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Review Article

Restoration Ecology: A Step towards Sustainability

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ABSTRACT
Human induced interferences and changes have led to extensive long term damage to the ecology of earth evoking several associated negative implications. Direct habitat destruction and interference with ecosystem dynamics has indirectly affected the global climate posing threat to the survival of entirety of living beings. Ecosystem repair is a plausible solution to the imposed threat with several key strategies to be undertaken. Amongst these, ecological restoration has emerged as a sustainable and effective strategy as it has new ideas and opportunities for conserving biological diversity, managing ecosystems, and testing ecological theories as well. It aims to establish the ecosystems that are able to sustain in the future environment. Restoration ecology is likely to be one of the most important strategies in the twenty first century towards achieving sustainable development.

Key Words: ecosystem dynamics, ecosystem repair, restoration ecology

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INTRODUCTION
Ecological restoration is the application of ecological principles to return the ecosystem that has been disturbed by human activities to a condition as similar as possible to their natural state [1]. Recovery process is relatively longer in comparison to the time taken for degradation. Restoration might take place naturally but that is a very slow process. Restoration ecology initiates and speeds up the recovery process.

The key strategies in restoration ecology are Bioremediation and Biological augmentation. Bioremediation is the use of organisms (prokaryotes, fungi, plant etc.) to detoxify polluted ecosystems by accumulating the toxic components in their bodies. Biological augmentation is the opposite process where limiting nutrients were provided with the help of particular organism (e.g., nitrogen fixing plants in nitrogen deficient environment).

Restoration is not only a tool to address the degradation problem but also a tool for ecological research which enhances our understanding about the ecosystem [2]. Reassembling a broken instrument to its previous functional state will give us a complete idea about its functioning of it; restoration is useful in the same way.

RELEVANCE OF RESTORATION ECOLOGY
Although world’s economic systems are enjoying remarkable expansion, ecological systems have been degraded at an alarming rate. Rapid increase in human population has resulted in deforestation, industrialization and uncontrolled use of various toxic substances etc. It is possible that there are many flora and fauna which become extinct before their identities are known.

Approximately 117 million acres of wetlands have been lost in the United States since the 1780s excluding Alaska [3]. Conversion of natural habitats into agricultural and industrial landscapes and ultimately into degraded land is one major impact of human activities on natural environment [4]. To reverse this trend an increase in efforts to restore the degraded land throughout the world were initiated [5, 6]. Restoration is necessary to relieve changing climate pressure and to get maximum ecosystem services and a balanced species relationship which may directly or indirectly have a positive impact on the upliftment and sustainable growth. Aesthetic reasons like cultural, regional, religion and people faith are some of the other reasons behind the restoration.

Restoration projects: issues, success and assessment procedures
Restoration ecologists face practical consequences of genetic variation when selecting plants and animal materials for restoration projects. Genetic variability gets increased attention in restoration practice and research [7,8] because it is the basis of adaptation to uncertainty in environment and reduces the effect of inbreeding. Many flora species help to restore their degraded native site as they contain some special features. Some species like *Lupinus albus* L. and *Lupinus elegans* Kunth are used for ecological restoration [9] because they have nitrogen fixing capacity. Other species like *Ammophila breviligulata* is extensively used for restoration [10] as it reproduces almost asexually and shows broad genetic differentiation across its geographic range.

Many researchers suggested that restoration success could be based on their vegetation characteristics [11], species diversity [12], or various ecosystem processes [13]. At the restored sites only plant populations do not indicate the success of restoration practices, the restoration success depends on all ecological processes and occurrence of vertebrates and invertebrates and prokaryotes (bacterial community, decomposers, nitrogen fixing bacteria) etc. For example, the recovery of a coastal dune in South Africa was estimated by measuring seedling, millipedes, beetles, birds and shrews [14].

The society for Ecological Restoration (SER) International with a goal to promote ecological restoration as a means of sustaining the diversity of life on earth and re-establishing an ecologically healthy relationship between nature and culture was established in 1988. SER International had produced the list of nine parameters to measure the restoration success in 2004, those are

1. Similar diversity & community structure in comparison with reference sites,
2. Presence of indigenous species,
3. Presence of groups which are necessary for long term stability,
4. Physical environments capacity to sustain reproducing populations,
5. Normal functioning,
6. Integration with the landscape,
7. Elimination of potential threats,
8. Resilience to natural disturbances and

As restoration requires a lot of time, financial investment and as degradation of restoring ecosystem is faster than restoration so in order to attain successful restoration there is a need for:

1. Regular monitoring of restored site and soil quality etc.
2. Protection to overgrazing, weeds and pests.
3. Plantation of native species population etc.

**GENETIC STRUCTURE AND DIVERSITY OF RESTORED POPULATION**

Population size of species is directly related to their genetic variation, small population carries less genetic variation than large population [15]. In natural population genetic diversity is more than the restored population. Restoration starts with a relatively small number of individual that represent only a sub sample of genetic diversity found in natural population. The interplay between small population size and reduced genetic diversity can affect population success [16].

**Some successful restoration projects in India**

Worldwide, there are hundreds of restoration projects which were reported to be completed successfully. In India also various restoration projects are in progress and many of them were completed successfully. In Delhi itself, the Yamuna Biodiversity Park which is a collaborative effort of Delhi Development Authority and Centre for Environmental Management of Degraded Ecosystems (CEMDE), University of Delhi contains flora and fauna which used to exist 100 years ago and now extinct locally (DDA website). Mangrove restoration in Andhra Pradesh, India is another successful example of restoration project. In Odisha, the Chilka Lake was restored and salinity and biodiversity was revived (UNEP website).

**CONCLUSIONS**

It seems that Biologist E.O. Wilson’s thought that the next era will be the era of restoration in ecology is greatly relevant in present day scenario [17]. Along with the common peoples interest towards restoration, the scientific studies related to ecological restoration is also becoming very popular as number of papers in ISI web of Science database containing the keyword restoration is doubling in every five years [17]. Restoration is a multidisciplinary approach where people from various disciplines ranging from the ecologist to the engineer, landscape architect to the community worker, and indeed from the politician to the ordinary person are likely to be involved. Successful restoration can only be achieved
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with this multidisciplinary approach [18]. The human society as currently known may not survive if ecological restoration and preservation are not practised widely [19]. We also have ethical responsibilities for both future generations and the other organisms with which we share the planet [20].

REFERENCES

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