Using Multiple Long-term Data Sets to Evaluate Dynamics and Characteristics of Managed Uneven-aged Northern Forest Stands

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Completion date:= 30 June 2019

- *Single-tree selection cuttings in uneven-aged northern hardwood stands created and maintained a stable structure over multiple cycles.*
- *Selection-like cuttings in even-aged stands resulted in a changing and unpredictable structure through six cutting cycles*

Funding support for this project was provided by the Northeastern States Research Cooperative (NSRC), a partnership of Northern Forest states (New Hampshire, Vermont, Maine, and New York), in coordination with the USDA Forest Service.
http://www.nsrcforest.org

Project Summary

Selection system silviculture should create and maintain a stable diameter distribution that managers can repeatedly recreate over multiple cutting cycles. The target diameter distribution has a reverse-J shape sustained by regular recruitment of new trees, coupled with sufficient growth of trees in all age classes to compensate for mortality and removals. We investigated uneven-aged northern hardwood stands treated with single-tree selection cuttings, and even-aged stands managed with selection-like cuttings. Both scenarios applied the popular uneven-aged guidelines recommended by Arbogast (1957) to regulate stem density across the diameter classes. We evaluated the outcomes using long-term data from 31 northern hardwood stands in New York, Michigan, and Wisconsin. Two stands remained uncut, three even-aged ones had these selection-like cuttings, and cutting in the 25 uneven-aged stands followed the Arbogast (1957) guidelines. We visually assessed changes in the diameter distributions over time, and statistically tested the significance of that change within each cutting cycle, and between consecutive ones. In addition, we compared the long-term variation of median diameter, stem density, basal area, and the shape and scale of the three-parameter Weibull function used to describe the diameter distributions. Selection-like cutting in even-aged stands failed to create and maintain a stable diameter distribution through six 10-year cutting cycles. Also: 1) tree density decreased through time; 2) the single cohort shifted to larger diameters; and 3) a mound-shape structure developed, as reflected by values of the Weibull shape parameter. By contrast single-tree selection cuttings in uneven-aged stands created and maintained more regular reverse-J diameter curve through time, with sufficient recruitment to the small diameter classes and adequate upgrowth through the size classes to stabilize the diameter distribution. This was reflected in the consistency through time of general stand characteristics, and with the Weibull parameters. Findings demonstrate that the selection system will sustain consistent structural characteristics in uneven-aged northern hardwood stands. By contrast, treating second-growth even-aged northern hardwoods with selection-like cuttings results in structural instability through time, necessitating alternative approaches for their management.

First Experimental Study

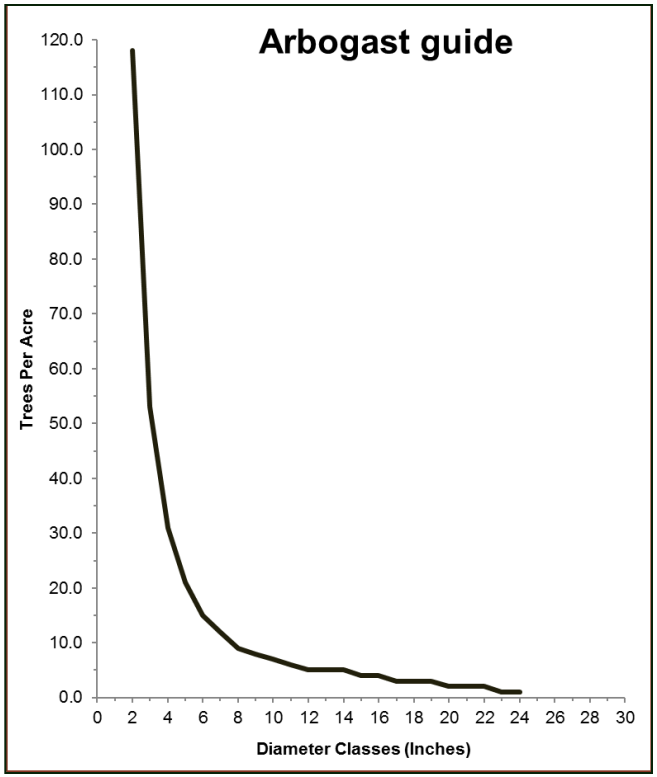
An experimental research initiated in 1932 in old-growth northern hardwood stands at Dukes Experimental Forest (MI) to develop guidelines for uneven-aged silviculture.

