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The Human Factor in Mining Reclamation

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ABSTRACT.--With rapid urbanization of the landscape, less space is available for wildlife habitat, agriculture, and recreation. Mineral resources (especially non-metallic construction materials) become unrecoverable due to inaccessibility caused by development and other competing land uses. Commercial or residential buildings are usually not razed to make way for greenbelts or gain access to aggregate for construction. The situation is politically charged and inefficient, not to mention expensive. With a continuing demand for the production of construction materials, including sand and gravel, crushed stone, dimension stone, and clay, economical recoverable reserves of stone are still being covered by urban encroachment or made off-limits by open space. The remaining viable aggregate resources are frequently not permitted due to vocal opposition from neighboring citizens. Mineral extraction does alter the landscape and is perceived as harmful to the environment. However, closing off access to a resource does not reduce the demand for it nor prevent changes in ecosystems.

By reviewing the literature for actual and proposed reclaimed quarry sites, land planners, industry, and the public may recognize there are innovative designs in the past and present. Though some disastrous mine sites are described, attention needs to be drawn to thoughtful reclamation projects for better future management. The human perception of mining is examined for possible confusion from a historic perspective, regarding regulation, and the definition of landscape. Selected sites are examined in terms of their history, landform, design approach, and visual discernment. Only in seeing and recognizing our own visual prejudices can we hope to evaluate land use issues wisely.

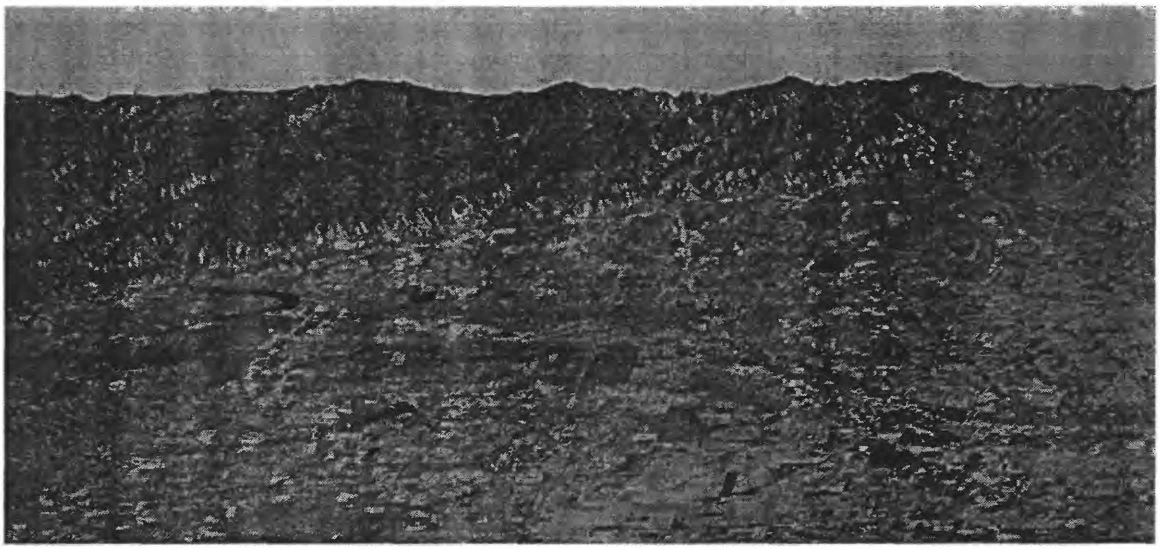


Figure 1. Stylized oblique aerial view, 3-D illustration of Colorado front range.

OVERVIEW

People want affordable homes and new schools, green lawns, more and improved roads, cheap and abundant fuel, and convenient shopping. Many of those same people do not want natural aggregate mines, dams to collect and store water, more drilling rigs, and uncontrolled growth. Conflict is inevitable and outwardly irreconcilable: material things that people desire cannot be provided without the undesirable processes that produce them. However, with careful resource management, many undesirable processes can be eliminated or minimized. This report describes the dilemma of wanting everything green and pretty while demanding all the modern conveniences.

The growing human population uses more and more mineral resources for industries ranging from agriculture and commerce to residential housing and recreation. The effect of these human enterprises is to constantly change the landscape. Political, economic, and aesthetic influences vary over time, causing complex, frequently not understood, pressure on the aggregate industry, land use planners, and Earth's ecosystems. Planners say new residents will triple the population of the Colorado Plains over the next decade. State growth (estimated at four million people by 1999) is a concern for most residents (Sanko, 1997). Many residents support stronger state laws to prevent urban sprawl and preserve wildlife habitat (Morson, 1997). One research group claims Colorado communities pay more than they earn from new resident taxes. Thus, tax revenues cannot cover the expenses for basic infrastructure such as schools, sewer service, fire protection, and recreation facilities (Brinkley, April 1997). Denver International Airport and Interstate E-470 may bring employment, demands for housing and business, but growth comes with a price for water, land, and wildlife.

This report examines that part of the problem that deals with extraction, processing, and reclamation in the aggregate industry, and how this essential activity can coexist with continued public pressure to restrict it, while still meeting reasonably-priced product demands for the same public. A very important aspect is the reclamation of extraction and processing sites--turning undesirable features (mines and pits) into something perceived as desirable by the public (reservoirs, recreation sites, etc.). Past approaches to mining and reclamation are examined in an attempt to identify those factors that contribute positively and negatively to successful reclamation projects and to the public perception of the aggregate industry as a whole.

BACKGROUND: PERMITTING AND REGULATION

Some rock product journals report fewer new mining permits are being granted by urban counties. One article pointed out Jefferson County, Colorado, as consistently denying new aggregate mining permit applications from the period 1982 to 1989 (Carter, September 1989). Karen Berry, currently with the Jefferson County Planning Department, states mining permits are assessed on a case by case basis and examined site-specific for allowable use. Ms. Berry says more construction material mines are approved than denied and that some permits are withdrawn by the applicant. Since 1989 at least six applications have been approved, including two sand and gravel pits permitted last year that totaled over one thousand acres. It is new, large hard rock quarries that tend to be disapproved, although some existing operations have been granted amendments to enlarge. Remarkably little specific information is available from some Colorado urban county planning departments so it is difficult to accurately quantify precise operation types. Table 1 gives the summary of applications county by county along the Colorado urban front range.

Table 1. Construction mine (including sand & gravel, hardrock) permits for 1992-1997.

Counties	Application	Approved	Denied
Adams	8	7	1
Arapahoe	2	2	0
Boulder*	9	6	0
Denver**	1	1	0
Douglas	3	2	1
Jefferson	3	3	0
Larimer	12	11	1
Weld***	--	--	--
TOTAL	38	32	3

* Two special use reviews are in progress and one has been withdrawn.
** Denver city limits are the same as the county. No permits have been issued since 1956 with one exception. Due to a prior mineral agreement with Adams County, operator approval was granted when land was annexed for Denver International Airport.
*** County Planning Services would not release information.

The importance of operator credibility cannot be underestimated in the mine approval process. Mining is negatively perceived when a local news headline reads "Broken vow the pits to neighbors of Boulder mine" (Finley, 1997). The apparent lack of communication between the original land owners (Flatirons Sand and Gravel) and community led to a neighborhood outcry when an approved restoration plan was legally altered with the knowledge and approval of government agencies, years later. The National Stone Association ". . . encourages its members to work with community leaders and citizen groups in developing plans for appropriate uses of the land in the community interest . . ." (1995, p. POLICY-9). Flatirons Sand and Gravel ended up with a potential public relations problem for the industry. The mining company had won an environmental award and one year later was in the news because neighborhood citizens felt betrayed by a change in land development plans.

Public perception of nature and culture has led to an inconsistent approach to mined land reclamation. The western mind set of not wanting federal government interference and fear of bureaucracy has a role in the lack of cohesive land planning by individual competitive cities and counties. As a society we become angered by an aggregate pit in our neighborhood but find an 1880's wooden mine shaft in the mountains quaint and photographic. We argue against the production of sand and gravel yet make use of newer shopping malls, parking lots, and want additional freeway lanes (fig. 2). The total production averages about ten tons of aggregate per capita per year consumption. Forty thousand major shopping malls line our highways, two-thirds of them mega-malls. Ten thousand sand and gravel pits are a major ingredient in supporting the country's infrastructure. We tend to believe 'open space' is natural land when in reality there is precious little left. Society thinks it is being environmentally responsible by recycling newspapers and plastic, yet immense amounts of water continue to be consumed and grass clippings are put in plastic bags for refuse pickup.

Figure 2. ABOVE: Parking lot at south end of Park Meadows Mall, Colorado. BELOW: Suburban home construction in Arapahoe County, Colorado.

In the 1960s, Peter Blake brought attention to the deterioration of America's landscape. He quoted an acquaintance as saying "The national purpose of the United States, from the very beginning, has been to let everyone make as much money as he possibly can. If they found oil under St. Patrick's Cathedral, they would put a derrick smack in the center of the nave" (1979, p.23). Things have changed since the 1960s. The public might take issue with geologic exploration under a church, but in less clearly defined situations it takes vision and research to protect the environment and provide infrastructure resources.

Perhaps it is in our mass communications that messages to the public can become muddled. An environmental group reports "The federal office in charge of policing strip mines has been so derelict in its responsibilities that almost none of the 120,000 acres strip-mined in Colorado has been reclaimed . . ." (Brinkley, August 1997). A reader may easily overlook the word 'coal' halfway through the article and assume that most mines in Colorado have not been fully reclaimed. One needs to distinguish between surface mining (open pit, strip, or dredging), and underground mining operations, what constitutes reclamation, and understand how various laws regulate different commodities. Newspapers cover complex issues and ideas in a small amount of space, at times in as little as 25 words or less. The journalist is usually a non-scientist trying very hard to come up to speed on a myriad of studies, determine credibility, and report in layperson terms.

Twenty years ago, Congress passed the Surface Mining Control and Reclamation Act. The Act requires **coal** mining companies to restore all **surface**-mined land to its premining condition; however, no specific federal legislation requires such reclamation for minerals. "According to the Bureau of Mines, between 1930 and 1980 only 8 percent of the land mined for metals and only 27 percent of the land mined for minerals was reclaimed" (Owen and Chiras, 1995, p.504). The Bureau goes on to report that 75 percent of the land mined for coal was reclaimed. Who is correct--the defunct Bureau, the environmental group, or both? How much of that land is still actively permitted? The Colorado Department of Natural Resources lists 17 active coal and 377 sand, gravel, and aggregate mines (Hemborg, 1996) producing approximately 26 million and 40 million tons, respectively (Cappa and Tremain, 1995). Two-thirds of the coal in this state is mined underground while most aggregate is extracted aboveground. As a reporter, reader, or taxpayer it is easy to confuse the issues, be mislead by statistics, and lump all mining together. In order to better understand past mining approaches, four resource management practices have been examined.

HISTORY OF RESOURCE MANAGEMENT

For the last 200 years, four resource management approaches have been employed in the United States (Owen and Chiras, 1995): **exploitive, preservation, utilitarian,** and **conservation**. Whether examining farming, rangeland, forestry, or mining, land-use approaches have been historically similar. While the total land in the U.S. disturbed by mining is small, varying from 0.002 to 0.1 percent depending upon the reference, even the industry recognizes the great impact it has upon the land and the need for conservation and care of the environment. The transportation network in our country is responsible for far more landscape disturbance than all of mining. Agricultural land accounts for 60 to 70 percent of total land use. Cropland, range, road cuts, and railroads are not viewed as disturbed areas despite their high visibility; people tend to see them as a necessary part of their everyday life.

Exploitive

Owen and Chiras (1995) begin their examination of resource management with the age old exploitation approach (man conquering nature); viewing natural resources as inexhaustible commodities with nothing but individual profit in mind. The "get rich and get out" mining ethic had little concern for problems such as soil erosion, water and air pollution, or wildlife depletion. The purely exploitive approach to resource management did not consider problems created during the mining process or adverse effects that might occur in the future.

Mining does disturb land by removing surface vegetation, changing topography, and may affect hydrologic function and water quality; so does hiking, off-road vehicles, and trailing by animals (Toy and Hadley, 1987). Mining may also cause erosion, stream sedimentation, dust, lower water tables, destruction of wildlife and habitat. Additional vehicular traffic brings noise and increased wear on roads. With careful planning and responsible mineral extraction, most of these problems can be minimized or eliminated. Unfortunately, the damage created by exploitive aggregate producers and construction companies prior to the 1970s gave the industry a negative image, and the public has a long memory.

In today's world, the results of exploitive resource management usually require remedial action, often at taxpayer expense and with undesirable results. For example, in April 1997, the US Forest Service and Army Corps of Engineers approved a restoration plan for the San Miguel River at the South Fork, which allegedly was damaged by Telluride Gravel mining operations. The river was channelized and the water table lowered, with resultant death of trees along the banks. Telluride Gravel offered to provide labor and equipment for the restoration, but much damage had been done to the mining image. The public lost confidence in both the industry and public service representatives to do their job responsibly and stop further erosion (Editorials, 1997).

If they look objectively, even tourists seeking sun, sand, and surf in the Caribbean islands may find that their very presence has an environmental impact by increasing the need for local construction materials: sand mined from beaches can result in serious coastal damage due to wave and wind action, and contamination of fresh water aquifers with salt water. Scientists at the University of Puerto Rico's Sea Grant Program and Millersville University are studying the effects of beach mining and coastal area management (Caribbean Coastal Studies, 1997). Meanwhile, some islands have banned beach mining, resulting in higher costs, increased fuel consumption, and a search for alternative building supplies.

