DOES "RECLAMATION BY NATURAL COLONIZATION" PRODUCE DESIRABLE ENVIRONMENTS?[1]

by

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Abstract. If "natural colonization" could be developed into an acceptable reclamation method, some major problems both of nature conservation and the mining industry in West Germany could be solved. Most of the endangered taxa of plants and animals are found in habitats with extreme environmental conditions in West Germany. These special ecological niches include low fertility soils and water, arid and exposed sites, as well as all types of wetland. These extreme conditions may be the result of natural disturbances, but are also caused by human intervention such as mowing, burning, and surface mining. A field survey of 25 extraction sites, most of them brick fields, and some quarries, was undertaken in 1985. Vascular plants and Carabid beetles were recorded. An analysis of habitat representation and ecological qualities has been carried out. Toxic soils were exempt from the study. The results of the species inventory were analyzed and checked against literature on primary succession on skeletal soils. The results suggest that the environmental conditions available from extraction sites left to natural colonization may produce communities which are desirable in the cultural landscape. In fact, surface mines may afford a unique opportunity to support species which are associated with perturbation dependent ecosystems. These are the ecosystems which are rapidly disappearing from the German landscape. However, many of the sites included in the survey had been colonized by only a few species. An analysis of the factors responsible for the number of species reaching a site and surviving on it was therefore carried out. Conclusions are possible with regards to limits and possibilities of incorporating natural colonization into reclamation. Special methods and techniques need to be developed in order to direct the path of colonization and to monitor the seral stages of succession. Natural colonization may be a very good reclamation method for gravel extractions, sand pits, brick fields, and several types of quarries. The applicability of the idea to North American environments is discussed.

Additional Key Words: Brick fields, clay pits.

Pre requisites: landscape change and species loss

This paper is concerned with surface mine reclamation under the special environmental conditions of the cultural landscapes of West Germany (FRG). Similar conditions may be found in many regions of Europe and North America. In these regions, the majority of habitats of indigenous animals and plants have been altered by

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man for centuries, and many are entirely man-made, such as pastures and hedges. Intensive agriculture is the dominating land use producing large uniform tracts of land. Continuous infill and drainage of wetland and irrigation of dry lands results in a simplification of the natural features of the landscape. This homogenization of our natural surroundings reduces the variety of habitats available for wild animals and plants. Artificial fertilization produces an ubiquitous, uniform high level of nutrient availability, eliminating yet another variable in the natural system. The environmental changes have, within the past decades, been so rapid as to greatly preclude natural adaptation of wild species. This is especially true for species dependent on the extreme environmental conditions at either end of the ecological spectrum, such as severe conditions of exposed and arid sites, extremes of moisture and harsh infertile soil (Kaule 1986).

The resultant species loss has taken unprecedented magnitude. In the FRG more than 50% of all taxa are extinct or endangered. Taking invertebrates into account it has been estimated that we are losing approximately 90 species annually (Heydemann 1980).

The role of surface mining

At first glance, surface mining does not seem to be responsible for much of this species loss. Only 0.29% of the total area of the FRG (approximately the size of Oregon, 96,200 sq. miles) is used for surface mining (FRG statistical yearbook 1985) (Luettig 1981). However, a closer look reveals that regionally up to 35% of the land is used (Hofmann 1979, Bundesanstalt fur Geowissenschaften 1982). Aggregate mining in river valleys and tertiary moraines are prime examples. In these regions, surface mining is indeed responsible for many changes in the natural environment (Korneck et al 1978).

There is an implied, inherent responsibility, therefore, to direct a substantial part of reclamation efforts toward restoring natural vegetation and wildlife habitat. Through the re-creation of areas with a variety of different environmental conditions it may be possible to locally counteract habitat and species loss. the legal and political conflicts which may arise from this approach are not considered in this paper as they warrant separate treatment (Bruns 1986).

Some techniques of habitat restoration in surface mines have been developed already on the basis of detailed scientific investigations and observations of unmanaged ecosystem genesis in abandoned mines (Ratcliffe 1974, Lee & Greenwood 1976, Harrison 1979, Heydemann 1982, Bradshaw 1983, 1984, Gemmell & Connell 1984). Habitat restoration as a viable and necessary goal of surface mine restoration has even been incorporated into the standard textbook on gravel pit reclamation in the FRG (Dingetal et al 1985).

