

## **Historically-based reference ecosystems help guide large-scale restoration work in a rapidly changing biosphere**

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### **ABSTRACT.**

At its best, ecological restoration aims not only to recover lost or impaired ecosystem structure, composition, and functionality, but also something more elusive, namely historical continuity, which can be ecological, cultural, or both. The selection or construction of a reference ecosystem helps to determine a shared vision of a restoration project or program – and it directly impacts the project’s goals, priorities, timetable, budget, and obstacles. It also provides a basis for monitoring and assessing restoration outcomes over time – and revising the strategy as needed. Given the time-scales over which ecosystems exist and evolve, and the variation that is inherent even in undisturbed ecosystems, multiple or sequential models may be useful in some cases.

Moreover, in many cases, restoration hinges on the cessation or modification of human activities that are or appear profitable in the short-term, but unsustainable long-term. Therefore, when developing an ecosystem of reference, the benefits that accrue from restored ecosystems for people, namely, ecosystem services, must receive full attention, along with the ecological benefits at local, regional and global scales, namely, biodiversity maintenance and functionality.

We review the conceptual development of the idea of the reference ecosystem, and discuss some of the outstanding applications and results reported in recent restoration work in drylands, tropical forests, the oceans, and elsewhere. We then address the double challenge of how to adapt the reference concept in an era of rapid scaling-up to large-scale programs, and in a time of rapid biophysical change at the biosphere scale.