Closer to Colorado, county commissioners in Kansas considered a moratorium on sand dredging in the Kansas River. Dredges are used to mine via a floating platform and are a source of controversy. Tom Hittle, a landscape architect, told commissioners the prohibition is in the best interest of the community and state (Oakley, 1996). With sand and gravel deposits frequently found along stream valleys, dredging "is widely used in large U.S. rivers and can increase sediment bed load through resuspension, physically eliminate benthic organisms, and destroy fish spawning and nursery areas, all of which ultimately change aquatic community composition" (Starnes and Gasper, 1995). Kansas supporters of the moritorium claim dredging harms birds that use the shallow sand bars for feeding and increases soil erosion along damaged river banks. Opponents argue the bald eagle population is increasing and deny significant environmental problems. In some reaches of the River irresponsible dredging can lower the river bed, steepen and destabilize river banks, and cause increased erosion and channel widening. The Kansas legislature adjourned after sending the moratorium bill back to committee and approved a two-year study (by the state Department of Wildlife and Parks and the Kansas Water Office) of the river's potential for recreation (Associated Press, 1996).

In Colorado, ninety percent of wildlife habitat along streams and rivers has been destroyed (Leccese, 1996), largely by farming. Reclamation of sand and gravel pits to productive agricultural land, wetlands, or prairie is seen as a viable alternative to continued loss of habitat or hardscape development.

Preservation

A preservationist approach to resource management sets land and natural resources aside, protected from future development or alteration. From a natural science point of view, systems do not stay the same forever and will change over time in spite of their official designation. Aspen (*Populus tremuloides*) is a pioneer tree invading sunny disturbed areas, eventually yielding to evergreen forest species. Tourists and mountain resorts want the aspen and their local ecosystem to remain unchanged indefinitely. Ironically, aspen colonize sites disturbed by fire, avalanche, landslide, logging, or mining. While one does not often think about mine preservation, rural landscapes with significant historic mining are listed in the National Register and may include shafts, tunnels, pits, tailings, and surrounding communities. For example, the Central City-Black Hawk area is considered a National Historic Landmark District, but most Coloradans are more familiar with the towns' casinos. Now, it is competition for parking that, indirectly, may take Black Hawk off the National Historic Landmark list. The National Park Service (NPS) is threatening to "de-list" the city for wanting to move a gingerbread Gothic structure named Lace House. Thus, landscapes evolve both biologically and culturally.

Wilderness regulation, another format to preserve landscapes by prohibiting resource development, considers human beings visitors. The 1964 Wilderness Preservation Act legally defines wilderness as an area "where the earth and its community of life are untrammeled by man. . ." Thousands of visitors a year can have far greater impact on a landscape than a few hundred living on it. The NPS is actively engaged in reclamation planning and at the same time involved in road surfacing and rehabilitation of public buildings. Many people may not realize there are approximately 4000 abandoned and 150 active mine sites within U.S. national parks. Even Yellowstone National Park has a history of mining activity, including sand and gravel pits to help maintain the 350 miles of road within the park.

Despite 5000 acres being considered the minimum area practical for natural land management, attitudes towards what constitutes wilderness have changed. The concept of **pocket wilderness** is being used for smaller, isolated areas, so a small geographic area that has elements of significant landscape character, ecological systems, or fossil records may merit preservation. Features of historical as well as geologic value can impact a site. In Springwater, Ontario, an archeological survey, requested by the Ministry of Natural Resources, cost Cliff Varcoe Gravel Ltd. thousands of dollars (Lewis, 1995). The property, purchased for mining operations, turned out to be a significant historic native village and missionary site. The Canadian government ended up buying the land to preserve the 350-year old village and protect the regional heritage and culture. In unique cases like this, mining usually is not an option.

On a local level, the Denver Regional Council of Governments approved a plan to contain metropolitan development over the next 25 years. The plan includes regional open space, transit, and pollution control (Fong, 1997). Yet the 'Metro Vision 2020' plan does not include a map delineating extractable materials within the 700 urban square miles. The patchwork quilt and mosaic of American landform will continue without the benefit of designing the larger spatial pattern to integrate and preserve natural features and potential resources. Many decisions are made on a small, local scale, with eyes set on a short-time line. The macro view (including environmental data for off-site impact) over a long-time frame that could help prevent landscape fragmentation continues to be avoided, probably for political reasons. European governments frequently urge mining operators to look forward sixty years or more. Within the Unites States (the average young family moves every five years), many people will continue to view their environment much as city government--in short-time frames. With market demands for aggregate continuing to increase, mineral extraction from irreplaceable resources and the subsequent resculpted landscape need to be examined for areas that can be a high priority for mining operators and areas that are to be preserved in their present condition.

Utilitarian

The utilitarian approach stems from developing natural 'waste' land and making it productive. Germans have a name for dry wasteland of rocks and gravel--Unland (Wiedenbein, 1994). The sensibility of what constitutes waste and productive land has changed over time. "Until the late 1960s, reclamation in the semiarid west invariably meant irrigation of dry lands to make them productive" (Hodder, 1977, p.217). In other words, the 'natural' land was unproductive and waste. Despite a semi-arid climate (Colorado's average annual precipitation is seventeen inches per year), dry land can be a valuable ecological resource in itself. It should be noted topography greatly affects moisture as the higher elevations receive about three times more water than the plains. Early European explorers declared the Colorado area unfit for agriculture but farmers proved them wrong with irrigation ditches. North American Indians had cultivated the soil for centuries before. In recent times there has been a movement to preserve arid lands and return them to a natural state. It has been estimated that less than twenty percent of the country remains potentially natural (Stein, 1997). Within even that, wild indigenous vegetation is now exotic species. Often the open spaces we like to think of as pristine are degraded and naturalized by invaders such as Tamarix, Russian thistle (*Salsola kali L.*), or leafy spurge. Even the tumble weed associated with towns of the wild west is an introduced species.

Turning undeveloped, unused land (waste land) into something more productive is a major premise of housing development, but this development has a price. A green Kentucky blue grass lawn in Denver is no more "natural" than asphalt and requires frequent watering. With more than 15,000 herbaceous species in the family of Gramineae (grasses), relatively few are utilized in landscapes. Homeowners frequently are blissfully unaware of the damage they do in their own yards using fertilizer and pesticides. They do not want dust and noise from a quarry, but are attached to the lawn mower, edge trimmer and gasoline. The National Gardening Association estimates homeowners use up to sixty percent of the water supply in the West for lawn care. "And, according to the National Academy of Science, ten times more chemical pesticides are being used on lawns per acre than on farmland" (O'Neill, 1997).

In the United States, xeriscape has become a 90s catch phrase. Yet, the method is commonly not used because of the careful planning, higher initial expense, and expertise required to achieve a successful natural landscape in disturbed areas--new suburban developments or abandoned mines. Despite the lowered maintenance costs and water usage, xeric habitats are slow to be encouraged by developers, planners, and private parties. The composition and placement of native plants appear to be random when there is a complex underlying structure dependent upon soil and geologic structure. Considerable expertise is required to design a native plant community so that it looks natural. Hydrologic and climatic factors are important aspects of reclamation that are too often underevaluated. Precipitation and fluctuating temperatures impact slopes and accelerate soil weathering. Different vegetation may be required on south-facing slopes than north-facing. Xeric planning takes regional conditions into account and can be an important tool for reclamation efforts.

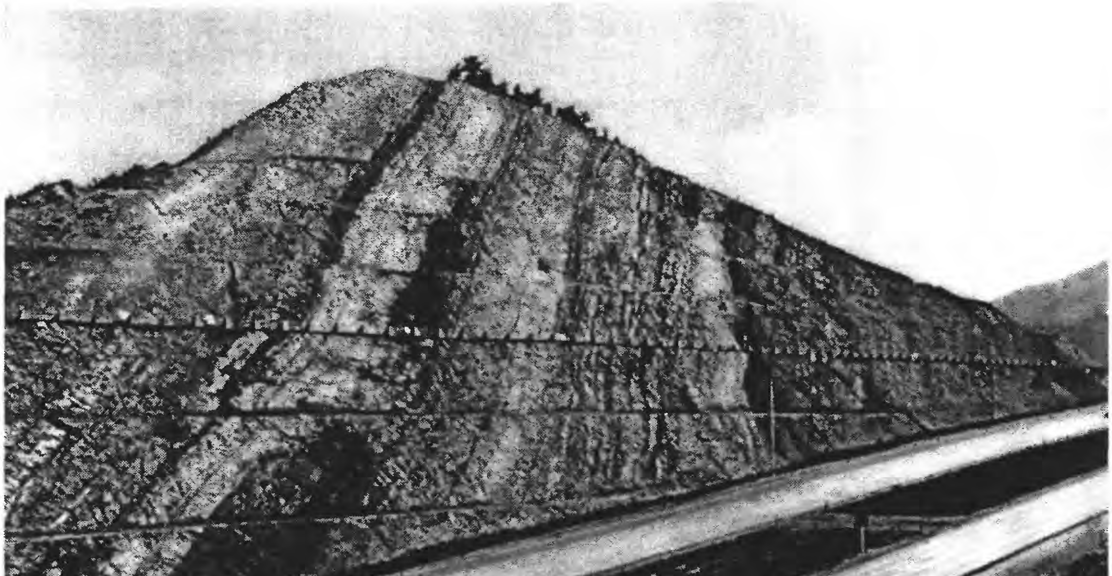
Conservation

Conservationists consider the ecosystem (including soil, wildlife, air, and water) as processes to be restored, protected, and enhanced. In an approach similar to sustainability, biological resources are managed to insure quality and quantity before consumption (harvesting) occurs. For instance, streams can be stocked with fish, logged forests replanted. Aggregate, on the other hand, is considered a finite source that once removed from its original site cannot be recreated. Aggregate is nonrenewable (House, 1995). The construction industry continues to require fresh aggregate despite efforts to recycle materials and reduce waste. The industry must compete with other interests, often conservation interests, for resource-bearing land. Balancing ecosystem protection (conservation), agriculture, and an aggregate industry is a new challenge for all parties.

The Minnesota legislature funded a multi-disciplinary study on gravel mining and native prairie protection. The study recognized the complex issue that "gravel deposits must be mined where they are found and cannot be relocated. Similarly, native prairie cannot be transplanted elsewhere" (Clay County Beach Ridges Forum, 1997, p.2). Both are nonrenewable resources. Even the vice president of one of the area's largest gravel producers, Bob Stabo, says, "We can't replace untouched, pristine native prairies" (Breining, 1996). Through scientific research, perhaps we can get closer.

Earth science conservation is "concerned with safeguarding the rich heritage of rocks, minerals, fossils and landforms" (Mills and others, 1995). Mining sites can expose geological features for study and produce diverse biological habitats, especially in areas of few natural outcrops (fig. 3). Along Interstate 70 (near Golden, Colorado), geologic outcroppings were exposed in a claypit wall and from blasting for the highway. In England, John Mills surveyed nature conservation among mineral planning authorities and mineral operators. Over 80 percent were found to have policies on nature conservation in reclamation, usually combined with other after-uses: recreation, education, and landfill. Preferred areas for mineral extraction should be based upon balanced appraisal of the resources, landscape value, and land use by a group of mineral planners, environmental specialists, and landscape architects.

Figure 3. ABOVE: Oscillatory ripple marks in upturned beds of the Kassler Sandstone Member of the South Platte Formation, 1982. Photograph by J.R. Balsley. BELOW: Sequence of tilted strata at I-70 roadcut through the hogback, Jefferson County, Colorado, 1972. Photograph by W.R. Hansen. Courtesy of USGS Photographic Library.



REGULATORY CONSIDERATIONS

Federal legislation such as The Clean Water, Clean Air, Endangered Species, and National Historic Preservation Acts impacts mining, but does not automatically mean we will prevent pollution, erosion, or loss of wildlife and its habitat, nor does it guarantee a readily available supply of quality aggregate. States may administer their own programs as long as their regulations are no less stringent than the federal law. Permitting and regulation of eighty percent of sand and gravel mining is under the jurisdiction of state and local governments (Starnes and Gasper, 1995). Effective enforcement requires money, while downsizing of corporations and government leads to fewer inspections.

Aggregate mining in Colorado has been regulated historically under the "Colorado Open Mining Land Reclamation Act of 1973." The Act, with subsequent amendments, requires an approved mining permit and reclamation plan. Concerns regarding the extraction of construction materials were addressed in 1995 and defined **reclamation** as

> "the employment, during and after an operation, of procedures reasonably designed to minimize as much as practicable the disruption from an operation and provide for the establishment of plant cover, stabilization of soil, protection of water resources, or other measures appropriate to the subsequent beneficial use of such affected lands" (p.5).

Land use regulations and zoning vary across Colorado from city to county. Mining laws for the Colorado Territory were enacted in 1861 after gold was discovered in the sand of the South Platte near Cherry Creek (1858-59). Two thirds of Colorado's population today lives in the South Platte Valley. Denver is situated in this broad, gentle river valley where landforms are visually more dominant than in the eastern United States. Gravel-capped terraces and Quaternary alluvium containing clay, sand, and gravel have been the source of local construction materials for many years.

