EFFECT OF VEGETATION COVER AND SEASONAL DROUGHT ON LOBLOLLY PINE SURVIVAL ON RECLAIMED MINE SOIL[1]

David Lang[2], George Hawkey[3], Judd Sanborn[3], Rebecca Buell[3],
Bill Roberson[4] and Victor Maddox[5]

Abstract: Step three of the Forestry Reclamation Approach is to plant tree compatible ground covers. The normal reclamation sequence at the Red Hills Lignite Mine in Ackerman, MS involves planting bermudagrass (*Cynodon dactylon*) followed by establishment of loblolly pine (*Pinus taeda*) with generally 70-80% survival. The objective of this study was to evaluate bermudagrass as a compatible species for establishment of loblolly pine. Vegetative ground cover and tree counts were conducted within randomly selected 81.4 m^2 circles. Seasonal droughts in 2006 and 2007 reduced ground coverage of bermudagrass in some areas, allowed encroachment of other volunteer species and had an adverse affect on loblolly pine survival. However, pine seedling survival was not related to the degree of bermudagrass coverage. A section of respread prime farmland (PFL) topsoil that had ground coverage of 100% bermudagrass in 2006 had only 30% pine seedling survival in 2007. Other areas reclaimed and seeded in 2006 that achieved only 20% coverage of bermudagrass and 50-70% bare soil also had only 30% pine seedling survival in 2007. The 20% bermudagrass areas developed a volunteer stand of giant ragweed (*Ambrosia trifida* L.) and marestail (*Conyza canadensis* L.) that had a 30% understory of volunteer white clover (Trifolium repens L.) in 2007. Marestail disappeared in 2008 and was largely replaced by volunteer stands of either white clover, sericea lespedeza (*Lespedeza cuneata* (Dum. Cours) or partridge pea (*Chamaecrista fasciculata* (Michx.). Pines replanted in 2008 had poor survival if either sericea or partridge pea was greater than 30%. There was a clear negative relationship between pine seedling survival and the presence of either sericea or partridge pea, however pine survival in bermudagrass was excellent prior to 2006 and in 2008 indicating that bermudagrass is a tree compatible species.

Additional Key Words: Competition, Volunteer Forbs, *Cynodon dactylon*

---

[1] Paper was presented at the 2009 National Meeting of the American Society of Mining and Reclamation, Billings, MT, ***Revitalizing the Environment: Proven Solutions and Innovative Approaches*** May 30 – June 5, 2009. R.I. Barnhisel (Ed.) Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

[2] David. J. Lang, Associate Professor, Dept. of Plant and Soil Sciences, Mississippi State University, Box 9555, Mississippi State, MS 39762, [3]George Hawkey, Environmental Manager, [3]Judd Sanborn, Environmental Specialist, [3]Rebecca Buell, Environmental Manager, Red Hills Lignite Mine, Route 3, Box 98, Ackerman, MS 39735, [4]Bill Roberson, ProTurf, Grenada, MS and [5]Victor Maddox.

Proceedings America Society of Mining and Reclamation, 2009 pp 709-721
DOI: 10.21000/JASMR09010709

http://dx.doi.org/10.21000/JASMR09010709

Introduction

The Forestry Reclamation Approach (FRA) was developed in Appalachia and was first described by Torbert and Burger (1990) and Torbert *et al* (1995). The Powell River Project in Virginia served as the proving ground for the FRA (http://arri.osmre.gov/FRApproach.htm) with improved tree growth (Burger and Zipper, 2002). There are five key steps under the FRA to reclaiming surface mined land to conditions suitable for forest production:

1) select suitable topsoil or topsoil substitutes
2) loosely grade selected soil materials to a depth of at least 4 feet
3) plant tree compatible ground covers
4) plant trees suitable for soil stabilization, wildlife and commercial forest production
5) use proper tree planting techniques.

