HOW OLD IS A BALSAM TREE?¹

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In forestry work the total age of a tree, as indicated by the number of annual growth rings at the base, is generally the only age considered. Studies in connection with the Green River Project on the history of spruce budworm outbreaks and on the vulnerability of balsam fir stands to these outbreaks have raised doubts as to whether the total age of a tree is always the best indication of its true physiological age on a given site.

The present study was made in the upper part of the Green River Watershed in Restigouche County, New Brunswick. This area supports virgin stands in which balsam fir is the predominant species. As far back as stand history can be traced there has been a succession of even-aged stands which were 'harvested' at maturity either by the spruce budworm or by wind storms. In most cases the mature stand was opened up to some extent by natural agencies prior to its destruction. This permitted the establishment, over a period of years, of a variable amount of advance growth which remained severely suppressed until the mature stand was destroyed. The balance of the reproduction for the next stand became established after the old stand was removed by wind or insects. Thus many of the trees in the present stands show a period of initial suppression in radial growth at the base. This period is quite variable in length and although generally it does not exceed 30 years, in some stands it may be as much as 100 years. Although the stands are essentially even-aged in other characteristics, the total age of the trees may therefore show a considerable variation.

The age of balsam fir is an important factor in determining the vulnerability of softwood stands to budworm injury, and by this we refer to its physiological age on a given site. It is therefore necessary to know what influence the initial suppression years, during which the tree made little gain in size, may have on its physiological age. If these years, within normal limits, are found to have a relatively minor significance with regard to the aging process of the tree, then they should be either discounted or perhaps disregarded entirely. In this case the age of the stand since initial release might provide a better guide than its total age.

The variable initial suppression period in these virgin stands merits consideration in forestry as well as in entomological work. For example, the height of codominant trees at fifty years of age, which is a common index of site quality, can be greatly influenced by this factor. Two stands on equal sites on the Green River can show a considerable difference as to site index by this method, the disparity being due entirely to the relative proportion of the trees which became established prior to the destruction of the preceding stand and to the length of the initial suppression period. Yield tables for the area based on the total age of these virgin stands would be

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very conservative if applied to the same area under management, since a shorter rotation would decrease the initial suppression period of advance growth.

In attempting to determine the effect of the initial suppression period on the life of the tree, three things have occurred to the writer which may provide an indication of relative physiological age and which lend themselves to quantitative measurement. They are sexual maturity, the beginning of decadence as evidenced in balsam fir by butt rot, and the rate of growth at maturity. A fourth might conceivably be the vulnerability to spruce budworm attack but it is felt that this factor is not sufficiently well understood at present to permit its use as a criterion of physiological condition. These three factors are discussed separately, using data taken in three stands on the upper part of Green River in October, 1947.

SEXUAL MATURITY

The incidence of sexual maturity is generally regarded as one of the landmarks in the physiological age of most organisms. In balsam fir this is represented by the initial production of cones, a phenomenon which can be readily dated since the cone axils remain on the trees for several years.

For this study a dense, almost pure stand of balsam fir was selected which showed initial release about 1920 following destruction of the original stand in the last budworm outbreak (1913-1918). The codominant trees had an average diameter between 5 and 6 inches and a height of approximately 30 feet. A few of them started to produce cones as early as 1940, but for the most part sexual maturity occurred only during the past year or two, and particularly in 1947 which was a heavy seed year for this species. Codominant trees were taken at random and felled, and the data summarized in Table 1 were recorded from the stumps at ground level. The measurements were restricted to codominant trees because the lower crown classes in the stand have not yet started to produce flowers. Random selection was used in order to avoid a possible bias due to crown exposure, an important factor affecting flower production.

It is interesting to note in Table 1 that the size of the trees does not appear to increase significantly with the length of the initial suppression period, suggesting that the advance growth was overtaken in size by the subsequent reproduction. Although it would be desirable to have a larger sample of trees in the higher suppression classes, the data in Table 1 show no correlation between the length of initial suppression and the age of sexual maturity. In other words, trees which were over 50 years in total age in 1947 did not become sexually mature any sooner than trees of equal size which were only half as old.

BUTT ROT

The beginning of senility is another physiological landmark in the life of all organisms and in balsam fir is generally marked by the incidence and progress of butt rot. This factor is also important in determining the economic maturity of stands.

TABLE 1
Relation of Initial Suppression Period and Sexual Maturity
in Stand of Balsam Fir Initially Released in 1920.

