Regenerating Quaking Aspen[1] On A Site Dominated By Buckthorn[2] In Upper Michigan: A Case Study

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ABSTRACT

Under-stocked or aging stands of quaking aspen (*Populus tremuloides*) in Upper Michigan can be infested by the exotic, invasive species: common and glossy buckthorn (*Rhamnus cathartica* and *R. frangula*). This shrub becomes the dominant species in the understory and can form dense, continuous canopies up to twenty feet thick; shading-out competitors. Given aspen's sensitivity to shade, buckthorn threatens to reduce aspen sucker density and vigor during the first few years after a regeneration cutting. An aspen stand in Escanaba, Michigan matching this description was selected for a regeneration trial. The buckthorn understory was chopped and sprouts were sprayed with glyphosate prior to clearcutting the parent aspen. Regeneration of all woody species was monitored for three years after the cut. After three years, aspen sucker density and vigor over-all was exceptional and buckthorn, although not eliminated, was seriously curtailed. Chopping and spraying sprouts provided at least a one-year window of opportunity to regenerate aspen. In the areas where aspen sprout density was at the high end of the acceptable range (25,000 sprouts per acre) aspen was dominating the buckthorn. In a few small areas where aspen sprout density was at the low end of the acceptable range (4,000 sprouts per acre) buckthorn may yet come to dominate. Commercial cost for the buckthorn control method used here was $150 – $200 per acre.

INTRODUCTION

Aspen

Quaking aspen (aspen) is a short-lived, shade intolerant, pioneering species occurring throughout the higher latitudes of North America. It is the second most abundant forest type in Michigan (Leatherberry and Spencer, 1996). Use of aspen fiber in Michigan nearly tripled in the twenty years between 1975 and 1995 as a result of mill expansions and mill construction (May and Pilon, 1995). The size of Michigan's aspen forest type has declined by about 36% during the last three decades although annual removals are still slightly below annual growth (Potter-Witter and Ramm, 1992). Only 33% of the remaining aspen stands are harvestable today. The rest are either too decadent (13%) or too young (54%) (USDA Forest Service, 1993).

A wide variety of wildlife species depend on aspen stands of various ages for food and shelter. Most notable among these are ruffed grouse (*Bonasa umbellus*) and white-tailed deer (*Odocoileus virginianus*) but the list includes many other mammals and birds including three rare or endangered species: the bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), and eastern timber wolf (*Canis lupus*) (Perala, 1977). Aspen regeneration in Michigan is an important issue for both timber resource and habitat managers.

Aspen on average sites reaches maturity by about age 60. At that point losses to pathogens begin to exceed annual growth. Without disturbance, these stands are gradually invaded by other species like red maple (*Acer rubrum*), white and green ash (*Fraxinus americana* and *F. pennsylvanica*), white birch (*Betula papyrifera*), American elm (*Ulmus americana*), and balsam fir (*Abies balsamea*) (Perala, 1990). Aspen will regenerate if sufficiently disturbed by fire, windthrow, or harvesting. Heavily disturbed areas with exposed mineral soil can provide an opportunity for aspen to become established by seed but forest management relies most often on vegetative reproduction.

[1] *Populus tremuloides.*
[2] Common buckthorn (*Rhamnus cathartica*) or glossy buckthorn (*Rhamnus frangula*).

A minimum of 50 well-spaced trees per acre (basal area of about 20 ft^2 per acre) are required to produce a fully-stocked sucker stand (Doucet, 1989; Perala, 1977; Perala, 1983). Sucker density in the first year after clearcutting may exceed 30,000 stems per acre (Perala, 1990). Initial densities as low as 1,000 suckers per acre can produce a fully stocked stand (Sorensen, 1968), but at least 4,000 – 5,000 per acre are desirable to allow for losses to injury, insects, and disease during stand development (Bates, *et. al.*, 1989; Perala, 1977).

Suckers become established in the first two years after cutting with 98% of the stand being recruited in the first year (Bates, *et. al.*, 1989; Krasny and Johnson, 1992). Eighty-six percent of sucker mortality occurs within the first 5 years following cutting (Krasny and Johnson, 1992). Most of the smaller suckers are gone from the stand by the third year leaving only dominant and co-dominant individuals. At maturity, well-stocked stands on good sites will have been reduced to 200 – 700 stems per acre (Bates, *et. al*., 1989; Perala, 1977).