The FRA developed in Virginia by Burger and associates has been found to be applicable throughout Appalachia with hardwoods and conifers. Reduced compaction is the key to improved forest productivity with FRA. Step three of the Forestry Reclamation Approach is to plant tree compatible ground covers. The normal reclamation sequence at the Red Hills Lignite Mine (RHM) in Ackerman, MS involves planting bermudagrass (*Cynodon dactylonL.*) followed by establishment of loblolly pine (*Pinus taeda L.*) with generally 70-80% tree survival (Lang et al, 2006; Lang and Hawkey, 2008). Competition from bermudagrass has been kept minimal due to lack of additional fertilizer and by adequate and copious amounts of rainfall that normally exceeds 1500 mm annually.

Mississippi Revegetation Success Standards for Commercial Forest require the Mississippi Forestry Commission to establish a stocking rate on a case by case basis in consultation with Mississippi Department of Environmental Quality. For RHM, the Forestry Commission recommended a survival rate of at least 500 live seedlings acre^{-1} (1236 ha^{-1}) at bond release. Mississippi's Commercial Forest Revegetation Success Standards further require ground cover to be at least 70%. RHM initially plants 1800 to 2000 seedlings ha^{-1} to offset natural seedling mortality and to avoid re-planting in the future to meet the 1236 trees ha^{-1} standard. As of February 2008, a total of 225 hectares have been reforested with 441,000 pine trees and 15 hectares have been planted with 11,000 mixed hardwoods.

The typical revegetation sequence at the RHM, following the respread of substitute topsoil, includes spring plantings of browntop millet (*Panicum ramosum*) at 22 kg ha^{-1} and common bermudagrass (*Cydonon dactylon*) at 33 kg ha^{-1}, planted simultaneously using a Brillion seeder (Fig. 1). These higher than normal seeding rates are essential for achieving quick and complete ground cover within 30 to 60 days. Reclaimed areas respread in late summer or early fall are planted with winter wheat (*Triticum aestivum*) into which bermudagrass and browntop millet are planted the following spring in order to establish a winter cover crop to reduce winter soil erosion as much as possible. Competition from bermudagrass is kept minimal due to lack of additional fertilizer and by adequate and copious amounts of rainfall that normally exceeds 1500 mm annually.

Figure1. Thirty day planted stand of browntop millet (right) is replaced by bermudagrass (left).

Fertilizer, as 17-17-17, is applied at 800 kg ha^{-1} and incorporated into respread soils during seedbed preparation for spring grass and winter grain plantings. Ammonium nitrate (34-0-0) is occasionally applied at 112 kg ha^{-1} during mid-summer to stimulate production of spring planted bermudagrass or spot treat areas within a bermudagrass stand that appear to be weak in appearance. Millet is mowed down within a month of spring seeding to prevent it from shading out germinating bermudagrass. Loblolly pine seedlings establish and mature to eventually shade out the bermudagrass (Fig. 2).

<u>Past Success 2002 To 2006</u>

Vegetation ground cover ratings greater than 90% were achieved within 30 to 60 days from 2002 to 2005 and were maintained following pine seedling establishment (Lang et al., 2006). Competition from the grass was not suppressed due to the high soil erosion potential and undoubtedly results in some seedling mortality and early growth reduction. Nonetheless, tree survival ranged from 60 to 80% and tree height growth was 0.7 to 1.5 m per year 3 to 4 years after planting (Lang and Hawkey, 2008). The heavy bermudagrass ground cover in years 1 to 3 diminished due to a lack of additional fertilizer and was replaced by native successional species. Unlike commercial pine plantings, hardwood species have been virtually absent during the first round of reclamation. Hardwoods sparsely volunteer within a normal southeastern USA successional pattern but they are not present until the pines are 1 to 2 meters tall and appear to have little initial potential to compete. Recruitment of grass and forb species from surrounding areas was common as bermudagrass declined.

Figure 2. Loblolly pine seedlings planted on a 2 x 3 m foot spacing (1982 trees ha^{-1}) into winter dormant bermudagrass (left) and typical success 1 year after establishment (right) .

Objective

The objective of this study was to evaluate the effect of bermudagrass cover and composition of invading forbs during drought and non-drought years on loblolly pine survival.

