MINED LAND RECLAMATION FOR WOOD PRODUCTION IN THE APPALACHIAN REGION[1]

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Abstract. The future economic viability of forest land in the Appalachian coal-bearing region may be threatened by common post-mining reclamation practices. The Surface Mining Control and Reclamation Act (SMCRA) of 1977 allows post-mining conversions of forest land to grass land. This mined land, ostensibly restored for pasture and hay production, is often abandoned from normal management, precluding its timely restoration to forests. Also, even when forest land is intended as the post-mining land use, revegetation procedures are most often geared for establishing the temporary ground cover rather than the permanent forest crop. As a result, mine soils are often compacted, salty, alkaline, heavily fertilized and heavily seeded. These conditions discourage optimum survival and growth of desirable forest tree species.

Additional Key Words: restoration, reclamation with trees, mined-land value

Introduction

The Original Forest

Except for the mountainous topography of the central Appalachian coal-bearing region, the most distinctive feature of the landscape is that it is nearly totally in forest cover. The region is covered predominantly by the upland oak-hickory and Appalachian mixed-hardwood forest cover types. The great range of geology, soil, microclimate, and topography results in a range of species composing the forest stand (Burns 1983). White (Quercus alba L.), northern red (Quercus rubra L), and black oak (Quercus velutina Larn.) are found throughout with scarlet (Quercus coccinea Muenchh.) and chestnut oak (Quercus prinus L.) on drier sites. Pignut (Carya glabra (Mill.) sweet), mockernut (Carya Tomentosa Nutt.), and shagbark hickory (Carya ovato (Mill.) K. Koch) are consistent in stands but are a minor component. Species mixtures may also contain yellow-poplar (Liriodendron tulipifera L.), ash (Fraxinus spp.), elm (Ulmus spp.), sugar maple (Acer saccharum Marsh.), red maple (Acer rubrum L.), blackgum (Nyssa sylvatica Marsh.), black locust (Robinia pseudoacacia L.), black cherry (Prunus serotina Ehrh.), American beech (Fagus grandifolia Ehrh.), black walnut (Juglans nigra L.), and birch (Betula spp.) among other less populous hardwood species. In disturbed areas and on some natural sites, pitch (Pinus rigida Mill.), Virginia (Pinus virginia Mill.), eastern white(Pinus strobus L.), loblolly (Pinus taeda L.), and shortleaf pines (Pinus echinata Mill.), eastern hemlock (Tsuga canadensis (L.) Carr.) and eastern red cedar (Juniperus virginiana L.) are found. Common understory species are flowering dogwood (Cornus floridas L.), eastern redbud (Cercis canadensis L.), sassafras (Sassafras albidum (Nutt.) Ness), downy serviceberry (Amelanchier arborea (Michx.)), witch-hazel (Hamamelis virginiana L.), and mountain laurel (Kalmia latifolia L.).

Forest Use and Potential

Since European man arrived in the region, the forest has acquired a 200-year history of use and abuse. The original forest was logged during 1890 through 1920, and was followed by high-grade logging of second and third growth forests. Logging practices were harsh on the forest site and in some cases abuse of the soil and landscape resulted in a permanent decrease in the productive potential of the land. However, the forest remains today as one of the largest and most valuable hardwood resources in the nation. Its multifaceted values include water quality and

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quantity control, wildlife food and cover, recreation, regional biotic stability, and wood supply. Wood supply has traditionally been the most important and tangible forest value. Several studies predict high rates of return for new investments in wood using facilities (Donnell 1987 and McCoy and Wisdom 1984), but non-financial factors such as lack of adequate transportation networks and disaggregated timber ownership must be overcome before these otherwise fruitful investments can be realized (Robles and Wisdom 1989).

Forest Restoration After Surface Mining

Despite past abuses, the forest of the region remains intact, healthy, and valuable. It is extremely resilient and has regenerated and persisted through disturbances such as site-degrading harvesting methods, severe soil erosion, catastrophic fires, severe floods, and intense disease and insect attacks. On an acre-by-acre basis these disturbances are minor, however, compared to the disturbance created by surface mining for coal. In the process of surface mining, both the above and below-ground components of the forest are literally removed.

Reclamation of the land after mining is conducted under the regulatory auspices of P.L. 95-87, or SMCRA. Besides very specific mandates for overburden handling, drainage, erosion and sediment control, maintenance of water quality and final contouring, the law requires restoration of the land to its original use or to one of greater value. The purpose of this paper is to access the effect of current regulations and reclamation techniques on the potential of mined land for wood production. Specifically, conversions to grassland and degraded forest site quality are reviewed.