It is the historical land abuse associated with coal and metallic mineral mining that has most influenced the current negative perception against all forms of mining. The first U.S. surface mining control legislation was limited in scope and enacted in 1939, by the state of West Virginia (Schaller and Sutton, 1978). Not until 1965, was the U.S. Department of the Interior directed to survey the environmental impact from strip and surface mining. It would take ten years before Congress passed the Surface Mining Control and Reclamation Act. The realities of topographic variation, climate, economic factors, and scarcity of research information continue to influence the effectiveness of mine reclamation.

Within the U.S., land-use laws governing reclamation limit impacts but are so broad that generally no review takes into account its aesthetic merit. Although the terminology may vary, the visual impact needs to be considered, both positive and negative. It is one way to interpret the landscape and no less important than its resources or geology. Landscape character needs to be assessed, including elements beyond the site. There is usually no overall design scheme to integrate quarry perimeters into the greater landscape. Title 23 of the US Code (governing the Federal Highway Administration) specifically considers "esthetic values" in balancing the "destruction of man-made and natural resources," costs, and the public interest. Yet, in Colorado and many other states, no landscape architect is required to review reclamation plans as part of the permit approval process. Agencies involved in the approval process for Colorado mining permits include:

The State Historical Society
Colorado Division of Water Resources
Colorado Department of Health, Air Pollution Control Division
US Bureau of Land Management or The US Forest Service (if the proposed operation is on federal lands)
US Army Corps of Engineers
County Planning Department

Colorado ranks among the top five state producers in coal and has experienced problems with land subsiding and fires in abandoned mines. It is the Appalachian coal fields that most publicized poor stewardship and "emasculation of physical resources" between the 1940s and 70s (Simpson, 1985). That negative viewpoint of mining was reinforced when the Summittville, Colorado, open-pit gold mine left acid-rock drainage requiring extensive remedial efforts. In 1992 the mine operator declared bankruptcy and abandoned the site. Cyanide solutions and soluble metal salts are just some of the environmental conditions requiring treatment at the gold mine. It is the horror stories (largely not related to aggregate mining) that make the headlines, not the successful, environmentally sound reclamation sites.

LANDSCAPE FORM AND CHANGE

Human kind has labored at earth movement for millennia. Natural caves, pits, mud-bricks, and turf were fashioned for shelter long before the advent of drywall and plywood. Mountainsides were modified for people to make a living by forming agricultural terraces, roads, canals, and mines. Ramparts and trenches were devised to provide refuge, defense, burials, and monuments. Figures 4 and 5 illustrate that many of these disturbed landscapes have a common design form etched on and of the landscape. Modern mining continues to be subjected to scorn despite similar geometric patterns created by other industries and nature.

Figure 4. *Earthworks for Hillside Housing.* Near Los Angeles, Calif. Photograph by Alex S. MacLean.

Figure 5. LEFT: Agricultural terraces in China. Courtesy of the Denver Natural History Museum. RIGHT: Tilted beds between Rawlins and Laramie, Wyoming. Photograph by J.R. Balsley. Courtesy of the USGS Photographic Library.

Mining provides an economic base and a natural resource to improve the quality of human life. Equally important is a sensitivity to the geologic origin and natural pattern of the land. Without knowing the location and quality of resources, it is difficult to plan where future growth should occur. Man's impact includes long-term changes to landform (movement/massing of earth), water table, and texture (soil disturbance and exposed rock surfaces). The use of rock stains (color), grasses, or trees is for quick visual relief.

Nature changes a landscape through long-term processes such as weathering (wind and water erosion) and short-term events, including volcanic eruptions and earthquakes. Individuals can also change land very quickly with subsequent long term effects. With a national trend toward increased use of hard rock, it is useful to examine the surface topography of hard rock and sand and gravel mines.

Surface Topography

With highwalls creating potential safety issues, some states have limited all surface reclamation grades to not exceed a 35 degree slope, generally the angle of repose for spoil material. Stone quarries have physical characteristics that may require blasting or backfilling to comply with such regulations, thus increasing reclamation costs. Fill material is subject to settling and needs to meet engineering standards for future use. Typically, along the Front Range of Colorado, reclamation of sand and gravel pits involves reducing side slopes, spreading topsoil, and establishing vegetation on the side walls, with a shallow lake covering the pit floor. Colorado law (1995) requires slopes no steeper than a ratio of 2:1 (horizontal to vertical ratio), except from 5 feet above to 10 feet below the expected water line, where slopes cannot be steeper than 3:1, when a lake or pond is produced as part of a reclamation plan. If swimming is to be permitted, the slope cannot be steeper than 5:1 in the swimming area. Safety benches are not specified. Wildlife also prefers gentler slopes yet high banks are the norm in reclamation. Nothing is mentioned in the regulations of the importance of nonlinear shorelines (coves), shallow waters, and islands for habitat value. Anticipating shallow waters can be the starting point for wetland design.

Dry and Wetlands

Reclamation of a mining area is commonly influenced by elevation above or below the water table. There is broad historical precedent for any number of successful after-uses: conservation, recreation, public facilities, commercial/industrial, residential, recycling, and storage. Agriculture is most needed in rural areas while recreation is useful for urban centers. The shallower slope of sand and gravel pits, requiring less earth moving and grading than quarries, makes them better suited for reclamation to residential, commercial, and agricultural uses. Sand and gravel mines are discouraged for use as landfills but offer great potential for lakes and retarding basins. Wet bottoms are more suitable for bird habitat or development for water sports. Table 2 summarizes various after-uses identified in the literature. With surface mining viewed as an interim use, planners and operators need to think of the long-term objective when impacting the water table.

TABLE 2.--Types of after-use for mines located below (wet bottoms) or above (dry bottoms) the water table. [# = sand and gravel pit, * = hard rock quarry]

LAND USE	WET SITE	DRY SITE
CONSERVATION	Fish Spawning #	Native Plant Revegetation * #
	Passive Lakes	Wildlife Habitat * #
	Aquatic Habitat * #	Historical *
	Waterfowl Habitat * #	Nature Center * #
	Riparian Habitat #	Threatened/Endangered Species * #
	Wetland Habitat * #	
	Beach Restoration #	
	Stream Restoration #	
	Threatened/Endangered Species #	
RECREATION	Active Lakes	Botanical Garden * #
	Waterslide Resort #	Golf Course * #
	Swimming * #	Casino #
	Water-skiing #	Hiking, Bicycle & Horse Trails #
	Fishing * #	Motorcycle Track #
	Boating & Sailing #	Theme Amusement Park #
		Public Parks # *
		Hunting, Camping #
		Soccer, Football, and Baseball Fields #
PUBLIC FACILITIES	Harbor *	College Campus #
	Tidal Pool *	Hospital #
	Sculptural #	Restaurant #
		Amphitheater * #
		City Hall *
		Sculptural * #
		Permanent Easement for Utilities & Highways* #
COMMERCIAL/ INDUSTRIAL	Academic Research * #	Academic Research * #
	Ferry Terminal *	Light Manufacturing #
		Office #
		Shopping Center * #
RESIDENTIAL	Sewage Treatment #	Housing * #
	Water Quality Improvement #	
RECYCLING	Ground Water Recharge #	Pasture * #
	Wastewater Treatment *	Cropland * #
		Forestry * #
		Composting #
		Methane Production *
STORAGE	Water Supply * #	Livestock Shelter *
	Flood Control #	Equipment *
	Inert Fill Material #	Food *
		Trains (city transit) #
		Cemetery *
		Sanitary Landfill * #

Although constructed wetlands are not the same resource as natural wetlands, they are capable of providing wildlife and recreational benefits while moderating and improving the quantity and quality of water. Wetlands are the subject of frequent argument and were sometimes considered waste areas to be filled or drained to make 'productive' lands. Once justifiably associated with mosquitoes and disease, misconceptions continue about wetland value. The rate of wetland destruction has slowed, but "over a period of 200 years, the lower 48 states have lost an estimated 53 percent of their original wetlands" (Dahl, 1990, p.1). A high percentage of wetland losses is attributed to agricultural land conversions. The term wetland is broadly used to describe areas that are transitional between terrestrial and aquatic systems. Wetlands include swamps, bogs, marshes, fens, and even certain bottomland forests, meadows, and floodplains. These areas play an important role in the environment by supporting specific aquatic, soil, and vegetative life. Geologically, wetlands are dependent upon disturbance or cyclic fluctuations in hydrology and will fill in without seasonal flooding. Mining reclamation can take a lead in both the research and demonstration of wetland production. The Des Plaines River Wetlands Demonstration Project in Lake County (north of Chicago, Illinois) utilized three abandoned quarry lakes in reconstructing wetlands for wastewater treatment (Smardon, 1989). Littoral zones (the area between shoreline and a depth of about six meters), a sediment trap for suspended solids, and backwater areas were constructed through the quarries. The experimental project will aggrade the river system and provide information on economic, ecological, aesthetic, and recreational benefits. Smardon points out a key question is whether user and public groups are able to perceive the benefits and whether this translates into public acceptance (p.293).

Water tables become an issue if the site is excavated into shallow aquifers. In alluvial valleys, where ground water could seep into sand and gravel pits, it is sometimes cheaper to let the site simply become a water storage facility by lining the pit with clay. That is changing with stricter water rights. Colorado requires the operator to make up the volume of exposed ground water lost to evaporation. Sites for future water storage may involve the purchase of water rights first, so no longer is this a cheap method of mine reclamation. Pit sites above the water table can be returned to certain pre-mining conditions more successfully (such as agriculture) than pits below the water table.

Natural and Cultural Patterns

In analyzing mine patterns, one recognizes elemental forms and identifes design opportunities. Bare and severe landscapes are considered unattractive unless a strong bold pattern can be detected. Antelope Canyon in Utah is a natural architectural wonder not unlike an abandoned hard rock quarry. The landscape character of irregular topography, steep vertical stone walls, the possibility of water, and a variety of microclimates are advantages to designers. The disadvantage is the vast areas modern equipment can excavate on a scale dwarfs the individual experience and if unreclaimed, can remain noticeable and desolate for years in arid climates. Low temperature, wind, and short growing season are other climatic factors that can hinder reclamation efforts, mining and slow land recovery. A number of terms are needed to illustrate some general attributes of hard rock quarries and sand and gravel pits. Landform refers to the image from a broader perspective, while enclosure is defined by the proximity and form of the overhead, base, and wall planes (in the case of mining, by the subtraction of mass). In both cases, quarry and pit, the space is not fully enclosed. Rather it is implied by the wall edge and level changes, termed inscribed space. The visual zone is that area which can be seen from the mine floor while the perspective view is from outside that zone.

Configuration is the basic spatial distribution of mines within the regional landscape. Consolidated rock quarries usually comprise large areas of the resource and operate for a longer duration (generally upwards from 30 years, some for more than 100 years); waste production is small. Sand and gravel operations tend to a larger number of pits occupying smaller narrow winding strips, due to the relatively small volume of available material, across the landscape with a shorter life span (often 15 to 30 years); little waste production. These are broad categories and not meant to be comprehensive. Table 3 lists the different attributes for quarry and pit mining.

TABLE 3.--Natural patterns of hard rock (quarry) and sand and gravel (pit) mines

NATURAL FORM	QUARRY	PIT
Space	Large-scale, deep	Medium-scale, shallow
Mass	Vertical	Curvilinear
Color	Light & shadow	Gray
Texture	Angular	Rounded
ENCLOSURE		
Perspective View	Perpendicular	Planar
Visual Zone	Shortened	Extended flowing lines
Configuration	Areal--Single large area	Linear--Narrow strip
GEOLOGY		
Origin	Magmatic, metamorphic, sedimentary	Stream valley and terrace, glacial deposits, marine terrace
Slope	Steep	Gentle
Soil	Unstable Faster weathering	Rather stable Slower weathering
Water	Retentive floor surface Less infiltration on slopes	Permeable floor surface Greater infiltration on slopes
Scarcity	More plentiful in East	More plentiful in West
Wildlife Habitat	Moderately complex	Simpler
CULTURAL		
Metaphor	Mountain, creation	Water, entropy
Mining Impact	Blasting, highwalls, smaller quantity of waste	Settling ponds, sometimes significant quantity of waste
Longevity	Long-term	Short-term

The emotional response to a landform is related to the use of metaphors. In Japan, since Zen Buddhism arose in the late 12th century, stone has been used to create **abstract nature,** a microcosm, or a view of the universe. For an eastern aesthetic, sand and gravel are natural elements to be designed, groomed, and raked into a contemplative dry landscape, **kare-sansui**. An ideal for the mind, water is suggested with coarse sand, and mountains (landforms) are symbolized by rocks. Empty space itself becomes as important as the surroundings. Ryoan-ji, Kyoto, Japan, is the most famous example (fig. 6). Raked river-bed quartz is bounded by a temple verandah, fifteen rocks are set out in five groups. The western eye can develop an appreciation for these minimal designs and recognize not all of nature is valued in green pastoral scenes. A sand and gravel pit offers more to be viewed and understood than "derelict" landscape. A photograph titled *Sorry,* at the Watari Um Museum in Japan, could be interpreted as representing the failure (or celebration) of construction materials as art (fig. 7). The site contains cement balls on a sand and gravel plane (7 meters by 7 meters). Imagine the same design laid out on a 2-acre site.

