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Editor

Prakash Gole

Restoration of an abandoned stone quarry pool

Restoration of valley bottom forest and a wetland

Restoration of mangroves

Foreword

This issue of the Society's Journal focuses on Restoration of Nature in India. Dr. Chaphekar, once of the Institute of Science, Mumbai, and one-time Trustee of this Society and an authority among restorers, if I may use the term, writes about Eco-restoration. His article gives ecologists food for thought, a new direction and a new hope. Our Society has, in fact, been busy demonstrating restoration work at the Panshet Dam near Pune for more than a decade. The pioneering pilot project has been applauded by many who have seen for themselves our work there under the guidance and direction of Prakash Gole. You can read about this hopeful attempt of restoration in the Journal, perhaps pay a visit to it when you are next in Pune and then decide for yourself its applicability in your part of denuded, debased natural India. You can then restore it to a healthy habitat for man and wild animal. Vast and ever-increasing area of our land is being desertified, wasted through unsustainable human practices related to the use (or misuse) of water, over-grazing and unthinking application of chemicals, insecticides, etc.

We have talked about development (sic) of watersheds for longer than I care to remember. There have been innumerable seminars where millions of words and tonnes of paper have been expended by so-called experts to produce nothing, no result, no development, no strategy for restoration. Instead degradation and denudation of our natural habitats and resources have continued apace. We have, as a people, yet to realize the very heavy price we will have to pay in the not too distant future for the folly. We have to take up restoration work in true earnest without losing any time. The coming century and millenium may be one of information technology. It will no less be of environment and ecology. Those countries will win out which have grasped these truths. Will India be one of them? Only we Indians can answer that question.

The Ecological Society offers this little piece of wisdom to those Indians who think like we do. The great wide, wonderful, beautiful world, so wantonly denuded and degraded of its wonder and beauty lies out there, waiting to be restored to its once pristine state.

Vice Admiral M. P. Awati (Retd.)
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Sharad Chaphekar

Introduction

Aspirations for better living standards are continuously on an increase in this country, as elsewhere. Globalization, privatization, communication through electronic media and free market, all have contributed in their own ways, to increasing demand for products for comfortable life. Increasing utilization of natural resources is the inevitable result of these phenomena. Demand on natural resources has an unavoidable adverse effect on the environment, causing its degradation. Though no right-thinking person wants the environment to be degraded, he is at present a helpless spectator of the degradation taking place on a large scale, all around him. Atmosphere in urban areas suffers from air and noise pollution, surface and soil water loses its quality and land gets depleted of its nutrient and water status, due to exposure and loss of protective plant cover. Different causes of land degradation are summarized in Table 1.

Of the three major abiotic components of the environment, air and water are more dynamic, in the sense that their capacity for self-purification is fairly high. Air will restore its quality within hours if no more pollutants are added to it. Water also reclaims itself within days, at the most a few weeks, when pollutants are prevented from entering the system. Land, however, is a resource that is unable to reclaim itself, at least within a reasonable time span of a human generation. It is hence mandatory that there is a deliberate effort for restoration of land that has got degraded due to one or other reason. Being aware of the poor state of plant cover on land surface in the country, less than 14% as against the prescribed 33% according to the Indian Forest Policy, it is logical that land restoration is undertaken with utmost urgency.

The philosophy of urgent land restoration deserves to be adopted at a national level, lest several queries about why, where, how, when, by whom, for who, etc. can be raised, as it happens in most efforts for environmental conservation. Even if it is agreed that we do not have answers to all the queries, including those from researchers and academics, to satisfy all the parties involved in the process, it is emphasized here that the effort for land restoration needs to be undertaken immediately.

Benefits

Conservation of at least the existing components of the ecosystem is an obvious benefit of restoration that leads to arresting further degradation of land. This involves arresting erosion of land as a resource, including nutrient minerals and soil water, which are targeted during restoration.

Conservation of bio-diversity in the ecosystem is a great resultant advantage of restoration, though it is of an intangible nature for many.

Not only health of the environment is sought to be improved through restoration effort, the more measurable criterion of health and safety of humans in the vicinity, should be attractive enough for necessary effort.

Instead of a degraded eyesore of land around, an aesthetically acceptable greenery with life in it – flowers, fruits, insects and birds – is certainly far more welcome to anyone.

Though most of the above criteria are of a qualitative nature, efforts have been made to quantify the advantages, for convincing decision-makers. For example, erosion is expressed in terms of tonnes of soil and kilograms of nutrients lost per acre of land per year, human health in terms of man-hours lost due to poor health or morbidity and aesthetics in terms of cost of (esp. urban) land realizable in the vicinity of a project. This article, however, will not go into the details of this aspect.

Methods – Principles

Certain basic principles have to be remembered before and during undertaking a restoration project. They may be enunciated briefly here, as :

i) Nature abhors vacuum – An ecosystem, left to elements, will tend to get occupied by components, as dictated by local geographic and climatic constraints and migration facilities available to living organisms from the neighbourhood – spores, zygotes, fungal hyphae, seeds, etc. Migrant animals would eventually follow, forming new ecosystems in the place.

ii) Development of an ecosystem on a degraded land takes place in course of time. Two constraints, however, are against waiting for this to happen naturally – *viz.* time required for natural restoration is extremely high, it may take thousands of years for natural rehabilitation of degraded land in arid and semi-arid zones. Secondly, there is always a danger of a 'disclimax' setting in. i.e. a seriously degraded piece of land may permit, or even encourage, setting of disseminules of exotics rather than of indigenous communities, giving rise to a 'deflected climax' type of community that is dissimilar to the one belonging to that place. It has been noticed that it is almost impossible to reclaim a tropical rain forest, once exposure of land to elements have washed away the very thin layer of fertile top soil.

iii) Restoration effort involves 'facilitation' to develop, rather than plantation of a community. Setting of pioneer organisms (e.g. grass in most of our natural plant communities) is facilitated and encouraged through nutrients and water supply and further development of a more complex community typical of the bio-geographical area is stimulated to take over.

iv) Management of the developing community is done intensively, through continous monitoring of the progress of development; mid-way corrections are incorporated as and when found necessary.

v) Inputs needed are generally high, especially if time available for restoration is limited. Generally, restoration process is slow, though accelerated by establishment of pioneers. Some hastening of development is possible by introducing members of the next seral (changing) community, rather than waiting for their natural arrival on the scene. It is not recommended, however, to resort to introduction of the final, climax stage, with high inputs and expect success of sustainable nature.

vi) Local involvement in any restoration programme is absolutely necessary, since establishment of disseminules, their propagation and further succession of communities is ensured only through the protective intervention afforded by the local human communities.

vii) Restoration programme based on sound ecological principles of community development is also referred to as Eco-restoration. It aims at developing a sustainable ecosystem on degraded land (or water). It does not, however, claim to duplicate the local natural ecosystems that have evolved over a long period of time, inclusive of all the components of biotic and abiotic nature, identical in structure and functions and inter-relationships encountered in natural cycling and energy transfers.

Methods – Planning

i. Compilation of bio-geographical information of the area of concern, to visualize the goal of restoration. (Development of a rose garden or coconut grove in arid zone is not a goal of restoration that is sustainable.)

ii. Study of the present status of the degraded area – especially physical, chemical and biological, nature of the soils and water status of soil.

iii. Pinpoint causes of degradation and assess options for removing (or, at least mitigating) the same.

iv. Organize material inputs and ensure their availability as and when needed. Main focus has to be on nutrients, mainly nitrogen, and water availability – the two main deficiency factors in most areas.

v. Organize work force, finances and nurseries, for initial and continuing plantation, monitoring and corrective steps.

vi. Decide goals of restoration programme meticulously and in consultation with decision makers as well as local human society – both immediate and ultimate. Several options for use of restored land are available (Table 1) which would help in planning the extent of landscaping needed. Since restoration is an expensive process (both in time and money), major goals will be achievable only through the co-operation of all concerned.

Execution

After observing the above-mentioned principles, deciding goals and preparing plans for execution of restoration programme, it is only a matter of proper execution, that is needed for actual restoration of degraded area to take place. Rather than narrating all details of working, a few case studies in the direction should prove illuminating. The same are given here as appendices to this article, along with visual results. It may be mentioned here that none of the projects is complete in all respects and that necessary work along the lines suggested in this article, is still in progress.

Decision Making

Like most other natural resources, we have always taken land also for granted. As a result, it becomes very difficult to persuade decision-makers to spend time, energy and money on degraded land, especially since such restoration work may or may not lead to perceptible benefits in immediate future. Like it or not, cost-benefit analyses of the venture becomes inescapable. A forceful argument based on sound scientific principles, practical wisdom for sustainable future of environment (as a resource) and realistic assessment of material inputs and perceived advantages (cost-benefits) should carry the day in favour of eco-restoration of all degraded lands.

Another approach of argument is what is adopted in the preparation of environmental impact assessment (EIA) statements. Consider the three options – Business as usual – i.e. if nothing is done to restore the degraded land; Land is converted for another land-use and Land is eco-restored. What will be the implications in the three scenarios, vis-a-vis the inputs for the three. The argument will, in most cases, be in favour of Eco-restoration.

Conclusions

Considering the present situation of land degradation in the country, it is necessary that restoration of land is undertaken as an urgent effort. Adequate technical and scientific information is available as the basis for launching the effort. A strong will is all that is needed.

Table 1. Causes of degradation of land

1.	Urbanization	:	Clearing of land Abandoned construction sites Municipal waste deposits Roadsides and rail-sides with dumped refuse Unused railway yards Misused playgrounds and public places and Seaside and beaches River banks with solid wastes
2.	Industrialization	:	Clearing of land Solid waste dumping Liquid waste disposal on land Air pollution damage in the vicinity Mining for metals Quarrying for stone and building material Overburden deposits Abandoned industrial sites
3.	Agriculture	:	Clearing of land Salinization and eutrophication Excessive irrigation Abandonment of land

4.	Natural Calamities	:	Storms, hurricanes, volcanoes, etc. Erosion of hills, river banks Flooding of plains, banks of rivers, creeks, etc. Coastal erosion

Table 2. Possible uses of restored land

1. Afforestation
2. Industrial plantation
3. Amenity development – Parks, Gardens, Playgrounds, Jogging tracks, Adventure sports, Recreation
4. Construction – Housing, Roads, Railways, Airports, etc., Industries, Industrial estates
5. Agriculture – Grazing, Cropping, Orchards (Produce needs to be tested for toxicity)

Appendix

Case 1 : Site – Zinc-Lead Mine

Aim : Stabilization of tailings

Status at the commencement of the project : Tailings lake of some 24 ha surface area and 5 to 10 M depth, full of gray dust, loose, with failed Euphorbia plantation.