Methods

During 2006, early rainfall events enabled strong stands of bermudagrass to be established on 2.5 hectares of reclaimed land respread with 0.3m of prime farmland (PFL) topsoil. Later plantings in June and July into 10 hectares of red oxidized (ROX) respread encountered seasonal drought and bermudagrass establishment was sparse. There was 100% ground coverage of bermudagrass in the PFL area by July, 2006 while later plantings achieved less than 20-30% bermudagrass coverage. This created a differential level of herbaceous competition for the planting of loblolly pines during the winter of 2007 (Fig. 3).

Figure 3. Top Left: Bermudagrass established in 2007 (Area 2008-5/ROX5); Top Right: Poor establishment of bermudagrass in 2006 (Area 2007-1/ROX1); Bottom left: Poor establishment of bermudagrass in 2006 (Area 2007-2/ROX2); Bottom Right: Bermudagrass established 2006 (Area 2007-4/PFL4).

Loblolly pines were planted as bare root 1 year old seedlings on a 2x3 m spacing (1982 trees ha^{-1}) in January, 2007. During the spring of 2007 there was an extended spring drought from March until July. Due to poor loblolly survival during the drought of 2007 each area was replanted with up to 1236 additional trees per hectare during January of 2008.

Vegetative ground cover was evaluated during the fall and early winter of 2007 and 2008 along two 90 to 180 m transects within four areas (4 to 6 ha) reclaimed in 2006 and planted to loblolly pines in January, 2007. A fifth area (5 ha) was planted to bermudagrass in 2007 and to pines in January, 2008. There were two randomly selected starting points for each transect per area. Ground coverage was recorded photographically every 1.8 m from a Nadir height of 1 m. This provided 3 viewing points for each of 60 photographs per 100 m transect. Species were identified within each photograph and the number points with vegetation were tallied as a measure of ground coverage and bare soil. Visual estimates of ground coverage and species composition were also taken every 16.5 m along each transect within 81.4 m^2 circles (1/50th acre). Loblolly pines were counted within each circle and along each transect and at random points 10 to 20 m on either side. Planting year (2007 or 2008) was noted if a clear distinction between trees could be made. Trees that were chlorotic or necrotic were not counted as healthy trees, but they were noted as living trees that may become healthy survivors in future years. Stepwise regression analysis was used to analyze the relationships between type of vegetative competition and loblolly pine survival.

Soil was sampled to a depth of 0-30 cm as composited samples every 30 m in a Zigzag pattern along each transect and analyzed for soil fertility characteristics as described in Lang et al. (2005). Acid Base Accounting (ABA) was determined on composited 0-30 cm samples collected as part of regulatory sampling within 4 ha grids.

<u>Results</u>

Each of the areas had substitute topsoil respread with excellent characteristics for establishment of loblolly pines (Tables 1 and 2). It consists of mixed red oxidized (ROX) near surface overburden that contains topsoil and thus a seed bank. Soil pH ranged from 5.4 to 6.7 suitable for pines (Baker and Langdon, 1990) and most other vegetation.

Table 1. Acid Base Accounting and Texture of Areas Planted to Pines in 2007 and 2008

Area	pH‡	ABA	NP	Total S	Pyrite	Sand	Silt	Clay	Soil
	s.u.	---- t kt^{-1} -----		------------------------ % ----------------------					
2007-1	6.7	4.2	4.9	0.028	0.02	33	40	28	ROX1
2007-2	6.2	4.5	4.6	0.015	0.01	38	34	29	ROX2
2007-3	5.6	2	2.6	0.035	0.02	32	36	32	ROX3
2007-4†	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	PFL4
2008-5	6.3	4.5	4.9	0.018	0.01	33	38	29	ROX5
$LSD_{(0.05)}$	0.7	3.4	3.2	0.03	0.02	19	12	9	

† Area 2007-4 was prime farmland soil not analyzed (n.a.) for ABA
‡ Soil pH in 0.01 mM $CaCl_2$. Analyzed at Texas Energy Laboratories