Bond release - objectives of this study

Beyond general experience, little is known which types of ecosystem may be expected to develop within certain time periods. This information is necessary, however, with regard to bond release. In West Germany, similarly to the US Surface Mining Control and Reclamation Act (SMCRA) (Public Law 95-87) of 1977, a certain amount of ground cover of living plants is required at the time of bond release. In practice, a great deal of attention is placed on the productivity of the soils as reflected by the ability to sustain this ground cover or a crop yield. However, the development of performance standards in ecological terms has been inadequately addressed (Tomlinson 1984), especially with reference to natural vegetation and wildlife.

Disused surface mines are likely to be subject to an invasion of pioneer species which find the absence of competing species an obvious advantage. Ecosystem development on skeletal soils is an evolutionary process, characterized by colonization of and competition between a certain number of species. Natural examples are dunes, land slides, river bank erosion, new gravel banks, glaciation, volcanic activity, only to name a few. The path of primary succession has been described with reference to several examples (Pfeiffer 1963, Lee & Greenwood 1976, Connell & Slatyer 1977, Andreae et al 1981, Bradshaw 1983). The progress of primary succession is not easily assessed by observed levels of shrub and tree growth, or by the measurement of biomass and nutrient build up. Species communities measured by comparison to established reference-areas would certainly provide more sophisticated proof of standards. This would be of particular importance if surface mines could support communities of wild animal and plant species which have become rare. Many pioneer species are in this category.

Several detailed studies have revealed the high value which abandoned surface mines can potentially develop as refuges for wild species in the context of ever increasing intensities of land use (Byrnes & Miller 1973, Kelcey 1974, Juerging & Kaule 1977, Mahler et al 1980, Dahl & Juerging 1982, Heydemann 1982, Davis 1982, Plachter 1983, Wartner 1983, Ash 1983, Peterson 1984). Many rare species have been found in unreclaimed surface mines, and for some amphibians, beetles, and birds of prey, these man-made habitats have regionally become the last refuges. In Europe, a large number of declared nature reserves were surface mines several decades ago, and their potential habitat value is widely recognized (Bradshaw & Chadwick 1980). But it must be taken into consideration that the value of abandoned surface mines as homes for wild and endangered species had been recognized mainly because the habitat value of other areas has decreased.

To provide further insight on habitat values of abandoned excavation sites, an investigation of 25 clay pits and quarries was conducted in 1985 in the Loess covered triassic highlands surrounding Stuttgart, FRG. Local loam, clay and marl provide excellent raw material for brick manufacturing. Brickfields occur throughout the area. Limestone is quarried as material for road construction.

The objective of the study was to describe the naturally occurring plant communities and some animal species in relation to supply of nutrienta, water and light on skeletal soils and cast

overburden of varying ages and slopes.

Methods

Investigations of vascular plants and carabid beetles were made during summer and fall of 1985 on 25 surface mines of abandonment dating back 1 to 2 years, and as far as 85 years. Plant cover estimates and composition analysis were made on 5x5 meter plots 3 times during the year according to the basic method of Braun-Blanquet (1932). The same plots were hand sampled for carabid beetles. Parallel to these systematic studies, observations of birds, reptiles and amphibians were made and checked against interview data collected locally on these species.

As the environmental niches of the recorded species are known and rated on standard scales, the data could be used as indicators of environmental quality. For vascular plants, the ecological classifications, "indicator values" according to Ellenberg (1979) were used and computed by data processing. For carabid beetles, equivalent figures were established on the basis of literature studies and experience (Treated by Trautner).

The relationships between site age and nutrient, water and light supply were computed. The increase of vegetation height and cover was related to site age, as well as to the criteria mentioned above. Typical communities were described with relation to the character of adjacent habitats.

Results

The results of the field investigations were checked against literature data on primary succession and studies on surface mining. It must be observed that the results are applicable on intensively farmed cultural landscapes in temperate climate regions. The following is a summary (publication of detailed data in preparation).

All surface mines, even those abandoned 1 to 2 years before investigation, supported some sort of animal and plant community.

Most plant species invade the abandoned site in the early stages of succession, different species becoming dominant at different stages. Plants arriving after vegetation cover is closed have little chance to play an important role during the 3 to 4 decades following complete coverage. The longer the site is partly uncovered, the greater the chance for variety in the plant community. The same characteristic could not be observed with animal communities.

