# NORTHERN RED OAK VOLUME GROWTH ON FOUR NORTHERN WISCONSIN HABITAT TYPES

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**Abstract.—**Northern red oak (*Quercus rubra*) grows across much of Wisconsin. Using site factors to aid in prediction of volume and basal area increment facilitates management of red oak and other species of interest. Currently, habitat type (Wisconsin Habitat Type Classification System) is often determined when stands are inventoried. If habitat type were strongly related to annual volume and basal area increment, it would be a valuable tool in making management decisions. The objective of this study was to determine if individual tree annual volume and basal area increment (last 20 years) of northern red oak was related to habitat type. Four common habitat types were selected: AAt (*Acer saccharum/Athyrium filix-femina;* 10 sites), ATM (*Acer saccharum-Tsuga canadensis/Maianthemum canadense;* 8 sites), AVb (*Acer saccharum/Viburnum acerifolium;* 7 sites), AVDe (*Acer saccharum/Vaccinium angustifolium—Desmodium glutinosum;* 8 sites). On each site, increment cores from 10 northern red oak trees were used to determine individual tree basal area and volume increment. Site index was also determined for each site. Generally, ATM grouped with AVb, and AAT grouped with AVDe. Of the four habitat types, three (AAt, AVDe, and ATM) had quite predictable basal area and volume increment (tight confidence intervals); however, AVb was much more variable. Habitat type, by itself, may be adequate for planning purposes on some habitat types, but on other habitat types, additional site factors may be necessary.

## INTRODUCTION

Oak (*Quercus* spp.) is very common in Wisconsin, covering more than 3 million acres. It represents >2 billion cubic feet of growing stock (Perry et al. 2008) and 30 percent of the total saw log harvest (Reading and Whipple 2007). Although oak is of great current importance on many sites, regeneration on high quality sites is unpredictable (Beck and Hooper 1986, Nowacki and Abrams 2008). Consequently, this cover type has declined on high quality sites (Perry et al. 2008). Because this decline has significant ecological consequences, the Wisconsin Department of Natural Resources (WI DNR) has listed oak regeneration as one of its statewide objectives (WI DNR 2004).

The habitat type classification system (HTCS; Kotar et al. 2002) has been used by foresters across Wisconsin as a method of classifying sites. It is based on using understory plants to predict climax vegetation communities. The system was a logical outgrowth of work by Daubenmire and Daubenmire (1968) and Daubenmire (1976, 1981), which used vegetation to predict productivity and other site factors. The system itself is easy to use, but its basic ecological foundation is Clementsian successional theory, which has been the subject of numerous revisions in the last 40 years (Cook 1996). Even with this constraint, much of the Wisconsin state forest land is already classified, as is some private land; thus, this system could be of great use as an indirect way to predict other parameters. Schwartz (2012) used habitat type as a predictor for oak advance regeneration under two canopy stocking conditions. Both overstory stocking and habitat type had a significant

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**Table 1.—Volume growth and basal area increment for northern red oak growing on four habitat types in northern Wisconsin (with means presented as ± 90-percent confidence intervals, and significant differences between habitat types at $\alpha$ = 0.1 indicated by superscripts a, b, c)**

| | | Annual increment (most recent 20 years) | |
|---|---|---|---|
| Habitat type | n | Volume ($ft^3$/tree) | Basal area ($ft^2$/tree) |
| AAt | 10 | $0.48 \pm 0.05^{a}$ | $0.019 \pm 0.002^{a}$ |
| AVDe | 8 | $0.52 \pm 0.12^{ab}$ | $0.020 \pm 0.004^{a}$ |
| AVb | 7 | $0.79 \pm 0.21^{bc}$ | $0.030 \pm 0.007^{b}$ |
| ATM | 8 | $0.83 \pm 0.09^{c}$ | $0.031 \pm 0.003^{b}$ |

impact on oak advance regeneration. In contrast, Bakken and Cook (1998) found habitat types to be very poor at predicting overall regeneration potential (due in part to large background variability in regeneration). Of note is that these two studies addressed completely different habitat types with no overlap, so direct comparison is impossible.

