THE FORESTRY RECLAMATION APPROACH AND THE MEASURE OF ITS SUCCESS IN APPALACHIA[1]

Patrick N. Angel[2], James A. Burger, Victor M. Davis, Christopher D. Barton, Michael Bower, Scott D. Eggerud, and Paul Rothman

Abstract: The Appalachian Regional Reforestation Initiative (ARRI) is a broad-based citizen/industry/government program working to encourage the planting of productive trees on abandoned and active coal mine lands. Forestry research has confirmed that highly productive forestland can be created on reclaimed mine land by using a five step straight-forward methodology called the Forestry Reclamation Approach (FRA). Data taken from Office of Surface Mining and state regulatory permit and bond release documents indicate that since the start of ARRI in 2005, a gradual increase in the planting of trees on coal surface mines has occurred. ARRI states reported about 9.4 million trees planted in 2005, 11.1 million trees planted in 2006, and 12.8 million trees planted in 2007. However, despite an aggressive technical outreach by ARRI, serious cultural barriers and other impediments to proper surface mine reforestation remain pervasive in the Appalachian coalfields. In 2007, the ARRI states reported that of the 12.8 million trees planted, only 3.4 million trees were planted using the full 5 steps of the FRA. The number of trees planted on conventionally reclaimed sites which were not FRA compliant was estimated at 9.4 million. One or more of the 5 steps of the FRA where not utilized on over two-thirds of the trees planted on surface mines in Appalachia over the past three years.

Additional Key Words: The Appalachian Regional Reforestation Initiative, ARRI, coal surface mine reforestation, tree planting, end-dumping, loose-grading.

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[2] Patrick N. Angel is a Forester/Soil Scientist, Office of Surface Mining, United States Department of Interior, London, KY 40741. James A. Burger is a Professor of Forestry and Soil Science, Department of Forestry, VA Tech, Blacksburg, VA 24060. Victor M. Davis is a Reclamation Review Specialist, OSM, USDI, Knoxville, TN 37902. Christopher D. Barton is an Assistant Professor of Forest Hydrology and Watershed Management, Department of Forestry, University of Kentucky, Lexington, KY 40506. Michael Bower is a Program Specialist, OSM, USDI, Pittsburgh, PA 15220, Scott D. Eggerud is a Program Development Forester, West Virginia Department of Environmental Protection, Charleston, WV 25304. Paul Rothman is an Environmental Scientist, Kentucky Department for Natural Resources, Frankfort, KY 40601.

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Introduction

The majority of the Appalachian coalfields region in the eastern United States was originally covered with rich hardwood forest. Over the years, surface mine reclamation resulted in forest fragmentation and a net loss of productive forestland. With the advent of the Surface Mining Control and Reclamation Act (SMCRA) (Public Law 95-87 Federal Register 3 Aug 1977, 445-532), special efforts were made to address land stability and sedimentation caused by past mining practices. Reclamation practices under SMCRA have been characterized by high soil compaction rates and aggressive ground covers. Many mined lands were restored as grasslands but are not currently used for hay or pasture by their owners. Native forests will eventually encroach on these areas by natural succession, but this process is slow (decades to centuries) and post-mining forest capability will likely be less than that prior to mining.

Researchers determined that tree productivity on many pre-SMCRA sites had growth rates equivalent to or better than that of forests growing on sites prior to mining. Most of these mined sites on which good growth was measured were on areas with low soil compaction. Forestry researchers at Southern Illinois University conducted studies during the 1970's and 80's to examine 30-year-old tree plantations on low compaction spoil piles in the mid-west region (Ashby et al., 1980). They found very high survival rates and growth rates for many hardwood species. They also documented far greater natural succession of native forest tree species in the areas planted to trees, than on adjacent unplanted areas. A more recent survey of pre-law forest productivity on mine sites in seven Appalachian and Midwestern states was reported by Rodrugue et al. (2002) who found that site quality and forest value was equivalent to non-mined sites. Research at Virginia Polytechnic and State University, and the Powell River Project, confirmed that the site index, which is a measure of forest productivity, can be significantly increased by changing current reclamation practices and adopting a Forestry Reclamation Approach (FRA) (Burger et al., 1998; Burger et al., 2005). The FRA will increase forest productivity and timber value, increase diversity through natural succession, increase soil and water conservation, provide wildlife habitat, and carbon sequestration. It is for these reasons that the Appalachian Regional Reforestation Initiative (ARRI) was formed in 2005.

