Multifunctional, Scrubby, and Invasive Forests?

Authors: Kull, Christian A., Tassin, Jacques, and Rangan, Haripriya

Source: Mountain Research and Development, 27(3) : 224-231

Published By: International Mountain Society

URL: https://doi.org/10.1659/mrd.0864

Mountain Research and Development Vol 27 No 3 Aug 2007: 224–231 doi:10.1659/mrd.0864

Christian A. Kull, Jacques Tassin, and Haripriya Rangan

Multifunctional, Scrubby, and Invasive Forests?

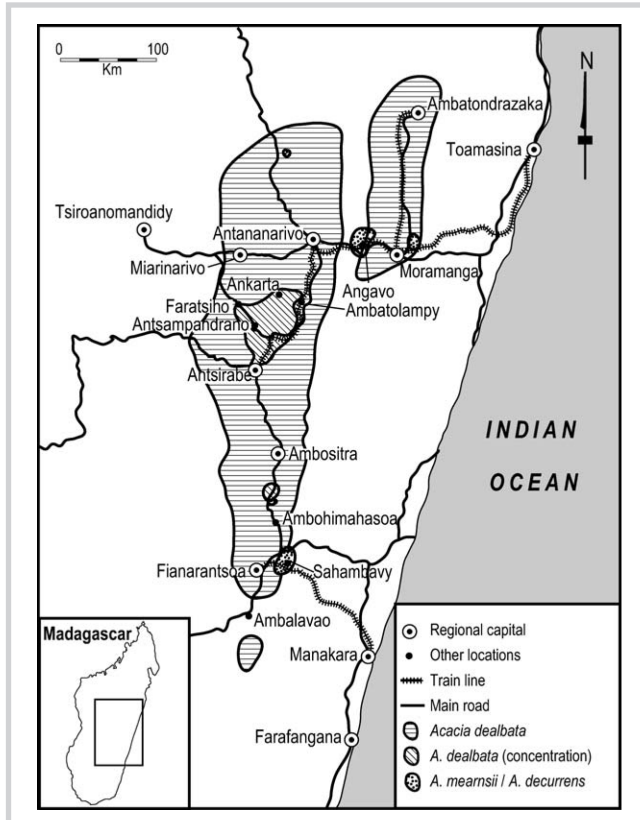
Wattles in the Highlands of Madagascar

Australian bipinnate acacias, known locally as mimosa, are widespread on the plateaus and mountains of Madagascar. Rarely, however, do these trees attain their full size, leading to a surprising landscape of 'scrubby' wattles. We review the introduction of the wattles, survey their multiple uses in rural livelihoods and environmental management, and analyze the forestry policies, tenure rules, and ecological factors that maintain the trees' scrubby state. This well-adapted plant is an important resource for farmers and serves to green treeless hills, but it may become a conundrum to conservation managers due to its non-native, invasive status.

Keywords: Acacia dealbata*; Acacia mearnsii; Acacia* decurrens*; non-timber forest products; invasive species; political ecology; Madagascar.*

Peer-reviewed: *April 2007* ***Accepted:*** *May 2007*

FIGURE 1 Distribution of bipinnate Australian wattles in Madagascar, based on field observation and personal communication with experts. The former plantation at Sahambavy is exclusively *A. mearnsii*; Angavo is largely *A. mearnsii*, but has a small portion of *A. decurrens*. East of Moramanga the failed plantation was probably *A. decurrens* (François 1925; Louvel 1951). (Map by Phil Scamp, Monash University)



Introduction

The silver wattle (*Acacia dealbata*) and, to a lesser extent, the black and green wattles (*A. mearnsii, A. decurrens*) are widespread in highland Madagascar (Figure 1). Here they play an important role in rural livelihoods and are appreciated by foresters, farmers, and policymakers for their role in 'greening' the barren hills. Native to southeastern Australia, these trees have been widely planted around the world for economic, environmental, and ornamental purposes. Despite their utility, they have been classified as invasive weeds of global concern, and are seen as important pests in places like South Africa, the Mediterranean, and Réunion (Lowe et al 2000; Midgley and Turnbull 2003; Tassin and Balent 2004; de Neergaard et al 2005).

