EFFECT OF GROUND SKIDDING ON OAK ADVANCE REGENERATION

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Abstract—Vigorous advance regeneration is required to naturally regenerate oaks. However, a reduction in the number of advance regeneration stems from harvesting activities could be an important factor in determining successful oak regeneration. This study assessed the harvest survivability of advance regeneration of oak (*Quercus* spp.) and co-occurring species in four mixed upland hardwood stands subjected to commercial clearcutting in Kentucky. Regression indicated a positive curvilinear relationship between height and survival and between ground line diameter and survival for oak. No significant differences were found in survival among oak species. Analysis of survival across all oak species by height class indicated a statistical difference in mean survival percent between oaks ≤ 3 feet (54.1 percent) and > 3 feet (87.4 percent) in height. Maple (*Acer* spp.) and other co-occurring species ≤ 3-feet-tall exhibited a slightly higher and significant ($p<0.05$) increase in survival compared to oaks ≤ 3-feet-tall. However, oak advance regeneration > 3-feet-tall maintained similar or greater harvest survivability compared to co-occurring species.

INTRODUCTION

It has long been known that oak (*Quercus* spp.) forests have been mismanaged and that successful oak regeneration is the key to their rejuvenation (Liming and Johnson 1944). It is also well understood that maintaining oak after a regeneration harvest requires the occurrence of advance regeneration and/or stems capable of stump sprouting (Cook and others 1998, Lorimer 1983, Ross and others 1986, Sander 1971, Sander 1972). These stems must be present prior to a regeneration event, and adequate numbers must survive harvest for oaks to successfully regenerate (Cook and others 1998).

Regeneration predictions and decisions regarding regeneration timing are often based on pre-harvest advance regeneration inventories. However, the use of these inventories does not account for losses that can occur to the advance regeneration pool during harvest operations. This research was designed to determine the survivability of advance regeneration of oak and co-occurring species subjected to ground skidding associated with a commercial clearcut.

STUDY SITE

The study was located at Berea College Forest on the western edge of the Cumberland Plateau Physiographic region in central Kentucky. Four 8-acre tracts were selected for study. Tracts were dominated by mixed upland oak species including white oak (*Q. alba* L.), black oak (*Q. velutina* Lam.), chestnut oak (*Q. prinus* L.), and associated species including yellow-poplar (*Liriodendron tulipifera* L.), hickory (*Carya* spp.), American beech (*Fagus grandifolia* Ehrh.), red maple (*Acer rubrum* L.), and, sugar maple (*A. saccharum* Marsh.). Tracts ranged in site index from 65 to 80 feet (upland oak site) and contained 90 to 120 square feet of basal area per acre with over 4,500 board feet (International 1/4 Rule) of harvestable sawtimber and associated pulpwood. All tracts were located on lower and toe slope positions with an average slope percent of < 20.

STUDY DESIGN AND ANAYLSIS

Each 8-acre tract was subjected to a commercial clearcut accomplished with chainsaw felling and ground skidding with wheeled skidders by one operator. Due to the relatively gently-sloping topography (slope percent < 20), wheeled skidders were not restricted to constructed skid trails but could move freely throughout the harvest area; loads were skidded directly from the stump to the landing.

Each tract was divided into 7 sections, and a set of regeneration plots were centrally-located in each of the sections. The regeneration plots included one 0.01-acre fixed area plot (28 total) and three 0.001-acre plots (84 total). All trees > 4.5-feet-tall to 10 inches d.b.h. in the 0.01-acre plots and all oaks between 0.5- and 4.5-feet-tall and all other species 1.0- to 4.5-feet-tall in the 0.001-acre plots were permanently tagged with a combination of a heavy aluminum tag and a nylon whisker tag pinned to the ground with #9 galvanized wire. Species, height, and ground line diameter (gld) were measured prior to harvest. Operators were unaware of the regeneration plots, and harvest operations, including skidding, occurred without bias to the plots.

