A REPORT TO THE LEWIS FOUNDATION

A NEW SHARED ECONOMY FOR APPALACHIA:

An Economy Built Upon Environmental Restoration, Carbon Sequestration, Renewable Energy and Ecological Design

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IN A COUNTRY ONCE FORESTED

The young woodland remembers
the old, a dreamer dreaming

of an old holy book,
an old set of instructions,

and the soil under the grass
is dreaming of a young forest,

and under the pavement the soil
is dreaming of the grass

By Wendell Berry
Given Poems,
2005

Table of Contents Page Number

A Tale of the Future

Imagine for a moment a time in the future. You are flying at a low altitude over an Appalachian Valley silently in an electrically powered ultra-light plane whose energy and propulsion is derived from solar cells that are incorporated into the fabric of the wings. Everything below you is green, but in the greenness there is both pattern and variety. In recent years the pattern and variety have been created anew as the result of humanly orchestrated biological restoration on the ground. The last time you saw this land was several decades ago when it was scarred and laid barren by the mountain top removal and valley fill surface methods of mining coal. Then it looked like a moonscape, devoid of both life and of people. Today it is different. You notice that the landscape patterns below are the product of the vegetation. There are both block and contour patterns. Some of the blocks and contours are comprised of trees. In some the trees all look the same and in others the tree types are diverse with different shapes. Trees, orchards and nut groves dominate on the slopes. Deeper into the valley other blocks are fields of waving grasses, grains, and pastures that reflect in their colors the diversity of the farms below. In some of the pastures there are livestock. Cattle, bison and goats graze in well-fenced paddocks. Fat active pigs are seen scurrying in and out of oak groves in their search for abundant foods.

The other big change is the number of people in the landscape, lots of them. Where once a few houses stood, but were eventually washed away by floods caused by rain, bare slopes, and the collapse of a coal slurry dam. They have been replaced by a thriving town, much larger than was typical when you were last there in the 20th century. A closer look shows other changes. The shear diversity of activities in the town is startling. There are libraries, a hospital, churches, galleries, shops, civic centers and, the pride of the town, new schools in the heart of the village. Integrated into its fabric are clusters of buildings in which manufacturing of various goods and a variety of services take place.

They supply not only the area, but in some cases, their products are sold throughout the world. Because the factories don't pollute the atmosphere or the water they have been situated where people live. In the heart of the town is a park defined by a stream that runs through it. The park honors the stream and the surrounding landscape that helps keep the waters pure. In its center there is a memorial to honor the people who had the courage and vision to transform the region into an ecological and economic jewel. The list of people is long.

As you bank the plane to have another look you see that the town is connected up and down the valley with three parallel ribbons of transportation for cars, light rail trains and walking and bicycling paths. The plane climbs to look for the airport. On the way it passes over a cluster of slowly turning windmills on a hill top ridge and then descends into the valley. You have come to visit the people who made your plane and observe first hand the efforts of their research and development. They have developed ultra high strength composite materials from local woods grown by forest farmers who are making the area famous for high quality trees. They are already using the new composite materials in the latest carbon neutral tractors and pickup trucks. It's a very busy place actively developing a plethora of new ideas. You discover that the firm, as are many of the other companies in town, is owned by the people who work in them. You also learn that the town, as well as the county in which is it situated, have invested in most of the businesses. The town is an ownership community.

You walk down town to the inn by the river. There is a bridge next door where many of the children are casting for trout. Within the town limits only children are allowed to fish in the streams. The meal that evening, including the wines and the cooking oils, all came from the valley. The town is now famous for its wild caught and locally grown and processed foods.

At dawn you are ready to depart. Like a soaring hawk you lift off with the sun and fly toward the west. The region has been transformed and you have seen the future.

A Theoretical Foundation for an Alternative Future:

The Promise of Ecological Design

"A nation that destroys its soils destroys itself. Forests are the lungs of our land, purifying the air and giving fresh strength to our people. "

Franklin D. Roosevelt

There are over one and one half million acres of strip-mined coal lands in Appalachia. Coal mining practices have removed mountaintops and filled valleys with the resulting overburden. Such mining practices have devastated landscapes, soils, watersheds, and communities. The primary rationale is that the nation needs coal for electricity. Fifty percent of the USA's electricity comes from burning coal. The result is increasing levels of carbon dioxide in the atmosphere that trigger climate change and threaten the ecological integrity of the planet.

Since 2002 coal prices have quintupled, rising from twenty-two dollars a ton to over one hundred and thirty dollars. Global consumption rose thirty-five per cent between 2000 and 2006. This increase in demand is putting even greater pressure on the coal lands of the world. The pressure to produce more is felt throughout Appalachia.

Over the last few years, however, analysts have begun to think that coal is not the bountiful, post petroleum energy resource that most of its proponents claim (D. Strahan, 2008). The industry has already produced most of the easily mined coal and, despite claims of huge reserves, obtaining that which remains is a significant challenge (G. Chapman, 2008). Some countries, the UK for example, have seen dramatic declines following their post WW II peaks. China, currently the world's largest producer, consumed more than it produced in 2007 and had to import coal to make up the difference. It has been estimated by Energy Watch in Europe that global output will peak as early as 2025, then fall into terminal decline (W. Zeitel, 2007).

We need to debate whether we want to build a future for Appalachia based on an economy that will destroy its natural resources and last for decades rather than centuries. Will continuing to remove mountain tops and fill valleys foreclose alternative options? Is there a genuine economic alternative to strip-mining coal? Might the best approach be to move directly to a renewable energy future, thereby protecting the natural resources still left? Why not explore the possibility of building permanent wealth for the region based on long-term opportunities that will extend well beyond the current century?

This paper explores such a future. The overarching design goal includes building a carbon neutral economic foundation, in which carbon is no longer the atmospheric pollutant known as CO2, but is sequestered in new soils and diverse biological pathways. It also includes the concept of an ownership society in which all the citizens of the region can share in the emerging wealth. The foundation for new wealth will include; broadly based education, remediation of mining toxins, restoration of coal lands, regeneration of natural resources including forestry and agricultural development, implementation of renewable energies for fuels and electricity, enterprise diversification and allied manufacturing, and, as a result of all these, the development of regionally specific infrastructures.

A profound economic change will further require a model of development that has yet to be fully implemented. Such a model needs to be based upon complex and dynamic systems derived from the workings of nature. At its core is a new theory of ecological design. It is a theory that integrates all the sub-elements of an economy and its attendant landscape into a new and coherent whole. It takes into account not only human enterprises, but also the changing nature of all of the ecological subsystems through time. This time-driving dimension is the equivalent of succession in ecology.

Steps Toward a New Theory of Design

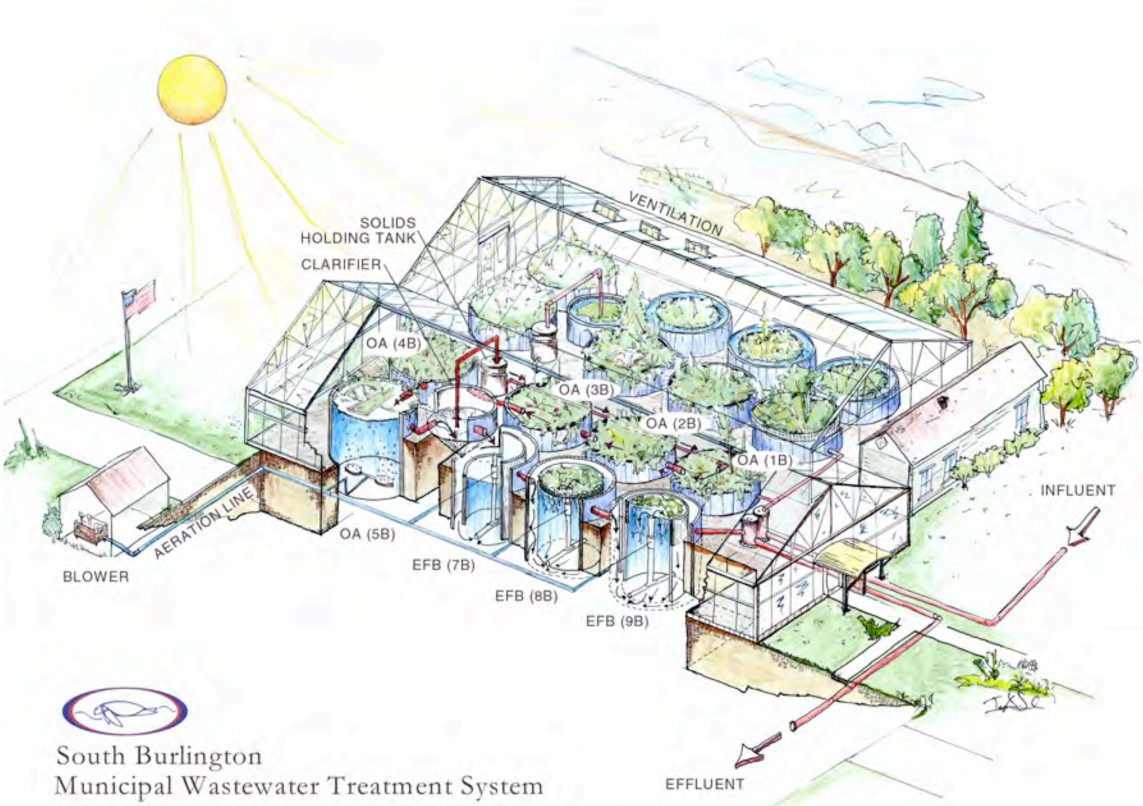
The theory is based upon several orders of ecological design. Each is characterized by a set of relationships that are, in and of themselves, intrinsic to the order. They are also natural building blocks that can be coordinated to provide the foundation for the next level or order of design.

First Order Ecological Design: Task Specific Natural Systems Technologies & Techniques

First Order Ecological Design draw on information and organisms derived from the natural world and directs them towards societal ends. Over the past several decades a number of practitioners have developed a series of ecological design principles based on the dynamics of natural systems. This has led to their inventing and implementing natural systems technologies like eco-machines, which are capable of generating fuels, growing foods, treating wastes, repairing damaged environments, breaking down or sequestering toxic compounds and regulating climate in buildings (J.Todd & B. Josephson, 1996). Over the last decade these new technologies have been employed in many settings around the world (www.toddecological.com).

Such technologies tap into the dynamics of the natural world to self-organize, self-design, self-repair and self-replicate. In designing these systems, the ecological practitioner directs unique elements within environments like that of the eco-machine toward a desired outcome. If, for example, sewage is to be treated, the ecological elements transform the waste into pure water as well as a host of potentially valuable biological products. Species from all five basic kingdoms of life need to be represented in the design. For optimal effectiveness it also needs to draw on at least three different ecosystems like marshes, ponds, streams, and a variety of soil and terrestrial environments.

Natural systems technologies and eco-machines are characterized by their relationships. All the elements are related in terms of energy, nutrient flows, life forms, biological needs and historical associations. This also characterizes task specific technologies developed through First Order Ecological Design. The species, and process flows are derived from the natural world and operate within an ecological framework shared by a variety of environments and ecosystems. Despite their uniqueness they are nonetheless natural systems.



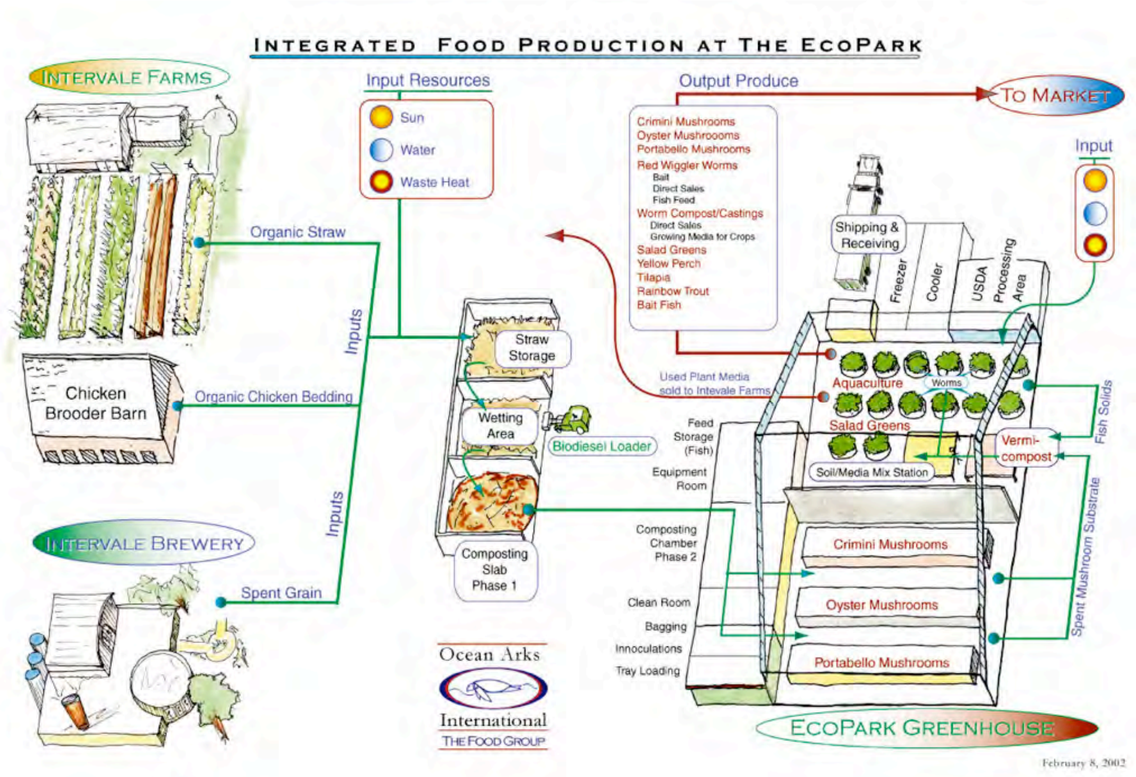
An Eco-Machine for Sewage Treatment

First Order technologies encompass a broader pallet of designs than the eco-machines described above. Utilizing techniques derived from worldwide experience and research, they can create fertile, carbon-sequestering soils, which are recombined using whole systems design. First Order technologies also include ecological design of biomass and forest ecosystems, agro-forests, and farms that integrate traditional and ecological knowledge. Soil building and carbon sequestering are absolute priorities. A region will not achieve sustainability without a central soil- building component.