In Madagascar, wattle forests are simultaneously (and paradoxically) invasive, multifunctional, and 'scrubby.' *Invasive* in that the trees' range and density increase when not controlled, displacing other plant communities; *multifunctional* in that they provide numerous products and services; and *scrubby* in that very few wattles grow to their full potential size. The present article seeks to explain the peculiar status of wattles in Madagascar, providing in the process a window into the complexities of balancing the multiple directives of sustainable development in mountain regions. We investigate how the wattles came to be found around the highlands, what function they play in present-day livelihoods, why they are scrubby, and what their invasive status implies for management.

Our findings are based on both archival research and interviews. The history of wattles in Madagascar was established from a variety of documents found in thorough searches of the National Archives of Madagascar (Antananarivo), the French overseas archives (Aix-en-Provence), and the libraries of CIRAD (Montpellier, Nogent-sur-Marne). Through historical analysis we can explain the presence of wattles, identify factors contributing to their spread, and highlight antecedents to today's policy attitudes. Documents consulted include colonial district annual reports, tree-planting statistics and maps, unpublished forestry monographs and reports, and letters between private individuals and government agents.

We conducted interviews with farmers in September 2006 to ascertain current uses of wattles, opinions about the plants, and regional variations. We undertook

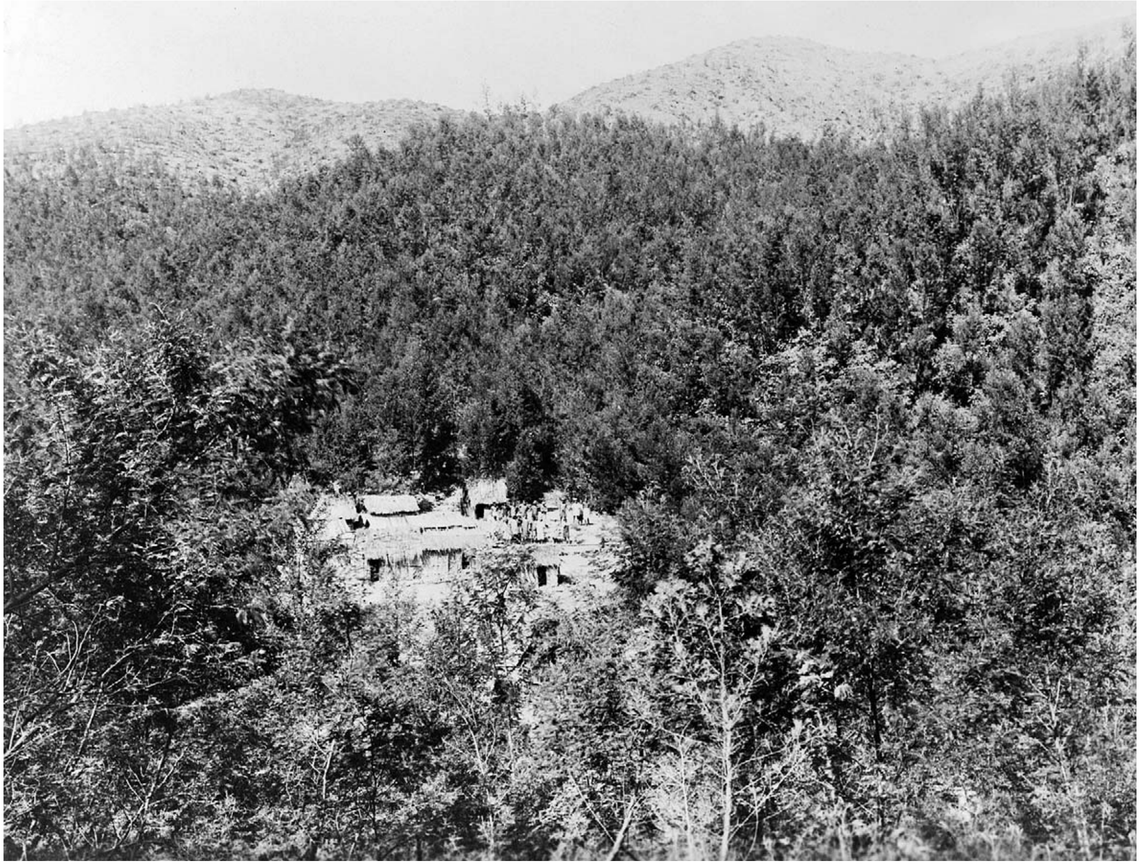
TABLE 1 Uses of wattle. Information based on interviews with 31 farmer groups around Fianarantsoa, Ambatolampy, Antsampandrano, and Antsirabe. The percentage of respondents does not differentiate between actual use and knowledge of that use.