Properties of the tailings material : Mostly silty (more than 70% silt size fraction of the dust), with poor water-holding capacity. Lack of nitrogen and deficiency of phosphorus. Presence of heavy metals like Zinc, Lead, Cadmium and Silver.

Action : Preference to organic manure (FYM) as a source of nutrients for plants, to augment N and P status and water-holding capacity. Assured supply of water available from treated waste water from the beneficiation process. Choice of grasses (*Cynodon dactylon*) to form carpet-like protective cover on ground, to protect tailings from wind erosion and runoff-induced erosion.

End-use decided : Promenade and playground. Consumption of grass as fodder not permitted.

Result : Grass growth satisfactory. Other plant species, including legumes and perennials migrated in third year, improving diversity of species.

Case 2 : Site – Abandoned Stone Quarry

Aim : Develop an amenity in the quarry.

Status at the commencement of the project : A 15-acre pit, 3 to 6 m deep, full of weeds (*Typha angustata*) growing densely on stagnant water and mud, mosquito menance serious, municipal and industrial wastes flowing into the pit freely.

Properties of land : Loose, slushy mud, highly eutrophic, water weeds present. Rock and thin soil exposed in some places of uneven bed.

Action : De-weeding and de-silting of extensive nature. Weeds embedded for composting. Water aeration and oxygenation with a series of fountains. Sewage diverted to town sewerage system. Alternative refuse dumping organized. Co-operation of inhabitants in the neighbouring hutments ensured through appeals by the local corporator and municipal staff. Landscaping done for separating lake (about 6 acres) from exposed ground. Plantation of ornamental plants and forest trees on ground. Nalla construction (stone and earth, not concrete) and its plantation with aquatic and amphibious plants to function as root zone filters. Nalla designed for carrying waste water from hutments.

End use decided : Amenity for society – forest, garden, jogging track, gymnasium, playground, study area, amphitheatre – all open-air amenities on ground. Lake for game fishing, boating. Upper lips of the quarry for observation posts and sight-seeing sites, recreation, refreshments kiosks, etc.

Present status : First of the three phases of work completed. Two nallas, three fountains and cleared lake functioning for the chosen purposes. Tree plantation and ornamental herbs for garden on cleared ground achieved, playground functional.

Case 3 : Site – Industrial site in coastal area

Aim : Development of green belt around an industry.

Status at the commencement of the project : Hundreds of hectares of abandoned salt pans, flooded with creek water at high tide. Grass growth on exposed ground during rains. Creek banks totally devoid of vegetation, barring an odd tree that had escaped axe of the locals.

Properties of land : Highly saline soil, deficient in nitrogen, excess of sodium, chlorides, etc., hard clay with caking tendency and coating of salt crystals when dry.

Action : Landscaping for raising ground above tide level. Exposed ground furrowed and left open to elements. Selection of salt tolerant plant species for plantation on less saline ground. Plantation of mangrove species along creek banks. Farm yard manure addition and harvested herbs (grass and legumes) ploughing into the ground as soil amendments to reduce salinity and improve nutrient status. Organization of fresh water supply for terrestrial plantation. Planning and execution of drip irrigation system for established tree species. Setting up of separate nurseries for land plantation and mangroves.

End-use decided : Green belt around industry, orchard for locally important fruit species, kitchen garden and ornamental garden near employees' residential and office areas, regeneration of coastal ecosystem.

Present status : Tens of lakhs of trees and mangrove trees growing in the area. Orchards yielding fruit which find way to local market. Contractual employment available to hundreds of local tribals. Nurseries being enriched with forest and ornamental plant species.

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Flood Pulsing in Restoration: A Feasible Alternative for India?

Beth Middleton

Abstract

The full restoration of natural flood pulsed conditions has only been attempted in a few places in the world because the politics behind the original destruction of the wetland generally impedes full restoration. Often the desire to restore wetlands for wildlife and other purposes is not strong enough to alter or eliminate the engineering projects such as embankment, diversion, interbasin water transfer and hydroelectric dams for water, irrigation and electricity that destroyed the original wetland. Unfortunately, we must find ways to provide plant and animal species flood pulsed habitats because many of these are not only adapted to, but dependent on this environment for their continued survival.

The restoration of flood pulsing has been accomplished only in a handful of places such as the Kissimmee River (Florida U.S.A.) and the Lodi Wildlife Area (Wisconsin U.S.A.). At the same time, many partial restorations have been successful removing or working with engineering projects. After the floods of the Mississippi River (U.S.A.), many people moved off the flood plain with the blessing of the Federal Emergency Management Agency. Now, several embankments (levees or bunds) have been removed, and areas are reverting to natural vegetation. Downstream from hydroelectric dams in the Cameroon (Africa) and near Pune (India), impounded borrow areas with bunds have created fisheries/vegetable gardens and wildlife habitat, respectively. Restoration of spring habitats in arid and montane regions can be as simple as removing cattle from the banks of streams as in the case of the "Magic Spring" near Cartago (Costa Rica). The inclusion of flood pulsing in riverine restoration in India is a new idea as it is everywhere, but we must give serious consideration to recreating the original conditions of the habitat for the benefit of the animals and plants that utilize these wetlands.

The Engineering of Rivers Worldwide

Complete restoration of floodplain wetlands must reestablish overflow flooding from river and stream channels across the floodplain (floodpulsing) during the rainy season of the year (Middleton 1999). Because most of the world's rivers have been reengineered by dams, embankment via levees or bunds, channelization, and/or diversion (Gregory 1977), often the conditions created by engineering projects need to be reversed before successful restoration can occur. However, the dried floodplains created by these engineering projects can make capital investment possible (Pearce 1991), so that, reversing these conditions may be politically impossible. Nonetheless, wetlands are very important to humans. Settlements in India are often directly adjacent to wetlands attesting to their importance for washing, bathing, drinking, livestock and irrigation (Figure 1) (Foote *et al*. 1996).

Embankments (levees, bunds) are designed to cutoff the transfer of water between the channel and the floodplain (Middleton 1999) and have been constructed worldwide to force the river into the channel and away from floodplains, e.g., along the Mississippi in the midwestern United States, Danube in Central Europe (Cowell 1997) and the Brahmaputra/Ganges/Meghna Rivers in Bangladesh (Brammer 1990a). While such reengineering allows humans to encroach the floodplain, it has serious consequences for the plants and animals that live on the floodplain that depend on the flood pulse for their growth and reproductive activities (Middleton 1999). Embankments impair the ability of fish to spawn and rear young on flood plains and so can be a serious economic problem in countries such as Bangladesh where 80% of the protein consumed comes from fish (Sklar 1993).

Embankments are dangerous to the humans living behind them since they pose the very real threat of bursting during floods (Middleton 1999). While embankments may protect settlements and farmland from flooding in small flood events, these cause downstream flooding by forcing water away from upstream flood plains (Leopold and Maddock 1954). Over time, embanked farmland develops a lower elevation than the river channel because it does not receive enriching sedimentation from the river as is the case along portions of the Mississippi River (U.S.) and three Chinese rivers (Brammer 1990a). Floods improve soil nutrient levels; agricultural production usually increases the year after a flood, because of the enriching action of flood waters (Brammer 1990b; Rogers *et al*. 1989).

Breaches in embankments create opportunities for partial wetland restoration on floodplains for the benefit of vegetation, waterfowl and wildlife (Trepagnier *et al*. 1995). After the floods of 1993-94 along the Mississippi River in which the majority of embankments burst along the river near St. Louis, MO, some of the embankments were not replaced because it was realized that the river had been constrained too far. Entire villages of peoples moved off of the floodplain after this major flood with the encouragement of the Federal Emergency Management Agency (U.S.) (Middleton 1999). In areas designated for flood retention along the American Bottom near St. Louis, embankments were removed or moved back from the Mississippi River. Natural vegetation reestablished in those places spontaneously from seed bank and seed dispersal processes but it did not resemble its original composition (Giedeman 1999).

Stream Diversion and InterBasin Water Transfers

The diversion of water away from a river for irrigation or drinking water obviously has a big effect on the volume of water involved in the flood pulse on the floodplains of rivers and thus has huge consequences for the biota along the river. Irrigation projects are common in arid lands and India has irrigation canals that have been operational for hundreds of years (Ali 1982). However, the consequences of these activities have been little considered from the perspective of wetland conservation and restoration.

Any engineering project that transfers water from previously unconnected water bodies creates a new corridor for the flow of water and biota. Such interbasin

Village in northern India dependent on a local wetland (photo by Beth Middleton) water transfers curtails the transfer of genetic material along the original corridor, and creates a new avenue of genetic transfer where none existed before. Other threats along these altered corridors include the invasion of new species of animals and plants, change of water quality and the spread of disease vectors (Davies *et al*. 1992).

Dams

Many significant rivers have been dammed in India (World Wide Fund for Nature India 1993) and some of these dams are thought to have been built as early as 3150 BC (National Committee for Geography 1968). While dams to create rice paddies and fish ponds create wetlands, these also destroy wetlands by diverting water from downstream areas (Foote *et al*. 1996). Large dams in particular threaten humans. Dams sometimes burst and cause human death and destruction, not to mention the thousands of people that are displaced by the construction of dams in the first place (Costa 1988).

Everywhere in the world, dams change biological processes both up and downstream regarding water flow, sedimentation, nutrient cycling and energy exchange (Sparks *et al*. 1990). Upstream from dams, sites become permanently impounded with little water fluctuation. Downstream, water is often reduced to a trickle. Worse yet for the biota, the operations of a hydroelectric dam, water is released suddenly and during inappropriate seasons of the year. This has severe consequences for those biota that are unable to adapt to these sudden extremes in water and sediment conditions (Middleton 1999). Dam building began along the Chambal River in the 1960s, and subsequently, crocodile number dropped because these could not adapt to the changes in the waterway (Sharma and Singh 1986)

Though an attractive idea, dam removal has not been uniformly successful in restoring wetlands. One big problem is that sediments build-up behind dams, and opening them allows a sediment plume to move downstream (Simons 1991). Sediments behind the dams can be difficult to revegetate (Shuman 1995). In certain cases, the sediments behind dams have toxins (e.g., PCB) and thus are an environmental hazard (Shuman 1995; Tofflemire 1986). Controlled releases of water from dams show some promise for simulating flood pulses and this has been tried with some success in the Grand Canyon of the U.S. since 1996 (Stevens 1997).