Natural systems technologies have enormous economic potential. Their diverse capabilities lend themselves to a variety of applications in the food, energy, natural resource, waste treatment, and environmental management sectors. In Appalachia they could provide a major catalyst for economic transformation.

Second Order Ecological Design: New Symbiotic Systems

Second Order Ecological Design is based on relationships not found in nature. They are created by connecting normally unrelated processes. A pollutant or industrial byproduct, for example, may be combined with an energy source like waste heat. Through ecological engineering this order of design can produce valuable new products. Ecological industrial parks represent new symbiotic systems created from normally unrelated activities. Several Agro-Eco-Parks that are currently emerging are among the most highly developed of ecological industrial parks. One early model formulated the design rationale for such systems. It involved using wastes from a brewery to build ecological food webs. These webs, powered by waste heat and solar energy, converted the waste into some dozen valuable agricultural products (J.Todd et al, 2003). It became a model for an agro-eco-park for Vermont as well as for the development of four new corporations based upon Second Order design principles.



Agricultural Eco-Park Schematic

Such models have potential for Appalachia. Agro-Eco-Parks do not derive their economic strength from economies of scale. They derive their vitality from sharing information, resources, technologies, and financial mechanisms among the different economic elements. In this way many of the costs can be borne by all the entities and capital cost per unit of production can be kept modest. It is possible to envision urban and rural systems combining food production, waste management, renewable energy generation, and light manufacturing with businesses like bakeries, breweries, restaurants and farmers' markets. The greatest limitations to the creation of symbiotic economic systems remain the blinders created by traditional single sector thinking and the limits of our imaginations.

<u>Third Order Ecological Design: New Economies Based Upon Bioregional, Carbon Neutral and Renewable Energy Frameworks</u>

If we are to achieve the transition from the present to a future rich in information while constrained in terms of materials and nonrenewable energies, designing for carbon neutrality is one of our greatest challenges. Information, especially knowledge from the natural sciences, will be a substitute for capital and fossil fuel.

Succession or the time-framed emergence of different systems, are intrinsic to Third Order Design. These are supported by different institutions at each stage in their economic and ecological evolution. Succession is almost universal in the natural world, as exemplified by a bare plowed field, which transforms itself through a series of ecological stages over time, into a mature prairie or mature forest.

Third Order Ecological Design is a complex process, based on several stages of development. The first stage provides the foundation for the second, the second for the third, and so on. They are like building blocks. At least five basic stages are involved. Each has its own appropriate institutional, economic and educational support base.

The first stage begins with a barren landscape that is to be restored by introducing mineral and ecological elements to begin the healing processes. It involves both modern scientific soil building knowledge and traditional wisdom. These must be integrated into an Appalachian context. Former mine workers utilizing some of their earth-moving machinery could play a pivotal role.

The second stage involves treating toxic mining wastes like the trillions of gallons of coal slurry held in impoundments. The scale of such activity could trigger the development of a large remediation industry. Preliminary evidence indicates that ecological and hybrid chemical/ecological technologies could treat such toxic byproducts. It might be possible to make useful products from the byproducts of remediation.

The third stage of establishing a natural resource base would include forestry, biomass forestry, agro-forestry, and ecological agriculture. The sequestration of carbon into timber and soils will be a measure of the success of the project. Annual measure of organic carbon content in the soils will be an indicator. Most North American landscapes are losing organic carbon from their soils. If global climate change is to be checked, this must be reversed.

The fourth stage includes developing a renewable energy infrastructure and manufacturing and processing based on regional natural resources. The list of potential industries includes bio-fuels, plastics, polymers, adhesives, building and composite materials, as well as a host of renewable energy technologies. The wind, solar and biomass potentials of the region are huge.

The fifth or capstone stage will be built on emerging economic diversification. It involves the transfer of the ownership of the land and natural resources to the people who live there, especially to those who have had a hand in its ecological transformation. This phase would require a financial institution, perhaps in the form of a regional land holding organization or cooperative. It would provide land owning mortgages or their equivalents to the new community of natural resource managers like soil builders, foresters, farmers, biomass growers and others. Once the land is capable of supporting a community, a 21st Century equivalent of a homestead act, with appropriate institutions to fund, it should be enacted. In the broadest sense of the term then, the land will be re-inhabited.

Institutional Succession on the Changing Landscape

Each stage of the development of former coal mining lands will need to be supported by appropriate institutions. The earliest stages, like soil building and reestablishing the biota of the region, would best be handled by not-for-profit organization(s). Start up capital would be in the form of grants. Society will have to pay for the renewal of a landscape that has been devastated to satisfy its demand for energy. Private philanthropy also has an important role to play. State and the federal government will have to underwrite the plan. The Federal Conservation Programs have set a precedent. The carbon neutral objective of the project would qualify it for support from emerging global carbon markets.

The early stages will not necessarily be profitable. It should be the goal of the regional land holding trust(s) to support the healing processes and provide the educational framework to educate the population in all aspects of environmental restoration and land use for carbon sequestering. Regional schools, colleges and universities of the region will play a vital role. The ideal would be a culture of people who see themselves as stewards of the land and understand that true wealth is an outgrowth of a well-tended landscape.

The not-for-profit early institutions will continue to have a key role during later stages. Their skills and perspectives for starting new economies can be transferred to other areas. Once soil building and natural resources are established in an area by land holding not-for-profit(s), they can move on. In this way the start up phases are constantly expanding to initiate new healing processes.

The institutional succession process has a logical set of stages. As the natural resource systems begin to mature, many new entrepreneurial corporations will emerge to take advantage of new resources. Processing and manufacturing companies will predominate. Some of the waste remediation efforts will spin out of early experimental settings into new companies, resulting in strong regional industries with highly developed remediation skills.

Land ownership would be held in trust by an entity that transcends private ownership. The early stages will require public support and public ownership. Following the re-establishment of a working landscape and the emergence of the entrepreneurial companies, an institution with financial lending strength becomes key. The goal would be to have those who work on the land and have developed stewardship skills own it. The trust would shift emphasis from a land holding institution to that of a financial organization and provide mortgages for the area. The trust would then divest itself of its lands.

The community would be made up primarily of landowners who work with natural resources on their own land. Before the soil building stage, the land would have had little value. By the time it can support a natural resource economy it will have real worth and there will be the skilled people to tend it. They should have access to mortgages, which would be at the heart of community building. The trust, having become a financial institution, could use the revenue to expand the new economy by acquiring new lands to repeat the process.

The final stage of institutional evolution on the land will involve independent people working together in cooperatives. Cooperatives have a long tradition providing communities with access to services, information and technical support that might not be available to individual farmers, foresters or biofuel growers. Cooperatives are owned by their members and have been successfully used to support natural resource development in the agricultural and energy sectors. They have access to initial support through a number of USDA programs as well as the Rural Electric Development Program. Successful cooperatives can both build community and stabilize a natural resource economy. In a maturing economy they provide institutional structure that supports both individual initiative and the collective needs of the community.

Ecological design as a field is scarcely three decades old. One of its founders was the visionary ecologist H.T. Odum. In his classic book *Environment, Power and Society* he envisioned a society closely integrated closely with the natural world; one which had shifted from an exploitive culture to one that tapped into nature's wisdom to redesign itself along ecological principles. Dr. Odum believed that only such a culture could persist and enrich itself over time. My hope is that the ideas presented here will help transform Appalachia and other parts of the country and the world into beautiful economic landscapes we will be proud to bequeath our grandchildren.

Creating World Class Soils on Abandoned Surface Mined Lands

This paper, and the ideas contained in it, is predicated on the view that the soil defines society and that creating deep rich soils is at the heart of any effort to build a durable and equitable economy. As a consequence, the paper begins with examining the influence of soils on the fate of societies and explores ways to create fertile soils upon the abandoned rubble of old mine sites.

In his recent book “Dirt: The Erosion of Civilizations” David Montgomery writes of how culture and civilizations have become impoverished or simply vanished due to the abuse and erosion of their topsoil (Montgomery, 2007). He offers evidence that the collapse of the Soviet Union in the 20th Century was caused in part by neglect of the soil. The Soviets had developed a plan to convert their grassy steppes into factory farms and began plowing the virgin grasslands. By the 1960s hundred of millions of acres had been brought into production. Frequent dust storms prevailed and their agricultural methods lost more than three million acres a year. The dry spell of the sixties caused a major Soviet dust bowl, and while little publicized, helped drive Khrushchev from power.

Modern agriculture, and to a lesser extent forestry, have substituted petroleum-based chemicals for ecologically-based fertility and soil building. Agriculture now consumes 30% of the world's oil. In an increasingly petroleum scarce future contemporary farming will be increasingly at risk and, in many parts of the world, the practice most likely will decline dramatically. To counter this Dr. Montgomery makes a compelling argument for a strategy of soil creation on a large scale. Not only would it ease our transition to a post petroleum era, through reduced plowing alone such a program has the potential to soak up a quarter of the world's industrial carbon dioxide emissions. By linking carbon sequestering techniques into soil building, the author of this report on Appalachian coal lands believes there is a much greater potential for reduction in atmospheric carbon. Cornell University scientists have calculated that new methods of soil creation could reduce carbon emissions produced by human activity by another 12% (Liang, et al, 2006).

At this crucial juncture of climate change and resource depletion, we are seeing new and revolutionary information on the twin goals of soil creation and carbon sequestration. In recent years a large number of discoveries from diverse scientific disciplines in many countries have created an enormously important body of knowledge that has the potential to have a powerful effect on the future of Appalachia. For perhaps the first time in history, we now have a knowledge base to transform even the most barren landscapes to areas of deep rich soils and, as a consequence, to create the foundation for new wealth based upon the inherent productivity in nature.

For terrestrial environments, soils are the mother of life. Soil formation is an extraordinarily complex geochemical, biological, ecological, and diverse process (Brady, 1990). It is now possible to create rich and fertile soils in relatively short periods of time; periods measured in years rather than decades or centuries. To achieve rapid soil formation requires a number of strategies which, when applied in concert, can produce excellent soils that, in turn, can underpin environmental restoration as well as support intensive agriculture, animal husbandry and agro-forestry.

These strategies include:

1; the remineralization of the landscape through the application of finely crushed rock powders that are rich in diverse minerals.

2; large scale composting techniques that incorporate into the process newly discovered nutrient binding methods.

3; the application of sprays comprised of dense cultures of soil microorganisms onto soils and crops.

4; the incorporation of ancient newly discovered Amazonian peoples' *Terra Preta,* or dark earth creation techniques, into the soil building.

Each of these for techniques has an important role to play in rapidly reclaiming former strip-mined lands. When combined and on a large scale, they have the potential to transform landscapes ecologically.

Mineralization

For years scientists and farmers have been using the rock fines, or rock powders, which are the spoils left over from rock quarrying, and applying them to the land to protect forests from the effects of acid rain, to enhance plant production and to improve soils. This effort, which has been global in scope, is beginning to create a significant body of knowledge that can be applied widely in the rehabilitation and management of ecological landscapes.

Typically soils that have been farmed for any period of time when exposed to the elements after plowing and harvest, lose organic matter and become leached of minerals, including trace minerals. The absence of carbon and available minerals limits soil fertility and productivity. However, soils can be remineralized with volcanic and/or glacial rock powders that have been ground to a size small enough to pass through size two-hundred-mesh screens. The benefits of re-mineralization have been found to be widespread, potent, and highly suited to many different environmental types.

The benefits that have been found include:

- Slow release of nutrients and trace minerals.
- Increased nutrient uptake by plants.
- Increased yields, in many cases, dramatic.
- Rebalanced soil pH.
- Increased growth of microorganisms and earthworms.
- Humus building
- Prevention of soil erosion.
- Increased storage capacity of the soil.
- Increased resistance to insects, disease and drought
- More Nutritious Crops
- Decreased need for fertilizers, pesticides and herbicides

* Effectiveness in regions with heavy rainfalls.

- More rapid growth of trees

Farming has been a beneficiary of remineralization. Dramatic results in terms of reduced input costs and high yields have been reported for a wide variety of crops ranging from bananas in Australia to rice in Malaysia. As for disease prevention, remineralization has proven effective in controlling citrus blight disease in Florida.

In the USA, the largest carrot farmer in the world, Grimmway Farms of northern California, is gradually remineralizing its total acreage of Cal-organic produce. It is applying one thousand tons of rock minerals a year at a rate of two hundred and fifty pounds per acre (http://www.calorganicfarms.org).