Use	Respondents (%)	Notes
Domestic fuelwood	100	When available, used along with other woody plants; appreciated for high energy content: 3500–4500 kcal/kg (Blaser et al 1993).
Minor construction wood	100	Especially roofing and fence poles; also tools, furniture, bed slats, fishing baskets.
Material for tying	included in above	Bark strips used to tie poles to crossbars or bundles of fuelwood.
Charcoal production	95	High quality: 6600 kcal/kg (Blaser et al 1993). Production concentrated in Antsampandrano area (see text).
Fertilizer and compost	95	Multiple techniques: gathering of litter under plants to spread on field; composting of green leaves and twigs; burning of cut branches on site (see chemical analysis in de Neergaard et al 2005).
Soil fertilization in crop rotation	included in above	In Ankaratra region wattles used in agricultural crop rotations to enrich soils through nitrogen fixation during fallowing.
Medicinal	88	Two uses recognized: treating stomach ailments with infusion of leaves and shoots (or bark); and use of leaves to absorb and stop bleeding.
Flowers as decoration	29	Flowers rarely sold in cities, but celebrated in annual fair in Ambatolampy called *Fête des Mimosas*, and in popular song.
Pollen for apiculture	14	Minor use (emphasis on eucalypts).
Cattle fodder	14	Leaves and seed pods, particularly during dry season. Browsed directly by cattle (not gathered).
Snack food	10	Seeds known as children's snack food.
Artisanal glue	10	Made from resin (gum); practice known but not currently practiced.
Ashes for artisanal products	10	Used in production of soaps or to add to tobacco in cigarettes.
Tannins	10	Bark of *A. mearnsii* contains up to 40% tannins; other species less. Use concentrated at former plantations, eg near Sahambavy and Angavo, with annual harvests of roughly 200 t at each site (interviews; B. McConnell, personal communication).
Shade, ornamental, and protection trees	Not surveyed	Tall trees next to homesteads provide shade, decoration, protection from wind and sometimes from bad spirits.

semi-structured qualitative interviews with 31 farmer groups encountered on transect walks through several highland regions (near Ambatolampy, Antsampandrano, Antsirabe, and Fianarantsoa). We actively sought out individuals of different sex, ages, livelihoods, and wealth, for example by specifically approaching houses that appeared to be poorer. Interviews were conducted outdoors, and usually attracted additional participants. Each interview of such a farmer group (varying between 1 and 10 individuals, generally of both sexes) is counted as one 'respondent' in Table 1.

Finally, additional open-ended interviews conducted in regional towns and the capital in September 2006 sought to determine the views of institutional actors on the wattle paradox and allowed us to gather additional factual details. Interviewees included 10 forestry officials (from senior administrators to field foresters), 8 local government offices (mayors and their staff in *communes rurales*, as well as *fokontany* presidents), 9 NGO or project staff (from international environmental NGOs or bilateral-aid funded environmental projects), 2 commercial forestry industry representatives, one hotel

FIGURE 2 An *A. mearnsii* plantation for tanbark production near Angavo owned by the Société Minière et Foncière, around 1930. (Courtesy of Historical Library of CIRAD [Centre de coopération internationale en recherche agronomique pour le développement])



operator in a key wattle zone, and several representatives from the tannin industry.

Trees, tannins, and trains

To explain Madagascar's invasive, multifunctional, and scrubby wattle forests one must begin with the history of the tree's introduction during colonization (archival sources listed at end of article). Economic goals, environmental ideas, and the constraints of geography shaped their spread. These factors persist in the spatial distribution of the plants today, in policies regarding their use, and in political discourse on environmental management.