Basic stocking and structure for

sustaining high sawtimber

The guide

The findings (Arbogast 1957) used to develop a guide for managing uneven-aged northern hardwood stands



Outcomes of selection system

- Later trials **verified their use** for optimum growth and best wood production.
  (Crow et al., 1981; Gilbert and Jensen, 1958)
- Others showed **flexibility** of the selection system in northern hardwoods.
  (Adams and Ek, 1974; Hansen, 1987; Hansen and Nyland, 1987; Gronewold et al. 2010)

A Stand at Cuyler Hill, NY. Picture by Ralph D. Nyland

What about even-aged stands?

Even-aged stand treated with selection-like cutting at Argonne Experimental Forest . Picture by Christel C. Kern

Later trials used selection-like cuttings in second-growth even-aged stands :

- Argonne Experimental Forest, WI (Erdmann and Oberg, 1973)
- Bartlett Experimental Forest , NH (Leak and Gove, 2008)

Objectives

Investigate **long-term structural stability** in northern hardwood stands

Uneven-aged stands treated with **single-tree selection cutting**

with

Even-aged stands treated with **selection-like** cuttings selection cuttings

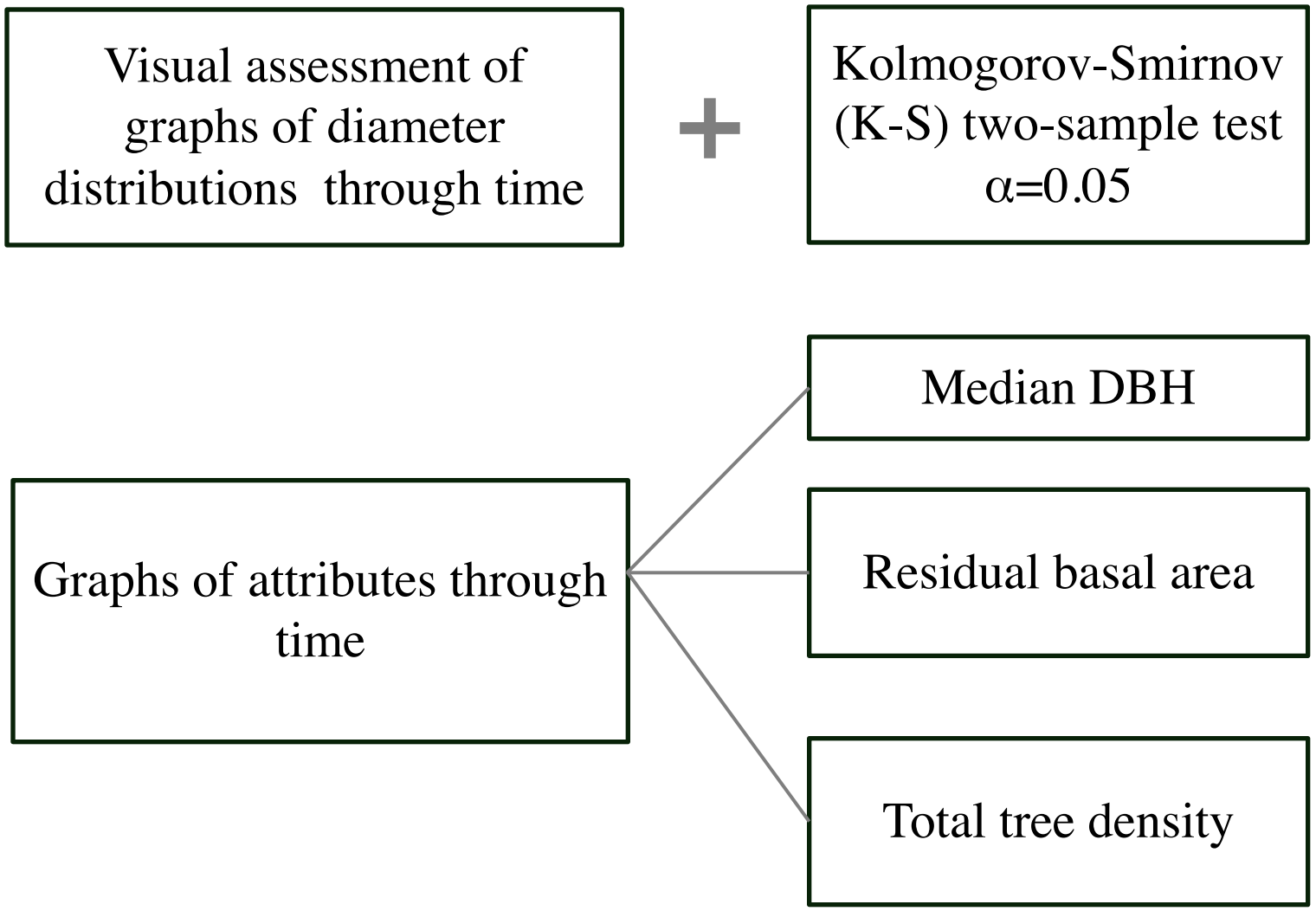
Both kind of stands treated with alternatives of single-tree selection cutting as described by Arbogast (1957).