These contrasting studies suggest that HTCS may have variable utility in classifying sites depending on the parameter of interest. The objective of our study was to determine if annual volume and basal area increment (last 20 years) of northern red oak was related to HTCS.

## METHODS

See Schwartz (2012) for specifics on site selection. Generally, WI DNR provided sites that were "at least 50 years old, five acres or larger and supported at least 40-50% oak in the overstory" (Schwartz 2012). We selected a subset of these sites which comprised four of the northern habitat types: AAt (*Acer saccharum/Athyrium filix-femina;* 10 sites), ATM (*Acer saccharum-Tsuga canadensis/ Maianthemum canadense;* 8 sites), AVb (*Acer saccharum/Viburnum acerifolium;* 7 sites), and AVDe (*Acer saccharum/Vaccinium angustifolium – Desmodium glutinosum;* 8 sites; Kotar et al. 2002). At each site, 10 dominant or codominant northern red oak (*Q. rubra*) trees were increment cored and their height was measured with a clinometer. Cores were mounted to wooden core blocks and measured with a digital caliper in 5-year intervals for 0-40 years and from 40 years to pith for the remaining rings. To estimate cubic foot volume, equations from Hahn and Hansen (1992) were used. Analysis of variance (ANOVA) with habitat type as the main factor and measured site index (SI) as the response variable was used to determine whether SI varied consistently with habitat type. To determine impact of SI, SI was used as the predictor in a linear regression with annual basal area increment as the response variable. Unbalanced ANOVA with main factor of habitat type and a covariate of proportion canopy cover was planned, but Levene's test for equality of variance demonstrated unequal variance for both response variables of interest: annual total cubic foot increment and annual basal area increment. The AVb habitat type had a much higher variance than the others (see Table 1 for confidence intervals). As a consequence, means were compared by using 90-percent confidence intervals.

## RESULTS

Site index explained 26 percent of the variance in annual basal area increment ($p$ = 0.003, $r^2$ = 0.26). Because SI has been consistently used as a predictor of growth, this result is not surprising. Site

**Table 2.—Moisture and nutrient regime of four habitat types in northern Wisconsin (information from Kotar et al. 2002)**

| Habitat type | Moisture regime | Nutrient regime |
|---|---|---|
| AAt | Dry-mesic | Medium to rich |
| AVDe | Dry-mesic | Medium |
| AVb | Dry-mesic | Medium to rich |
| ATM | Mesic to dry-mesic | Medium |

index was significantly different between habitat types ($p$ = 0.013, $r^2$ = 0.23) with ATM having a significantly greater SI than all other habitat types; however, none of the other three habitat types was significantly different in SI.

For annual volume increment, AAt and AVDe were not significantly different from each other although AAt produced less volume growth than either AVb or ATM. AVDe produced less volume than ATM but was not significantly different from AVb. AVb and ATM were not significantly different in volume production (Table 1).

For annual basal area increment, AAt and AVDe had the lowest basal area increment during the last 20 years of growth, but they were not different from each other (Table 1). AVb and ATM were not significantly different from each other (Table 1).

## DISCUSSION

Because the habitat type classification system is so widely known in Wisconsin and the data have already been collected on a considerable percentage of the land base, using HTCS to indirectly determine other parameters would be beneficial. Bakken and Cook (1998) demonstrated that despite extremely large background variance in numbers of both large and small seedlings, HTCS could be broadly used to predict dominant species in the regeneration. Schwartz (2012) showed that the presence of oak advance regeneration was influenced by habitat type, with AAt having the least and AVDe, AVb, and ATM grouping at a moderate level of advance regeneration. The ability to use this existing site information to predict other parameters such as annual basal area or volume increment would be valuable.