By 1897, only 2 years after conquest, the French colonial government had established research stations at Nanisana (outside the capital) and Ivoloina (near Toamasina) for testing potentially useful plants, 'acclimatizing' them, and producing seeds for distribution. These stations acquired seeds from all over the world, and had over a million plants by 1899, including *A. dealbata*. Its seeds were ready for distribution by 1904.

The colonial government immediately encouraged district officers to plant trees, particularly in the arid southwest and the barren highlands. The justification was environmental: to reforest tree-less lands, avoid soil degradation, increase rainfall, and secure future fuel supplies. The highlands, composed of mountain ranges, dissected uplands, inselbergs, and broad plains ranging in elevation from 1000 to 2600 m, were once a mosaic of savannah woodlands with pockets of montane and riparian forest. One thousand years of human occupation, however, converted much of the landscape into grassland, aside from irrigated rice fields in the valleys (Kull 2004).

Officers used a variety of means to plant trees, including forced labor. Preferred species varied by region, though eucalypts dominated. In the cooler highlands, however, wattle was popular. The *Chef de Province* in Antsirabe had planted 300,000 trees by 1907; by 1916 there were 6 million wattle seedlings in place in Ambatolampy district. The French also planted *A. dealbata* and other trees along roads for shade and erosion control—the 30 km stretch between Ambatolampy and Ambohimandroso was, in its day, lined by trees (Drouhard 1922).

French railway construction also led to more tree planting, as steam locomotives required wood to burn. The line connecting the port of Toamasina to the capital, Antananarivo, was built between 1901 and 1907, and extended to Antsirabe by 1919 and Ambatondrazaka by 1923. (Another line linking Fianarantsoa to the coast, built 1926–1936, was too steep for steam locomotives.) At first much use was made of nearby natural forests for fuel. It was soon realized that these supplies would not last and were more valuable as timber. Australian trees, which grow quickly despite poor soils, provided an attractive alternative: railway officials planted about 2.5 million trees by 1930 on designated plots. They chose mostly eucalypts, but planted some 2500 ha of wattles along the Antsirabe line (Louvel 1951). The species of preference was *A. dealbata*, for its frost tolerance (the railway climbs to almost 1700 m).

Private plantations supplemented those of the railway service. Individuals sought contracts to supply railway stations with wood. A dozen colonists operated wattle plantations along the Antsirabe line, yet they suffered stiff competition from Malagasy farmers who planted their own plantations and also harvested wood from open lands (in 1930, colonists delivered 1040 tons while Malagasy farmers delivered 21,646 tons). A glowing report from 1922 describes the impressive reforestation of the landscape between Ambatolampy and Antsirabe, and proudly reports that the wattles fueled not only the 160 km rail line, but also 2 factories and the electricity plant in Antsirabe (Drouhard 1922).

Around the same time, wattles began to get much more attention for another colonial economic use: tanbark. Already in the 1910s, the French leather tanning industry saw an opportunity to replace its dependence on South African tannin exports, and the colonial government endorsed this potentially profitable initiative. Wattle bark, particularly of *A. mearnsii*, is among the richest sources of vegetable tannins (Sherry 1971). Eight- to 10-year-old trees are stripped of their bark, which is dried, chopped, and distilled to extract the tannin. The rest of the tree can be sold for other purposes, including railway fuel. Tanbark wattles were introduced to Madagascar as early as 1907 (Carle 1928), and several trials began in the mid 1910s around the region (François 1925). Initially there was much confusion between the hard-to-distinguish and frequently hybridizing wattle species (the already widespread *A. dealbata*, the chief economic plant *A. mearnsii*, and another tanbark alternative, *A. decurrens*) (François 1925; Carle 1928).

French colonial companies established 4 commercial plantations in the 1920s, some acquiring seeds directly from South Africa. Companies received land concessions around Moramanga, Angavo, and Sahambavy, and had planted about 4000 ha by 1931 (Figure 2). Tanneries were set up in several of these locations, as well as in the capital. These mid-elevation locations near the eastern escarpment were chosen for their strategic location near railway lines, as well as for climatic conditions (humidity and lack of frost) that favored *A. mearnsii* and *A. decurrens* (François 1925; Sherry 1971).