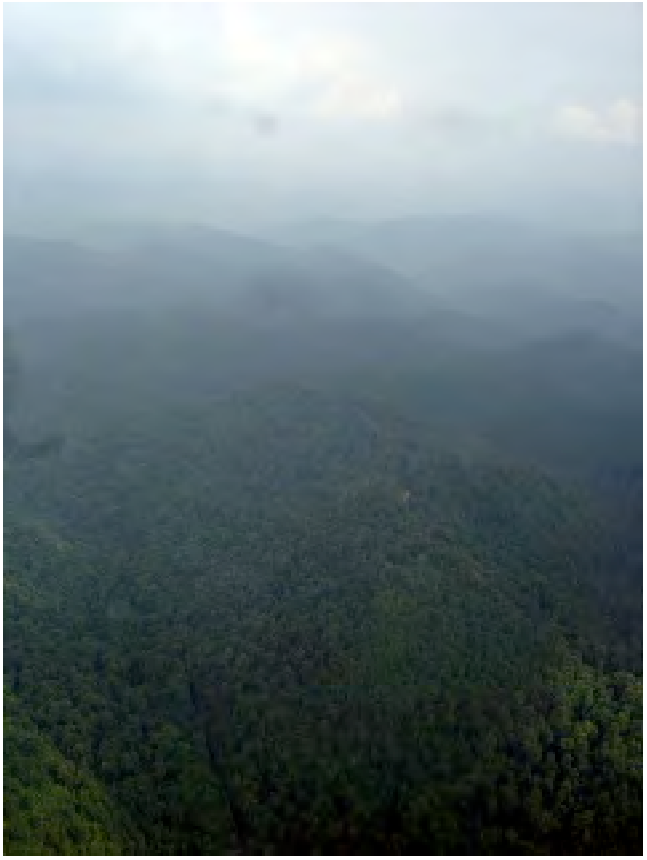
One of the most remarkable stories of the effects of remineralization on large acreages, and of the people who live there, comes out of Africa. Prof. Peter van Straaten from the University of Guelph in Ontario, Canada has described the remarkable effects of combining rock minerals with green manures from the fertilizer plant *Tithonia diversifolia* to restore the productivity of exhausted lands in Zimbabwe and Kenya. He reported that in western Kenya nine hundred thousand people were brought out of poverty using these methods (van Straaten, 2004).

Forestry has seen equally remarkable results, albeit over longer time periods. One remineralization study, carried out over twenty-four years, has shown a four-fold increase in yields of timber. In western Australia, Men of the Trees, an organization that plants millions of trees in arid landscapes, has achieved up to five times higher growth in seedlings and shortened the potting time from five months to six weeks by combining soil remineralization with microbial inoculations (http://www.remineralize.org/trees.php). The faster tree growth rate at the same time increases the uptake of atmospheric gases, including carbon dioxide. This is hopeful news in terms of carbon sequestration and climate stabilization (Von Sauter & Foerst, 2006).

Application rates for rock powders vary considerably depending on the type of rock dust, fineness, and the setting, be it a garden, a commercial farm, or a forest. Particularly for forest or plantation plantings, rock powders have been applied without other forms of fertilization, at rates from three to ten tons per acre. On badly degraded soils, as much as twenty tons per acre have been used successfully as a long lasting application.

Remineralization can also be seen as a key part of an integrated soil development strategy. In integrated programs lower application rates tend to be the norm. This is particularly true amongst farmers who are used to applying fertilizers on a yearly basis. In agriculture annual application rates of rock minerals vary from two hundred and fifty pounds to three tons per acre. The lower application rates apply when rock minerals are blended into compost during the composting process (http://www.remineralize.org).

Generally the best sources for rock minerals are local quarries, although some rock minerals are considered more potent than others. A diversity of hard silicate rock types, including those of volcanic origin, is usually better for building soils. Rock phosphates of oceanic origins offer trace mineral diversity and balance. In Appalachia the best results would most likely be derived from the blending of local bedrock, especially brown oxidized sandstones.



Composting

Composting, or the practice of recycling organic materials and wastes, once seen as a practice suitable only for those who garden as a hobby, can be at the heart of good agriculture at any scale. In the presence of oxygen, communities of microorganisms transform raw organic materials into rich matter that develops into humus. Humus is the Latin word for living soil. Compost can be made in static piles outdoors, in specially designed structures, or, most commonly, in windrows. As an oxygen rich internal environment is harder to maintain, static piles can take up to three years to compost. In mechanical systems composting is technologically complex and failure prone. Windrow systems are the best for large-scale compost. The size, although not the length, of windrows is important. The windrows are turned to aerate the piles. To avoid suffocation, compaction and scouring, windrow sizes are generally kept to approximately twelve feet in width and a maximum height of six feet. With modern windrow turning equipment, compost makers often turn the piles as many as ten to fifteen times over a six to eight week period. Recent research by the Rodale Institute suggests that nutrient retention, especially nitrogen, is best accomplished with only three turnings (http://www.newform.org). The energy equation and the economics of turning of the piles frequently, achieving composting in a shorter period, versus favoring more static piles and longer "cooking" periods, need to be analyzed on a project-by-project basis. In either case, temperature and moisture controls are critical.

Temperatures in the pile should be allowed to climb to a peak of 150 degrees F (66 C) in order to eliminate weeds and destroy phytotoxins and pathogens. Some compost producers use a water repellent cover over their windrows to regulate moisture. Moisture content in the windrow should hover around fifty to sixty per cent. Windrow turning machines have been developed that have water injection systems which can be turned on if moisture levels fall too low (http://www.globalrepair.ca).

The carbon-to-nitrogen ratio in the compost must be correct to foster optimal temperatures within the pile. Too much green matter and nitrogen leads to overheating and too much carbon can result in temperatures that are too cool. Experienced compost makers with an eye to rapid soil building, construct their windrows from a mixture of materials. They use materials like wood chips as a base onto which they pile manure and bedding, and above these green materials. They then add clay, gypsum, and pulverized rock powders including rock phosphates, which contain a broad spectrum of minerals. The necessity of adding natural clays to compost was deemed very important by early pioneers of composting like Ehrenfried Pfeiffer, a microbiologist and biodynamic agriculturalist in the 1940's and 1950's. Recent research at the Rodale Institute in Emmaus, PA has born this out (http://www.newfarm.org). Compost is applied at varying rates, but if the ingredients are of high quality, low levels of one to three tons per acre per year will suffice in most locations. A good reference source for information on compost, vermicompost (the use of earthworms in composting) and compost tea has is available in the book, *Vermicompost and Compost Tea* by Grace Gershuny, 2006.

Compost Teas

Compost teas are liquid sprays containing the large numbers of microorganisms found in compost. As an agricultural practice, utilizing compost teas as well as vermicompost teas is a relatively recent phenomenon. The large-scale application of these substances has been practiced only for the last few years. New technologies have made the application of high quality, low cost teas on lands and crops possible. Making compost teas is quite simple. Compost, often contained in cheesecloth-like bags, is suspended in buckets of water. The water is aerated with an air stone. Ratios vary, but a rule of thumb is about one pound of compost per gallon of water. Two distinct processes, extraction and brewing, are practiced.

Extraction raises the population numbers of beneficial fungi and bacteria in the liquid quickly and efficiently. The organisms are kept in an inactive state. Timing varies from six to twelve hours, depending on equipment and temperature. Extraction is generally considered useful for soil application when microbial populations become activated on coming into contact with carbon-containing materials in the soil.

Brewing is an additional process. Molasses, fish emulsion, seaweed extract, and in some cases, rock powders are added to the liquid. This causes the population of microorganisms to become active feeders almost immediately. This makes brewed compost tea a potent foliar feed. It is also effective in disease and pest control. The active microorganisms feed on pests and pathogens on the leaves and stems of the plants.
New technologies now permit the culturing of large volumes, of as much as ten thousand gallons of compost tea, every six hours. This makes the technology suitable for large-scale land and crop applications (http://www.erathearth.com). It has been reported that compost tea produced this way can be made for ten to fifteen cents per gallon. The potential to promote soil development, crop management and disease prevention has been proven. The uses and benefits of compost tea and vermicompost tea on the land are almost endless (http://www.soilfoodweb.com). This development puts a powerful new tool to the hands of land stewards to complement composting, re-mineralization and other ecological strategies.

***Terra Preta* or Amazonian Dark Earths**

In recent years fascinating scientific studies in the lower Amazon have led to the discovery of ancient soils that are both extremely fertile and stable. They occur in areas with high temperature and rainfall, where soils are notoriously prone to leaching and degrading (D. Mongomery, 2007). It has been found that *terra preta,* or black earth, are soils that were created by native peoples centuries before the arrival of Europeans. In some parts of the Amazon they pre-date the time of Christ. They have been described as islands of fertility in a sea of predominately nutrient-poor soils, covered an area larger than that of France, and were of human origin. *Terra preta* soils supported a large population in the lower Amazon, yet most of the people who knew how to make them died out after contact with Europeans. The knowledge was, to a large degree, lost.

The discovery of these soils and their significance has been chronicled in a technical book, *Amazonian Darks Earths: Origins, Properties and Management,* (J. Lehman et al. 2003) and in an excellent popular book entitled *1491(* C. C. Mann, 2005). A small international team of scientists has been trying to decode the composition of these soils investigating both their microbial ecology and their ability to survive and, in some places, to persist over the last five hundred years.

These dark soils have been found to have exceptionally high levels of organic matter, nutrients, and a complex humus structure. Associated with the high organic matter and nutrients is a unique microbial community with an ability to persist over time. It is known that the high levels of fertility were created through the addition of significant amounts of wood ash and charcoal, as well as domestic residues from intensive human occupation of an area. It is still somewhat of a mystery as to how this combination of factors could produce soils that, in some places, still grow in the present. Some charcoal retains its carbon in the soil for thousands of years and there are high levels of clay pot chards found in these soils. Clay may play an important, as yet under appreciated, role in *terra preta* formation. To complicate the story, it has also been found that crumbled ant and termite nests comprise a significant component of some *terra preta* soils.

What does seem clear, on reviewing the literature, is that knowledge of *terra preta* or dark earth formation is at least partially understood by some of the present inhabitants of the Amazonian basin. The Kayapo people in Central Amazonia use fire creatively and continue to make dark soils with techniques that may have wider global application. Additionally, contemporary scientists are closing in on many aspects of its formation and in Brazil have begun to experiment with methods to create modern dark earths. In early field trials with rice and sorghum, when they used bio-char or charcoal produced by the incomplete combustion of plants combined with fertilizer, they had yields as much as 880% higher than crops grown with fertilizers alone. These remarkable results occurred despite the fact that they did not attempt to establish the microbial communities used by the pre-European peoples.

There is news in this research for the rest of the world. Some, if not yet all of the inputs that went into the formation of *terra preta* are becoming known. Where there is sufficient biomass, moisture, and rain, *terra preta* formation can be duplicated in other tropical regions. It has been predicted that analogous techniques will work in temperate regions as well.

During the dry and windy weather of the winter of 2007 in Costa Rica, El Centro Verde, an ecological agriculture organization in Guanacaste Province, experimented with combining *terra preta* formation with composting. Trenches were dug to a depth of about a meter and a half along the contour lines on the slopes of the hills. Tree limbs and branches were placed in the bottom of the trenches and set on fire. Once combustion was initiated, green organic matter and soil were added on top of the burning limbs to slow combustion and lower oxygen levels. This resulted in charcoal, or bio-char, formation. As the pile cooled green matter, mainly banana stocks, was added, along with soil and clay to inoculate the compost. The hillside contours planted with vetiver grass on the downward side to reduce erosion. This will not only control runoff and capture moisture; it will also function as an effective sinks for nutrients (J. Todd, 2007) and will prevent the downhill leaching of nutrients away from the farm. This approach may have merit for Appalachia. Such methods can be scaled up. The combination of nutrient retention and erosion prevention should prove effective for the steep slopes of former coal lands.

Carbon Sequestration as Part of Land Restoration

In a recent news release by Cornell University, Dr. Lehmann is quoted as saying:
“ The knowledge that we gain from studying the Amazon’s dark earths not only teaches us how to restore degraded soils, triple crop yields, and support a wide variety of crops in regions with agriculturally poor soils, but can also lead to technologies that sequester carbon in the soil and prevent critical changes in world climate”.

A major carbon sequestration project in Appalachia, where coal production contributes significantly to climate change, could represent a twofold benefit for the people of the region and for the world. The bio-char technologies discussed above have been shown to put most of the carbon absorbed by the plants and the forests back into the soil in a stable form. Such a land management system would remove carbon from the air and provide a storage mechanism in the form of the new soils being cultivated on formerly strip-mined lands (B.Liang et al, 2006). If the four approaches to soil building described here, remineralization, composting, compost teas, and a modern version of dark earth formation were combined, they could transform the soils and the lands of Appalachia. They could also set the stage for large-scale employment for people working to manage the rapidly developing natural resources and economy of the region.

