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Evaluating Old Age for Forests in Minnesota from Forest Inventory Records

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Background

The question of how long a forested stand can be expected to survive before succumbing to the eventual loss of tree numbers, basal area and volume seen on many decadent and senescent stands is especially pertinent to the development of stand yield models. Some models follow a single, even-aged cohort from stand initiation to stand breakup, e.g., the ZEO model (Zobel et al. 2014, 2015). However, many earlier models (or tables) carry yields to some advanced age and then essentially leave it to the users to assume that accrued volume is either carried forward or diminished with advancing ages. Recent interest in extended rotation forest management and carbon sequestration argue for improved quantification of maximum forest stand age. Here we report on an analysis of statewide forest inventory data; specifically a tabulation of advanced forest stand ages in Minnesota.

Key words: Forest inventory, stand age

Introduction

The literature provides a glimpse of oldest observed tree ages for given species with observations compiled by Zobel et al. (2014, 2015). However, fixed expectations for oldest surviving cohorts (e.g. more than 1 surviving tree) do not match well with observations of per acre stand volume given stand age. As stands age, we expect the volume attribute to shrink to zero at the same age at which the cohort ceases to exist. Hence, maximum expected stand age is a critical parameter for yield models assuming eventual cohort senescence. Unfortunately, the maximum stand age parameter used by ZEO has been difficult to estimate, partly due to conflation of oldest living trees with oldest cohort age.

A short script is developed to produce desired summaries of stand ages observed by USDA Forest Service Forest Inventory and Analysis (FIA) field plots in MN. Results show the mean of observed ages for the oldest set of whole FIA plots from each forest cover type. By the term "whole," we mean that only plots with all four subplots showing the same "condition" or covertype and age class were used. This avoided very small groups of trees that might not comprise an entire stand. Thus results are relevant to whole stand growth and yield models assuming the eventual decline of single-origin cohorts due to inter and intra-specific competition, normal stand development (e.g., demographic transition and the exclusion/suppression of less vigorous stems), stochastic disturbance events, and other factors.

Methods

The FIA data from Minnesota were used in this research. The publicly available DataMart Access database (Miles 2014) was provided by the USDA Forest Service, and summarizes forest inventory efforts conducted since 1977. 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. (2014) in the FIA Database users' manual. Summarized data for inventory efforts completed prior to January 2017 are used for this analysis.

Detail from the FIA Database users' manual describes the estimation of stand age from field observations of dominant and codominant trees. In summary, 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.

For interpretation, we should point out the difficulty in estimating tree age. Counting annual rings to determine tree age can be subject to a variety of errors depending in part on the species. In aspen the rings are very difficult to discern. For maples and oaks, early years can be underestimated when stems have been repeatedly browsed. Older trees may also have internal decay that precludes a full count of rings.

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The short script developed for this analysis used Visual Basic for Applications (Microsoft 2016) within Microsoft's Access Database architecture (Appendix A). This script enumerates common forest cover types, then iterates over the list of cover types to select whole plot observations matching the requirements of a dynamically generated SQL query. This query limits returned records to those with stand ages in the top 5 or 2.5% of stands corresponding to whole plot conditions. A separate query was generated for each cover type and stored as an Access Query object. This enabled the use of database functions to summarize query results. The DAvg function was used within this loop to summarize observations in either the top 5 or top 2.5% of stand age for each cover type. Results were then iteratively inserted into an output table using another dynamically generated SQL query.

Results and Discussion

Results in Table 1 show the mean of observed ages for the oldest whole FIA plots from each forest cover type. Examining results for the oldest plot, the 5 oldest plots, and the top 2.5% of stand age gives slightly different estimates of maximum age in most cases. Using the oldest 1 or 5 or even 2.5% of stands provides a slightly different estimate of how long a given cohort might be expected to survive and dominate a site. The first gives us an expectation of maximum longevity of a cohort. The other two results suggest how old a stand/cohort will live given typical growing conditions, including stochastic disturbance.

Some readers may be aware of local stands that exceed the above ages. That is quite possible given the limitations of the FIA statewide sample size. For example, the authors are aware of an older red pine stand on the University of Minnesota's Cloquet Forestry Center. Still, we offer the Table 1 results as a guide pending the accumulation of more data.

Implications for growth and yield modeling are substantial. Previous models proposed by Gevorkiantz and Duerr (1938) and Walters and Ek (1993) and others have not accounted for the stochastic, but inevitable loss of basal area and volume as stands age. Here we have confirmed that while some individuals may live to very old age, the typical breakup of a cohort is more predictable and occurs sooner.