Forests to Grasslands Conversions

Reforestation can shorten or skip stages of primary forest succession. In its simplest form, forest succession can be described as a natural process whereby, following a disturbance, a community gradually regains the structure and floristic composition of adjacent communities on comparable sites by an orderly and predictable process (Clements 1916). The process entails species replacement and site amelioration. Several successional phases are commonly recognized (Figure 1): They include "pioneer," "building," "mature," and "climax stages." Other divisions and names have been used to describe successional stages, but this oversimplification is sufficient to contrast natural versus induced succession.

Because of steep slopes, shallow soils, and bedrock near the land surface, replaced "topsoils" are most often mixtures of A, E, B, and C_r soil horizons. In many cases no "true" topsoil is recoverable and mine spoils are used as topsoil substitutes. In either case, if left to natural colonization by plants and animals, succession would begin at a primary level. Pioneering herbs, grasses and shrubs would invade and colonize the site followed by nitrogen fixing herbaceous and woody shrubs and trees during the "building" stage. Opportunistic hardwood and pine species would become dominant during the transition between the building and mature stages. Species would include sweet birch (Betula lenta L.), sourwood (Oxydendrum arboreum (L.) DC.), red maple, tulip tree, black cherry, and sycamore (Platanus occidentalis L.), and white, Virginia, and pitch pines. As these species developed into a mature forest, birds and rodents would move the heavier-seeded oaks and hickories onto the site. Over time, the somewhat-shade-tolerant oaks and hickories would persist in the understory and eventually make their way into the canopy as the biotic and abiotic character of the site changed to their advantage.

The rate at which succession would proceed through these stages would be highly variable, depending on the nature of the site and adjoining sources of propagules. It would probably require one to three hundred years for the oaks to dominate if forest restoration were left entirely to nature.

Reforestation procedures as recommended by Torbert et al. (1986 a,b) in Virginia involve hydroseeding acid-tolerant, low-statured grasses and legumes such as perennial ryegrass (Lolium perenne), redtop (Agrostis gigantea), birdsfoot trefoil (Lotus corniculatus), and "appalow" sericea lespedeza (Lespedeza cuneata var. appalow) with moderate to low rates of nitrogen fertilizer in order to provide adequate cover for erosion control, while minimizing the height of the ground cover. Low rates of nitrogen-fixing autumn olive (Elaeagnus umbellata), bristly (Robinia fertilis) and black locust, and European black alder (Alnus glutinosa) are hydroseeded with the ground cover as site-building nurse trees. Finally eastern white pine seedlings are planted as commercially-valuable crop trees.

This reforestation strategy is designed to shorten and "stack" the first three stages of natural succession described earlier. Instead of a slow process of species replacement over time, species representing each of the first three successional stages are sown and planted at once. All are acclimated to biologically depauperate soils, and all are relatively compatible with one another if sown at controlled rates. The grasses, serving as the pioneer vegetation, quickly yield to the legumes when applied nitrogen is minimized. The slow-starting ground-sprawling legumes allow the nitrogen-fixing nurse trees and the planted pines to become established and free to grow before totally covering the site. The legumes enrich the site and eventually give way to the tree cover. Because the nurse shrubs and trees are woody stems prone to pests, the white pines ultimately dominate the site and should become of harvestable age after 40 years on productive sites. During this time other species will invade and be poised for growth and development since the pines could be removed for their economic value. If the pines are harvested, a landowner may allow the site to

