Owned by Yale University and managed by the School of Forestry and Environmental Studies, the Yale School Forests represent 10,880 acres of forestland in Connecticut, New Hampshire, and Vermont. Some of the nation's oldest sustainably managed forests, Yale's lands provide educational, research, and professional opportunities for faculty and students as well as serving as an asset to the School's investment portfolio. Faculty and students use the School Forests as a laboratory for teaching, management, and research. A member of the faculty serves as Director and students working as apprentices carry out all management. The forest is maintained as working land, which includes selling timber and non-timber forest products. Research conducted at the forests in stand dynamics and regeneration ecology continue to have a formative impact on natural forest management paradigms worldwide, and groundbreaking studies on aquatic and meadow systems are beginning to play an important role in our understanding of the impacts of land use and climate change on ecological communities.

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The School Forests are a program within the Global Institute for Sustainable Forestry (GISF), a collection of programs that focus on issues on forest ecology and management. The institute also includes the Program on Forest Certification, The Forests Dialogue Secretariat, Landscape Management Systems, the Program on Private Forests, and the Yale Forest Forum. For more information visit the website at http://research.yale.edu/gisf or call (203) 432-5117.

The Mission of the Global Institute for Sustainable Forestry

To better understand and support sustainable forest management worldwide. To create and test new tools and methods. To foster leadership through innovative programs and activities in research, education and outreach.

Yale School Forests

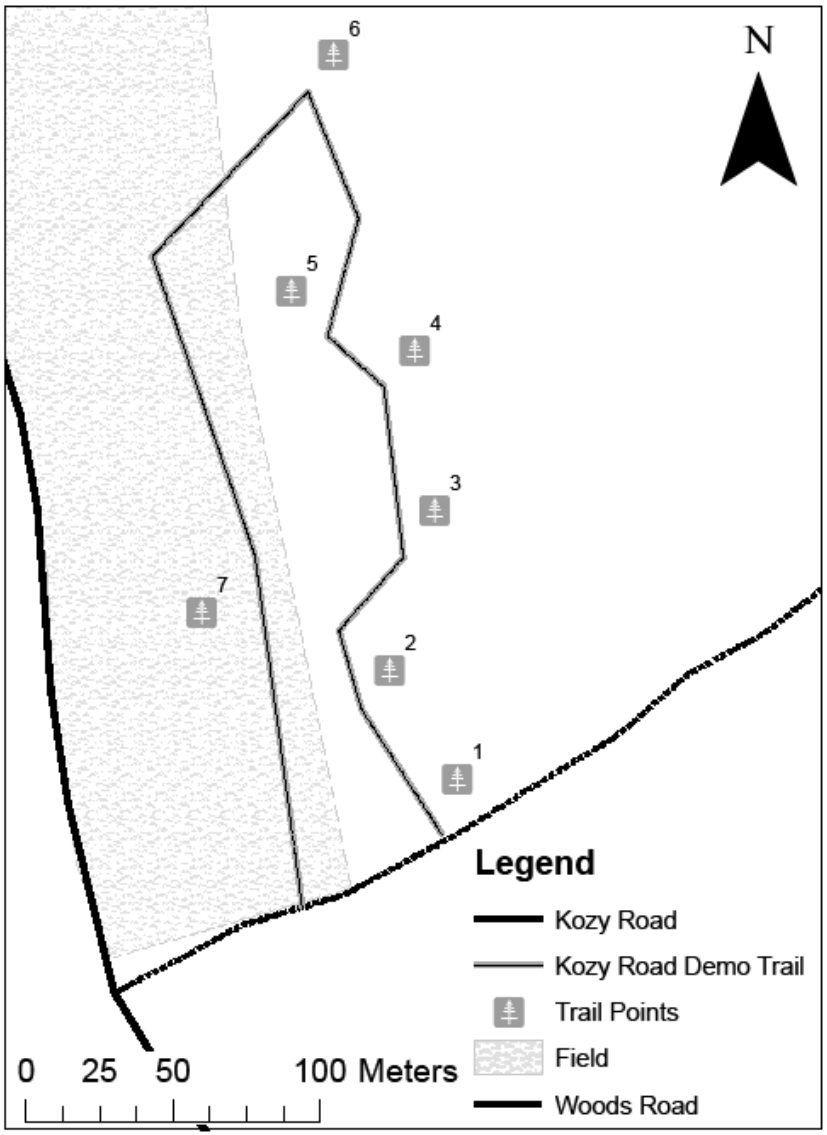
Global Institute of Sustainable Forestry