Each tag was located directly after harvest, and the stem was coded as either present or absent. Stems were also coded as to type and degree of damage (data not presented). At the end of the first growing season after harvest, trees were measured, and a damage code was assigned to each stem including no damage, missing, and present but dead. Each tree was placed into a height and a basal diameter class for analysis. Regression was used to determine relationships between survival (dependent variable) and gld and height (independent variables). Analysis of variance was used to determine differences among species and sizes using arc sine transformed survival data.

RESULTS AND DISCUSSION

Harvest survival of oak advance regeneration varied with height and gld. Figure 1 indicates the effect of height on harvest survival across all oak species. Data points represent the average oak survival by height class, and the curve represents the best fit equation $y=0.759376+(-1.219738)*\exp(-x/0.77275)$ ($r^2=0.7676$). Analysis by height class (data pooled across species and tracts) indicated a statistical difference ($p<0.05$)

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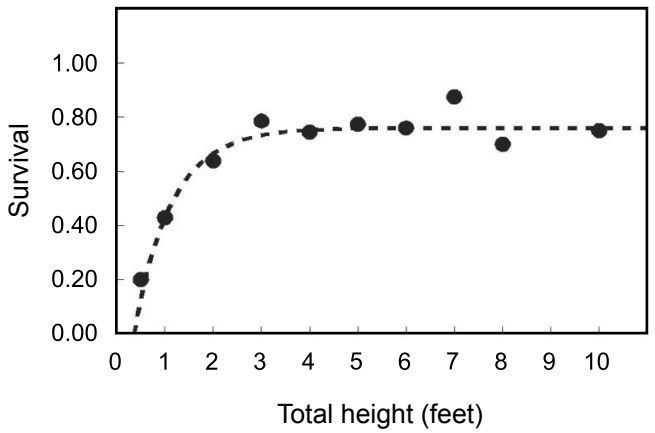

Figure 1—Effect of height on harvest survivability of *Quercus* spp. advance regeneration. Symbols represent mean survival for each height class. The line represents the best fit equation: y=0.759376+(-1.219738)*exp(-x/0.77275) (r^2=0.7676).

in survival between oaks ≤ 3-feet- and > 3-feet-tall (54.1 versus 87.4 percent, respectively). While no statistical difference in survival percent was found among tracts, analysis indicated mean tract survival ranging 43 to 65 percent for oaks ≤ 3 feet in height (fig. 2). All tracts maintained 80 to 90 percent survival for oaks > 3-feet-tall. All oak species had lower mean survival for trees ≤ 3-feet-tall compared to trees > 3-feet-tall. However, significant differences ($p<0.05$) were only found in scarlet and chestnut oak, while white, northern red (*Q. rubra* L.), and black oak exhibited no statistical difference among height groups (fig. 3).

Figure 4 shows the relationship between height and survival percent for red maple and sugar maple, pooled, and other species pooled [predominately sourwood (*Oxydendrum arboretum* [L.] DC), blackgum (*Nyssa sylvatica* Marsh.), eastern dogwood (*Cornus florida* L.), American beech, hickory, and

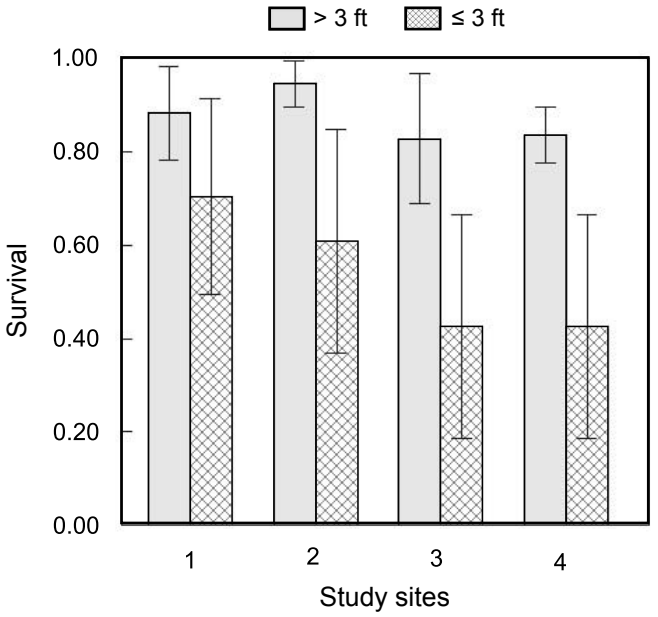

Figure 2—Mean survival of advance regeneration of *Quercus* spp. by study site (tract) pooled by height class ≤ 3 feet and > 3 feet in height.