Preparing the Ground For Ecological Reclamation

Prior to the SMCRA -- the Surface Mining Control and Reclamation Act of 1977 -- exhausted and abandoned coal lands were laid bare to severe erosion, sedimentation losses and large-scale mudslides. Following the passage of the act, to help alleviate these problems, the formerly mined landscapes have been excessively compacted with heavy grading machinery. In areas where the slopes are not steep, the denuded tops of former coal seams and the newly filled valleys are heavily compacted. This has resulted in attempts in land reclamation through the establishment of grasses, most of which are not native to the area. These are not landscapes that can support the native plants and wildlife of Appalachia. Trees can scarcely grow in the compacted fill, which restricts the growth of their roots. (J. Burger, 1999). Where the slopes are too steep for the heavier equipment, planted trees can become established in the looser material (Skousen and King, 2004).

If the goal of renewing the land includes establishing forests capable of supporting diverse plants and wildlife, as well as creating a foundation for a forest-based economy, another critical factor must be taken into account. This is the depth of the growing media in which the trees are planted. The media is can be comprised of the overburden of rock and dirt cleared from the land. Sometimes the media is siltstone, coal, and shale rubble, which are not particularly suitable for reforestation. However, the depth of the media remains critical. In one study with the depth of the media was only 12 inches, the land yielded only $123/acre after 30 years of tree growth. When the depth was 24 inches thick the land yielded $1,755/acre. When it was 48 inches thick the forest land yielded $3,480/acre of high quality trees (Burger & Zipper, 2002). The return on the investment was 28 times greater with the deeper soils because of the growth of vigorous roots systems. The economic prospects of the new forests could be further increased, perhaps by an order of magnitude, if the methods described earlier to enhance soil development were combined with plantings in media that is at least four feet deep.

The Appalachian Regional Reforestation Initiative (ARRI)

The Appalachian states are fortunate in the development of Appalachian Regional Reforestation Initiative (ARRI). ARRI is a cooperative effort involving foresters, forest researchers and ecologists at universities and colleges from nine states, along with state and federal mining regulators, and officials with the federal Office of Surface Mining. Included are non-government organizations (NGOs) and private affiliates. This initiative is a unique and effective "brain trust" based upon the concept that the future of Appalachia is predicated on the extent and health of its forests. Its primary goal is the reforestation of former mining lands.

ARRI's practices and programs are scientifically and ecologically based. They practice a three-pronged approach to promoting forest planting and management. The first is cultural in that they are interested in demonstrating the economic viability of tree planting and reforestation. They have been able to show, for example, taking into account all of the costs, that converting ex-coal lands to forests costs half as much as converting it to hay and pasture (Burger & Zipper, 2002). They have also demonstrated, that under proper planting and management practices, it is possible to obtain a return on investment of around 10% from the value of the trees alone (Probert, 2001) This return on investment does not include the accumulating value of such secondary activities as early removal of overcrowded trees for biomass production, cultivated medical herbs, or the harvesting of nut and fruit crops. Nor does it include the value of on-site milling of timber or the subsequent fabrication of primary products such as flooring materials.

ARRI's second thrust is technological and ecological. Research has, and is, being carried out on a variety of forest management practices. They include ecological succession, investigating the value of native and non-competitive ground covers to enhance young tree growth, and planting several classes of trees. Early succession trees are planted for soil stabilization and later succession varieties for commercial value. The scientific and technical advisory committee to ARRI publishes the *Forest Reclamation Advisory*. The first *Forest Reclamation Advisory (FRA)* described ARRI and its mission (Angel et al., 2005). The second *FRA* outlined a five-step program for the successful creation of forests on formerly surface mined lands (Burger et al., 2005). The latter document is an excellent example of clearly written, scientifically based, technical information of practical use to land owners and mining companies.

The third function of ARRI is regulatory, The goal, through education, is to show mining companies and mine land owners that, despite widespread skepticism, the regulations regarding reclamation need not impede high quality reforestation. Neither need they interfere with the release of bonds held under the terms defined by the Surface Mining and Control Regulation Act (SMCRA) following reforestation.

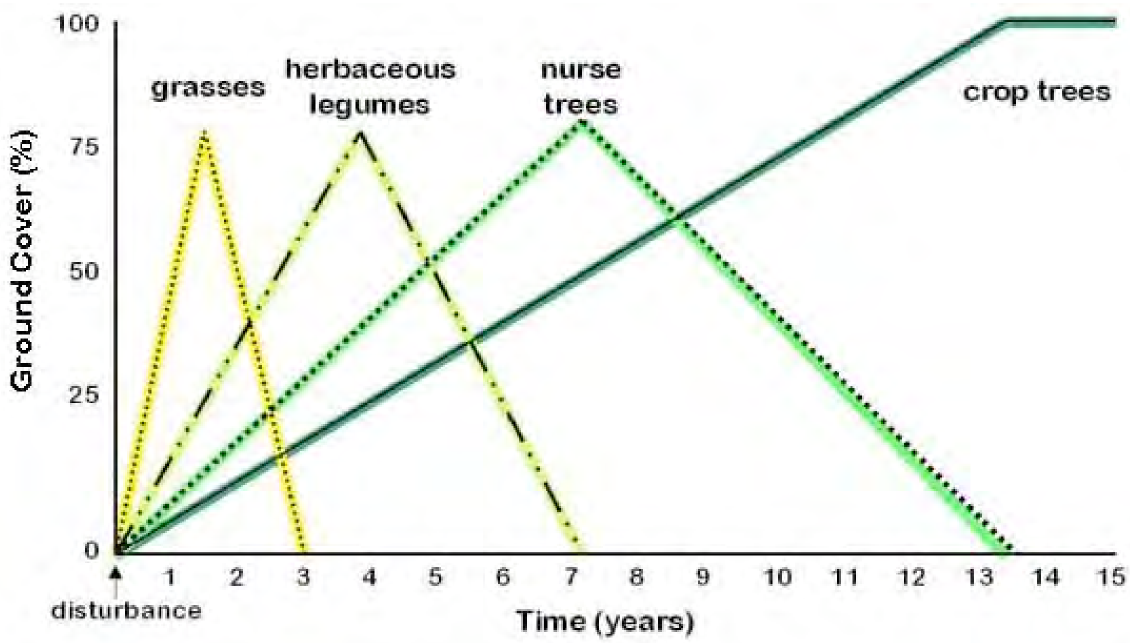
Ecological Succession & Biodiversity Enhancement

Ecological succession demonstrates the patterns of natural evolutionary processes. Ecosystems self organize and self design. Over time they recruit new species better adapted to the conditions that have emerged. There is a natural progression in nature that exists on a continuum. A bare exposed field that is colonized by windborne seeds will become a young meadow dominated by pioneer species of annual plants. Through the years it will evolve to a community shaped by shrubs and perennials that, in turn, are replaced by the trees of a young forest ecosystem. After decades, the young forest is transformed one that is mature forest and sustains an almost incomparable diversity of life forms. Nowhere else in the temperate regions of the world is this extraordinary diversity better developed than in the mature forests of Appalachia.

Ecological succession can be envisaged as a powerful force for reclaiming surface mined lands and for shaping new forestry, agro-forestry and agriculture in the region. For landscape designers, whether they are farmers, foresters or land restorers, the patterns of nature have meaning. By utilizing the patterns and the forces that shape ecological change it is possible to create a landscape that has an evolving economic dimension. Each stage has, in theory, the potential to support an economic crop. In the early years this could be a medical herb, such as Echinacea, or purple coneflower, *Echinacea purpurea,* that can be grown in full sun. As the canopy begins to close in, American Ginseng, *Panax quinquefolius,* might be the most adapted crop of value. As the new forest matures, a log-based culture of valuable mushrooms could be an economic crop highly adapted to a mature forest environment. Other analogs, paralleling the herbs and mushroom example, could be developed for fruit and nut crops as well.

Ideas from ecological succession are being promoted by ARRI and being applied to the reclamation of former mining land. Since 1980, Virginia Tech's Powell River Project has been researching reclamation practices. The work is based on an ecological approach to landscape management. As discussed, successful establishment of a new forest on mining lands requires an ecological succession of plant species (Burger & Zipper, 2002).

Figure 1: Forest Succession from Burger & Zipper, 2002

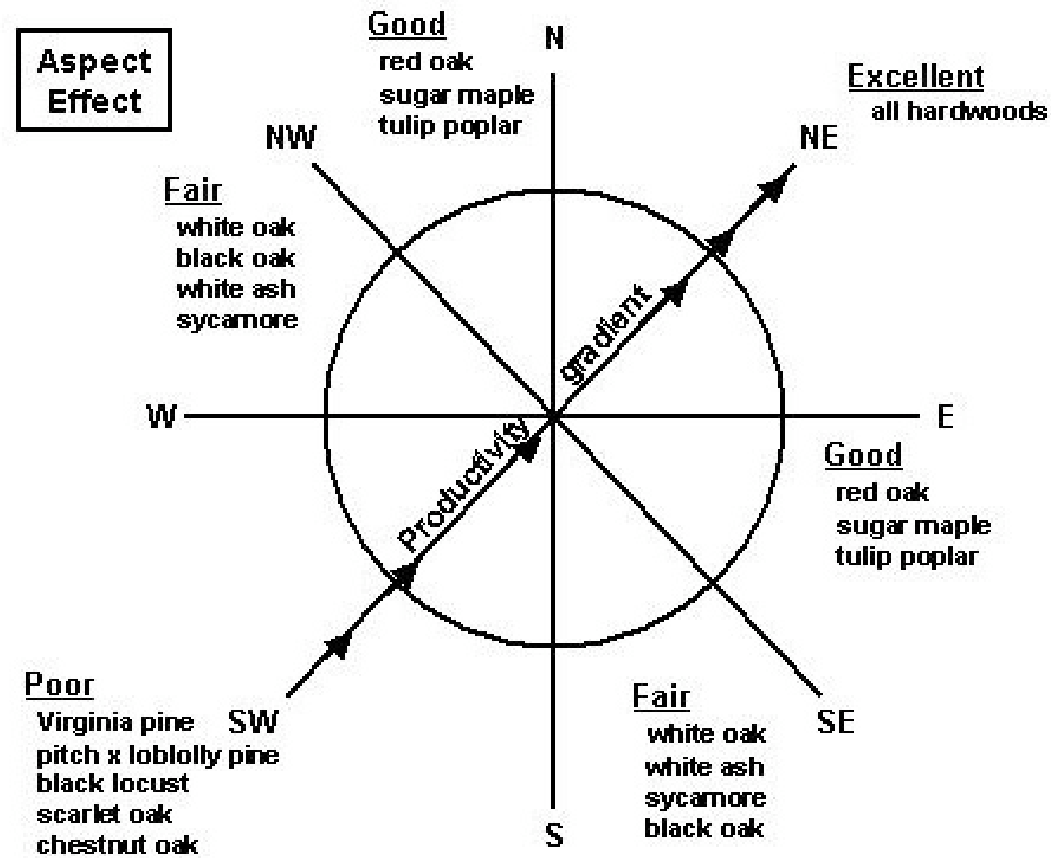


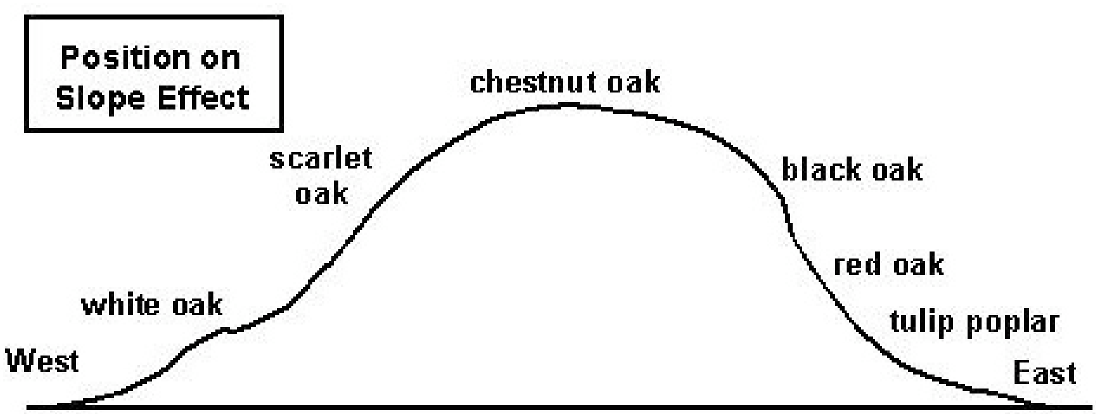
In the beginning four categories of plants are planted on the bare ground. The role and influence of the various groups changes over time. In the first year plants such as foxtail millet, *Setaria italica,* for example, and annual ryegrass, *Lolium multiflorum,* provide tree-compatible groundcover and help stabilize the soil against erosion and weathering. In the second year slow growing cool season grasses, such as redtop, *Agrostis gigantean* and perennial ryegrass, *Lolium multiflorum* will predominate. After several years their influence wanes and nitrogen fixing legumes come into their own. The annual legume, Kobe lespedeza, *Lespedeza striata var Kobe,* is a low aspect plant that supports but does not shade young trees. The perennial legume, birdsfoot trefoil, *Lotus corniculatus,* serves a similar function. The legumes can add up to 50 pounds/acre of nitrogen to the soil. As their suitability declines after six or seven years, they are shaded out by nurse trees, which are trees that help prepare the ground for later crops and young commercial trees.

