American Elm in Mine Land Reforestation

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Figure 1. American elm trees in a natural setting show the typical urn-shaped form (credit: www.treeinabox.com)

Introduction

Reforestation of mined land in the Appalachians realizes many important benefits and provides important ecosystem services. Because much of the reclaimed mine lands in Appalachia were previously in forest, reclaiming these drastically disturbed areas to forests is desirable, feasible and cost-effective. The Forestry Reclamation Approach (FRA) provides a five-step procedure to achieve successful mine land reforestation (Burger et al. 2005, Zipper et al. 2011).

Because high tree species diversity is a hallmark of the Appalachian forest, one of the steps of the FRA is to reforest the site with a variety of native tree species so that the resulting stand is diverse and sustainable. Our research has demonstrated that a variety of Appalachian hardwood species do well on reclaimed mine sites, but some species do not survive well, or do not tolerate the extreme conditions on newly reclaimed mine sites. Also, the practical use and availability of species may change over time. For example, eastern ash species (*Fraxinus*) have historically been good reclamation species and widely planted (Rathfon and others 2004). However, an invasive insect, Emerald ash borer, is threatening to extirpate ash trees, so ash is no longer recommended for planting. Thus, it is necessary to continue to refine the recommended planting mix and expand the possibilities.

We can also use the planting mixtures on reclaimed lands as a means to provide important ecosystem functions or services. For example, recent work with American chestnut (*Castanea dentata*) suggests that it may be a good candidate for mine land reforestation. Planting blight-resistant American chestnut on mined lands may serve the added benefit of re-introducing American chestnut to the landscape (McCarthy et al. 2010).

American elm (*Ulmus americana*) was a small component in the eastern USA forest, but more importantly as an urban shade tree. It has desirable silvicultural characteristics, historically had a very wide distribution, and occurred in a variety of sites naturally (Figure 1). It seeds prolifically, and these seeds can be carried long distances by the wind and animals, and the seed germinates very quickly. Elm leaf litter is high in nutrients and decomposes quickly, making those nutrients quickly available to the trees and other organisms and improves the soil in the vicinity of the tree.

Dutch elm disease (DED) is caused by a sac fungi (*Ophiostoma novo-ulmi*) that is spread by the elm bark beetle. The fungi was originally native to Asia and accidently introduced into America and Europe in 1920. The name "Dutch" elm disease refers to its discovery and identification by Dutch tree pathologists. Since its introduction, DED has swept through urban areas, and has altered the role of elm in forest ecosystems. Elm trees often survive to seed producing age, but later die from clogging of water-con-

Figure 2. American elm foliage showing symptoms of Dutch elm disease. Typical symptoms include discoloration and wilting of foliage, followed by branch dieback, and eventually tree death.

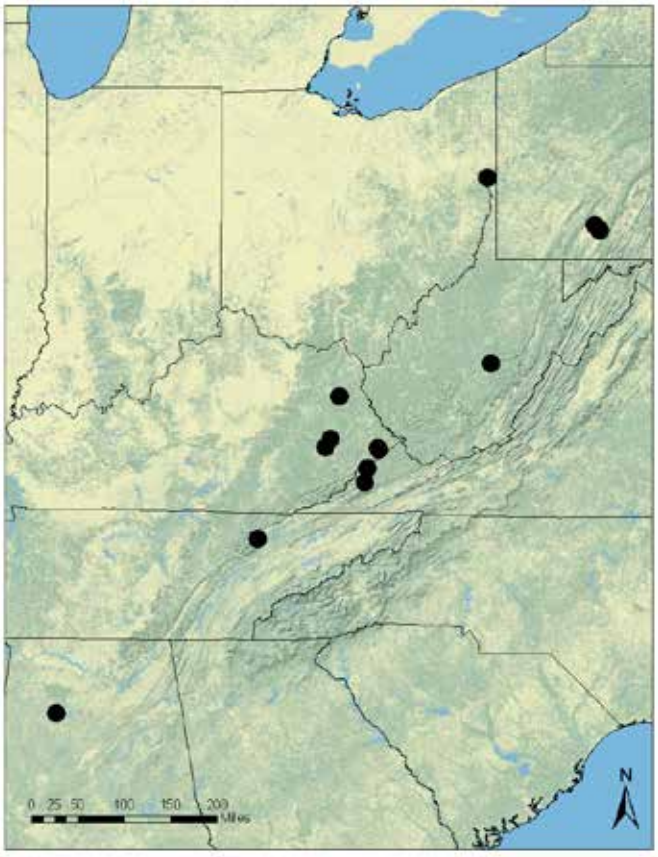

Figure 3. Reclaimed mine sites where DED-tolerant American elms have been planted.

ducting tissues (Figure 2). While DED has not eliminated elms from the landscape, the elms die before becoming large trees. Dutch elm disease tolerance has been noted in some elm trees and breeding programs have resulted in DED-tolerant American elms (Slavicek and Knight 2012) that may be planted into the landscape.