Data

Site	Number of Stands	Age Characteristic	Treatment	Number of entries	Total number of years
Argonne Experimental Forest (AEF)	3	Second-growth Even-aged with residuals from past high-grading	Selection-like	6	54
Dukes Experimental Forest (DEF)	2	Old-growth mature with history of high grading	Single-tree selection	3	80
Dukes Experimental Forest (DEFN)	10	Uneven-aged	Single-tree selection	1-4	21
Secord Hill State Forest (SHF)	1	Uneven-aged	Single-tree selection	1	26
Cuyler Hill State Forest	5	Uneven-aged	Single-tree selection	1-3	36-43
Archer and Anna Huntington Wildlife Forest (HF)	8	Uneven-aged	Single-tree selection	1	28-30

Analysis (SAS 9.4 M1)

Trees with DBH ≥ 4.6 inches grouped into 1-inch diameter classes



Analysis (SAS 9.4 M1)

Trees with DBH ≥ 4.6 inches grouped into 1-inch diameter class

Fitting 3-parameter Weibull probability density function

+

Plotting scale and shape parameters through time

$$g(y)= (c/b)((y-a)/b)^{c-1}exp\{-((y-a)/b)^{c}\} \; ; \; y \geq a, \; b>0, \; c>0$$

(Bailey and Dell, 1973)

a: location **(Fixed at 4.5) MLE**

b : scale

c: shape

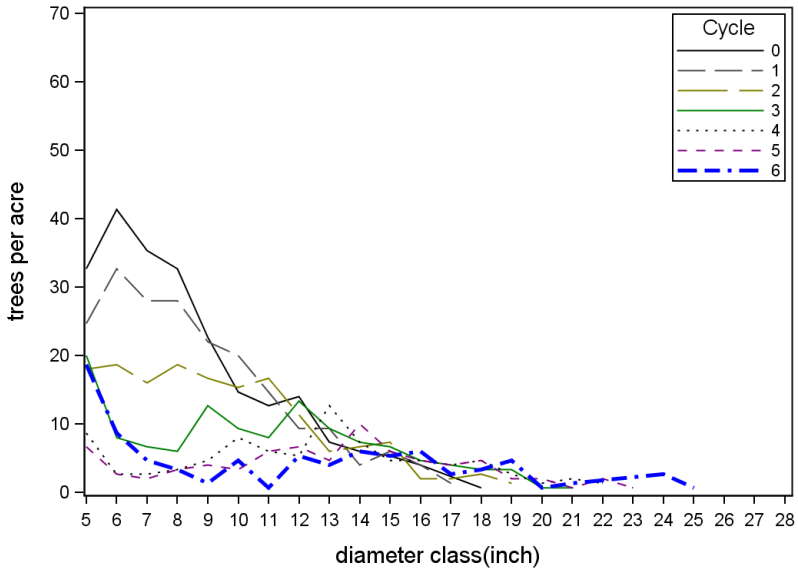
Results

- Graphs show trends through time for both the uneven- and even-aged stands given this management.

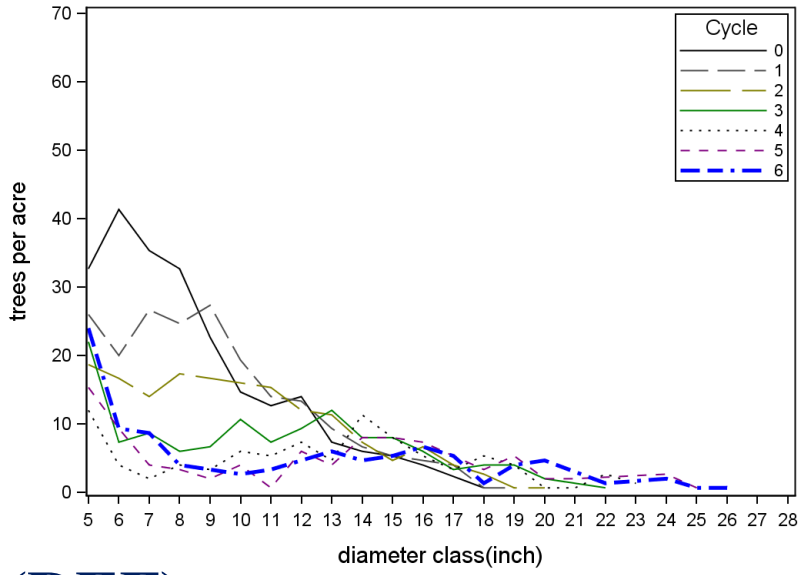
Diameter Distribution

Even-aged (AEF)