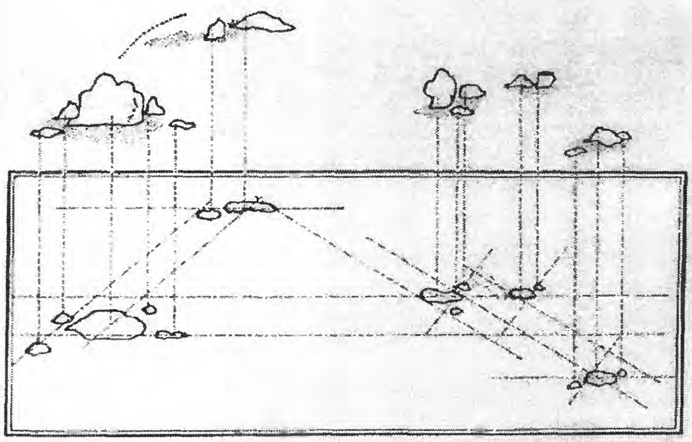


Figure 6. Ryoan-ji, *c.*1488-99. Within the Daiju-in monastery, Kyoto. From *The Landscape of Man* (New York: Thames and Hudson Inc., 1987) p.96. LEFT: Zen garden of contemplation. Photograph by Susan Jellicoe. RIGHT: Diagram showing plan view. Drawing by Geoffrey Jellicoe.

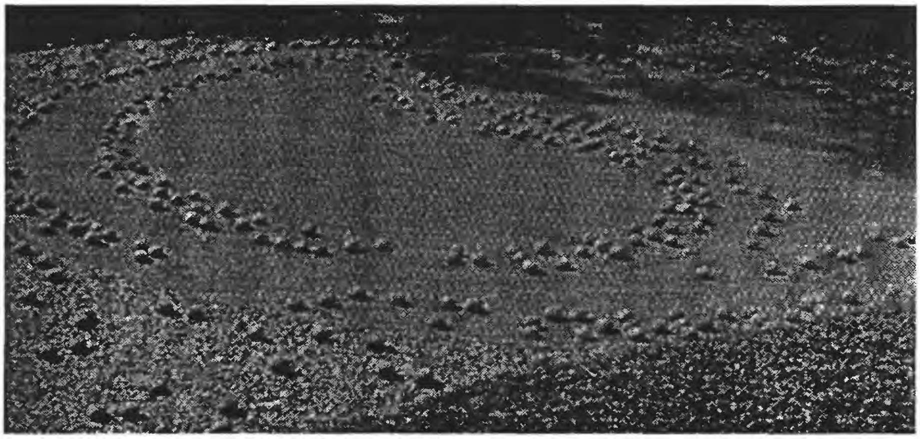


Figure 7. *Sorry,* 1995. Sand, gravel and 1,000 cement balls. Watari Um Museum, Tokyo.

AESTHETICS AND ECOLOGY

Many land-use decisions are not based upon visual attributes and aesthetics because these factors are viewed as 'nonscientific'. No matter how scientifically sound a mining operation may be, it is the visual impact that can generate immediate and vocal opposition. John Mills and others report there is a visual preference for the more diverse landscape (1995) yet confusion arises in what we expect nature to look like. The National Environmental Policy Act defines aesthetics as "the science or philosophy concerned with the quality of visual experience." We make aesthetic decisions every day in a basic biological way. The dress or tie I wear to work, the meal I choose at a restaurant, is subject to sensory resources including sight, smell, taste, sound, touch, and movement; all part of a physiological function. Webster's defines **aesthete** as a noun having or affecting sensitivity to the beautiful, especially in art. Everyone has an aesthetic sense with definable attributes and perceptions of nature/landscape rooted in culture, past experience, and evolution. It is the emotional response to a given landform that is highly personal. One hypothesis called **habitat theory** seeks to relate pleasurable sensations in the experience of landscape to environmental conditions favorable to survival. Aesthetics become simple pleasurable or anxious responses to the landscape and its ability to satisfy our biological needs.

It is in the visual perspective and understanding of landscape that individual heritage and life experience impact us. Landscape architects merge art with science in creating land forms with a social function, designing elements for a specific experience; recognizing a meaningful place connects us to the environment. One landscape can tell different stories to many people. Unconsciously, we compare new spaces with old, visually choosing familiar sights over unfamiliar. Local values impact a Dakotan finding the blank canvas of an open field more attractive than the dense understory woodland preferred by a Virginian. A farmer looks at fields of linear geometric patterns as signifying agricultural bounty, while an environmentalist may see soil erosion and poisons. The farmer views water as a necessary commodity for his crops, the hydrologist a precious resource to be saved, the geologist a factor in surface erosion, and the meteorologist an atmospheric measurement to help with weather predictions. All are valid points of view.

Figure 8. *Wheat Fields on Tablelands Cut by the Marias River.* Cutbank, Montana. Photograph by Alex S. McLean.

Our western concept of nature is predicated upon our visual bias favoring a 'clean, tidy' landscape. Culture is our beliefs, customs, economics, and social patterns, while nature is the flora and fauna in a community (including climate and geology). Death and decomposition are part of nature; realities considered 'messy' and experiences to be ignored or at least 'prettied' up by our society. A site may be designed well ecologically, but without public understanding of its function or positive visual reinforcement, it could end up doomed. Indigenous buffalo grass (*Buchloe dactyloides*) is looked upon by some people as a sign of an unkempt lawn since it is slow to green up in the spring, a natural dormancy character for adaptation to extreme weather conditions. Its value is low to people without an understanding of its biological function. A scientific experiment may involve contouring a mined-out pit to fit the surrounding topography, leaving nature to take its course. If the community perceives the site as messy and complains, the project has failed in the sense viewers are responding with a preferential judgment rather than evaluating the landscape from a natural process.

Webster's shows 'landscape' as a verb meaning "to modify or ornament. . . by altering plant cover" and as a noun, where visual connotations come to mind of scenic vistas and regional landforms. In the past, human beings viewed the landscape as wild and fearful; something to be tamed and controlled. If scientists and designers became familiar with the term 'landscape'more fully, they might see their work as beneficial. The interaction of people and place is a powerfull process. Landplanners, developers, and scientists are becoming more aware of the need to communicate in a common language. The word 'design' is also both a verb and noun. Wisely shaping our environment requires we prepare a plan with a scientific process (verb) and produce a product (noun). Design work for reclamation needs to respond to a site's physiography, ecology, function, artistic form, and public perception.

DESIGN APPROACHES

A study of landfill and sewage treatment by Mira Engler (1995) discussed eight different approaches to designing waste landscapes. Mining generates a disturbed landscape that many consider waste until it is reclaimed by nature or people. The language appears adaptable to reclaimed mine sites with minor reinterpretation of her terminology (table 4).

Table 4.--Design approaches to reclaiming mine sites.

AUTHOR'S LIST	ENGLER'S LIST	DESCRIPTION
Natural		Allow nature to reclaim site with no, or minimal human influence
Camouflage	Camouflage	Conceal mining facility using visual screens and buffers
Restoration	Restoration	Return the land to its approximate original contour
Rehabilitation	Recycling	Use site for public amenities
Mitigation	Mitigation	Repair a mined-out site from extensive human or natural damage
Renewable Resource	Sustainable	Recycle man-made or natural resources on site
Education	Educative	Communicate mining or other resource information through outreach
Art	Celebrative	Treat site as work of beauty and unique experience
Integration	Integrative	Combination of approaches integrating art and science

One approach Engler did not mention is the oldest one around--nature itself. A concept being used more and more by public agencies, it is recognized that people may sometimes do more damage going into an area in the attempt to repair it. Although a combination of the above approaches is most often applied, it is still useful to examine the specific categories with examples.

Natural

Wait long enough and no matter the disturbance, nature works to regenerate with or without help from human beings; thus the adage "time heals all wounds." A conscious natural design approach may be one of hands off. Some areas devastated by fire, landslide, volcanic eruption, or quarrying manage to recover well without human intervention. Land damaged by strip mining, where the top soil has been removed, are more difficult for new life to emerge. The same is true for man-made toxic lands or the endangerment of a species due to loss of habitat. Given enough geologic time, a small site scale, and stable (non-disturbed) adjacent ecosystems, disturbed areas recover without man's input. Alaska's moist climate, dense vegetation, and remoteness are suited for some abandoned pits to be passively reclaimed by nature. Heavy equipment brought in to recontour these old sites may do far more damage to the existing ground cover and surface soil than the benefit gained. Long-term natural recovery may or may not bring about the specific changes people find desirable. How many people living near Appalachian mining sites want to wait thirty years for hardwood seedlings to sprout? Disused quarries also offer an opportunity for 'pioneer' or early successional plant species to establish. In Scotland, the rare plant *Lychnis viscaria* usually occurs only on rocks and cliffs, but the plant is abundant in one disused quarry (Usher, 1978). Studying nature's ability to heal is one way scientists and designers can learn new techniques for reclamation, taking maximum advantage of natural geological and biological processes.

In Colorado, little remains of undisturbed prairie due to grazing and farming. Reestablishing short-grass prairie would provide a native vegetative cover that is self-sustaining, requires little maintenance, fertilizer, or water. Of great benefit is the establishment of wildlife habitat and the possibility of providing physical linkages for different areas of habitat. The initial cost to establish a prairie grass may be higher than conventional seed mixtures, but the long-term benefits are considerable. Adjacent to the Poudre River, Colorado, a sand and gravel pit was used to test natural seedfall for restoration of cottonwood (*Populus* spp.) and willow (*Salix* spp.). The WREN pit project, a cooperative study, was conducted by Western Mobile Corporation, Colorado State University, and the US Geological Survey. Controlled flooding was used to "simulate historic spring flooding conditions along the Poudre River" to establish vegetation (Gladwin and Roelle, 1997). Undesirable exotic saltcedar (*Tamarix chinensis*) seedlings were exterminated by timed floodings. With short seed viability for some seeds (for example, less than 2 weeks for willows) flood timing is critical (Manci, 1989). In arid regions, irrigation may be necessary for the first 150 days to ensure cottonwood roots gain access to the water table. The WREN pit is an example of semi-native riparian vegetation being used to reclaim a site with little human involvement and cost.

Figure 9. Cottonwood and willow restoration in a mined-out sand and gravel pit, Fort Collins, Colorado.

When health and safety become a factor, a natural approach may not be appropriate and some form of treatment may be required. Abandoned quarries can become dangerous water holes, filthy waste sites, or subject to land slides. Derelict sites often make news such as when closed granite quarries in Quincy, Massachusetts, are used for youthful rites of passage. Since 1963, twelve boys have been killed jumping into the deep pools of water (Sullivan, 1996). Such quarries may have impermeable floors that must be fractured for the rock to allow water drainage or require regrading of steep slopes.

Camouflage

Camouflage uses visual screens and buffer zones to conceal the mining facility. It is a cosmetic surface treatment of problems that have complex solutions. Typically, an immediate response by the industry is to utilize fences, earth berms, and plantings (small-scale features) to visually isolate the activity from residential areas. Sand and gravel pits are harder to camouflage than hard rock quarries because the ground plane is silhouetted against the sky. As an interim approach, the visual relationship between the project site and physical setting (large-scale features) and environmental patterns needs to be considered. The National Environmental Policy Act calls this relationship the "visual equivalent of good manners and can be very important to community acceptance of a project" (American Society of Landscape Architects, no date). Ideally, a natural buffer zone would remain undisturbed throughout the active mining phase but economics usually force mining as close as possible to the edge of the permitted area. Setbacks from streams are even more important environmentally and should be at least 200 feet wide (Norman and Lingley, 1992).

Figure 10. Vehicular entrance to mining facility. Photograph courtesy of Western Mobile.

The camouflage approach is frequently associated just with the site perimeter. Wide buffer zones are frequently abandoned in the interest of cost. Linear, uniform rows of quick growing plant species are commonly used for wind breaks and camouflage, and do not necessarily reflect a long-term planning scheme. A longer-term approach could include using quick growing species as part of a matrix containing slower growing native species matched to grow in overburden or spoil material. Another consideration should be the profound effect vegetation has on water (infiltration and erosion).

Operators and neighbors do not want noise and dust from an active mine. Nor does the state environmental protection division or US EPA want problems with dirty air and water. Exposed surface area is kept to a minimum while dust suppression is usually accomplished with pressurized water and a surfactant. Dry dust emissions are also controlled by filters on equipment. On-site equipment, accompanying vibrations and noise, also creates an impact and frequently needs to be screened. Engler points out that by masking sites, "we continue to inhibit public perceptions and restrain public care for waste problems" (1995, p.17). The reality is people want the product but do not want the inconvenience of its production. We all produce waste water but do not want to see beyond the toilet bowl. An educational opportunity is lost by pretending mining does not have an impact on the landscape. While some cities have made historical walking tours out of the miles of underground water and sewage pipes, western society prefers such infrastructure systems remain out of sight, hearing, and smell.

Peter Austin calls using landscape skills "merely to provide a cosmetic touch to an otherwise ravaged landscape, an exercise akin to putting lipstick on a pig" (1995). This may have been true in the past when reclamation took a backseat to exploration but there are still instances where a minimal approach is justified.