Generally, annual volume and basal area increment were quite well predicted by HTCS. AAt and AVDe seemed to group as lower productivity sites and AVb and ATM seemed to group as higher productivity sites (although this result was clear for annual basal area increment, it was somewhat more complicated for annual volume increment). Kotar et al. (2002) listed ATM as moister than the other three habitat types (Table 2), so its grouping as more productive than AAt and AVDe is not unexpected. The relationship of growth rate to habitat type seems logical. Fassnacht and Gower (1998) showed annual net primary productivity (ANPP) to be strongly related to habitat type. Their mean ANPP by habitat type tended to increase as soil moisture regime became more mesic and as soil nutrient regime became richer. Additionally, the higher variability (greater confidence intervals) of AVb could in part be due to the variable nutrient regimes (from medium to rich) that are listed as characteristic for that habitat type. Whereas the means for the other habitat types had relatively narrow confidence intervals (most likely adequate for predicting growth rates relative to management activities), AVb was significantly more variable with 90-percent confidence intervals of annual basal area increment of 0.023 to 0.037 square feet per tree compared to 0.017 to 0.021, 0.016 to 0.024, and 0.028 to 0.034 square feet per tree for AAt, AVDe, and ATM, respectively. It is quite possible that habitat type may be adequate, by itself, to predict annual basal area and volume increment on some habitat types but that for sites with other habitat types (in this case AVb), other parameters may be necessary to get an adequate prediction. What those parameters might be is only speculation with our current data set.

Overall, habitat type appears to have potential use in the prediction of annual basal area increment and volume growth for individual dominant and codominant trees on some habitat types. Refining this information for broader use seems warranted based on this exploratory project.

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## LITERATURE CITED

Bakken, P.N.; Cook, J.E. 1998. **Regeneration potential of six habitat types common to north-central Wisconsin.** Northern Journal of Applied Forestry. 15(3): 116-123.

Beck, D.E.; Hooper, R.M. 1986. **Development of a southern Appalachian hardwood stand after clearcutting.** Southern Journal of Applied Forestry. 10: 168-172.

Cook, J.E. 1996. **Implications of modern successional theory of habitat typing: a review.** Forest Science. 42(1): 67-75.

Daubenmire, R. 1976. **The use of vegetation in assessing the productivity of forest lands.** The Botanical Review. 42(2): 115-143.

Daubenmire, R. 1981. **The scientific basis for a classification system in land-use allocation.** In: Land-use allocation: processes, people, politics, professionals—proceedings of the 1980 convention of the Society of American Foresters. Washington, DC: Society of American Foresters: 159-162.

Daubenmire, R.; Daubenmire, J.B. 1968. **Forest vegetation of eastern Washington and northern Idaho.** Tech. Bull. 60. Pullman, WA: Washington Agricultural Experiment Station. 104 p.

Fassnacht, K.S.; Gower, S.T. 1998. **Comparison of soil and vegetation characteristics of six upland forest habitat types in north central Wisconsin.** Northern Journal of Applied Forestry. 15(2): 69-76.

Hahn, J.T.; Hansen, M.H. 1992. **Cubic and board foot volume models for the Central States.** Northern Journal of Applied Forestry. 8(2): 47-57.

Kotar, J.; Kovach, J.A.; Burger, T.L. 2002. **A guide to forest communities and habitat types of northern Wisconsin.** Madison, WI: University of Wisconsin-Madison and Wisconsin Department of Natural Resources. Variable pages.

Nowacki, G.J.; Abrams, M.D. 2008. **The demise of fire and "mesophication" of forests in the eastern United States.** Bioscience. 58(2): 123-138.

Perry, C.H.; Everson, V.A.; Brown, I.K.; Cummings-Carlson, J.; Dahir, S.E.; [et al.]. 2008. **Wisconsin's Forests, 2004.** Resour. Bull. NRS-23. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 104 p.

Reading, W.H., IV; Whipple, J.W. 2007. **Wisconsin timber industry: an assessment of timber product output and use in 2003.** Resour. Bull. NRS-19. Newtown Square, PA: U.S. Department of Agriculture, Forest Service. Northern Research Station. 93 p.

Schwartz, K. 2012. **Oak regeneration across central and northern Wisconsin.** Stevens Point, WI: University of Wisconsin-Stevens Point. 202 p. M.S. thesis.

Wisconsin Department of Natural Resources [WI DNR]. 2004. **Wisconsin's statewide forest plan.** Madison, WI. 70 p.