

## Analyzing global forest regeneration strategies and techniques

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### Abstract

Human induced and natural activities have not only disturbed the environment as a whole but also causes degradation of surrounding and forest tree species and reduction in global carbon stock. The forest structure is changing rapidly and many species are threatened or become extinct. These activities have also shown impact on regeneration of species. Thus, there is a need of global and regional level strategies on conservation of rare and threatened plant species up to species and ecosystem levels to make them locally abundant and to enhance their role in ecosystem functioning. Forest mapping and modeling with standard parameters can be involved in forest inventory assessment and remote sensing and specially designed computer software can be applied in forest conservation and regeneration programmes. Moreover, the forest tree conservation schemes like domestication of species, forest certification system, REDD can be a milestone in preservation of global wilderness.

**Keywords:** species diversity, forest conservation, forest regeneration

### 1. Introduction

#### Global Forestry: Status and Future Prospects

Forest fulfills the basic human needs and people have given special emphasis on consuming rather than generating. The extent of world forest is decreasing and at present 30.6% of global land area is under forest, of these 93% is natural and 7% is planted forest area (FAO, 2015) <sup>[9]</sup>. Globally, forest wood accounts for 6% of the total primary energy supply (TPES) and is increasing in developing countries with the increase in rural poor population dependence on forest for wood energy. Forests are the center of formal and informal employment accounting to two-thirds in Asia and Oceania, nearly 90% in Latin America and the Caribbean, and more than 95% in Africa. In several countries the forest maintenance services remains largely unrecognized and very few countries have recognized forests as national wealth (FAO, 2014) <sup>[8]</sup>. The human induced activities are converting tropical forest into modified landscapes and also affecting plant characters resulting in new environmental gradients (Mendes *et al.*, 2016) <sup>[17]</sup>. The changes in biodiversity has altered ecosystem processes and modified the resilience of ecosystems to environmental change. Thus, human activities are triggering the sixth major extinction event of life resulting massive changes in the global distribution of organisms (Stuart *et al.*, 2000) <sup>[28]</sup>.

Anthropogenic along with the natural activities affect life-cycle characteristics and population structures in pioneer tree species and influence populations of a species with limited seed dispersal. The microclimate and biota modifications of the site determine the patterns of establishment, survival and reproduction during initial forest succession. The number of colonizers, source populations, gene flow rates, and the level of human disturbance determine genetic diversity and structure of the pioneer species and mainly affected by gap dynamics, colonization, and pollen and seed dispersal (Silvestrini *et al.*, 2015) <sup>[26]</sup>. It has modified forest stand structure, species composition, and regeneration capacity and there is a need to analyze these alterations on stand structure and species composition (Njepang, 2015) <sup>[19]</sup>. In Asian tropical forests the

shifting cultivation undergoes cycle of clearing, cultivation and forest regeneration during vegetation recovery and the composition of successional sites and uncut forest differs due to anthropogenic disturbances (Teegalapalli and Datta, 2016) <sup>[29]</sup>. The Asia-Pacific region which has witnessed massive afforestation and reforestation programs and projects, in present circumstances also requires forest climatic niches modeling and mapping (Wang *et al.*, 2016) <sup>[32]</sup>.

The extinction of species is a natural phenomenon, but human activities have brought it to be occurring at an unnaturally rapid rate. Many wild and valuable species have been eliminated from areas dominated by human interferences (Stuart *et al.*, 2000) <sup>[28]</sup>. The changing environment has influenced population development of the species and requires a wide knowledge about the niche differentiation along different environmental gradients and species (Marinšek *et al.*, 2015) <sup>[15]</sup>. The Himalayan forest species that differs in patterns in functional traits compare to Neotropics (Teegalapalli and Datta, 2016) <sup>[29]</sup> have shown alteration in glaciers, snow and vegetation morphology along with soil chemistry. This change causes alteration in cryosphere and glacier reduction and not only effects soil from the top horizon to the bottom but also the water balance and phenology resulting in extensive losses of species (Chersich *et al.*, 2015) <sup>[7]</sup>. In future the optimum land use is going to emerge as an important issue to fulfill the increasing global demand for food and energy and conserving natural ecosystems (Paul and Knoke, 2015) <sup>[21]</sup>.