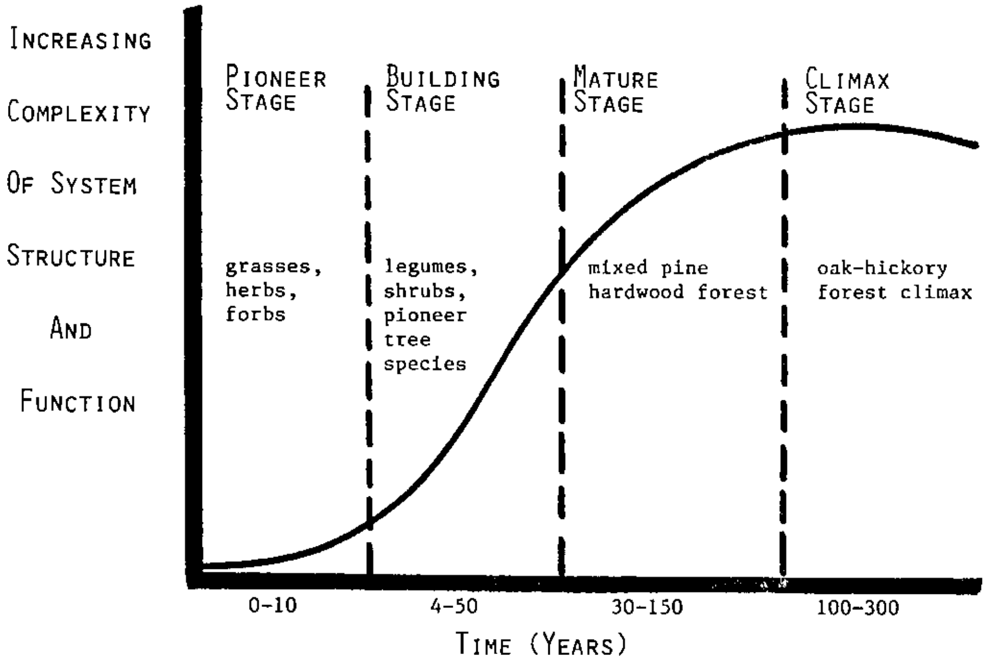

Figure 1. Primary succession on mined land in the Appalachian Region showing likely successional stages if land were not seeded or planted.

regenerate naturally or re-establish another even-aged pine plantation.

A major constraint of timely reforestation using this silvicultural scenario to "compress" natural succession is the option of converting forests to post-mining grasslands. Conversion of forest land to grassland is allowable under Sec. 816.133 of the OSMRE Permanent Program Regulations as "higher or better uses." During the decade of the eighties about 40 percent of the previously-forested mined land in Virginia was converted to grassland. In eastern Kentucky and southern West Virginia the amount was greater than 70 percent. Creation of as much grassland that could reasonably be used for livestock pro-duction in the region is good because it would help diversify the mining-based economy. But grassland established on steep, remote areas with no chance of being used for the intended purpose does not constitute a "higher or better use" than returning the site to its original land use --forestry.

The reality of post-mining land-use patterns in the Appalachian coal fields is that after all possible alternative uses are realized (including forage for livestock production), it is likely that nine out of ten surface-mined acres will return to forest land. This reforestation will occur either by design or by default. Designed reforestation will occur as a result of post-mining procedures that include tree planting such as that described above. Reforestation by default will occur as abandoned grassland is slowly invaded by forest tree species over time.

Compared to designed reforestation, default reforestation can set back the economic potential of the reclaimed land by 50 to 100 years. Grasses and legumes such as Ky-31 tall fescue (<u>Festuca arundinacea</u>, selection Ky-31) and sericea lespedeza are very persistent and yield very slowly to the successional chronology described above. In Virginia, land mined 15 to 25 years ago and revegetated under the auspices of state laws established in 1963 are still dominated by the fescue, lespedeza and black locust community that was established during reclamation. Even the most opportunistic non-leguminous hardwood pio-neers such as red maple, sourwood and black cherry have difficulty emerging. Abandoned grassland remains in the building stage of succession for a longer period of time than if lesser-competitive or native pioneer plants were planted.

<u>Restoring Forest Site Quality</u>

The productive capability of an Appalachian hardwood forest is hard to measure because it is difficult to define. Theoretically, its value should be defined on the basis of the quality and quantity of water, wildlife habitat, recreation, and wood production. In reality the current post-mining productivity standard for forest land is not defined or measured in terms of any of these forest values; rather it is defined on the basis of the number of surviving woody stems per acre having a certain minimum height after a given period of time.

Unfortunately there is no basis for assuming that a certain number of five-year-old woody stems can be extrapolated to a representation of equal of better post-mining forest-land capability. A reclaimed corn field in the Eastern Interior Coal Region that contains the optimum number of stems at maturity (survival) but produces little or no grain (production) would not meet productivity standards. Reclaimed forest land in the Appalachian coal region that produces tree stems but no useable wood should also not meet productivity standards! It is unreasonable to assume that a stem count is all that is needed for a biologically and economically viable forest. Instead, a forest with a certain species composition growing on a restored mine soil that has the physical, chemical and biological properties "to put wood on those stems" is required.