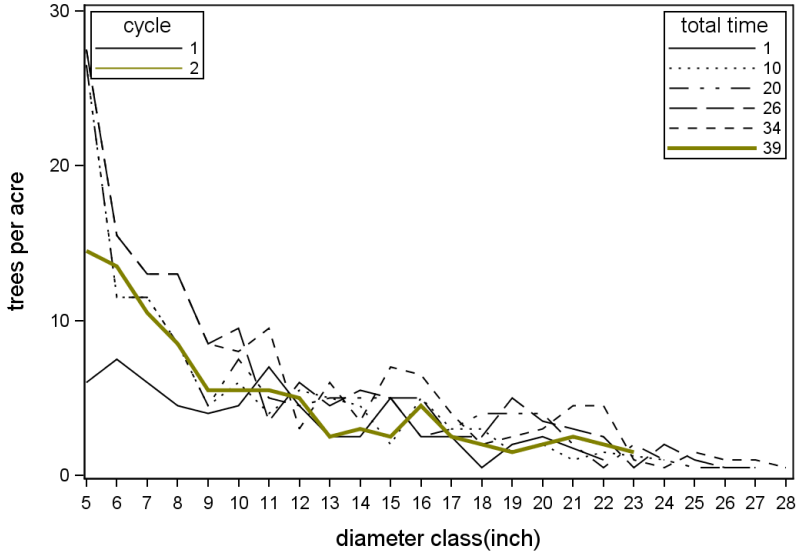
Beginning

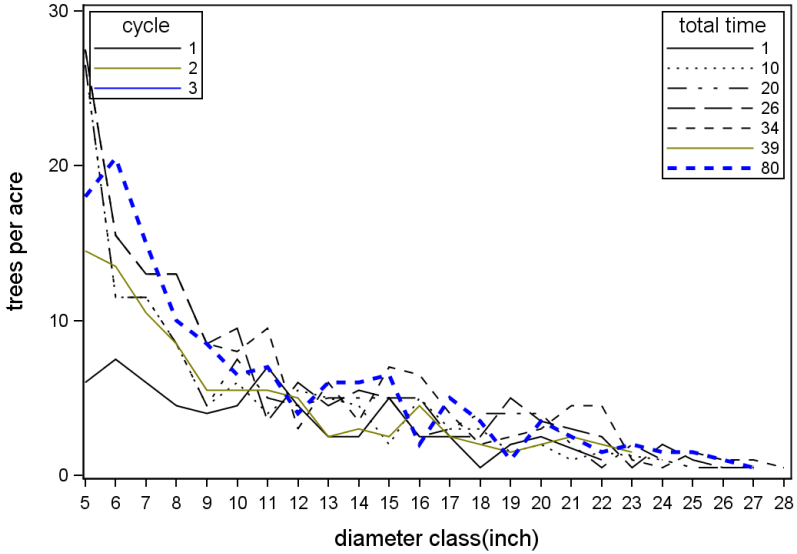


End



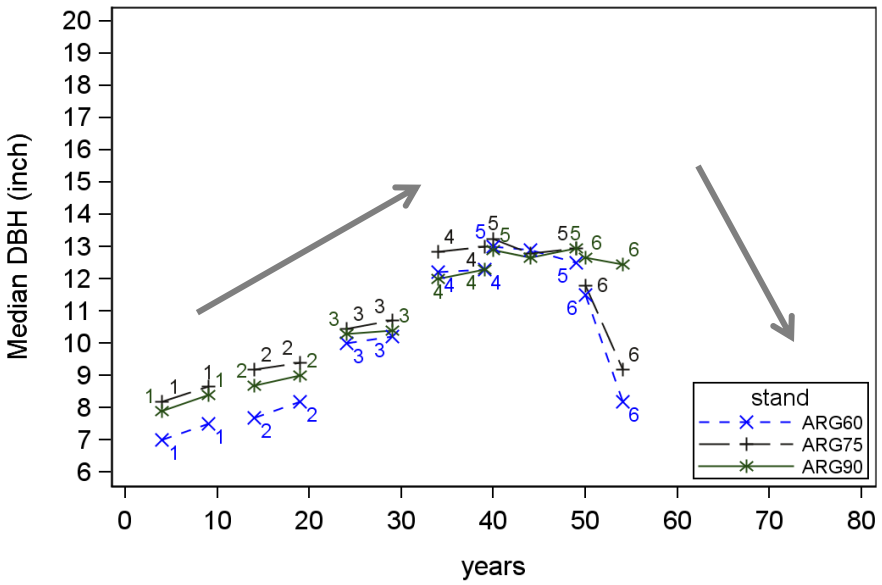
Uneven-aged (DEF)



