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Evidence of Rapid Forest Change in Minnesota

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Background

Tree species composition change can occur rapidly within a forest covertype and for a specific stand. These changes are typically related to stand age or stage of development and natural and human disturbance. One result is a change in stand covertype. Here we describe such covertype change for forested plots in Minnesota from recent five-year remeasurements of statewide forest inventory data.

Key words: Forest covertype, change, disturbance, inventory

Introduction

The rate of stand development and associated covertype change is a common interest in the analysis of silvicultural alternatives and overall forest management planning. Such change is also a consideration in the design of forest inventories. The Generic Environmental Impact Statement (GEIS) on Timber Harvesting and Forest Management in Minnesota examined covertype change rates in Minnesota for 1977-1990 for fourteen covertypes and found them to be substantial (Jaakko Poyry, 1992). The data used were drawn from the USDA Forest Service Forest Inventory and Analysis (FIA) field plots for that period. Since then the inventory design has changed including a move to 5-year plot remeasurements in Minnesota. See Bechtold and Patterson (2005) for details of the latest FIA design including covertype determination. This study examined these data and assessed the rate of FIA covertype change between two FIA cycles, 2007-2012 versus 2013-2016.

Methods

The publicly available DataMart Access database (Miles 2014) was provided by the USDA Forest Service. Statistical approaches used in this version of the FIA database follow Bechtold and Patterson (2005). The database itself is described in great detail by O'Connell et al. (2017) in the FIA Database users' manual. Detail from the manual describes the determination of stand age and covertype. Stand age is assigned based on the average total age, to the nearest year, of the trees in the stand-size class of the condition. Field estimation of age in the Northern Lake States is typically based on increment cores extracted at breast height, with a species-specific number of years added for the tree to achieve Dbh. Covertype determination is determined as the forest type which best describes the tree species with the plurality of live stocking on the condition class that are not overtopped. The forest types used here are those used by the MN DNR with the exception of the oak types. In this case, the oak type was separated into the FIA Oak-hickory and Oak-pine types. The FIA plots consist of a

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cluster of four subplots encompassing roughly 1/6th of an acre in total, dispersed in a triangular pattern. Here we assume these clusters of plots will approximates change for the stands they lie in.

For the FIA data, each plot was observed twice, 5-years apart, in each cycle. For example, a plot observed in 2007 is observed again in 2012; a plot observed in 2008 is observed again in 2013. In the tables below, these changes consider all re-measured plots sampled from 2012-2016. In total, 6,285 plots are distributed across the 17,591,745 acres constituting Minnesota's forestland (Miles 2017). To accomplish the assessment of change, a short script was developed to produce tables showing the percentage of re-measured FIA plots that retained their initial covertype over the 5-year period; and for those that did not, which covertype they had become at the end of the period. The resulting tables, or change matrices, are shown below. Because of the affect that stand age might have on change rates, change matrices were developed for non-harvested stands: all stands (i.e., all ages), young stands (ages 0-39 years) and mature stands (ages 40+ years). Additional change matrices can be produced showing total acres of forestland changing to a given covertype. These complementary tables are not considered here, but can provide additional detail regarding the direction and magnitude of cover type change.

Results and Discussion

Factors affecting species composition and ultimately covertype are natural succession and natural and human disturbance, including harvesting and forest management. The most common natural disturbances are insects, disease, windstorms, animal damage and fire. The most common human disturbance is timber harvesting.

Tables 1, 2, 3 indicate the loss of plots from a covertype and what covertype they become for non-harvested plots. Note the rounding to the nearest percent and that a dash (-) indicates no observations.

Table 1 considers all plots and all stand ages. As an example, results indicate that 84% of the original 1,827 aspen plots remained in that covertype. However, approximately 16% of the original 1,827 aspen plots changed to another covertype. The recipient cover types were numerous, but are dominated by hardwoods. For red pine, 83% of the original 162 plots remained in that covertype. However, 17% changed to another covertype. The most frequent change was to the aspen covertype. For jack pine, known to be declining in acreage (Kilgore et al. 2005), 29% of the plots changed to another covertype. Interestingly, the non-stocked covertype retention rate was 34%. Thus 66% of the plots move to another covertype. In other words, non-stocked plots were rapidly becoming stocked (as typically desired) and moving to a diverse set of covertypes, often aspen. Overall, most covertype retention rates were between 70-90%. The arithmetic average for all tabled covertypes was 70%. The average weighted by the number of plots was 79%.