Despite great intentions, the tanbark industry remained modest. Only 2 big plantations remained functional by the 1950s (Louvel 1951); one of these, Sahambavy, was converted to tea in the 1970s. Only one industrial tannery exists today, at Anjeva outside the capital, and it stopped buying locally-grown tanbark around 2001, choosing instead to rely on chemical tannins (chromium sulphate) and to import better quality wattle extract (from Africa). A diminishing number of small artisanal tanneries continue to use several hundred tons of local tanbark annually, harvested and sold by local farmers from the self-reproducing tree stands in and around the original plantations (eg McConnell and Sweeney 2005).

From mid-century onwards, interest in wattles refocused on their use in reforestation and domestic fuelwood supply. Removal of tree cover was widely accused of increasing flooding and soil erosion, causing rice field siltation, and lowering the water table. As a result, reforestation was seen as a panacea, and inspired many policies and projects for watershed protection through reforestation. In the 1960s, President Tsiranana strongly pushed reforestation, to the point of requiring all males to plant a certain number of trees per year. Efforts redoubled in the 1980s with a variety of state policies and NGO projects (Uhart 1962; Gade and Perkins-Belgram 1986; ONE/Instat 1994).

For these efforts, foresters tested hundreds of trees from around the world, yet continued to emphasize the traditional favorites: eucalypts, pines, and wattles (Chauvet 1968). *A. dealbata* was widely sown from the 1950s onwards, occasionally even from airplanes, to revegetate barren hills and protect watersheds (it is ironic that today, South Africa is removing its wattles, blaming them for reducing water resources; de Neergaard et al 2005). Eucalypts and pines are the most common trees planted, but in the Antsirabe region, about one-sixth of tree planters (whether individuals, companies, state foresters, NGOs, or schools) use *A. dealbata* in their mix of species. In many village forestry projects, for every 100 eucalypts or pines planted, 20 wattle seedlings were added for the undergrowth.

As a result of a century of widespread planting, and due to their own ability to reproduce and slowly spread, wattles now grow in a wide swath of the highlands (Figure 1). Changing economic situations along the way certainly conditioned their spread: the mid-20th century replacement of steam locomotives by diesel engines and a concurrent decline in tanbark plantations probably led to the abandonment of some plantations, facilitating wattle growth and spread (for a similar situation, see Tassin and Balent 2004).

Utilization

Today, highland residents use wattles for a wide variety of purposes, particularly for household fuelwood, minor construction work, and as green manure. Stressed by high levels of poverty—Madagascar being one of the world's poorest nations—farmers appreciate wattles because they are free, fast-growing, and useful. The trees grow well in the poor highland soils, even improving fertility through nitrogen fixation (Sherry

FIGURE 3 Uses of wattles. Clockwise: a sack of tanbark; a firewood bundle; use of leaves as cattle forage; use for posts and tying. (Photos by Christian A. Kull)

1971; de Neergaard et al 2005). As a result, wattles are self-reproducing multi-purpose shrubs utilized frequently by nearby farmers for a wide variety of purposes (Table 1; Figure 3).

Throughout the highlands, most wattles are cut before they reach 3 or 4 m in height (this 'scrubby' wattle phenomenon is discussed further below). There are 2 chief exceptions: the more humid and forested areas around the former *A. mearnsii* tanbark plantations (discussed above), and the *A. dealbata* charcoal-producing Antsampandrano area in the Ankaratra mountain range. High altitudes (1900 to 2300 m), regular winter frosts, and volcanic soils characterize this region. Rice cropping is marginal, at best, so the economy here revolves around charcoal, milk, and apples (Rakoto Ramiarantsoa 1993; Bertrand 2001). Due to the value of tree crops around Antsampandrano, almost all available land has been claimed, and woodlots now cover most uncropped ridges and slopes (Figure 4). The wattles are initially planted from seed. Farmers occasionally thin their woodlots; they harvest the trees after about 5 years (when the trees reach 5–6 m in height), sending up to 200 ox-carts of charcoal to the local market daily. On slopes, farmers typically allow the wattles to re-sprout from their stumps; on flatter land, particularly near settlements, they often cultivate potatoes or corn in the nitrogen-enriched soil before reseeding wattles (Rakoto Ramiarantsoa 1993).

