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Published on *Solutions* (http://www.thesolutionsjournal.com)

Beyond Coal: A Resilient New Economy for Appalachia

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Volume 1: Issue 4: Page 45-52: Aug 02, 2010

In Brief:

Coal mining has dominated the economy of Appalachia for more than a century and has drastically altered much of the regional ecology. Among the primary impacts of coal mining are degraded soils, slurry impoundments, contaminated streams, polluted air, human health effects, and a reduction in biodiversity. We address the broad issue of Appalachia's future by proposing an alternative to the devastating large-scale practice of surface mining in central Appalachia, including mountaintop removal and valley fill surface coal mining.

We propose a theory of ecological design for the remaking of damaged landscapes and the creation of a diverse new economy with the broad participation of the people of the region. Our design approach applies ecological principles to the healing of the landscape and the formation of an economy based on natural resources and renewable energy. It includes ecomimetic technologies and techniques for the generation of new soils, the revegetation of the landscape, the treatment of wastes (including mining waste), the cultivation of foods, and the generation of fuels and other products. We see soil formation on a broad scale as the primary driver for a durable future. Without it there can be no viable economy.

Ecological design operates at three levels, or orders, of organization. It includes succession, or a time dimension, that reflects changes in the nature of the landscape and in the institutions most appropriate for each stage in the evolution of the land and its economic elements. First-order ecological design includes the formation of new soils and ecosystems, including farms, biomass plantations for energy production. It also includes ecomimetic technologies, such as Eco-Machines used for a variety of functions ranging from fish farming to the detoxification of mining wastes and the repair of damaged aquatic environments. In central Appalachia, we have begun a pilot program to create soils using perennial warm season grasses and soil-building techniques that include the addition of biochar as a carbon source. We have also established a research Eco-Machine for the study of mining waste detoxification.

Second-order ecological design links processes across different sectors such as energy and natural resources. Examples of this are ecological industrial parks where diverse entities are brought together to create new symbiotic systems utilizing each other's materials, wastes, and energy. We recommend that ecological industrial parks, with a natural resource focus, be integrated into any development plan.

Third-order ecological design provides a time dimension to the formation of a new landscape and its economic activities. For example, our Appalachian restoration model shows the transition of activities on the landscape over a 16-year period. The first year involves soil building and the cultivation of plants for biofuels and biochar. By the eighth year, agroforestry has been established, the coal slurry is being detoxified, and an Agro-Eco-Park has been established. By the sixteenth year, forestry, agriculture, biofuel production, and natural resource based materials are being manufactured. Institutions most effective in supporting the transition will also go through a succession process. NGOs, land trusts, and government should implement the first stages, followed in time by academic institutions and new regional companies. Finally, we propose that financial institutions be established to underwrite the sale of lands to the people who are working on the landscape and the creation of locally owned natural resource and energy cooperatives. Cooperatives would provide collaborative and educational support to the people of the region.

Key Concepts:

- Mountaintop removal coal mining threatens the economic future and biodiversity of Appalachia. It also negatively affects global climate stability.
- We believe that a durable economy can be created for the region, based on ecological principles. This economy would depend on natural resources, renewable energy sources, and the broad participation of the people of Appalachia.
- Ecological design—employing nature's operating instructions—forms the basis for this proposal. It takes place at three levels, with each level, or order, providing the foundation for the next level of integration. In aggregate, the levels provide an infrastructural framework with the potential to underpin a new economy and the environment.
- First-order ecological design addresses the strengthening of weakened ecosystems, rapid soil creation, natural resources development, and ecomimetic technologies that support new economic activities. Second-order ecological design involves the development of new symbiotic systems that link across sectors, including energy, natural resources, and regional resource-based manufacturing of a range of products and services. Third-order ecological design adds a time dimension or succession, both on the landscape itself and of the institutions required to transform the landscape into a durable economy that serves the people of the region.
- Experiments in the restoration of surface coal mined lands have begun incorporating native warm season grasses and soil building techniques adopted from soil-forming practices employed in other parts of the world. The biofuel feedstock potential of these early succession native grasses is being investigated, and Eco-Machines for the detoxification of coal slurry are described.