Restoration in a Water Regulated World

Effective restoration needs to be accomplished at the landscape level. Paradoxically, the procedures used to destroy wetlands were typically accomplished at that level. To undo these problems, we need to rethink our approaches on the same large scale (McCorvie and Lant 1993). There are only a few examples of rivers or streams being restored on a landscape level in an attempt to put them back into their original condition and those include the Kissimmee River project (Florida, U.S.A.) and the Lodi Wildlife Area Project (Wisconsin, U.S.A.) (Middleton 1999).

Why should we attempt to create the original conditions in wetland restoration with flood pulsed conditions? Restoration attempts that have not attempted to recreate the original conditions have not been very successful. While wetland restoration has been practiced for at least 30 years in the United States, many of these have been deemed failures because of hydrological problems. While little study exists of their success, in one study based mostly in Florida (USA), less than 63% of the wetland restorations were successful (Erwin 1991).

The key to restoration is to provide species with the environment to which they are adapted. The life history of some species are so closely tied to a flood pulsed environment, that these cannot survive without it. Most plant species germinate and their seedlings only thrive in drawdown conditions (Middleton 1999). Not surprisingly, species of monsoonal wetlands are closely adapted to annual drawdown stemming from the yearly drought (Finlayson 1991; Middleton 1999; Middleton *et al*. 1991). In the Amazon, a millipede species (*Cutervodemus adisi* Golovatch) spends the flood season on tree trunks, and reproduces only on the drawdown forest flood (Adis *et al*. 1996). In cases where life history is very closely adapted to the flood pulsed environment, if that environment is altered by human engineering projects, the species will not survive (Middleton 1999).

Admittedly, natural flood pulsing on the flood plain is sometimes unacceptable for purely political reasons. If the goal in a region is to use all or even part of the flood plain for housing, agriculture or other human purposes, it is essential to control unpredictable flooding on the flood plain. However, the reality is that people cannot be completely protected with either embankments or dams for the purpose of holding back the water during floods. The devastating and recurring floods along floodplains of the Mississippi River (Mississippi River Corridor Study Commission 1995), the Danube in Europe (Cowell 1997) and Brahmaputra/Ganges/Meghna Rivers in Bangladesh

(Brammer 1990) have taught us that we can not control rivers all the time.

There are some very successful projects that partially restore flood pulsing along rivers. The Project Pisciculture Lagdo has maximized water for fisheries and vegetable farming along a dried floodplain downstream from the Lagdo Reservoir along the Benue River in Cameroon (Slootweg and van Schooten 1995). In addition to creating wetlands downstream from the hydroelectric plant, the project also helped to compensate fishermen for the loss of their resource after the dam was put in place.

The Ecological Society of India has created borrow areas with small bunds to impound water below the Panshet Dam near Pune, India. The project has created wildlife habitat for a large variety of birds, fish and amphibians (Middleton 1999). In upland areas of the same watershed, the hillsides were stripped of vegetation. Natural revegetation occurred and created habitat for a wide variety of wildlife after cattle were excluded (Gole 1990).

Other wetland restoration projects have only been successful after cattle have been excluded, particularly in arid and/or montane situations. In Costa Rica, one mountain stream dried up because of cattle grazing near Cartago, Costa Rica in the Vulcán Irazú watershed. After the cattle were removed, water flow returned to this stream. The "Magic Spring" that had been sacred to the indigenous tribal people there, reappeared as a permanent water body (Don Angel Rodriguez and Margarita Boloños, personal communication).

It would seem that either full or partial wetland restoration projects have been accomplished throughout the world. The benefits of wetland restoration are clear for the preservation of the world's threatened biota, but at the same time can be equally beneficial for humans. All flood plains cannot be made completely safe from dangerous floods, and certainly some of these can be put to better use as wetland habitats. In addition, engineering projects can be made to accommodate the needs of people and wildlife to a greater extent than they have in the past. These approaches all present opportunities for wetland restoration in India and other parts of the world.

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Restoration of Degraded Lands : An Ecological Perspective

A. N. Pandey

Introduction

In ecological restoration four words are in common use – restoration, rehabilitation, remediation, reclamation – although there are others (Bradshaw 1997). The word restoration implies the act of restoring to the original condition or perfect condition. Rehabilitation is referred to as the action of restoring a thing to previous conditions, but there is little or no implication of perfection. Remediation is the act of remedying. To remedy is : to rectify or to make good. It emphasizes the process rather than the endpoint reached. Reclamation is defined as : to bring back to proper state. There is no implication of returning to an original state, but rather to a useful one. When the restoration of ecosystem is being referred to, the suggestion is that we are particularly interested in the restoration of the fundamental ecological process by which ecosystems work (Bradshaw 1997). An ecosystem is characterised by many attributes and these can be suitably simplified into two main components, structure and function. In particular it points to the fact that restoration may not be easy. It may be possible to restore the functions fairly completely, but to achieve the original structure may be more difficult. It is to recall here that ecosystems are not static, but in a state of dynamic equilibrium. This suggests that it is restoration of function(s) that is more important than restoration of a precise structure. Restoration is influenced by geographical and climatic factors and the ecological conditions of the site (Thorhaug 1980). Disturbance may take the form of mining activities, fire, wind throw, volcanic eruption, grazing, deforestation and others, each of which may have different effects on the subsequent development of the vegetation.

One approach to understanding this process is to examine the successional sequence of higher plants. However, this is rarely possible because succession normally occurs over centuries, but our life is too short in this respect. An alternative method is to study spatially separated areas (sites) for which different lengths of time have elapsed since a specific disturbance (Drury and Nisbet 1973; Austin 1981). The spatially scattered information can be translated over time to assess the dynamics of restoration in the natural conditions.

The Study Area

Pandey and Singh (1985) reported the mechanism of recovery for forested ecosystems in the Kumaun Himalaya following landslide damage. The term 'recovery' is commonly applied to changes in communities or ecosystem properties following external disturbance (Likens *et al.* 1978). Thus, recovery and restoration have a similar meaning. For their study they selected seven spatially separated sites of known ages since the date of the landslide disturbance. The sites were located within a diameter of 6 km. All sites were in moist temperate oak-forest belt near Naini Tal (29°23' N, 79°30' E) and within the altitude range of 1600-2200m. The soil was a residue originating from the rocks of the Krol Group on all sites except site 5, where it has originated from the rocks of Blaini Formation. The landslides were of medium scale. During a lanslide, the vegetation is uprooted and fallen trees are removed from the site. Subsequent to this main event, portions of soil from upper edges are detached and roll down the slope. During the whole process, a pronounced mixing of the soil occurs. Also, a significant proportion of the fine soil from the detached soil mass is lost due to siltation during subsequent rainfall. Site 1 experiences a landslide each year as a result of road building close to a geological fault and was taken as the 1-year-old site. Sites 2-7 were 3, 6, 13, 21, 40 and 90 years old, respectively. Each site included an undisturbed portion as a control and those stands, corresponding to sites 1-7, are referred to as U1 to U7, respectively. Details of the sites are given in Table 1.

Material and Methods

The study encompasses four aspects : sequence of species, change in plant biomass, changes in soil nutrients; changes in hydrological response. The herbaceous vegetation was recorded along 1m wide transects in the first week of September 1981. The relative frequency, relative density and relative basal area of each species were determined and summed to yield importance value index (IVI). The density of shrubs and trees seedlings was determined from fifteen 5 x 5m quadrats on each site. Tree density on the undisturbed and on 40-year-old site was determined at the peak growth stage, i.e., in the second week of September by harvest method. For the determination of shrub biomass, five individuals (of average size for each species) were subjectively chosen and clipped at the soil surface, oven dried and weighed and the total biomass of each species was calculated. The total tree biomass was determined by using allometric equations (Negi *et al.* 1983) or inter-species allometric equations (Tiwari and Singh 1984) depending upon tree species composition at the site. Surface runoff and sediment output were measured during the monsoon seasons of 1981 and 1982 using representative runoff channels of known drainage area. More details are given in Pandey *et al.* (1983). The soil samples were analysed for total N, available P, exchangeable Ca, K and Na. Analytical details for soil N, P, K, Ca and Na follow Jackson (1958). Soil organic carbon was determined following Piper (1944).

Results and Discussion

Herb Layer

The 1-year-old site had a mixture of annual and perennial species, while the 3- and 6-year-old sites were dominated by annuals. The 13-year-old site was dominated by a mixture of perennials alone. Species content increased with time (Fig. 1) and ranged from 8 species on the 3-year-old site to 36 species on the 90-year-old site. The density of herbaceous plants was minimum (7 shoots m^{-2}) at the 1-year-old site and maximum (278 shoots m^{-2}) at the 90-year-old site. Species diversity increased and reached a maximum level by 40 years, when it was slightly higher than that on the undisturbed sites. Species content explained 85% variability in the species diversity ($r=0.922$, $p<0.01$) of the developmental stages. There was a progressive increase in similarity between the disturbed and adjacent undisturbed sites and by 40 years the herbaceous vegetation on the disturbed site became indistinguishable from that on the corresponding undisturbed site. The annuals in the early developmental phase are characterized by high rates of growth and reproduction (r selection). During the later phase of ecosystem development, higher numbers of perennials are characterized by lower gowth potential but better capabilities of competitive survival (k selection). The chronosequence of dominant herbaceous species (annuals ® annuals + perennials ® perennials) represents a situation similar to 'relay floristics' or facilitation model.

Shrub Layer

Shrubs appeared on the 13-year-old site. Species content was maximum (8) at 13-year-old site and minimum (3) at the 90-year-old site exhibiting no definite pattern over time. Shrub density (individuals m^{-2}) was 6.8, 5.4, 3.9 and 1.3 in 13-, 20-, 40- and 90-year-old sites, respectively. Species diversity was erratic across the successional stages (Fig. 1) and depended highly on species content ($r=0.986$, $p<0.01$) and consquently little on equitability. The shrub layer on the disturbed sites became very similar to that on adjacent undisturbed sites by 21 years. Perennial herbs and shrubs appeared together and stabilization of their populations was parallel in time.