We propose that planting DED-tolerant American elm may be a good means to increase tree species diversity on reclaimed mine lands and to help spread DED-tolerant elm individuals in the coal mining region of the eastern USA. Planting DED-tolerant elm seedlings may help restore some ecosystem functions.

Methods

In 2013 and 2014, initial selections of reputed DED-tolerant American elm seedlings were planted at 14 sites in the Appalachian coal fields from Alabama to Pennsylvania (Figure 3). Elevations ranged from 220 meters to more than 900 meters, and sites included FRA sites, legacy sites (sites that had previously been reclaimed under SMCRA 1992-2005), and AML (abandoned mine land) and bond forfeiture lands. Seed was produced at a USDA Forest Service seed orchard in Delaware, OH. Known DED-tolerant cultivars were used in controlled breeding efforts to create trees with increased tolerance (Slavicek and Knight 2012). Crosses performed for this effort include the R18-2 female X Valley Forge male, and R18-2 male X Valley Forge female. Seedlings were grown at the West Virginia State Tree Nursery at Clements,

Site	State	Elev (m)	Date Planted	Site History	Site Prep	Mine Soil
Pike Co. A	KY	510	3/7/2013	Legacy mine site, reclaimed ~1998	ripped to 36 inches	mine spoil
Pike Co. B	KY	500	3/13/2013	Legacy mine site, reclaimed ~ 2000	ripped to 36 inches	mine spoil
Breathitt Co.	KY	420	3/24/2013	AML site	ripped to 36 inches	1/3 soil, 2/3 mine spoil
Lawrence Co	KY	460	3/28/2013	Bond forfeiture mine land, reclaimed 2012	ripped to 36 inches	mine spoil
Wise Co.	VA	556	3/27/2013	Legacy mine site, reclaimed about 1995	ripped to 36 inches	mine spoil
Campbell Co	TN	915	4/4/2013	Legacy mine site; reclaimed about 1992	ripped to 36 inches	mine spoil
Walker Co	AL	220	2/16/2013	Legacy mine site, reclaimed ~1998	ripped to 12 inches (lightly)	sandy soil

Table 1. Characteristics of sites where Dutch elm disease tolerant elms were planted on mined sites in the eastern USA coal region.

WV. Fifty elm seedlings (1-0) were planted per site in a circular plot 15.24 m in radius.

Survival, diameter and height were measured on seven of these sites (Table 1) over the first two years following establishment. Seedlings were assessed for vigor class and browsing, using scales shown in Table 2. Elm performance was compared with yellow-poplar (*Liriodendron tulipifer*a) seedlings planted on the same sites at the same time.

Results and Discussion

These American elm seedlings performed well when out-planted on reclaimed mined lands. The average first year survival by the planted seedlings was 80 percent, and percent survival after two growing seasons exceeded 75 percent on all of the sites, except for the site in Breathitt County, KY, where survival was only 65 percent (Table 3). The lower two-year survival on the Breathitt County site is attributed to browsing of 26 to 50 percent of the stems by deer and elk. The second-year average height was significantly lower on this site (34.6 centimeters) but the vigor class indicated that the seedlings were under relatively little stress, despite moderate browsing.

After two growing seasons, American elms averaged 62 centimeters in height, ranging from approximately 35 to 70 centimeters across the seven sites. When compared to yellow-poplar, the American elm average height after two years was similar (Figure 4) across all sites where both species were planted. The average vigor class was slightly greater for American elm, and the average browse index was slightly less for American elm relative to yellow-poplar (Figure 5), suggesting that browsing may have been slightly less, or have had a smaller effect.

The results of this trial suggest there may be utility in planting American elm on reclaimed mined lands throughout the Appalachians (Figure 6). There is an obvious need to monitor these trees into the future to see whether these positive results continue and whether the relative success at this early stage translates into successful reproduction. Also, it will be important to know whether these trees tolerate DED. An important hurdle to overcome before widespread planting of DED-tolerant American elms is finding sufficient seedlings of sufficient genetic diversity and provenance. These early results suggest such an effort may be worthwhile. As

Rating	Vigor Class	Browse Class
0	Dead	No impact/no browse
1	Nearly dead	Light (1-25% of stems are browsed)
2	Stressed	Moderate (26-50% of stems are browsed, seedlings not hedged)
3	Little Stress	Heavy >50% of stems are browsed, seedling hedge (top greatly missing)
4	No Stress	Severe >50% of stems are browsed, seeding hedged < 6 inches tall

Table 2. Vigor and browse classifications used for seedlings.

