Journal of the Minnesota Academy of Science

Volume 36 | Number 1 Article 7

1969

Regeneration of White Cedar in Northern Swamps

Walter H. Petraborg
Minnesota Department of Conservation

Regeneration of White Cedar in Northern Swamps

WALTER H. PETRABORG*

ABSTRACT — Regeneration of white cedar in six northern Minnesota swamps by layering, suckering, and seeding was found where surface and subsurface soils were circum-neutral (median pH 7.1 for surface soils and 7.0 for subsurface soils) but not on more acid soils. Regeneration was best where the peat soil was coarsely decomposed and little compacted, and where the water table was high with some flow of ground water through the swamp. Sphagnum moss grew on all regeneration sites but was also found on more acid, unsuitable sites. No single associated ground-cover plant appeared to be a specifically reliable indicator species for regeneration sites, but the most usual were tamarack *(Larix laricina)*, Labrador tea *(Ledum green-landicum)*, and creeping snowberry *(Gaultheria procumbens)*. Suggestions are given for restoring cedar swamps for use as deer yards.

The great value of swamps of white cedar (*Thuja occidentalis L.*) as feeding and winter yarding areas for white-tailed deer in the northern states is well known. In Minnesota, mature cedar in swamps are often clearcut for posts and poles. Often, fairly high stumps are left, especially where the base of the tree is crooked or "dog-legged." The lower branches on such stumps often root and produce new trees by layering (see back cover); or reproduction can occur from seedlings. However, the amount of such regeneration, whereby cedar stands are restored, varies considerably in different swamps. Factors related to such regrowth, or lack of it, are of considerable practical interest in forestry and game management.

In 1963 and 1964, the amount of regeneration in six previously cut cedar swamps was studied. These swamps are in Aitkin, Cass, and Itasca Counties of north-central Minnesota. All have been or are being used as yarding areas. Three yards were selected as being representative of those showing good regeneration (Hill City cedar swamp, Ododikossi cedar swamp, and Deer River cedar swamp); and three others are representative of those having poor cedar regeneration. Samples of surface soils from beneath vegetation (including moss) and subsurface soils, taken at a depth of 12 to 15 inches, were taken at 90 stations and analyzed for pH with a LaMotte-Morgan soil testing kit. Information was gathered on the kinds and abundance of ground cover plants and white cedar, the occurrence of other swamp trees, and nature of the soil. General observations were made on ground water levels and drainage. Aside from cedar, the only trees on these areas were tamarack (*Larix laricina*) (Du Roi) Koch, black spruce (*Picea mariana*, Mill.) BSP, and — on drier sites — balsam fir (*Abies balsamea* (L) Mill.).

HIGH pH SOIL SIGNIFICANT

Emphasis was placed on pH analyses because it has long been known that white cedar is most commonly associated with calcareous soils (Fernald, 1919) and is usually found on swamp soils with a higher pH than those occupied by other northern swamp conifers. For example, in an early study of the reaction of swamp forests to drainage, in Minnesota, by Averell and McGrew (1929), it was found that, in cedar areas, the soil was only slightly acid (pH 6.2-6.7) in contrast to 4.1-4.8 for poor sites of black spruce areas and 6.2-6.7 for fair, good, and excellent sites. Soil in the single tamarack stand they studied had a pH of 5.6.

That relationship also has been emphasized by Lutz and Chandler (1946) and by Nelson (1951). Godman (1958) points out that the cedar leaves are acid with a pH range of 4.0-4.9; and it has long been known that sphagnum moss, which often makes dense growth in northern swamp forests, including cedar swamps, has a usual pH range of 4.0 to 5.0. Even lower readings, down to pH 3.5, are known from "umbragenous" peat bogs of the British Isles (Gorham, 1961). Since it has been shown by Nelson (1951) that germination of Cedar seeds is best under conditions of fairly high pH (7.0 to 8.0), it appears likely that the extensive cedar stands of northern Minnesota were established when conditions of near-neutrality of soils existed and that more acid-surface soils may have developed since then.

FINDINGS FROM 90 SITES

For the 90 sites at which pH analyses of the soil were made, a pH range of 5.2-7.4 was found for the surface soils with a median of 6.5. An identical median and range was found for the subsurface soil. At some stations, however, it was noted that the subsurface soils were more alkaline than those at the surface—a phenomonen also noted earlier in Minnesota by Averell and McGrew (1929). Most soils analyzed in the present series were only slightly acid. Eighty-three percent of the surface soils and 89 percent of the subsurface soils fell within a range of 6.0 to 7.0.

Mature white cedar grew on 63 of the sites. On those the pH ranged from 6.0 to 7.2, with a median of 6.5 for both surface and subsurface samples. Black spruce also was growing in these same swamps, mainly on soils having both a lower pH range (6.0 to 6.8) and median (6.3) and tamarack slightly higher (range 6.4 to 7.2, median 6.7 and 6.8), than was associated with white cedar. However, cedar *reproduction* (seedlings and vegetative) was found where the soils had a somewhat higher median pH reading (7.1 surface and 7.0 subsurface).