Over the years the Powell River Project and other researchers have tested and, in some cases, rejected various nurse trees for reclamation. The most successful have been the European black alder, *Alnus glutinosa,* the bristly locust, *Robinia fertilis,* the redbud, *Cercis canadensis,* and the shrub, bicolor lespedeza, *Lespedeza bicolor*. These trees and shrubs improve the soils, support wildlife, and provide a suitable growing environment for the surrounding crops trees. After about fifteen years tree crops begin to dominate in the ecosystem. The nurse trees begin to die back and, in some cases, can be harvested. They may be utilized as a fuel source in bio-energy projects.

Suitable timber trees include but are not restricted to, the pines, *Pinus spp,* the oaks, *Quercus spp,* the ash, *Fraxinus spp,* and the maples, *Acer spp*. White pines do well in good soils. The pitch/loblolly pine hybrid is more tolerant of soil and site conditions. The red, white and black oaks, sugar maple, white ash, black cherry and tulip-poplar do well on good sites, whereas green ash, red maple, and sycamore are better adapted to poorly drained soils. The following illustration provides an example of the ecological succession pattern described here (Burger & Zipper, 2002).

Figure 2: Species –Soils-Aspects Relationships, from Burger & Zipper, 2002





Ideas derived from ecological succession are suitable not only in forestry, but are also highly applicable in agro-forestry, orchardry, and in sustainable, or regenerative, agriculture. They also have a role to play in integrating the landscape into an environment optimal for hunting, fishing and exploring the natural history of an area.

Agro-Forestry and the Working Landscape

Agro-forestry is the practice of combining agriculture with forestry and in many cases it introduces livestock such as cattle or sheep into the multi-dimensional landscape. It is a form of agriculture that combines tree crops, with pastures and hay, row crops and the selective grazing of livestock. It is actively supported by the United States Department of Agriculture as an alternative model to industrial scale, single crop farming. The USDA established the National Agroforestry Center in association with its Sustainable Agriculture Research and Education Program (SARE), and the Forest Service Research and Development Branch. State, private forestry and the USDA Natural Resources Conservation Service are also collaborators. They publish *Inside Agroforestry,* and *Agroforestry Notes* (www.unl.edu/nac). A textbook entitled *Agroforestry: An Integrated Science and Practice* has been written and published by the American Society of Agronomy (2000).

There are strong economic arguments for an agroforestry landscape. It diversifies income and helps protect landholders from fluctuating markets, international competition and unpredictable weather patterns. Agroforestry practices also conserve energy on the farm. Heating and cooling costs in buildings can be cut by up to 25 percent if they are protected by windbreaks comprised of valuable trees. Row crops planted in alleys between stands of crop trees improve the efficiency of water use efficiency, thereby reducing irrigation costs.

Agroforests have been shown to improve soil fertility and increase productivity, as well as improve product quality. The trees protect crops and livestock, as well as soils and water resources. In cold weather livestock protected by trees exhibit weight gains by as much as 10% and require up to 50% less feed. Milk production has been shown to increase by 8-20%. Tree based agriculture can eliminate disastrous losses of newborn lambs and calves from blizzards.

During periods of low rainfall and drought, alleys of planted trees can increase row crop yields by as much as 25% and hay yields by 60-80%. Trees moderate the effects of hot drying winds that normally increase evaporation and plant transpiration. It should be added that there is a deep aesthetic associated with a landscape that is varied with a mixture of trees and fields. During all the seasons of the year they are inviting places.

Agroforests for the Production of Game

Agroforests can be designed ecologically to provide excellent environments for game: reintroducing hunting as an economic resource for the land. The Eastern Wild Turkey provides an example of this approach. The wild Turkey is a species for which agroforests can be designed not only for the enhancement of their populations but for timber, pasture, and forage. Turkey flocks occupy a large home range, typically several thousand acres and, in some areas, may exceed 10,000 acres. Reclamation projects of 1000 acres or more could be specially designed for turkey flocks. Turkeys require a mix of open agricultural and forested land. The trees need to be spaced for enough light to penetrate the trees to provide good under-story forage (Tjaden, 2003).

Turkey flocks evolve through three seasonal stages in a given year. Each stage requires somewhat different habitat conditions. The first stage is the spring or nesting season. Ideal conditions for nesting are areas where the ground cover has a woody component of shrubs, small trees, and briars that are usually less than four feet tall, with an herbaceous component. Water is important. If there are no streams or natural ponds, rain fed ponds should be dug. Turkeys have a fondness for a wide range of shrubs, grasses and forbs as well as vines (Robinson, 2005). Trees that provide them with foods are pines, oaks, persimmon, pecan and hackberry. To enhance flock survival during the nesting period, trees need to be planted with a 25 to 45% open cover in two or three row sets with 30 to 40 foot alleyways for pasture. It is also important to establish native warm season grasses. If the pastures are to be grazed by livestock, the forage should kept at a grazing height of 8 to 10 inches or cattle should be kept off the land until late June. Finally, to create optimal conditions for turkeys, 20 to 30% of the grazing area should be planted to shrubs.

The second stage in the year of the flock is the summer/fall season. Vegetation at that time of year is more diverse. Once the turkeys have hatched they move to grassy areas. For their first month they feed almost exclusively on insects, which are abundant in forest clear-cuts and high quality pastures. In their second month the diet of the young begins to mimic that of the adults as they shift to feeding on soft and hard mast and forages foods like grasses and legumes. Grown open forests containing oaks and soft mast-producing trees, as well as open pine forests provide an ideal habitat at this stage. Ten to thirty percent of the host agroforest should be comprised of mast producing trees. It is important to maintain legumes as a forage component for livestock and turkeys.

For the third stage in winter, the agroforest has to provide adequate food and cover from inclement weather. This can be accomplished through a number of management techniques, such as block planting of oaks and management of the forage. Cool season grasses should be planted and areas for warm season grasses should be over seeded with wheat or annual rye grass for winter grazing and foraging. The pastures should also be over seeded with cool season legumes for winter and spring foraging.

Adding the management of game like wild turkeys, to agroforestry development is important for the diversification of economic activity on reclaimed lands. Conditions ideal for turkeys might provide close to optimal conditions for the forest farming of pigs as well. The most sought after and expensive hams in the world come from the oak forests of Spain. Especially if rotational feeding is practiced, an analogous system could well work in North America.

.**Agroforestry and the SMCRA**

What is not clear to me, the author, is whether agro-forestry made up of a mixture of pasture and forest ecologies, would qualify under the Surface Mining Control and Reclamation Act (SMCRA) regulations for bond release and therefore be a suitable hybrid strategy for landowners undergoing reclamation. The Appalachian Regional Reforestation Initiative (ARRI) has shown flexibility towards the types of tree crops systems that might be suitable for reclamation purposes. Working landscapes that employ people on the land will be, in the long run, more sustainable environmentally and will strengthen local communities.

NEW ENERGY PRODUCTION FOR APPALACHIA: BUILDING THE MIX FOR A CARBON NEUTRAL FUTURE

Half a century from now energy production will be comprised of a very different mix of technologies than those currently utilized. Petroleum production is near, or past, its peak (Boyle et al, 2003). Many now see remaining coal deposits as the primary energy resource for the future. It has been touted that the USA, at to-day's extraction levels, has several hundred years of available coal reserves and that it is the energy source for the future. According to the West Virginia Coal Association, even liquid fuel will be derived from coal (West Virginia Coal Association, 2006).

The coal industry's rosy picture of the future is not shared by all analysts, some of whom predict that coal extraction will begin to decline dramatically when the more accessible sources have been mined. On April the 5th, 2007 the Energy Watch Group (EWG) released a report stating that global coal production could peak in as few as fifteen years and that the promise of coal as a future energy source has been overstated (EWG, 2007).

A month later in May of 2007 a report entitled "The Future of Coal" written by B. Kavalov and S.D. Peteves, from the Institute for Energy, was submitted to the European Commission Joint Research Center (Kavalov & Peteves, 2007). Unlike the EWG report their document does not attempt to predict when coal production will peak. However the report does state that economically recoverable global coal reserves are decreasing. It further claims that coal production costs are rising rapidly and that higher costs will discourage the deployment of anti-pollution technologies. Complicating the future of coal are changes in the structure of the industry. Increasingly the industry is being concentrated in fewer countries and becoming dominated by fewer and larger corporations. The report suggests that this consolidation could lead to expanded market imperfections.

A major study recently released by the faculty at MIT entitled "The Future of Coal in a Carbon Constrained World" does not look at future coal supplies but at the environmental consequences of relying on coal (McFarland et al, 2007). Coal as an energy source has several major drawbacks. Coal mining has adverse environmental consequences. When coal is burned it produces CO2, which affects atmospheric gases. It also generates such toxic materials as sulfur dioxide, nitrogen oxides and mercury that pollute the air, water and soils over vast distances.

Cleaner coal burning technologies have been developed, but the coal and electrical generating industries have been notoriously slow in adopting pollution prevention technologies (Goodell, 2006). Coal, compared with oil or natural gas, is hard to transport and a disparate amount of energy is consumed in transportation and delivery to end-users. Coal has remained competitive with other energy sources because the external costs, both to the environment and to human health, are not reflected in the selling price. These external costs are huge. Estimates range at 2 cents to 6 cents for each kilowatt/hour of electricity produced from coal plants (Keoleian &Volk, 2005). Based on Department of Energy figures for 2005, the US used 4,055 billion kilowatt hours of electricity and 49.7% of it was from coal, for a contribution of 2,015 billion kilowatts of electricity. The annual external costs of burning coal are between 40 and 120 billion dollars at 2005 levels of electrical generation.

An Alternative Energy Future for Appalachia

There is an alternative energy future for Appalachia. The region has solar and wind potential that ranges from good to excellent. The wind farms of the future could be built on former coal lands with favorable wind regimes. The emergence of large scale wind farms in Europe, and more recently here in North America, attest to the maturation of wind energy and to the growing importance of energy from non-polluting and carbon neutral sources. Wind power, based on cost, life cycle analysis (LCA) and freedom from pollution, can be a future energy source in any area with favorable winds.

The major drawback to wind is that its electrical energy must be backed up by alternative standing stocks of energy, in order to balance electrical power generating loads with the demands of users. Solar power has the same drawback. However, if wind power is paired with another renewable energy source such as biomass, then a viable energy system can be created. Such a system could be the foundation for a carbon neutral future.

Appalachia has the potential to generate a carbon neutral energy mix that will benefit both the environment and the atmosphere. The area's biotic potential is exceptional. Appalachia has an incredible blend of climate, rainfall, and biological diversity that is, perhaps, unrivaled anywhere else in the country. This combination of factors make it possible to produce significant amounts of biomass energy for conversion to solid and liquid fuels from fast growing trees. Biomass energy could provide the region with energy and fuel independence, play an important role in capturing carbon dioxide, and provide the economic engine for a broad revitalization of the economy. The key to this future is the cultivation of trees and the development of industries that employ woody materials for a diversity of purposes.

Woody biomass can be used for generating electricity, for refining fuels and for the manufacture of a wide range of products ranging from plastics to polymers, thermosetting polymers and adhesives. In recent years, biotechnologies and bio-refineries have been developed for the conversion of woody biomass into liquid fuels from such trees as willows and poplars. One basic method, called cellulosic ethanol production, utilizes bacteria and yeast to break down fiber-containing compounds like cellulose, hemicellulose and lignin in the parent woody material and then converts them via a "brewing" process to ethanol (Scahill, 2004). In terms of net positive energetics, (the energy in the fuel minus the energy to produce and deliver the fuel) woody biomass far outshines corn or soy-based ethanol production, which currently dominates the multi-billion gallon a year alternative fuels market. Tree-based fuel is a more sustainable energy source and much more effective than corn or soy at sequestering carbon from the atmosphere. New clean burning technologies have been developed to burn woody biomass directly in order to produce heat and electricity (Scahill, 2004). These co-generating technologies work at many different scales from individual buildings to full-scale power plants. The States of Vermont and New York are actively promoting biomass production for energy use and the use of co-generating plants for businesses and large institutional buildings such as regional schools.

The European Example of Biomass Growing on Coal Lands

The Europeans are beginning to utilize former coal mining lands for biomass energy for the production of fuels and to reduce CO2 in the atmosphere. Although soil fertility of these lands is poor, they are beginning to employ techniques of tree culture that are beginning to show great promise. On two former lignite coal lands two comparative trials were carried out, one in the north east of Germany on the Lusatia coal lands and the other in central Germany on the Helmstedt coal lands (Guenwald, et al, 2007). The trees planted in N. E. German site were black locust, *Robinia pseudoacacia,* willow, *Salix viminalis,* and hybrid poplars, Androscoggin, and Hybrid 275 both crosses of the black cottonwood, *Populus trichocarpa* and the Oriental cottonwood, *Populus maxmowiczi*. At the Central German site the willow was replaced with the Poplar clone, Beaupre, a cross between the black cottonwood and the eastern cotton wood, *Populus trichocarpa X Populus deltoides*.

In the north-eastern Germany trials the soils in which the trees were planted were all treated similarly. The soils were made up of relatively infertile sandy loam overburden materials. Lime was applied to the land at 15 tons per hectare (6 tons/acre) and mineral fertilizers were applied at 100 kilograms per hectare (89 pounds/acre) each for nitrogen, phosphorus and potassium (N/P/K).

The central Germany trials compared three types of soil amendments, chemical fertilizers alone, chemical fertilizers combined with compost, and compost alone. On this site 116 tons of lime were applied per hectare (47 t/acre). Minerals were added at 100 kilograms each for N/P/K per hectare, compost alone at 100kg of N per hectare, and the combination as 100 kg N per hectare plus 50 kilograms of N/P/K per hectare. Yields of biomass were reported as oven dry weight tons (odt).

