Assisted Migration: A Strategy to Ensure Forest Survival in a Changing Climate

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ABSTRACT

Assisted migration involves the intentional movement of tree populations or species to climatically suitable habitats in response to changing climate. It enhances forest resilience by improving the adaptive capacity of tree species, conserving biodiversity and sustaining ecosystem productivity and services. By mitigating the risks of climate-induced forest decline such as reduced growth, regeneration failure and species loss, assisted migration ensures forest survival and supports sustainable forest management.

INTRODUCTION:

Climate change is rapidly altering the environmental conditions that govern the distribution, productivity and survival of forest ecosystems worldwide. Although tree species have naturally migrated in response to climatic changes since the end of the last glacial period, contemporary climate change is occurring at an unprecedented rate that exceeds the natural migration capacity of most forest trees (Aitken *et al.,* 2008; Gray and Hamann, 2013). Fossil and pollen records indicate that forests have repeatedly reorganized themselves over millennia. However, there is a significant mismatch between the climatic conditions to which tree populations are genetically adapted

and the habitats in which they currently exist due to the current pace of warming, habitat fragmentation and rising environmental pressures. Forest trees are particularly vulnerable because of their long gestation period and limited seed dispersal abilities, making it difficult for them to naturally track shifting climatic niches. As a result, forests are increasingly exposed to drought, wildfires, pest and disease outbreaks, altered precipitation patterns and reduced regeneration and productivity, threatening both biodiversity and ecosystem services. Given that natural migration may require several centuries to allow tree populations to establish in newly suitable habitats, conventional forest management practices and existing seed transfer guidelines are insufficient to address the challenges posed by rapid climate change. In this context, assisted migration has emerged as a potential climate adaptation strategy that involves the deliberate movement of tree genotypes, populations or species to climatically suitable locations to enhance forest resilience, conserve biodiversity and maintain ecosystem functions.

Definition of Assisted Migration

Assisted migration is the human-assisted deliberate movement of genotypes, populations or species to the areas outside their current ranges to maintain biological diversity or ecosystem function in response to climate change (Richardson *et al*., 2009; Schwartz *et al*., 2012). It is also referred as assisted colonization, managed relocation or managed translocation.

Types of Assisted Migration

Assisted migration can be divided into three broad categories viz., Assisted Population Migration, Assisted Range Expansion and Assisted Species Migration (Johnston *et al*., 2010; Winder *et al*., 2011).

- **Assisted Population Migration (APM)**: Human-assisted movement of populations (genotypes) within a species' established range in order to maximize adaptation to climate change.

- **Assisted Range Expansion (ARE)**: Human-assisted movement of populations or species to areas immediately adjacent to their current geographic range where future climatic conditions are expected to become suitable. It facilitates or mimics the natural range expansion of species in response to climate change while remaining close to their native distribution

- **Assisted Species Migration (ASM)**: Inter-regional, transcontinental or intercontinental movement of a species far outside its current geographic range into regions that are inaccessible through natural dispersal processes, often through inhospitable areas or over large geographic barriers such as oceans, lakes, deserts and mountain ranges.

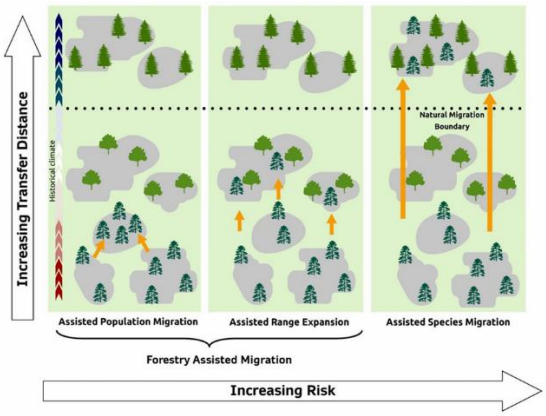

Figure 01: Three types of assisted migration (Source: Bower *et al.,* 2024)

Significance of Assisted Migration

1. **Conservation of Threatened and Climate-Sensitive Tree Species**

Assisted migration helps protect tree species that are threatened by rapid climate change and habitat loss. It is particularly valuable for

endemic, rare and endangered species with limited natural dispersal ability. By relocating these species to climatically suitable areas, it reduces the risk of population decline and extinction. This approach strengthens biodiversity conservation and safeguards valuable forest genetic resources for future generations.

2. Enhancing Forest Adaptation and Resilience to Climate Change

Climate change is altering temperature and rainfall patterns beyond the tolerance limits of many tree species. Assisted migration enables trees to establish in areas where future climatic conditions are more favorable for growth and survival. It increases the resilience of forests against drought, heat stress, pests, diseases and wildfires. As a result, forests become better equipped to withstand and recover from environmental disturbances.

3. Maintaining Biodiversity and Ecosystem Functioning

Trees form the ecological foundation of forest ecosystems by supporting diverse plant and animal communities. The loss of climate-sensitive tree species can disrupt ecological interactions such as pollination, seed dispersal, and nutrient cycling. Assisted migration helps maintain species diversity and ecosystem stability by preserving key tree populations. This ensures the continued functioning of forest ecosystems and their associated ecological processes.

4. Conserving Ecosystem Services and Supporting Human Well-being

Healthy forests provide essential ecosystem services, including carbon sequestration, water regulation, soil conservation, and climate regulation. They also supply timber, fuelwood, medicinal plants and other non-timber forest products that support local livelihoods. Assisted migration helps maintain these benefits by ensuring forests remain productive under changing climatic conditions. Consequently, it contributes to environmental sustainability and the well-being of forest-dependent communities.

5. Preserving Genetic Diversity and Supporting Sustainable Forest Management

Genetic diversity enables tree species to adapt to changing environmental conditions and resist biotic and abiotic stresses. Assisted migration conserves this diversity by establishing genetically suitable populations in future climate-compatible habitats. It also supports climate-smart forestry by improving the success of afforestation, reforestation and ecological restoration programs. This contributes to sustainable forest management and enhances long-term forest productivity.

6. Supporting Long-term Forest Conservation and Ecological Restoration

Assisted migration is a proactive strategy that addresses the inability of many tree species to naturally track rapid climate change. It facilitates the establishment of tree populations in suitable habitats before existing populations decline. When guided by scientific evidence and ecological risk assessment, it strengthens ecosystem restoration and landscape connectivity. Ultimately, assisted migration promotes resilient forests capable of sustaining biodiversity and ecosystem services in the future.

Although assisted migration offers considerable potential as a climate change adaptation strategy, its implementation is constrained by several ecological, genetic and management related challenges. Potential risks include invasive behaviour of relocated species, competition with native species, pest and disease transmission, establishment failure, genetic hybridization and unintended impacts on ecosystem structure and function.

Furthermore, uncertainties associated with future climate projections and suitable habitat selection may affect the long-term success of translocated populations. The ecological risks of assisted migration tend to increase with greater migration distances, particularly when species are moved beyond their native ranges. Consequently, careful species selection, climate-based modelling, risk assessment and long-term monitoring are essential components of any assisted migration programme.

CONCLUSION

Assisted migration represents a promising strategy for ensuring forest survival in a changing climate. By facilitating the movement of climate-adapted tree populations to suitable habitats, assisted migration can enhance forest resilience, maintain biodiversity, sustain ecosystem services and reduce the vulnerability of forests to climate-induced disturbances such as drought, pests and wildfires. When implemented using sound scientific evidence and adaptive management practices, assisted migration can help forests cope with rapidly changing environmental conditions and contribute significantly to sustainable and climate-resilient forest management.

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