The objectives of this paper are to 1) describe the ARRI organization, its goals, and the outreach effort to promote proper reforestation across the coal industry in Appalachia and with the general public; 2) present the five steps of the FRA in detail; 3) report ARRI's efforts to measure the success of the implementation of the FRA on the regional and site level; and 4) present a case study that demonstrates reforestation success at the site level when all FRA steps are used.

Appalachian Regional Reforestation Initiative (ARRI)

ARRI is a broad-based citizen/industry/government group working to encourage planting of productive hardwood trees on reclaimed coal mined lands and abandoned mine lands. ARRI's vision is not only to plant more trees, but also to build a productive forest ecosystem that encourages natural succession of native forest plants by promoting the use of the FRA technology. The goals of ARRI are to plant more high-value hardwood trees on reclaimed coal mined lands in Appalachia, increase the survival and growth rates of planted trees, and accelerate the natural process of succession and reestablish forest habitat. The ARRI states are Kentucky Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia.

By using a combination of private and governmental resources, the program facilitates and coordinates the coal industry, university researchers, the environmental community, and government agencies that have an interest in creating productive forestland on reclaimed mined lands (Angel et al., 2005). ARRI has identified a Core Team that includes members from each Office of Surface Mining Reclamation and Enforcement (OSM) Field Office, and members from each State Regulatory Authority in the Appalachian Region. This Core Team has the responsibility to develop reforestation partnerships and promote ARRI. ARRI has also formed a Science Team which is drawn from Universities and other groups and agencies in nine states. It is the job of the Science Team to insure that state-of-the-science reforestation procedures are advocated by ARRI and that mined land reforestation research is advanced.

Through its initial work with the mining community, ARRI has identified several barriers that must be eliminated for mine land reforestation to proceed:

- Cultural Barriers – ARRI is aggressively working to change the perception that tree planting is more expensive and risky than reclamation to pastureland. A major part of this effort is to change the perception of what good forestry reclamation should look like.
- Technical Barriers – ARRI is working to promote the use of FRA technology, and to encourage additional research as needed.

- Regulatory Barriers – OSM and the Appalachian region states have determined that the FRA technology can be implemented under the current State and Federal regulations. However, ARRI members are continuing to review State and Federal regulations to identify and resolve impediments to reforestation. ARRI is working to change the perception that the regulations impede effective reforestation techniques.

The mining community has taken lessons learned from past mining practices and current research to modify mining practices to create more productive forestland. This evolution of "best reclamation practices" has culminated in a set of procedures called the Forestry Reclamation Approach (FRA). The FRA presented here is a general guideline and each state is encouraged to develop a FRA that fits their unique environmental conditions.

Forestry Reclamation Approach

1. Create a suitable rooting medium for good tree growth that is no less than four feet deep and comprised of topsoil, weathered sandstone, and/or the best available material

The selection of the best growth medium will depend on the local environmental conditions and the best available soil material. Topsoil is a valuable resource and it should be conserved and replaced when possible. However, in the mountainous areas, topsoil is limited and alternate growth media have been shown to support productive forestland (Fig. 1).

During mining operations, all highly alkaline materials with excessive soluble salts and all highly acidic or toxic material should be covered with four to six feet of a suitable rooting medium that will support trees. Growth media with low to moderate levels of soluble salts, equilibrium pH of 5.0 to 7.0, low pyretic sulfur content, and textures conducive to proper drainage are preferred (Burger et al., 2005). Native hardwood diversity and productivity will be best on soils with a sandy loam texture where the pH is between 5 and 7. These types of soils can be formed from overburden materials comprised of weathered brown or unweathered gray sandstone, especially if these materials are mixed with natural soils. Shale may be used in combination with sandstone; however, high concentrations of shale and other fine-grained spoil materials should be avoided. Many times these materials have higher pH values, which encourages heavy ground cover and inhibits tree growth. On re-mining sites, topsoil/sandstone may not be available in sufficient quantities. In these cases a combination of spoil materials will be required to create the best available growth medium.

Figure 1. Photo shows the White Oak reforestation research plots in east Tennessee where an alternate growth media is being loosely graded to form a soil medium suitable for tree growth under the FRA (photo by Vic Davis).