The soil is the great connector of our lives, the source and destination of all.
—Wendell Berry, *Unsettling of America*

Coal Mining in Appalachia

Coal mining has been practiced in Appalachia since the Revolutionary War. An upsurge in extraction began with the twentieth century.[1] By its end, increased mechanization produced enough coal to provide over 50 percent of the electricity for the United States, thereby emitting nearly 40 percent of the country's carbon dioxide emissions.[2,3] With increasing demand from such developing nations as India and China, Appalachian coal is also being shipped overseas.[2,4]

Coal slurry is a major contributor to environmental degradation. It consists of a mixture of minute particles of coal, chemicals, water, and waste rock.[5,6] Normally it is stored in impoundments built in valleys and hollows or is pumped underground into abandoned mines.[7] The earthen dams that hold back the impoundments are built from waste materials from mining. Many of the chemicals in the slurry are toxic petrochemicals from coal washing and include polyaromatic hydrocarbons (PAHs) and benzopyrene and other coagulants, flocculants, and surfactants. Such coal wastes release other metals and metalloids through acid mine drainage. The mixture can also contain arsenic, cadmium, lead, selenium, and mercury.[8,9]

Compounding the danger, earthen-dam impoundments can be unstable and are often at risk of failure. A major flood at Buffalo Creek, West Virginia, in 1972 released 132 million gallons of slurry over 16 counties.[8,9] Massey Energy, one of the largest coal companies in the country, predicts that in the event of an impoundment failure, the release of coal slurry into waterways and onto property would result in major damage to the natural resources, wildlife, and overall environment of the area.[6] Mining has dammed 2 billion tons of slurry in 700 impoundments and has degraded over 1 million acres of land, 1,000 miles of streams, and 400 mountains.[8–10]

Along with affecting the region's ecology and economy, the coal industry contributes deeply to social inequity. It has contributed to the acute poverty and sickness prevalent in local communities and has altered their relationship to the landscape. Such communities have been dispossessed from their land, and absentee landowners own two-thirds of the region.[11-13] The coal industry extracts the second-largest tonnage of coal in the country from West Virginia, yet it contributes to only 3 percent of the state's employment.[14] In 1960, the federal government created the Appalachian Regional Commission to address issues of poverty and welfare—it appears that many of the problems have not abated; in some cases, they have worsened.[15]

A sustainable future based on coal is unlikely. But there is a promising alternative. Appalachia is privileged to be home to one of the world's richest, most biologically diverse landscapes. Such diversity could promote the healing of damaged

ecosystems and help establish the foundations for the next economy.

This paper explores ways to make a transition in the region from coal mining to a diversified, durable economy within an ecological framework. The goal is to build a carbon-neutral economic foundation through which carbon and carbon dioxide are no longer atmospheric pollutants but rather are sequestered into new soils and diverse biological pathways. The economy would be based on a wide range of activities and industries, including place-based education; restoration of coal lands and the contaminated landscape; detoxification of coal slurry; and the regeneration of natural resources, including forestry and agriculture. Equally important to the new economy would be the formation of renewable energy sources, enterprise diversification, and manufacturing based on natural resource feedstocks.

In envisioning such a future, however, we first have to address the devastation of the past. Mountaintop removal mining must end. It contributes less than 10 percent of the total coal production in the United States but has a tremendously disproportionate effect throughout the region.[2,9,10] We can heal the lands and waters, but we cannot bring back the mountains or the streams. Although federal rules consider stream creation a valid form of mitigation for mountaintop removal, they acknowledge the lack of science documenting its efficacy. Senior Army Corps of Engineers officials have testified that they do not know of a successful stream-creation project after mining.[5]

Appalachia needs an economy based on the larger workings and legacy of nature. Profound economic change requires a new model of development. Such a model must be based on complex and dynamic systems derived from the workings of nature. Such ecological design integrates all the subelements of the 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.

Steps Toward a New Theory of Design and Its Potential for the Region

Ecological design is characterized by a set of relationships that are intrinsic to it. With this framework, we can approach the ecology and economy of Appalachia with a clear set of objectives. Such objectives, or orders of design, are structured as natural building blocks that can be coordinated to provide the foundation for another level, or order, of design.

First-Order Ecological Design: Task Specific Natural Systems Technologies and Management Structures

The first order of ecological design draws on information and organisms found in the natural world and incorporates them into techniques and technologies for serving societal needs. This has led to the invention and implementation of natural systems technologies capable of generating fuels, growing foods, treating wastes, and repairing damaged environments as well as breaking down or sequestering toxic compounds and regulating climate in buildings.[16] The dynamics of the natural world offer many models for self-organization, self-design, self-repair, and self-replication that have been applied in such fields as sustainable forestry, biointensive and permaculture food systems, gray water recycling, and composting with very positive results.