Restoration

Returning the land exactly to its original condition is a restorative approach. Mining is then considered a temporary activity that leaves a disturbed area requiring a return to its pre-mining biological conditions. Restoration as defined above is seldom possible because we do not currently have the information and skill required to return ecosystems exactly to their original structure. Germany has made attempts in coal mining, recording the location of every tree and rock in a premining survey. Furthermore, complete biological restoration is seldom possible because many native organisms do not return to the same ecological niche. Instead the new land will be environmentally unstable, and exotic species are ready to invade disturbed sites. Some states do not even require companies to remove and replace the topsoil. A more realistic approach is to restore the new habitat as close as possible to its original function and recapture the landscape character.

Planned, sequential mining of aggregate deposits accompanied by **concurrent** reclamation emerged in the mid-1970s (Carter, 1990). As each mineral section of a mine is depleted, reclamation begins segmentally. This is a different strategy from **progressive** reclamation where overburden is replaced when the minerals are removed. Progressive or continuous reclamation is frequently used in strip mining coal. If sand and gravel producers must blend different aggregate sizes from the site, progressive reclamation is impractical from a production standpoint. Earth moving is an expensive business. Concurrent reclamation reduces the amount of land disturbed at one time and enhances the final soil quality rather than attempting reclamation at the end of all mining. Costs are lowered as equipment is still on site and less earth is moved.

About a 15 percent loss of topsoil occurs each time it is moved and severe degradation occurs just in storage over time (Norman and Lingley, 1992). Traditionally, native seed mixes are spread over the disturbed area. Three other seeding methods may be used. The first 1) a **natural** approach has already been discussed. The others involve 2) bringing in clumps of soil containing seeds and plant material or 3) a technique termed **flailing** (English China Clays Int., 1997). Flailing involves collecting seed-bearing branches from the surrounding area, mixing the plants into a mulch, and spreading the seed mulch over the disturbed area. The advantage of these methods over commercially prepared seed mixes is a closer restoration to the local native flora.

As a reaction to landscape scars caused by coal mining, reclamation came to be legally defined as "back to approximate original contour." The recommendation of the Secretary of the Interior for reclamation was to correct damage to the lands and waters of the vicinity and leave the area in a usable condition (Simpson, 1985). Scientific data and budget constraints were not dealt with by public servants in reacting to the destructive practices of coal mining. Lawmakers reasoned in the 1970s that the best land use was to restore it to its original condition. Does that mean the way the land looked before European settlers arrived, before Indians set wild fires to the Great Plains, or prior to the last ice age? In attempting to reshape the land back to its pre-mining form, billions of dollars would be required to move millions of cubic yards of earth to fill thousands of acres for aesthetic purposes and it would still not meet 'original condition'.

If returning land to its pre-mining form were taken practically, the WREN Pit in Fort Collins, Colorado, would become a cattle feedlot again rather than a natural riparian landscape. The final design was an attempt to cover the former mining site with native vegetation (figure 11). During the 1920's, reclamation laws governed how mined-out land had to be restored to productive agricultural pre-use. Recovery of land for cultivation of fruits, seed crops, and timber may take years and has been successfully demonstrated, mainly in rural areas. Cherries, corn, alfalfa, and apples have been harvested on a former mined-out gravel pit in Ontario, Canada (Kuennen, July 1983). Exhausted sites have also been utilized for tree nurseries and saw timber. In the first years of reclamation for agricultural use, it is critical to limit harvesting and grazing. Thorough planning is essential to restore the topsoil and subsoil to minimum thickness. A growing number of people are demanding land reclamation be measured by how well the landscape functions, not by how well the landscape resembles the pre-mining form.

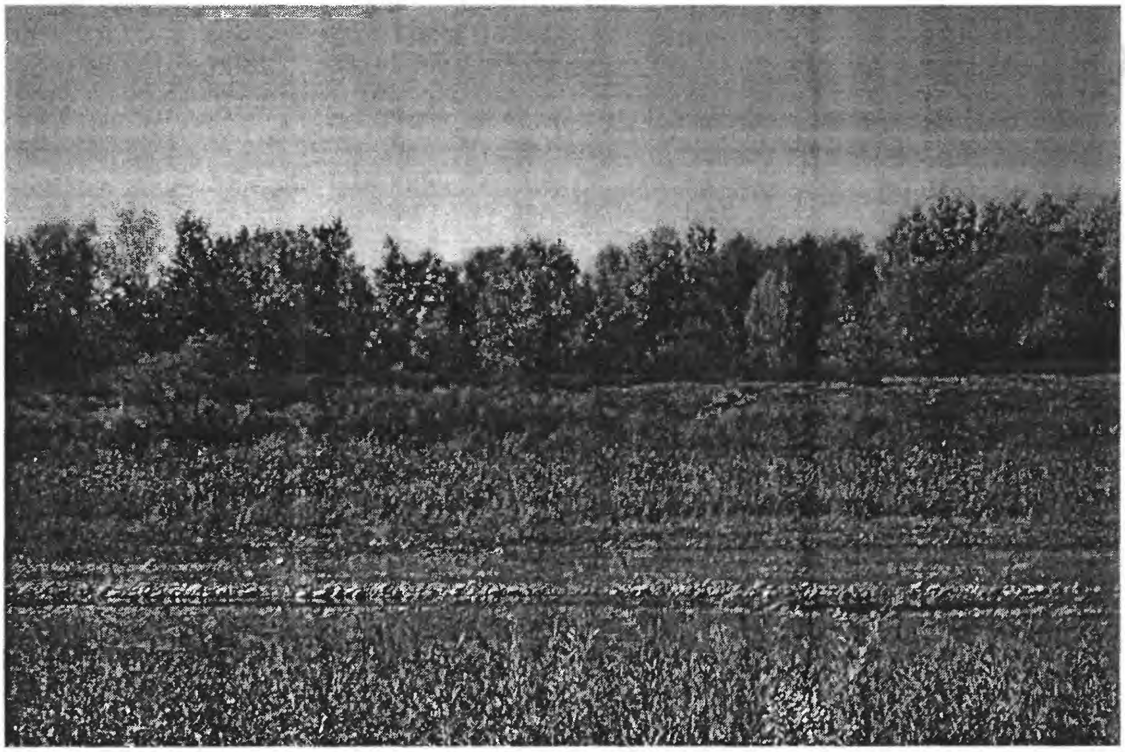


Figure 11. View west from within the WREN pit, east-central Fort Collins, Colorado.

Rehabilitation

A rehabilitative approach targets social or economic benefits by reusing the site for public amenities, most often in urban centers. The disturbed site ends up with a specific land-use plan for people. Developers are sometimes are allowed to expand their amenities into a mining buffer zone. Examples include (West and Block, 1994):

Utilities (potable water, sewer, gas, and power lines)
Storm water drainage
Highway right-of-ways
Recreation--
including horseback riding trails; baseball, soccer fields; a rod and gun club with skeet, target shooting; fishing in creek-fed ponds; meeting and banquet halls for social functions such as bingo, dances, weddings

The city of Hagen, West Germany, located its city hall on the site of an inactive quarry (Dietrich, 1990). Many of the natural rock outcroppings were left and the interior/exterior surfaces of the building made use of the surrounding rock. Golf courses have been built over abandoned quarries from New York to Florida, California to Texas. Some mining companies have even built golf courses while still operating, with years of reserves left. This frequently requires special permits for recreational use in a residential or commercial district. Townhouses, shopping centers, or industrial parks are other examples of a rehabilitative approach.

Near Mombassa, on the coast of Kenya, an abandoned quarry illustrates a more comprehensive rehabilitation plan. Once barren land, with almost no underground water, it is covered with grass and trees. Rene Haller, a Swiss agronomist, introduced agriforestry, animal farming (including cattle, sheep, oryx, tilapia, and crocodiles), and tourism to the wasted landscape at low cost (Myers, 1990). Rather than introducing monocultures, he took an approach in which everything, from farm garbage to regrowth of wood fuel, is interrelated.

There is a long history of quarries being used for horticultural purposes from gardens and orchards to parks. Beginning in 1904, Butchart Gardens in British Columbia, Canada, was reclaimed from fifty acres of an exhausted limestone quarry to a premier botanical garden. Opened to the public in the 1940s, more than a million visitors tour the site each year. This grand, artificial landscape is only one in a long line of quarries reclaimed as gardens, aesthetically pleasing to the public as cultural art, but ecological not a copy of nature. More recently, the Memorial University of Newfoundland Botanical Garden, Canada, approved a former gravel pit for use as an arboretum.

Figure 12. Before and after pictures of Butchart Garden, Vancouver Island, BC. Photographs courtesy of Butchart Gardens Ltd. LEFT: Historical photo showing the creation of flower beds in the sunken garden circa 1912. RIGHT: The Sunken Garden--Spring.

Thorpe Park (near London, United Kingdom) is an amusement park developed on the site of an active sand and gravel operation (Dietrich, 1990). Such intensive interim use as a tourist attraction is unusual in the industry. Oakwood Lake, in the San Joaquin Valley, California, is a commercial waterslide park with a 6,000 seat amphitheater in a reclaimed aggregate mine (Mencacci and Carter, 1989). There are people with fond memories of swimming in quarries renovated with diving platforms or scuba diving facilities (Canham, 1986). In the 1950's, near northwest Toledo, Ohio, one exhausted limestone quarry/swimming hole even had an outdoor dance floor and orchestra shell where the big bands (including Tommy Dorsey and Benny Goodman) played (D. Knepper, oral commun., 1998). Rehabilitation is a frequent design approach in urban areas with large population centers.

Mitigation

Some mined areas have undergone major changes, either human or natural, after mining. A mitigation approach attempts to include scientific input to protect the environment and return these mined areas to beneficial use. Environmental data utilized in mitigation planning include: geomorphic setting, watershed, viewshed, hydrology, soil and waste characterization, climate, vegetation, wildlife habitat, and historical.

Companies in California and the United Kingdom have used mined-out quarries as authorized landfills with the resulting methane sold for profit (Kuennen, September 1983). The future use of quarries for landfill is questionable given the need to protect ground water aquifers. Some states have enacted bans on mined-out aggregate pits for landfills because of ground water contamination fears due to the permeability of sand and gravel floor surfaces. Excavated sand dunes are harder to reclaim due to steep slopes and lack of overburden. Resulting sand tips can remain barren for years without human intervention so industry is focusing on research to improve the reclamation.

English China Clays developed the needed expertise in establishing vegetation by means of hydroseeding and the early grazing of sheep to build up soil fertility (1997). Hard rock quarries are more expensive to grade and yield steeper slopes but the design opportunities are extensive. Blasting the side walls to create talus (coarse angular rock fragments at the base of steep rock slopes) and sculpting the slope to blend with surrounding landforms aid in creating a more natural landscape. On quarry or pit sites, large stones and wood can be recycled for reptile and invertebrate habitat.

Illegal dumping can seriously degrade a mined-out site. The Department of Defense and Atomic Energy Commission dumped contaminated debris into the 9-acre Weldon Spring Quarry (30 miles west of St. Louis, Missouri) for nearly thirty years (Department of Energy, 1996). Groundwater contamination spread toward well fields that supplied homes and industry throughout the area. Cleanup of the bulk waste began in 1989 by the Environmental Protection Agency (EPA) Superfund Program and the State of Missouri. Beginning in 1993, 120,000 cubic yards of contaminated soil, rock, and metal were removed to a temporary storage facility. This left over two acres of quarry floor and up to 60-foot highwalls (figure 13).

High quality clay soil is required to construct the permanent disposal facility and make it impervious to water. Nearly 2 million cubic yards of clay will be excavated from over 200 acres of land in nearby Weldon Spring Conservation Area. In this case, the cleanup of one mine site requires the construction of another. What sounds like a fairly easy decision, to restore a quarry, became a draft plan requiring approval of the EPA and state. One decision is whether to: 1) plug the quarry on the upstream side for water containment or 2) let the water run through the quarry and continue groundwater remediation downstream.

Figure 13. Quarry at Weldon Spring, Missouri. Photographs courtesy of Morrison Knudsen Corporation. ABOVE: The visual effect of dumping operations from 1940's to 60's. Waste types included TNT/DNT, thorium, radium, and uranium. BELOW: Excavated quarry basin.

Nature can also degrade mined-lands. Over a 35-year period, Cooley Gravel Co. extracted more than 26 million tons of aggregate from a site along the South Platte River, Colorado. Floods in 1965 and 1973 breached levees and changed river channels, with catastrophic impact on the land. Cooley reclaimed the land and donated 425 acres to the city of Littleton. Today, together with adjacent land dedicated by Littleton, South Platte Park is one of the largest wildlife parks within city limits in the United States. Cooley worked closely with a number of government agencies, including the South Suburban Park and Recreation District, Army Corps of Engineers, and Soil Conservation District.

The design incorporated native seed mixes, trails, fishing along the South Platte River, and the opportunity for educational tours a the Carson Nature Center.