2. Loosely grade the topsoil or topsoil substitutes established in step one to create a non-compacted soil growth medium

The use of pans and other rubber tire equipment must be eliminated during final grading. The practice of tracking-in with dozers to create a smooth and compacted final grade is not advisable, and is an unnecessary expense. The majority of the backfill should be placed and compacted using the currently accepted practices and site stability must be achieved first and foremost. The difference is only during the replacement of the growth medium in the last four to six feet. In area mining, haul trucks are used to dump the growth medium in a tight arrangement, and final grading is accomplished with one or two light passes with a dozer to strike off the tops of the dump piles (Diagram 1, Fig. 2). Likewise, in a dragline operation, the growth medium is placed in piles and a dozer lightly grades the area leaving a rough, non-compacted growth medium (Diagram 2, Fig. 2).

In steep slope mining areas, the majority of the backfill is placed and compacted as usual, but the final four to six feet of growth medium is dumped and lightly graded to achieve the required final grade. This low compaction technique will actually reduce erosion, provide enhanced water infiltration and restore the hydrologic balance, and allow trees to achieve good root penetration. Research conducted by the University of Kentucky, at the Starfire Reforestation Project, has shown that reduced compaction rates result in superior tree survival and growth rates (Graves et al., 2000). Ripping can alleviate compaction, and research has shown that this will increase tree growth. However, this is an unnecessary expense that can be avoided by limiting compaction during final grading.