The foundation for a renewed economy requires building new soils. Healthy loams filter toxins and water, cultivate vegetation, and sequester carbon. In Appalachia, compacted and nutrient-depleted soils have been major hindrances in reestablishing the native eastern hardwood forest.[9,17,18] Soils that have not been dumped from mountains into valleys or contaminated from washing coal are likely to be covered with unmanaged and unproductive scrub grasses.[19] A study from Miami University in Ohio reported that the deforestation of the landscape for mining and its subsequent conversion to scrub grasslands translated into a loss of over $2 billion in timber value and subsequent ecosystem services for climate regulation as well as in recreation revenue.[20]

Older mined landscapes have shown that the forest will grow back after hundreds of years, but Appalachia does not have the time to wait for so gradual a process of regeneration. Techniques for developing healthier soils have been researched extensively.[21-25] Research into building new soils in terms of decades would harness tools of ecological succession and would explore management practices with minimal inputs that are economically feasible. Our work investigates soil formation on coal lands using ecological strategies.

Potential Revenue Sources for Economic Redevelopment in Appalachian Coal Mining Areas

By: Michael Hendryx

The plan proposed by John Todd and colleagues is an ambitious one: to build a new economy for Appalachia based on principles of ecological and economic sustainability. These are great ideas, deserving our attention and efforts. But even under the best conditions, implementing these new economies for the region will take years, occurring in piecemeal fashion, one location here, another there. Appalachia cannot afford to wait that long. What can be done now to help the region improve its economic base and prepare for the sustainable future envisioned here?

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Mine Restoration Field Research in Wise, Virginia

In southwestern Virginia, we performed field research concerning native perennial grasses on reclaimed mine soils in Wise, a coal-mining town near the West Virginia and Kentucky border. The research is on 1.5 acres of land owned by the Red River Coal Company and is currently managed by the Powell River Project (PRP), a mine reclamation research center of Virginia Tech University. The mine soils are characteristic of reclaimed mines in Appalachia—heavily compacted sands and silts, rocky, acidic, and nutrient deficient.[26] The predominant factors that inhibit native forest succession are severe compaction and lack of available nutrients for growth. In the past, the majority of coal lands were reclaimed with invasive scrub grasses such as tall fescue (*Fescue arundinacea*) and Chinese lespedeza (*Lezpedeza cuneata*). These hydroseeded cold season mixes outcompete native species. However, they do not provide much in the way of standard ecosystem services, such as nutrient cycling, carbon sequestration, and soil formation.

We chose to sow native warm season perennial grass mixtures under different treatment conditions to determine the best and most economic way to restore soil productivity and to provide a dynamic medium for native succession.[27] The grasses include switchgrass (*Panicum virgatum*), Atlantic coastal panicgrass (*Panicum amarum*), and big bluestem (*Andropogon gerardii*), all of which are tolerant to acidic and nutrient deficient soils. These plants also have the potential to produce large amounts of biomass for biofuel generation.[28] We are experimenting with biochar as a soil amendment to increase vegetation yields as well as to promote nutrient cycling, water retention, microbial habitat, and soil aggregate formation.[29] Our objective includes carbon capture in the newly forming soils. The goal is to determine the productivity of both biochar and biofuel feedstocks from the native perennials grown on the reclaimed soils.

Second-Order Ecological Design: New Symbiotic Systems

Second-order ecological design is based on relationships that are not found in the natural world. These relationships are created by connecting normally unrelated processes.[30] A pollutant or industrial by-product, for example, may be combined with an energy source like waste heat to develop a new product. A recent manifestation of second-order design is the ecological industrial park in which energy and food production and preparation create new symbiotic systems. It is our contention that ecological industrial parks, based on agriculture and natural resources, could be the lynchpins for economic diversification in Appalachia.

Third-Order Ecological Design: New Economies Based on Bioregional, Carbon-Neutral, and Renewable Energy Frameworks

Carbon neutrality will be central to a transition to a society that is rich in information and constrained in the use of materials and nonrenewable energies. Knowledge from the natural sciences can provide renewable substitutes for capital and fossil fuels.

The time-framed emergence of different systems—succession—is intrinsic to third-order ecological design. Such systems are supported by different institutions at each stage of their economic and ecological evolution. Third-order ecological design is a complex process, based on several stages of development. Like building blocks, the first provides the foundation for the second, the second for the third, and so on. Each has its own appropriate institutional, economic, and educational support base.

The first stage in restoring our hypothetical former mine site begins with rebuilding the soils. This involves both modern scientific soil building and traditional knowledge. Following soil restoration must be the transformation of coal slurry. Such activity on a large scale could trigger the development of a remediation industry, which will require much of the same knowledge and infrastructure used in the coal mining process. NGOs and government entities assisted by academic institutions would drive this stage of the process.