Table 2.Soil Fertility of Areas Planted to Pines in 2007 and 2008

Area	pH†	OM	P	K	Ca	Mg	Zn	Na	SO_4-S	CEC
	s.u.	%	------------------- mg kg^{-1} ----------------------							cmoles$^+$ kg^{-1}
2007-1	6.3	0.90	23	97	1350	708	2.2	62	54	14.9
2007-2	5.7	1.26	31	145	1561	1117	2.9	69	85	21.3
2007-3	5.8	1.33	33	133	1755	1072	4.3	82	235	21.4
2007-4	5.4	1.28	18	87	1185	436	2.7	46	234	13.6
2008	6.0	0.57	26	90	1716	871	2.8	58	38	18.6
$LSD_{(0.05)}$	1.1	0.38	8	18	394	204	1.3	11	66	2.8

† Soil pH in water. Extractable Nutrients at Mississippi State University Extension Soils Laboratory (Crouse, 2001)

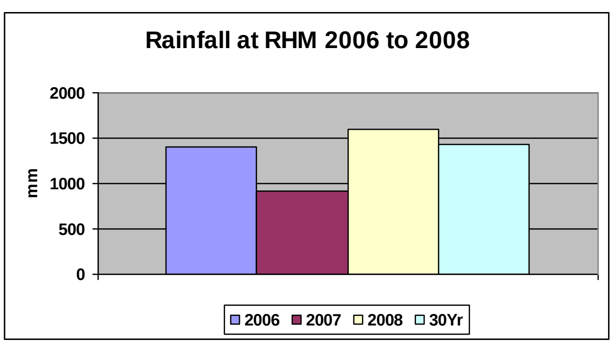
Loblolly survival in the fall of 2007 was 500 to 900 trees per hectare in each of the four areas, regardless of herbaceous vegetative competition (Table 3). Bermudagrass ground coverage ranged from 18 to 31% in ROX1, ROX2 and ROX3. Marestail (*Conyza canadensis* L.) was the dominant species in these areas with up to 60% bare soil. Bermudagrass growth in the PFL soil was vigorous following adequate rainfall in late July into August, 2007 with sparse invasion of *Solidago* and *Eupatorium* species (<5%). Since these stocking densities were less than 1236 per hectare required for bond release, each area was replanted in 2008. New bermudagrass established in 2007 and planted to pines in January 2008 had good establishment of bermudagrass and 88% pine survival.

Table 3. Loblolly Population Changes Following Planting in 2007 and Replanting in 2008

Pines Planted	Initial	Fall2007	Spring2008	Fall2008	Bermuda 2007	Soil
Year-Area	---------------------- trees ha^{-1} ------------------------------				% Cover	
2007-1	1982	590	1579	1285	25	ROX1
2007-2	1982	884	1844	1664	31	ROX2
2007-3	1982	776	1814	1048	18	ROX3
2007-4†	1982	576	2224	786	99	PFL4
2008-5	1982	np	2138	1754	92	ROX5

† PFL area. Target Population for bond release is 1236 trees ha^{-1} (500 ac^{-1})

Although rainfall in 2006 was near normal for the year (Fig. 4), there was a period of rainfall deficits from April to August that affected establishment of bermudagrass. Trees planted in 2006 generally had good survival (70%) due to above average rainfall in January and February, 2006. Trees planted into relatively bare soil in January 2007 encountered a period of drought from February that extended into June 2007. Above average rainfall in July 2007 enabled bermudagrass planted in 2007 to recover from earlier months of drought and generally had 80 to 100% ground cover by fall 2007. Trees planted in January 2008 had near normal amounts of rainfall. Rainfall during the spring and summer of 2008 was nearly or slightly above normal.