The speed of vegetation closing depends almost entirely on the quality of the substrate, the slope, the exposure, and the water level (including seasonal variations). Most clay and loam sites are colonized and covered within the first 2 to 4 years. On slopes greater than 30% erosion is halted within the first 2 to 89 years, as vegetation reaches 80 to 90% coverage. Even close to vertical loam faces vegetative up to 70% within the first 20 years. Gravel and porous rock are covered slower than clay and loam. Quarries usually consist of steep rock faces, preferred nesting sites for some specially adapted birds, and of rather flat terraces and quarry floors. Fine material collects here which is covered by vegetation up to 80% within the first 10 years. Tailing deposits, or cast overburden may reach the same coverage in the same period of time, but remain patchy for more than 85 years if slide motion is strong enough. Dry and well drained sites develop vegetation cover more slowly than moist sites, which do not dry out seasonally.

Topsoil deposits are characterized by 100% vegetation closure within 1 to 2 years. A small number of competitive plants which were contained in the humus as plant parts or as propagules dominate at once. Monotonous swards develop which are usually very resistant to germination of tree and shrub seeds.

The highest number of plant and carabid beetle species were found in early successional stages, before shrub and tree canopy began to close. Canopy closure begins ca. 20 years after abandonment of the site. It may be complete within 5 years on easily penetrable loamy soils. On rock surfaces, sliding slopes, and in seasonally or permanently submerged ponds, canopy closure may not be complete within 85 years. these sites retain high numbers of species for a long time.

The monotonous grass covers of nutrient rich sites may be colonized by shrubs and trees which form rhizomes or root polycormes. The result is usually an equally monotonous stand of shrubs and trees.

The more varied the topography of the site, and the more varied the environmental conditions are, the higher is the total number of species found here.

A close relation between the location of a surface mine within the landscape and the dispersal mechanisms of settling species can be observed. Species with low dispersal capacities will only appear on the site if they already existed on sites in the immediate vicinity. Surface mines located within monotonous farmland regions may be regarded as isolated islands and are mainly invaded by species with very good dispersal capacities. These are usually species which typically live in transitory and scattered habitats. They are characteristic of dynamic ecosystems and seem to depend on perturbations such as sliding surfaces, erosion, accumulation of sediments, or certain traditional farming techniques. The majority of plants found on those sites have seeds easily transported by wind and birds. The majority of animals found are capable of flying.

Discussion

The most common approach in current reclamation practice is to cover scars in the landscape as fast as possible. The factors that normally limit vegetation growth are manipulated to produce an instand green cover. Fertilization, irrigation, hydroseeding and application of topsoil are an extension of agricultural practices which produce a monotonous unvaried vegetation

with minimal species variety. This offers no habitat for pioneer species dependent on extreme conditions found in surface mines.

The results of this study suggest that the environmental conditions produced by surface mining operations may support varied communities of wild animals and plants which are desirable in the cultural landscape. In particular, aggregate and clay mines, as well as quarries, may afford unique opportunities to support communities associated with perturbation dependent ecosystems. These are ecosystems which are rapidly disappearing from the German landscape.

If the rehabilitation of skeletal soils is to occur through primary succession and not by artificial seeding, one is dependent on the surrounding environment as a species pool for natural colonization. There is no point in tailoring environmental conditions within the mined area to be rehabilitated for a set of desired species if these species cannot physically reach the site. This means that donor habitats must be in the vicinity.

The wait and watch method using natural colonization to rehabilitate an quarry or mine may sound especially appealing from a cost standpoint, since many of the traditional expenses are eliminated. However, one must not forget the structural tailoring of habitats that is required. The site needs to be shaped morphologically and hydrologically (Gemmell & Connell 1984, Lee & Greenwood 1976). A detailed time schedule needs to be observed with respect to the expected types of communities and rates of succession (Kaule 1986).

Bond release should be granted if criteria related to provision of a variety of land forms, substrates and water conditions are met. It is suggested that monitoring of ecosystem development be obligatory.

There are still regions where the success of natural colonization as a reclamation measure seems uncertain, for example in deserts. Here, habitat related research on primary succession is still necessary.

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