The second stage includes developing sustainable forestry initiatives for timber and bioenergy, agroforestry, and ecological agriculture. The sequestration of carbon in timber and soils will be a measure of the success of such a project. There are many examples of developing sustainable forestry industries in Appalachia. They include such organizations as the Healing Harvest Forest Foundation that is helping restore native forest systems through animal powered extraction. Other models are the Appalachian Sustainable Development and Mountain Association for Community and Economic Development (MACED), which helps landowners manage timber and bioenergy while protecting the forest ecology. Agroforestry landscapes can also provide resources for non-timber forest products like ginseng and other medicinal plants as well as for craft making and food crops. American ginseng (*Panax quinquefolius*) sells for up to $400 a pound and has been harvested in Appalachia and sold all over the world for centuries.

The third stage involves economic diversification and the beginning of an entrepreneurial stage. It includes developing both a renewable energy infrastructure and also manufacturing and processing based on regional natural resources. The renewable energy potential of the region is huge. In addition to a range of renewable energy technologies, ancillary manufacturing of materials and products from natural resources offers great opportunities. The list of prospective industries includes biofuels, plastics, polymers, adhesives, and building and composite materials as well as wind and solar technologies.

There is already community support for establishing a wind farm in West Virginia. The Coal River Wind program reported that developing a wind industry rather than removing a mountain for coal would create more jobs, produce local renewable energy, and minimize environmental degradation.[31]

A Restoration Model Based on Third-Order Ecological Design

Succession on the landscape should dictate biological, technological, and industrial activities at a given site in any given year. Such models have potential for Appalachia. Soil restoration and slurry could feed into a system that produces bioenergy. Agroforestry, conservation forests, and an ecological industrial park would be established on a reclaimed mine site. The interconnected systems would be supported by large amounts of carbon that have been sequestered from the atmosphere to establish an enduring soil foundation. The site would be initially seeded with native grasses. The harvested grasses will be pyrolyzed or burned in a low-oxygen environment. Synthetic fuels from the biochar process would go to power the machinery for managing the landscape. The biochar by-product could be applied to newly established grass plots to increase productivity and soil restoration. The coal slurry could be processed in Eco-Machines that decontaminate the mixture.

After eight years, the soils will be sufficiently mature to grow tree crops. Half of the formerly mined managed grassland area will be designated for a mixture of forest and grasses intended for bioenergy feedstocks and agroforestry. The gas generated will be used for establishing an ecological industrial park. The grassland area will continue to be managed for biofuel feedstock production.

After 16 years, the site will have evolved into a native eastern hardwood forest. It will not yet be mature but will resemble the native forest structure. Half of it will be managed for agroforestry and timber production and the other half for conservation and recreation. Biochar will not be needed on the forest floor. Natural leaf litter will provide the carbon, water retention, and other nutrients necessary for continued growth. The former slurry ponds, having been decontaminated, could be used for aquaculture projects that provide freshwater catfish, bigmouth buffalo fish, and other native species for local restaurants. Excess biochar will be used at the next restoration site, and the entire cycle will be repeated on new lands available for reclamation.

The above constitutes an outline of a workable model for developing a new ecological and economic infrastructure. This would be achieved in part by dissolving the distinction between resource and waste. As is the case in nature, all wastes become nutrients. Ecological design anticipates that every output from an industrial process should become an input in another. The objective is to establish a sustainable economy that starts at restoration and evolves into community development based on widespread education.

Social Frameworks on the Evolving Landscapes

The final stage in restoring the region will be built on emerging economic diversification. It will involve the transfer of ownership of the land and natural resources to the people who live there, especially those who have had a hand in its ecological transformation. The work of Marie Cirillo and the Woodlands Community Land Trust (WCLT) offers one model. WCLT accumulated a large acreage of mountainous lands from absentee landlords and allocated it to local families and businesses to work and manage.

Such a project would require flexible financial institutions, perhaps in the form of regional land-holding organizations or cooperatives. They could provide landowning mortgages or their equivalents to natural-resource managers such as soil builders, foresters, and farmers. Once the land is capable of supporting a community, a twenty-first century equivalent of a Homestead Act should be passed.

Through such initiatives, Appalachia could become a model for the communities of the future, demonstrating how to transform an extractive single-resource economy into a vibrant and diversified one based on environmental stewardship, sustainable development, and social justice. Then in the fullest sense of the term, the land will be reinhabited.

Acknowledgments

The authors thank M. Hendyx and several anonymous reviewers for their comments and suggestions. We have tried to do them justice. We also thank Audrey Barnes for her rendering of the restoration land-use model.

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