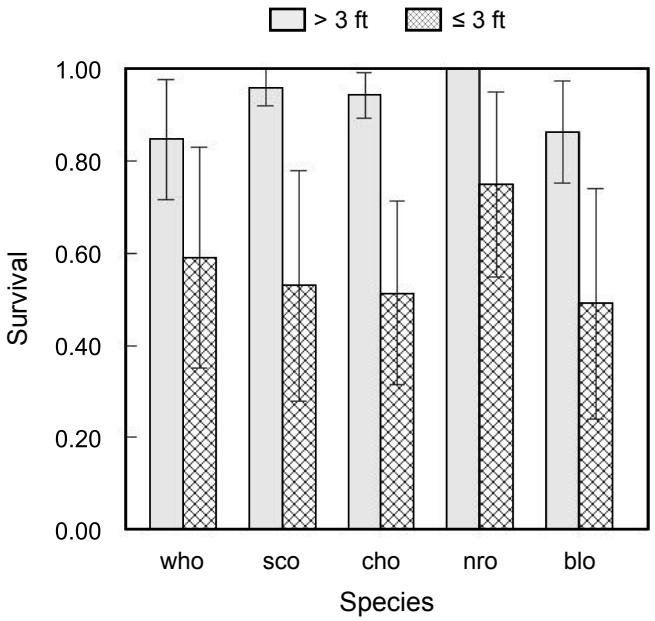

Figure 3—Mean survival of advance regeneration of *Quercus* spp. by species pooled by height class ≤ 3 feet and > 3 feet in height.

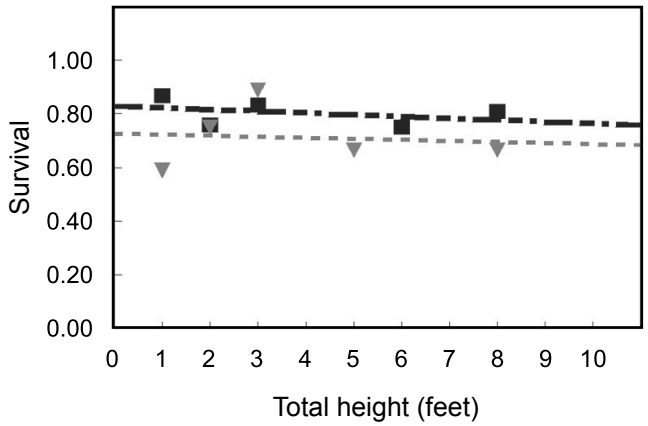

Figure 4—Effect of height on harvest survivability of *Acer* spp. (square) and miscellaneous species, predominately *Oxydendrum arboretum*, *Nyssa sylvatica, Cornus florida, Fagus grandifolia,* and *Carya* spp. (triangle). Bold line represents best fit linear equation for *Acer* spp. (y=-0.006382x+0.829129) and for miscellaneous species (y=-0.003903x+0.72663).

others]. Data points represent means by height class. The dashed line represents the best fit linear equation for maple (y = -0.006382x + 0.829129), and the solid line represents the best fit linear equation for other species (y = -0.003903x + 0.72663). No statistical difference in survival percent by height class was found either between or within these two species groups.