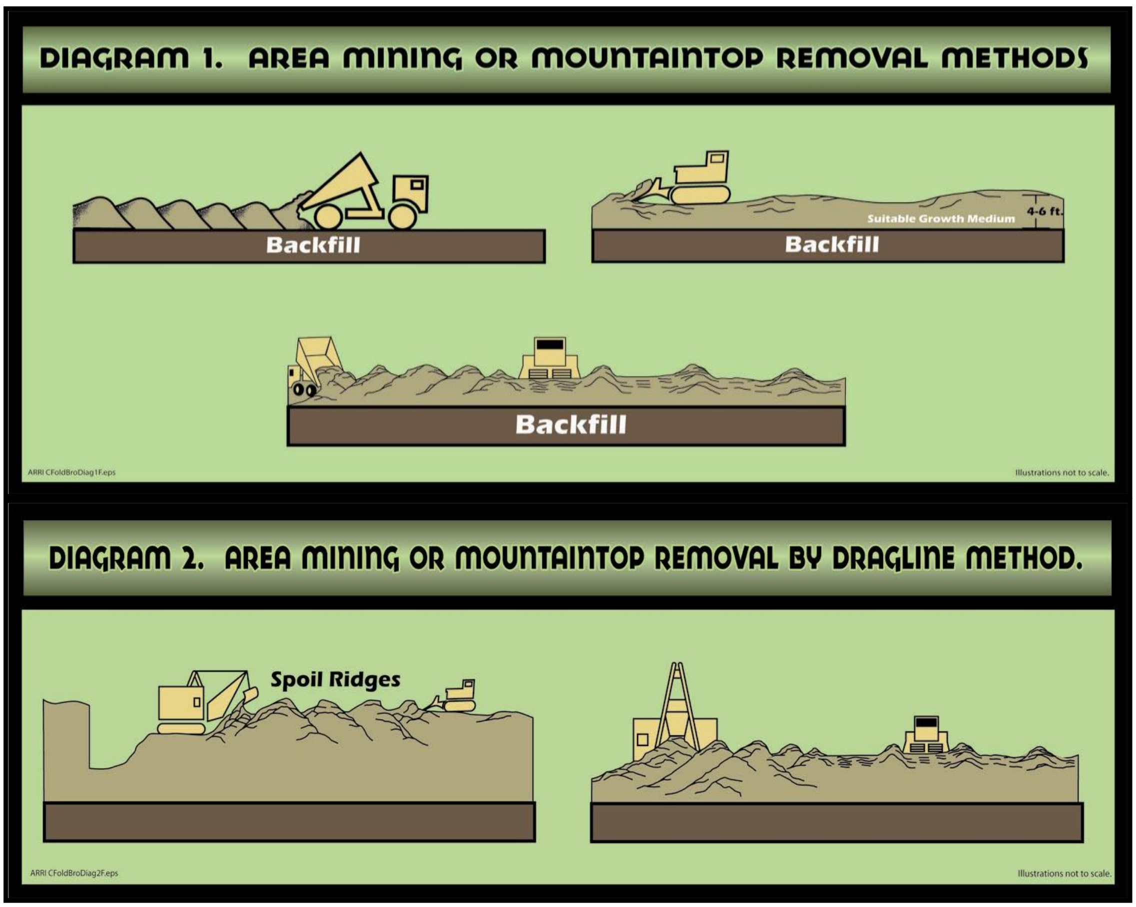

Figure 2. Preparation of non-compacted mine soil growth medium using loose-graded techniques under the FRA on area mining or mountaintop removal methods (Diagram 1) and area mining or mountaintop removal by dragline method (Diagram 2). (Angel et al., 2005)

3. Use less competitive ground covers that are compatible with growing trees

Ground cover vegetation used in reforestation requires a balance between erosion control and competition for the light, water, and space required by trees. Fast growing and competitive grasses such as Kentucky 31 fescue (*Festuca arundinacea*) and aggressive legumes such as sericea lespedeza (*Lespedeza cuneata*), and yellow sweet clover (*Melilotus officinalis*) should not be used where trees will be planted (Fig. 3).

Seeding rates should be reduced in order to limit ground cover competition to planted tree seedlings. This is possible because loosely-placed mine soils recommended in Step 2 allow greater rates of water infiltration which reduces the potential for soil erosion. Competitive ground cover will inhibit both tree survival and productivity. Tree compatible grasses include foxtail millet (*Setaria italica*), rye (*Secale cereale*), red top (*Agrostis palustris*), perennial ryegrass (*Lolium perenne*) and orchardgrass (*Dactylis glomerata*) (steep slopes only), and compatible legumes include birdsfoot trefoil (*Lotus* corniculatus) and Ladino clover (*Trifolium repens*). By using these species in a mix with other appropriate species, seedling survival will be increased and erosion will be controlled. Fertilizer rates should be low in nitrogen to discourage heavy ground cover growth while applying sufficient rates of phosphorus and potassium for optimal tree growth (Burger et al., 2005).

Figure 3. This photo shows a mine site in eastern Kentucky where a thick cover of Kentucky 31 fescue (*Festuca arundinacea*), sericea lespedeza (*Lespedeza cuneata*), and yellow sweet clover (*Melilotus officinalis*) would provide too much competition for tree seedlings to survive (photo by Patrick Angel).

4. **Plant two types of trees – early succession species for wildlife and soil stability, and commercially valuable crop trees**

Nitrogen-fixing trees and shrubs act as nurse plants for the higher quality hardwoods and some provide wildlife food and cover. Good nurse/wildlife plants include redbud (*Cercis canadensis*), hawthorn (*Crataegus mollis*), dogwood (*Cornus florida*), and black locust (*Robinia pseudoacacia*). Crop trees should be selected according to the soil and environmental conditions. Research has shown that commercially valuable hardwoods can be successfully grown including northern red oak (*Quercus rubra*), white oak (*Quercus alba*), green ash *(Fraxinus pennsylvanica)*, black cherry (*Prunus serotina*), sugar maple (*Acer saccharum*) and yellow-poplar (*Liriodendron tulipifera*) (Burger et al., 2005). Using the FRA also encourages natural succession of early-successional native forest plants. By planting nurse and wildlife species, mid and late successional tree species, and creating conditions for early successional species to volunteer, a shorter amount of time is required to reach a diverse, commercially-valuable mature forest (Fig. 4).

Figure 4. An emerging hardwood forest established on an active mine site in Virginia as a demonstration of the FRA (photo by Vic Davis).

5. Use proper tree planting techniques

The importance of proper tree planting cannot be over stated. The best planting stock available should be selected and maintained in cold storage until planted. Tree seedling roots exposed to air for as little as 15 minutes can significantly increase the mortality rate. From the time seedlings are removed from cold storage to the time they are planted, they should be handled with care. The seedlings must be kept moist and immediately placed in the planting bag; their roots should never be pruned. The planting hole must be made as deep as possible, to accommodate the entire root system. The planting hole must be completely closed and the soil around the seedling firmed with the planting tool or boot to eliminate air pockets. In most cases, the extra cost of hiring professional tree planters will be well worth the investment (Fig. 5).