#### 2. Forest Inventory Assessment

The assessment of forest inventories is a great challenge in biodiversity management and monitoring (Giorgini *et al.*, 2015) <sup>[10]</sup>. The forest sectors have to pay attention in sustainability reporting using specific indicators that are relevant to forest management and influence forest enterprises (Ševčík *et al.*, 2014) <sup>[25]</sup>. The spatial distribution of inventory traits exhibited by tree species correlate with spatial patch metrics, and tree assemblages at broad spatial scales have to spatially reorganize and restructure into modified landscapes

(Mendes *et al.*, 2016) <sup>[17]</sup>. The tree species with small fruit and seeds that are dispersed by animals or insect-pollination shows colonization, and uncut forests are dominated by tall, self-dispersed, wind-pollinated tree species (Teegalapalli and Datta, 2016) <sup>[29]</sup>. During the alpha, beta and gamma species diversity measurement, it is observed that beta and gamma diversity of woody species can be used to predict the beta and the gamma diversity of all vascular plant species, whereas the alpha diversity of woody species alone cannot predict the alpha diversity of all vascular plant species (Giorgini *et al.*, 2015) <sup>[10]</sup>. The special emphasis should be on genetic diversity indicators that should be based on ecology and demography of adaptive diversity and genetic markers along with capacity of identifying genetic erosion and gene flow. The intra-specific variation assessment provides status of tree genetic diversity and able to reflect possible stress that causes threat to genetic diversity. The knowledge of genetic resource mobilization, development and management discloses the current status and helps in improving international policy processes (Graudal *et al.*, 2014) <sup>[11]</sup>.

Species richness and area relationships can be well employed to assess habitat loss and fragmentation in a modified forest ecosystems. The dominance of large canopy tree and intensity of management were found to be different on distinct species groups and also helps in promoting native vegetation diversity and can limit alien invasive species (Lomba *et al.*, 2013) <sup>[14]</sup>. The spatial and environmental variation helps in analyzing the distribution patterns of forest tree species. Niche partitioning is an important process influencing forest species abundances and tree compositional distribution can be explained by spatially structured environmental and fine-scale spatial variables, along complex environmental gradients and niche characterization. The factors determining the gradients and the species distributions and niche characteristics has potential in conservation management or minimizing threats arising due to changes in land uses and climate change (Olthoff *et al.*, 2016) <sup>[16]</sup>. The concept of plant domestication which is a naturalization of plant species under human-induced growing conditions plays a significant role in tree species conservation and management. The domestication in agroforestry systems and commercial tree-crop plantations helps in controlled exploitation of wild tree products. It is also noted that the identification of candidate species for tree domestication, its production and management, acceptance by communities and marketing varies from place to place and more difficult in small places where transportation is limited and transaction costs are high but local markets may be small (Nichols and Vanclay, 2012) <sup>[18]</sup>. Moreover, the opportunities and challenges of developing indigenous fruit trees (IFT) in the tropical regions and their relation with the introduced naturalised fruit trees requires domestication and adoption of complementary conservation strategies like Field Gene Banks for the management of their diversity (Awodoyin *et al.*, 2015) <sup>[2]</sup>.

### 3. Forest Inventory: Traditional and New Methodologies

Programme for the Endorsement of Forest Certification (PEFC) which is the world largest certification system ensures that timber and non-timber forest products are produced with ethical standards. Another system i.e. Forest stewardship certificate (FSC) works to improve forest management worldwide, and encourages forest owners and managers to follow best social and environmental practices and helps in

protecting biodiversity, along with worker's and indigenous peoples, right's, and areas of significant environmental or cultural importance. Among the PEFC and FSC certification systems the former system has more potential in forest management (Hajek *et al.*, 2015) <sup>[12]</sup>. The forest manager are adopting multi-aged compared to even-aged management systems for keeping resistance and resilience that will arise in future due to climate changes and disturbances. Both the system shows a slight difference in productivity; however Multi-aged strategies contain several age classes and potential pathways for post-disturbance management and recovery. The managers should also assess disturbance integration management strategy to match or surpass disturbance effects with management and planning and build variable treatment intervals during management regimes (O'Hara and Ramage, 2013) <sup>[20]</sup>.

The ancient or closed forest species are considered the indicator value of plants and coexisting ancient forest species (CAFS) in various forest groups indicates forest communities with high diversity are significantly related to species richness and helps in evaluating continuity of forest habitats (Stefańska-Krzaczek *et al.*, 2016) <sup>[27]</sup>. Woody plants are ecosystem engineers and considered principal landscape modulators in many terrestrial ecosystems and generally differ from their growing environment and species composition. They shows a large impact on herbaceous species, and combination of weather and biotic induced gradients influences species richness by altering the pattern along rainfall gradient and generating biotic gradient of abiotic conditions. The increase in leaf area index of woody species shows strong negative correlation with the species proportion (Agra *et al.*, 2015) <sup>[11]</sup>. The sampling methods, duration, and delimitations of the given area generally affect the structure and functions of the species thus the species richness estimation of woody and herbaceous species should be carried out cautiously (He *et al.*, 2016) <sup>[13]</sup>. Reducing Emissions from Deforestation and Forest Degradation (REDD) scheme, focusing people's behavior in purchasing certified wood product has potential in sustainable forest management and can mitigate deforestation problems that are responsible for global warming and depletion of biodiversity of tropical forests of the world (Sakagami *et al.*, 2014) <sup>[24]</sup>. The assessment of large-area forest provides information about biodiversity conservation and improvement of rural livelihoods. The countries which are engaged in REDD scheme need to give quantitative evidence of their progresses in increasing their forest resources that should be relevant for all geographic levels across the globe. In developing country like India the monitoring and analysis of forest ecosystems can be better carried out by National Forest Inventory (NFI) system that requires a financial assistance and qualified scholars specially from forest mensuration, inventory and remote sensing disciplines (Tewari and Kleinn, 2015) <sup>[30]</sup>.