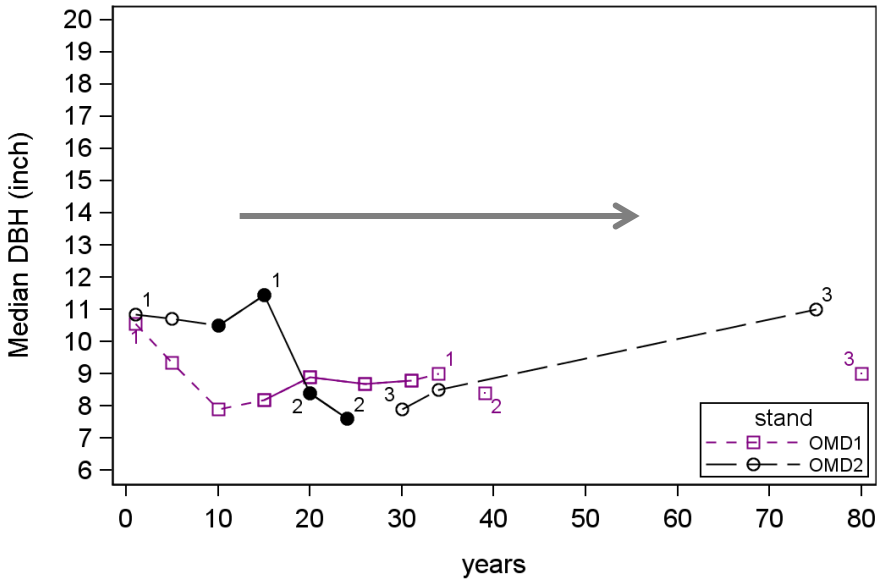


Median Diameter

Even-aged (AEF)



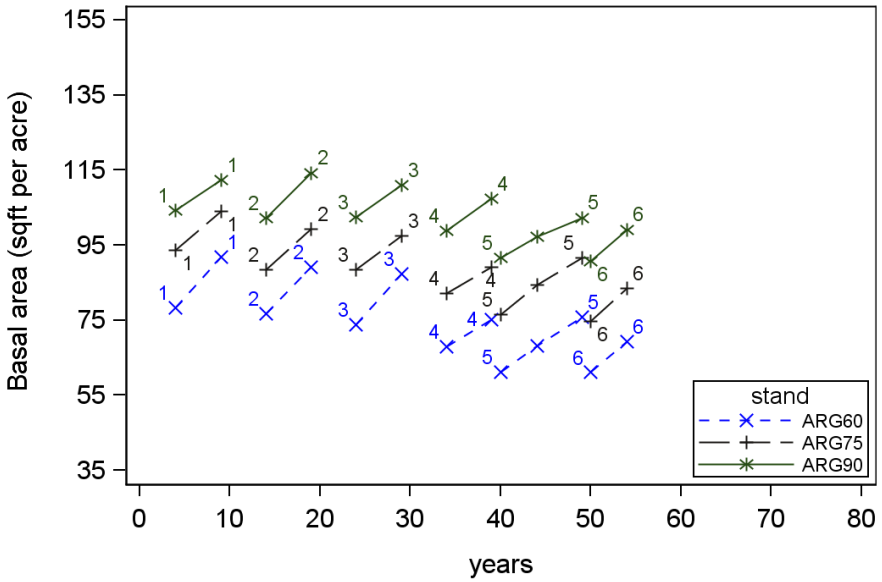
Uneven-aged (DEF)

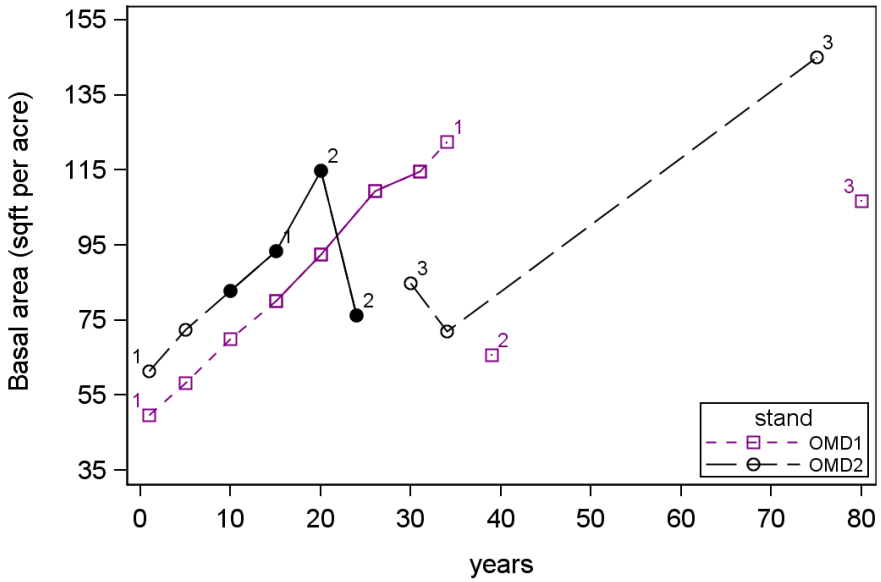


Even-aged (AEF)