Figure 5. Tree seedlings must be carefully planted by hand in order for the fifth step of the FRA to be implemented properly (photo by Vic Davis).

Measuring Success of ARRI and the Forestry Reclamation Approach

ARRI's Outreach to the Industry and Public

Since its creation in 2005, ARRI members and partners have been spreading the word about the FRA through numerous avenues. Each spring, every ARRI state has conducted one or more

Arbor Day Event where coal companies, citizen volunteers, government workers, school children, and others get out on a mine site to plant trees, celebrate the value of forestland, and promote the reforestation of surface mines. In 2008, over 28,000 trees were planted at ARRI sponsored Arbor Day Events. The events usually attract considerable media attention and as a result, ARRI, the industry, and the participants have enjoyed positive and upbeat local and regional news coverage.

ARRI 'Signing Ceremonies' is another avenue by which word of the FRA is being spread. These high profile events are associated with ARRI's Statement of Mutual Intent (SMI) which is a way for agencies, organizations, and individuals to pledge support for the FRA and ARRI's goals. The 276 SMI signatories that have been collected to date represent 143 different organizations, which include 49 government agencies, 49 industry organizations, 22 environmental groups, 18 academic institutions, 5 citizen groups, and numerous individuals. The work of ARRI has attracted considerable international attention because the FRA is universal and applicable to all types of mining and in all places worldwide. Also, the development and execution of this science-based, multi-agency initiative is serving as an organizational model for other groups around the world whose goal is to restore disturbed landscapes through reforestation.

Each year ARRI has presented the Excellence in Reforestation Awards to individuals, operators, and/or organizations for their exemplary efforts in forestry reclamation on Title IV and Title V mine sites that utilize the FRA in Appalachia. The Excellence in Reforestation Awards Program was created to acknowledge and give public recognition to those responsible for Appalachia's most outstanding achievements in forestry reclamation and to encourage the exchange and transfer of successful reforestation technology. ARRI's newsletter and website (http://arri.osmre.gov) routinely report on the tree planting events, ceremonies, and awards that occur.

FRA training for ARRI partners exists in numerous formats. Formal reforestation training has been conducted throughout the region. These courses, seminars, field trips, and lectures focus on the five steps of the FRA and the organizational structure of ARRI so that participants know where to find help and seek out resources. Two very successful annual Mined Land Reforestation Conferences have been held so far drawing upwards to 200 interested participants. The first conference was held in Abingdon, Virginia in 2007, and the second in Logan, West

Virginia in 2008. The third conference will be held in Prestonsburg, Kentucky in 2009. Several very fine instructional videos featuring the FRA have been produced by ARRI partners. One goal of the ARRI Science Team is to generate a series of guidance documents called Forest Reclamation Advisories which will describe state-of-the-science procedures for coal mine operator and other mine reforestation practitioners, agency personnel, and mine land owners. Five Advisories have been published, distributed, and made available on ARRI's website to date and several others are expected to be released very soon.

ARRI has been most successful in spreading the FRA by building partnerships with groups and individuals that share the common goal of science-base surface mine reforestation. One good example of a very successful ARRI partnership is centered on the American chestnut tree. ARRI and The American Chestnut Foundation (TACF) have formed a strong partnership to use FRA compliant surface mines as the 'springboards' for disease-resistant chestnuts back in the forests of Appalachia. Under the joint ARRI/TACF project called 'Operation Springboard', 11,809 American chestnuts were planted in 2008 on surface mines that will aid both the research and repopulation of these monarchs of the eastern forest. Another example of a successful ARRI partnership that is spreading the FRA involves the Cerulean warbler. This small, neo-tropical, migratory songbird breeds throughout the central and eastern US and relies on large tracts of mature deciduous hardwood forests during the breeding season. Cerulean populations have declined at a rate greater than 3% each year since 1966, prompting a petition in 2000 to the U.S. Fish and Wildlife Service asking it to be listed as threatened under the Endangered Species Act (Sauer et al., 2008). ARRI is actively facilitating partnerships between the coal industry and conservation groups like the Cerulean Warbler Technical Group, the American Bird Conservancy, the Appalachian Mountains Joint Venture, numerous South American groups, and government agencies and university researchers. The conservation groups win by addressing habitat needs, the industry wins by voluntarily addressing habitat needs outside of a regulatory mandate, and ARRI wins by getting more trees planted. ARRI is also helping to facilitate a three-way coal/coffee/Cerulean partnership between conservation groups, the coal industry in North America, and the coffee industry in South America.

