SITE PRODUCTIVITY – CURRENT ESTIMATES, CHANGE, AND POSSIBLE ENHANCEMENTS FOR THE NORTHERN RESEARCH STATION

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Abstract.—Site productivity (SP) is the inherent capacity to grow crops of industrial wood. SP identifies the potential growth in cubic feet/acre/year and is based on the culmination of mean annual increment of fully stocked natural stands. Changes in SP were summarized for timberland and the associated effects on net growth and removal estimates were investigated using data from the Forest Inventory and Analysis program from the early to late 2000s. Change in area by SP class ranged from 4.8 to 19.6 percent, depending on the state. Actual changes on the ground are not this common. Net growth credited to unproductive-to-productive change varied from 0.0 to 11.2 percent of total net growth depending on the state; removals due to productive-to-unproductive change varied from 0.0 to 38.7 percent of total removals, depending on the state. A comparison of SP derived from current methods versus complementing with net growth information shows 12.5 percent of currently classified unproductive area could be classified productive and 10.3 percent of forest land area could receive a more productive SP class. Artificial change in SP class should be minimized, especially for sites that are marginally productive or unproductive. Restricting new calculations of SP when valid measurements already exist will lessen erroneous change.

INTRODUCTION

Forest site productivity (SP) is the inherent capacity to grow crops of industrial wood. SP identifies the potential growth in cubic feet (ft^3)/acre/year and is based on the culmination of mean annual increment of fully stocked natural stands (U.S. Forest Service 2010). By definition, forest land assigned a SP less than 20 ft^3/acre/year is unproductive. Timberland is productive, i.e., capable of producing at least 20 ft^3/acre/year, so changes in SP status affect net growth and removal estimates on timberland. This study's objectives include summarizing changes in SP and the associated effects on annual net growth and removals. Following these results, the study focuses on ways to improve SP assignments using observed net growth estimates and limit artificial change in SP assignments.

Data from the Forest Inventory and Analysis program of the Northern Research Station (NRS-FIA), U.S. Department of Agriculture, Forest Service, were compared from the early to late 2000s (Table 1). NRS-FIA uses site index (SI), the most commonly accepted measurement, to estimate SP. SI represents the average total height in feet that dominant and codominant trees are expected to attain in fully stocked, even-age stands at a specific base age (usually 50 years for NRS-FIA states). Changes in SI can represent magnitudes of change in SP. For eastern white pine (*Pinus strobus* L.), an SI of 48-59 feet represents an SP of 50-84 ft^3/acre/year, and an SI of 60-74 feet represents an SP of 85-119 ft^3/acre/year. NRS-FIA uses seven SP classes expressed in ft^3/acre/year as follows: class 1 at 225+, class 2 at 165-224, class 3 at 120-164, class 4 at 85-119, class 5 at 50-84, class 6 at 20-49, class 7 at 0-19.

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Table 1.—Change in SP class and effects on net growth and removal estimates for growing stock on timberland, by state, NRS-FIA 2005-2010

Region	State	Total forest-to-forest area	Forest-to-forest area changed SP class	Total net growth	Net growth on unproductive-to-productive area	Total removals	Removals on productive-to-unproductive area
		million acres	*percent*	*million ft³/year*	*percent*	*million ft³/year*	*percent*
Western NRS-FIA	Illinois	4.4	19.6	214.9	0.0	66.1	13.2
	Indiana	4.5	10.7	274.0	0.0	89.0	0.0
	Iowa	2.7	10.3	79.1	0.0	40.6	0.0
	Kansas	1.9	9.5	36.6	0.0	12.9	28.6
	Michigan	19.1	10.6	695.1	0.6	337.5	2.2
	Minnesota	15.9	17.1	384.9	3.4	255.7	3.1
	Missouri	14.4	12.3	464.2	2.3	174.4	2.8
	Nebraska	1.1	9.5	21.7	2.5	14.2	1.9
	North Dakota	0.7	8.1	6.8	11.2	2.6	38.7
	South Dakota	1.7	9.5	38.2	6.1	25.5	0.1
	Wisconsin	16.1	11.8	563.8	0.5	308.9	1.6
	Western NRS-FIA	82.6	12.8	2,779.3	1.2	1,327.4	3.4
Eastern NRS-FIA	Connecticut	1.7	7.4	93.4	4.6	17.2	0.0
	Delaware	0.3	13.9	15.2	0.0	13.8	7.4
	Maine	17.5	11.4	663.2	0.6	587.7	0.0
	Maryland	2.4	15.7	145.5	0.0	56.8	0.0
	Massachusetts	2.9	10.2	176.0	0.9	40.2	2.0
	New Hampshire	4.7	7.4	185.9	0.1	100.0	0.2
	New Jersey	1.9	9.0	81.9	4.0	24.2	14.8
	New York	18.3	9.5	617.8	1.0	288.9	0.0
	Ohio	7.7	11.0	393.6	0.0	182.7	0.0
	Pennsylvania	16.1	4.8	762.9	0.1	374.7	1.3
	Rhode Island	0.3	7.1	18.0	9.7	2.7	0.0
	Vermont	4.5	8.1	195.0	0.0	102.1	0.0
	West Virginia	11.7	8.9	608.5	0.9	248.1	3.4
	Eastern NRS-FIA	90.3	9.1	3,956.8	0.7	2,039.0	0.9
NRS-FIA	NRS-FIA	172.9	10.8	6,736.2	0.9	3,366.4	1.9