Since there was a possibility that certain ground cover

* The author received his B.A. degree from Carleton College. He is a game biologist for the Minnesota Department of Conservation at Brainerd.

or otherwise associated plants might serve as indicator species for sites most favorable for cedar regeneration, information was gathered on the commoner plants on each site and their abundance.

In all, occurrence and distribution data were collected on 44 species, all common boreal bog species of the region. The soil pH ranges and medians associated with the commoner kinds are given in Table 1. It will be noted that, although all of these plants were found at pH ranges overlapping that for cedar reproduction, none had as high a median pH and most were about a half a pH value lower. None appear to be specifically usable as an indicator species. The closest are tamarack, with medians of 6.7 and 6.8; Labrador tea (*Ledum groenlandicum*, Oeder) with 6.5 and 6.6; and creeping snowberry (*Gultheria hispidula* (L.) Bigel.) with 6.5 and 6.3. The last two species often grow in sphagnum moss, and the occurrence of the moss probably aids cedar reproduction by layering in that it provides a moist substrate for bases of branches (Nelson, 1951). Sphagnum moss enclosed in a plastic cover is often used by nursery men to promote root formation on branches of certain woody plants. Vegetative reproduction of white cedar by root suckers was found to be common in the cut-over portion of one of the cedar swamps. Godman (1958) has said that this rarely occurs.

Sphagnum moss was found at 61 of the 90 sampling sites and ranged in depth from one to eight inches. It occurred on all eleven sites with cedar regeneration, and here also ranged in depth from one to eight inches. Spagnum, therefore, indicates that a site has possibilities for vegetative cedar regeneration but is not a certain indictor. Sphagnum, however, provides a poor germinating medium for cedar seeds (Nelson, 1951).

MATURE TREES, BUT NO REGENERATON

Soil structure and drainage of the bog or swamp appear to be important. The sites with no cedar regeneration had finely decomposed and composted peaty soils. On these, where cedar occurred, trees were mature. Such sites were fairly dry and evidently (though this was not ascertained) have a water table that is some distance below the surface of stagnant ground water. The most acid soils were found on such sites.

On sites where the soil was only coarsely decomposed and less compacted, the pH was somewhat higher, the water table higher. Drainage from these areas was more active, often by a bog stream. Near the stream, pH values of the soil were usually lower than at some distance from it, suggesting less buffering effect of lime-carrying ground waters received from adjacent glacial drift.

At sites with best cedar regeneration, the soil was only partly decomposed and little compacted. The water table was near the surface at these sites, and the bog had active drainage or seepage.

It should not be concluded, from the foregoing, that there is a constant relationship between the surface and water table depth in bogs. Indeed, over a period of years, as shown by Manson and Miller (1956), there is considerable variation in the distance between the surface of the bog and the water table. This largely reflects precipitation, with the water table usually highest in late spring and early summer.

As demonstrated by Averell and McGrew (1929) cre-

TABLE 1. Soil pH and Associated Plants in Six White Cedar Swamps in Aitkin, Cass, and Itasca Counties, Minnesota, at 90 Sampling Sites

SPECIES	SURFACE SOIL[1] N	Range	Median	SUB-SURFACE SOIL[2] N	Range	Median
Trees and Tall Shrubs						
Black ash (*Fraxinus nigra*)	30	6.0-7.2	6.2	30	6.0-7.2	6.2
Mountain maple (*Acer spicatum*)	43	6.2-7.2	6.3	42	6.0-7.2	6.2
Black spruce (*Picea mariana*)	12	6.0-6.8	6.3	12	6.0-6.8	6.3
Balsam fir (*Abies balsamea*)	36	6.0-7.2	6.3	36	6.0-7.2	6.2
Red-osier dogwood (*Cornus stolonifera*)	43	5.1-7.2	6.4	42	6.0-7.2	6.4
White cedar—mature (*Thuja occidentalis*)	63	6.0-7.2	6.5	63	6.0-7.2	6.5
White cedar—reproduction (*T. occidentalis*)	11	6.6-7.2	7.1	11	6.6-7.2	7.0
Speckled alder (*Alnus rugosa*)	11	6.2-7.2	6.6	11	6.2-7.2	6.5
Tamarack (*Larix laricina*)	6	6.4-7.2	6.7	6	6.4-7.2	6.8
False lily-of-the-valley (*Maianthemum canadense*)	35	6.0-7.0	6.3	35	6.0-7.0	6.3
Low Shrubs and Herbs						
Rattlesnake grass (*Glyceria canadensis*)	45	6.0-7.0	6.3	45	6.0-7.0	6.2
Dwarf blackberry (*Rubus pubescens*)	41	6.0-7.2	6.3	41	6.0-7.2	6.3
Meadowsweet (*Spiraea Alba*)	5	6.2-6.8	6.3	5	6.4-6.6	6.5
Bunchberry (*Cornus canadensis*)	57	6.0-7.2	6.4	57	6.0-7.2	6.2
Crested shieldfern (*Dryopteris cristata*)	52	6.0-7.2	6.4	52	6.0-7.2	6.3
Goldthread (*Coptis groenlandica*)	24	6.0-7.2	6.4	24	6.0-7.2	6.3
Labrador tea (*Ledum groenlandicum*)	41	6.0-7.2	6.5	41	6.0-7.2	6.6
Creeping snowberry (*Gaultheria hispidula*)	28	6.0-7.2	6.5	28	6.0-7.2	6.3