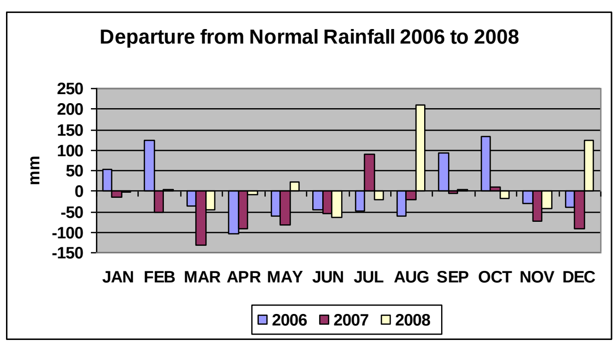


Figure 4. Total annual rainfall and departure from normal, 2006 to 2008.

Each of the three ROX areas had different volunteer compositions in 2008. ROX1 had a robust population of white clover, giant ragweed, S*olidago spp*, *Eupatorium spp*, bermudagrass and vaseygrass (*Paspalum urvillei*). This area had 590 loblolly pines per hectare (30% survival in the fall of 2007 and increased to 1285 trees per hectare (56% survival of 2008 planted trees) in the fall of 2008, sufficient to meet bond release (Table 4).

Table 4. Tree Survival and Pearson Correlation Coefficients (r) for Vegetative Ground Cover in ROX1, October 2007 and October 2008

Year		Baresoil	Bermudagrass	Marestail	Giant Ragweed†	White clover
	Trees ha^{-1}	-------------------------- % ------------------------------------				
Oct 2007	590	56.4	28.3	4.1	1.8	1.8
	Pearson r	0.53 P=0.0008	-0.51 P=0.0013	0.15 P= 0.366	-0.44 P=0.0059	0.19 P=0.256
Oct 2008	1285	7.0	25.4	0	24.8	35.6
	Pearson r	0.29 P=0.176	-0.33 P=0.120	Not present	-0.06 P=0.77	0.20 P =0.34
2007 Tree ha^{-1} = 400 +4.5*Baresoil – 36.3*Ragweed R^2 = 32.3 P =0.0013						
2008 Regression Not Significant (P>0.15)						

† Marestail and giant ragweed dominated in 2007 and ragweed was about 50% of the broadleaf plants in 2008 along with *Solidago, Eupatorium* and *Lespedeza spp*.

Regression analysis indicated that bare soil was positively related to tree survival in ROX1 and the presence of giant ragweed was negatively related. These accounted for only 32% of the variability and other factors such as low rainfall may explain much of the unexplained variability. Trees replanted in 2008 at a rate of 968 per hectare had 70% survival and increased tree population to 1285 per hectare or above the 1236 trees ha^{-1} needed meet bond release success standards. Survival in 2008 in this area was not related to degree of ground cover or any particular vegetative species. This area had vigorous vegetative growth with 93% total ground cover. Poor survival in 2007 was likely more related to drought than vegetative ground cover. Similar results were found in ROX2 (data not shown).

Two areas became heavily invaded with sericea lespedeza and or partridge pea (*Chamaecrista fasciculata syn. Cassia fasciculata*) in 2008. The west half of ROX3 developed a 60 to 90% stand of partridge pea and sericea lespedeza (*Lespedeza cuneata*) and had poor survival of 2008 planted trees (Table 5). The PFL area retained a healthy bermudagrass stand, but had areas with up to 90% partridge pea on two thirds of the east end. The west half of the PFL area had a 20-30% stand of partridge pea along with abundant *Solidago, Eupatorium* and other <u>Asteraceae</u> *spp*. (Table 6). There was a clear negative relationship between the occurrence of broadleaf plants, particularly partridge pea and sericea lespedeza, and loblolly pine survival during a normal rainfall year (2008).

