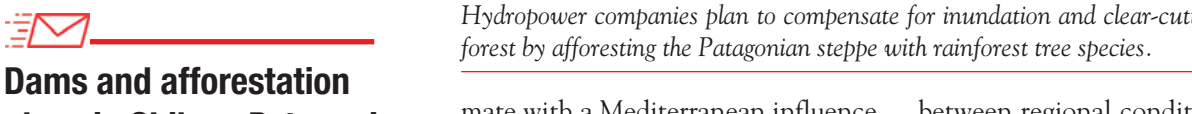
Tipping elements in the Earth's climate system. *P Natl Acad Sci USA* **105**: 1786–93.

Mumby PJ, Hastings A, and Edwards HJ. 2007. Thresholds and the resilience of Caribbean coral reefs. *Nature* **450**: 98–101.

Veron JEN, Hoegh-Guldberg O, Lenton TM, *et al.* 2009. The coral reef crisis: the critical importance of < 350 ppm CO_2. *Mar Pol Bull* **58**: 1428–36.

doi:10.1890/11.WB.002



Dams and afforestation plans in Chilean Patagonia

Two large hydropower projects (involving seven dams in total) in Chilean Patagonia will, upon acceptance of their environmental impact studies (EISs), lead to the inundation and clear-cutting of almost 12 000 ha of natural forest. The EISs presented by the hydropower companies acknowledge that vegetation (including forest cover) will be heavily impacted by each project. A companion project will also include construction of a 100-m wide, 2300-km-long power-line corridor – resulting in further clear-cutting of forest. To fulfill Chilean environmental legislation, the companies behind such projects must compensate for the area of removed forest by afforesting a similar area of land with tree species of the same type as those that have been removed. The companies claim that their afforestation plans will be highly successful, but we believe the plans associated with these projects contain important flaws that undermine their viability.

First, seedling establishment is the major bottleneck in any afforestation process. Although a precise knowledge of species' ecological requirements is recognized as essential for establishment success, the requirements of native Patagonian forest species are largely unknown. Moreover, the submitted plans that propose afforestation of Patagonian sites – where growing seasons are typically short and temperatures cold – follow tree plantation protocols developed for use in forests located northern to Patagonia, which are subject to a climate with a Mediterranean influence (Luebert and Pliscoff 2006).

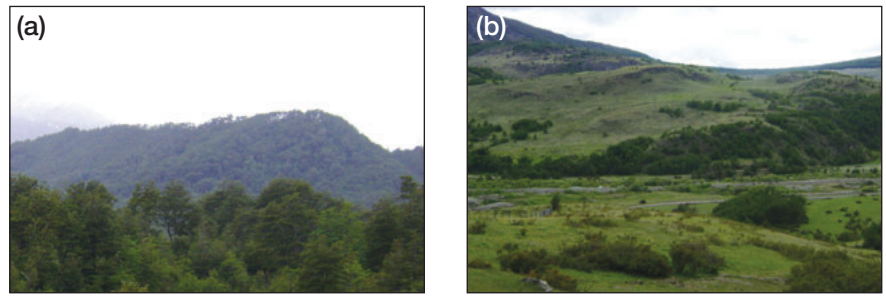


Figure 1. *(a) Evergreen rainforest and (b) steppe ecosystems in Chilean Patagonia. Hydropower companies plan to compensate for inundation and clear-cutting of natural forest by afforesting the Patagonian steppe with rainforest tree species.*

Second, these protocols, which have demonstrated success with fast-growing, exotic tree species (eg *Pinus radiata*, *Eucalyptus globulus*), require the elimination of competing vegetation within plantations – thereby ignoring the importance of ecological processes such as facilitation (ie positive plant interactions). Indeed, it is the presence of other plant species (facilitation) rather than their absence that determines whether slow-growing species will establish successfully at less productive sites with relatively harsher environmental conditions (Callaway 2007). In this regard, there are alternatives to traditional tree-planting protocols that may better ensure successful afforestation. For example, survival of *Nothofagus pumilio* – a widespread Patagonian tree species – can be greatly increased if seedlings are planted in groups (Fajardo and McIntire 2011) instead of in isolation, as dictated by protocols.

Third, some of the sites that the companies have already acquired for afforestation are located within the steppe belt of Patagonia, where few trees occur naturally and where selected surface conditions are quite different from those of the evergreen rainforest that will be affected by the dams' construction. Thus, attempting to afforest the Patagonian steppe (<500 mm annual precipitation) with species belonging to the evergreen rainforest (>2000 mm annual precipitation; Figure 1) seems likely to fail because of the mismatch between regional conditions and the physiological requirements of the associated species.

Finally, we believe that these afforestation plans are based on a "trial and error" approach, which is an inefficient use of time and money.

It has been suggested that large dams result in mostly negative impacts on ecosystems, and that early cooperation between ecologists, dam engineers, and affected people is essential to improve the effectiveness of compensatory measures (WCD 2000). Unfortunately, such collaboration was not considered when the afforestation plans for the Patagonian hydropower projects were being drawn up. If the current proposals are implemented as intended, another failure in environmental mitigation may be added to the list.

Frida I Piper* **and Alex Fajardo**
Centro de Investigación en Ecosistemas de la Patagonia, Coyhaique, Chile
(fpiper@ciep.cl)

Callaway RM. 2007. Positive interactions and interdependence in plant communities. Dordrecht, The Netherlands: Springer.

Fajardo A and McIntire EJB. 2011. Under strong niche overlap conspecifics do not compete but help each other to survive: facilitation at the intraspecific level. *J Ecol* **99**: 642–50.

Luebert F and Pliscoff P. 2006. Sinopsis bioclimática y vegetacional de Chile. Santiago, Chile: Editorial Universitaria.

WCD (World Commission on Dams). 2000. Dams and development, a new framework for decision-making. Chapter 3: ecosystems and large dams: environmental performance. London, UK, and Sterling, VA: Report of the World Commission on Dams.

doi:10.1890/11.WB.003