Forest productivity is more than just wood production; however, when a proper composition of tree species is healthy and growing vigorously it usually results in a forest with higher levels of the other associated values. Therefore, since tree growth is relatively easier to measure, it might serve as an indicator of overall forest productivity. Studies of mine soil productivity in Virginia using white pine as an indicator species show the extent to which productivity varies (Torbert et al. 1988). In fact, the entire productivity spectrum is represented by sites on which trees are unable to survive, to sites on which trees are growing at rates faster than the average for undisturbed natural soils.

Because a forest crop is slow-growing, long-lived, and physically large when compared to an agricultural crop, it is difficult to see, measure and appreciate the different levels of production. In forestry, site quality or productivity is usually measured with an index defined as the average height of the canopy trees at a certain age. The data in Table 1, for example, compare the projected heights of white pines on three sites having different productive potentials due to different mine soil depths (Torbert et al. 1988). Projections are for 50 year old trees; however, since they are growing on sites of different quality due to different mine soil properties, their heights at age 50 are 60, 80, and 100 feet. This means that the sites on which they are growing have site indices (SI) of 60, 80, and 100, respectively. These SI's correspond to fair, good, and excellent for white pine in this region, since a SI of 80 is average for undisturbed soils (Beck 1971).

A mine soil able to produce a white pine stand 100 ft tall at age 50 versus a mine soil able to produce a 60 ft tall stand at age 50 may not impress one as being all that different until stand height is expressed in terms of relative wood volume and the value of that volume. Based on established stand volume tables, a mine soil having a SI=60 would produce 5.0 million board feet (MBF) of wood at a harvestable age of 35, compared to 32.1 MBF of wood on a minesoil of SI=100. Although tree height on the SI=60 site is 60 percent that of tree height on the SI=100 site, the volume is over six times greater on the better site. Because larger trees have more valuable uses, sawtimber versus mine props for example, the disparity between the fair (SI=60) and excellent (SI=100) mine soil is even greater. The product value of the wood from the excellent site is ten times greater ($3,214) than that of the poor site ($308)! If only the stem count was used in this hypothetical case, a SI=60 mine soil would have been judged as productive as the SI=100 mine soil. This is clearly not the case. Final product value of the harvested wood is the reclamation productivity standard that should be used to judge reforestation success. This is analogous to using the value of bushels of corn, or soybeans, or tons of hay harvested from reclaimed agricultural land. Productivity standards for forest land must be based on attributes of mine soils that result in productive forest sites. In Virginia, preliminary studies show that soil strength (exploitable mine soil volume) and chemical toxicities (total salts) (Torbert et al. 1988), and nutritional imbalances caused by pH extremes (Torbert et al. 1989; Moss et al. 1989) most limit the growth and development of forest trees.

Required reclamation practices in the Appalachian region appear to be detrimental to tree establishment and long term growth. Hauling, grading, and "tracking-in" compact mine soils, severely impeding normal root growth and nutrient and moisture uptake. Topsoil substitutes with a near-neutral pH are often selected for the surface to avoid liming and to ensure vigorous growth of ground cover that is also heavily fertilized. Trees, especially coniferous species, do best at a pH between 4 and 6 and require little to no fertilization. Vigorous growth of ground cover during the first two years suppresses tree establishment and often results in poor survival or complete failure. This problem is further addressed by Torbert and Burger (1990) in another paper in this proceedings.

Summary

Developing economically-viable post-mining forests requires little or no additional effort or expense beyond that required for initial site stabilization. If site requirements and reclamation procedures are specifically geared for this land use, highly productive forest land can be created in a timely manner. If post-mining land uses are permitted based on their probable ultimate use, a higher proportion of the mined acres will be reforested at the outset.

High quality sites and timely reforestation are simple concepts; if these concepts were pursued to their fullest potential, the economic value of mined land and restored forests could be considerably improved. As the regional economy ultimately makes the transition from its coal base, communities will again turn toward the forest as a valuable, renewable resource in which to live, recreate, and derive income.

Table 1. Comparison of mine soil quality and forest production and value.

Mine Soil Depth[1]	Site Index	Volume[2]	Wood Products	Total Value
(inches)	(age 50)	(MBF)		($/acre)
11	60	5.0	mine props/pulp	308
24	80	14.2	small sawtimber	920
43	100	32.1	large sawtimber	3,214

1/Torbert et al., 1988.

2/Million board feet (MBF)

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