Formulating an Expanding-Gap Regeneration System for *Quercus* Dominated Stands

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Presentation Outline

- What is an irregular shelterwood system?
- Rational for applying an irregular shelterwood system in *Quercus* stands
- “Proof of concept” study and future exploration

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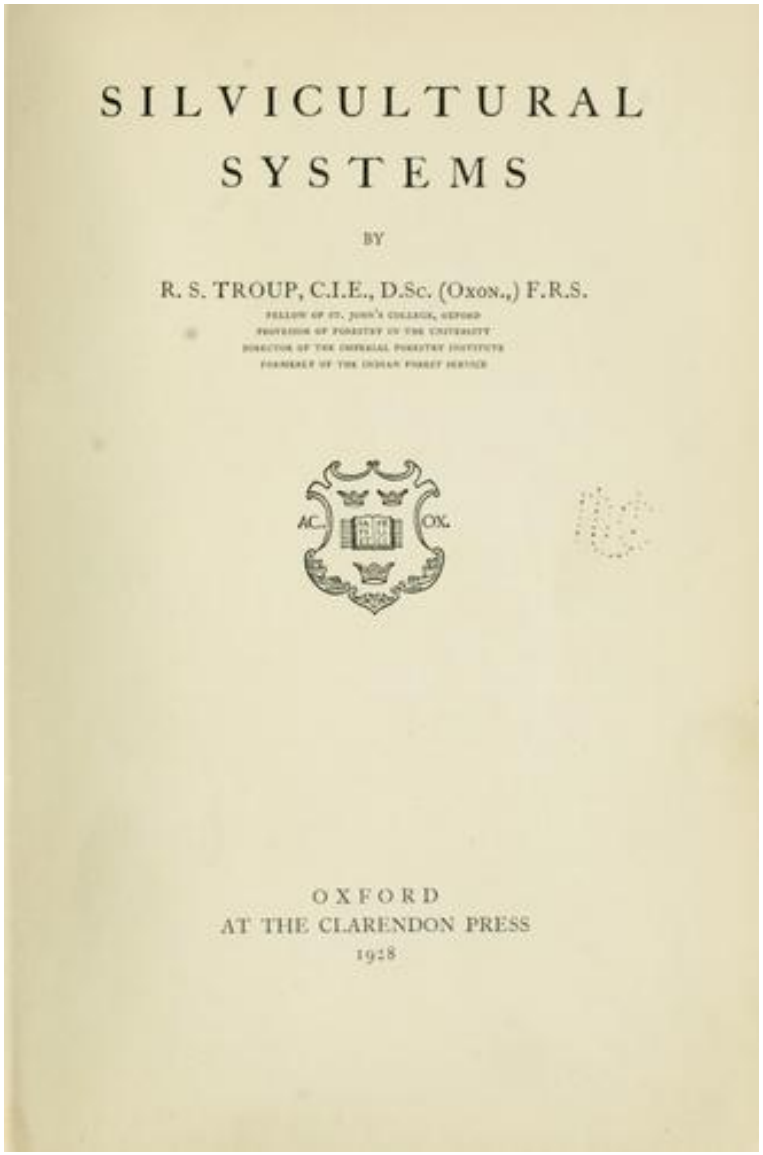
Historical Context



SILVICULTURAL
SYSTEMS

BY

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OXFORD
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1928

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Historical Context

The Irregular Shelterwood System: Review, Classification, and Potential Application to Forests Affected by Partial Disturbances

Patricia Raymond, Steve Bédard, Vincent Roy, Catherine Larouche, and Stéphane Tremblay

ABSTRACT

Structurally different from even-aged and balanced uneven-aged stands, irregular stands are an integral part of forested landscapes in northeastern North America. The maintenance or restoration of irregular stand structure may be desirable, especially in areas under ecosystem-based management. This can be achieved at the stand level through the implementation of irregular shelterwood systems. The objectives of this synthesis are to assemble the existing knowledge about the system, clarify the terminology in use, and discuss its place in silviculture in northeastern North America. Irregular shelterwood is compared with other regeneration methods and we propose a classification based on three variants. This silvicultural system is compatible with ecosystem-based management in forest types driven by partial stand mortality and gap dynamics and provides opportunities for maintaining old-growth forest attributes. However, it presents important challenges, especially with regards to planning, growth and yield prediction, and operational application.

Keywords: ecosystem-based management, irregular uneven-aged silviculture, multiaged stand, irregular shelterwood variants, regeneration methods

In many North America jurisdictions, the management of public forestlands has gradually shifted from timber production to ecosystem-based management, with a focus on late-successional habitat (Kohm and Franklin 1997). In a managed territory, applying principles of ecosystem-based management is a way of achieving sustainable forest management objectives (Galindo-Leal and Bunnell 1995). This implies that silvicultural practices must emulate ecological processes and interactions if composition, structure, and ecosystem function are to be maintained within their limits of natural variability (Kaufmann et al. 1994, Seymour et al. 2002, Gauthier et al. 2008) at multiple spatial and temporal scales (Galindo-Leal and Bunnell 1995). At the stand scale, the growing interest in ecosystem-based management brings into question current silvicultural practices and how they can contribute to maintaining ecological values (Guldin 1996, Puettmann and Ammer 2007).

This article focuses on the silviculture of irregular stands. In American forestry textbooks, even-aged stands are clearly distinguished from uneven-aged stands (Smith et al. 1997, Nyland 2002). Even-aged stands are composed of trees in the same age class, with the oldest and youngest trees differing

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Irregular Shelterwood System Defined

Three general classifications:

- Expanding-gap irregular shelterwood
- Continuous cover irregular shelterwood
- Extended irregular shelterwood

Raymond, P., S. Bedard, V. Roy, C. Larouche, and S. Tremblay. 2009. The irregular shelterwood system: Review, classification, and potential application to forests affected by partial disturbances. Journal of Forestry 107(8):405-413.

Irregular Shelterwood System Defined

Expanding-gap irregular shelterwood -

"Aims to regenerate new cohorts in groups that are gradually enlarged until the stand is totally removed"

Raymond, P., S. Bedard, V. Roy, C. Larouche, and S. Tremblay. 2009. The irregular shelterwood system: Review, classification, and potential application to forests affected by partial disturbances. Journal of Forestry 107(8):405-413.

Irregular Shelterwood System Defined

Continuous cover irregular shelterwood –

"Sequence of cuttings is applied more freely in space and time, which permits maintenance of a multicohort structure and a continuous forest cover "

Raymond, P., S. Bedard, V. Roy, C. Larouche, and S. Tremblay. 2009. The irregular shelterwood system: Review, classification, and potential application to forests affected by partial disturbances. Journal of Forestry 107(8):405-413.

Irregular Shelterwood System Defined

Extended Irregular Shelterwood –

"Aims to regenerate the whole stand while … two cohorts are maintained for at least 20% of the rotation length"

Raymond, P., S. Bedard, V. Roy, C. Larouche, and S. Tremblay. 2009. The irregular shelterwood system: Review, classification, and potential application to forests affected by partial disturbances. Journal of Forestry 107(8):405-413.