Seedlings and Saplings

Seedlings of *Sapium insigne* were recorded at 1- and 13-year-old sites, and of *Alnus nepalensis* at the 21 year old site. Seedlings of *Quercus leucotrichophora* and *Fraxinus micrantha* appeared at the 40-year-old site. Saplings of *Q. leucotrichophora* and *Q. floribunda* were present at the 40-year-old site.

Tree Layer

Sparse and Juvenile second growth trees of *Q. leucotrichophora* and *Q. floribunda* occurred on 40-year-old site. Tree density on this site was 8 shoot ha^{-1} with a basal cover of $0.22m^2$ ha-1. Result suggests that some degree of improvement seems to be required for the recruitment of trees. The climax Oaks were able to establish directly on disturbed sites without following a sequence of intolerant and intermediate tree species.

Therefore, it should be possible to shorten the time-lag in the appearance of the climax species through suitable management practices such as dibbling of seeds and establishing a herbage cover. Dibbling is necessary to protect the Oak seeds lying on the bare ground from their predators. Introduction of N_2-fixing species, such as *A. nepalensis* may accelerate the process of establishment of climax species.

Biomass Accumulation

Above-ground and under-ground biomass of herbaceous vegetation increased over time (Fig. 1). Shrub biomass did not show a definite pattern over time. Total tree biomass at the 40-year-old site was 2.3t ha^{-1}. Among the reference forest stands, except for U4 sites, tree biomass ranged 41-88.7t ha^{-1}. On site 4, the tree biomass was 300t ha^{-1}. The biomass of herbaceous layer stabilized at 40 years although the floristic composition stabilized earlier (i.e. by 21 years). Thus the optimum mix of species subsequently establishes itself firmly by exploiting available resource.

Soil Nutrients

Changes in the concentration of soil nutrients over time are shown in Fig. 2. There was significant difference over time in the concentration of total nitrogen ($P<0.01$), available phosphorus ($P<0.05$), exchangeable calcium ($P<0.01$). The concentration of potassium did not differ significantly with age. Bormann and Likens (1979) suggested that for the Hubbard Brook system, the nutrients stored within the ecosystem provide the capability to ameliorate change in the functional characteristics of the ecosystem. The concentration of nutrients in the soil increased with time and returned gradually to the characteristic level of the reference forest stands over a period of 40 years. The rate of change in soil nutrients declined as succession progressed. The nutrient enrichment of the soil became stable at the same time as the plant biomass. The recovery of nutrient and biomass accumulation exhibit, in the initial stages, a positive feed back, moving the system quickly towards stable nutrient status and recycling. It is suggested that the added carbon from the developing vegetation stimulates the immobilization of nutrients which are constantly being generated by the ecological weathering aided by rainfall, in the soil biomass. This would counteract the process of leaching and release the nutrients at a slower but more stabilized rate for recycling by the vegetation. Later, proportionately, greater immobilization of nutrients occurs in the aggrading biomass of the developing tree layer, and nutrient cycling is further stabilized.

Hydrological Response

Overland flow as percentage of incident rainfall was maximal (0.60%) from 6- and 13-year-old sites and minimal (0.45%) from 21-year-old site. The 40-year-old site generated a little higher overland flow than did the reference forest stand, mainly because of the greater slope at the former. The overland flow was very low, since the Himalayan systems are subsurface flow systems (Pandey *et al.* 1983). Biotic regulation of the hydrologic cycle is lost immediately after disturbance and consequently surface flow increases. As the ecosystem develops, regulation by the vegetation is again achieved, which converts the increased surface flow to transpiration and finally a steady state is obtained. Sediment output decreased with recovery of the vegetation. Seasonal soil loss declined from 81 Kg ha^{-1} from the 6-year-old site to 37 Kg ha^{-1} from the 40-year-old site. Soil loss from the 40-year-old site was positively related to overland flow according to

$$Y = -78.63 + 16.61X \quad (r=0.910,\ P<0.01)$$

where, Y = soil loss (Kg ha^{-1}) and X = overland flow (mm).

The examination of natural course of restoration of degraded lands has heuristic and didactic significance. Bradshaw (1983) summarised the problems of derelict lands and their treatment.

Treatments

The simplest treatment for any existing area of degraded land is to add new soil surface on which a new ecosystem can quickly be established. In progressive mining operations, it is mandatory for surface soils to be conserved and replaced. However, maintenance of soil structure, drainage and retention of water should be taken into account. In many situations, soil cannot be imported and the material existing on a damaged site has itself to be treated directly to achieve restoration. Physical properties of surface soil should be made favourable for seed germination. Seeds of early successional species can be sown. Having dealt with physical problems, one has to deal with a series of problems connected with nutrient supply. Inorganic fertilizers can be added to the developing site. The disturbed lands are sometimes contaminated with heavy metals. Thus metal tolerant plants can be introduced. In natural ecosystem development species invade slowly. This can be accelerated by adding species at different stages of development. However, very little is known regarding the requirements of seedlings for their establishment. Nitrogen fixing plant

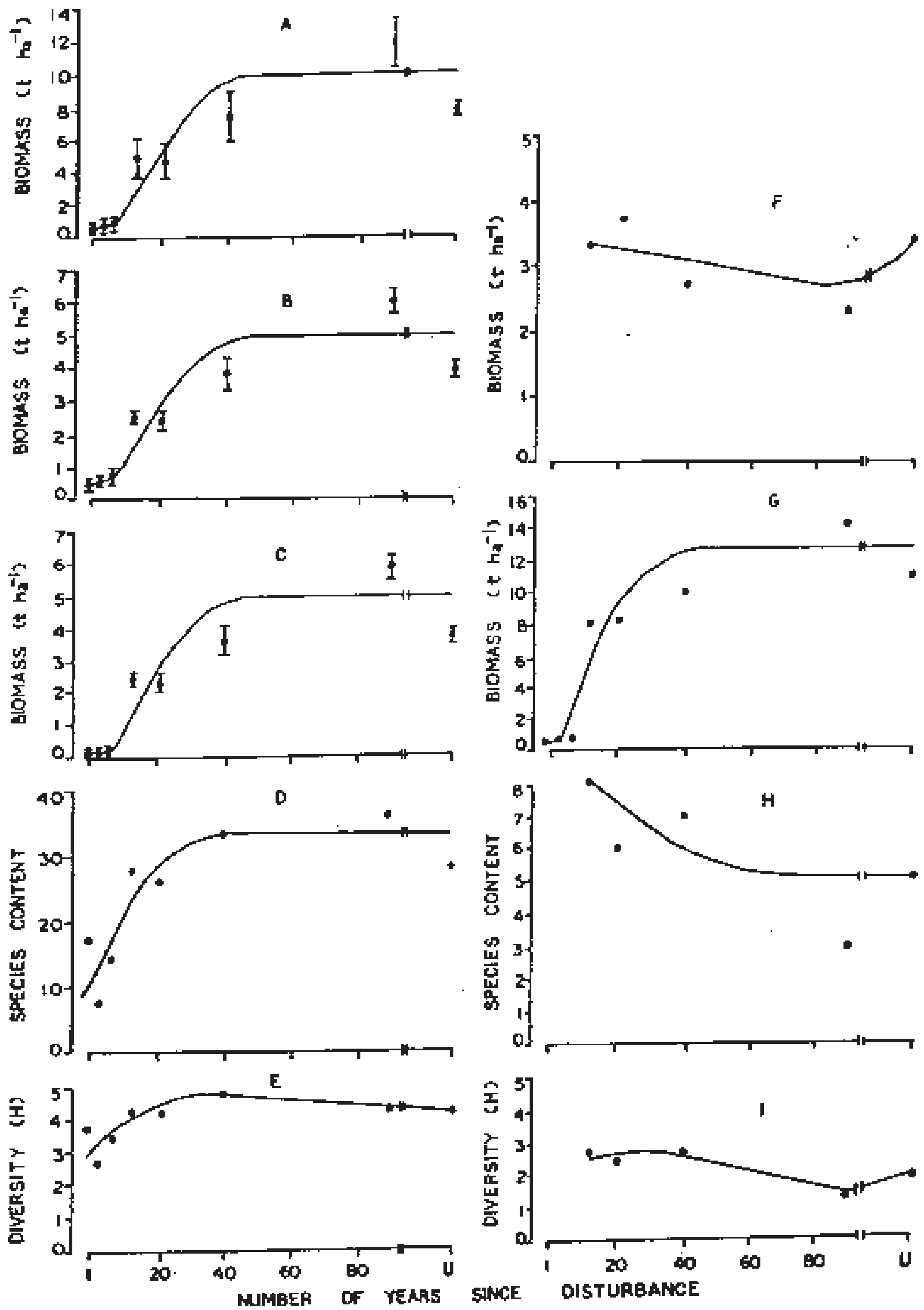

Fig. 1 : Changes in the herb and shrub layers across the developmental stages. Curves are eye-fitted. A, total herb biomass (above ground + underground), B, above-ground herb biomass, C, underground herb biomass, D, herb species content, E, herb layer diversity, F, above-ground shrub biomass, G, total herb + shrub biomass, H, shrub species content, I, shrub diversity, U, represents undisturbed forest site. Vertical bars represent 1SE.