The clear winner at both sites was the black locust. In the north-eastern sites the black locust accumulated, over 6 years, a biomass of 29.8 tons/hectare, equivalent to an annual production of 5 tons/hectare. The hybrid poplars averaged 2 tons per hectare per year. At the central German site, as compared to the other treatments, all the trees responded dramatically when grown in a mixture of compost and chemical fertilizers. Hybrid poplars produced 2.2 tons/hectare/year with chemical fertilization and 3.9 tons/hectare/year when grown in the compost/ chemical combination. The black locust produced 3.2 t/h/yr on chemical treatment, 4.6 t/h/yr on compost alone and 5.8t/h/year on compost plus chemical fertilizers.

The soil improvement techniques recommended in this report would no doubt create higher yields of some, if not all, of the species grown in Germany. These soil improvement techniques, in combination with the considerably longer growing season in the southeastern USA, would probably result in, on average at least, a doubling of the yield potential for biomass in Appalachia. Black locust is susceptible to insect attack in the region, but many of the poplars and hybrid poplars are well adapted to the area (Johnson, 2001). A potential oven dry weight yield of 7-10 tons/hectare/year (2.8-

4.1tons/acre/year) on former coal lands utilizing the soil building techniques recommended here could be expected.

The Intensive Cultivation of Willows in the USA

The most significant work on developing biomass for energy in the USA could be the intensive cultivation of willows (Volk et al., 2002). Willow plantings have been shown to have a wide variety of environmental, economic, and rural benefits. They sequester carbon and increase carbon levels in poor soil. They can be grown near electrical power plants and bio-refineries and have been shown to increase economic benefits. It has been calculated that for every 4,000 hectares (9,880 acres) in New York State up to seventy-six jobs and $540,000 in local and state tax revenues can be created (Volk et al, 2002).

The culture of willows is becoming quite specialized and mechanized. The willow species, *Salix spp,* that have been tested are shrub willows of the subgenus, *Caprisalix spp,* of which there are 125 species worldwide. This is important in breeding for insect and disease resistance. The species most researched for potential is the shrub willow, *Salix viminalis*. Willows have attributes that make them important for future biomass production. They produce high biomass quickly and, with selective breeding, their yields have increased up to 143%. They are easy to breed and can be readily mass propagated from cuttings.

Additionally willows can be coppiced and will re-sprout after cutting. Indicative of their high yielding characteristics they can be coppiced so as to yield between 7 and 10 harvests at three to four year intervals from a single planting. Planting in double row configurations allows the use of agricultural equipment in both planting and harvesting. Typically 10,000 to 20,000 are planted per hectare (4,050 to 9,000 plants per acre). Site preparation and weed control measures are done in the fall. In the spring willows are planted with four and six row planting machines. The machines plant 25 cm (10 inch) sections cut from willow whips, which are pressed down flush with the soil surface.

Harvesting is done with agricultural equipment that cuts and chips the biomass. The biomass is then blown into a wagon attached to the cutter/chipper. Now in prototype, but soon to come on the market, is a harvester that cuts and collects the material as whole stems, allowing for easy natural drying of the material (Volk et al, 2004). This represents an important technological breakthrough for large scale growing of willow biomass.

Yields of up to 30 oven dry tons (odt)/ hectare/ year (12 odt/acre) have been achieved in demonstration plantings, but until now large commercial plantings yields tend to be lower, averaging 6 odt/ hectare/year (2.5 odt/acre/year). Better varieties, matched to local soils and conditions and combined with improved management techniques, should bring commercial yields to well above 10 odt/hectare/year (4odt/acre/year) (Keoleian, 2005).

The Energetics and Environmental Impact of Woody Biomass Production and Use

Willow biomass, and to a comparable degree fast growing poplars, have extremely favorable energy and environmental potential for a world with excess greenhouse gases and declining fossil fuel resources. It has been predicted that in the future up to 45% of global energy will be derived from biomass with the majority coming from short rotation woody crops (Keoleian, 2005).

A net energy ratio is the ratio of electricity generated to the life cycle of fossil fuels consumed in the overall process of the electricity production. For willow biomass the ratio is extremely favorable, ranging from 10:1 –13:1 for direct firing and for gasification processes respectively (Table1). Grid energy nationwide is 50% coal based. Generating electricity from willow biomass could reduce greenhouse gas emissions, as well as NOX, SO2 and particulate emissions between 70-90 %. Burning fossil fuels on average costs society 2-6 cents a kilowatt/hour in the air pollution it creates. Biomass can go a long way toward eliminating these environmental costs. Table 1 looks at air pollution, global warming potential, and the net energy ratio, for willow biomass electricity generation, other renewable energy sources, and the co-firing of coal with willow biomass.

Table 1

TABLE 6

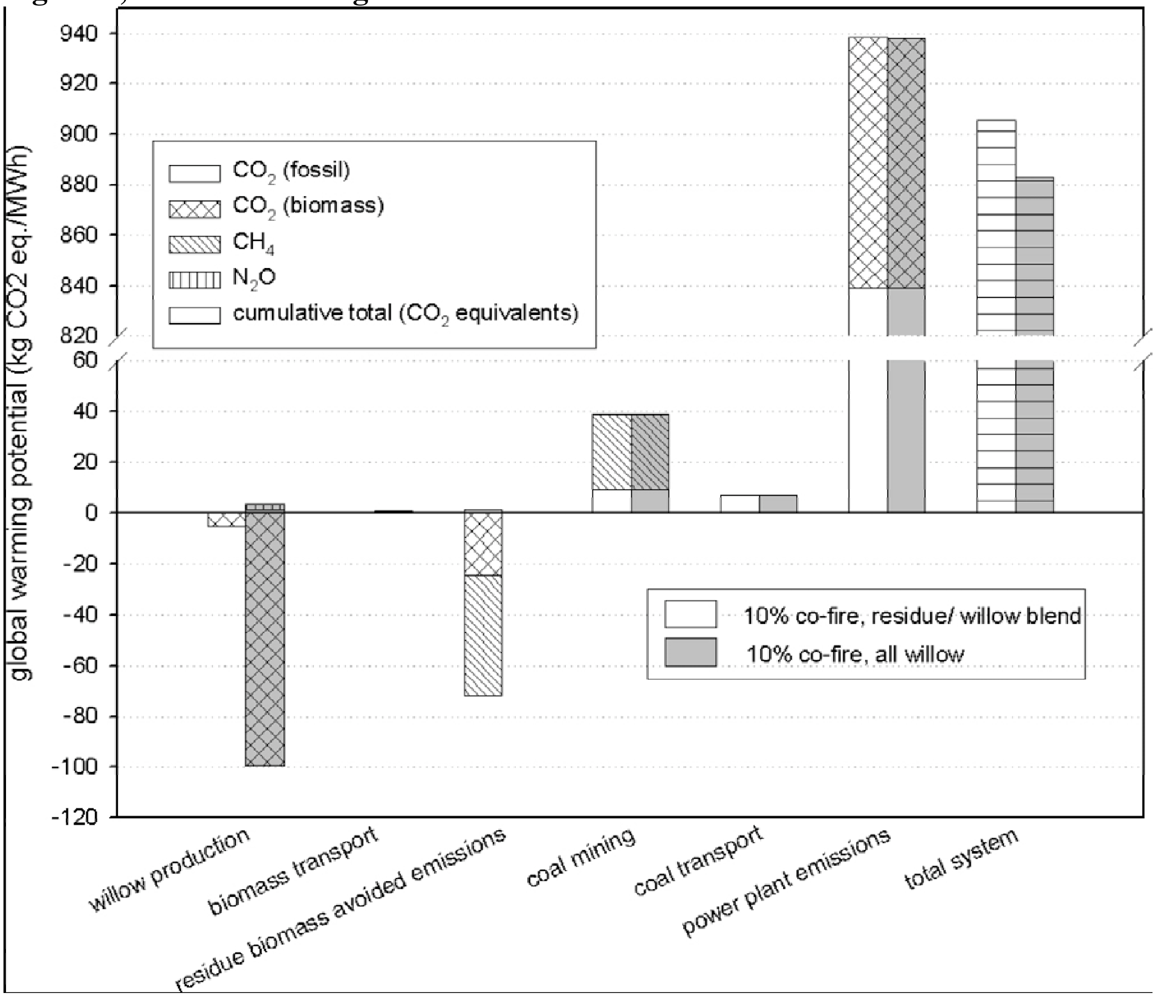
Total system air pollutants, global warming potential, and net energy ratio for biomass co-firing, dedicated willow biomass electricity generation, and other renewable energy sources

	CO (g CO/ MWh_{elec})	NO_x (g NO_2/ MWh_{elec})	SO_2 (g SO_2/ MWh_{elec})	Non-methane hydrocarbons (g/MWh_{elec})	Particulates (unspecified size) (g/MWh_{elec})	Global warming potential (kg CO_2 eq./MWh_{elec})	Net energy ratio
10% co-fire, residue & willow blend[a]	152.4 (−3.2%)	1868 (9.7%)	13670 (−9.6%)	84.1 (−10.1%)[b]	707.6 (−6.3%)	905.7 (−7.4%)	0.341
10% co-fire, all willow[a]	160.1 (1.7%)	1614 (−5.2%)	13675 (−9.5%)	86.4 (−7.6%)[b]	705.8 (−6.6%)	882.7 (−9.9%)	0.342
Average US grid[c]	416.8	3329.9	3207.5	44.1	2136.0	989.1	0.257
Willow production & transport with...[d]							
NREL gasifier	69.9 (−83.2%)	645.0 (−80.6%)	373.9 (−88.3%)	524.6 (1089%)	34.0 (−98.4%)	38.9 (−96.1%)	13.3
EPRI gasifier	277.3 (−33.5%)	816.6 (−75.5%)	941.9 (−70.6%)	105.5 (139.1%)	>31.4 (−98.5%)[e]	40.2 (−96.0%)	12.9
EPRI direct-fired	1769.2 (324.4%)	278.9 (−91.6%)	>161.0 (−95.0%)[e]	235.9 (434.6%)	>40.8 (−98.1%)[e]	52.3 (−94.7%)	9.9
BIPV[d,f]	43.3 (−89.6%)	247.6 (−92.6%)	512.2 (−84.0%)	67.5 (53.0%)	574.8 (−73.1%)	59.4[g] (−94.0%)	4.3
Wind[d,h]	na	30 (−99.1%)	20 (−99.4%)	na	na	9.7[g] (−99.0%)	30.3

[a] Parentheses are percent change relative to coal-only (no co-fire) operation.
[b] Biomass contribution to stack emissions.
[c] TEAM database, version 3.0 (Ecobalance).
[d] Parentheses are percent change relative to average US grid.
[e] Power plant stack emissions not specified; values shown are from feedstock production and transportation only.
[f] BIPV = building integrated photovoltaic. Reference: (Keoleian and Lewis, 2003).
[g] Global warming potential contains CO_2 contributions only.
[h] Schleisner (2000).

The potential improvement for the global climate if woody biomass is used to generate electricity is startling in comparison that of coal fired electricity generation. Figure 3 illustrates the positive contribution of converting to biomass as an energy source.

Figure 3; Global Warming Potential



It is interesting to note that both Table 1, as well as Figure 3, illustrate the positive benefits of mixing biomass with coal in existing power plants. Also co-firing coal plants with a coal/woody biomass mixture can significantly reduce greenhouse gas emissions.

The impact of different energy strategies on total life-cycle costs and global greenhouse gas emissions is depicted in Figure 4 (Spitzley & Keoleian, 2004). From an environmental point of view, biomass is the best option especially when stocks of biomass energy are combined with renewable energies such as wind power.

Figure 4

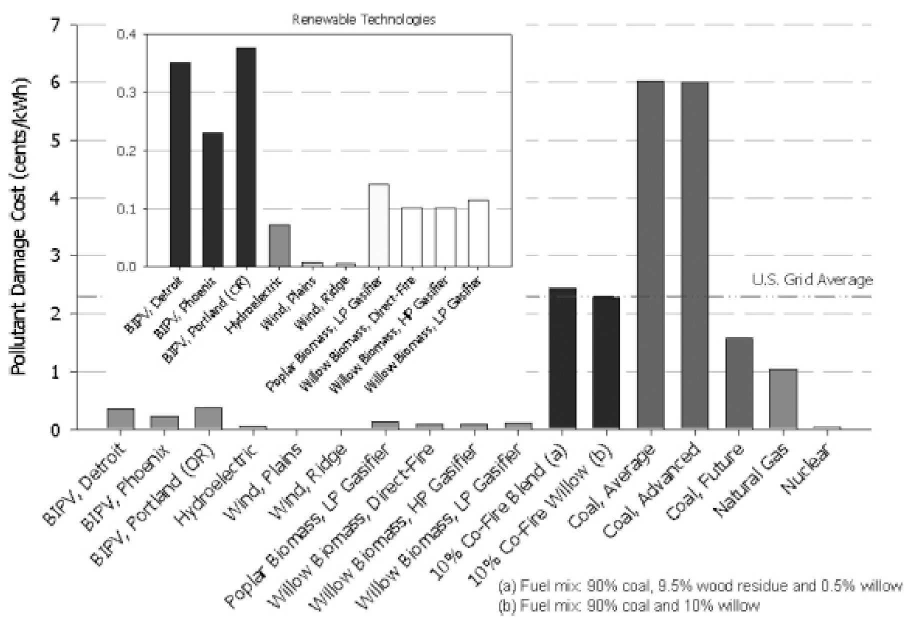


FIG. 8. Total life cycle cost of pollutant damage for electricity generating technologies (Source: Spitzley and Keoleian, 2004).

