Lake States
Fire Science Consortium

Long Term Demographic Study of Trees in an Oak Savanna/Woodland

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We initiated Project **GLADES** (**G**rid for **L**andscape **A**nalysis and **D**emographic *S*tudy) in 1988 to document long-term changes in the demography and spatial patterns of trees in an oak savanna/woodland in east-central Minnesota. In 1988, a 16 ha square grid, consisting of 10 x 10 m cells was established in a portion of the oak savanna/woodland habitat at the Cedar Creek Ecosystem Science Reserve in East Bethel, MN.

In each cell, several variables were recorded at the study's beginning, including total soil nitrogen, amount of bare ground, number of thatch ant (*Formica obscuripes*) mounds, and elevation (determined by Mark Hurd, Inc.). In 1995, all trees with diameters of 2 cm or greater were tagged. Their location within their respective cells was also recorded, meaning that each tree in the grid was documented with a specific location in an x,y coordinate system. More than 10,000 trees/stems were originally tagged. These included trees from ten species, with two of the species, *Quercus macrocarpa* and *Quercus ellipsoidalis*, representing nearly 90% of the trees at the outset. *Populus tremuloides* and *Prunus serotina* were each represented by several hundred trees/stems. A small number of trees were represented by *Acer rubrum, Fraxinus pennsylvanica, Betula papyerifera, Ulmus americana, Acer negundo,* and *Crataegus sp*.

All trees have been checked annually (through 2020, i.e., for 25 years) and their status recorded: L (live), D (Dead and standing) or DF (Dead fallen). Every five years, the dbh of all living trees is measured, 2020 being the last year dbh was measured. The grid consists of three different burn units. One was not burned until 2000 and has been burned approximately every other year since. Another has been burned approximately every other year since 1988, while the other has been burned approximately every fourth year since 1988. Data have been managed by ArcMap and Excel.

Credit: Mark Davis

Fig. 1: A portion of GLADES study site.

Management Implications

1. Efforts to restore and manage oak savannas using frequent burns over several decades may not significantly decrease shrub cover and may increase the cover of *Quercus ellipsoidalis* resprouts/grubs.
2. Frequent burns over several decades will dramatically increase the dominance of *Q. macrocarpa.*
3. The initiation of controlled burns will likely increase the aggregation of individual species, but the level of aggregation will decline with future fires.
4. Frequent fires over several decades eradicated thatch ants, *Formica obscuripes*, from the study grid.

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Our Findings

Trees

- In the absence of fire, tree encroachment into openings was approximately 7 cm/yr.
- Total soil nitrogen is inversely associated with elevation (meaning also inversely associated w/ distance to water table).
- Total soil nitrogen is lower in openings than in cells with trees.
- Tree aggregation is higher among small trees.
- Tree aggregation is inversely related to the abundance of the species.
- Fire initially increases tree aggregation but aggregation declines with more fires.
- *Q. ellipsoidalis* grows more densely with conspecifics than does *Q. macrocarpa.*
- *Q. macrocarpa* is randomly distributed with respect to elevation.
- *Q. ellipsoidalis* is positively associated with elevation; unlike *Q. macrocarpa,* it is seldom found near wetlands.
- 69% of the trees alive at the start of the study were dead in 2020.
- Originally *Q. macrocarpa* represented 56% of the trees on the grid. That changed to 80% in 2020.

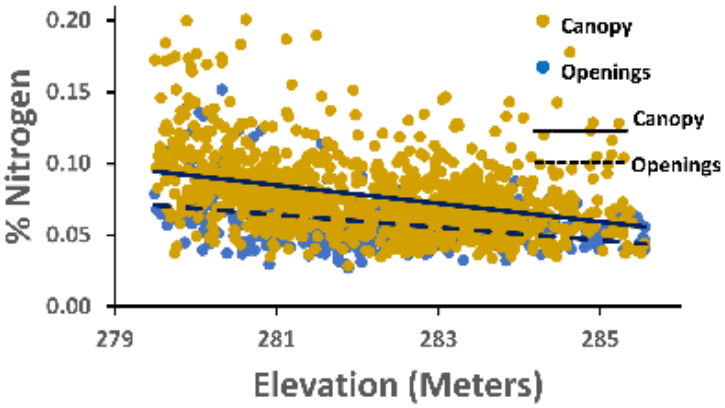

Fig. 2: Percent total soil nitrogen of cells in with and without tree canopies shown as a function of elevation.

Ants

- Fire has eliminated ant mounds in the grid.
- Before they were eliminated, ant mounds were much more likely to be in cells with *Q. macrocarpa* than *Q. ellipsoidalis.*

Snags

- Both bird species richness and abundance were positively associated with the number of snags (standing dead trees).

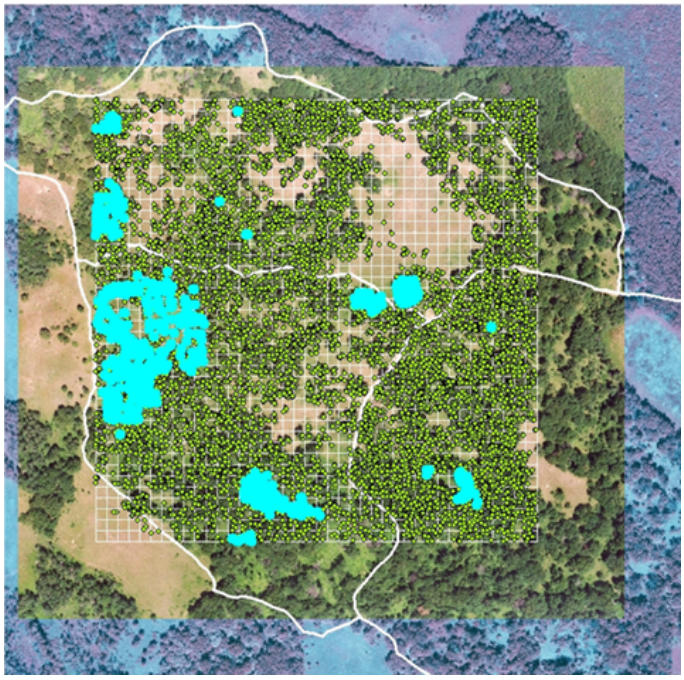

Fig. 3: The 16 ha grid showing the more than 10,000 trees and firebreaks. *Populus tremuloides* trees are shown in blue and indicate the locations of low elevation/wetland areas.

- Although the introduction of fire initially resulted in an increase in the number of snags, repeated fires eventually caused the number of snags to decline substantially.

Shrubs

- With respect to shrubby vegetation, after 25 years of frequent fires, parts of the grid consist of almost impenetrable shrubs, parts consist of dense *Q. ellipoidalis* resprouts/grubs, and parts contain few to no shrubs (mostly areas that had few shrubs in 1995).

For Further Reading

Davis, M. A., A. Duke, T. Ibsen, H. Tran, and R. Rhodes. 1997. Spatial Distribution of Penstemon grandiflorus(Nutt.) and Geomys bursarius in a fragmented oak woodland in Minnesota, USA. Natural Areas Journal 17:136-143.

Davis, M. A., C. Curran, A. Tietmeyer, and A. Miller. 2005. Dynamic tree aggregation patterns in a species-poor temperate woodland disturbed by fire. Journal of Vegetation Science 16: 167-174.

Davis, M. A. and A. Miller. 2018. Savanna restoration using fire benefits birds using dead trees, up to a point. American Midland Naturalist 179:94-104.

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