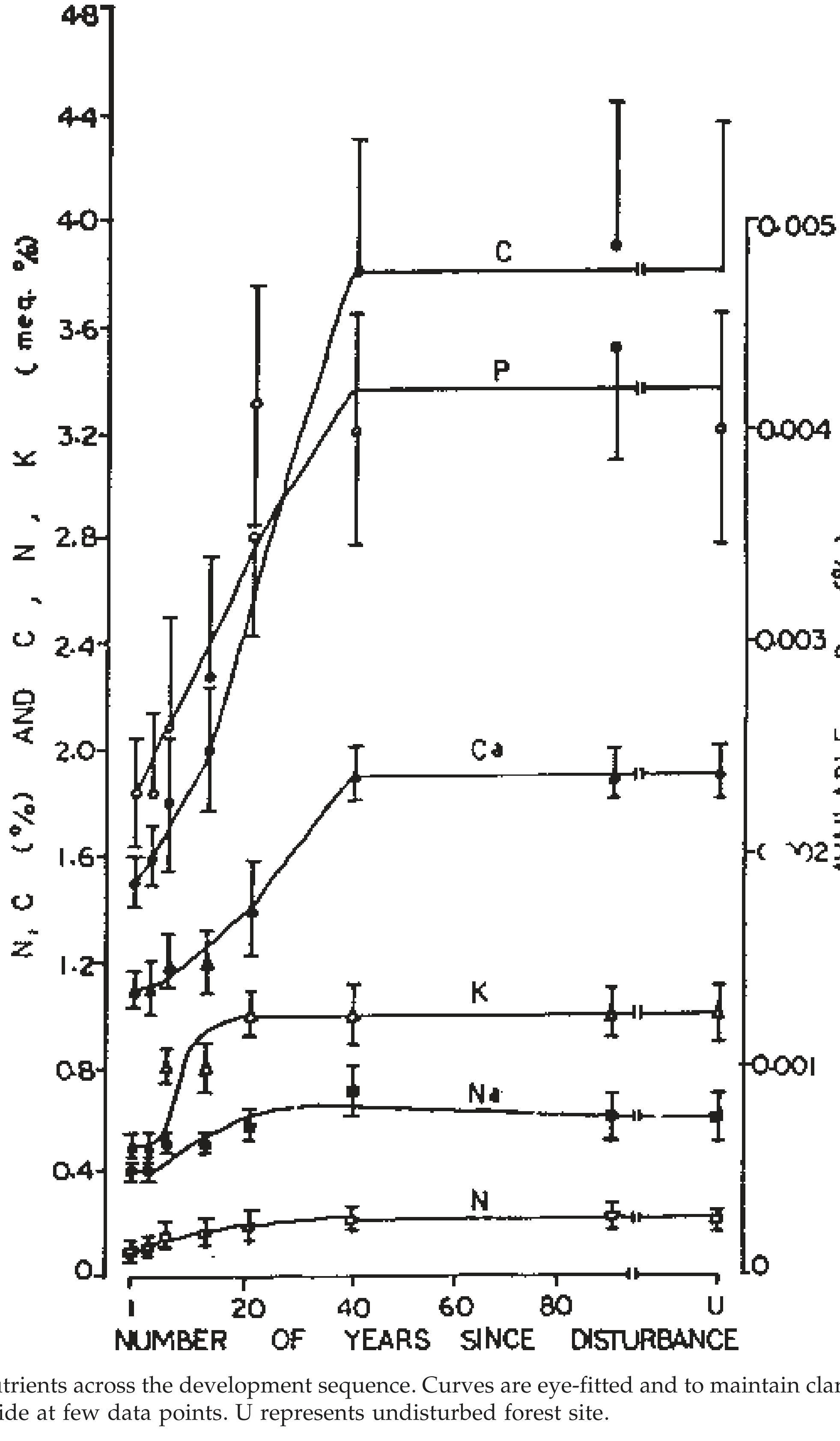

Fig. 2 : Soil nutrients across the development sequence. Curves are eye-fitted and to maintain clarity, SE is shown only on one side at few data points. U represents undisturbed forest site.

species can be introduced to improve the soil fertility. There is still a great deal of understanding to be gained for restoration of degraded lands.

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Table 1. Characteristics of seven sites near Naini Tal, Himalayan Range.

Years since disturbance	Altitude (m)	Slope (□)	Dominant tree species in undisturbed sites	Fine soil content (%) (mean ± 1SE) Disturbed site	Undisturbed site
1	1600	38	*Quercus leucotrichophora*	15±4	40±3
3	2150	36	*Q. floribunda*	34±9	51±6
6	2100	36	*Q. floribunda*	38±8	52±8
13	1800	38	*Q. floribunda* + *Cupressus torulosa*	33±2	44±3
21	2200	38	*Q. leucotrichophora*	39±4	49±2
40	2040	40	*Q. floribunda* + *Q. leucotrichophora*	42±9	44±5
90	1960	38	*Q. leucotrichophora*	26±3	31±2

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Restoration of a Degraded Land in a High Rainfall Area

S. D. Mahajan

An ecological restoration project initially started as ecological plantation activity by a group of thirteen nature lover enthusiasts in Kolhapur District, Maharashtra State, India, encompasses interesting findings and noteworthy results. Ten members of 'Nisarga Mitra' Kolhapur purchased 10 acres of non-agricultural land at throw away price near Amba Village, 74 km towards north west of Kolhapur, on Kolhapur-Ratnagiri State Highway in May 1986. The aim was to start some concrete eco-friendly activity, particularly afforestion with indigenous plant species and develop an ideal locality to undertake environmental orientation camps, workshops and excursions. It was decided to plan the activities in low cost budget, with local peoples' co-operation; even participation if and when so possible but without any government aid as far as possible.

Initial Situation

It is a picturesque undulating land rising to high hills towards west and traversed by two streams meandering towards south east and joining each other to form a rivulet. The hills outside the area sustain a typical semi-evergreen forest over lower slopes and plateaux. The upper steeper slopes showed open grassy patches, shrubby thickets and bare escarpments at places. The soil in most of the area with some gradient was too poor to be designated 'soil' in its real sense. It was gravelly and sandy with pebbles, stones and exposed bedrock here and there, light brown in colour. Two three somewhat plain, levelled patches at the base amounting to less than 10% of the total area had shallow soil – a mixture of silt, fine sand and gravel. The humus content was very very poor. The chemical analysis of soil samples revealed deficiency of all essential macronutrients with near absence of available nitrogen. Soil pH was 7.00.

The previous owner of the land, a poor local farmer had a practice of cultivating about 50% of the area in rainy season. The crop used to be invariably 'Nachani' (*Eleusine coracana* L. Gaertn.) fetching him meagre income of Rs. 300/- to 400/- per acre. He said that the family owned the land for three generations with a practice of having monsoon crop of nachani or other minor millets.

The average annual rainfall in the region is between 2000 mm to 3000 mm pouring down in 4-5 months of rainy season, with a dry winter and hot windy summer. The original semi-evergreen forest might have been destroyed about 100 years ago by cutting and felling of trees to bring the land under cultivation.

The removal of the forest resulted in heavy soil erosion due to torrential rains and surface flow action. The sheet erosion, rill erosion as well as gully erosion had taken heavy toll of the surface soil in course of time. The remnant vegetation along the streams consisted of shrubby, crooked trees of *Terminalia crenulata* Roth (Aain), *Lagerstroemia microcarpa* Wight (Nana), *Syzygium cumini* (L.) Skeels (Jambhul), *Terminalia chebula* Retz (Hirda), *Terminalia bellerica* (Gaertn.) Roxb. (Behada), *Pongamia pinnata* (L.) Pierre (Karanj) and *Memecylon umbellatum* Burm. f. (Anjani). Several species of shrubs, ferns and climbers were present in the streamside narrow strip of vegetation as well as scattered clumps all over the terrain.

The Restoration Project

The restoration project designed and executed was simple, unconventional and inexpensive. We didn't fence the area (except for a trial for a few months), no watchman was appointed, no construction was made – not even a hutment; moreover, no plant was ever watered! All efforts were made to allow the nature to develop by reducing the pressure of human disturbance in various direct and indirect methods.

A gist of activities carried out in course of a decade (1986-1996) is given below :

1. A preliminary botanical survey of the adjoining semi-evergreen forest was done with a view to undertake ecoplantation if possible, at least on border areas. 65 tree species were recorded.
2. With a view to use indigenous species for afforestation as far as possible, seeds were collected from the adjoining forest. Seeds and fruits of Pisa (*Actinodaphne angustifolia* Nees), Gela (*Randia dumetorum* (Retz.) Lam.), Parjambhul (*Olea dioica* Roxb.), Bhoma (*Glochidion ellipticum* Wight), Shendari (*Mallotus philippensis* Lam Muell), Hirada (*Terminalia chebula* Retz), Alavi (*Meyna spinosa* Roxb ex Link) were procured in April-May 1986. The same were scattered over suitable area in next June, with a very disappointing result. Hardly any seed germinated, none survived past seedling stage.
3. Collecting seedlings from the forest proved to be next to impossible. An effort to uproot a one-and-half-foot Gela seedling took four hours! Its tap root was five feet and more deep!
4. Plantation of seedlings of as many species as possible from all available sources was undertaken during monsoon months in 1986, 87 and 88. Stump plantation method was adopted for teak (*Tectona grandis* L.), while rhizome buds of bamboo (*Dendrocalamus strictus* (Roxb.) Nees) were used. Large number of seedlings of Nilgiri (*Eucalyptus* spp.), Australian Babhul (*Acacia auriculiformis* A. Cunn.) and Suru (*Casuarina litorea* L. Diss) were most unwillingly planted. Subabhul (*Leucaena leucocephala* Lam. De Wit.) was strictly avoided as it attracts grazing animals. Other species included Shivan (*Gmelina arborea* Roxb), Kaju/ Cashewnut (*Anacardium occidental*e L.), Karanj (*Pongamia pinnata* (L.) Pierre), Jambhul (*Syzygium cumini* (L.) Skeels), Behada (*Terminalia bellerica* (Gaertn.) Toxb.), Shisam (*Dalbergia sissoo* Roxb.), Nirgudi (*Vitex negundo* L.), Kasheed (*Cassia siamea* Lam.) and many others.
5. Plantation was done without digging conventional pits, neither was it indicated. The loose, wet, sandy-gravelly soil allowed scooping out a small pit with any instrument within minutes. Seedlings with roots covered by a lump of black clayey soil were placed in position. It was almost sure that they will be rain-watered soon, in the months July and August!
6. Co-operation was sought from the villagers by arranging meetings, establishing rapport with influential persons and persuading them to start similar activities in their own fields. Some farmers had already started tree plantation activity while some others on both the sides of our plot joined hands with us. We successfully encouraged them to abandon the conventional, orthodox, non-profitable farming and turn to plantation projects. This eventually brought our land at the centre giving fairly good indirect protection from intruders, shepherds and poachers.
7. Grazing was minimised by developing friendship with Dhangars in the nearby Dhangarwadi. As four of our thirteen participants are medical doctors, we arranged free medical camps for them and other local people. They were gradually, at least partly convinced of our bonafide activities and the adverse effects of grazing and cattle roaming and tampering the fields. We provided them fodder free of cost by allowing them to cut and carry the grass as per schedule decided and directed by us.
8. Many seedlings died in the first or second dry season. They were replaced by fresh ones during the following rainy season. Mulching was done wherever possible, by using local grass and dicot weeds.
9. External manure was used very sparingly. Handfull of urea granules was manually dropped in each pit during two consecutive rainy seasons.
10. Soil conservation techniques particularly digging trenches were avoided as far as possible, or rather judiciously applied in less than 20% of the total area having higher gradient. The size of the discontinuous contour trenches was 3m x ½m x ½m.

