Structure and dynamics of jack pine in central Minnesota

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Summary

Historically, jack pine stands in north-central Minnesota followed even and un-even aged development pathways. Stand dynamics were investigated by documenting the range of variation of structural characteristics, including age and spatial structures. A majority of stands did not follow even-aged recruitment patterns but showed extended periods of jack pine recruitment, usually exceeding 20 years. These patterns were most often observed in stands classified as FDc12 and FDc23 communities and suggest that management approaches and expectations for these systems may need to be broadened to account for the prevailing patterns of natural regeneration establishment. This may include the use of regeneration methods such as seed-tree-with-reserves or variable retention harvest systems that retain mature trees on site to provide a long-term seed supply and source of structural diversity.

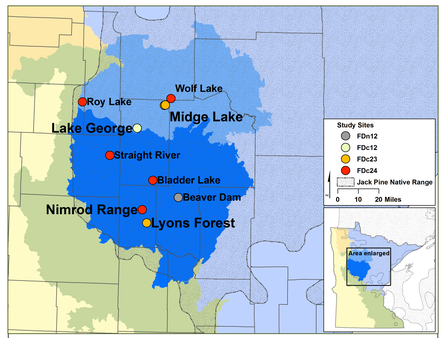


Figure 1. Location of study sites along the southwestern margin of jack pine's native range in the western half of the Minnesota Drift & Lake Plains ecological section. Icons are colored according to the native plant community designation of the stand.

Introduction

Jack pine (*Pinus banksiana*) reaches its southwestern range limit in central Minnesota (Fig. 1) where it displays traits, including low-levels of cone serotiny, that differ from other portions of its range. In many cases, it tends to dominate forest and woodland communities found on sandy soils of marginal quality. Historical summaries of forests in this region suggest that jack pine forests and woodlands in these areas may not have followed even-aged developmental patterns, such as contemporary clearcutting-based regeneration methods, but a broader range of recruitment patterns that resulted in primarily multi-aged stands. Nevertheless, studies of the historic natural stand structure and dynamic patterns have never been conducted for these systems.

OBJECTIVES:

1. Document range of natural variability of stand structure and dynamics for jack pine in the central floristic region

2. Establish reference conditions for the development of regional adaptive management techniques.

Methods

In order to study historical characteristics, ten naturally-recruited, unmanaged stands with canopy tree ages greater than 60 years were intensively sampled for a variety of structural characteristics using a square 0.62 ac study plot at each stand. All trees ≥ 4" were sampled for species, size, age, and location. Increment cores were used to develop age structures and recruitment windows. The recruitment window was defined as the number of years it took for establishment of the middle 90% of total jack pine recruitment. Spatial structures of jack pine were analyzed using Ripley's K[1], which is a metric of mean tree spacing.

1 Ripley, B.D. 1976. J. of Applied Probability 13:255-266

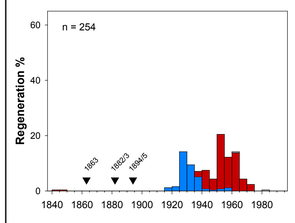
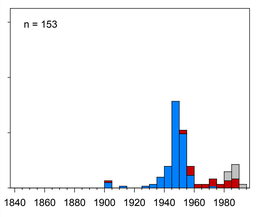
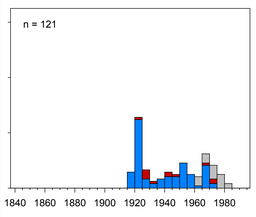
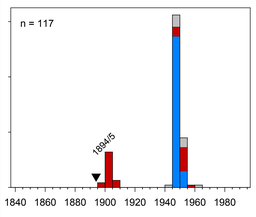
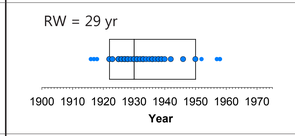
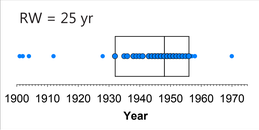
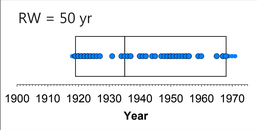
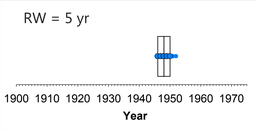
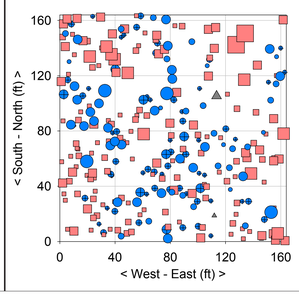
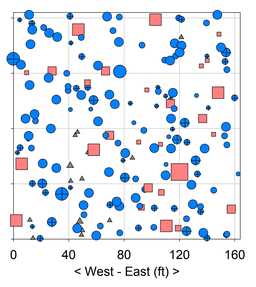
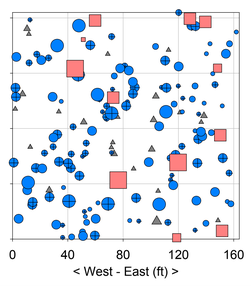
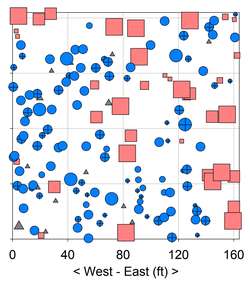
	Legend	Study-wide mean ± SE	Lake George FDc12	Lyons Forest FDc23	Midge Lake East FDc23	Nimrod Range FDc24
Total metrics		All / Jack pine	All species / Jack pine	All species / Jack pine	All species / Jack pine	All species / Jack pine
	Den (tr/ac)	230 ± 24 / 109 ± 21	366 / 94	209 / 141	152 / 91	181 / 96
	BA (ft²/ac)	96.6 ± 8.8 / 48.2 ± 4.8	131.7 / 38.0	83.2 / 51.8	68.8 / 38.0	130.9 / 48.1
	IV (%)	/ 49.8 ± 5.6	/ 27.3	/ 64.8	/ 57.4	/ 44.7
	Mean DBH±SE (in)	8.2 ± 0.3 / 9.2 ± 0.4	7.6 ± 0.2 / 8.4 ± 0.3	8.1 ± 0.2 / 8.0 ± 0.2	8.3 ± 0.4 / 8.3 ± 0.4	10.5 ± 0.4 / 9.5 ± 0.2
	Snag Den (tr/ac)	/ 108 ±11	/ 112	/ 79	/ 112	/ 84
	DWD (ft³/ac)	3.5 ± 0.7 /	1.5 /	1.0 /	2.1 /	2.8 /
Age structure	Jack pine / Red pine / Other species					
Jack pine recruitment window	Year with Recruitment / Recruitment window	RW = 21 ±4 yr	 RW = 29 yr	 RW = 25 yr	 RW = 50 yr	 RW = 5 yr
Tree locations	Jack pine / Red pine / Other species					