Reducing the Cost of Biomass Production

Biomass production systems, including those of woody biomass, are still in their infancy. There are many opportunities and options to reduce costs. The operational benchmark is the price of coal. When environmental costs are not included, coal costs between $1.40 - $1.90/ GJ (giga-joules). Currently woody biomass costs $2.60- $3/ GJ (Tharakan, et al., 2005). There are, however, several ways to lower costs and make biomass more competitive with coal and other fossil fuels. The first would be to increase yields and reduce harvesting costs. An 18 % increase in biomass yields would reduce the costs by 13% (Tharakan, et al., 2005). Improved harvesting has the potential to reduce harvesting costs by 25%. Both of the above are readily attainable goals and, when combined, lower biomass costs to the range of that of coal in many areas of the country.

A second method for achieving parity would be to credit the environmental benefits of biomass versus those of coal through a carbon tax based on atmospheric emissions during coal mining and burning. The use of a carbon tax to reduce atmospheric CO2 could be effective and rapid. The political traction to legislate such a tax, however, is not evident in a nation addicted to fossil fuels, as well as to the notion that a liquid fuel derived from coal will readily replace petroleum.

There are government programs that, if utilized by woody biomass growers, would bring prices into line with coal. The first is the Federal Conservation Reserve Program (CRP). Through this program the costs of production and maintenance are shared. It has been calculated that growing willow on CRP land would reduce the delivered price of biomass to $1.90/GJ making it competitive with current coal prices (Keoleian & Volk, 2005).

There is also the Federal Conservation Reserve Enhancement Program (CREP) through which woody biomass grown on CREP land would be even more competitive although the land is more restrictive. As currently defined, only targeted watersheds are available in the program.

The Federal Renewable Energy Tax Credit for closed-loop biomass like willow is 1.8 cents/kilowatt/hour. This tax credit reduces the cost of willow biomass to around $1.90/GJ making it competitive in price. Some states also have Renewable Energy Portfolio Standards (RPS) for mandating that a certain amount of energy must be derived from renewable energy sources. New York State has mandated that 25% of its energy must come from renewable energy by 2013 (Keoleian & Volk, 2005). The Appalachian states could set comparable or even higher goals for the future.

Land Required for Woody Biomass Fuels

Land is available in Appalachia for the intensive cultivation of woody biomass in combination with ecological forestry, agro-forestry and agriculture including hundreds of thousands of acres of unproductive grasslands and scrublands (Sullivan et al., 2006). The long-term recovery of the region should be based on an overarching effort to create rich soils and to sustaining a landscape rich in diversity. Woody biomass has a place in this mix. It has been estimated that between 3.9 –5.8 million hectares (9.6-14.3 million acres) of energy crops will be required to meet a 20% Renewable Energy Portfolio Standards (RPS) by 2020 (Haq, 2002). This represents about 24-37% of the land currently in the national Conservation Reserve Program (CRP).

To support an electrical power generating facility, for example, a 100 MW biomass gasifier operating at 37% efficiency and 80% capacity would require 26,865 hectares of land (66,357 acres) in willow crops. This amounts to 1.3% of the total area within an 80 kilometer (50 miles) radius of the plant (Keoleian &Volk, 2005). By combining biomass with other sources of energy such as wind, there is a very real opportunity for communities and regions to develop their own electrical and fuel supplies. If electrical power generation facilities were combined with bio-refineries as well as wood based materials manufacturing in Ecological Industrial Parks (EIP), the synergies would go a long way towards stabilizing regional natural resource based economies.

The biggest stumbling block to widespread application of fast growing trees for energy and fuel is societal. Our culture does not yet widely understand the importance of trees to our future. Neither their economic and environmental significance, nor their potential for national security, have entered mainstream debate. The advantages of tree biomass production need to be communicated. Fast growing trees are superb "workhorses" at sequestering CO2, improving soil and water quality, preventing erosion, providing wildlife habitat and increasing biodiversity. They represent a stock energy resource. Equally importantly they have the proven ability to be the foundation for a rural developmental renaissance.

Financing the Reforestation of Coal Lands

High yielding biomass trees, including willows and poplars, have the potential to become economic "engines" where they can be directly coupled to nearby bio-refineries and processing plants, as well as to electrical power producing facilities. The reforestation of long rotation white pines (30 years) or mixed hardwoods (60 years) for high value timber will require a different set of financing mechanisms. A financial analysis of different reforestation scenarios has been completed recently (Sullivan et al., 2006). The study modeled different planting varieties (pines versus hardwoods), variation in land management intensity, land quality, yields, profitability or Land Expectation Values (LEV), against a backdrop of different stakeholders who pay the initial costs of reforestation. They looked at scenarios in which the landowners paid all the costs of reforestation in contrast to the mining company, which had destroyed the forest, financing its replanting or else a governmental entity purchasing carbon credits as part of a carbon sequestration plan for the state or nation.

Estimates for the cost of reforestation vary for coal land. Costs as low as $741/hectare ($300/acre) have been reported (Burger and Zipper, 2002). Sullivan and his associates provide a detailed description of current costs, including soil preparation, fertilizers, lime, and weed control for up to three years (Sullivan et al., 2006). Their estimates go as high as $2,700/hectare ($1,100/acre) for intensively managed woods. The estimates were based upon initial planting densities of 1,344 seedlings/hectare (544/acre).

Different modeling scenarios resulted in different economic conclusions. In cases where the land owner pays all the reforestation costs for a hardwoods forest with a 60 year rotation, only a combination of high timber prices, better quality lumber, more intensely managed land, and a low Alternative Rate of Return (ARR) was commercially viable. When a mining company pays for initial reforestation and weed management, a much wider range of scenarios showed a positive Land Expectation Value (LEV), although there was not a large margin of profitability.

The white pine scenarios, with a shorter rotation period of 30 years, demonstrated a similar pattern. When the landowner paid the up front costs for reforestation, there were more positive economic combinations of variables when plantings of white pine were compared with hardwoods. The bottom line is that the reforestation of former mining lands can be economically viable, but the profitability is not sufficient to initiate the widespread privately financed reforestation of white pines or hardwoods.

Carbon Markets

In attempting to grapple with atmospheric pollution and climate change the world increasingly is turning to carbon trading and a carbon market. For Appalachian coal lands a system needs to be devised that would pay landowners to sequester carbon by growing forests. Currently most former mining areas are now scrub or grassland, which are economically marginal. Reforesting poses an economic dilemma for a landowner. Forests take between 30 and 60 years to become economically viable and there is usually very little income to support the necessary management until the trees can be harvested. The knowledge to plant and sustain new woodlands exists, but there are few mechanisms or incentives to plant trees. It is, however, in the best interests of the nation and the world to reforest. The benefits, including cleaner air, purer water, increased biodiversity and economic expansion and diversification, are widely appreciated. What is not so appreciated is the ability of forests to sequester CO_2 from the atmosphere and to store the carbon in the woody tissue of the trees. To a large degree climate stabilization on a global scale will depend on the ability of newly planted trees to store carbon.

Emerging carbon markets could provide the means for financing the reforestation of coal lands and other degraded lands in Appalachia. While these markets are still in their infancy in the US, they have been studied in relation to reforestation (Sullivan et al., 2006). The study looked at two types of carbon markets. The first option involved annual payments based upon the **accumulated carbon** added to the site each year. Payments were calculated on the number of tons of **accumulated carbon** found on the site in a given year. This option was established to reward landowners who retained the carbon on the site for considerable periods of time.

The second option for annual payments to landowners is based upon the **incremental carbon** added to the site each year. The annual growth of new woody material is the basis for payment. This option rewards owners of fast growing trees who harvest more frequently in order to optimize carbon uptake. The model to calculate rates of payment included such factors as interest rates, management effort, and land quality as well as the types of trees being grown, which would be either white pine or mixed hardwoods. The objective of the models was to determine the minimal levels of payment that would make the conversion of grasslands and scrublands to forest economically attractive. They do not represent optimal remuneration levels for carbon capture.

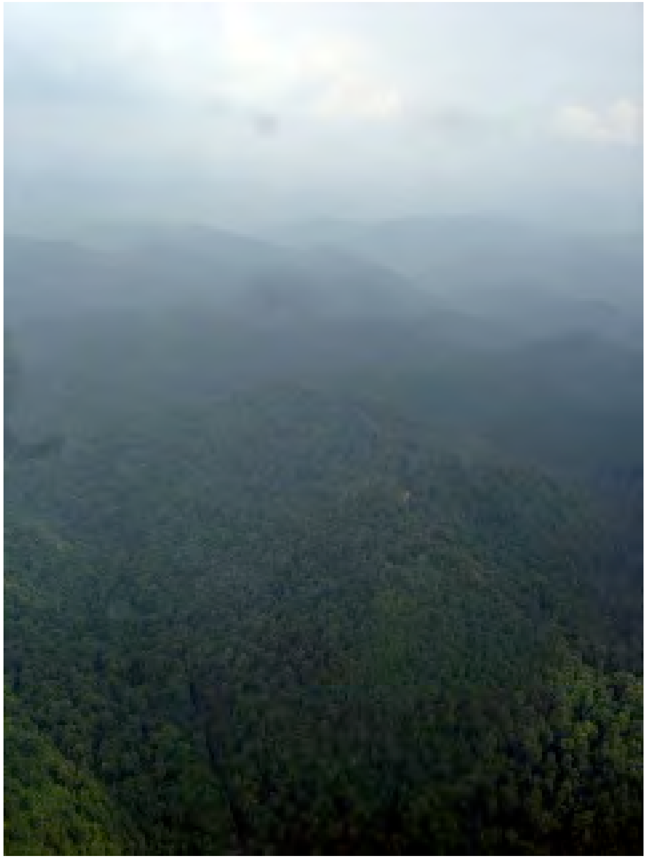
The **accumulated**, or total carbon, option resulted in payments that ranged from $0 per ton to $9.39 per ton for white pine forests. The highest payment numbers were generated by the high interest rate from intensive management of poor quality lands. When the best land, intensive management and moderate 5% Alternative Rates of Return (ARR) were combined, to be economically viable the minimal payment for white pine was $ 0/ton. On low production sites, with higher ARR, intensive management, allowing for poor prices for timber, payments would need to be as high as $9.39 per ton of carbon per year.

For mixed hardwood sites comprised of poor quality land, high intensity management and high interest rates, again allowing for poor timber prices, carbon payments would be $ 4.52/ton/year. With high intensity management on the best quality land and a 5%ARR, the carbon payment would be $1.75/ton/year.

The second type of carbon market modeled involved analyzing **incremental carbon** capture. Annual payment occurs only once in the **incremental carbon** model at the time the carbon is sequestered. The **accumulated carbon** model pays annually at a rate based on accumulated standing stocks of carbon. For this reason the **incremental carbon** models show much higher rates of payment on a per ton basis, but the number of tons would be much lower as they represent only the previous year's new growth.

For mixed hardwoods the **incremental carbon** payments ranged from $8.66-$71.88/ton/year, with the higher numbers reflecting the poorest land, high ARR, with high intensity management and poor prices for timber. For white pines the range of payments varied between $0/ton/year on good lands with medium to low ARR to $83.29/ton/year on the poorer lands with intensive management.

The Sullivan et al., study concludes that the carbon payments described in their models might not be sufficient to launch a major reforestation initiative. The reasons for this are many and may be reflected in absentee land ownership patterns, less than optimal land use laws, lack of financial guarantees and perhaps most importantly, business structures not suited to landowners, especially smaller land holders whose livelihoods are derived from the land.



Developing Cooperative Business Structures To Manage Natural Resources

In recent years there have been a number of important efforts to facilitate and bring together crop production and markets. A willow growers' cooperative in New York State, the Salix Consortium, offers an example. The wood producers realized that to successfully sell their crops as fuel to local utilities they would have to band together for a number of reasons, particularly because the power generation companies prefer to contract with one entity. The growers might have sold their biomass to a private broker, but would have given up their power to negotiate a fair price and the broker's commission would have eaten into their fairly narrow profits. They learned that their best emerging market were electrical generating plants that were co-firing woody biomass along with coal. Through banding together, they were able to find the financing to install wood handling equipment at the power station. They then went on to collaborate with plant breeders at the SUNY College of Environmental Science and Forestry to search for high yielding and pest and disease resistant willow varieties. They also collectively purchased the expensive planting and harvesting equipment necessary for profitable biomass growing (Newhauser & Edick, 2001).

The growers could have chosen from a number of business models, but the size of most of the plantings and the relatively narrow profit margins from biomass production pointed to a cooperative business structure. A cooperative helps them reduce production costs in addition to other expenses, like marketing and delivery. A cooperative model also gives them opportunities to increase the value of their crops.

Agricultural Cooperatives have a long history of both successes and failures. Currently new cooperatives are proving viable business structures. The legal basis for cooperatives was created in 1926 by the Capper-Volstrand Act. The law stated that the cooperative owners must also be users of its services and that the cooperative must be democratically controlled. Each member has one vote and the benefits are distributed according to the extent to which a given member uses the cooperative. A member that delivers 20 tons of biomass annually, for example, might have 20 shares, but still only one vote. One share of common stock is given to each member to assure a voting privilege. Preferred stock can be purchased but does not result in additional voting privileges. Federal law limits returns on preferred stock to 8 % annually.