Table 5 Tree Survival and Pearson Correlation Coefficients (r) for Vegetative Ground Cover in ROX3, October 2007 and October 2008

Year		Bare soil	Bermudagrass	Marestail	Broadleaf Plants†
	Trees ha^{-1}				
Oct 2007	776	71.8	18.2	4.8	6.1
	Pearson r	0.43 P=0.084	-0.26 P=0.319	0.55 P= 0.023	-0.44 P=0.006
Oct 2008	884	25	7.5	0	67.5
	Pearson r	0.12 P=0.676	-0.06 P=0.410	Not present	-0.66 P<0.001
2007 Trees ha^{-1} = 1287 -82.5*Marestail – 18.6*BLP R^2 = 0.50, P=0.0075					
2008 Trees ha^{-1}= 1714 -10.2*BLP R^2 = 0.44, P <0.001					

† Broadleaf Plants (BLP): Marestail and giant ragweed dominated in 2007. Partridge pea and sericea lespedeza were about 50% of the broadleaf plants in 2008 along with *Solidago, Eupatorium* and *Asteracea spp*.

Table 6. Tree Survival and Pearson Correlation Coefficients (r) for Vegetative Ground Cover in PFL, October 2007 and October 2008

Year		Bare soil	Bermudagrass	Partridge Pea	Broadleaf Plants†
	Trees ha^{-1}				
Oct 2007	576	0	99.0	Not present	n.d.
	Pearson r		-0.15 P=0.450		
Oct 2008	786	4.1	67.7	50.6	9.9
	Pearson r	0.54 P=0.001	-0.025 P=0.164	-0.54 P=0.002	0.36 P =0.041
2007 Regression Not Significant (P>0.15)					
2008 Trees ha^{-1} = 1571-9.0*PP +14.6*Bare soil -5.6*Bermuda R^2 = 0.46, P <0.0001					

† Broadleaf Plants (BLP) were virtually absent in 2007. Partridge pea (PP) was about 80% of the broadleaf plants in 2008 along with *Solidago, Eupatorium* and *Asteracea spp*.

Discussion

Negative effects of partridge peas on loblolly survival as indicated in this study have been reported in Texas by Redmon et al. (1997a, b). They evaluated warm season legumes as a companion crop for loblolly pines for three years after loblolly establishment. There was a 22% mortality of loblolly pine seedlings after twelve months when grown in association with partrigde pea compared with 10% mortality when loblolly was alone or with cowpeas (Redmon et al., 1997a). Root growth was also reduced in the presence of partridge peas by 38% compared with seedlings grown without a legume. There was 10% reduction in root growth when loblolly was grown with cowpeas. Loblolly pine grew to a height of 3.1 m with a DGH of 6.3 cm after 3 years in the presence of cowpeas (*Vigna unguiculata L.*) ($P<0.10$) compared with no legumes (Redmon et al., 1997b). Taller growing partridge peas reduced the growth of loblolly (2.7 m height, 5.3 cm DGH) compared with cowpeas, but growth was similar to pines growing without any summer legumes (2.8 m height, 5.7 cm DGH). We found a more severe effect of partridge peas, sericea lespedeza and other broadleaf plants on loblolly pine survival even during a year with normal rainfall (2008) indicating that other competitive interference factors such as allelopathy may be active.

Numerous studies have demonstrated that herbaceous vegetation control increases early juvenile growth of loblolly pine (Miller et al, 2003 and references cited therein). On 13 sites throughout the southeastern USA, loblolly growth volume increased following initial herbaceous control by 23 to 121% at 15 years. Herbaceous and woody vegetation control during the first 1 to 5 years following loblolly establishment has been adopted as a best management practice. On surface mines, however, vegetation cover provides critical soil erosion control and helps to restore other ecological functions (Lister et al, 2004; Rodriguez and Burger, 2004). Within FRA, noncompetitive grasses and forbs have been adopted as an alternative to vegetation suppression with herbicides (Burger and Zipper, 2002). Nonetheless, banded application of herbicides may have beneficial effects on loblolly survival and growth on reclaimed sites with vigorous vegetation competition. Herbaceous vegetation control at RHM has not been practiced in order to maintain protective erosion ground coverage with bermudagrass. Survival success of loblolly pines has been 60 to 80% from 2001 to 2006 (Lang et al, 2007; Lang and Hawkey, 2008). Herbaceous forbs such as *Solidago sp.* and *Eupatorium sp.* have been common early successional invaders of reclaimed soil at RHM along with marestail during the first season after bermudagrass establishment.