METHODS

Site Productivity via NRS-FIA

NRS-FIA crews measure diameter at breast height (d.b.h.) and height of a suitable SI tree to represent each forested condition on a plot. This information is used to estimate SI and subsequently SP; data is maintained in the National Information Management System (NIMS). An acceptable SI tree should meet minimum requirements of size (≥5 inches d.b.h.), age (15 to 120 years), quality, and species. Crews may reuse a previous SI tree. Crews have the option to reject previous trees if they do not meet the minimum requirements. This option is usually employed when there is an assessment difference between the previous and current crew. If no previous valid tree exists, the crew should collect data from a new tree pending availability. With no suitable trees, a default or estimated SP class is assigned later in NIMS. For the western NRS-FIA states[2], an average SI and associated SP are assigned for the species most frequently observed for the field forest type and physiographic class of the condition in question. For the eastern NRS-FIA states[2], a default SP class of 6 is assigned and the default class is also assigned when the calculation of SI and SP indicate an unproductive status (class 7) but the crew in the field classified the condition as productive. Unproductive assignments by crews for eastern NRS-FIA states also supersede productive assignments indicated by SI and SP calculations.

Sometimes more than one valid SI tree is available from previous inventories and this circumstance often results in different SPs. The suitable tree with the highest SP should be prioritized (the rule used in NIMS) but the crews do not have the SP information. At times, crews have chosen the tree associated with the relatively lower SP and deleted the other formerly valid ones.

[2] Western NRS-FIA states include IL, IN, IA, KS, MI, MN, MO, NE, ND, SD, and WI. Eastern NRS-FIA states include CT, DE, ME, MD, MA, NH, NJ, NY, OH, PA, RI, VT, and WV.

Analysis

This study examined changes in SP and effects of this change from the 2005 (2001-2005) to 2010 inventory (2006-2010). Structured Query Language (SQL) determined estimates. Area by SP for each state was compared. Average annual net growth of growing stock on timberland was estimated for unproductive-to-productive change. With a change to productive status, the volumes of associated trees are credited, not only the average annual net growth between inventories. Average annual removals of growing stock on timberland were estimated for productive-to-unproductive change. Volumes of trees cut since the previous inventory and volumes of trees still living in the recent inventory are credited with changes to unproductive status. Only living trees are included in the effects on removals presented in this study. To potentially improve SP class assignments, a new class was assigned using the net growth of growing stock for each condition of the 2010 inventory when the net growth indicated a higher SP than the normally employed methods. To minimize artificial change in SP class, the study determined where measurements of SI could be prohibited when valid measurements were previously acquired. This is currently feasible when a one-forest-condition plot occurred in a previous inventory (time 1) and remains a one-forest-condition plot in the next inventory (time 2). Lack of acceptable SI trees can contribute to changes in SP so the study identified how often SP was estimated versus calculated from SI.

RESULTS

Change

Working with the forest-to-forest areas (forest at time 1 to forest at time 2) from the 2005 to 2010 inventory, change in area by SP class and state ranged from 4.8 to 19.6 percent (Table 1). Across NRS-FIA states, 10.8 percent of area changed SP class with 2.3 percent changing by two or more SP classes. Thirty-four percent of unproductive area changed to productive (460,000 acres) and less than 0.5 percent of productive

area changed to unproductive (393,000 acres). Net growth credited to unproductive-to-productive change varied from 0.0 to 11.2 percent of average annual total net growth, and removals due to productive-to-unproductive change varied from 0.0 to 38.7 percent of average annual total removals, depending upon the state.

Complementing with Net Growth

Working with the forest-to-forest areas from the 2005 to 2010 inventory, a comparison of SP derived from current methods versus complementing current methods with net growth information shows that 12.5 percent (260,000 acres) classified as unproductive could be classified productive and 10.3 percent of forest land area (18.4 million acres) could receive a more productive SP class assignment across NRS-FIA states (Table 2). Results varied by region; 14.3 and 6.2 percent of currently classed unproductive area could be classed productive in the western and eastern NRS-FIA states, respectively. A more productive class could be assigned to 5.6 and 14.7 percent of forest land area in the western and eastern NRS-FIA states, respectively.