Expanding-gap irregular shelterwood

Variant	Expanding-gap irregular shelterwood
Other names	Bayerischer Femelschlag Acadian Femelschlag Irregular group shelterwood Bavarian shelterwood Coupe progressive irrégulière par trouées agrandies
Period of regeneration	>20% rotation length
Harvesting pattern	Group gradually expanded
Final removal	Optional
Arrangement of cohorts	Juxtaposed cohorts New cohort established besides the previous one
Vertical structure	Regular at small scale Single layer
Horizontal structure	Irregular Mosaic of cohorts

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Irregular Shelterwoods and *Quercus* Forests

- *Femelschlag* systems are used throughout Europe
- While interest is gaining, no examples of expanding-gap irregular shelterwoods exist in North American oak forests
- Potential benefits of expanding-gap systems include:
  1. Structural complexity and continuous forest cover
  2. Multiple income flows over rotation
  3. Regeneration of diverse species groups, from shade intolerants in gap centers to intermediates and shade tolerants along gap edges

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Research Goal

Our long-term goal is to develop an expanding-gap based silvicultural practices that address the oak regeneration problem present within the Central Hardwood Forest Region (CHFR)

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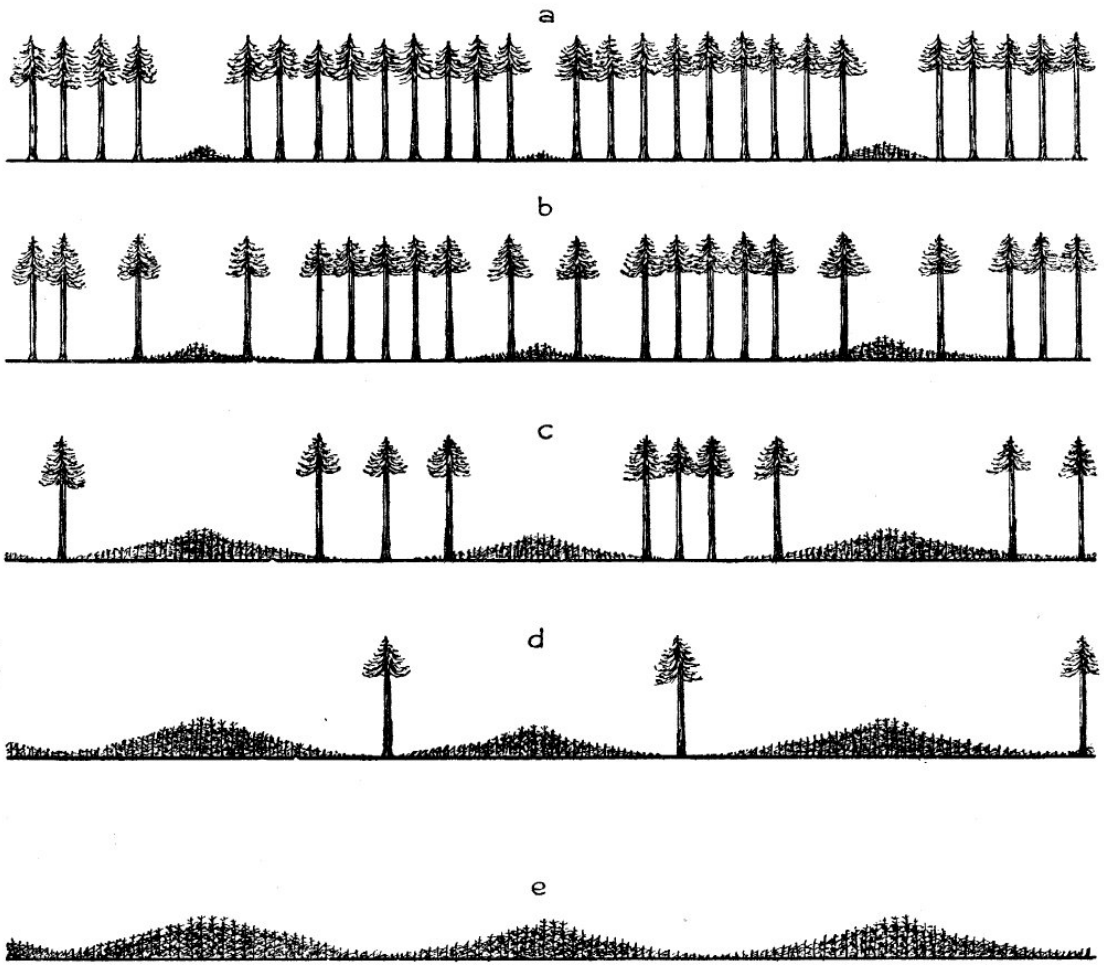
Research Needed for System Development



Source: Troup 1928

Research Needed for System Development

Developing a expanding-gap regeneration system requires understanding of how the following factors influence spatial variation in resource gradients and regeneration dynamics:

- Gap size
- Edge effects
- Canopy structure in the forest matrix

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Research Needed for System Development

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This presentation integrates results from complementary research studies that together support the basis for applying expanding-gap regeneration systems in oak dominated stands

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Research Studies

Gap Size

Lhotka (In Press) tested the effect of three gap sizes on oak recruitment 48 years following treatment

Edge Effects

Lhotka and Stringer (In Review) characterized the relationship between distance from anthropogenically created edge and the height and density of oak reproduction

Midstory Removal

Parrott et al. (In Press) evaluated the effect of midstory removal on understory light availability and oak seedling survival and growth after 7 growing seasons

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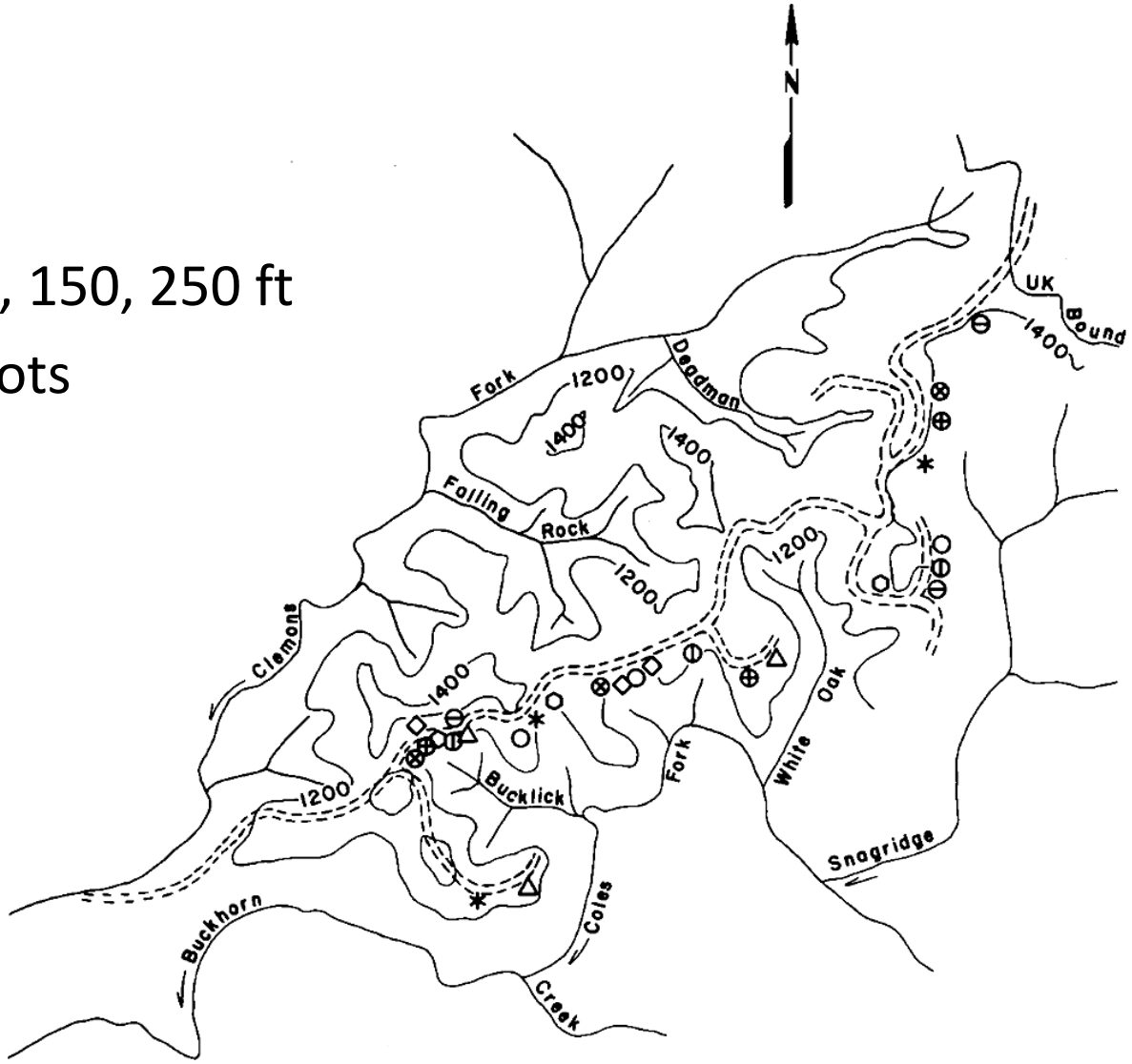
Robinson Forest Gap Size Study

