deforestation and water pollution; and land-ownership turnover) can arise in the wake of road paving. In addition, participatory maps of municipalities revealed specific locations where participants felt problems would be most likely to arise.

Information from these workshops can be joined with information from other sources to support development of future scenarios in dynamic simulation models. These scenarios provide visual representations of possible future changes as mapped over a landscape. Because the models are based, in part, on local stakeholder input, they can inform local planning and improve local environmental governance, thereby avoiding negative outcomes of road paving.

Photos: Stephen G. Perz

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Ecological Services of Exotic and Native Tree Plantations in Northwest India

Kamaljit Kaur

Pre-1988 forest policies in India promoted wide-scale plantations of exotic *Eucalyptus tereticornis* mainly for the short-term visible gains from timber because of its straight bole, fast growth rate, high productivity per unit area, and minimal requirement for post-plantation care. However, the scientific community, private growers, and the public have been divided over the merits and demerits of *Eucalyptus* plantations in the past. One reason for this is that our current accounting system considers only the economic gains from wood and fails to consider the cost of lost ecological services when comparing exotic vs. native trees. Instead, we compared the total value of exotic *E. tereticornis* plantations in comparison with native *Dalbergia sissoo* plantations.

Total value included estimating economic (monetary) gains from wood (timber and fuel-wood), soil nutrients and their return through litter decomposition, and understorey plant diversity. Two age groups of plantations, i.e., 6-8 y (young) and 19-21 y (old), were selected to compare net benefits as exotic *E. tereticornis* plantations deliver most of their benefits (especially wood) by 8 y of age, while native *D. sissoo* plantations deliver benefits after 12-15 y of age. The diversity of plant species, nutrient content in soil, and nutrient return through litter were greater in *Dalbergia* than in *Eucalyptus* plantations. A comparison of plantations at 8 y suggested that the total monetary value of ecological services (tangible and non-tangible) was 1.6 times greater from *Eucalyptus* than from *Dalbergia* plantations, chiefly because of timber (Table). However, ecological benefits (intangible) were 1.8 times greater from *Dalbergia* than from *Eucalyptus* plantations. At 19-21 y of age, total benefits were 2.7 times greater from *Dalbergia* than from *Eucalyptus* (Table).

The study suggested that exotic plantations are more profitable than native tree plantations only over the short term and in terms of timber, which is at the cost of many ecological services. However, over the longer term the total benefits from native plantations are far greater where the value of intangible and tangible products and services increases over time, and adds to the continuum of services and sustainability of a system. The study suggests a need to consider both tangible and intangible services over the long term and to carry out total value assessment of exotic and native tree plantations for sustainable gains and to design policy accordingly.

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Monetary Gains (Rs./ha)	8 y old plantations		21 y old plantations	
	E. tereticornis	*D. sissoo*	*E. tereticornis*	*D. sissoo*
Use and non-use ecological services (for recreation, education, solitude, shade and wildlife value)	26	46	26	46
Soil nutrients	85,087	113,647	64,418	87,383
Plant diversity	31,680	58,095	11,053	63,894
Nutrient return from litter (N, P and K)*	2,561	6,709	2,56	6,709
Calculated benefits for 1, 3 and 4 services (Rs./ha) over plantation age, i.e., 8 yr and 21 yr	274,136	518,800	286,440	1 483,629
Total benefits for 1, 2, 3 and 4 -services over plantation age	359,223	632,447	350,858	1,571,012
Timber and other non-wood products (fuel, eucalypt oil, ash, fodder)	1,339,671	458,205	5,211,669	13,438,843
Total returns (Rs./ha) for 1, 2, 3, 4 (ecological services) and 5 (tangible services) over plantation age	1,698,894	1,090,652	5,562,527	15,009,855

The total monetary value (in Indian Rs./ha) of various tangible and intangible benefits from *Eucalyptus tereticornis* and *Dalbergia sissoo* plantations.

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