Aspen is shade intolerant. Of particular interest here, is the well documented adverse effect of shade on suckering. Shade seriously reduces both the density and vigor of suckers (Bates, *et. al*., 1989; Doucet, 1989; Huffman, *et. al*., 1999; Prevost and Pothier, 2003; Stoeckeler and Macon, 1956). A well established, dense canopy beneath an aspen stand would undoubtedly interfere with suckering during the critical first few years following harvesting. This was the case in our test stand where the species forming the dense canopy was buckthorn.

Buckthorn

Buckthorn is native to Europe and western Asia where it was noted for producing the finest quality charcoal for gunpowder and a wood hard enough for the manufacture of artificial teeth. It was introduced to North America in the late 1800s where it has become naturalized. Initially distributed as part of windbreak and wildlife plantings, it is now spreading naturally and invading many native plant communities (Converse, 1984; Godwin, 1943; Frappier, *et. al*., 2003).

Buckthorn's success at invading and capturing sites from native vegetation derives from (Converse, 1984; Godwin, 1943; Sanford, *et. al*., 2003):

- Frequent and abundant seed crops.
- Ease of dispersal by birds and small mammals.
- Rapid and vigorous germination of seeds.
- High tolerance to shade and ability to capitalize on canopy openings.
- Populations build rapidly due to heavy seed-fall under pioneers.
- Plants take advantage of early and late portions of the growing season by leafing-out earlier and retaining their leaves longer than most native species. Personal observations indicate that this is particularly true of young sprouts.
- Plants vigorously sprout from the stump if the top is damaged.
- Tolerance of wet sites where a limited number of native shrubs can compete.
- Seeds may accumulate in the soil beneath existing plants for as many as 3 ½ years (Godwin, 1943) but it seems more likely that because seeds germinate with high vigor (Hubbard, 1974), only a small fraction of the annual seed crop would remain dormant and viable for future years.

Studies have documented that buckthorn can reduce the density and diversity of native species in areas where it becomes established. It does this both by limiting the regeneration of seeded species (Fagan and Peart, 2004; Frappier, *et. al*., 2004) as well as shading established saplings that become overtopped by buckthorn's dense canopy (Frappier, *et. al*., 2003).

As buckthorn's value for making gunpowder and false teeth has declined and as the threat to native vegetation has become clear, intentional plantings have been discouraged. Instead, a search for methods to eliminate it from the landscape has begun. This would be a simple task if not for the fact that buckthorn often occurs in mixture with desirable species that must be protected.

A detailed bibliography of buckthorn control research can be found in Converse (1984): The following is only a summary. No methods are selective enough to eliminate only buckthorn when applied broadly, so control methods must be directed at the "pest" while shielding the "crop." Individual stems of buckthorn can be; (1) physically uprooted or excavated, (2) mechanically or chemically girdled, or (3) cut down and treated to prevent re-sprouting. These treatments can be effective but are most certainly expensive and time consuming. Therefore they are only practical in small or highly sensitive areas.

Control methods for use in larger areas must also be targeted carefully to avoid undesired effects. These methods might include; (1) light burning, (2) foliar application of herbicides, or (3) mowing or chopping buckthorn and treating either the stumps or sprouts with an herbicide.

Experience in Michigan's Upper Peninsula indicates that buckthorn can form multi-layered understories beneath mature stands of aspen. The buckthorn crowns occupy an increasingly large proportion of the growing space as the aspen begins to lose dominance of the site. Given that aspen sucker density and vigor are sharply curtailed by shade, it seems certain that management techniques to reduce the competitive advantage of buckthorn in these stands are necessary to encourage aspen. In this Case Study we attempted to eliminate, or at least curtail, the buckthorn to provide a regeneration "window" for the aspen.

METHODS

A ten-acre aspen stand at the Upper Peninsula Tree Improvement Center in Escanaba was found to have a nearly senescent overstory and a dense understory of buckthorn. It required intervention in order to maintain the aspen type and to improve stand health and productivity. The site was fairly level with deep Charlevoix (sandy loam) soils. Most of the site was somewhat poorly drained with moderate moisture capacity and medium natural fertility. The water table was well below the surface during all but the spring of the year[3]. This area averaged 28" of precipitation annually, 140 frost-free growing days, and 1,171 growing degree days[4].

A series of aerial photographs showed that the stand became established in a pasture that had been abandoned around 1940. This stand gradually developed by invading pasture vegetation and may have therefore been less dense than had it invaded an open site. Measurement of the aspen indicated a site index of about 70. By the year 2000, the stand was approximately 60-years-old, was poorly stocked (195 non-buckthorn stems per acre), had 31 cords per acre (70% of which was aspen), and 107 square feet of basal area. Seventy-one percent of the basal area was composed of aspen and the rest of associates like sugar maple (*Acer saccharum*), red maple, and American elm. The health of the aspen was beginning to decline and the stand seemed destined to become dominated by buckthorn.