Table 2 considers all plots for stand ages 0-39 years. Here results indicate that 88% of the original 980 aspen plots remained in that type. However, 12% changed to another covertype. The recipient covertypes were again numerous. For red pine, 85% of the original 70 plots remained in that type while 15% changed to another covertype. The most frequent change for red pine was again to the aspen covertype. For jack pine, 21% of the plots changed to another covertype. Interestingly, the non-stocked covertype retention rate remained at 34%. Overall, most covertype retention rates were between 60-90%. The arithmetic average for all tabled covertypes was 63%. The average weighted by the number of plots was 77%.

Table 3 considers all plots for stand ages 40+ years. Here results indicate that 79% of the original 847 aspen plots remained in that covertype. Thus 21% of the plots changed to another covertype. The recipient cover types were again numerous. For red pine, 81% of the original 92 plots changed to another covertype and 19% remained. The most frequent changes for red pine were to jack pine and aspen covertypes. For jack pine, 35% of the plots changed to another covertype. Overall, most covertype retention rates were between 60-90%. The arithmetic average for all tabled covertypes was 72%. The average weighted by the number of plots was 79%.

For the 17 covertypes in Table 2, ten had retention percentages less than those in Table 1, and one (non-stocked) remained the same. For the 16 covertypes in common to Tables 2 and 3, Table 3 had ten retention percentages higher than the same covertypes in Table 2. However, aspen, with a large percentage of the plots in both tables, showed a higher retention in Table 2 (ages 0-39) than in Table 3 (ages 40+). Thus, the retention at various ages is very much a function of species.

Table 4 was added to present covertype change information for 469 re-measured plots with observed cutting of trees sampled between 2007 and 2016. Note the FIA data harvesting code (TRTCD = 10) is defined as "Cutting – the removal of one or more trees from a stand." Further, "The area affected must be at least 1 acre in size." Thus, this cutting indicator may include clear-cutting, thinning and variations. Here results indicate that 84% of the harvested aspen plots remained in that covertype, while 16% changed to another covertype. The recipient cover types were again numerous. For red pine, 88% of the original 25 plots remained in the red pine covertype while 12% changed to another covertype. The most frequent changes for harvested red pine were to the oak - pine and aspen covertypes. For jack pine, 62% of harvested plots changed to another covertype. Overall, most covertype retention rates were again between 60-90%. The arithmetic average for all tabled covertypes with observed cutting was 61%. The average weighted by the number of plots was 72%.

In summary, results indicate covertype change can be rapid and substantial, even over a period of just 5 years. Results also show large differences among covertypes, regardless of age and with harvesting. However, these are not unexpected given differences in regeneration and growth patterns among the various species involved. The results here are summarized across diverse ownership, stand origin, history, physiographic, soil and site conditions. Given that, the direction of change (to other covertype) can be difficult to predict precisely. Thus, further inspection by ownership, stand origin, silvicultural treatments, etc. may be instructive. Such inspection may also provide an improved understanding of forest change and perhaps insight on forest succession and silvicultural treatment possibilities.

Finally, the evident rapid change in covertype implies a need for frequent forest inventories, especially for updating key data for management such as stand covertype. For example, with Table 1 aspen the stand covertype retention rate after ten years would be 0.84 x 0.84 = 71%. For twenty years, the retention would be only 47% --clearly very limiting for effective management.

Literature Cited and References*

Bechtold, W.A.and P. L. Patterson. [Editors] 2005. The enhanced forest inventory and analysis program - national sampling design and estimation procedures. USDA For. Serv. GTR SRS-80. 85 p.

D'Amato, A. W., N. W. Bolton, C. R. Blinn, and A. R. Ek. 2009. Current Status and Long-term Trends of Silvicultural Practices in Minnesota: A 2008 Assessment. St. Paul, MN: Dept. of Forest Resources, Univ. of Minnesota. Staff Paper Series No. 205. 25 p. plus appendices.

Ek, A. R., and H. E. Burkhart. 1976. Silvicultural considerations in timber inventory. *Journal of Forestry* 74: 435-437.