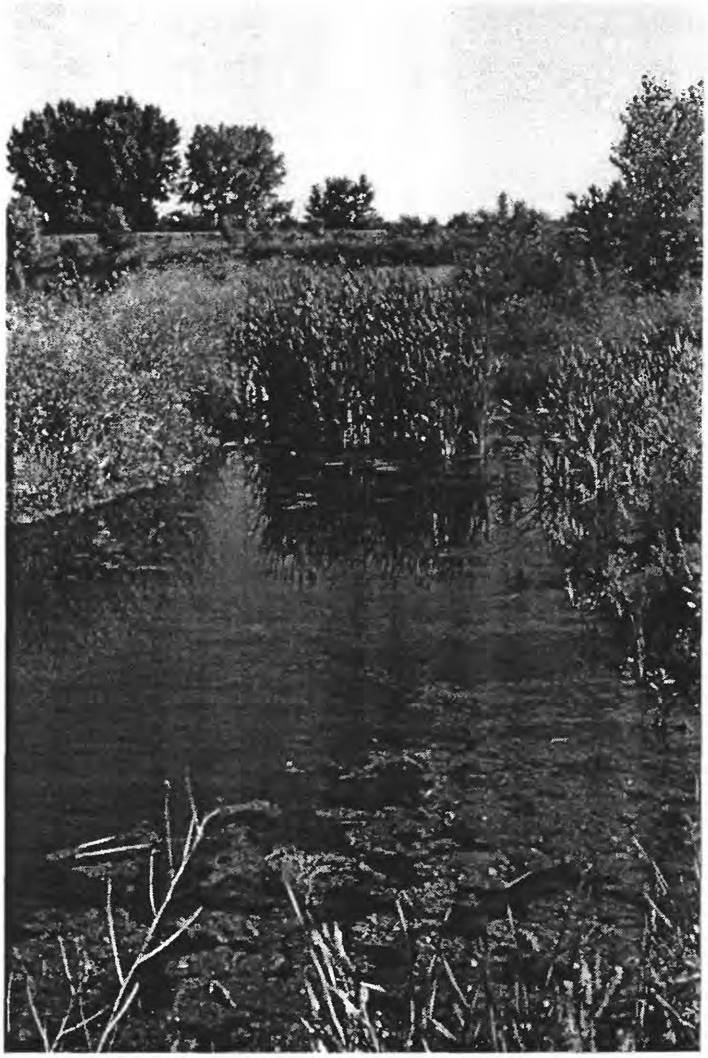


Figure 14. ABOVE: Aerial view of South Platte Park, Colorado, 1988. Photograph by Bill Bevington.
RIGHT: 10,000 Trees Wetland Lake #2, South Platte Park. Photograph by Raymond Sperger.

Efforts to mitigate the biological impact of mining include industry, state, and federal agencies. States check for endangered or threatened species within an area proposed for mining. The Preble's meadow jumping mouse (*Zapus hudsonius preblei*) is listed as a "threatened" species under the federal Endangered Species Act (Gerhardt, 1998). With the mice residing in moist lowlands with dense vegetation along the Front Range, there could be an impact on gravel operations close to waterways.

The Department of Geology and Mineral Industries in Oregon awarded the Oregon Concrete and Aggregate Producers Association for their work in improving salmon habitat. This was accomplished by

> "connecting off-channel ponds in the floodplain to provide rearing habitat for young coho salmon. Historic farming practices and urban development have eliminated natural backwater areas needed for migrating fish" (Priem, 1997, p.29).

The Torrance Quarry, west of Pittsburgh, Pennsylvania took steps to preserve the endangered eastern woodrat in cooperation with state officials (article in *Stone Review,* February 1997). Woodrat habitat was not mined and a run was constructed to provide shelter and connect two areas.

Renewable Resource

Mined-out land can be a source of, or a place to process renewable resources. Renewable resource use is a complex issue and implies that a project has environmental sensitivity, biological controls, and results in a reduction in resource/energy inputs. Engler terms the approach sustainability. . .a concern with the economics, conservation, and self-sufficiency of a site. Conservation land management is similar in requiring human input to maintain the renewable conditions. Nature has a hand in minor renewal of some sand and gravel deposits **(alluvial)** during floods. An important resource, thin or small deposits of sand and gravel can be moved downstream, where they collect into larger workable deposits from floodplains and terraces (Bliss and Page, 1994). It is extremely difficult to implement a sustainable design on a micro-landscape scale. In a real sense most projects are not sustainable since there is usually an impact outside (output) the project site on the larger surrounding region. Land managers realize that incompatible land uses and artificial boundaries make it difficult to maintain the ecological integrity of a self-sustaining system even within large parks such as Yellowstone.

One method for sustainable landscape is where minimal land management allows succession to occur. Termed **protected-natural** landscapes, buffer zones are added to prevent human input affecting the local site (Franke, 1996). In mining reclamation, wide perimeter setbacks might be an example. The second term, **modified-self-sufficient** landscape minimizes inputs and ecologically harmful outputs. Reclamation of gravel mining pits at the Farm (Boulder Valley, Colorado) to wetlands is an example. One of the most dramatic effects that human beings have on the ecosystem relates to loss of wetlands. During the period 1780's to 1980's, Colorado lost about half of its wetlands (Dahl, 1990). The Farm design incorporates oxbow lakes and more than 39,000 plants native to prairie wetlands in a hundred-acre site (Leccese, 1996). One important aspect of this project is the operators' recognition of their impact on natural riparian ecosystems and the renewal of water resources.

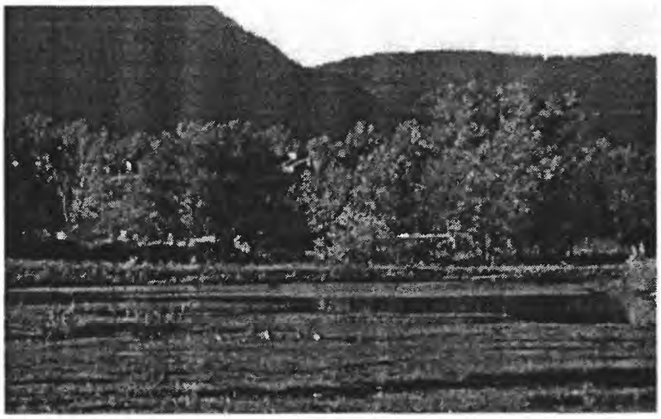


Figure 15. Restored wetlands from gravel mine site, Boulder Valley, Colorado. Photograph courtesy of Western Mobile.

Silver Creek Materials has a composting operation on its sand and gravel site in Fort Worth, Texas (Turley, 1995). The term **modified-redeveloped** landscape is applied to a system where ecological management is as important as financial profit. Other examples are mine sites where power companies dump tree trimmings, local dairies ship manure, waste haulers bring biodegradable materials, and local residents can purchase compost in bulk. The mining company is able to make use of equipment already on site, protect their investment, and continue to run a viable business. Where gravel pits are in farming or ranching country with resultant excess manure, a cooperative agreement between mine operators and neighbors could lead to production of on-site soil amendments. Transportation costs continue to be a big factor in the economics of renewable resources.

For some experts, a sustainable relationship with the earth will only come about by controlling growth, reducing our consumption of goods, and preserving diverse landscapes. Recognizing the limited supply of mineral resources and encouraging recycling efforts are beneficial steps. England and Wales have established planning guidelines, whereby one objective is to reduce the proportion of stone removed from land, from the current 83 percent to 68 percent, by 2006 (Richardson, 1995). A tremendous amount of construction material is wastefully landfilled and is an under utilized resource. The current reuse of cement, building rubble, and macadam meets only about ten percent of the demand for aggregate. Old building foundations, lintels, and broken pavement can be used to construct fountains, pools, and retaining walls.

Figure 16. Sandstone fountain and pool, located in the central courtyard of NEC America headquarters in Hillsboro, Oregon, constructed of old building foundations and lintels. From *Landscape Architecture* (Washington, DC: ASLA, 1989) p.90.

Aggregate base course, screened rock, and structural backfill have been processed for highways, airport runways, hotels, and sports arenas. Unfortunately, recycling programs do not play a significant role in reducing consumption. Some mine operators contribute to reuse by saving a location for recycling of concrete, macadam, glass, and other resources. There is a usually a minimum fee to dump concrete and asphalt debris for recycling. Unless one is a large contractor and customer, the collection fee (from $12 to $40 a load) for disposal and handling is not waived. For the individual, recycling makes sense from an environmental standpoint. Depending upon sanitary landfill fees and hauling distance, the effort may or may not make economic sense.

Figure 17. Recycled asphalt for other projects (Recycled Materials Co.).

Crushing asphalt and concrete on site for reuse can be of benefit in public works. Recycled Materials Co. (based in Arvada, Colorado) brings a portable processing plant, including crusher/pulverizer, conveyer, and screens, to projects for a fraction of the cost of disposal. Broken concrete (a magnet separates the steel for scrap), asphalt, and masonry rubble are crushed to specification, including state Department of Transportation requirements, with a typical price around $5 per ton. Mobilization fees are extra and vary with scale of operation and distance to the site.

Mixed-color glass is also recycled as an ingredient in Enviro-Fill, a self-compacting, flowable structural fill for public utility works, first used in 1995. The product (25 percent processed glass, 75 percent aggregate and flyash--a byproduct of coal-fired power plants), was developed in a public-private partnership with three organizations: Western Mobile, City of Boulder Environmental Affairs and Public Works Department, and Eco-Cycle. Enviro-Fill is considered an environmentally friendly construction material and helps extend the availability of landfill space.

Figure 18. Stockpile at Western Mobile Boulder's Glass Crushing Center. Photograph courtesy of Western Mobile.

Education

In the educative approach one tries to effectively communicate mining information through outreach, so that citizens can make informed choices about future land use. Europeans tend to be ahead of the US in this regard, perhaps, due in part to their limited available land. They also focus on aesthetics as much as the functional after-use. For example, scientists in the United Kingdom have understood the importance of gravel pits as habitat for birds since the 1930s and 40s. A 200-acre site of reclaimed land in Cambridgeshire, United Kingdom, is a nature preserve with more than 160 species of birds observed. The ECC Quarries reclamation of a sand and gravel mine has been listed "Sites of Special Scientific Interest" by the Nature Conservancy Council (Carter, 1990). At the Caistron nature preserve (created by the Ryton Sand and Gravel Group) masonry and wooden blinds await visitors viewing wildlife (Dietrich, 1990). ARC Ltd. (Buckinghamshire, UK) has researched reclamation of sand and gravel pits for nature conservation in an open-air experimental laboratory for over twenty years.

Figure 19. NSA/ASLA Student Competition First Place: Linda Attaway, Mary Dewing, University of Colorado at Denver. From *Landscape Architecture* (Washington, DC: ASLA, 1991) p.79.

In the U.S., The National Stone Association (NSA) and American Association of Landscape Architects (ASLA) jointly sponsor an Annual Landscape Architecture Student Competition, aimed at giving aggregate operators new ideas on reclamation and beautification. Unfortunately, the NSA does not keep historic records of the winning entries other than names. Judged on creativity, practicality, and design, winners earn cash prizes and an opportunity for feedback from the producers. The first place winner for 1991 was published in *Landscape Architecture* and provided an environmental retreat "for the gathering of people to confront and resolve pressing environmental issues for the 21st century" (Thompson, p.79). These tantalizing projects have been going on for 22 years and are worthy of being archived for future reference. A yearly publication of private, governmental, and industry awards for reclamation efforts would raise public awareness of mining land stewardship.

A small (12-acre pit) mining operation cited as an example of land stewardship and community service in this country is Davis Sand and Gravel, Sequim, Washington (Smith, 1997). Geology and forestry students from the local college tour the site as part of their studies and the company supports the conservation district and high school.

Wildflowers and trees follow a planting of cover crops; nursery plants are irrigated with recycled water from ponds that provide waterfowl habitat. Runoff water is collected in the ponds and tested monthly for pH. On another operating scale is a mined-out 640-acre gravel pit purchased by Pierce County, Washington, that includes 2.5 miles of Puget Sound shoreline (Thompson, 1997). Utilizing biosolids generated from an adjacent wastewater treatment plant, the county, in cooperation with the University of Washington, is developing a research and demonstration program for reclamation of the mine.

The Nature Conservancy restored a 65-acre gravel pit next to the Bluestem Prairie Preserve, Minnesota, as a test site. The reclamation was expensive (due to burning, spraying for exotics, contouring) and lacks native biological diversity (Breining, 1996). Costs would have been reduced if land had been graded while equipment was still on site for operations, but the project is still considered successful by the Conservancy. The Minnesota Department of Natural Resources is restoring two gravel pits in Buffalo River State Park with locally harvested native prairie grasses.

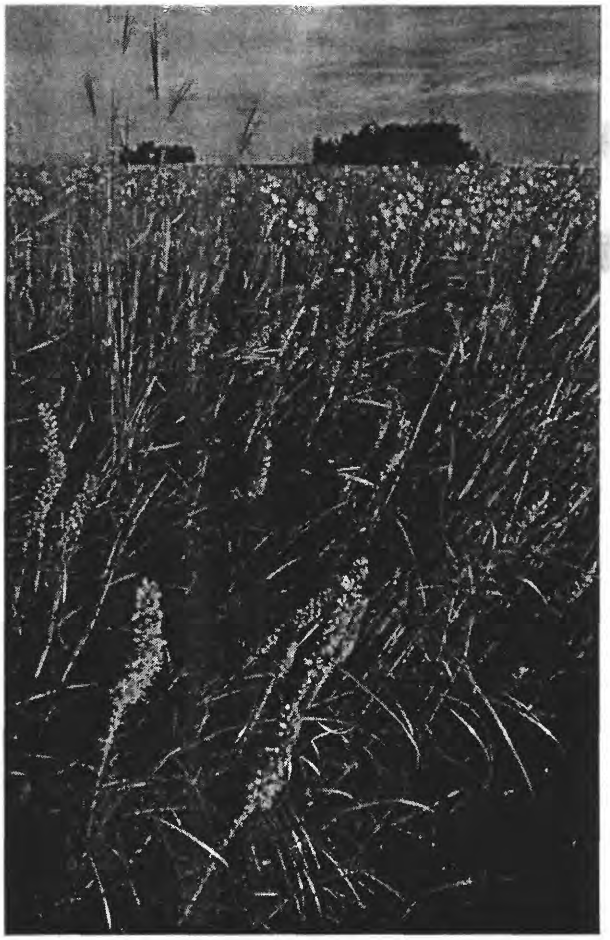


Figure 20. Complex vegetation of the Minnesota prairie. Photograph by © Richard Hamilton Smith.