Figure 1: Buckthorn forms an impenetrable understory in a senescing aspen stand near Escanaba, MI.

The understory of the stand was thoroughly occupied by buckthorn. An inventory of the stand showed there to be over 300 stems per acre of buckthorn that exceeded two inches DBH and smaller buckthorn saplings choked the middle canopy of the stand. Smaller buckthorn saplings and seedlings were so numerous that walking through the stand required tremendous effort (Figure 1). No other advanced regeneration was apparent in the area. It seemed clear that if the overstory was removed and the buckthorn understory was unhindered, it would shade and suppress new aspen suckers and rapidly dominate the site after a harvest. Something had to be done to reduce

[3] Soil Survey of Delta County and Hiawatha National Forest of Alger and Schoolcraft Counties, Michigan. USDA Soil Conservation Service.
[4] Michigan State Climatologist's Office. 3-year averages for the period 1951 through 1980. Growing degree days based on 50°F.

the competitive advantage enjoyed by the buckthorn in order to ensure that aspen suckers would thrive to form a healthier and more productive stand.

Figure 2: Basal application of triclopyr ester in fuel oil to buckthorn stems or cut stumps is a selective and effective control method.

Uprooting the buckthorn by hand on a site of this size was recognized as a ludicrous idea. Since much of the buckthorn on this site was quite tall, foliar application of systemic herbicides would have threatened the overstory as well. A weakened overstory would have produced fewer, less vigorous aspen sprouts after the harvest. A 30% solution of triclopyr ester (Garlon 4™) in fuel oil was applied to the bases of buckthorn in small portions of the stand using both a wick applicator and a hand-held sprayer. This method was highly selective and effective at killing the buckthorn but was also immensely time consuming and therefore abandoned. Cutting buckthorn stems with a handsaw and treating the stumps with the same triclopyr formulation used for basal stem applications was also found to be highly selective and effective but prohibitively time consuming (Figure 2). The strategy finally adopted here was to mechanically chop most of the existing buckthorn plants and to kill or suppress sprouts which subsequently issued from the cut stumps using a foliar application of a 2% aqueous solution of glyphosate (Accord™).

Figure 3: Buckthorn plants were chopped with a special mower, allowed to resprout, and then sprayed with glyphosate to achieve a reasonable level of control prior to clearcutting this senescent aspen stand near Escanaba, MI.

In early July of 2001, a specialized mowing machine maneuvered among the overstory trees and chopped all the buckthorn it could reach[5]. This removed nearly all of the taller saplings and seedlings and left shattered stumps behind which immediately began to re-sprout. In mid-August, these stump sprouts together with any remaining buckthorn seedlings were sprayed with glyphosate[6] (Figure 3). Had this site preparation work been done commercially, it would have cost between $150 and $200 per acre. This is comparable to site preparation and planting costs for conifer species in this region.

The overstory was removed by a commercial logger in the fall of 2001. Trees were harvested by a tracked processor and moved with a 4-wheeled forwarder. Regeneration began as soil temperatures rose during the following spring.

An inventory of aspen and buckthorn regeneration was made in the fall of 2002, 2003, and 2004 as these regenerating plants developed (Table 1). The 2002 and

[5] The machine worked approximately 2 hours per acre @ $50 to $75 per hour.
[6] Spraying by hand with a backpack sprayer took approximately 3 man-hours per acre.

2003 inventories used 25 ft^2 (1/1724th acre) plots, arranged along transects to obtain a count of aspen seedlings and an estimate of the proportion of the area covered by buckthorn regeneration. The 2004 inventory used 88 ft^2 (1/500th acre) plots arranged in a systematic grid to obtain a count of both “large” and “small” stems of all species present on the site. The height and species of a dominant sapling in each plot was recorded during the 2004 inventory. “Large” stems were defined as being at least half as tall as the dominant sapling, while “small” stems were defined as those less than half as tall as the dominant sapling in each plot.

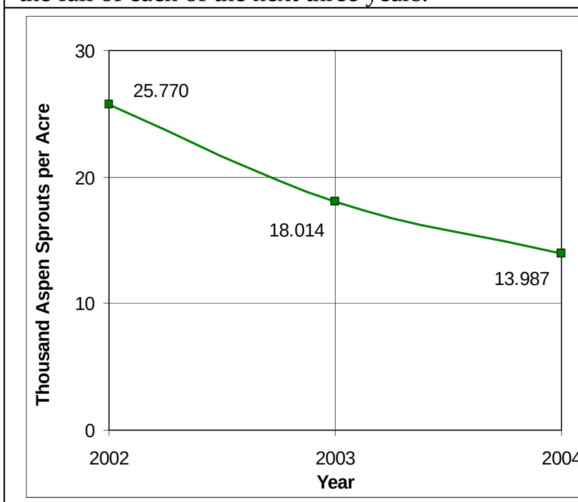
Table 1:
Descriptions of the inventories made in a regenerating aspen stand near Escanaba, MI.