Jaakko Pöyry Consulting, Inc. 1992. *Maintaining productivity and the forest resource base.* A technical paper for a generic environmental impact statement on timber harvesting and forest management in Minnesota. Prepared for the Minnesota Environmental Quality Board. 305 p. plus appendices. https://conservancy.umn.edu/handle/11299/169578
(See Section 2.3.8 and Table 2.24)

Kilgore, M. A., A. R. Ek, K. A. Buhr, L. E Frelich, J. M. Hanowski, C. M. Hibbard, A. O. Finley, L. C. Rathbun, N. P. Danz, J. W. Lind and G. J. Niemi. 2005. Minnesota Timber Harvesting GEIS: An assessment of the first 10 years. St. Paul, MN: Dept. of Forest Resources, Univ. of Minnesota. Staff Paper Series No. 182. 119 p. plus appendices.

Miles, P.D., 2014. EVALIDator-PC (Version 1.6.00.00) [Software]. Newtown Square, PA: USDA For. Serv., Northern Research Station. http://apps.fs.fed.us/fiadb-downloads/datamart.html

O'Connell, B. M., B. L. Conkling, A. M. Wilson, E.A. Burrill, J.A. Turner, S. A. Pugh, G. Christianen, T. Ridley and J. Menlove. 2017. The Forest Inventory and Analysis Database: Database description and user guide for Phase 2 (version 7.0). USDA For. Serv. 830 p. https://www.fia.fs.fed.us/library/database-documentation/.

Wilson, D. C. and A. R. Ek. 2017. Evaluating old age for forests in Minnesota. St. Paul, MN: Dept. of Forest Resources, Univ. of Minnesota. Minnesota Forestry Research Notes No. 303. 5p.

*Minnesota Forestry Research Notes and Staff Papers of the University of Minnesota's Department of Forest Resources are available online at https://www.forestry.umn.edu/our-department/publications

Table 1. Five year percent change from a covertype on Minnesota forest land; non-harvested FIA plots from 2007-2011 vs 2012-2016. N = 6,047 plots*.

2007-2011	2012-2016																		
	Asp	**Bf**	**Bp**	**Ba**	**Bs**	**Ch**	**Jp**	**Lh**	**Ns**	**Nh**	**Nwc**	**Oh**	**Op**	**Oth**	**Pb**	**Rp**	**Ta**	**Wp**	**Ws**
Aspen	84	9	18	6	3	7	5	6	18	5	3	4	5	10	12	4	2	8	9
Balsam fir	1	64	1	0	2	1	3	2	1	1	3	-	-	7	3	1	0	3	6
Balsam poplar	1	1	69	1	0	1	-	1	3	0	0	0	0	1	1	0	0	-	0
Black ash	1	1	3	79	0	3	0	8	2	2	2	1	-	5	4	0	0	-	4
Black spruce	1	4	0	0	87	-	4	1	2	-	2	-	0	2	2	1	5	1	0
C. hardwoods	2	1	-	1	-	62	-	5	1	2	-	4	1	2	0	1	0	-	-
Jack pine	0	1	0	0	1	-	71	0	0	0	-	0	7	-	0	3	0	2	-
L. hardwoods	1	1	1	4	0	5	0	63	3	1	0	0	-	3	0	-	0	-	-
Non-stocked	0	2	0	1	1	-	2	2	34	0	0	1	-	-	-	-	1	-	1
N. hardwoods	2	1	1	1	0	1	1	2	4	79	0	3	1	5	3	1	0	-	-
N. white-cedar	0	3	1	2	0	-	-	-	1	1	86	-	-	-	1	-	2	1	2
Oak-hickory	2	-	0	1	-	14	1	3	2	6	-	83	2	2	2	1	0	-	1
Oak-pine	1	1	1	-	0	2	5	0	-	1	-	-	61	3	1	2	-	5	-
Other	1	3	1	0	0	1	1	1	8	0	-	0	3	42	1	1	-	1	5
Paper birch	2	3	1	2	1	1	1	2	5	2	1	1	6	8	64	1	1	3	1
Red pine	0	-	0	-	0	1	4	1	2	0	0	0	8	-	1	83	0	1	1
Tamarack	0	2	1	1	4	0	1	3	8	-	1	0	0	4	3	0	86	2	2
White pine	0	0	-	-	0	1	-	0	2	0	-	0	5	-	-	1	0	73	-
White spruce	0	1	1	-	0	-	-	-	1	-	0	0	-	6	0	0	-	-	67
2016 Total %	**100**	**98**	**100**	**100**	**100**	**100**	**100**	**100**	**99**	**100**	**100**	**99**	**99**	**100**	**100**	**100**	**100**	**100**	**100**
2016 Total Plots		**153**	**156**	**357**	**619**	**177**	**134**	**172**	**53**	**414**	**251**	**480**	**113**	**64**	**363**	**162**	**436**	**44**	**49**

* Twenty plots representing cover types with fewer than 10 samples were omitted from this summary. This omission and rounding preclude columns summing to exactly 100%. Total Forested Acres = 17,591,745.