- Established 1960
- Three gap sizes: 50, 150, 250 ft
- 27 experimental plots



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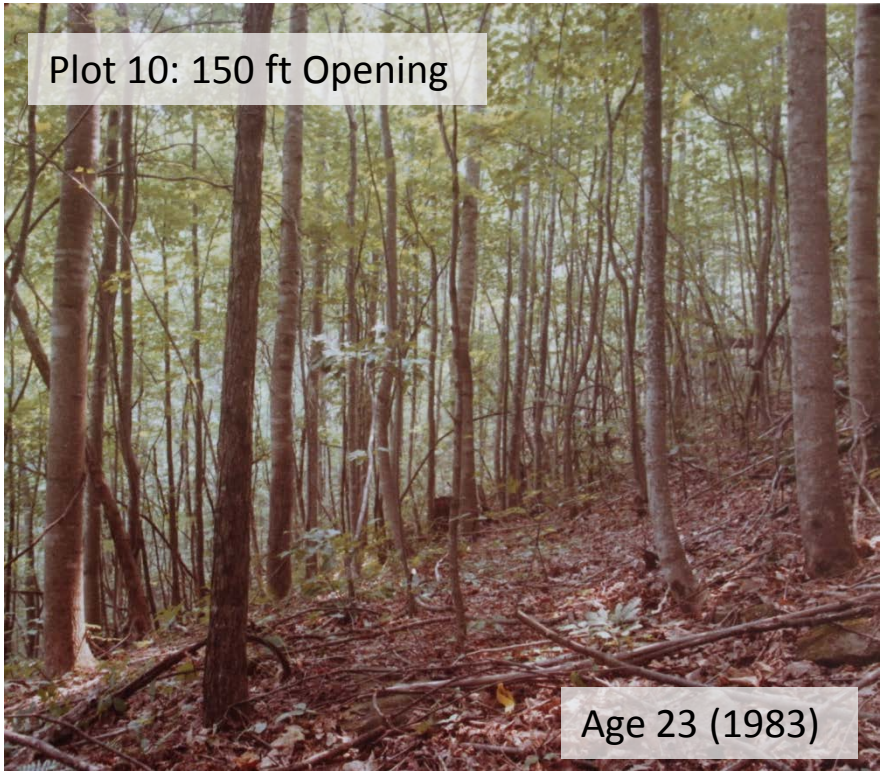
Robinson Forest Gap Size Study

Hill and Muller (UK): 1981, 1985, 1987
USDA Forest Service: 1991



Lhotka: 2008
*Thanks to Matt Strong

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Robinson Forest Gap Size Study - Results

Stand Structure after 48 Years

Opening Size	BA ($m^2\ ha^{-1}$)	Trees (ha^{-1})	QMD (cm)	Top Height (m)
50	12.2^{a*}	1008.2^{a}	12.2^{a}	19.8^{a}
150	21.1^{b}	953.7^{a}	17.0^{b}	26.6^{b}
250	21.6^{b}	719.1^{a}	19.7^{c}	28.6^{b}

*Means with similar letters are not statistically different ($\alpha = 0.05$)

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Robinson Forest Gap Size Study - Results

Overstory Trees ha^{-1} by Treatment following 48 Years

Species Group	Opening Size		
	50 ft	150 ft	250 ft
Oak	27.4^{a*}	89.3^{b}	49.5^{b}
Maple	82.2^{a}	51.4^{a}	52.4^{a}
Yellow-poplar	0^{a}	39.3^{b}	50.4^{b}
Hickory	12.1^{a}	4.7^{a}	2.9^{a}
Other Commercial	6.1^{a}	2.7^{a}	4.9^{a}
Other	9.1^{a}	5.4^{a}	3.4^{a}

*Means within a species group that have similar letters are not statistically different ($\alpha = 0.05$)

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Robinson Forest Gap Size Study - Summary

Size of opening influenced structure and composition and apparent trends suggest:

- 50 ft opening favored maple
- Dominant and codominant oak density was “maximized” in 150 ft opening
- Yellow-poplar increased with larger opening sizes

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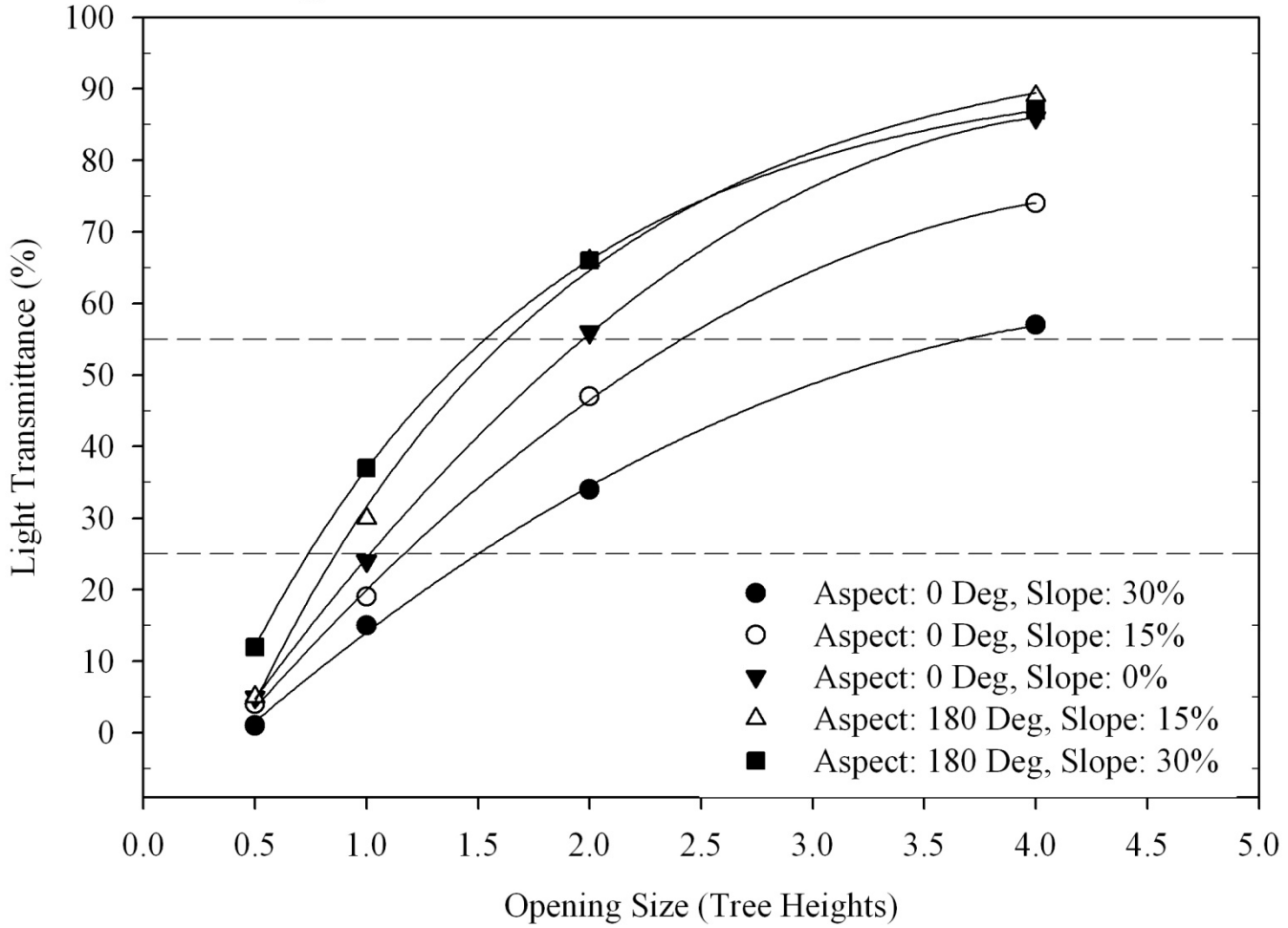
Gap Size Study : Role of Light in Species Trends

From: Fischer, B.C. 1981. Designing Forest Openings of the Group Selection Method. SO-GTR-34. pp 274-277.