Year of Inventory	Plot Arrangement	Number of Plots	Plot Size	% Sample	Measurements (see notes)
2002	4 transects	180	25 ft^2	1.2%	a, b
2003	5 transects	142	25 ft^2	1.0%	a, b
2004	Systematic grid	98	88 ft^2	1.4%	c, d, e, f, g, h
Notes:	a – Total number of aspen sprouts in plot.				
	b – Proportion of the plot occupied by buckthorn crowns.				
	c – Height of the average dominant tree in the plot.				
	d – Species of the dominant tree measured for ‘c.’				
	e – Number of large aspen (greater than ½ of ‘c’).				
	f – Number of large buckthorn (greater than ½ of ‘c’).				
	g – Number of small aspen (less than ½ of ‘c’).				
	h – Number of small buckthorn (less than ½ of ‘c’).				

RESULTS AND DISCUSSION

Aspen regenerated quickly following the harvest. Density was about 26,000 stems per acre in the first year and decreased in each subsequent year (Figure 4), precisely at the rates[7] predicted by Perala (1977). By the third year 76% of the stand had aspen sprout densities of about 13,000 stems per acre – which is at the ‘high’ end of the acceptable range (Burns and Honkala, 1990). The remainder, occurring in scattered patches, had densities of about 4,000 stems per acre – which is at the ‘low’ end of the acceptable range (Bates, *et. al*., 1989; Perala, 1977).

Figure 4: Aspen density on a site near Escanaba, MI during the first three years after clearcutting. Cutting occurred in the fall of 2001 and counts were made in the fall of each of the next three years.



After three years, 90% of the dominant trees were aspen and 80% of all ‘large’ stems were aspen. There were relatively few ‘small’ aspen after three years, confirming that most of the aspen stems that remained were already recruited into the developing stand. ‘Small’ buckthorn were relatively abundant everywhere but numerous ‘large’ buckthorn were only found in the few areas where aspen stocking was ‘low’ (Table 2).

Buckthorn was diffusely scattered throughout the stand during the first year, covering only 9% of the average sample plot. Its abundance increased by the end of the second year, so that it covered about 20% of the average plot. This level of abundance continued through the third year. Our treatment apparently produced a one-year window of opportunity for aspen sprouts to become established. We can say this was sufficient in the majority of

[7] 25% to 30% of stems are lost annually to mortality in stands of this age on sites of this quality.

areas where aspen sprout density was 'high.' It is not yet clear if aspen or buckthorn will dominate in areas where aspen sprout density was 'low.'

The aspen density decreased as buckthorn density increased (Figure 5), but areas of "medium" and "high" buckthorn density were small and scattered. It is unlikely that buckthorn was excluding aspen but rather that factors like high soil moisture, compaction, or grass competition were inhibiting aspen and thereby providing the opportunity for buckthorn to dominate these difficult sites. That is to say, aspen dominated the better portions of the site (Figure 6) while buckthorn was relegated to the poorer portions where aspen could not grow well. This trend can be demonstrated (albeit weakly) by plotting the density of both large aspen and large buckthorn against site quality as estimated by the height of the dominant tree in each plot (Figure 7). This analysis of the data shows a trend for aspen density to increase and buckthorn density to decrease as site quality improves. These trends, based on third-year data, are weak and bear following into the future.

Table 2:
Distribution of aspen and buckthorn stems by size class in a 3-year-old regenerating aspen stand near Escanaba, MI.

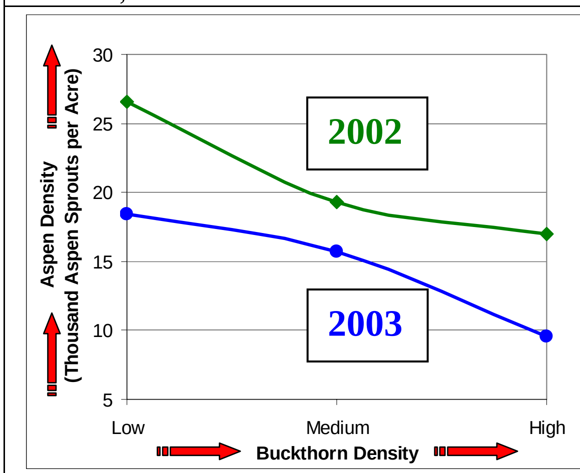
	'High' Aspen Stocking Areas	'Low' Aspen Stocking Areas
Height of dominant tree	8.6'	4.4'
Large Aspen (stems per acre)	12,810	4,604
Large Buckthorn (stems per acre)	2,554	7,125
Small Aspen (stems per acre)	1,115	354
Small Buckthorn (stems per acre)	5,608	1,958

Note: "Large" stems were at least half the height of the dominant tree while "small" stems were less than half the height of the dominant tree in each plot.