Table 1

Structural characteristic results (rows) from four study sites (columns; Lake George [LG], Lyons Forest [LF], Midge Lake East [ME], and Nimrod Range [NR]) of three different native plant community designations (listed below site name). Total stand metrics (density [Den], basal area [BA], importance value [IV], and mean diameter at breast height [DBH]) were calculated using living trees, except for snag density and downed woody debris (DWD) volume. IV was calculated as: (Relative BA + Relative Den)/2. Ages for trees correspond with their age at recruitment (30cm). Individuals are grouped into five-year bins for age structures and annually for recruitment windows. Triangles in the age structure figures indicate fire scar dates. Jack pine recruitment windows (RW) represent the middle 90% of total jack pine recruitment; vertical bars indicate the years where 5, 50, and 95% of individuals had recruited. Tree location icons (●, □, and Δ) represent the location and species of sampled individuals; the size of the icon is scaled according to DBH and snags are indicated by a '+'.

Structural Characteristics

Structural characteristics (Table 1) varied across the region. Metrics of stand density (Total metrics) were generally on the lower side of reported values for non-range-margin stands but average DBH were higher. Living jack pine had an average importance value (IV) of 50%; the high density of jack pine snags reflected these stands were in the break up stage and were transitioning to more mixed composition.

Age distributions (Table 1, Age structure) indicated primarily uneven-aged structures when considering all species. Jack pine often showed an initial pulse of recruitment but rarely as a clearly defined cohort (see Recruitment Windows below). Red pine (*P. resinosa*) was the most common associate and recruited at various points of stand development. Other associated species, primarily oaks (*Quercus rubra* and *Q. macrocarpa*), most often recruited later in stand development and were not in canopy positions.

Recruitment Windows

Jack pine recruitment windows (Table 1; RW) were calculated to quantify the time taken for a majority of current trees to establish. RWs ranged from 5-50 years. Six of the ten stands had extended RWs that spanned greater than 20% of the average rotation age (see Lake George, Lyons Forest and Midge Lake East); of the four even-aged stands three were classified as FDc24 communities (see NR) and one as FDn12.

Extended RWs were most often a result of an understocked initial regeneration pulse followed by additional jack pine recruitment.

Spatial Arrangements

Jack pine demonstrated significant aggregation (clumping) at distances greater than 16ft in many stands. Clumps of recruitment were often observed in gaps between existing trees (Table 1, Tree locations, NR) or in the initial regeneration pulse (the case at LG, LF, and ME). This suggests that, given a seed source, gaps as small as 250 ft² may provide adequate light environments for jack pine recruitment and that additional recruitment can supplant initial understocking. However, on lower quality sites structurally heterogeneous woodlands with low-levels of continuous recruitment may develop (see ME).

Management Implications

Central floristic jack pine stands have historically developed along a variety of pathways, likely due to the abundance of non-serotinous cones, and a variety of management systems can be ecologically justified. The system chosen should depend on the short- and long-term goals for the stand and the landscape. If mature jack pines are retained, passive scarification through summer harvests or light active scarification (prescribed burning or anchor chains) should encourage initial recruitment or create conditions conducive to additional or understory recruitment, especially where competition from shrubs and deciduous species is high (FDc24). Even so, expectations of time to full-stocking should be extended for FDc12, FDc23, and FDc24 communities in this region.

FDc12 & FDc23: Two-aged and variable retention harvests would reflect the heterogeneous age and spatial structures of these communities. Such systems could encourage jack pine resilience on a site that could also provide cover for longer-lived red pines, given an adequate seed source, and other understory community associates.

FDc24: Even-aged management (seed-tree or clearcut) appears to be most appropriate for these communities. Mature trees should still be retained as a source of seed and structure. Understory treatments to reduce competition will be necessary if jack, red or white pine are the desired long-term species.




Acknowledgments

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