The Present State of Affairs

Out of the total 20,000 and odd tree seedlings planted, about 12,000 are surviving giving the 60% survival rate. The most successful species are *Casuarina* (Suru, Khandsherani) and *Acacia auriculiformis* (Australian Babhul). Some *Casuarina* trees have reached the height of about 15m (50′) and trunk diameter about 30cms (12"), their lofty growth in some patches giving conifer-forest-like appearance to the landscape. Australian Babhul on the other hand has developed closed canopy over slopy areas. Height of these trees is 4 to 7m and trunk diameter 15 to 25cms. Both the species are nitrogen fixers due to associated nitrogen fixing symbiotic bacteria. Abundant litter forming humus and increasing nitrogen content of the soil has started the desired soil building process. This has developed fairly good undergrowth, particularly in *Casuarina* stands. Seedlings of the following tree species naturally grown and established were observed in September 1999 :

1.	*Actinodaphne angustifolia* (Roxb.) Mig.	Pisa
2.	*Bridelia retusa* (L.) Spreng.	Asana
3.	*Callicarpa lanata* L.	Ishwar
4.	*Careya arborea* Roxb.	Kumbha
5.	*Casearia graveolens*	Kirkira
6.	*Eleodendron glaucum* (Rottb.) Pers.	Bhutya
7.	*Diospyros sylvatica* Roxb.	Madai
8.	*Garuga pinnata* Roxb.	Kakad
9.	*Grewia subinaequalis* DC.	Falsa
10.	*Maytenus rothiana* (Walp) Lab.	Ikhal
11.	*Litsea stocksii* Hook. f.	Kanel
12.	*Neolitsea cassia* (L.) Kost.	Pisi
13.	*Mallotus philippensis* (Lam.) Muell-Arg.	Shendari
14.	*Memecylon umbellatum* Burm f.	Anjani
15.	*Olea dioica* Roxb.	Par-jambhul
16.	*Randia dumetorum* = *Catunaregum spinosa* (Thunb) Tirven.	Gela
17.	*Symplocos spicata* Roxb.	Mirjoli
18.	*Syzygium cumini* (L.) Skeels	Jambhul
19.	*Terminalia crenulata* Roth.	Aain
20.	*Trema orientalis* (L.) Blume	Gol

In addition to tree species, host of other species of climbers, shrubs, grasses, dicot herbs and ferns were observed. According to rough assessment, the biodiversity seems to have doubled that of the original one.

Cultivation / plantation of Teak, Bamboo and even Nilgiri has turned out to be gross failures. Nilgiri trees grew well in the beginning. Some even reached the height of about 10m. But most of them are wilting and dying even during the favourable season. The same are being replaced by planting seedlings of various species to increase biodiversity.

The soil colour is turning darker due to increasing amount of humus. The soil pH, though slightly varying at different spots, is between 6.50 and 6.75. The water retention capacity of the soil has been definitely increased as evidenced by occurrence of many species of mesophytic herbs all over, well after the monsoon months.

Conclusion

Natural regeneration process (ecological succession) has been started and the ecosystem is heading towards improvement. Ecological restoration process, although rather slow, is well established. The low-budget restoration experiment (Rs. 7,000/- per acre approx.) has become successful.

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Restoring Natural Capital

Prakash Gole and Narayan Desai

Economic development often involves destruction or degradation of natural capital : forests, rivers and streams, sea-coasts and mangroves, lakes, grasslands and fertile soils. Economic development generates man-made capital but it can never be the perfect substitute for the natural capital. For the services that the latter provides are unique : atmospheric, hydrological and biogeochemical cycles, biodiversity, in a sense all the life-supporting systems. Man-made capital can neither provide these services nor is it expected to cater for these basic things. The case for restoration of natural capital therefore, appears to be beyond any argument. If economic development results in imbalances in atmospheric, terrestrial or aquatic life cycles, restoration of disturbed eco-systems becomes imperative.

It is well-known that construction of large dams and canals creates imbalances in a number of things and at a number of places. There is submergence of fertile lands in flood-plains, destruction of forests in valleys and devastation of landscapes with alteration of drainage patterns in and around dam and canal sites. Panshet dam was constructed 45 kms west of Pune city in the outliers of Western Ghats at an altitude of 620 metres (Lat. 18° 05" N and Long. 73° 19" E). A small river, the Ambi, rising in the crestline of Western Ghats was impounded creating a large reservoir that submerged valley lands and displaced 23 villages. The construction of the dam involved excavation in the surrounding hills, the resulting quarries supplying rock and soil to build the dam. Hill slopes were denuded as their forest cover was shorn off. A lot of flat and undulating land lay waste as its soil and vegetation were removed. The conditions in quarries are harsh and present many problems for plants attempting to colonize including low seed input, high seedling mortality, limited nutrient and water availability, invertebrate attack etc. (Willen 1995).

We began restoring such lands around the dam site since 1986. Initially we concentrated on restoring forest cover on degraded hill-slopes adjacent to the dam. Then we directed our attention to degraded lands just downstream of the dam. Our plan was to restore abandoned stone quarries, pits and depressions to their vegetative cover and to their productivity by building a system of wetlands.

To the dam-builders our project area downstream of the dam signified a 'borrow area' from where soil and rock were borrowed to build the dam. When borrowing operations ceased, the area was abandoned and came to be used by cattle who grazed the meagre grasses that grew there, and by people who cut the bushes for fuel-wood. Cutting, grazing, trampling and occasional fires in the dry season, had scoured the land of humus and moisture contents.

The land belonged to the government's Irrigation Department who had built the dam and were looking after its maintenance. We requested their officials that as preliminary measures the following would be necessary : 1. Fencing to arrest cattle-grazing and wood-cutting and 2. A series of check dams to arrest the flows of water in the quarries and pits and depressions. In the summer of 1996 the area was partially fenced and 5 bunds were in place creating a series of shallow ponds. A deep quarry filled up with rain water over the years made up the eastern end of this system of multiple ponds. Water from a leaking pipeline was channelled into the ponds. This water moving through the five ponds flowed into an old quarry pool and thence joined the river channel. The system of wetlands thus possesses an inlet and an outlet. The check dams or bunds ensure water residence time, one of the important characteristics of wetlands.

The project site falls into the region immediately to the east of the Western Ghats crestline. The crestline receives the full force of the northwest monsoon with an average annual rainfall of more than 6000mm. Towards the east the average rainfall declines rapidly. The project site which lies 30 kms east of the crestline, shows an annual average of around 2000mm rainfall. Distribution of rainfall during the period June to September during the last three years is as follows :

Month	1995-96	1996-97	1997-98
June	30.00	423.20	557.20
July	931.60	882.40	732.60
August	177.50	401.90	1049.20
September	445.50	189.30	64.00
October	91.80	332.00	1.00
Total	1676.40	2228.80	2404.70

Geographically the Western Ghats are formed as a result of a series of Volcanic eruptions in the late Cretaceous. The major rock formation is basalt. Its weathering forms a series resulting in Murrum (decomposed rock), before its further decomposition in soil. As the upper layers like soil and murrum were mostly removed from the project site, soil and its ingredients were mostly absent from a large part of the project area. Wherever existing the thin soil layer, when analysed showed that it was almost neutral in pH(6.48), with low organic content and moisture holding capacity. Available nitrogen, potassium and phosphorus were, however, not lacking.

At the beginning of our work the inventory of vegetation was as follows :

Type of Vegetation	No. of Species
Tree	24
Shrub	19
Herb	33
Climber	Nil
Grass	14

The working plan that was envisaged included :

1. Getting to know the landscape : its area, its features, its habitat pattern and dominant plant communities.
2. Monitoring seasonal changes in vegetation and habitat structure.
3. Introducing suitable terrestrial and aquatic plants to accelerate the process of restoration.
4. Carrying out incidental work especially strengthening protection, soil-working and seeding and fertilizing experiments to facilitate restoration, and
5. Interacting with local communitites with a view to increase their understanding of the short-term and long-term benefits of restoration.

The main physical features of this 'borrow area' include steep slopes of the hill to its north, followed by gentle dry slopes that converged into middle pits and depressions (the main quarry area), the plateau or uplands to south and southwest and undulating grasslands to the east. The existence of flowing water from the pipeline as well as from the hills during the monsoon period, has created distinct wet and dry zones in this landscape. The broad habitat pattern of our project area depends mainly on slope, altitude and wet and dry conditions. The project area can be divided into the following broad habitats :

Habitat	Area
Steep slopes	0.7 ha.
Dry meadows	2.3
Wet meadows	1.5
Wetlands(ponds)	2.2
Uplands	1.3
Grasslands	1.5
Rocky outcrops	0.5
Total estimated area	10.00 ha.

The steep slopes displayed shrubs and a few trees desperately clinging to eroded mud cliffs. These included *Lantana camara, Vitex negundo, Albizzea amara* and *Zizyphus rugosa.* The gently sloping dry lands below the cliffs were covered with grasses such as *Heteropogon, Aristida* and *Themeda,* coppiced *Acacia* and *Lantana.* The wet areas around ponds showed *Cyperus, Pogostemon* and stunted *Lantana* and *Pongamia spp.* In the wetlands grew *Typha, Jussea, Polygonum* and *Limnophyla spp.* The rocky outcrops had some lichen cover while the uplands exhibited stunted growth of *Pongamia* and bushes of *Lantana.* The heavily grazed part was dominated by a few inedible herbs such as *Alternanthera sessilis.* Dry depressions had some coppiced *Acacia* trees while the deep quarry pool to the east showed floating and submerged masses of *Hydrilla, Chara* and *Vallisneria spp.* This pool was surrounded by *Typha, Jussea* and *Ipomoea carnea.* In restoration projects competition from nuisance species is a primary limitation to the growth of many wetland plant species (Davis, M. M. *et al* 1995).