In Alaska, the NPS Geologic Resources Division is studying a comprehensive sand, rock, and gravel resource plan for Katmai National Park and Preserve. The intent is to achieve maintenance goals while reducing impacts to natural resources (Ziegenbein, 1997). Parks need to quantify existing and new resource needs and assess environmental impact from extraction. With fifty existing sand, rock, and gravel pits (forty are abandoned) at Katmai, only one is being considered for long-term use. The site is being considered for reopening because it is naturally well hidden and contains quality material. One long-term plan is to mine large slugs (twenty-year supply) and reclaim the slopes immediately. The stockpile is then left for future use and the cost of keeping equipment on site is minimized. One proposal is to use the gravel site as an interpretive opportunity during bus tours. The goal is to raise visitor awareness that their presence requires infrastructure and thus mining.

Another example of educational outreach is in Albuquerque, New Mexico, where Western Mobile replaced the grass lawn at its corporate headquarters with a xeriscape garden. The ground cover, parking lot, pavement, signage, and building make use of aggregate and help educate people and promote the industry's products. The garden requires about 10-20 percent of the water previously needed and is open to the public.

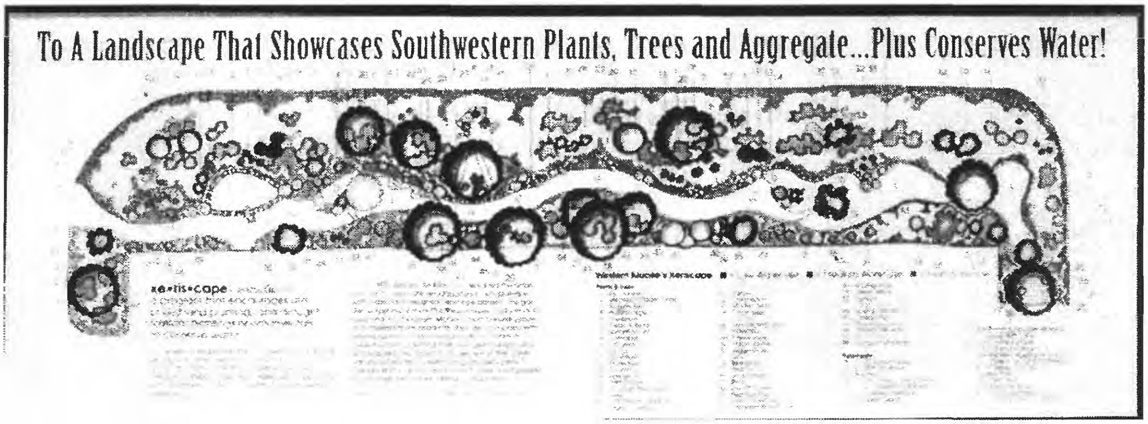


Figure 21. Western Mobile's xeriscape garden in Albuquerque, New Mexico. Courtesy of Western Mobile. ABOVE: Plan showing vegetative scheme. BELOW: View showing the relationship between pedestrian walkways and the "borrowed landscape" of native plants and aggregate

Research by the industry includes plots planted and tested by Angell Brothers, Oregon, for revegetation techniques and species selection over the next twenty years (Priem, 1997). Scientific investigations have led to publications regarding the following:

Optimal soil preparation and compacting
Appropriate landforms
Treatment of overburden (topsoil and subsoil)
Runoff water, subsurface drainage
Waste used as backfill, methane gas production
Vegetative mixtures, plant species for best survival and vigor

Specific research and demonstration areas within the U.S. on mined land reclamation need to be preserved and listed. Similar to the *National Register of Reclamation Research and Demonstration Areas on Mined Land* (Ashby, 1992), the proposed publication would cover non-metallic mining. The current publication emphasizes lands mined for coal.

Art

An artistic approach is one where the site is celebrated as a work of beauty and unique experiences. Engler categorized the approach as celebrative; people can become fully aware of the connection between the production of an item and their everyday lives. One pioneer in the earthworks-as-art movement was Robert Smithson. Smithson made field trips to abandoned quarries and experimented with the sculptural qualities of earth, calling such projects **abstract geology** (Bourdon, 1995). He proposed "Art can become a resource that mediates between the ecologist and the industrialist" (Holt, 1979). Smithson explored the sculptural potential of asphalt and mud, specifically gravity and viscosity (Bourdon, 1995). In 1969, a truckload of asphalt was poured down the side of a quarry near Rome. The extreme piece, titled *Asphalt Rundown,* does not qualify as environmental reclamation. Sites examined include Smithson's *Broken Circle*, Parc des Buttes-Chaumont, Aexoni Quarry, *Opus 40*, and *Untitled (Johnson Pit #30)*.

The public Parc des Buttes-Chaumont in Paris (*c.*1864-1869) is "the most dramatic early example of the art of landscape to re-create shape and form from apparent waste" (Jellico, 1987, p.257). Designed by Adolphe Alphand, the park was built upon old quarried limestone and gypsum pits, abandoned gallows, a sanitary sewage dump, and a mass grave. After reclamation, Parisians could stroll "aimlessly while observing the city's changing physical and social structure" and appreciate "artistic urban accomplishments" (Meyer, 1991, p.19). Four grass mounts and an island were sculpted from the quarry with infrastructure including iron bridges, cafes, gatehouses, and a railroad. The mounts presented different panoramas of the urban landscape, including Montmarte. The site's geology was celebrated with a limestone cave, including artificial concrete stalactites. From a historical standpoint, the subsurface structure of the quarry is "preserved" in a grotto complete with an engineered water fall. Alphand superimposed the technology of his time, using concrete and metal, into a park meant to reflect that culture, not as a re-creation of nature. Views of the built environment were important with walking being the primary recreation.

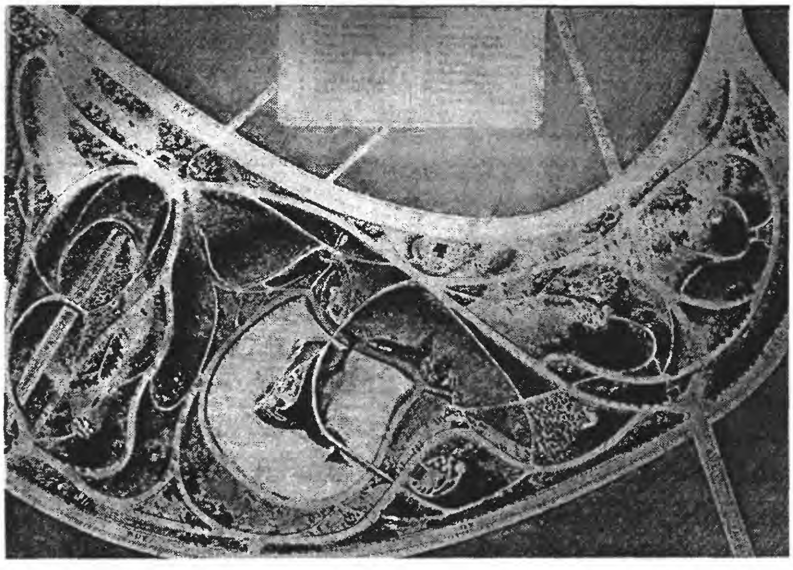


Figure 22. Parc des Buttes-Chaumont, Paris. From *Les Promenades de Paris* (1867-73) in *The Landscape of Man* (New York: Thames and Hudson Inc., 1987) p.257.

A sculpted quarry at Aexoni, Greece, celebrates music and dance, while the natural landscape is acknowledged, thus expressing the Greek philosophy of the unity of all things. Completed by the local municipality and Ministry of Regional Planning and Environment in 1992, the functional end use is to accommodate performing arts and exhibitions. This can also be viewed as an example of the ***rehabilitative*** approach. Regional vegetation was planted and sculptural forms relate to adjacent rock formations (Golanda, 1994). Nella Golanda expressed the floor plane and backdrop of the stage design as an impression of excavation--a cave (figure 23). For today's generation it is more reminiscent of a space station's docking platform. In an abstract sense one can feel the intended spatial imagery and varied topography, but it is questionable if it re-creates a pictorial quarry. Quarries can make dramatic amphitheaters. One of the earliest and most famous Italian Renaissance amphitheaters was modeled about 1590 in the Boboli Gardens of Florence, Italy. The quarry had provided stones for the Pitti Palace.

Figure 23. Aexoni Quarry, Greece. Photograph by Dimitri Ualapodas. From *The New European Landscape* (Oxford: Butterworth-Heineman Ltd., 1994) p.145.

In the Catskill Mountains, near Woodstock, New York, is an old stone quarry (abandoned, ironically, due to the increasing use of concrete). Using traditional 19th-century tools and a pickup truck, Harvey Fite created display areas for his Maya-influenced sculptures through the 1940s and '50s (Dalton, 1985). In the early 1960s, he realized the quarry was a work of art in itself and moved the sculpture to adjacent lawns. Calling the quarry *Opus 40*, Fite constructed multiple ramps, terraces, steps, and pools in strong geometric forms reminiscent of a hardscape Italian garden. Today, weddings and concerts are held at the site.

A sand pit and body of water were utilized by Robert Smithson in 1971 to create a more open sculptural form. A circular jetty and canal, titled *Broken Circle,* was constructed in the Netherlands as part of an international art exhibition. About 140 feet in diameter, the symmetrical landform suggests yin and yang, inviting human passage. The earthwork also evokes images of dikes and polders that are the backbone of Dutch landscape.

Smithson became aware of the constant changes in nature and believed it could interact and enhance art on disturbed land. Flooding, evaporation, soil chemistry, and plant life would modify earthwork and site alike.

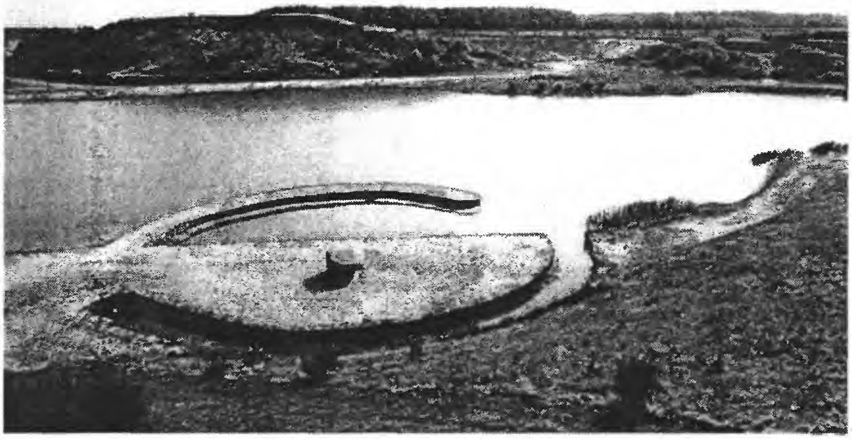


Figure 24. *Broken Circle.* Photograph by Pieter Boersma. From *Designing the Earth* (New York: Harry N. Abrams, Inc., 1995) p.214.

Another site-specific earthwork is *Untitled (Johnson Pit #30)* by Robert Morris, a minimalist sculptor. Sponsored by the King County Arts Commission, Washington, Morris formed an earth sculpture from an abandoned four-acre gravel pit in 1979. Emulating a strip mine with concentric terraces (Morris even cut down fir trees that had been growing on the pit rim), residents complained the site was simply being exploited once more. Morris said,

> *". . .the selling point was, is, that the art was going to cost less than restoring the site to its 'natural condition.' What are the implications of that kind of thinking. . . that art should be cheaper than nature?. . .The most significant implication of art as land reclamation is that art can and should be used to wipe away technological guilt. . . Will it be a little easier in the future to rip up the landscape for one last shovelful of non-renewable energy source if an artist can be found (cheap, mind you) to transform the devastation into an inspiring and modern work of art?. . . It would seem that artists participating in art as land reclamation will be forced to make moral as well as aesthetic choices." (King County Arts Commission, 1979, p.16.)*

For those who want to know what it 'means', Morris replies ". . .it does not seek control through explanation. That it offers the freedom to experience and question is not an opportunity that its audience always welcomes." The critical stance of Morris toward land disturbance, and his decision not to design an idyllic place, is understood a little better today.

A 1997 renovation of the site involved concessions to address residents concerns: more accessibility, interpretive materials, fencing and gated parking, improved drainage, and the rotted tree stumps replaced with "ghost trees" composed of pressed cedar.

Figure 25. *Untitled (Johnson Pit #30).* Photographs courtesy of the King County Arts Commission, Office of Cultural Resources. LEFT: Aerial view shows constructed descending concentric benches, cleared of trees and planted in rye grass. RIGHT: Perspective view from highway.