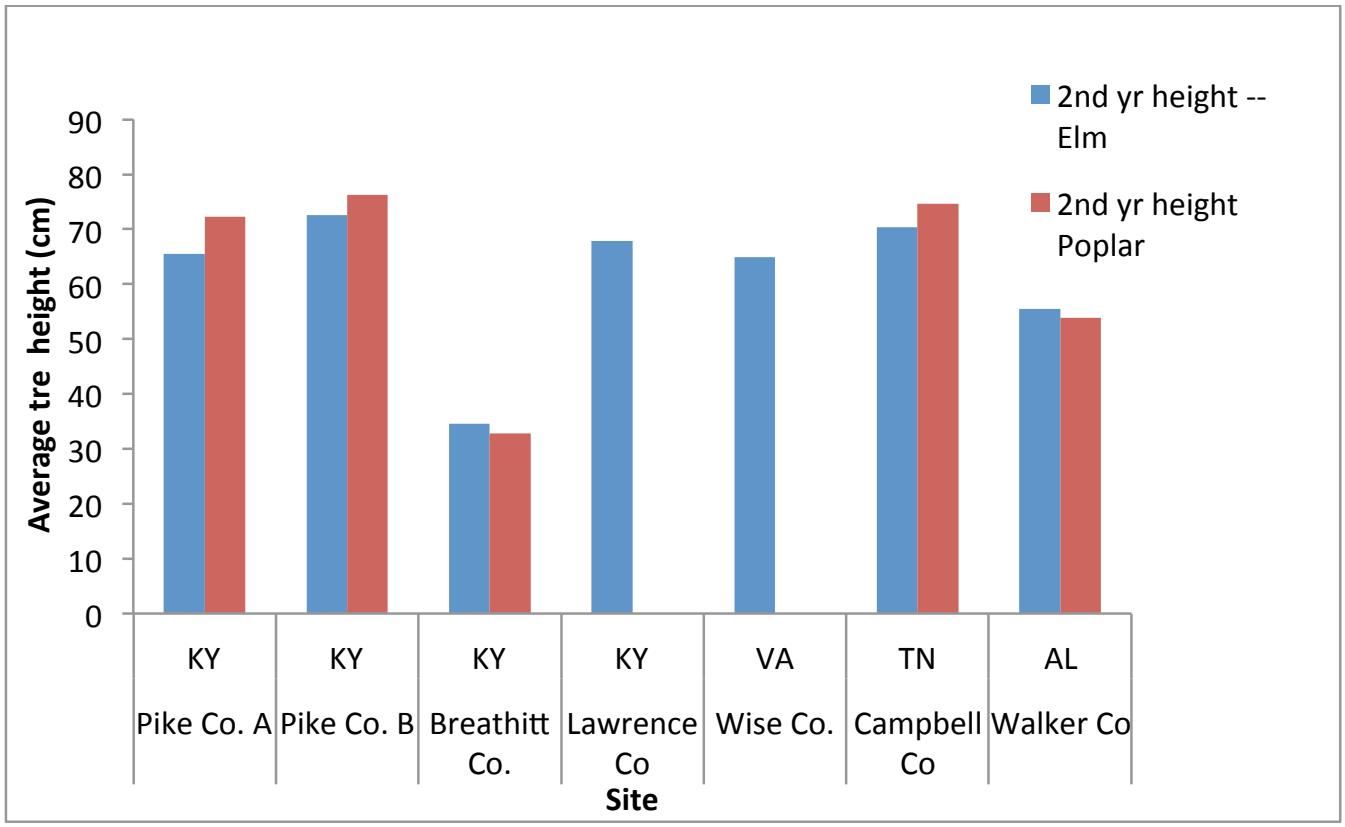

Figure 4. Second-year height of American elm and yellow-poplar.

the number of tree species available for reforestation of disturbed lands decreases, continued development of novel seed sources should occur so that new trees or disease-resistant trees can be introduced without loss of forest diversity.

Conclusions

The DED-tolerant American elm seedlings performed well during the first two years of a field trial across the Appalachians. Survival was high, exceeding 75 percent in most cases, but browsing may be a problem in some areas. There is considerable promise in out-planting these seedlings. The tolerance of these trees to DED and other stressors will be determined with time on these sites and will help managers know whether American Elms can be re-planted into the forest.