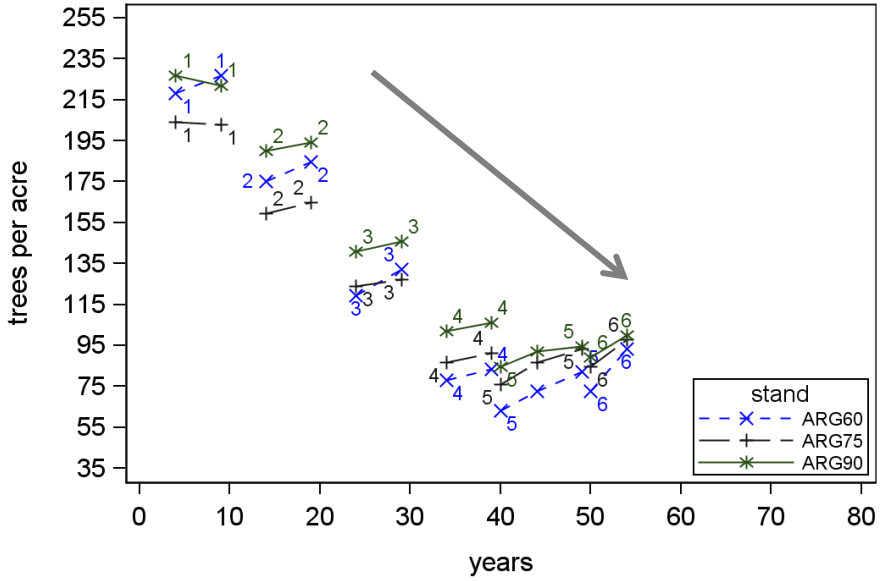
Uneven-aged (DEF)

