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HEART ROT OF BALSAM FIR IN THE LAKE STATES, WITH SPECIAL REFERENCE TO FOREST MANAGEMENT[1]

FRANK KAUFERT

INTRODUCTION

Balsam fir (*Abies balsamea,* Mill.) is just beginning to emerge from its status as an inferior species in the Lake States. It is being used in increasing quantities for pulpwood, boxboards, lumber, and lath. Altho somewhat inferior to spruce as a pulpwood, the shortage of spruce has forced paper mills in the region to accept larger and larger quantities of balsam.

Silviculturally, balsam fir has many desirable characteristics. It produces large quantities of seed at frequent intervals. It reproduces in dense shade, as seen by the reproduction under stands of aspen, Norway or white pine, and the hemlock-hardwood stands of Wisconsin. Because its tolerance permits it to grow under dense canopies without injury to its crown, it responds rapidly when released. If grown in short rotations, balsam fir grows more rapidly and yields more than spruce. Because of its aggressiveness and superior reproduction, balsam fir will no doubt be in greater demand than white or black spruce and will play a more important part in the management of much of the better forest land of the Lake States in the future.

The principal objections to balsam fir are its susceptibility to attack by the spruce budworm and wood-rotting fungi, principally those attacking the heart-wood of living trees. The damage in the Lake States done by the last spruce budworm epidemic has been described by Graham (3). Foresters and cruisers are well acquainted with the fact that many Lake States balsam fir stands are very defective, and that wind-breakage due to weakening of the trees by butt rot causes heavy losses. Hubert (4) has described the occurrence of a brown cubical butt rot, caused by *Polyporus balsameus* Pk. in balsam fir stands in the Lake States. The yellow stringy butt rot caused by *Poria subacida* (Pk.) Sacc. has also been found by several workers in this region. McCallum (5) and Spaulding and Hepting (9) have shown that this fungus causes serious losses in eastern balsam fir stands. The red rot caused by *Stereum*

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sanguinolentum Fr. has also been observed in the upper bole of overmature trees. The causal organism of this rot, which is so prevalent in stands of balsam fir in the Eastern United States and Canada, was first determined by Faull and Mounce (1).

OBJECTS OF THE STUDY

Altho there is observational evidence on losses caused by heart rot of balsam fir in the Lake States, a careful investigation of the extent and nature of these losses has never been made, and the object of this investigation was to obtain more precise information. Specifically, the objects were to obtain information on the following:

1. The actual volume of wood culled under present commercial culling practices because of rot.
2. The probable volume of cull under somewhat closer utilization practices.
3. The actual volume of rot and the pathologic rotation for balsam fir in the Lake States.
4. Whether a relationship exists between diameter and decay or between diameter and cull.
5. The influence of land type and rate of growth on the prevalence of decay and cull.
6. The reliability of external signs of decay as indications of heart rot.
7. The identity of the fungi causing most of the decay and cull losses and their points of entrance.

FIELD METHODS

The results of this study are based on data from about 1,170 sample trees of which more than 900 were of merchantable size, or would yield at least one 8-foot bolt with a minimum top diameter of 3.0 inches (inside bark). The trees were taken from 19 sample plots in Lake, St. Louis, Koochiching, Itasca, and Aitkin counties in Minnesota and Price and Sawyer counties in Wisconsin. Between 30 and 100 trees were cut from each sample plot. Some of the areas sampled were on the Superior, Chippewa, and Chequamegon national forests; some were on the George Washington and Cloquet Valley state forests; and some were on lands of the Northwest Paper Company and of the Minnesota and Ontario Paper Company.

Two methods of sampling were followed: (1) clear-cutting small areas; (2) cutting all trees within two feet on either side of a compass line run through the stand. When the trees in pulpwood operations were measured, all the merchantable trees cut by the loggers plus any small or obviously defective trees were taken. It is felt that these sampling methods should yield as near a representative sample as any known method. All types of stands were sampled. Some plots were on lowland; others were on ridges; some were in young rapidly growing stands; and some were in overmature balsam stands, growing as an understory in stands of white and Norway pine or hemlock and hardwood. Whenever possible, the largest samples were taken in the types most common in this region.

Since balsam fir grows on a wide range of sites and under such extremes of density, its size for a given age varies considerably. Even trees growing side by side are not alike. This great variability necessitated a larger sample than would have been required for more exacting species.

On pulpwood operations, the sections usually were eight feet long, the stump one foot high, and the top diameter three inches. Whenever possible, the age of each tree was determined on the stump. Because of the large amount of butt rot, however, the age of about 50 per cent of the trees had to be determined at points from 1 to 12 feet above the stump and then corrected for age at the ground.

General notes on location, ground cover, forest type, site quality, associated species, etc., were taken for each plot. In addition, the following data were obtained for each sample tree:

DBH (outside bark to nearest 1/10 inch)
Crown class
Local land type
Total height
Condition of tree
Age at stump, where this could be obtained, or higher when butt rot was present
Wounds (type, location, size, etc.)
Insect damage
Type of decay
Location of decay
Causal organism (where decay was so typical as to be readily recognized)
Avenue of entrance of causal organism
Top diameter of stump inside bark
Bottom and top diameter of each bolt (inside bark to the nearest 1/10 inch)
Length of top (to nearest foot)
Length and diameter of butt and top rot (at four-foot intervals)
Length and diameter at small and large ends of bolts culled according to present culling practices
Length and diameter at small and large ends of bolts containing top or butt rot (theoretical cull)

CULLING PRACTICES

The question of how to cull is a difficult one. As pointed out by Schmitz and Jackson (7), utilization standards change continually, and, as they change, culling practices change also. What is cull today may not be cull tomorrow. For this reason two culling standards were arbitrarily adopted in this study, and two sets of figures were obtained for cull losses, in addition to those on the actual volume of rot. The present culling practice used in pulpwood operations in Northern Minnesota was adopted as one method. Altho practices of various companies and even individual pulpwood cutters differ, the same general principles are followed by both. In general, sections less than eight feet long and those with butt rot or with the advanced stages of red top rot are discarded and left in the woods. In some cases the short sections are discarded because of excessive knots or sweep, but more often because rot is present. This type of cull is termed commercial or *actual cull.*

The second method adopted was the method used by McCallum (5) and by Spaulding and Hepting (9). In this method only those sections of the merchantable portion of the tree having either top or butt rot were culled. All sound short sections and sections that would be considered unmerchantable under present woods practices were considered merchantable. This type of cull is termed probable or *theoretical cull.*

The cull loss according to present utilization practices is of greatest immediate value to the forester and private timber owner, altho data on probable or theoretical cull may be of more value in the future when economic conditions make closer utilization possible and other than 4-, 8-, and 12-foot sections are accepted. Because wood is now culled that in the future will perhaps be utilized, the figures for actual cull are higher than those for theoretical or probable cull.

METHOD OF COMPILATION

The method of compilation outlined by Schmitz and Jackson (7) was followed. All volumes were computed in cubic feet inside the bark. The stump was considered a cylinder with a diameter equal to the top of the stump. The volume of each section was computed by Smalian's formula and the volume of the top by the formula for the volume of a cone. Both total and merchantable volume were computed. The merchantable volume included only the wood from stump height to a three-inch top; total cubic volume included, in addition, the volumes of the stump and top. The volume of butt and top rot and the volumes of culled bolts were also computed by Smalian's formula.

A single mimeographed sheet, on which all the field information and office computations were recorded, was used for each tree. This arrangement eliminated copying of the data and speeded up the computations, checking, and analysis.

Since the age of each tree was determined either at stump height or from 1 to 12 feet above ground, a correction for age at the ground was