NEWLY formed sapwood of quaking aspen (Populus tremuloides Michx.) is white and normal heartwood is cream to grayish brown. However, most commercial sized aspen trees have considerable sapwood and heartwood which is sound but darkly pigmented (3). These pigments darken groundwood pulp (2), greatly limit the number of veneer-size trees suitable for peeling face-quality sheets, and are also defects in quality matches and in cutstock for furniture.

The pigmentation, which is chiefly found in the parenchyma and vessels, generally look brown in the boles of aspen trees, but hues of red, gray, yellow, olive and black also appear. The complex color patterns in cross-section commonly look like targets or circles with protruding fingers. Scattered throughout the colored wood are flavonoid pigments which fluoresce brilliantly under ultraviolet light (8). Discolored wood also has twice as much mineral ash as adjacent white wood. The center stem has the largest volume of discolored wood but any wood except rings just beneath the healthy cambium may be affected.

Our investigations combined with those in the literature indicate that the dark colors found in aspen are associated with three phenomena: (a) decay, (b) wounds through the bark into the xylem, and (c) branch-stem intersections.

(a) Completely rotten wood in aspen is commonly surrounded by a band of colored decaying wood (3, 5). Above and below this decay discolored wood may extend many feet into wood which seems completely sound. Radially and tangentially decay is surrounded by a narrow band of color. Micro-organisms are found in the colored wood but as already indicated decay fungi are infrequent (1, 3, 4, 5). The role of micro-organisms in forming the pigments is unclear. Causes of pigment production are more fully explored in a separate manuscript now in preparation.

(b) By slicing three entire trees into 1-inch cross sections, and by slicing and splitting portions of about 50 more, it was learned that any hole through the bark into the xylem results in a band of color limited radially and tangentially by the dimensions of the wound but extending many feet above and below it. Thus the target pattern was traceable to insect galleries, and central discoloration to a root borer or overlapping Saperda galleries. Serious discoloration in the outer sapwood of one veneer bolt was caused by Ambrosia beetles, and large side pockets of color by fire-scarring. Many

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wounds had the sour odor of wetwood, and organisms were undoubtedly present. Shigo (9) found branch stubs to be an important avenue leading to discoloration in several northern hardwoods. Future work may show them to be an important avenue in aspen, but to date aspen appears different in that a band of dark color invariably forms while the branch is still alive and does not appear to spread after the branch dies, unless decay enters the stub.

(c) The color found at branch-stem unions of living branches first appears about the fourth to sixth year. It begins in the secondary xylem in the angle formed by the branch and stem piths. Appearance of the color coincides with the extreme distortion of the wood elements and spreads out the branch and very slowly up the tree. Many branch stubs examined 5 to 20 years after death showed no evidence of extension of this color into a central column.

Information to date on the rate of spread of discoloration resulting from wounds is scanty. Dissection of insect wounds of various ages suggests that when the wound heals the color stops spreading. This important hypothesis is supported by research with controlled wounds in aspen (7) and other species (6).

Knowledge of the association of discoloration with decay, wounds and branch-stem intersections allows the predicting of the occurrence of this defect. Excessively limby trees, slow growers, and trees with outward signs of insect attack, disease, or mechanical wounds will have a sizeable amount of discolored wood. Fast growing trees with long clear boles will generally have a low incidence of discoloration. Fast growth is important because once the wound is closed by callus, the discoloration stops spreading.

Managing aspen for minimum discoloration should require no special technique, but cognizance of its association with wounds and decay should provide added incentive for adhering to management goals which minimize disease, insect attack and mechanical damage. Further knowledge of this association should aid purchasers in selecting the clearest aspen bolts.

LITERATURE CITED