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Berea Forest Edge Effects Study

- Initiated by Lhotka and Stringer in 2011
- Goal was to further understanding of how forest edge influences the development of advance reproduction along the gradient extending from a regeneration opening into adjacent, intact forest areas
- 48 m transects surround to 9-year-old clearcuts on Berea College Forest

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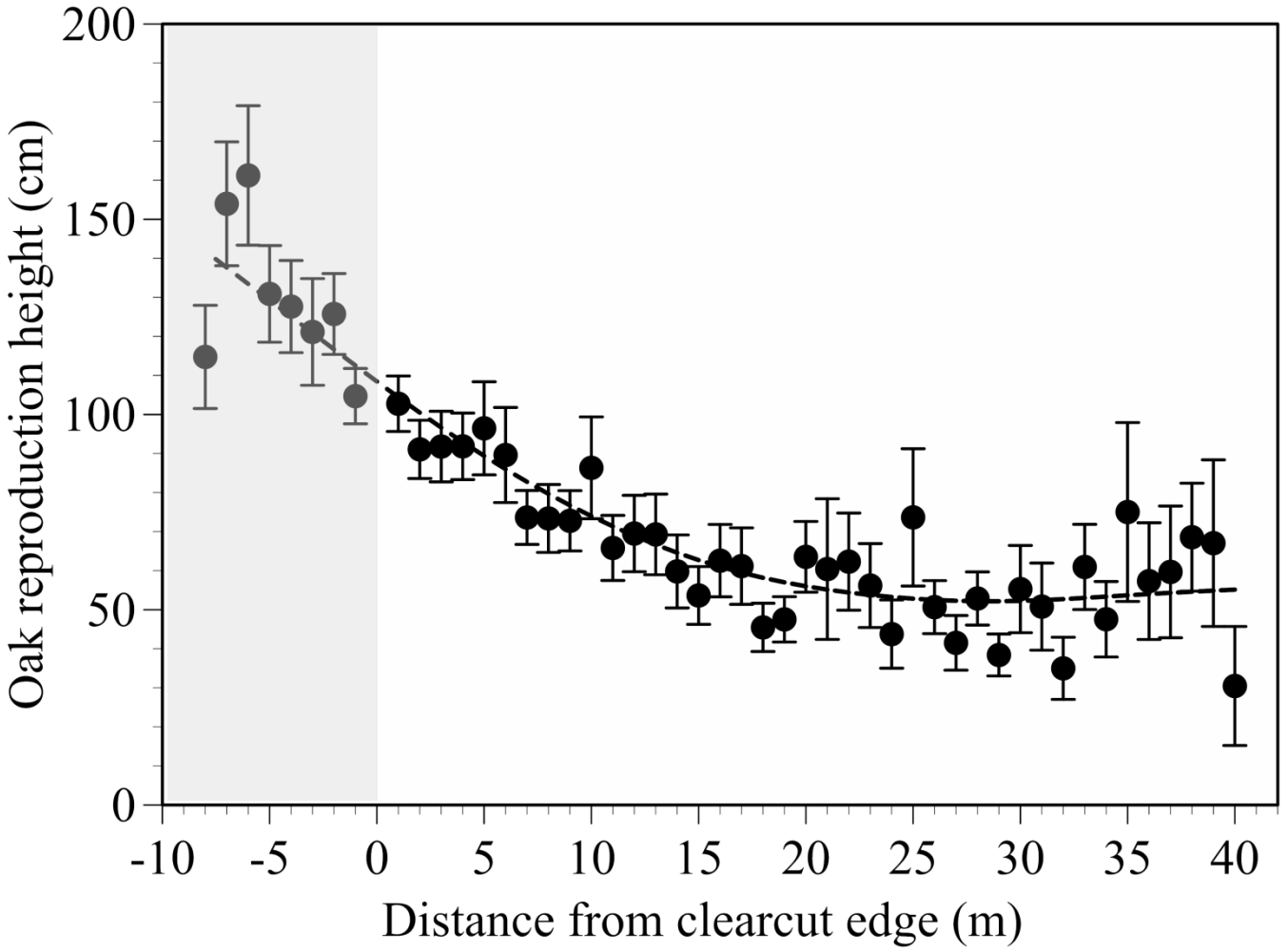
Berea Forest Edge Effects Study – Seedling Heights



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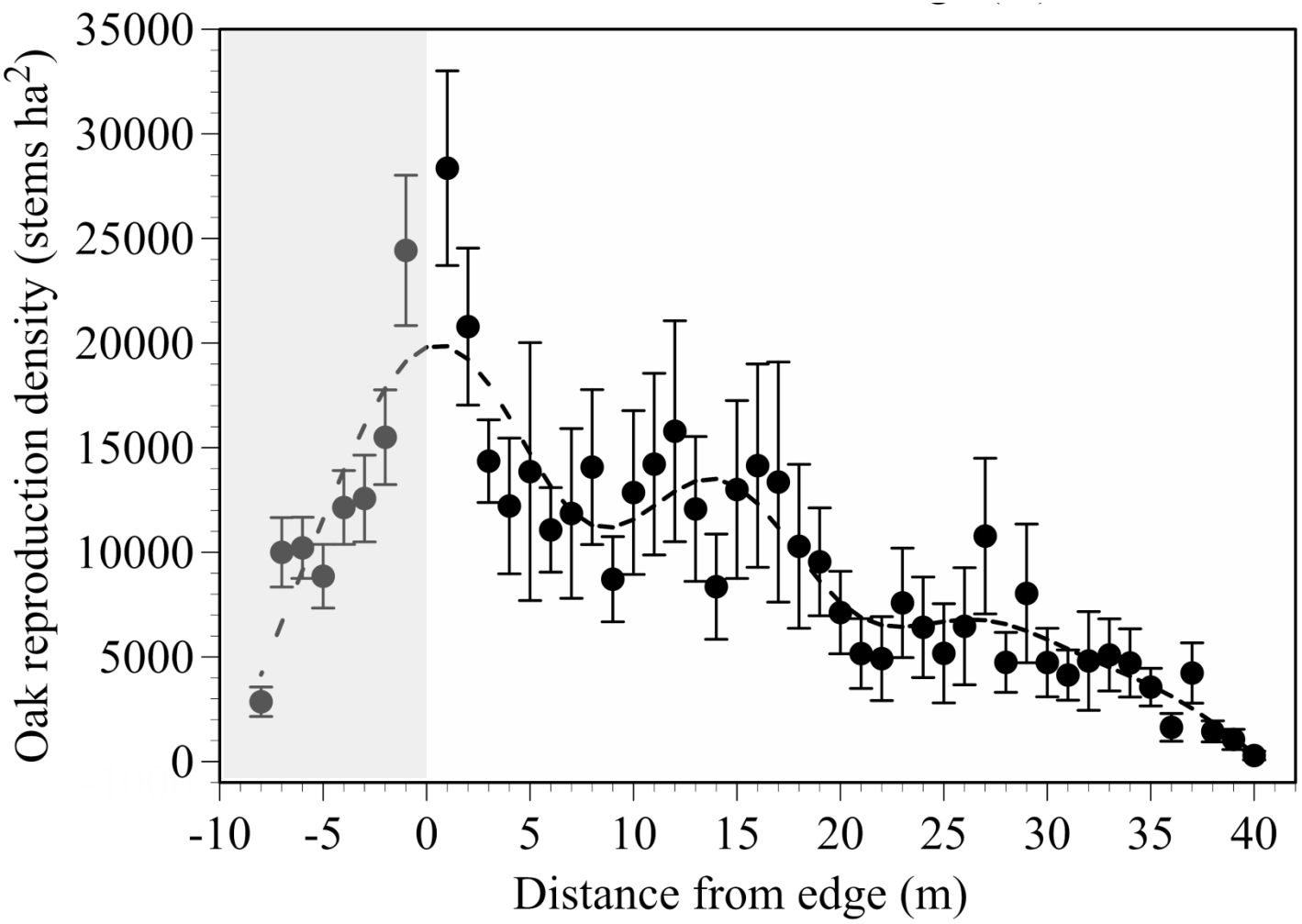
Berea Forest Edge Effects Study – Seedling Density