Measuring Success on the Regional Level

Data taken from Office of Surface Mining and state regulatory permit and bond release documents indicate that since the start of ARRI in 2005, a gradual increase in the planting of trees on coal surface mines has occurred (Fig. 6). ARRI states reported about 9.4 million trees planted in 2005, 11.1 million trees planted in 2006, and 12.8 million trees planted in 2007. However, despite an aggressive technical outreach by ARRI, serious cultural barriers and other impediments to proper surface mine reforestation remain pervasive in the Appalachian coalfields. In 2007, the ARRI states reported that of the 12.8 million trees planted, only 3.4 million trees were planted using the full 5 steps of the FRA. The number of trees planted on conventionally reclaimed sites which were not FRA compliant was estimated at 9.4 million. One or more of the 5 steps of the FRA where not utilized on over two-thirds of the trees planted on surface mines in Appalachia over the past three years.

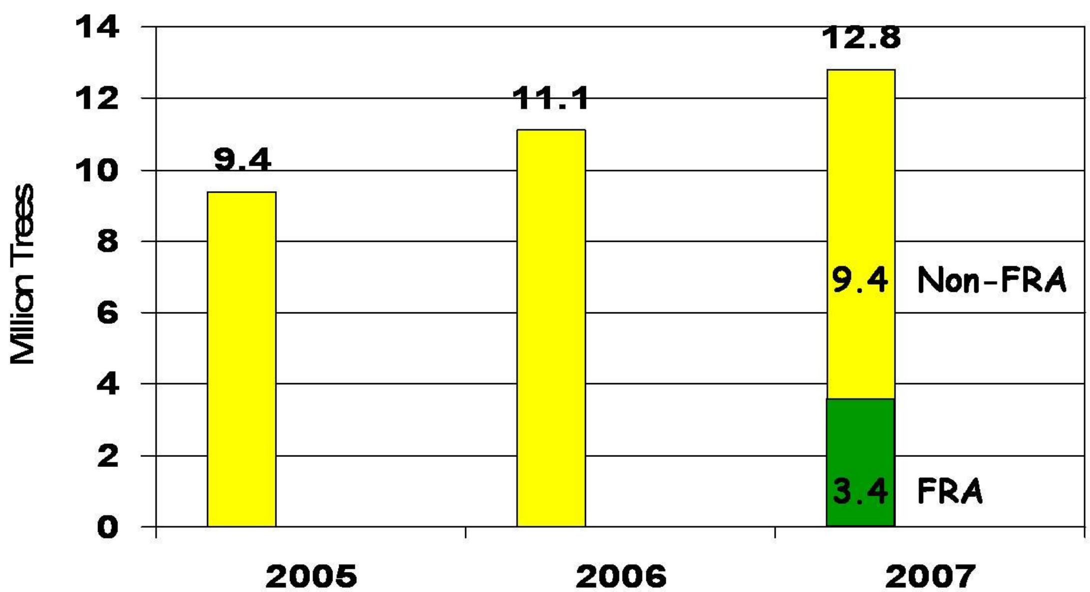

Figure 6. Number of trees planted in ARRI states in 2005, 2006, and 2007.

Each year, OSM's Annual Report presents the area of Phase I and Phase II bond releases granted by each coal producing state in the US. This is mined land that is generally considered to be "reclaimed" by the state regulatory authorities and the federal government. Together, the seven ARRI states reported 16,239 hectares (40,129 acres) reclaimed in 2005 (USDI, 2009). Of this acreage, ARRI estimates that approximately 6,313 hectares (15,600 acres) or 39% were planted to trees. That percentage remained consistent from 2005 to 2007. As the number of hectares that are being reclaimed each year is rising (about 16 thousand in 2005, 19.3 thousand in

2006, and 21.9 thousand in 2007), the number of hectares planted to trees each year is also rising (6.3 thousand in 2005, 7.5 thousand in 2006, and 8.5 thousand in 2007). Therefore, the percent of acres reclaimed to trees is staying steady at about 39%.