[1] Top 4 inches of soil
[2] Soil at 12 to 15 inch depth

ation of a drained layer of soil in bogs provides better conditions for the growth of swamp trees. It seems likely, therefore, that cedar and its natural regeneration is benefitted by some natural drainage. Also, it is likely that drainage influences the soil pH, causing the soil to be more alkaline. As found by Wilde (1946), circum-neutral soils (pH 6.6 to 7.7) are characterized by high activity of micro-organisms, rapid humidifications, and nitrification, and high availability of plant nutrients.

The survival of cedar, especially seedlings, may be directly related to the quality of the ground water and its influence on the hydrology of the bog, as it affects the pH. Godman (1958) states that cedar is the only conifer which does not have a mycorrhizal fringe associated with its roots. This may have a bearing on the failure of cedar regeneration, and the success of other conifers, on the more acid bog soils. Along this same line, Ahlgren and Ahlgren (1965) found that populations of bacteria, streptomycetes, and fungi rose to high levels in sandy loam, with an initial pH of 4.8 to 5.2, after prescribed burning of jack pine (*Pinus Banksiana* Lamb.) They attributed the increase to leaching of ash minerals.

Bay (1966) found higher pH levels and more diverse vegetation, such as balsam, cedar, birch, and tamarack, in a swamp having a continuous flow with the regional water table; whereas spruce swamp bogs, which are perched above the regional water flow system had lower pH values.

DISCUSSION

In six white cedar swamps of north-central Minnesota that had previously been cut, regeneration of cedar by layering, suckering, and seeding was found only on those that were slightly acid to slightly alkaline (pH 6.6 to 7.2, median 7.1). Improvement of internal drainage, which includes movement of water in and through the swamp site, seems to be important, since such drainage provides, or at least is associated with, soils of most favorable structure and circum-neutral pH. No plant indicator species was found that was diagnostic of most suitable sites for cedar regeneration.

Best sites for vegetative reproduction have a ground cover of sphagnum moss, but this is also found in areas where there was no cedar regeneration and where the soil pH is lower. Here, black spruce, tamarack, and balsam fir were the characteristic trees.

Since the success of cedar regeneration is best on bog soils of a fairly high pH, liming the soil or burning of slash on cutting sites may benefit natural regeneration of stands. Godman (1958) notes that seedlings are "aggressive" on burns on both upland and swamp soils and that packing of mossy soils, such as occurs on skid roads, is also beneficial. Since vegetative reproduction of cedar by layering and root suckering is more rapid and sooner available to deer than seedlings, it may be possible to produce higher pH levels for such reproduction by improving the internal drainage system.

Acknowledgment

The writer wishes to thank Dr. John B. Moyle of The Minnesota Division of Game and Fish for aid in planning the investigation and preparation of this paper.

References

AHLGREN, I. F. and AHLGREN, C. E. (1965) "Effects of Prescribed Burning on Soil Microorganisms in a Minnesota Jack Pine Forest. Ecol. *46*(3), 304-310. Spring.

AVERELL, J. L. and MCGREW, P. C. (1929) "The Reaction of Swamp Forests to Drainage in Northwestern Minnesota. Minn. Dept. Drainage and Waters. 66 pp.

BAY, R. R. (1966) "Ground Water and Vegetation in Two Peat Bogs in Northern Minnesota." North Central Exp. St., U.S.D.A., Ecol. Vol. 48, No. 2. 3 pp.

GODMAN, R. M. (1958) "Northern White Cedar. Silvical Characteristics of N.W.C." Lake States Exp. St. No. 87, U.S.D.A., 18 pp.

GORHAM, E. (1961) "Water, Ash, Nitrogen, and Acidity of Some Bog Peats and Other Organic Soils." Ecol. *49*, 103-106. Feb.

LUTZ, H. J., and CHANDLER, JR., R. F. (1946) "Forest Soils" John Wiley and Sons, Inc., New York. 130 pp.

MANSON, P. W. and MILLER, D. G. (1956) "Ground Water Fluctuations in Certain Open and Forested Bogs of Northern Minnesota," Univ. of Minn. Ag. Exp. Sta. Tech. Bull. 117, 29 pp.

NELSON, C. T. (1951) "A Reproduction Study of Northern White Cedar," Game Division, Dept of Conservation, Lansing, Michigan. 86 pp.