Cooperatives can secure capital through a variety of non-member mechanisms such as through the COBank, which is part of the Farm Credit System and has over 24 billion dollars in assets. Other governmental programs and non-member investors can provide additional sources of capital.

There are three types of cooperatives, namely marketing, purchasing and service providing cooperatives. Often cooperatives combine all three roles by marketing the products, purchasing the inputs needed by the producers and providing such services as insurance, credit, and forest management or skills training to members.

There are other instances of recently formed Bioenergy Cooperatives (Downing et al.,1998). Their experience to date would be germane for similar future initiatives in the Appalachian states. The Bioenergy Cooperatives are interested in using biomass as feedstock for a variety of purposes. Woody biomass can provide combined heat and power energy or produce electricity using gasification technologies, which are more efficient and less polluting than combustion. It can be converted to liquid fuels. Biomass also supplies feedstock for co-firing with coal in several electrical power generating stations.

The Prairie Lands Bio-Products, Inc. based in Iowa offers an example (Neuhauser and Edick, 2001). This coop was formed in 1997 as a not for profit organization to investigate marketing and financing options. Several years later the 40 participants, all of whom grow Bioenergy energy crops, decided to become to a cooperative. The majority of them produce switch grass for co-firing in an Alliant Energy power station. They made the decision that the switch grass will remain the property of the cooperative. They rent 5% of Alliant Energy's capacity and use it to produce, and sell, kilowatt hours from their crops. The cooperative was funded in part through the Department of Energy Biomass Power for Rural Development Initiative

The Minnesota Valley Alfalfa Producers Cooperative with 223 owner-members is another pioneering example. The members are alfalfa growers. The cooperative supports activities on the farms as well as processing the raw materials into a range of animal feeds. It is their intention to utilize the "waste" alfalfa stems as a bioenergy fuel source for Northern States Power Company. As of the beginning of 2001 the cooperative had not been able to find funding for a gasifier, but their diversity of agricultural products has kept them viable while they explore new markets for alfalfa stems.

The Minnesota Agro-Forestry Cooperative is a bioenergy cooperative with members that grow hybrid poplars. They market their materials for electricity production, as pulpwood for lumber mills and as a raw material for oriented strand fiberboard manufacturing. Research into the economic viability of such a cooperative, funded by the University of Wisconsin and the W. H. Kellogg Foundation, determined that a hybrid poplar cooperative had the potential to be a successful business. As a consequence both the State and the Federal Departments of Agriculture provided start up support. The cooperative membership fee is $500. This gives a member one vote and the right to market 20 acres of hybrid poplars. One of the most innovative aspects of the Minnesota Agro-Forestry Forest Cooperative is its Producer Capitalization Program, which helps members with cash flow from the planting period until harvest 7-12 years later. The program pays for establishment costs and maintenance payments for the first three years. Members are also able to obtain advance payments against the projected harvest. The cooperative sells the poplar, retains the costs and advance payments, and takes out 5% for administration and to enhance the Producer Capitalization Program.

It is apparent from the above examples that the cooperative can be a viable business model. They further have the ability to respond to emerging energy, fuels and materials markets. Equally important, they can provide their members needs as demonstrated by the cash flow support provided by the Producer Capitalization Program. The USDA's Rural Business-Cooperative Service is an excellent source of information at www.rurdev.usda.gov/rbs/pub/cooprpts.htm

There are a number of funding sources for cooperatives:

1: USDA Business and Industry Program.

2:CoBank, as part of the Farm Credit System, provides loans to cooperatives

3: Rural Economic Development Loan and Grant Program.

4: Rural Utilities Services

A future option for a biomass energy cooperative would be to co-develop bio-refineries for the production of liquid fuels and other valuable materials from their feedstock with manufacturing partners. Other options would be for biomass producers to integrate with rural electrical cooperatives, or to start their own biomass based electrical cooperative. The Rural Electric Development Loan Program (REDL) provides zero interest loans to electrical cooperatives.

TOWARD A SHARED ECONOMY

It has been said that the only sensible strategy for long term national security lies in reversing the present radical redistribution of wealth (Gates, 2003). Between 1997 and

2000 the people on the Forbes 400 richest people list increased their wealth by and average of 1.44 billion dollars each. The average daily increase in wealth was 1.92 million per person. The financial wealth of the top 1% now exceeds the combined household wealth of the bottom 95% of our society. The very wealthy shelter their financial resources in tax havens offshore or overseas. The amount of money held this way has been estimated at $8 trillion (Gates, 2003). The loss to society is immeasurable.

Just before the Great Depression, a similar, albeit not so dramatic, radical redistribution of wealth took place. In response to the financial crisis in 1934, a former Southern governor, Huey Long, announced a "Share Our Wealth Program" in a speech entitled "Every Man a King but No Man Wears a Crown." He then went on to create Share-Our-Wealth Clubs nationwide. By April of 1935 he was able to claim that 7.7 million people belonged to 27,431 of these clubs (Gates, 2000). In his book "My First Days in the Whitehouse" the populist laid out the basis for a plan to create a broader, ownership based society in America. He had presidential ambitions to run against Franklin D. Roosevelt in 1936, but was gunned down in the Louisiana State House in Baton Rouge and died at forty-two years of age.

Huey Long's son, Russell Long, became a member of the US Senate and in 1984 proposed, and helped create, legislation that encouraged employee stock ownership plans, or ESOPs. Since that time ESOPs have been used by employees to acquire an expanded ownership in their companies.

Broadening ownership of the natural resources of Appalachia should a high priority. The trend towards increasingly large corporate and absentee ownership throughout the region should be reversed. It is well documented that resource extraction activities like mining often impoverish the very regions that are the source of the wealth that is generated there. This holds true for the coal mining regions of Appalachia (Burns, 2005).

Under Federal law it might be possible for a region as a whole, or for each Appalachian State, to form a General Stock Ownership Corporation (GSOC) in which each resident would have a stake in the company. Such a company could hold title to the royalties from coal mining. The Alaska Permanent Fund established in 1997 provides a precedent, in this case with oil royalties. More than $7 billion have since been paid to state residents on a 1999 principal exceeding $26 billion. In 1999 an Alaskan family of five received $8,849. The total dividend payment for that year was more than $ 1 billion. There are other pathways to democratize assets and spread out the community ownership of a region's resources. Many of these should be assessed for their suitability for the coal regions of Appalachia (Gates, 2000).

Appalachian Natural Resource Corporations: A New Economic Model Based on Ecological Design

Nature is ever changing. Processes of change -- ecological succession -- shape the biology of landscape. In Appalachia after lands are clear-cut and surface mining operations have removed most of the soils, invasive annual grasses begin to colonize. After a few years perennial plants start to establish themselves and the process of soil creation begins amongst the root networks of an increasingly diverse plant community. The hardy shrubs next begin to appear. After a number of years scrublands start to dominate the landscape.

The hardy shrubs create environments that enable the newly forming soils to provide habitat for a variety of beneficial organisms and burrowing animals, including earthworms. As the years become decades, further changes occur. Hardy and fast growing trees, such as poplar, locust and cherry, start to establish themselves. In Appalachia they in turn provide conditions that set the stage for the return of the great hardwood forests, forests that host some of the most bio-diverse and productive tree combinations in the nation. If left to the forces of nature the whole healing process, might take over a century to re-establish the forest to its full bounty.

As has been discussed earlier in this paper, people can facilitate and speed up the transformation of bare land to forest. The key to doing so lies in applying modern knowledge of soil formation combined with recently developed techniques and technologies that speed up the process of soil creation. With intensive management and active stewardship of the land, economic landscapes can be created in much shorter time scales, in periods measured in years rather than decades or centuries. In this ecological context economic activity on the land can begin almost right away although the nature of the economic activity will have to change over time (Todd, 2004).

It is possible to design a corporation that also mimics nature's operating instructions. It is technically possible to create a corporation that goes through a process of ecological succession. Such a corporate succession would be tied to time scales occurring on the land. Over time, the diversity and complexity of the company's activities would increase. Concomitantly the number of people it could employ would grow to match the expanding diversity and complexity. An Appalachian Natural Resource Corporation(s) could be designed and engineered ecologically from the outset. It could start as an educational organization, possibly a not-for-profit entity that would train people in a host of new skills appropriate to its mission. A large nursery for trees and other valuable plants could be integrated into the educational programs. The organization could manage the land and at the same time begin to develop viable biomass energy initiatives, which would be followed by farming and forestry. Each of these activities would, in turn, set the stage for the next activity.

Another branch of the enterprise could be financed with investment capital in order to develop and manufacture new natural resource based products. These could include liquid fuels and a variety of wood based materials and products. Low impact tourism could be part of the mix. This tourism might include hunting and fishing along in conjunction with the infrastructures to support these activities, such as lodging and feeding guests. The educational division could teach agricultural, forestry and rural skills to visitors interested in learning or skill development vacations.

At some key transitional point the Appalachian Natural Resource Corporation(s) should shift its emphasis and become a lending institution. The purpose would be to finance the purchase of blocks of company land by its employees. After the land becomes productive and the land management skills of its people are well developed, the company could begin to sell off the reclaimed and productive lands. It could achieve this by underwriting mortgages for the local people originally trained and hired to work on land restoration. At this stage the company could begin to divest itself of the improved land. At the same time, however, the company should expand its services to the benefit of the growing population of new landowners. With the money earned from mortgages held by employees and others, the company would then be in a financial position to look for new lands in need of reclamation, and the cycle would begin all over again. The stages of evolution would be:

<u>Stage 1: Healing the Land (Not-for-Profit)</u>
1: purchase land and develop education programs
2: establish a major tree nursery
3: ecological restoration

<u>Stage 2: A Commercial Economy (Capitalized Corporation)</u>
4: forestry and farming with ancillary economic activities
5: manufacturing

<u>Stage 3: Divesting the Land and Expanding Services (Cooperative)</u>
6: land divestiture to employees and qualified land stewards
7: services to the new landowners

<u>Stage 4: The Cycle is Repeated</u>
8: The cycle repeats itself on other former coal mining lands and degraded properties

An ecologically designed company by would have to be place-based. It would have to take the best interests of the land and local communities to heart. It would need alliances with NGO’s serving the region as well as to progressive land owning and mining companies, which have demonstrated a commitment to the welfare of the region. It would further need to develop close ties with some of the region's excellent educational institutions.

The "architecture" or structure of an Appalachian Natural Resources Corporation(s) should go through its own succession over time. In the beginning it might be a not-for-profit organization, managing the education and nursery and land restoration. Then, as the biomass energy and fuels and farming and forestry systems start to be mature commercially, the most appropriate structure might be a fully capitalized for-profit entity. Finally, as the land is divested and services to the new landowners are increased, a member owned cooperative might prove the best model. In the author's view, financing for each of these stages is possible through a variety of well-established government, philanthropic and commercial vehicles.

The company's vision would be to serve the land and the people, as well as to create a broadly based economic foundation for the region. It should include dedication to widely shared ownership by the people of the area. Equity and shared ownership are the twin pillars of a lasting and durable economy. The wealth created should work like an ecosystem within the region, recycling and reusing its "energy" and "materials" to build a strong community. It is time to stop the exodus of wealth from Appalachia that currently mostly serves the distant interests of absentee masters.

Epilog

To many this paper may seem an impractical blueprint for the future of the coal lands of Appalachia. Its focus on soil building and ecological succession, using nature's subsidies to create the foundations of an economy may seem ephemeral and impractical. Others may argue that a post-petroleum era is not yet upon us and there is little need for biologically based fuels or renewable energy. Some may say that America needs coal to maintain its economy and standard of living, and if that means sacrificing land in

Appalachia or disrupting the lives and communities of the people there, that is the price to pay to support the nation. Apologists for big coal overlook the enormous damage that mountain top removal and valley fill mining has done to the region, leaving it with poisoned streams, buried soils and impoverished biodiversity.

This paper has not dwelt on the environmental or social impacts of what has and is happening in the region. Destruction of the landscape on such a huge scale has taken its toll on the region and its people. Also this paper may seem naive. In order for the proposal presented here to become a reality there will need to be strong leadership, organizational skills and business savvy to achieve its vision. Such leadership will have to be grafted onto broad participation of the citizens and involve every sector of the community. It could be argued that in areas where the mines are the largest and most active, the people are the most demoralized. This would make all the more challenging to encourage their democratic participation in building an alternative, equitable, and shared ownership future. Knowing the difficulties ahead, however it is essential, to try to include as many people as possible.

In the long run there may be no other choice then to begin work on a new self-sufficiency model for Appalachia; one that has not been seen for perhaps a century or more. The world is changing quickly. We are approaching an era of severe resource limitations. With these limitations, comes obligation to return to fundamentals. Nothing is more fundamental to a people than the health of their soils, their natural resources, strong communities and the freedom to shape their own destinies. We are going to have to begin anew.

There will always be those who mock the long view. There will be others who say the status quo is fine. We are part of a vast global enterprise. Such people are wrong. They are sleepwalking into the future. We cannot fix our problems simply by improving our efficiency or tinkering at the margins of the problems. In the long run only bold initiatives will carry the day. The time to act is now.

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