The Kozy Road Trail at Yale-Myers Forest

The silviculture and dynamics of managed complex mixed stands

School Forests
School of Forestry and Environmental Studies
Yale University

Kozy Road Trail



7. Old Field Colonization and Ecotone and Edge Dynamics - Development Stage: Varied

As you walk back notice the natural succession occurring in the meadow just north of the trail. The wind dispersed seeds of the white pine have germinated in this abandoned field and have flourished as they are able to both outcompete grasses and avoid browsing pressure. Old fields like this one were once common throughout New England as farmers deserted the land for more lucrative jobs. Now the landscape is mostly forested and the remaining open fields have increased in value as wildlife habitat as their abundance has decreased.

White pine (*Pinus strobus*) is able to outcompete grasses and forbs on old pastures and abandoned fields, and so quickly becomes the dominant native species. In addition, several species of non native plants have become established in this field including multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), glossy buckthorn (*Frangula alnus*) and Russian olive (*Elaeagnus angustifolia*). Birds consume the berries of these species and help spread the seeds to new locations. Without mowing or other management these invasive species will quickly become established and outcompete the native species.

The ecotone along the edge of the meadow is another important habitat feature. A wide variety of wildlife species are attracted to the dense cover and variety of plant species that are found in the transition area between meadow and forest. For example, to avoid predation from hawks and other raptors, rodents such as red backed voles and white footed mice stay near the edge and disperse seeds as they move about. Oak and ash seeds have been deposited and are beginning to encroach from the edge into the meadow.

5. Canopy Stratum Thinning (crown thinning) - Developmental state: Understory Reinitiation

In this treatment oak trees whose crowns were competing with the other oak and white ash were removed to allow more growing space for the crop trees. In the intervening years the crowns of the remaining trees have expanded to fill the additional growing space. Advance regeneration of sugar maple is present in the understory, as are true understory trees such as witch hazel and musclewood.

6. Experimental Linear Gap - Development Stage: Stand Initiation

This large opening is part of an experiment begun in 1998 to examine how differences in disturbance patterns and light and moisture regimes affect the regeneration of a stand. The interactions of these variables create small microsites that influence species establishment. This study seeks to understand how vegetation responds to these variables. This experiment has been replicated in five locations throughout southern New England. Each ELG was carefully located to represent slightly different slopes, soil types or exposure.

Within each gap there are six east-west strips, created in the winter of 1999-2000 with two different treatments repeated in each strip. Plots with pink flagging reflect a severe disturbance: bare soil and no vegetation. This is expected to favor species whose seeds are transported by wind or that were already buried in the soil. Green plots have had all vegetation taller than two meters removed to examine the dynamics of advance regeneration that is already established on the site and released from competition.

Welcome:

This walk is intended to provide a close look at how even-aged mixed hardwood stands respond to different silvicultural prescriptions on mesic sites. It combines principles of silviculture and stand dynamics in order to demonstrate the effectiveness of silvicultural systems designed to mimic natural ecosystem processes. Each station along the trail was treated in 1975 with a different silvicultural prescription. In addition, various experiments were set up in the understory to monitor how well species regenerate under different light levels in each treatment area.

As you walk along the trail, following the blue arrows, look for numbered stops and read the corresponding description in this guide. Please stay on the trail, as many understory experiments are on-going. The numbered posts correspond to the numbers in this booklet to describe the treatments that have been applied to the forest around you. The white blazes indicate the treatment boundary for each station.