Now as we look at the project area after 3 years of initiating the work, a perceptible change can be seen in vegetation cover and fauna. This has come about mainly through control over grazing and cutting, utilizing the available water in such a way that it irrigates a greater area and introducing plants that can withstand lack of soil and scarcity of moisture. In wetlands we improved flow conditions and reduced stagnation. Draw down of water in the ponds was also effected to imitate pulsing (Middleton 1999). This helped control opportunistic species such as *Typha. Limnophylla, Typha* and *Jussea* were also physically removed. The draw down controlled *Polygonum.* These measures made some leeway for other species to colonize the wetlands. *Azolla* proliferated in one pond. As there was no reference wetland anywhere in the vicinity from where wetland plants could impregnate our ponds, we borrowed soil from other wetlands and introduced it here. This way regenerated species of *Cyperus, Scirpus* and *Nymphea.*

With greater protection in terms of control over cattle grazing and wood-cutting, herbs and grasses began to cover the area as the first (1996) monsoon season progressed. In October 1996 the count of herbs was 99 (from the initial 33) and of grasses 35 (from the initial 14) spp. The heavily cut and coppiced trees and bushes began to recover. There was a perceptible increase in their foliage and bush size. From the clumps of bushes popped out saplings that germinated anew. 17 new tree species and 9 new bushes were counted in October-Novermber 1996. The above ground biomass in the dry meadow area increased by 188 per cent and that in the wet meadow area by 112%.

During the 1996 monsoon we had introduced 10 species of indigenous trees by first raising saplings from seeds in our nursery and then planting them in places where they would be protected from grazing and trampling. Locations where the moisture could be retained for a longer time than usual were selected for planting these saplings. In wetlands there must have been some increase in the availabilty of fish and crustaceans as tribals visited wetlands more frequently and caught greater numbers of crabs and larger sized fish than before. At the end of the 1996 monsoon our project area came to be covered by different types of vegetation in the following proportions :

Habitat	Pre-monsoon cover	Post-monsoon cover
Barren and grazed land	65%	29.5%
Grass	10%	18%
Herbaceous	5%	26%
Trees	2%	5.5%
Scrub	8%	9%
Amphibious plants	10%	12%

Grazing of animals was controlled, not eliminated. The number of grazing cattle and buffaloes went on decreasing as 1996 progressed and there was also decline in the number of hours they spent in grazing. During the monsoon 30 animals grazed the area for almost 8 hours per day. At the end of 1996 their number was reduced to 5 and the number of grazing hours per day to 2. The estimated quantum of biomass grazed by them per month declined from about 6 tonnes to 400 kgs. This estimate was based on the rate of consumption by cattle observed in nearby villages : cattle 6 kg per day, buffalo 9 kg per day.

As the dry season progressed, we had to irrigate the introduced saplings. The naturally regenerated species were not watered but given protection to reduce moisture loss in their surroundings. In wetlands while removing obstacles in water flow to reduce stagnating conditions, we, for the first time brought about some draw down by diverting water flow to other depressions unconnected with the pond system.

The activities undertaken in the next 2 years did not differ in their essentials. We introduced saplings of new species of trees in terrestrial habitats. Introduction of *Lemna gibba* in wetlands was not successful as it was immediately grazed by waterfowl. The survival rate of saplings introduced in 1996 was 88% though their growth was moderate due probably to lack of suitable soil and humus. At the end of 1997 monsoon we noticed the following increase in the numbers of species of different kinds of vegetation :

Vegetation Type	Number of species recorded in 1996	Number of species recorded in 1997
Trees	24	56
Shrubs	19	38
Herbs	33	139
Grasses	14	55
Climbers	0	9
Orchids	0	1

Out of the 56 tree species 26 were introduced. That means 6 new species germinated naturally. No other kind of terrestrial vegetation was introduced in the project area. Shrubs, herbs, grasses and climbers showed net increase in their numbers. In the dry meadow area post-monsoon above ground biomass showed an increase of 200% while in wet meadow area it was somewhat less than 200%.

In the 1998 monsoon though over 300 saplings were planted, no new species of tree was introduced. The survival rate of saplings introduced in 1996 and 1997 was found to be over 80%. A marginal increase in the number of tree, shrub, herb, climber and orchid species was recorded at the end of 1998 monsoon. The number of grass species did not show any increase. The increase in percentage vegetation cover is shown below :

Habitat	Vegetation Cover (%)			
	Pre-monsoon 1996	Post-monsoon 1997	1997	1998
Barren Land	65	29.5	18	10
Grass	10	18	27	30
Herb	5	26	26	23.5
Shrub	8	9	9	11
Tree	2	5.5	8	13.5
Amphibious	10	12	12	12

At the end of 1998 we for the first time came into a position to supply free fodder to local communities. About 1000 bundles of grass, i.e. over 2 tonnes of fodder was given to them free of charge. Certain wetland plants introduced at the end of 1998 survived well. They were *Cyperus, Nymphea* and *Marselia spp.*

In the summer of 1999 a drawdown was effected by diverting the waterflow completely to other depressions. In a period of 15 days the pond system ran dry. The water in ponds was drained by opening a sluice in the lower-most bund. The ran down conditions were retained for 15 days after which the flow was resumed. The resumption of the flow coincided with the break up of the monsoon.

During the draw down *Typha* was physically removed and also burnt. The drawdown affected *Polygonum* whose incidence was reduced by 90%. *Jussea* and *Limnophyla* were also removed to some extent. At the end of 1999 monsoon there was a partial regeneration of *Jussea* and *Limnophyla*. *Typha* grew less extensively and was completely gone from the uppermost pond. *Polygonum* did not show much revival. *Azolla sp.* grew vigorously. A lot of fibrous algae also began to grow.

What are the indicators of success of restoration? Improvement in vegetation cover, increase in the number of flowering and fruiting species, the return of indigenous, climatically right species, the return of fauna, improvement in soil quality, improvement in above ground biomass and increase in micorrhizal fungii may be important for eco-system sustainability, productivity, nutrient retention and biotic interactions (Ewel 1987).

Return of birds to the project area was noticeable immediately. Two Chestnut Bittern (Ixobrychus cinnamomeus) pairs nested in the overgrown Typha and *Cyperus* during the 1997 monsoon. In subsequent years their number increased to 3. Kingfishers (Alcedo atthis and Halcyon smyrnensis), Pond herons (Ardeola grayii), Redwattled Lapwings (Vanellus indicus) and a covey of Spotbilled Ducks (Anas poecilorhyncha) are regular visitors though they do not nest. Lately Little Cormorants (Phalacrocorax niger), Common Sandpipers (Tringa hypoleucos) and Wagtails (Motacilla spp.) are also attracted to the wetland.

Terrestrial and arboreal birds include Kites (Milvus migrans govinda), Drongos (dicrurus adsimilis), Mynas (acridotheres tristis), Quails and Partridges (Perdicula and Francolinus spp.), Bulbuls (Pycnonotus sp.), Bee-eaters (Merops orientalis), Munias (Lonchura spp.), Flycatchers (Muscicapa parva) and White-eye (Zosterops palpibrosa). Large flocks of Jungle bush quail (Perdicula asiatica) and Spotted Munia (Lonchura punctulata) are a regular feature. They feed on abundant grass and weed seeds and nest in grassland habitat. Over 60 species of birds have so far been recorded in the project area.

Six species of snake (see appendix), hare, fox and hyena, turtles and monitor lizards have also been frequently sighted. Butterflies, moths, spiders, grasshoppers and a variety of bugs and beetles have been collected in the project area. Their identification, especially of the latter, is still in progress. Honey bees have been sighted on the inflorescence of *Acacia, Bombax* and *Erythrina spp.* and on that of *Themeda,* a grass species.

Has the system achieved functional stability? Is it on its way to regain its natural evolutionary pathway? Probably it is too early to say anything definite in this regard. The main eco-system components appear to be in place now. A range of primary producers from algae to trees and climbers forms now a broad enough base of the food pyramid. Fruiting and flowering seem to have regained their natural rhythm attracting pollinators for their continued propagation. They are complemented by an equally broad range of consumers from fish to reptiles and mammals. A varied habitat pattern will probably induce them to take up residence here. The mycorrhizal count has improved in the project area compared to the unprotected area outside the project site. Their function is to contribute significantly to the nutrition of many plants, especially under nutrient-poor conditions (Mooney 1984).

In future if anthropogenic influence (including indiscriminate grazing) is kept in check, as it is now, the system is most likely to achieve functional stability on its own.

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Appendix

Soil Analysis of Samples collected from the wetlands in the Project Area and from a wetland (Donor Wetland) from where soils were collected for introduction in the Project area.

Parameter	Project Area	Donor Wetland
pH	6.02	8.05
Electric conductivity (millimole)	0.26	0.41
% Organic Carbon	1.35	0.31
Available Phosphorous (kg/ha)	23	24
Available Potassium (kg/ha)	216	438

Above Ground Biomass

Habitat	Pre-monsoon 1996	Post-monsoon 1996
Dry Meadow	345.3 gms/sq.m.	663.3 gms/sq.m.
Wet Meadow	833.3 gms/sq.m.	966 gms/sq.m.

Number of Flowering and Fruiting Plants

Name	1996	1998
Acacia nilotica	9	108
Acacia catechu	1	11
Acacia auriculiformis	29	116
Trema orientalis	4	9
Pongamia pinnata	0	40
Leucaena leucocephala	5	10
Bombax ceiba	0	5
Psidium guajava	0	8
Erythrina frondosa	0	4
Butea monosperma	0	3
Cordia myxa	0	2
Thevetia spp.	0	1

Vascicular Arboreal Mycorrhizae (VAM)

Habitat	Average number of spores per one gram of soil sample
Dry Meadow	7
Wet Meadow	1
Unprotected land	2

Snake Species Recorded

Common Name	Specific name	Family
Indian rat snake	*Ptyas mucosus* (Linnaeus, 1758)	Colubridae
Checkered keel-back water snake	*Xenochrophis piscator* (Schneider, 1799)	Colubridae
Common Vine snake	*Ahaetulla nasutus* (Andersson, 1898)	Colubridae
Spectacled cobra	*Naja naja* (Linnaeus, 1758)	Elapidae
Russell's viper	*Daboia russelli* (Shaw and Nodder, 1797)	Viperidae
Indian Saw-Scaled viper	*Echis carinatus* (Schneider, 1801)	Viperidae

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Restoration : What it is?