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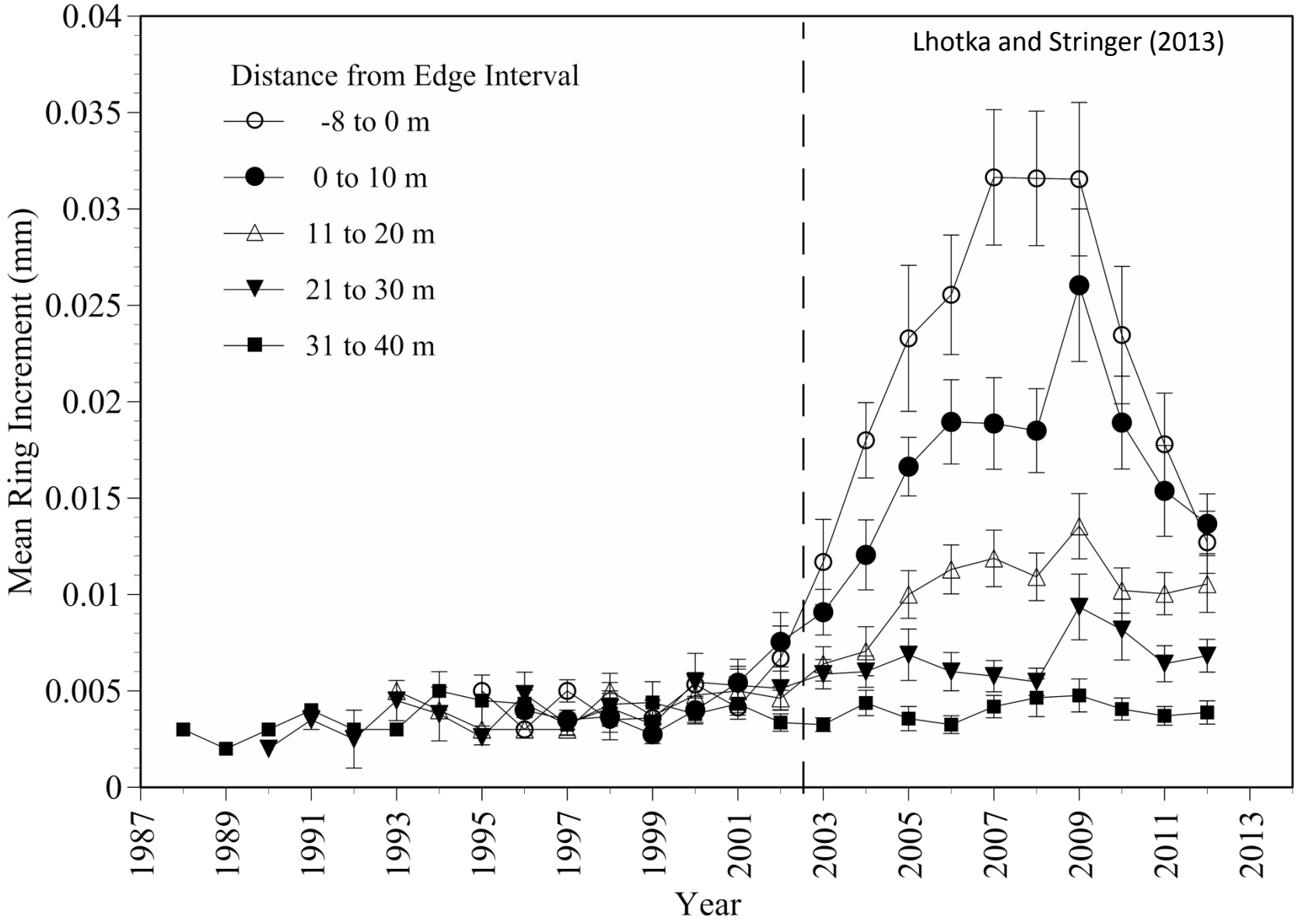
Edge Environment: Seedling Radial Growth



Berea Forest Edge Effects Study - Summary

Data indicate that environments associated with forest edges can increase the size and density of oak reproduction and that the edge influence may extend up to 20 m

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Berea Midstory Removal Study

- Initiated by Dillaway and Stinger (2004)
- 4 sites, Berea College Forest
- Midstory removal treatment (20% basal area reduction)
- Natural advance reproduction and underplanted seedlings
- Monitored 7 years
- Understory microclimate characterized

Berea Midstory Removal Study - Results

- Midstory removal increased understory light availability
  - Removal 10.3% full sunlight
  - Control 1.5% full sunlight

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Berea Midstory Removal Study – Results

Seven-year natural and underplanted seedling responses to midstory removal (Parrott et al. In Press)

	Natural Reproduction			Underplanted	
	Black Oak	White Oak	Red Maple	Black Oak	White Oak
Survival (%)					
Control	---	70.4*	80.6*	15.7*	46.0*
Midstory Treatment	---	85.9*	87.9*	45.8*	78.3*
Mean height (cm)					
Control	52.3	28.9 *	41.6 *	37.4	31.0 *
Midstory removal	77.1	45.3 *	69.8 *	51.4	46.3 *
Mean GLD (mm)					
Control	8.5	4.7 *	6.5 *	7.0 *	7.4 *
Midstory removal	13.0	7.8 *	10.1 *	9.9 *	9.1 *

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Developing a expanding-gap regeneration system

Understanding factors that influence spatial variation in resource gradients and regeneration dynamics:

- Gap size
- Edge effects
- Canopy structure in the forest matrix

An Expanding-Gap Approach for Oak

What about gap size?

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An Expanding-Gap Approach for Oak

What about gap size?

Research indicates that silvicultural gaps 1.5 to 2.5 times the dominant tree height can:

1. Improve oak recruitment within gaps
2. Create edge environments that may increase density and height of oak reproduction in the adjacent forest matrix

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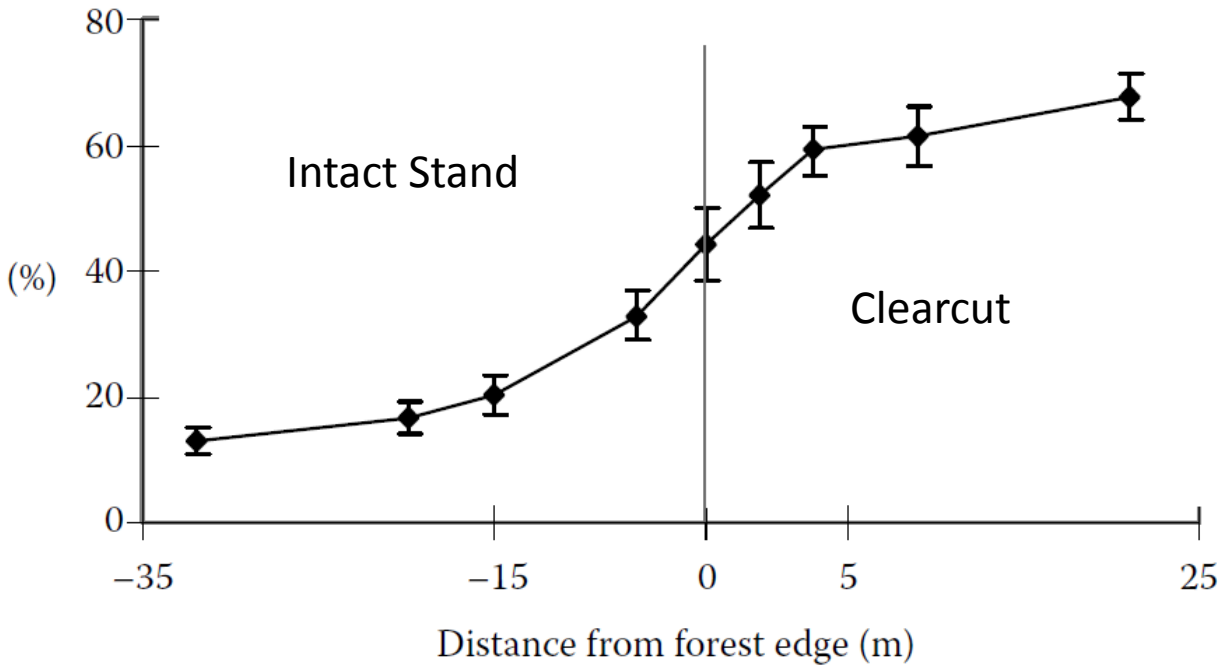
What about edge effects and forest structure in matrix?



Schmid, I., K. Klumpp, and M. Kazda. 2005. Light distribution within forest edges in relation to forest regeneration. Journal of Forest Science 51(1):1-5.