Consistency

Across the NRS-FIA states for the 2010 inventory, 76 percent of forest-to-forest plots were one-forest-condition plots at time 1 and time 2 and had previously valid SI trees. In the 2010 inventory, about 95 and 79 percent of SP assignments were derived from SI trees for the western and eastern NRS-FIA states, respectively. Remaining SPs were estimated or assigned a default SP class value.

DISCUSSION

Change

Estimates of change in acreage by SP are substantial for some states. Actual changes in acreage by SP are not as common on the land as predicted in the estimates, but estimates change, usually from using different SI trees or obtaining an acceptable SI tree for the first time. In many cases there are only marginally acceptable trees or no acceptable tree (McRoberts 1996). Subsequently, this increases the chance of choosing different SI trees for a given plot and condition over time. In some states, artificial change in SP status accounts for substantial portions of average annual net growth and/or removals on timberland. For net growth, the volume per tree credited with a change to productive status is usually many times more than the average annual change in volume credited with no change. Removal estimates are impacted by counting the volumes of living trees associated with a change to unproductive status. The most noticeable impacts are usually associated with states that have relatively low total removals.

Complementing with Net Growth

Complementing current methods with net growth estimates can identify productive areas that are currently classified unproductive. Barring no major site quality changes, holding SP class as productive on these sites would decrease effects on net growth and removal estimates for timberland. Net growth estimates also identify areas that should probably be designated at higher SP classes. This is most evident in the eastern NRS-FIA states where more investigation is warranted. More study is also required for some species in the western NRS-FIA states where SP is used when calculating volume, which subsequently influences net growth. Inaccurate values of SP can confound net growth estimates. Benefits of these possible enhancements should be weighed against the cost of implementation. Maintaining a steady SP class over time on marginally productive or unproductive areas provides the greatest benefit.

Consistency

SI tree collection on one-forest-condition plots at time 1 and time 2 with previously valid SI trees should be prohibited to minimize erroneous changes in SP. Based on observations between the 2005 and 2010 inventory, consistency could be ensured on about 76 percent of forest-to-forest plots.

Table 2.—Change from unproductive to productive and increase in productivity using average annual net growth of growing stock versus SI, by state, NRS-FIA 2005-2010

Region	State	Unproductive forest-to-forest area using SI	Unproductive area using SI but productive using net growth	Forest-to-forest area more productive using net growth vs. using SI
		thousand acres	*percent*	*percent*
Western NRS-FIA	Illinois	14.9	0.0	5.4
	Indiana	0.0	0.0	3.7
	Iowa	40.8	46.2	4.4
	Kansas	102.9	3.8	2.0
	Michigan	247.5	29.4	7.9
	Minnesota	488.5	11.9	5.3
	Missouri	175.9	16.2	3.7
	Nebraska	94.3	0.0	6.4
	North Dakota	214.7	1.0	2.3
	South Dakota	87.3	13.5	14.6
	Wisconsin	155.3	23.1	5.2
	Western NRS-FIA	1,622.3	14.3	5.6
Eastern NRS-FIA	Connecticut	8.5	0.0	22.4
	Delaware	3.6	0.0	17.8
	Maine	178.8	3.1	11.7
	Maryland	5.3	0.0	11.3
	Massachusetts	41.2	0.0	19.7
	New Hampshire	25.5	12.7	11.6
	New Jersey	13.6	0.0	14.4
	New York	41.4	0.0	13.8
	Ohio	5.3	0.0	15.0
	Pennsylvania	57.7	18.3	18.9
	Rhode Island	0.0	0.0	16.8
	Vermont	20.2	0.0	14.0
	West Virginia	55.2	16.0	14.4
	Eastern NRS-FIA	456.4	6.2	14.7
NRS-FIA	NRS-FIA	2,078.6	12.5	10.3

When multiple SI trees are available for a condition, NIMS and subsequent public reports use the tree with the highest associated SP. Following this precedent, only trees with the highest SP should be sent to the field. Otherwise, field crews can unknowingly chose a different tree which can change the assigned SP class. Some SP values are estimated or assigned a default value when there are no suitable SI trees. The number of sites without suitable trees should decrease by measuring the same plots over time. After suitable trees are acquired, new SP values and associated classes can be used in most subsequent inventories.

LITERATURE CITED

McRoberts, R.E. 1996. **Estimating variation in field crew estimates of site index.** Canadian Journal of Forest Research. 26: 560-565.

Woudenberg, S.W.; Conkling, B.L.; O'Connell, B.M.; LaPoint, E.B.; Turner, J.A.; Waddell, K.L. 2010. **The Forest Inventory and Analysis database: Database description and users manual version 4.0 for Phase 2.** Gen. Tech. Rep. RMRS GTR-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 336 p.