Initial Suppression Period (years)	0	1-5	6-10	11-15	16-20	21-25
No. of trees	34	21	28	13	14	5
Mean D.S.H. (inches)	5.5	5.3	5.7	5.6	5.4	6.2
Mean annual radial growth in suppression period (inches) ..	—	0.03	0.02	0.02	0.02	0.01
Per cent of trees producing cones by 1947	64.8	57.2	53.6	53.8	35.7	60.0
Mean period between initial re- lease and initial cone produc- tion (years)	25.8	26.0	25.8	26.0	26.8	26.6

Two recently cut stands were used in studying the relation of butt rot to the initial suppression period, and the data were obtained from the stump ends of butt logs in pulpwood piles. The period required for the tree to reach stump height (approximately 1½ feet) is therefore neglected but for comparative purposes this is not a serious omission. On a small proportion of the butt logs in the piles advanced rot in the center made it impossible to count the initial suppression rings.

The first stand was initially released in 1870 and contained trees which had been present as advance growth some 30 years prior to this release. Thus the total age of the trees in 1947 varied from less than 77 years to 107 years. At the time of the last budworm outbreak on the Watershed this stand was too young to suffer serious damage. The data are summarized in Table 2. For this stand, as for the others examined, the data were recorded in a more detailed form but since a preliminary plotting has shown no relation between the variable measured, it is sufficient for the present purposes to group the results in broad classes. Table 2 indicates that the initial suppression period, up to a limit of at least 30 years, has no influence on either the incidence of butt rot or its extent on the cross-sectional area of the stump.

The second stand used in the study of butt rot had its initial release in 1850 and contained some trees which became established as early as 1750. The total age in 1947 varied between limits of roughly 100 years to 200 years. This was one of the few stands in this age class which escaped severe budworm damage in the last outbreak. A partial cutting operation, guided to some extent by diameter limit, was carried out in this stand and our figures are therefore based mainly on the larger dominant and codominant trees. The data are shown in Table 3. It is rather surprising to see that a balsam tree 200 years old, when severely suppressed for the first 100 years, is not more susceptible to rot than a 100-year old balsam in the same stand.

TABLE 2

Relation of Initial Suppression Period to Butt Rot and to Growth Rate
in Stand of Balsam Fir Initially Released in 1970

Initial Suppression Period ... (years)	0	1-10	11-20	21-30
No. of trees	61	22	38	16
Mean D.S.H. (inches)	9.6	8.4	9.3	10.3
Mean annual radial growth in suppression period (inches)	—	0.02	0.02	0.01
Mean radial growth 1938-1947 inc. (inches)	0.62	0.57	0.60	0.62
Per cent of trees with butt rot in 1947	39.4	36.3	42.2	37.5
Mean per cent of stump cross- section of infected trees rotten	15.1	15.6	7.5	11.7

RATE OF GROWTH

The rate of growth at maturity is the weakest of the three indices of physiological age which we have chosen. Maturity has been defined in different ways and for some purposes the rate of growth is a factor used in determining maturity. It will not be attempted here either to define physiological maturity or to say what is the age of maturity for balsam fir on Green River.

TABLE 3

Relation of Initial Suppression Period to Butt Rot and to Growth Rate
in Stand of Balsam Fir Initially Released in 1850

Initial Suppression Period (years)	0	1-20	21-40	41-60	61-80	81-100
No. of trees	24	48	52	25	18	13
Mean D.S.H. (inches)	12.0	12.2	11.7	12.2	12.4	13.8
Mean annual radial growth in suppression period (inches) ..	—	0.02	0.02	0.01	0.01	0.01
Mean radial growth 1938- 1947 inc. (inches)	0.55	0.53	0.62	0.73	0.57	0.56
Per cent of trees with butt rot in 1947	50.0	54.3	55.8	48.1	66.7	46.2
Mean per cent of stump cross- section of infected trees rotten	14.5	11.4	7.7	16.0	11.7	11.3

One would suspect, however, that a stand is becoming over-mature when butt rot becomes of common occurrence.

Data on radial growth rate were taken on the same trees used in the study of butt rot and the radial growth for the 10-year period 1938 to 1947, inclusively, was measured. The results are presented in Tables 2 and 3. Here again the period of initial suppression is seen to be of no importance in the life of the tree.

SUMMARY

This brief study is based on rather localized data and no attempt is made to draw broad conclusions. The results suggest however, that for the upper part of the Green River the physiological age of balsam trees, as indicated by sexual maturity, susceptibility to butt rot and rate of growth is not influenced by the length of an initial suppression period. Thus for many purposes, both in entomology and in forestry, the age since initial release is a more reliable criterion than the total age of the trees or stands.