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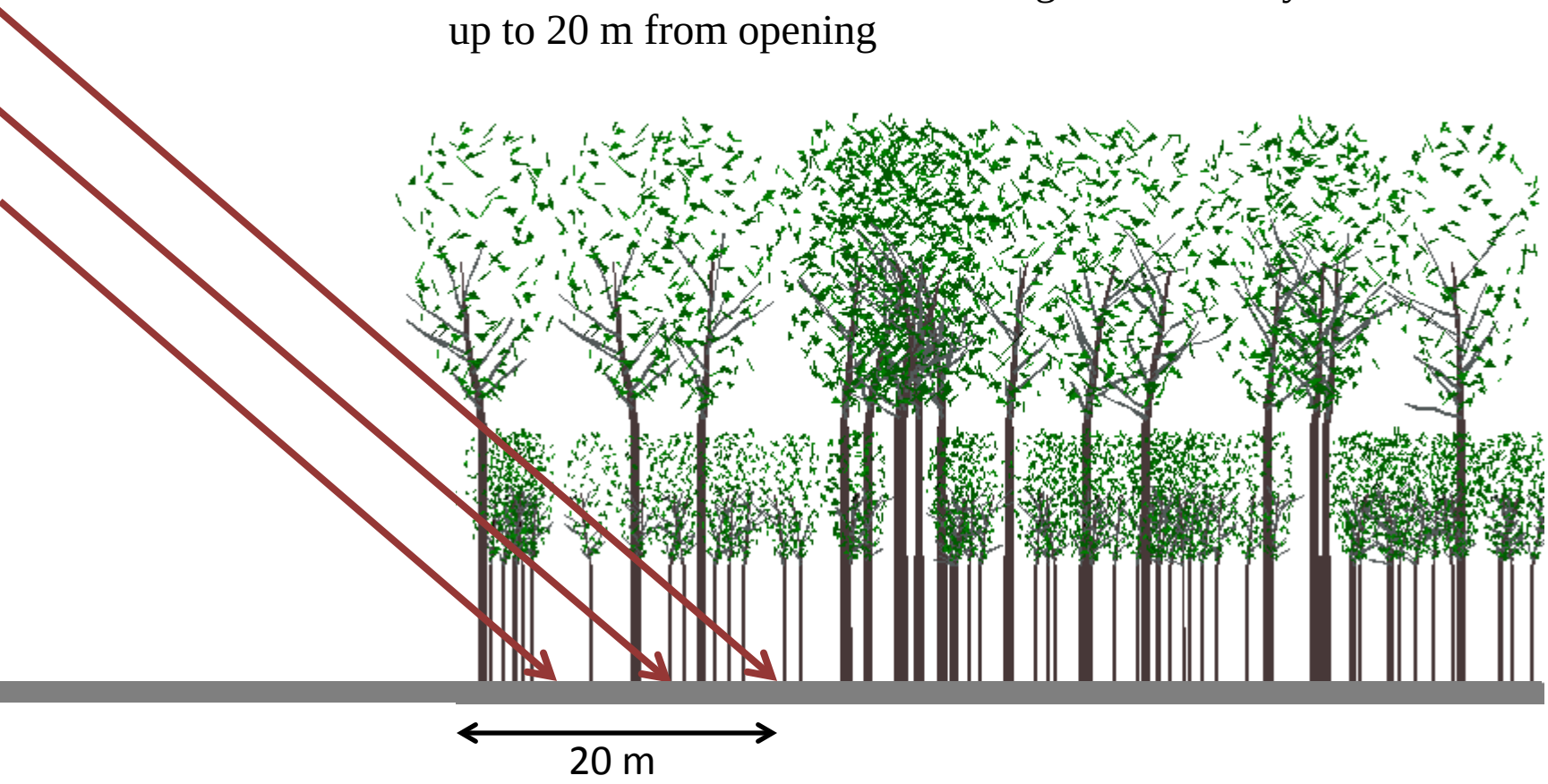
What about edge effects and forest structure in matrix?

Environmental effects of forest edges on oak may extend up to 20 m from opening



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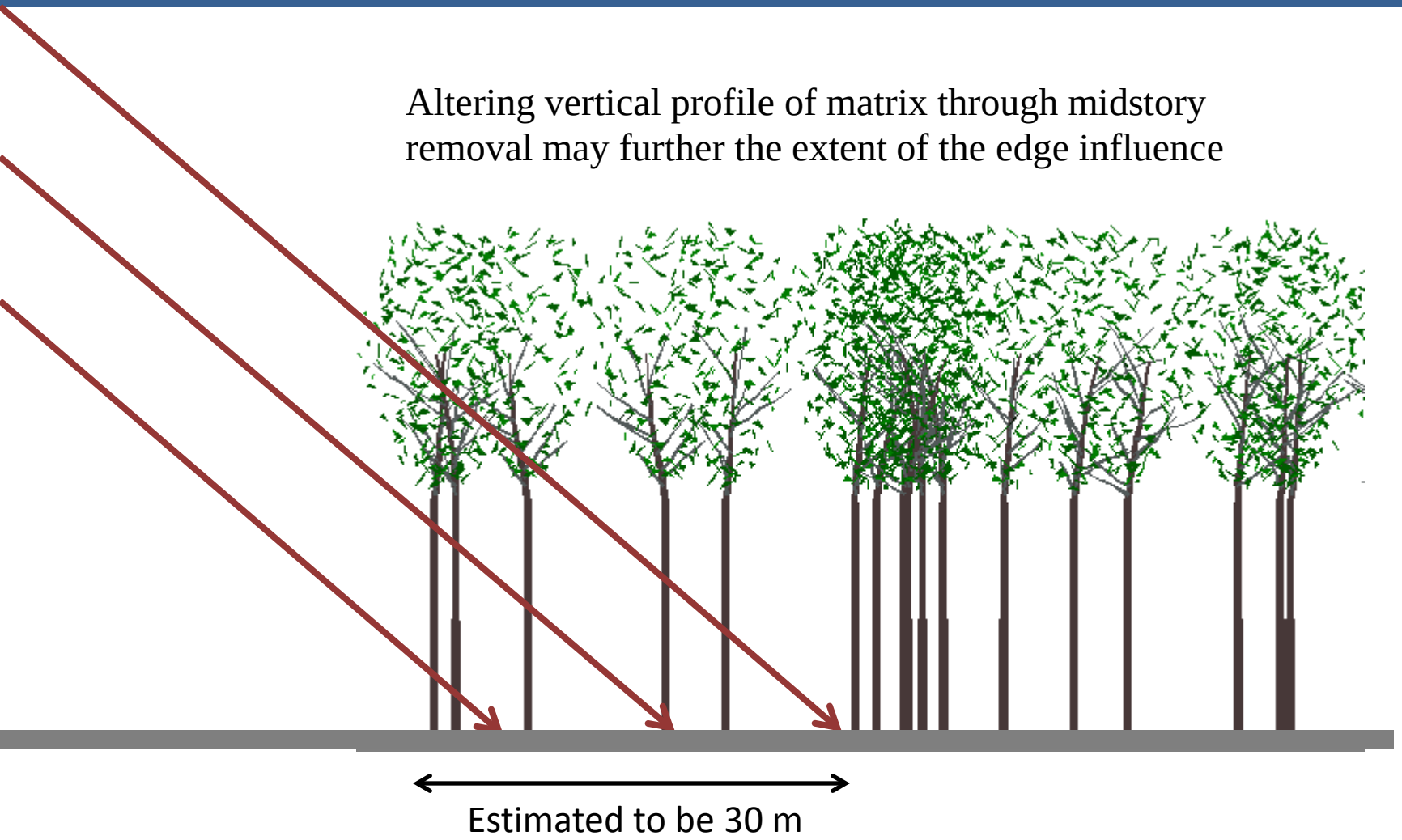
What about edge effects and forest structure in matrix?

Altering vertical profile of matrix through midstory removal may further the extent of the edge influence



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An Expanding-Gap Approach for Oak

What about edge effects and forest structure in matrix?