As would be expected, the same pattern of trends and differences were found between gld and survival as was found between height and survival. Regression yielded y=0.783527+(-0.436994)*exp(-x/0.28592) for oak survival percent by gld (r^2 = 0.7270) (fig. 5). Oaks ≤ 0.5 inch gld averaged 57 percent survival and were significantly different ($p< 0.05$) from trees 1 to 10 inches in gld (78 percent). Maples

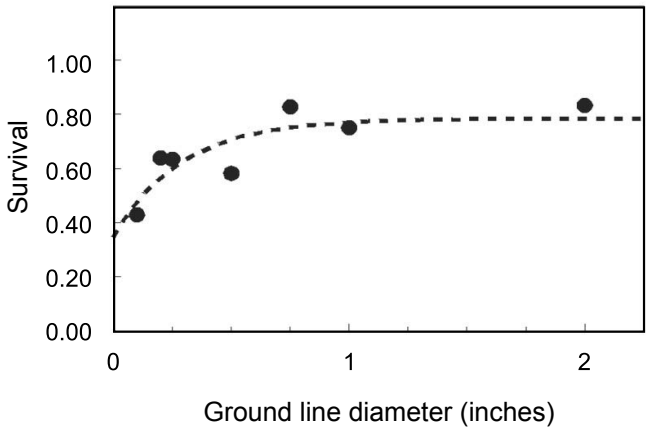

Figure 5—Effect of height on harvest survivability of *Quercus* spp. advance regeneration. Symbols represent mean survival for ground line diameter class. The line represents the best fit equation: y=0.783527 + (-0.436994)*exp(-x/0.28592).

and other species showed no relationship between gld and survival percent (fig. 6) averaging 76.6 and 73.4 percent survival, respectively.

CONCLUSIONS

Over all tracts and size classes, oak averaged 66.7 percent harvest survival. The maples averaged 80.1 percent, and miscellaneous species had an average survival of 71.1 percent. However, significant differences in survival percent among species groups were found only in stems ≤ 3-feet-tall. This study indicates that significant harvest losses can be expected in oak advance regeneration pools, particularly those trees ≤ 3-feet-tall. These losses can vary by harvest unit. Not only can commercial clearcutting with wheeled skidders significantly reduce the population of this sized oak advance regeneration, but oaks incur proportionally higher losses in smaller size classes compared to co-occurring and competing species. However, this study indicates that oak advance regeneration > 3 feet in height can maintain similar or greater harvest survivability compared to co-occurring species.

The results of this study suggest that models predicting regeneration outcomes from data collected in pre-harvest inventories should be adjusted to account for proportionally higher losses of oak advance regeneration < 3-feet-tall compared to maples and other co-occurring species. This study also indicates that oak advance regeneration > 3-feet-tall is required if stable advance regeneration species proportions are to be maintained after a harvest. From a silvicultural perspective, this research provides operational support to previous guidelines indicating the need for oak advance regeneration with a minimum height of 4.5 feet prior to the implementation of a regeneration harvest in upland oak stands.

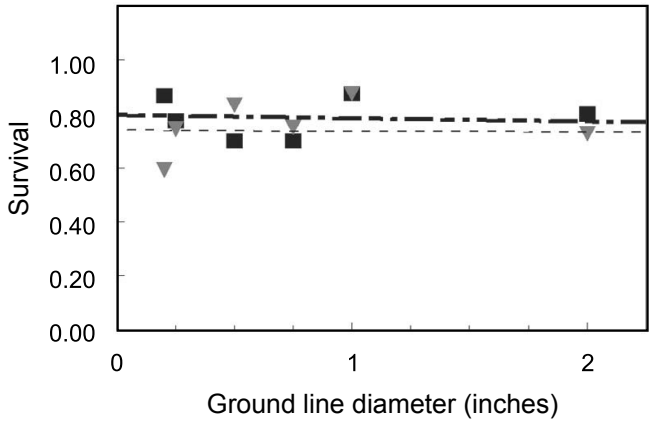

Figure 6—Effect of height on harvest survivability of *Acer* spp.(square) and miscellaneous species, predominately *Oxydendrum arboretum*, *Nyssa sylvatica, Cornus florida, Fagus grandifolia, Carya* spp. (triangle). Bold line represents best fit linear equation for *Acer* spp. (y=-0.0063x+0.8292) and for miscellaneous species (y=-0.0038x+0.7445).

ACKNOWLEDGMENTS

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