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Site Location	State	Survival (%)	Height (cm)	Vigor Class (0-4)	Browsing (0-4)
Pike Co. A	KY	78	66	3.7	0.3
Pike Co. B	KY	82	73	3.0	0.5
Breathitt Co.	KY	65	35	3.0	2.2
Lawrence Co.	KY	75	68	3.9	1.3
Wise Co.	VA	80	65	3.6	0.2
Campbell Co.	TN	80	70	3.9	0.2
Walker Co.	AL	78	56	3.7	1.0
Average		77	62	3.5	0.8

Table 3. Average survival, height, vigor and browsing of Dutch elm disease tolerant American elm seedlings grown on surface mines in the eastern USA coal mining region.

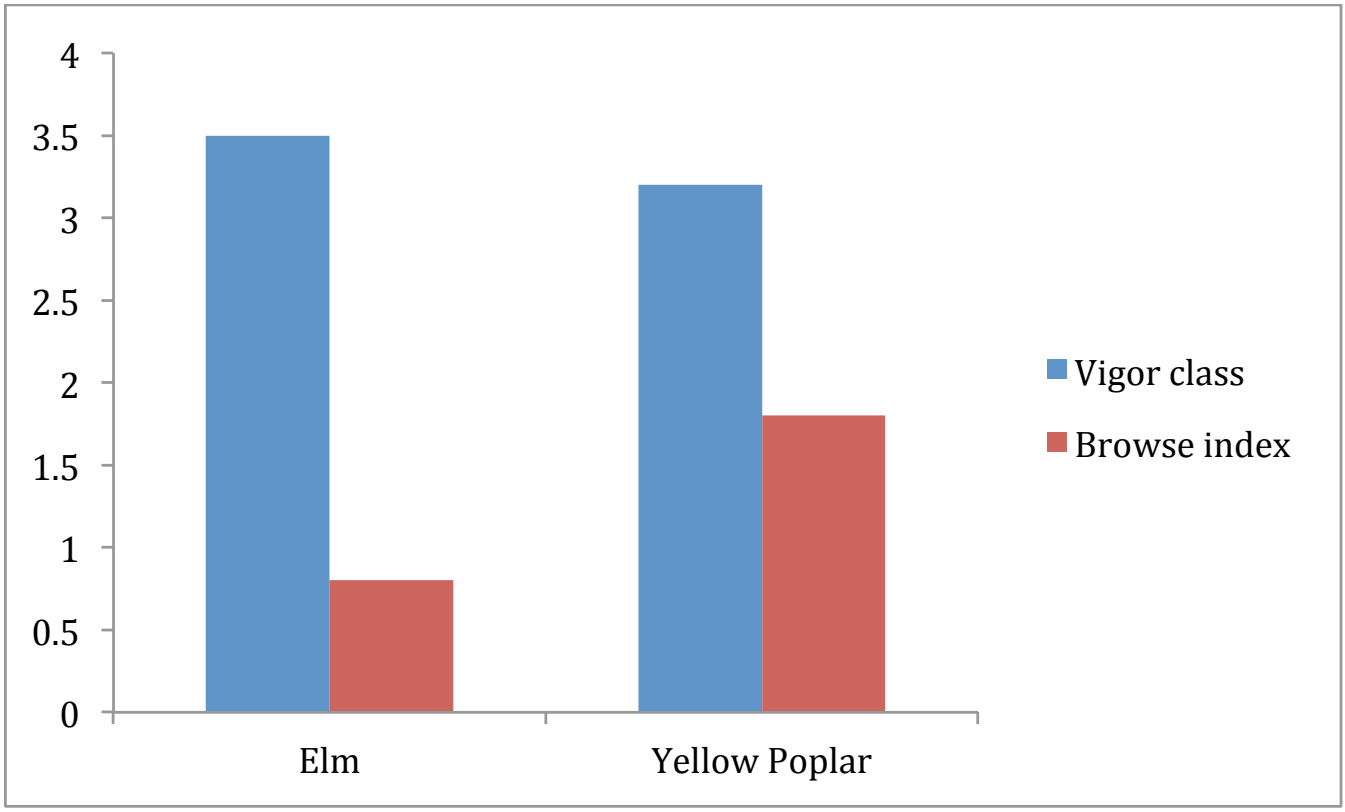

Figure 5. Average vigor class and browsing of American elm and yellow-poplar.

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Figure 6. American Elm seedling planted on reclaimed mine land, after one growing season.