Removal of midstory canopies around silvicultural gaps may:

1. Improve oak survival and growth in areas to be released during subsequent gap expansions
2. Extend the enhancement effect of the edge environment on oak reproduction further in the forest matrix

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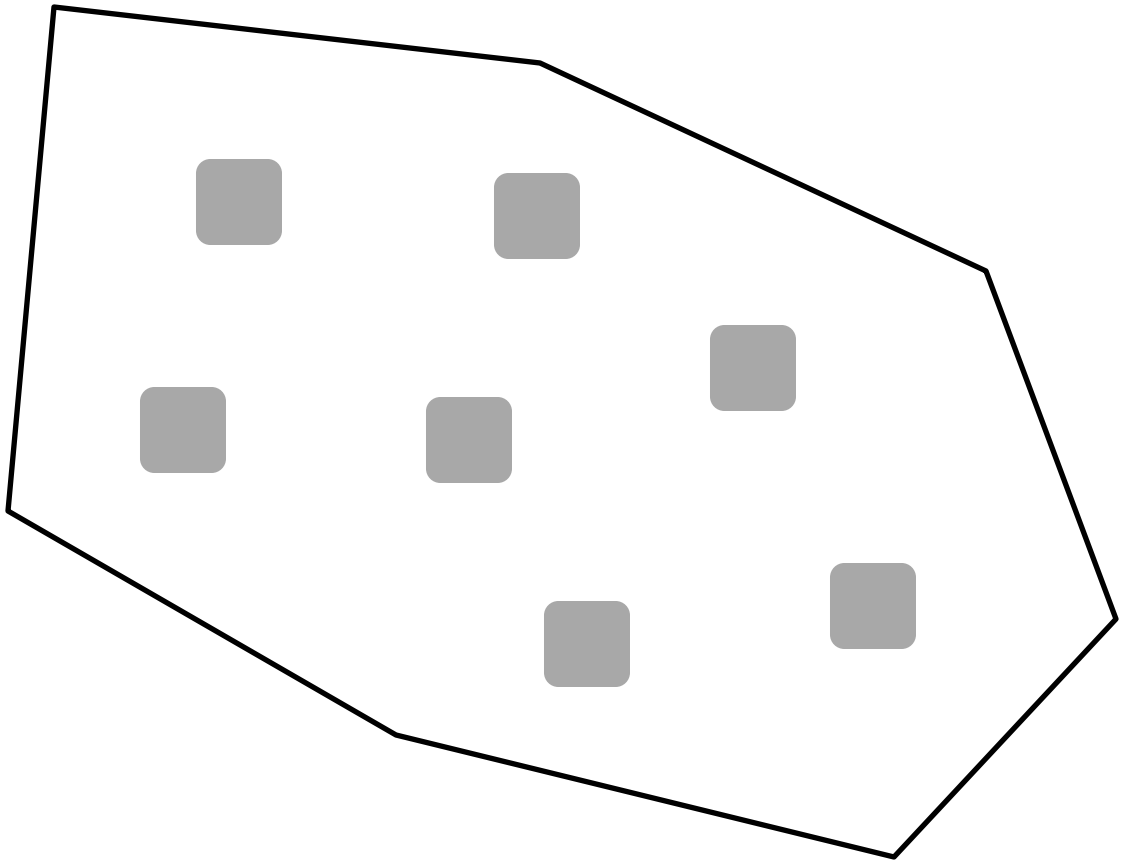
An Expanding-Gap Approach for Oak

An expanding-gap irregular shelterwood that uses intermediate gap sizes and midstory removal as a preparatory treatment around gaps may represent a novel silvicultural practice for increasing oak regeneration potential within the CHFR

Expanding-Gap Irregular Shelterwood for Oak

Initial Gaps: 1.5 to 2.5 tree heights



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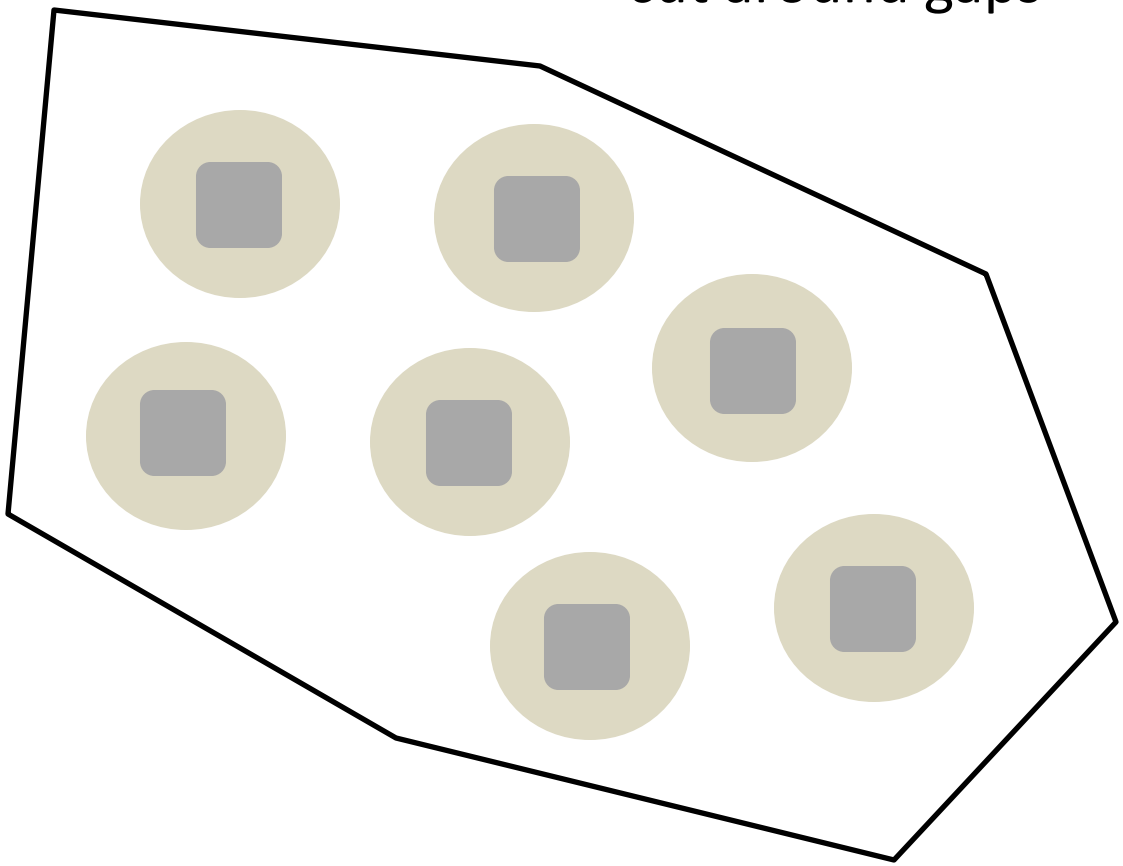
Expanding-Gap Irregular Shelterwood for Oak