Table 2. Five year percent change in covertype on Minnesota forest land; non-harvested FIA plots 0-39 years of age; 2007-2011 vs 2012-2016, N = 1,816 plots.

2007-2011	2012-2016																
	Asp	**Bf**	**Bp**	**Ba**	**Bs**	**Ch**	**Jp**	**Lh**	**Ns**	**Nh**	**Nwc**	**Oh**	**Op**	**Oth**	**Pb**	**Rp**	**Ta**
Aspen	88	10	15	18	3	13	5	10	18	18	4	7	6	13	19	4	3
Balsam fir	1	68	0	-	3	-	1	2	1	-	22	-	-	5	6	0	2
Balsam poplar	0	-	72	-	-	-	-	1	3	-	-	2	1	2	1	-	-
Black ash	1	0	2	61	0	-	-	9	2	1	8	4	-	6	6	-	-
Black spruce	1	3	1	-	85	-	2	1	2	-	13	-	-	-	2	1	8
C. hardwoods	1	-	-	3	-	60	-	5	1	0	-	7	1	3	1	1	-
Jack pine	0	1	1	1	-	-	79	-	0	0	-	-	11	-	-	2	-
L. hardwoods	0	-	3	3	-	3	-	50	3	3	-	2	-	3	1	-	-
Non-stocked	0	3	-	3	0	-	0	2	34	-	-	2	-	-	-	-	0
N. hardwoods	1	2	-	3	-	0	-	3	4	64	-	-	3	3	3	0	0
N. white-cedar	0	1	1	1	-	-	-	-	1	0	41	-	-	-	2	-	1
Oak-hickory	1	-	0	-	-	8	0	3	2	3	-	67	2	-	1	1	-
Oak-pine	1	-	1	-	-	4	5	1	-	2	-	-	43	5	4	3	-
Other	1	2	-	-	-	4	0	4	8	-	-	1	4	48	2	2	-
Paper birch	1	1	1	3	2	2	0	4	5	5	11	2	7	3	42	0	3
Red pine	0	-	0	-	-	2	5	3	2	2	-	2	17	-	3	85	-
Tamarack	0	3	1	3	7	1	1	-	8	-	-	-	-	3	8	-	82
2016 Total %	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
2016 Total Plots	**980**	**52**	**77**	**29**	**73**	**41**	**62**	**52**	**53**	**57**	**9**	**41**	**32**	**37**	**71**	**70**	**80**

* Twenty-one plots representing cover types with fewer than 9 samples were omitted from this summary. This omission and roundin ʒ preclude columns summing to exactly 100%. Total Acres < 40 years: 5,704,003.

Table 3. Five year percent change in covertype on Minnesota forest land; non-harvested FIA plots 40+ years of age; 2007-2011 vs 2012-2016, N = 4,173 plots.