Measuring Success of the Site Level

When measuring FRA success on the site level, ARRI considers survival, growth, and natural regeneration. Foresters who plant native, bareroot, hardwood seedlings by hand on undisturbed soils target an average survival rate of 70%. In other words, up to 30% mortality after the first year is considered successful on an old agricultural field that was hand planted to hardwood seedlings. A variety of climatic and biotic factors can influence survival the first year after planting; the number of trees planted usually exceeds the average final stocking hoped for by about 30%. In addition to simply surviving, trees must grow at rates typical for a given species in order to be successful. Early growth rates are fairly good indicators of long-term forest growth and capability. Finally, the ability of native species, both herbaceous and woody, to volunteer, emerge, and become established on mined sites in structural and functional compositions, equivalent to what might be expected on non-mined sites, is a third indicator of reforestation success at the site level. Current forestry research conducted by the University of Kentucky and Virginia Tech, has confirmed that highly productive forestland can be created on reclaimed mine land by using the FRA (Burger et al., 2005).

Case Study Demonstrating Success of FRA Techniques: The Bent Mountain Reforestation Research Complex. In March 2005, a set of research plots was established by the University of Kentucky on Appalachian Fuel's active mountaintop mining operation located on Bent Mountain near the community of Meta in Pike County, Kentucky (Latitude N 37° 35′ 49″, Longitude W 82° 24′ 19″) (Angel, 2008). The purpose of plots was to evaluate tree performance, natural regeneration, and the mineralogical, chemical, and physical characteristics of three different types of loose-graded spoils. The three spoil types involved were: (1) predominately brown weathered sandstone; (2) predominately gray un-weathered sandstone; and (3) equally mixed brown weathered sandstone, gray un-weathered sandstone, and shale material (mine-run spoil). The three spoil types will henceforth be referred to as 'BROWN', 'GRAY', and 'MIXED'.

The three loose-graded spoil types were the three treatments in this experiment. The three treatments were randomly assigned to six square plots, each of which measured approximately 64 m on each side. The average area of the plots was approximately 3,658 m^2. The three treatments were replicated once across the six plots or experimental units, creating two BROWN plots, two GRAY plots, and two MIXED plots. The three different spoil types were transported directly from the working surface mine and dumped into tightly placed piles to form the final configuration of the six plots. The BROWN, GRAY, and MIXED spoils were hauled to the plot sites in separate loads by large dump trucks.

The spoil was dumped out of the end of the dump trucks ('end-dumped') into piles that averaged about 3.5 m in height. The piles were placed in parallel rows in such a way that they closely abutted one another across each of the six plots. The tops of the spoil piles were then 'struck-off' with one pass of a small bulldozer (Caterpillar D5H, straight blade) down the length of each parallel ridge of spoil, pushing the spoil into the parallel valleys on both sides. The one pass with the bulldozer cut the piles down in elevation by about 1 m, lowering the final average height of the piles to approximately 2.5 m. The final grade configuration of the spoil resembled many natural forest sites in the area with a hummocky microtopography characterized by small mounds, depressions, rocks, and boulders. Four species of tree seedlings were hand planted on 2 April 2005 on a 1.8 m by 2.4 m spacing in the loose-graded spoil of the six plots. The four species were white oak, green ash, northern red oak, and yellow-poplar. No herbaceous ground cover was established and no fertilizer or soil amendments were added.

Observations indicate that by the third year after planting, the GRAY spoil had an overall higher average survival (88%) than the BROWN spoil (86%), and the MIXED spoil (81%) (Table 1). In 2007, no significant differences were observed in the survival between the BROWN spoil and GRAY spoil for all species combined, but both BROWN and GRAY were significantly different than MIXED. The averages for all species on all spoil types were well above the baseline considered successful on native, undisturbed soils. White oak and green ash survival were impressive (93-100%). Even the lowest percent survival (65-72%) for such a demanding species as yellow-poplar was acceptable. However, it must be emphasized that all 5 steps of the FRA were employed on these test plots. Since stocking rate is the only measure of success in regards to bond release in all states (except West Virginia), applying all 5 steps of the FRA will ensure good stocking for a timely bond release and a fast-growing productive forest that will be of value for the landowner.

Table 1. Third year percent survival by spoil type for all species at the University of Kentucky's Bent Mountain Research Complex in Pike County, KY (Angel, 2008).