This mechanism may explain how native associates come to be present in other regenerating aspen stands. It seems unlikely that any plant could easily compete in the midst of 25,000 rapidly growing aspen sprouts per acre. Associates would naturally be relegated to the patches where fewer, less vigorous aspen were growing. Here they could develop and be recruited into the mature stand.

Although buckthorn was not able to dominate the aspen on most of this site, it seems to be out-competing other native species. Maple and elm associates found in the original stand and others commonly found with aspen, like white birch, ironwood (*Ostrya virginiana*), and ash are absent here. This has resulted in a two-species stand that is less diverse than the parent. Buckthorn competition may not be the only explanation for the absence of these native associates of aspen but the reduction in species diversity is troubling.

Figure 5: Aspen density decreased as buckthorn density increased in each of the first two growing seasons following clearcutting of an aspen stand near Escanaba, MI.



In a twist of fate, despite the common wisdom that white-tailed deer do not prefer to browse buckthorn, they are demonstrating just the opposite on this site. Nearly all buckthorn stems within the reach of deer have been browsed (Figure 8), while very little aspen has been browsed. Observations indicate that some clumps of buckthorn are beginning to die after three successive years of heavy browsing (we find it hard to control our excitement). The species composition of this stand may continue to change as one invasive species (*Odocoileus virginianus*) feeds on another (*Rhamnus cathartica*). We can only hope that the purgative properties of buckthorn (Godwin, 1943) will induce some chronic, bulimic condition in the deer to hasten their demise as well.

Figure 6: A densely-stocked portion of an aspen site near Escanaba, MI. at the end of the second growing season following clearcutting.

Figure 7: Third-year aspen density increased and buckthorn density decreased as site quality increased on a clearcut site near Escanaba, MI. Poor-quality sites composed only a small proportion of the total area.

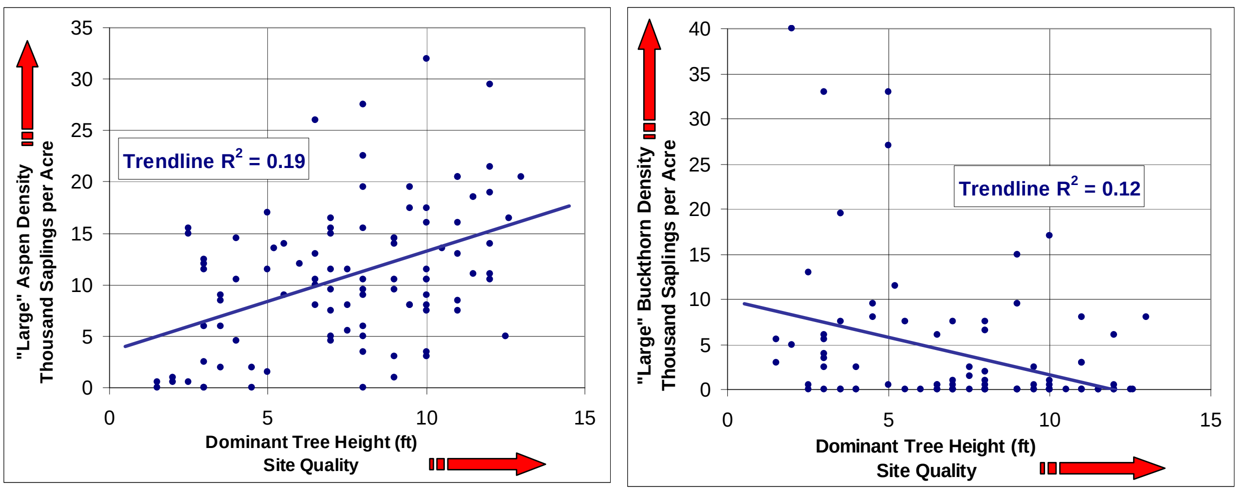


Figure 8: A heavily browsed buckthorn plant in a two-year-old aspen clearcut near Escanaba, MI.

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