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Table 1: Ages of oldest USDA-FIA plots for common forest cover types in Minnesota.

USDA-FIA Forest Cover Type Name	Code	Oldest plot	Five oldest plots	Oldest 2.5% of plots	# Plots in top 2.5%	# Total Records
Jack pine	101	144	128	108	20	874
Red pine	102	146	130	120	15	684
Eastern white pine	103	220	160	160	5	165
Balsam fir	121	171	160	117	30	1,401
White spruce	122	126	108	111	4	198
Black spruce	125	191	183	142	85	3,718
Tamarack	126	186	175	153	42	1,922
Northern white-cedar	127	272	259	193	32	1,504
E white pine / northern red oak / white ash	401	135	125	132	2	58
Eastern red-cedar / hardwood	101	126	102	126	1	12
Other pine / hardwood	409	135	118	124	3	129
White oak / red oak / hickory	503	145	139	135	12	470
White oak	504	110	83	110	1	4
Northern red oak	505	125	114	117	4	165
Bur oak	509	140	133	133	6	169
Cherry / white ash / yellow-poplar	516	35	32	35	1	2
Elm / ash / black locust	517	130	105	120	2	91
Mixed upland hardwoods	520	136	122	123	5	212
Black ash / American elm / red maple	701	195	163	149	14	574
River birch / sycamore	702	70	62	70	2	13
Cottonwood	703	105	87	105	1	20
Willow	704	73	59	73	1	22
Sycamore / pecan / American elm	705	80	80	80	1	2
Sugarberry / hackberry / elm / green ash	706	140	123	126	4	115
Silver maple / American elm	707	107	93	107	1	26
Red maple / lowland	708	96	77	96	1	12
Cottonwood / willow	709	110	88	110	1	4
Sugar maple / beech / yellow birch	801	225	192	175	8	373
Black cherry	802	110	110	110	1	1
Hard maple / basswood	805	123	118	114	11	436
Red maple / upland	809	95	83	95	1	50
Aspen	901	232	158	95	241	11,205
Paper birch	902	213	160	117	44	2,010
Balsam poplar	904	130	114	101	22	997
Pin cherry	905	95	58	95	1	7

Appendix A: Visual Basic script used in FIA Access database. The script is initiated by clicking a button on the Update Old Age form.

```
Private Sub cmdOld_Click()
Dim db As DAO.Database
Dim rsOld As DAO.Recordset
Dim rsFType As DAO.Recordset
Dim sqlFType As String
Dim sqlGetOld As String
Dim updateSQL As String
Dim FType As Integer
Dim OldAge As Integer
Dim QueryName As String

Set db = CurrentDb()
createSQL = "CREATE TABLE OldStands (FORTYPCD INTEGER, STDAGE Double);"
db.Execute (createSQL)
db.TableDefs.Refresh

sqlFType = "SELECT DISTINCT FORTYPCD FROM COND WHERE FORTYPCD
IN(101,102,103,121,122,125,126,127,401,402,409,503,504,505,509,516,517 ,520,701,702,703,704,705,7
06,707,708,709,801,802,805,809,901,902,904,9 05);"
Set rsFType = db.OpenRecordset(sqlFType)
With rsFType
.MoveFirst
Do While Not .EOF
   FType = rsFType![fortypcd]
   sqlGetOld = "SELECT TOP 5 STDAGE FROM COND WHERE CONDID = 1 AND
CONDPROP_UNADJ = 1" & " AND FORTYPCD = " & FType & " AND BALIVE > 25 ORDER BY
STDAGE DESC;"


  QueryName = "qryOld_" & FType
```

```
        If IsNull(DLookup("Name", "MsysObjects", "Name='" & QueryName & "'")) Then

            CurrentDb.CreateQueryDef QueryName, sqlGetOld     Else

            CurrentDb.QueryDefs(QueryName).SQL = sqlGetOld     End If

         Set rsOld = db.OpenRecordset(QueryName)

         If rsOld.RecordCount > 0 Then

            OldAge = DAvg("STDAGE", QueryName)

         Else

            OldAge = -999

         End If



   updateSQL = "INSERT INTO OldStands(FORTYPCD, STDAGE) SELECT " & FType & " AS
FORTYPCD, " & OldAge & " AS STDAGE;"

  db.Execute (updateSQL)

  .MoveNext

Loop

End With

End Sub
```