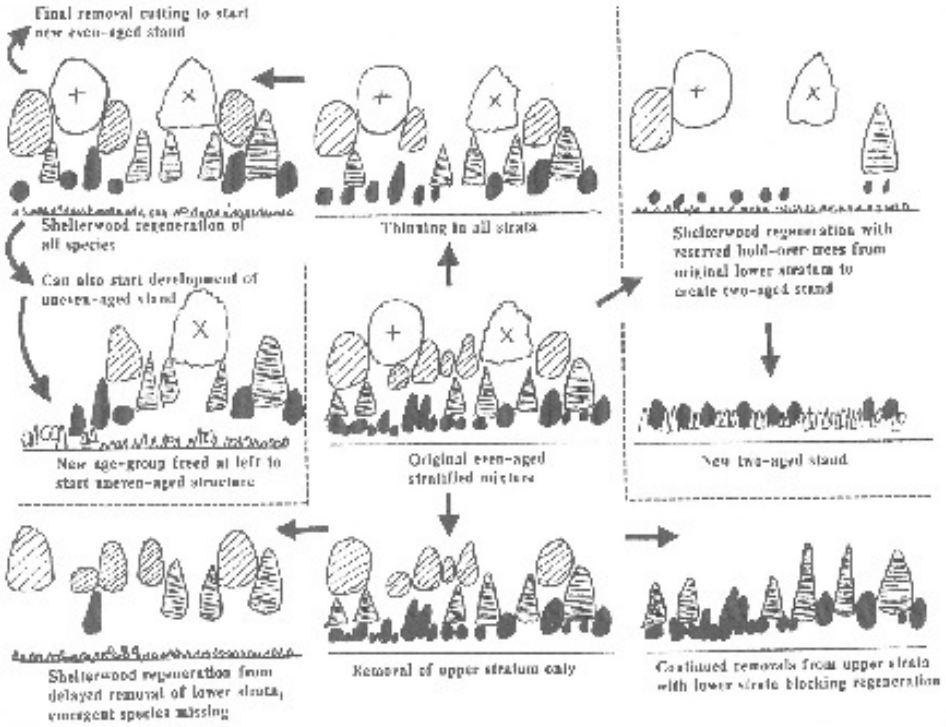
About the Kozy Road Site

The hardwood cover type found on this site is characteristic of mesic sites in central New England. The rich moist soils that typify this area are excellent for growing trees. These stands tend to have canopies dominated by relatively fast growing shade intolerant species such as red oak (*Quercus rubra*) and white ash (*Fraxinus americana*). These two species are also the most commercially valuable. In the long run, however, this site would be considered best for sugar maple.

Although all of these trees are about the same age the diameter distribution resembles a "J-shaped curve." The highest numbers of trees are in the smallest diameter class with a gradual progression to relatively few large diameter trees. This type of distribution is typical of a balanced, even-aged mixed species hardwood stand.

To simply cut a few of the mature trees in several successive cuttings with the hope of providing a continuous supply of maturing timber is a frequent misconception. The five treatments in this demonstration area and the resulting species mix help to illustrate this point.

The silvicultural options for the site can be seen in the diagram on the following page.



Beginning with an uncut stand in the center panel, there are three options for treating the stand. The first is to prolong stand development through a crown thinning as seen in the upper middle panel. This preserves the current dynamic, though allocates growing space to the fewer trees that are left. A second option is to remove the upper canopy (bottom middle panel), reallocating growing space to the shade tolerant subcanopy, and hastening the successional process. The final option is to begin to regenerate the stand using the shelterwood system (upper right). The regeneration thatcomes will depend on the seed source, but will likely be a combination of shade tolerant and intolerant species.

Each of the stops on the trail is represented by one of these diagrams.

3. Emergent Stratum Removal (Selection thinning) - Developmental stage: Understory Reinitation

This treatment was designed to resemble a diameter-limit cutting. Harvesting the largest trees effectively removed all the emergent red oak and ash. This left behind a subcanopy dominated by shade tolerant sugar maple with some hemlock and shagbark hickory. Since the initial treatment more than 30 years ago the subcanopy has grown and become crowded. Any potential seed source for oak regeneration was eliminated when the site was harvested. The existing dense canopy allows very little light to reach the forest floor. Shade tolerant dogwood, ironwood and witch-hazel grow under these low-light conditions, though they are members of the same age-class as the canopy trees. **refer to section 2 for color key for marked trees*