The remote sensing methods helps in understanding forest regrowth and used for regional or global analyses. It can be used to estimate biophysical forest changes during forest succession as it is a continuous process causing increases in aboveground biomass. However, the estimation may be heterogeneous with biases depending on sensor type, processing, ground truth availability, and forest characteristics. The data on spatial patterns for successional forests is more reliable than individual stands (Barbosa *et al.*, 2014) <sup>[3]</sup>. The use of Airborne laser scanning (ALS) and computer software

the IPython Notebook composed of Python programming language, is a very flexible and efficient data analysis tool that helps to assess stand attributes over large forested areas (Sabot *et al.*, 2016) [23]. The potentiality of model like Climate AP that helps in creating a number of climate variables for point locations in random forest, help to analyze inventory data and climate data on forest vegetation to assess the impact of climate change in shifting geographic distribution and studying the suitability of tree species to match future climate (Wang *et al.*, 2016) [32]. Aerial Seeding (AS) is another method and comparatively more effective than the Natural Regeneration (NR) for restoring carbon stocks in highly degraded areas, which is an important indicator of cumulative ecosystem productivity, and can be applied in areas with limited seed sources and road accessibility (Xiao *et al.*, 2015) [33].

#### 4. Sustainable Management

Humans have altered the global environment, modified global biogeochemical cycles, transformed land and enhances the mobility of biota. The combustion of fossil-fuel and deforestation has caused increased in CO<sub>2</sub> by 30% in the past 300 years (Stuart *et al.*, 2000) [28]. The forest managers have experienced changes in biodiversity loss at global, regional and national level and created wealth of indicators with potential to support sustainable growth of the world's tree genetic resources (Graudal *et al.*, 2014) [11]. The sustainable management in forestry begins in the mid-18<sup>th</sup> century and currently certification systems are common in various parts of the world (Hajek *et al.*, 2015) [12]. At present 52% of world forest and in tropics 200 million ha forest area is under protection (FAO, 2015) [9]. The current climatic variability and developing strategies pertaining to forest management for future climate change adaptation is a matter of concern in front of forest managers around the world. The impact of climatic changes for a particular species will only provide an indication for future management and require more extreme measures if this change exceeds the range. Thus there is a need of policy and infrastructure support and understanding of plantation management in more variable climates for a greater planning at regional and national levels that will inform and re-direct adaptation strategies in the future (Pinkard *et al.*, 2015) [22]. According to IPCC report the deforestation has resulted in 10% global GHG emission and land-use sector have 20% potential in abatement of the problem. The Tropical forest alliance 2020 founded in 2012 at Rio+20 with an aim to reduce deforestation in tropical forest countries, by improving planning and management, providing expertise and knowledge for ecosystem conservation and commodity production, and improving monitoring processes can play a decisive role in tropical forest conservation (TFA, 2016) [31]. International Panel on Climate Change (IPCC) has recognized the trees that are destroyed due to natural disturbances as a best option for bioenergy resources. One of the best management techniques of dead wood adopted globally should be their utilization as a source of fiber, pulp and paper, wood chips, wood pellets and liquid biofuel (Barrette *et al.*, 2015) [4].

The forests itself plays a crucial role in conservation of forest species and agricultural land. The research should be mainly focused on improving afforestation and agroforestry on degraded lands and to investigate effects of diversification on the landscape scale and there should be a concrete link between forest and agriculture land and their uses (Paul and Knoke,

2015) [21]. Industries throughout the globe have to take initiative in managing intensive productive forest plantations for growing roundwood demand. However, their source of raw material is natural and semi-natural forests but the limitations related to logistics, profit and ownership structure affects the supply especially in boreal and temperate zones. Thus there should be global industrial forest plantations strategies that can face economic, environmental and social challenges (Barua *et al.*, 2014) [5]. The ecological knowledge used by tribal and non-tribal agencies approaches multiple ways of knowing the forest, and varied most distinctly under the influence of cultural identity or metaphysical connections to the forest for knowledge generation, transmission, and content (Bussey *et al.*, 2016) [6].

Thus, it can be concluded that the global forestry is passing through a crucial phase and every country with rich forest resources have to frame national policies and programme based on forest management to ensure a sustainable supply of forest products and services for future generations. The forest recovery and management requires tree genetic resources mobilization, domestication and certification systems and implication of new technology in forest inventory for regenerating and protecting the wilderness.

#### 5. References

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