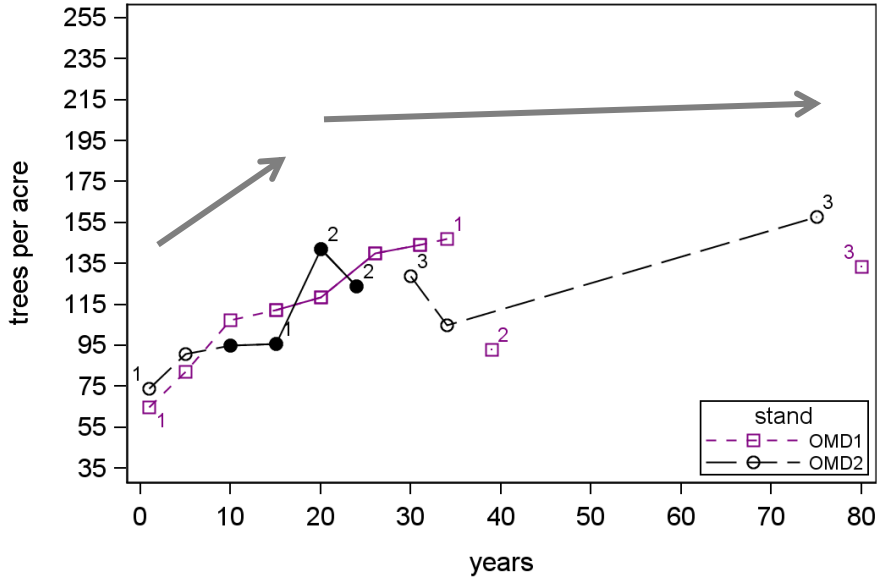
Residual Basal area





Total Tree Density

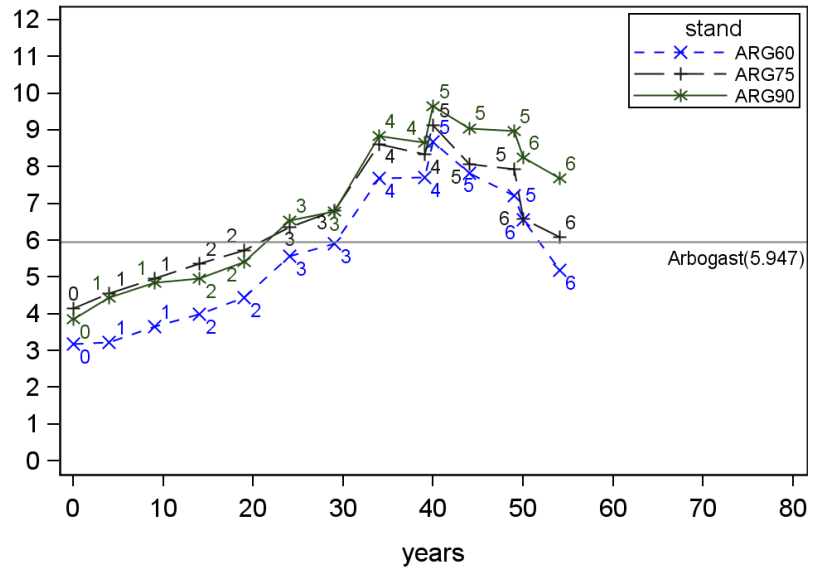


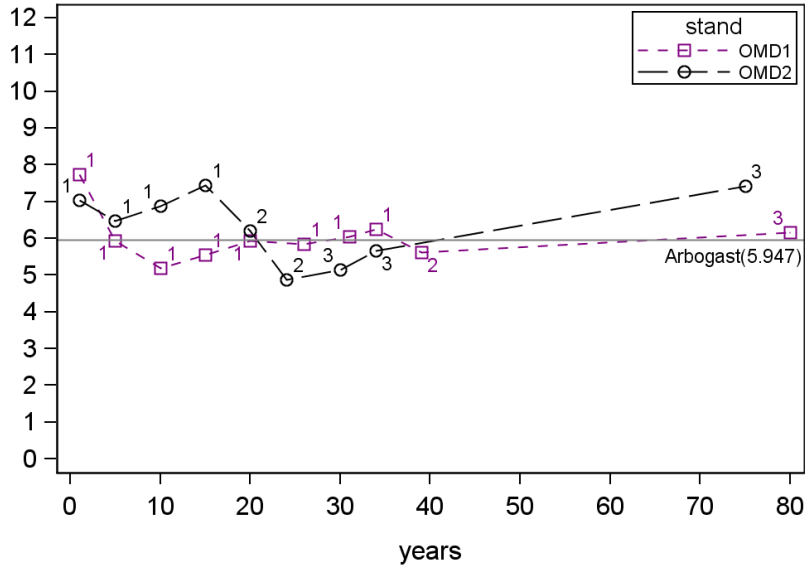


Even-aged (AEF)

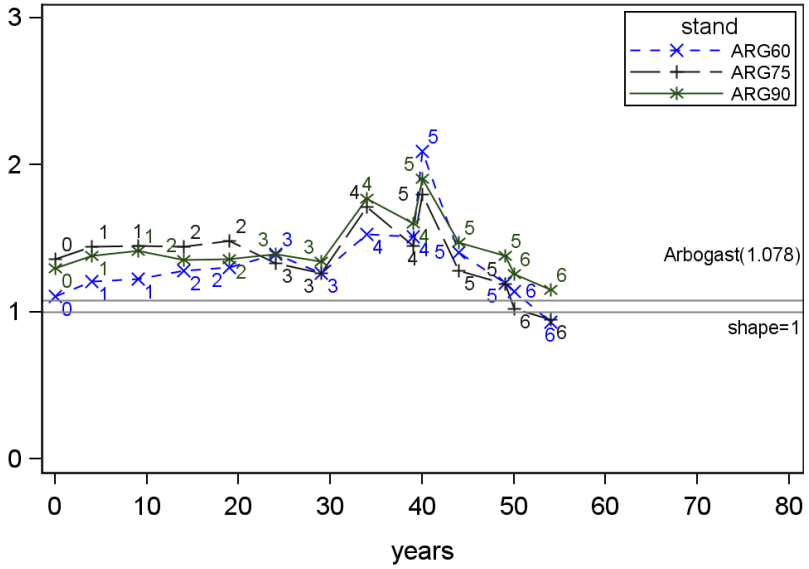
Uneven-aged (DEF)