Midstory removal as preparatory cut around gaps



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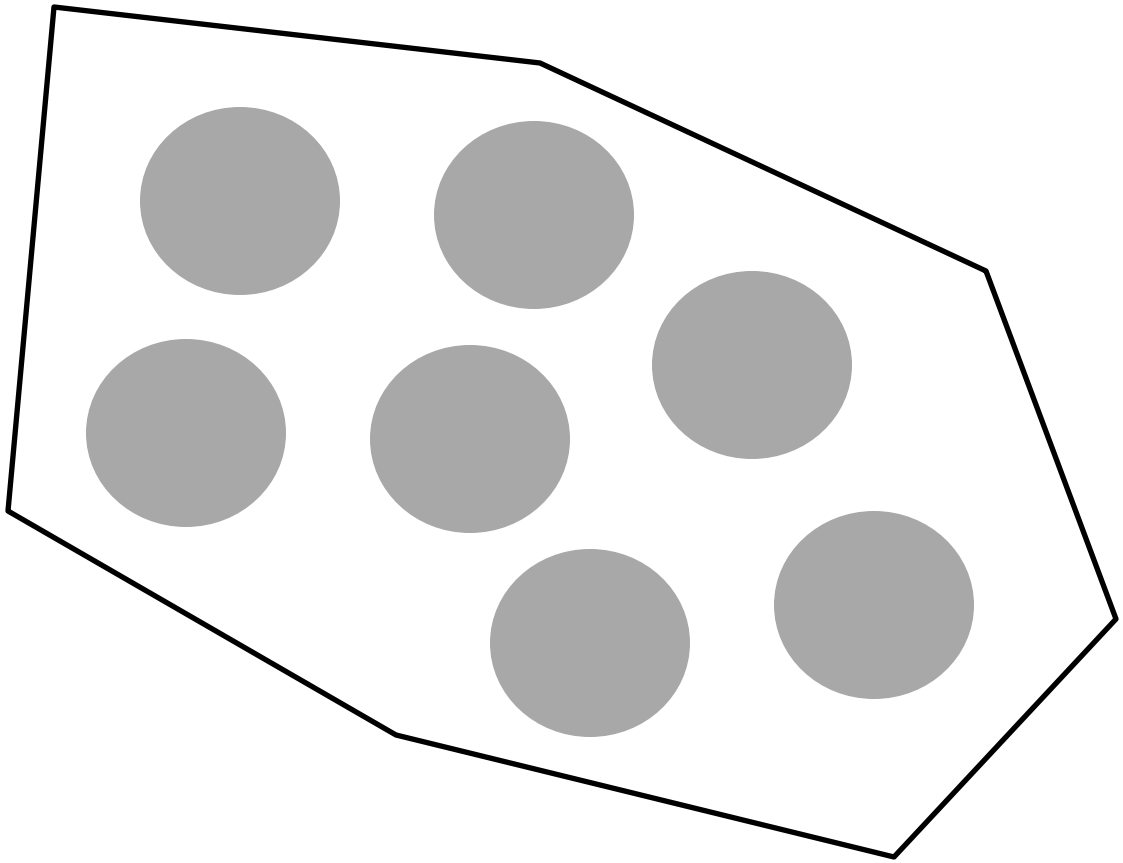
Expanding-Gap Irregular Shelterwood for Oak



Subsequent gap expansion into midstory removal areas based upon oak reproduction development

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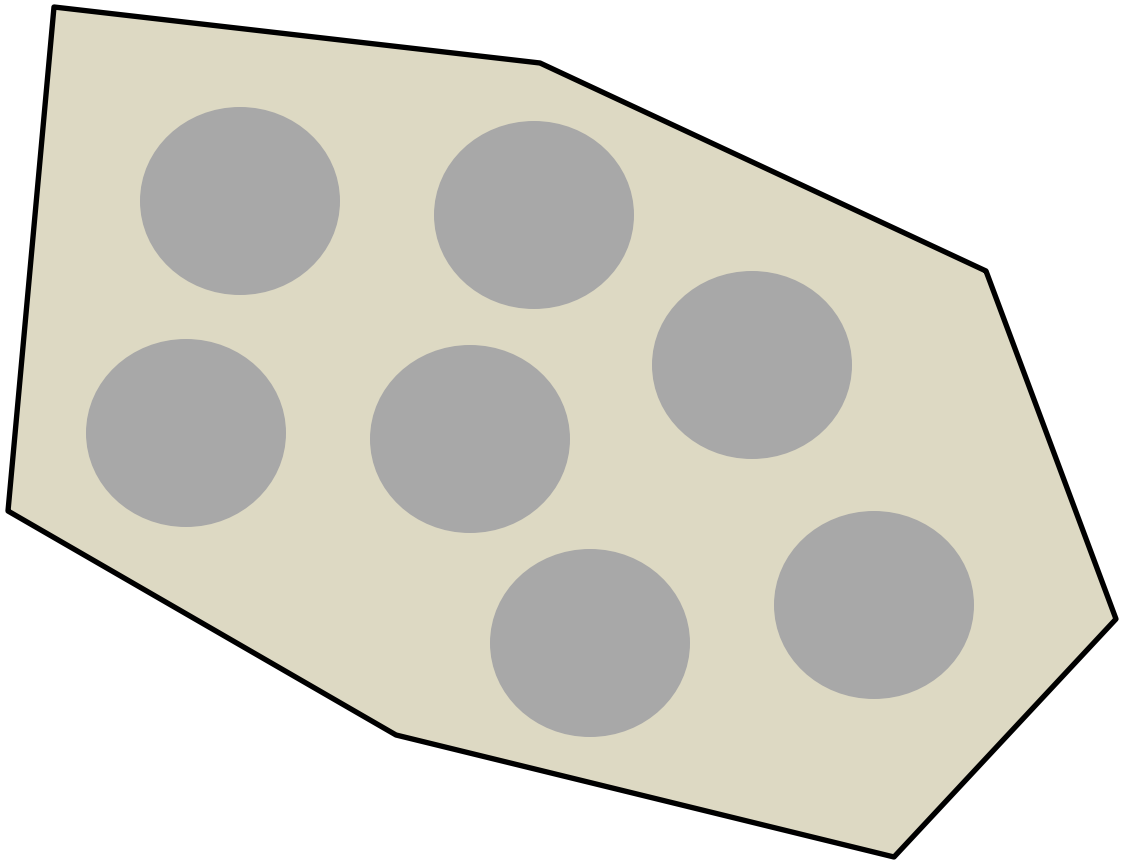
Expanding-Gap Irregular Shelterwood for Oak



Midstory removal following gap expansions

Berea Forest - Proof of Concept Study

- Expanding-gap Study
  - Lhotka, Stringer, Patterson
  - 12 replicated gaps
  - Two treatments
- Research foci:
  - Establishment and growth dynamics
  - Light transmittance modeling

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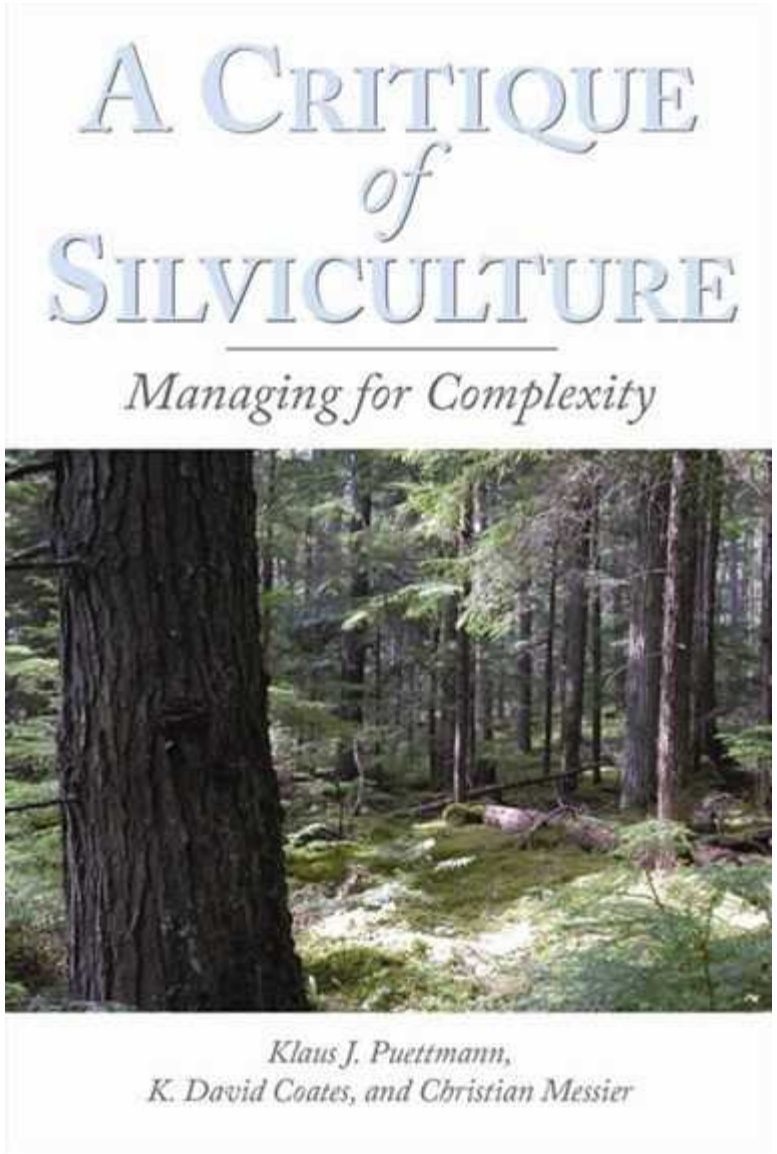
Future Extensions



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