Bill Jordan III

There has been a lot of discussion about 'restoration', and how to define it in recent years, but it is important not to let all the talk confuse you. The idea of restoration is simple. The Webster's Dictionary says that 'to restore' means 'to bring back into existence or use,' or 'to put back into a former . . . state.' So 'ecological restoration' means doing that to an ecological system such as a tallgrass prairie in Illinois or perhaps habitat for tigers and elephants in India. The idea is simple. The reason it generates so much discussion, and even argument, is that when you actually try to do restoration, you face a lot of questions. For one thing you have to decide what you are going to restore to, that is, what will be the model for your project? Then you have to decide how you are going to define the model, that is, exactly what features you are going to try to 'bring back into existence'? And then you have to face up to the fact that, strictly speaking, restoration is impossible. We cannot ever put anything back exactly the way it was, and certainly not anything as complex as an ecosystem. This, however, does not mean that restoration is a silly idea, or a sentimental idea. In fact, as conservationists in many parts of the world have discovered, it has great value as a model, an ideal or a protocol for managing nature. What restorationists have learned over the past decade or so is that, though restoration may be impossible in the strictest sense, it is often quite possible to create a system that closely resembles an historic model in many respects. In fact, if you want to ensure the survival of 'natural' or historic landscapes over long periods of time, restoration offers the best chance of doing that. Another is the virtue of humility that is fostered by a restoration project unless it has three qualities :

1. Its goal is defined by an historic model.

2. The aim is to re-create that model as completely as possible. The resulting system should not only include all the species present in the model system, it should also function and behave like it.

3. The process is active and deliberate.

Of course, many projects do not meet these criteria. In fact, it is often impossible, impractical or even inappropriate even to try to meet them. When this is the case, the proper way to talk about a project is not to stretch the word 'restoration' to fit what you are doing. The proper way to talk about it is to say that it is not restoration in certain ways, and to call it what it really is. When a project is not modeled on an historic system, for example, then we should call it 'agriculture' or 'forestry' or 'gardening,' or, more vaguely, 'stewardship' or 'management'. 'When the aim is to restore only certain features of a system, such as a rare species, or a hydrological feature, then we should call it 'rehabilitation' or 'reclamation.' If the aim is to restore the health of the system, we can use the term 'rehabilitation' or perhaps 'healing.' And when the project is not active, and involves only removing a source of disturbance and letting the system recover, then we can call it 'recovery.' Some have argued that this strict definition is unrealistic in practice. Of course it is. It defines an ideal. But that ideal is important, and it is important to protect it by using language carefully when talking about it. Others have said that restoration is a peculiarly American or New World idea, and that it is not useful in Old World countries like India that have long and compelx land-use histories. This concern, however, rests on the idea that 'restoration' is about the re-creation of 'nature' or 'natural' ecosystems. As I have defined it, restoration is not aimed at the creation of 'natural' landscapes, but at the re-creation of historic landscapes, whether these have been influenced by human activities or not. I am thinking, for example, of the efforts to restore the vegetation at Buddhist shrines in India. These are excellent examples of restoration projects in the strict sense of the word. Understood this way, the idea of restoration is as useful to conservationists in Old World countries like India as in New World countries like the United States or Mexico.

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Ecological Restoration : Old Fort Bayou Tract near Ocean Springs, Mississippi, U. S. A.

Narayan Desai

This project consists of approximately 1,860 acres in Jackson County, Mississippi, north east of Ocean Springs. It is bordered on the west by the Ocean Springs unit of the Mississippi Sandhill Crane National Refuge (MSCNWR).

The property is owned by The Nature Conservancy (TNC) and is managed by TNC's field office. George Ramseur heads the Ocean Springs field office. TNC has negotiated with André Clewell to become the restoration ecologist on a contractual basis through the firm of A. F. Clewell, Inc. I spent three days on the project area along with David Borland, Restoration Practitioner in October 1999. The details of the project are as follows :

Historical aerial photographs from 1942 revealed that the project site was once a vast prairie with only here and there small clusters of longleaf pines on higher ground or stands of pondcypress along an incipient stream. Similar vegetation currently exists at the adjacent MSCNWR. Frequent surface fires maintain this vegetation. During the 1940's and 1950's, the project site was densely row-planted with slash pines. Fire was suppressed, allowing gallberries and other woody undergrowth to establish copiously beneath the planted pines. This conversion from prairie to pine and gallberry discouraged Mississippi Sandhill cranes that formerly inhabited the prairie. These Cranes are considered as endangered.

The exceedingly wet soils deterred pine tree growth and profitability to the point that the tract was abandoned before all of the planted pines were harvested. Although much of the original prairie vegetation survived, it remains suppressed beneath a prolific growth of gallberries and the few stands of planted pines. Sandhill cranes continue to avoid the project site.

Restoration promises to return the prairie to its former condition. The land would once again be suitable for Sandhill cranes. The restored land would unite the currently frangmented properties comprising the MSCNWR, making it perhaps the largest expanse of wet prairie anywhere along the Gulf of Mexico. Wet prairie is exceedingly diverse botanically. They are becoming rare from development pressures and from fire suppression. This restoration project helps assure the persistence of this formerly widespread community.

The Goals of the project are threefold : 1. Recreate the landscape mosaic as it appeared on 1942 aerial photographs, 2. Attract habitation by Mississippi Sandhill Cranes, 3. Reestablish the species composition and structure of plant communities that were damaged or destroyed.

According to David, to achieve these goals, the return of frequent and regular prescribed fire is paramount for the successful restoration and continued health of these communities.

Restoration of Riverine Forest at Hall Branches on Phosphate-mined Land, Florida

Along with Dr. Andre Clewell, I visited 1.5 ha riverine headwater forest (Hall branch) that was created 11 years earlier on phosphate-mined and reclaimed land near Tampa, Florida, U.S.A. This project area is east of Sun City center, 60 miles from Tampa. Nearby area is dominated by tomato, citrus and strawberry agricultural farms and allied industries.

Basic soil structure contains 95% fine sand, clay and limestone. Below the limestone layer there is a remarkable presence of phosphate deposition. Plant sapling mortality is due to clay content in the soil. Too much clay makes soil problematic in summer. It acts like brick and so there is high mortality.

The Hall Branch River begins in southeastern Hillsborough County and discharges into the South Prong Alafia River and ultimately into the Gulf of Mexico at Tampa. River water color was black due to tannin from Cypress tree. In 1983, almost the entire catchment was surface-mined for phosphatic ore.

The goal of Hall Branch restoration as stated in the vegetational restoration program was to initiate and foster the development of vegetation, which closely resembles, floristically and ecologically, the natural riverine vegetation of the south Prong Alafia River system. Top canopy comprises of *Nyssa biflora, Acer rubrum, Liquidambar styraciflua, Magnolia virginiana, Ulnus Americana* and *Taxodium ascendense.*

In 1990 the land was given to Florida State as a national park. According to Dr. Clewell, seventy-three species at the restoration site were characteristic of the mature, undisturbed reference ecosystem. A corresponding area within the reference ecosystem contained essentially the same number of species and the same array of life forms. Copious plant reproduction has transformed the planted forest into an intact ecosystem that no longer needs restoration assistance.

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Restoration Education Efforts in India

Narayan Desai, Prakash Gole*

India being a developing country needs to implement socio-economic developmental plans. In doing so, overuse of natural resources to some extent is inevitable. Now time has come to give some thoughts to restore natural systems to their near original states. An attempt is being made to restore this mankind – nature relationship in the Panshet watershed area, 45 km west of Pune by the Ecological Society.

The focus is on educating and involving the local community in restoration work. We feel that local community should be made aware of the importance of the same and should be educated for sustainable use of natural resources as well as restored resources. The Panshet project has served as an example to the villagers as to how their own environment can be restored and made productive for both, human beings and wildlife. There is a growing response from local community, as they now understand the importance of this restoration project.

We are trying to educate members of the urban community also (a community which is the major recipient of benefits of developmental activities), non-governmental organizations (active and effective at grass root level), and government agencies (potential funding agency) as well as to make the efforts more broad-based. Training programmes are devised to meet the needs of all such groups.

We are using multiple media for education programmes, depending upon the audience, with a great degree of success, such as organized eco-tours, slide shows, seminars, poster presentations, regional press publicity, meetings and discussion sessions, etc.

We organize an year-round education programme to advocate importance of restoration through orientation camps and workshops for undergraduates students, a post graduate diploma course and a special course for government officials. The Panshet project site is developed as a research site for the above education programmes. It is advisable to join Society's courses to grasp in-depth knowledge in restoration ecology.

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The Society for Ecological Restoration

The Society for Ecological Restoration (SER) was founded in 1988 as an international membership organization with the mission of advancing the science and art of restoring damaged ecosystems. The Society's membership includes more than 25000 members in 24 nations and all 50 U.S. states, with ten regional chapters and guilds. SER believes that active restoration of damaged ecosystem, in combination with preservation and management of key natural areas, will be a vital component of strategies to maintain biological diversity and function in the coming century.

SER's members practise and study restoration in nearly all ecosystem types, including prairies, savannas, scrublands, forests, woodlands, deserts, tidal, and freshwater wetlands, coastal ecosystems, and alpine and arctic habitats. SER's diverse membership includes staff of public agencies, private conservation groups, university research departments, and environmental consultants, representing a wide range of disciplines including forestry, fisheries, range and wetland ecology, botany, zoology, population biology and genetics, horticulture, landscape architecture, engineering, education and many others.

The Society offers two main journals in the restoration field to its members and the interested public. Restoration and Management Notes, published by the University of Wisconsin Press, has been the defining venue for the field since in 1981. Restoration Ecology, the first peer-reviewed scientific journal on the subject, was initiated by SER in 1993 and is published by Blackwell Science. The Society also organizes the main annual international restoration conference, now in its tenth year.

The Society for Ecological restoration is a registered non-profit organization under Section 501©(3) of the US Internal Revenue Code, and all contributions are fully tax-deductible.

For more details, please browse SER home page : www.ser.org

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From 1999, India has joined SER as a chapter, named as SER-India Chapter. This is the result of unvarying encouragement by Prakash Gole, Director Ecological Society, Pune 411008. The main goal of SER-India chapter is to promote restoration work in India. A dynamic component and essential part of the India chapter is to bring people into a network to stimulate new restoration projects throughout India. For more details of SER-India chapter, please contact :

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International Workshop sponsored by
Eco Foundation and The World Bank

Early Bird Announcement

Eco Foundation, a non-profit public organization with support from The World Bank and in collaboration with Lions International, is proposing to conduct an International Workshop in Hyderabad, India on 3rd and 4th February 2000.

The topic of the workshop is *'The Role of NGO's in Environmental Protection, Economic Development and Education of Rural and Tribal Areas near Visakhapatanam.'*

This 'early bird' announcement is being made to facilitate your planning. Please spread the word around to interested parties. For more details, please browse

Eco Foundation home page :
http:/www.geocities.com/RainForest/Andes/9217

or

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Restoration of land used for fly ash disposal

Restoration of hill slope forest