4. No Treatment - Developmental Stage: Understory Reinitiation

This area was left untreated for comparison to the other sites. As is typical of an 80 year old mixed hardwood stand, the ash, red and black oak, and hickories occupy the emergent stratum, with more shade tolerant sugar maple and some hemlock in the lower strata. The shade tolerant understory is mostly witch-hazel (*Hammamelis virginiana*) and musclewood (*Carpinus caroliniana*). The ground cover is mostly herbaceous forbs and grasses with some seedling stage sugar maple existing as advance regeneration. **refer to section 2 for color key for marked trees*

A Note on Research

Before entering the demonstration area, notice the yellow flagging and two yellow slashes on a tree near the road immediately west of the first post. This marking indicates a series of transects that run north/south across the entire Yale Forest. Begun in 1978, these plots continue to be measured every 10 years as part of a long-term project monitoring ecosystem health and regeneration dynamics in the forest. At each point along the transect, a fixed area plot is used to record information about the site. Researchers record the number of woody seedlings, the presence or absence and frequency of understory species, the percent cover of mountain laurel (*Kalmia latifolia*), hay-scented fern (*Dennstaedtia punctilobula*), and sedge (*Carex spp*.), and the density of coarse woody debris. They also collect information about the age of the stand, slope, aspect and soil characteristics. At each point along a transect the forest management is noted to help understand the influence of silvicultural treatments on understory floristics. Given the longevity of a tree, this type of historical data collection is invaluable for researchers to help understand long term forest patterns.

1. Irregular Shelterwood - Developmental Stage: Stand Initiation

In this treatment, aimed at regenerating the stand, parent trees have been left at approximately 60-foot intervals to act as a source of seed and partial shade for the regeneration of a shade-intolerant and partially tolerant stand. The treatment is designed to replicate in a simplified manner the regeneration process during and after a catastrophic disturbanc e such as conventional windstorms or hurricanes. The stand is regenerating mainly to hardwood species. The regeneration dynamic here is much the same as the one-cut shelterwood at station 2, though the retention of overstory oaks as a seed source means that there is a higher representation of oak regeneration in this stand.

Notice the two types of regeneration in the stand - seedling growth and sprout growth. Species such as red

maple sprout readily following cutting, and these sprouts having the benefit of an established root system, will often dominate the stand in its initial phases.

Stations 2 to 5 were cut in 1975 as part of Professor D.M. Smith's research into the silviculture and dynamics of complex mixed complex mixed stands. The plots continue to be used today.

2. One Cut Shelterwood - Developmental stage: Stem Exclusion

The overstory trees in this treatment were removed to release the existing advanced regeneration of sugar maple (*Acer saccharam)*, and hickory (*Carya glabra and C. ovata*) that were growing as advance regeneration at the time of the harvest. This treatment was designed to resemble a catastrophic natural disturbance of the sort that is needed to regenerate this type of mixed hardwoods.

In response to the additional growing space and the disturbed soil after the harvest, seeds buried in the soil were released and wind dispersed seeds germinated on the site. The area was initially covered with *rubus spp*. (such as raspberry or blackberry), gray birch (*Betula populifolia*) and pin cherry (*Prunus pensylvanica*) which were in the buried seed bank and emerged following the treatment.

The pioneer species of *rubus* and pin cherry have died now and the hardwoods are well established. Black and white birch are growing ahead of the hickory, while sugar maple grows in the understory. Oak is not present at this station because of the lack of advance regeneration a the time of treatment. While the stand passes through the stem exclusion phase the more vigorous trees seek a dominant position in the canopy at the expense of slower growing neighboring trees. Notice the high number of birch branches covering the forest floor from trees that have self thinned as branches died from lack of light.

Color Key for Marked Trees (for stops 2, 3, and 4)

Bright Yellow	Dark Yellow	Orange	Red
Very fast growing, Very shade intolerant	Fast growing, Shade intolerant	Medium growing, Intermediately shade tolerant	Slow growing, Shade tolerant
pin cherry, paper birch	black birch, black cherry, white ash	Red oak, shag-bark hickory	Sugar maple, hemlock