2007-2011	2012-2016																	
	Asp	**Bf**	**Bp**	**Ba**	**Bs**	**Ch**	**Jp**	**Lh**	**Nh**	**Nwc**	**Oh**	**Op**	**Oth**	**Pb**	**Rp**	**Ta**	**Wp**	**Ws**
Aspen	79	9	20	5	3	6	6	5	2	3	4	5	6	10	3	1	3	8
Balsam fir	2	62	1	0	2	1	4	1	1	2	-	-	9	3	2	0	3	14
Balsam poplar	1	2	66	1	0	1	-	1	0	0	0	-	-	0	1	0	-	-
Black ash	1	1	3	81	0	4	0	8	2	2	1	-	5	4	0	0	-	8
Black spruce	1	5	-	0	87	-	5	1	-	2	-	1	4	2	1	5	-	-
C. hardwoods	2	1	-	0	-	62	-	5	2	-	4	1	2	0	1	0	-	-
Jack pine	0	0	-	-	1	-	65	0	-	-	0	6	-	0	4	0	2	-
L. hardwoods	1	2	0	4	0	6	0	68	0	0	0	-	3	0	-	0	-	-
N. hardwoods	3	1	2	1	0	1	2	1	82	0	4	1	7	3	2	0	-	-
N. white-cedar	0	3	2	2	0	-	-	-	1	88	-	-	-	1	-	2	1	1
Oak-hickory	3	-	-	1	-	16	1	2	6	-	85	1	4	2	1	1	-	-
Oak-pine	0	1	1	-	0	1	5	-	0	-	-	68	-	1	1	-	4	-
Other	1	4	2	0	0	0	2	-	0	-	0	3	34	1	0	-	1	2
Paper birch	3	5	1	2	1	0	2	1	1	1	1	5	15	69	1	1	3	-
Red pine	0	-	1	-	0	1	4	-	0	0	0	4	-	0	81	0	2	2
Tamarack	1	1	1	1	4	-	1	4	-	1	0	1	7	2	0	88	3	-
White pine	0	-	-	-	0	1	-	0	0	-	-	6	-	-	2	0	78	-
White spruce	1	1	-	-	0	-	-	-	-	0	0	-	6	0	1	-	-	62
2016 Total %	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
2016 Total Plots	**847**	**102**	**79**	**328**	**547**	**136**	**72**	**120**	**356**	**242**	**439**	**81**	**27**	**292**	**92**	**356**	**36**	**21**

* Eight plots representing cover types with fewer than 9 samples were omitted from this summary. This omission and rounding preclude columns summing to exactly 100%. Total Acres ≥ 40 years: 11,887,742.

Table 4. Five-year percent change in covertype on re-measured plots with observed harvest; FIA plots from 2007-2011 vs 2012-2016. N = 469 plots*.

2007-2011	2012-2016																	
	Asp	**Bf**	**Bp**	**Ba**	**Bs**	**Ch**	**Jp**	**Lh**	**Ns**	**Nh**	**Nwc**	**Oh**	**Op**	**Oth**	**Pb**	**Rp**	**Ta**	**Wp**
Aspen	84	30	66	13	7	10	-	7	17	17	29	8	-	21	12	-	4	-
Balsam fir	1	55	-	-	-	4	-	-	-	3	-	-	-	11	7	3	-	-
Balsam poplar	2	-	22	10	-	-	-	-	-	-	-	1	-	2	-	-	-	-
Black ash	1	-	-	50	-	4	-	5	-	-	-	-	-	-	-	-	-	-
Black spruce	0	-	-	-	93	-	-	38	31	-	-	-	-	-	-	-	-	-
C. hardwoods	1	-	-	-	-	61	-	-	-	1	-	4	-	7	-	1	-	-
Jack pine	1	-	-	-	-	3	38	-	17	-	-	-	-	2	-	0	-	-
L. hardwoods	-	-	-	-	-	-	-	45	-	1	-	-	-	-	-	1	-	-
Non-stocked	1	-	-	-	-	-	28	-	3	-	-	-	-	-	-	-	-	-
N. hardwoods	3	-	-	7	-	-	-	5	5	65	-	7	-	-	-	-	-	31
N. white-cedar	0	4	12	-	-	-	-	-	-	-	45	-	-	-	2	-	-	-
Oak-hickory	2	-	-	4	-	9	-	-	-	8	-	74	-	-	5	2	-	-
Oak-pine	1	-	-	-	-	-	-	-	3	3	-	3	100	-	-	5	-	-
Other	2	-	-	-	-	4	34	-	-	3	-	-	-	56	17	-	-	-
Paper birch	1	-	-	6	-	-	-	-	19	3	-	1	-	-	57	-	-	-
Red pine	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	88	-	-
Tamarack	1	10	-	9	-	-	-	-	3	-	26	-	-	-	-	0	96	-
White pine	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	69
2016 Total %	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
2016 Total Plots	**128**	**8**	**4**	**12**	**6**	**23**	**3**	**5**	**7**	**40**	**4**	**39**	**4**	**14**	**12**	**25**	**5**	**3**

* Plots representing cover types with fewer than 3 samples were omitted from this summary. This omission and rounding preclude columns summing to exactly 100%. Total Acres = 773,797.