Integration

The combination of art and science in a "human-nature ecosystem where work and leisure coexist" is an integrated approach (Engler, 1995). Ideally, these become spaces of aesthetic merit, utility, fulfill recreational needs, protect fragile ecosystems, and relate to their unique cultural context (Rainey, 1994). Combining art with science has been ridiculed by professionals on both sides. Scientists complain of artists being imprecise, touchy-feely, subjective, making poor use of scientific information. Artists retort scientists are narrow minded, too specialized, and lose touch with aesthetics. Designers need information in a user friendly format and layperson terms. The public often considers scientists and artists elitist and isolated from the community they are supposed to serve. There is a common ground where all sides need to meet, understand each others' limitations, and take mining reclamation to the next level. In France, a multi-disciplinary team consisting of a departmental architect, two representatives of the associations for the protection of the environment and nature, as well as heads of the mines, agriculture, public works, health, and social surveys make up a commission to examine quarry sites (Arnould, 1994).

Oregon's state Department of Geology and Mineral Industries created a Reclamationist of the Year award for individuals who go beyond state guidelines. First awarded to Paul Ruff, a lead equipment operator with Rogue Aggregates, Ruff typifies the successful blending of art and science. Operating his bulldozer blade as an artists brush (Priem, 1997), Ruff instinctively moves earth in nature's own style. He creates sensuous landforms with irregular slopes, islands, complex pond edges, diverse habitats, and conserves large trees. Ruff has an unusual combination of artistic talent and heavy equipment experience that gets the job done efficiently for industry while acknowledging environmental needs.

In the past, exotic or naturalized plant material was used extensively in reclamation schemes. This mind set continued because of lower cost and short-term goals, such as erosion control and environmental tolerance (for example, drought or flood). Products used to stabilize the soil include: fibrous blankets, bog mats, **coir logs**, and **fascines** (Stein, 1997). Coir logs are made of coconut fiber and used in shallow channels. Fascines are bundled wands of living wetland shrubs placed along the stream bank. Using native plants with the goal of greater diversity is difficult given the lack of nursery stock, low availability of seed, and higher cost. Consultants are beginning to specialize in revegetation plans with native flora (including rare and endangered plants) and establishment of appropriate ecosystems--wetlands, riparian forest, savanna, etc. (Habitat Restoration Group, 1997). An aesthetic component is gained with native vegetation, providing an important balance to the landscape.

Perhaps there will be a return to the neighborhood swimming hole, prairie grasses, and recycling plants in abandoned pits. If a community has a sense of need for the reclamation end-use, there is a better chance for mining approval. Three representatives of the integrated approach are the Clay County Beach Ridges Forum, Quarry Cove, and *Effigy Tumuli*.

A portion of Minnesota has native tallgrass prairie over gravel resources. By addressing potential resource problems in both the macro and micro landscale before serious conflict arose, the Forum showed people (landowners, gravel producers, conservationists, government agencies) their common interests are stronger than their different viewpoints (1997). Selected viewpoints expressed in a report (Clay County Beach Ridges Forum, 1997) include:

- Maximize utilization of aggregate resources (the concept being to minimize land surface disturbance by exhausting the resource on an approved site by mining deeper and using aggregate resources of the highest quality when feasible)
- Promote aggregate recycling (including a public information fact sheet)
- Consider aggregate resources in future land use decisions throughout the county
- Provide incentives through the permitting process to avoid native prairie (one suggestion is to expedite the permitting process for proposals sited outside of prairie)
- Minimize development of new haul roads across prairie
- Use prairie grasses and forbs for gravel pit reclamation whenever possible

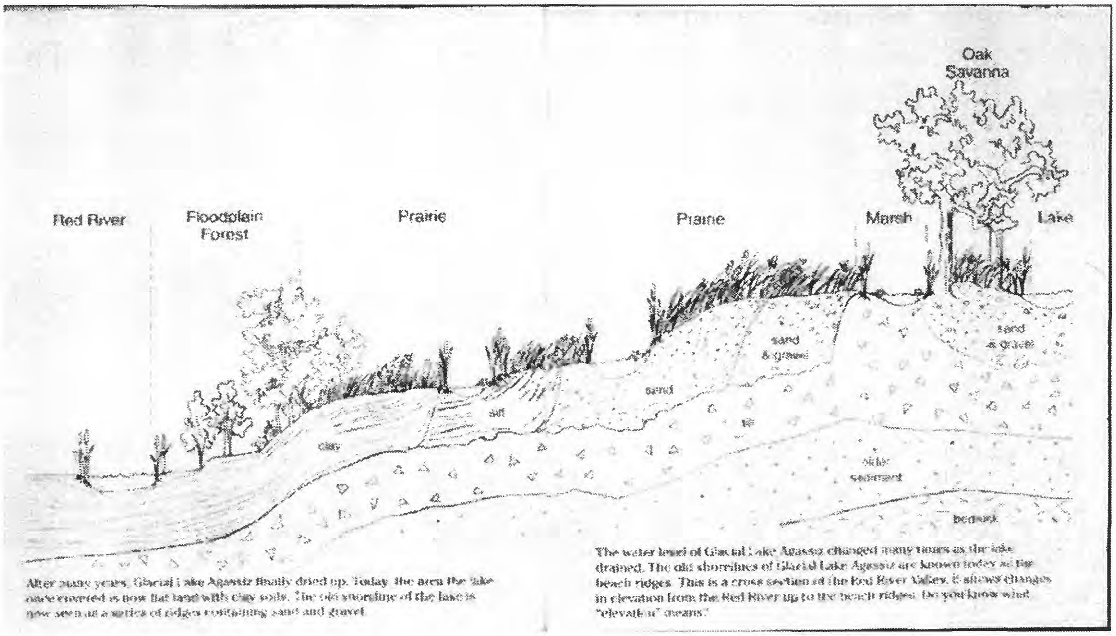


Figure 26. A tool "in teaching our children about working in partnership to achieve balanced natural resource management." From *Lake Agassiz Beach Ridges A Coloring Book for Children* (St. Paul, Minn.: Minnesota Department of Natural Resources, 1997) p.4-5.

Moving from the prairie to the Oregon coast is Quarry Cove, the first quarry converted into a man-made tidal zone fed and nourished by wave action (Thompson, 1996). Developed by the Bureau of Land Management, the site is wheel-chair accessible, provides a variety of wildlife habitats, and is expected to have species diversity comparable to a natural tidal pool within five to ten years. Graduate students in marine biology are conducting research and visitors can view nature taking its course as marine life invades the area. It is an exciting example of an exhausted site becoming a 'natural' biological laboratory with community outreach.

Figure 27. Quarry Cove, Yaquina Head Outstanding Natural Area, Oregon. Photographs courtesy of Bureau of Land Management, Salem District. LEFT: View of worked-out quarry. RIGHT: Transformed cove at low tide; quarried below sea level with site open to the ocean.

On a larger architectural scale is a design by sculptor Michael Heizer. Sited on land disturbed by coal mining, the reclamation plan celebrates the region's history of Indian burial mounds with earth shapes or tumuli; water strider, frog, turtle, snake, and catfish (Massie, 1985). The five sculpted animals (the snake is 2,070 feet long and 18 feet high) are visible to visitors, air, and boat traffic. Located on a sandstone bluff above the Illinois River, the 150-acre outdoor work was a cooperative effort by Ottawa Silica Company, a nonprofit organization, and state and federal governments (Illinois Department of Conservation, 1997). The artist minimized expensive earth moving by studying existing mine site topography for hidden forms. Named *Effigy Tumuli,* the project includes treatment of millions of gallons of acid water, neutralizing acid spoil, and seeding with wildflower and grass. Buffalo Rock State Park offers canoeing and camping, and the earth sculptures contain hiking trails. Although this instance concerns a coal mine, reclamation can be tailored to include landform sculptures as demonstrated under the **Art** section. Interestingly, Heizer commented "I don't support reclamation art sculpture projects. This is strictly art. I love mining sites. My whole family has been in the mining business" (Bourdon, 1995, p.226). Yet, the design addresses environmental concerns for toxic waste while creating a public recreational facility.

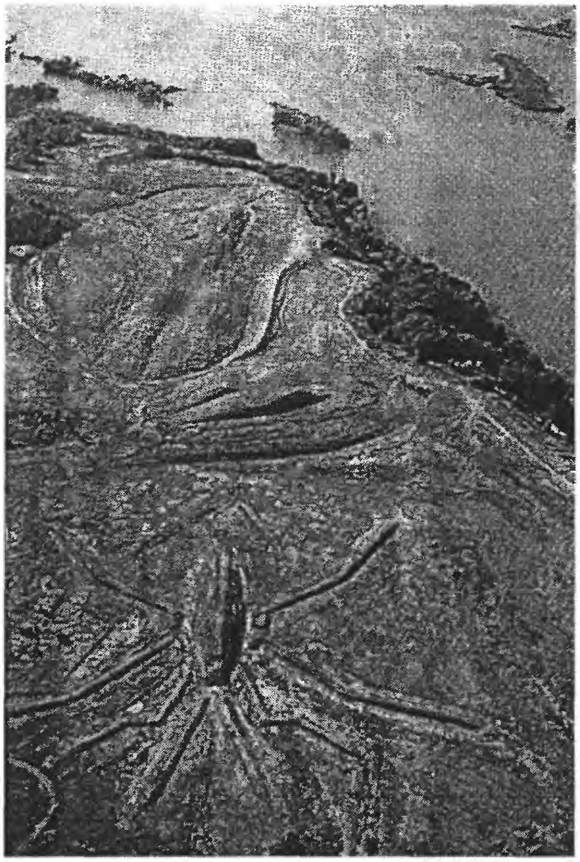


Figure 28. Water strider earthen sculpture from *Effigy Tumuli*, 1983-85. Courtesy Department of Natural Resources, Buffalo Rock State Park, Illinois.

CONCLUSION

Whether a mining site is active or abandoned, if it is in sight, it is in the mind. Given environmental concerns, an operating or reclaimed site can no longer be considered isolated from its surroundings. Site analysis of mine works needs to go beyond site-specific information and relate to the regional ecological context of the greater landscape. Permitted mine areas could be planned to link regions with continuous natural corridors, rich in plant and animal life. Only by finding preferred areas can we make use of quality material while disturbing the land as little as possible Our attitude toward mining today is very different from 100 or even 50 years ago.

Cultural attitudes toward land management and mining reclamation need to catch up with the reality of the 21st century. Failure to perceive the real demand for raw materials in an ever growing society hinders decisions on how to manage resources and create meaningful landscapes. Optimists believe new technologies, substitutes, and more efficient recycling will allow continued supplies of new mineral resources for society (e.g., concrete will be produced with a longer life span). On-site recycling for construction materials offers potential lower costs and environmental sensitivity for a natural resource. Research on technology to separate drywall and wood from cementitious material needs to continue. Pessimists think we must reduce the demand for minerals by population control and per capita consumption. The natural and built worlds yield wide ranges of experience and options. Surface mining will probably not stop although additional regulations may be enacted.

Forums such as the two-year study in Minnesota provide an informal, balanced setting for building relationships between competing peoples with similar problems. Planners are using landscape architects to help "enhance the native character of the created or restored site, fitting the built landscape into the natural design of the surrounding area." (Manci, 1989, p.18.) Is there a need for a state aggregate material tax (a production tax based upon the weight or volume removal of gravel) to be distributed for county road and bridge improvements or as a reserve for the restoration of abandoned pits? Performance bonds are already usually required to assure reclamation work. Compliance with filed reclamation plans, enforcement of reclamation acts, and addressing abandoned mines requires money.

Design guidelines are needed concerning: ecotype plant palettes with a large gene pool, hydrologic impact due to mines in a watershed, mitigation of landscape damage (i.e. geologic research in soil structure to pre-determine spoil character and best land use), construction details that reinforce the regional identity, and wetland reclamation. Research into constructed wetlands (on exhausted pits) for wastewater treatment and wildlife habitat may have great benefits for society and the earth. We must educate the public and industry that landscape is more than a 'garden', and grass more than a 'lawn'. The public needs to understand the economic value of the aggregate industry and the industry needs to recognize the ecological, cultural, and aesthetic value of an area.

There is a wealth of scientific information needing to be standardized, integrated, and presented in a usable format. An annotated list of aggregate and hard rock research and demonstration areas would be helpful. The scientist's perception of landscape should not exclude the public viewpoint. The difficult part is articulating and classifying landscape components. Maps that make use of multiple overlays of digital datasets yield valuable information for future land planning decisions at local levels. Landscape itself needs to be viewed as one--a natural and human process. It is not the case of one ruling over the other. A mining site within an urban corridor may require a different design approach from one in a wilderness area. The National Park Service has elected to close roads and add visual screens to designated sites if an environmental impact assessment determines it appropriate. Today, progressive aggregate companies recognize the value of including landscape architects early in the planning stage.

By discovering the true landscape and understanding it, when mining occurs, we can concentrate on designing and planning the site with information on ecology and development, research and technology, culture and nature, science and art. The data may not tell us what choices to make but it can help with wise options. Whether a geologist, biologist, landscape architect, or city planner, we all experience change in our environment. Wetlands are a geologic disturbance just as mining is a man-made disturbance. It appears there will be a definite trend towards design with greater biodiversity in mind. More wildlife, less water use and reliance on chemicals, are expected of industry, responsible homeowners, and business. Even though the industry's bottom line may be profit and meeting legal requirements, most operators would agree good public relations and aesthetics are an important part of business. Earth will be left for future generations with land that is degraded or improved. It is a living canvas testifying to all of our behaviors.

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