First year survival has been shown to increase following herbaceous vegetation control on compacted, drought prone sites (Yeiser and Williams, 1996) or in years or areas with low rainfall (Miller et al, 2003; Dougherty and Lower. 1991). Survival increased in Oklahoma from 31% without vegetation control to 81% with vegetation control. In Georgia with greater rainfall survival was 74% without vegetation control and increased to 87% with vegetation control Dougherty and Lower, 1991).

In southwest Arkansas and southeast Oklahoma, Yeiser and Williams (1996) found that herbaceous control increased loblolly survival on 11 of 13 sites. Their study included bermudagrass pasture sites at Allene, AR and Valiant, OK that had variable loblolly survival responses. Allene site 1 had heavy bermudagrass competition (4000 kg ha^{-1}), but loblolly survival was excellent regardless of herbaceous control (91.2 to 96.9%) during the first year. However, Allene site 2 with 2600 kg ha-1 of bermudagrass competition had an increase in loblolly survival from 78% in the untreated plots to 95% in the treated plots. Poor loblolly survival occurred on unripped, heavily compacted pasture sites at Valiant. Survival increased from 12 to 36% following herbaceous vegetation control at Valiant site 1 that had 1950 kg ha^{-1} herbaceous cover. At Valiant site 2, loblolly survival was 3.5% in the untreated plots and 47.5% in the treated plots with 1800 kg ha^{-1} of competition in the untreated plots. Overall, Yeiser and Williams found a 17% increase in loblolly survival with most of the increase occurring on compacted pasture sites. Miller et al (2003) found no significant increase in loblolly survival on 11 of 13 sites in response to complete herbaceous and woody vegetation control. Most of Miller's sites were in the eastern portion of southeastern USA with generally adequate rainfall. The two sites where loblolly survival increased in response to vegetation control were in drier western portions of southeastern USA. Loblolly survival response to herbaceous vegetation control was important on compacted sites or in regions or seasons with inadequate rainfall and may be more important than reduction of competition from bermudagrass per se.

Grass competition induced reductions in soil moisture can adversely affect first year growth and survival that would be magnified during drought years. The effect of crabgrass (*Digitaria spp.*) competition during induced water stress on loblolly seedling growth was studied in a 2 m deep rhizotron by Ludovici and Morris (1997) for 32 weeks. Seedling survival was reduced by 16%, height was reduced by 33% and diameter was reduced by 50% compared with seedlings grown in the absence of crabgrass. Soil moisture was 50% lower in rhizotron cells in mixed pine-grass compared with pine only cells.

Bermudagrass competition in 2007 was not a primary factor at the three ROX locations, but may have contributed to poor seedling survival in 2007 at the PFL4 site. Herbicide suppression of bermudagrass in 2007 at the PFL site may have been beneficial during drought. It remains an open question as to whether routine herbicide applications should be made to bermudagrass on reclaimed land prior to planting loblolly pines. The ROX5 location had an aggressive stand of bermudagrass prior to planting pines in 2008 with good survival during a normal rainfall year. Suppression would need to occur the fall before planting without knowing if rainfall would be limiting the following spring. Mississippi experiences seasonal droughts such as occurred to some extent in 2006 and more so in 2007 about once every five years, so there's a 20% chance that herbicide suppression would be beneficial to loblolly pine survival. Given that the risk of soil erosion is high in an environment with 1500 mm annual rainfall, and that pine survival has generally been sufficient to successfully establish 1200 to 1500 trees ha^{-1} without use of grass vegetation control, omission of grass suppression herbicides appears to be warranted. Control of bermudagrass in particular may not be beneficial, except on prime farmland respread, since it lacks its normal competitive ability without additional nitrogen fertilizer, indicating that bermudagrass is a tree compatible species for establishment of loblolly pines.

Literature Cited

Baker, J.B. and O.G. Langdon. *Pinus taeda* L. Loblolly Pine. *In:* Burns, Russell M., and Barbara H. Honkala, Tech. Coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC.