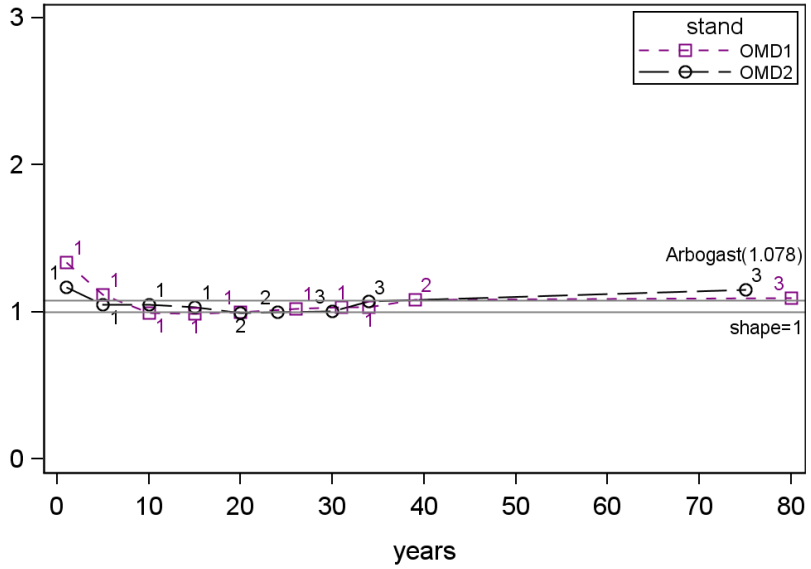
Scale





Shape





Outcomes

- Structural stability means consistency through time of :
  - Median DBH
  - Residual basal area
  - Tree density
  - 3-parameter Weibull parameters

- **Single-tree selection** cuttings in **uneven-age**d northern hardwood stands **created and maintained** a target diameter distribution that remained **stable** with repeated treatment through consecutive entries. General stand characteristics remained consistent.

- With **selection-like** cuttings for six 10-year cutting cycles in even-aged stands the structure morphed away from a reverse-J shape through time, becoming **unstable** and **unsustainable.** General stand characteristics changed through time.

- **Consistent recruitment and regular upgrowth** are key to maintaining structural stability.

This project was presented

Poster

- New York Society of American Foresters (NYSAF) 2018 Annual Meeting, Syracuse, NY, USA
- Society of American Forester (SAF) National Convention 2017, Albuquerque, NM, USA
- The 10th IUFRO International Workshop on Uneven-aged Silviculture, Little Rock, Arkansas, USA. 2016

Related Presentations

•Wisconsin Society of American Foresters Statewide Meeting 2018, Rothschild, WI. (2 presentations)

•New York Society of American Foresters 2018 Annual Meeting, Syracuse, NY

•Society of American Forester National Convention 2017, Albuquerque, NM

•10th IUFRO International Workshop on Uneven-aged Silviculture, Little Rock, AK

•*ForestConnect* Webinar, Cornell Cooperative Extension Service, October 2919

•New England Society of American Foresters 2019 Annual Meeting, Burlington,. VT

Implications and applications in the Northern Forest region

- Important to have long-term empirical data to understand the growth dynamics of stands after cutting

- Important to know and consider the regeneration and growth characteristics of a stand when deciding the appropriate management

- **Selection-like cuttings will not result in long-term stability and sustainable development when applied to even-aged stands. Need other alternatives to sustainably manage the developing second-growth forests in the Northeast U.S.**

Future directions

- Follow-up on the development of the even-aged stands for more cutting cycles using selection-like cuttings
- Investigate the age structure of the developed stands after multiple cutting-cycles of selection-like cuttings
- Research on even- to uneven-aged conversion in northern hardwood stands.

List of products

- ***Bassil, S. 2018. Long-term Structural Stability in Northern Hardwood Stands Treated With Different Alternatives of Partial Cutting.*** *PhD Thesis Dessertation, SUNY-ESF, 168 p.*
- ***Bassil, S., 2018. Lessons About Partial Cutting from Argonne and Dukes – Differences in Long-term Structural Stability (Presentation).*** *Wisconsin Society of American Foresters (WISAF) Statewide Meeting 2018, Rothschild, WI, USA.*
- ***Bassil, S., Nyland, R.D., Kenefic, L.S., Kern, C.C., 2018. Do selection cuttings ensure long-term sustainable development of both even- and uneven-aged northern hardwood stands? (Presentation and poster).*** *New York Society of American Foresters (NYSAF) 2018 Annual Meeting,* Syracuse, NY, USA **.**

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- ***Bassil, S., Nyland, R.D., Kenefic, L.S., Kern, C.C., 2017. Do different selection system strategies Ensure long-term sustainable growth of northern hardwood stands? (Presentation and poster).*** Society of American Forester (SAF) National Convention 2017, Albuquerque, NM, USA.
- ***Bassil, S., Nyland, R.D*.., 2016. Do different selection system strategies insure long-term sustainable growth of uneven-aged northern hardwood stands?** (poster).10th IUFRO International Workshop on Uneven-aged silviculture, Little Rock, Arkansas, USA**.**
- ***Bassil, S., Nyland, R.D., Kenefic, L.S., Kern, C.C., 2019.*** **Structural stability after selection cutting in uneven- and even-aged northern hardwood stands: a long-term evaluation.** Accepted Can. J. For. Res., Aug. 2019.