are associated with scorch, wilting, yellowing, defoliation, and dieback that resemble the symptoms of Dutch elm disease in elms. Small diseased elms often wilt, and large ones may develop general dieback. Wetwood wilt and dieback of elms are most common in the Great Plains. In poplars, wetwood may develop in trees as young as 2 years. It is associated with branch death in large cottonwoods and with dieback and premature death of Lombardy poplars. Small trees may wilt and die suddenly, but most die back over a period of years.

The diverse bacteria in wetwood are able to tolerate low oxygen concentrations, and some are obligately anaerobic. Several species often inhabit a single tree. *Methanobacter arbophilicum*, which produces methane in poplars, and *Clostridium* species in oaks are anaerobes. Bacteria of the sort found in wetwood are common in soils and on plant surfaces. Soil is therefore thought to be a source of populations that build up within trees. Examples are *Corynebacterium humiferum* in poplars, a similar but unnamed organism in white fir, and the following in elms: *Bacillus megaterium*, *Enterobacter agglomerans* (syn. *Erwinia herbicola*), *E. cloacae* (syn. *Erwinia nimipressuralis*), *Pseudomonas fluorescens*, and *Klebsiella oxytoca*. Many wetwood bacteria remain unidentified.

Virtually all large elms and poplars have bacterial wetwood. Wetwood is also common in aspen, fir, hemlock, maples (including box elder), mulberry, oak, and white pine. Less frequently affected are apple, mountain ash, paper birch, butternut, western red cedar, dogwood, sweet gum, magnolia, mesquite, Russian olive, pines native to western North America, redbud, sycamore, tulip tree, and walnut. Many other kinds of trees are affected occasionally.

No controls for wetwood are known. Slime flux can be alleviated for cosmetic purposes by installing drain tubes (plastic is satisfactory) that allow wetwood liquid to drop to the ground rather than run down the bark.

References: 328, 382, 415, 747, 930, 1371, 1372, 1439, 1646, 1670, 1741, 1909, 2007, 2064, 2102, 2243, 2244, 2276

- A, B. Discolored streaks caused by wetwood slime on bark of sugar maple and horsetail casuarina, respectively. Brown liquid seeps from a crack in the maple trunk and from an old pruning wound on the horsetail casuarina (NY, May; FL, Mar).
- e. Slime flux at a pruning wound on Siberian elm. Cambial dieback, as at left and lower right sides of the wound, is sometimes caused by toxic chemicals in the fluxing liquid (IL, Jun).
- D. Cross-section of an American elm trunk about 20 years old. A brown core of wetwood occupied the center of the trunk. Discolored spokelike mark— show the pattern of holes bored 2-3 years earlier near the level of the slice to allow injections for disease control. Wherever the drill bit entered wetwood, the discolored core began to expand and involve all wood present at the time of wounding. In this case, the injection wounds closed and became covered with normal sapwood. Often, however, injection wounds that penetrate wetwood become sites of flux and do not close normally (NY, Aug).
- E. Cross-section of a 7-year-old eastern cottonwood trunk. A core of wetwood occupies portions of five annual layers of wood (MS, Apr).