Burger, J.A. and C.E Zipper. 2002. How to Restore Forests on Surface-Mined Land. Virginia Tech Ext. Pub 460-123. http://www.ext.vt.edu/pubs/mines/460-123/460-123.html

Crouse, K.K. 2001. Soil testing and plant analysis in Mississippi: Procedures used by the Mississippi State University Extension Soil Testing Laboratory. Mississippi State University Extension Publication. 131 pp.

Dougherty, P.M. and R.F. Lower. 1991. Spot-Size of Herbaceous Control Impacts Loblolly Pine Seedling Survival and Growth. South. J. Appl. For. 15:193-199.

Lang, D.J., G. Hawkey, B. Chow, and V. Maddox. 2006, Revegetation Success at the Red Hills Lignite Mine in Mississippi, Proceedings America Society of Mining and Reclamation, 2005 pp 667-677. http://dx.doi.org/10.21000/JASMR05010667.

Lang, D.J., G. Hawkey, B. Chow, and V. Maddox. 2006, Revegetation Success at the Red Hills Lignite Mine in Mississippi, Proceedings America Society of Mining and Reclamation, 2006 pp 421-430. http://dx.doi.org/10.21000/JASMR06010421

Lang, David J. and George Hawkey. 2008. Reclamation Success at the Red Hills Mine in Mississippi. *IN*: J. Skousen (Ed.). Reclamation Matters. 3(2): 19-23.

http://ces.ca.uky.edu/asmr/Magazine/Issue%2010.pdf

Lister, T.W., Burger, J. A., and S. C. Patterson. 2004. Role of Vegetation in Mitigating Soil Quality Impacted by Forest Harvesting. Soil Sci. Soc. Am. J. 68:263-271. http://dx.doi.org/10.2136/sssaj2004.2630.

Ludovici, K.H. and L. A. Morris. 1997. Competition-Induced Reductions in Soil Water Availability Reduced Pine Root Extension Rates. Soil Sci. Soc. Am. J. 61:1196-1202. http://dx.doi.org/10.2136/sssaj1997.03615995006100040027x.

Miller, J.H., B.R. Zutter, S.M. Zedaker, M. B. Edwards and R.A. Newbold. 2003. Growth and Yield Relative to Competition for Loblolly Pine Plantations to Midrotation –A Southeastern United States Regional Study. South. J. Appl. For. 27:237-252.

Redmon, L.A., F.M. Rouquette, Jr., C.L. Goad, G.R. Smith, M.J. Florence, and J.W. Stuth. 1997a. Interseeded Legumes with Loblolly Pine. I. Effect of Phosphorus and Legume Variety on Pine Seedling Establishment and mortality. J. Plant Nut. 20:1755-1764. http://dx.doi.org/10.1080/019041697093653724.

Redmon, L.A., F.M. Rouquette, Jr., C.L. Goad, G.R. Smith, M.J. Florence, and J.W. Stuth. 1997b. Interseeded Legumes with Loblolly Pine. II. Effect of Phosphorus and Legume Variety on the Growth of Pine Seedlings. J. Plant Nut. 20:1765-1772. http://dx.doi.org/10.1080/01904169709365373.

Rodrigue, J.A. and J.A. Burger. 2004. Forest Soil Productivity of Mined Land in the Midwestern and Eastern Coalfield Regions. Soil Sci. Soc. Am. J. 68:833–844. http://dx.doi.org/10.2136/sssaj2004.83304.

Torbert, J.L. and J.A. Burger. 1990. Tree survival and growth on graded and ungraded minesoil. Tree Planter's Notes 4(2):3-5.

Torbert, J.L, Burger, J.A. and T. Probert. 1995. Evaluation of Techniques to Improve White Pine Establishment on an Appalachian Minesoil. J. Environ. Qual. 24:869-873 http://dx.doi.org/10.2134/jeq1995.00472425002400050012x

Yeiser, J.L. and R.A.Williams. 1996. Planted Loblolly Pine Survival and Growth Responses to Herbaceous Vegetation Control. South.J . Appl. For. 20:53-57.