	BROWN	GRAY	MIXED
Green ash	97 (a)	96 (a)	96 (a)
Red Oak	77 (ab)	80 (a)	73 (b)
White Oak	100 (a)	100 (a)	93 (b)
Yellow- poplar	70 (a)	72 (a)	65 (a)
All species	86 (a)	88 (a)	81 (b)

Comparisons are made between spoil types for each species. Spoil types with the same letter are not significantly different at $p = 0.05$ level.

A second measure of a successful FRA effort at the site level is tree productivity or growth. The BROWN spoil at the Bent Mountain Reforestation Research Complex showed significantly more growth in height, diameter and tree volume index than the GRAY and MIXED spoil (Angel, 2008). The average height in cm for BROWN was 65.8, MIXED was 44.7, and GRAY was 35.2. The average volume in cm^3 for BROWN was 235, MIXED was 36, and GRAY was 84. The tree species that preformed the best in terms of tree volume index on all three spoil types was yellow-poplar. By 2007 on the BROWN spoil, yellow-poplar grew over twice as much in volume than its closest planted tree competitor, green ash. Yellow-poplar achieved the highest volume (mean = 466.3 cm^3), followed by green ash (mean = 228.8 cm^3), and then by red oak (mean = 177.2 cm^3). White oak had the least volume on the BROWN spoil (mean = 96.6 cm^3).

The White Pine Productivity Standard for commercial forestry used by the West Virginia regulatory authority is an average annual height growth of 45.7 cm (18 in) for three consecutive years (Federal Register, 2000). Figure 7 shows a 6 year old white pine planted in FRA compliant spoil with an annual growth interval of over 1.2 m (4 ft).

ARRI considers natural regeneration as the third measure of FRA success. Natural regeneration is defined as any native volunteer plant species that sprouts from root propagules in the growth medium or which is brought to the planting site by wind or animals (not planted as part of the reclamation) and takes root on its own. Figure 8 shows the natural regeneration at

Bent Mountain three years after site preparation. After the third year, the best plots had 66% ground cover and 61 different species (58% of which were native species) (Angel, 2008).

Figure 7. Six-year-old eastern white pine planted in FRA compliant spoil in WV with an annual growth interval of over 1.2 m (4 ft) (Photo byScott Eggerud).

Figure 8. Three years of natural generation producing 66% ground cover and 61 different species at the University of Kentucky's Bent Mountain Reforestation Research Complex in Pike County, Kentucky (Angel, 2008).

The amount of natural regeneration and the stocking success and productivity of species planted on FRA sites are practical ways to measure relative success; however, the type of species (i.e., the function of a species or the presence of different functional groups of species) might be a better measure of reforestation success and will be considered as we learn more about plant community dynamics on FRA-prepared mined sites.

Conclusion

ARRI members and partners are similar to the captain and crew of a gigantic, oceangoing oil supertanker who want to stop, turn, and proceed with the huge vessel in the opposite direction. A supertanker cannot be turned on a dime and neither can the ingrained attitudes and practices that have been pervasive regarding mined land for the past 30 years. Negative perceptions of forestry post-mining land uses developed after the implementation of the SMCRA because trees planted on post SMCRA compacted, heavily-vegetated mine soils often failed. Even with new and proven FRA practices, reforestation advocates are finding it slow-going and difficult to change the direction of the culture associated with reclamation practices. But ever so slowly, change is coming to the coal fields and many are hopeful that once again forestry will be the post-mining land use of choice where it is the logical and highest and best use. ARRI partners expect to see a lag time of 3 to 4 years between the time that mine operators started inserting FRA language into new permit applications and the time that trees are finally planted on those mine sites. We may not see substantial impact of ARRI's outreach for several more years. The percent of the permits currently being issued that have a forestry post-mining land use varies from state to state. In West Virginia, 80% of the permits issued over the past 5 years will have trees planted and 87% of those specify the use of the FRA (Scott Eggerud, WVDEP, personal communication).

Forestland enriches us all by providing numerous environmental and economic benefits. Forestland is also a renewable resource. By working together, State and Federal government agencies, the coal industry, landowners, university researchers, and local citizens, can indeed create highly productive forestland on reclaimed mine land by using the Forestry Reclamation Approach. We invite any and all interested parties to join the Appalachian Regional Reforestation Initiative and become Reforestation Champions.

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