Scrubby wattles

Black and silver wattles can grow into medium-sized trees, sometimes reaching heights of nearly 30 m (Sherry 1971). If these wattles are so widespread in highland Madagascar, then why in most regions do they remain small, scrubby saplings, barely 4 cm in diameter and 3 m in height. The answer lies not in soils or climate—tall silver wattles can be seen shading homes near Ambatolampy, and black wattles 20 m high have been recorded on commercial plantations. Clearly, heavy exploitation by impoverished rural residents, for the reasons listed in Table 1, must play a role. Yet this answer is insufficient, as other trees growing in the highlands, from exotic pines and eucalypts to endemic *tapia*, are also exploited but commonly do grow to their full height. The full explanation lies in the combined factors of exploitative use, species characteristics, forestry policy, resource tenure institutions, and fire ecology.

To begin with, wattles have characteristics different from the other trees of highland Madagascar (Table 2). Eucalypts, favored by farmers for woodlots, can grow much larger, provide high-value construction wood, and be coppiced repeatedly for charcoal production (Rakoto Ramiarantsoa 1995). Pines, frequently planted by state foresters as well as farmers, also produce construction wood that is in high demand. In contrast, wattle timber is solid but smaller and less straight. It is, as a result,

FIGURE 4 The charcoal-producing heights: hills covered with *A. dealbata* woodlots at Antsampandrano; charcoal market in nearby Kianjasoa. (Photos by Christian A. Kull)

used for minor construction and as good fuelwood, and appreciated because it is more available and faster-growing than most other alternatives (whether fruit trees, ornamental trees, or native forest trees).

Colonial forestry legislation classified trees based on their utilitarian value. Precious hardwoods (1st category) were distinguished from other construction wood, including pines and eucalypts (2nd, 3rd and 4th categories), and from 'auxiliary' trees such as secondary species used for fuel (5th category). Wattles fell into the latter category. This schema allowed foresters to apply different restrictions to each category, protecting more valuable types. Auxiliary products such as wattles were left more open to exploitation. Legislation also distinguished between cultivated and natural forest, and between gazetted forestlands and other lands. Today, wattles grow largely spontaneously outside the formal forest domain (as defined by the state), so they receive the lowest protection priority. As one forester interviewed in 2006 stated, "the wattle isn't a real tree," implying it is not worthy of much attention.

Indeed, on-the-ground application of forest service rules leaves the door open for people to exploit wattles much more intensively than other woody species. In principle, any tree-cutting requires permits from local authorities and the forest service. Control occurs when shipments of forest products pass through roadside police checks. In practice, however, only people exploiting commercial quantities obtain permits, such as the charcoal producers of Antsampandrano. Domestic use is not regulated. Thus, wattle cutting is nearly always overlooked, particularly as wattles are perceived as unimportant shrub-sized trees relied upon for domestic fuelwood.

This situation is complemented by rules regarding tree tenure. The act of planting a tree is customarily seen as conferring a right of resource access on the planter. In addition, tree planting is an officially recognized means of claiming vacant, communal land: legislation allows people who have made use of land for 10 years to register it in their name (Rakoto Ramiarantsoa 1993, 1995). However, nowadays, few people plant wattles (outside the charcoal region of Antsampandrano, where private lots are jealously guarded). Because wattles self-reproduce so vigorously, most farmers generally consider them 'wild' (and un-owned) as opposed to cultivated (and owned), like pines and eucalypts. As a result, no one has moral grounds upon which to restrict people from exploiting wattles, regardless of whether land is private or communal.

A final factor shaping the 'scrubby' wattle forests is fire. Bushfires frequently burn much of the highlands (Kull 2004). Fire can provoke the sprouting of wattle seeds in the soil, yet wattle trees and saplings are relatively intolerant of fire and easily killed. Thus fire simultaneously promotes and limits wattle growth, constantly rejuvenating the population. As wattles are typically 'wild,' unowned, and a low priority for foresters, few pay attention when a hillside of grasses and scrubby wattles burns. In contrast, farmers actively protect their valuable private wattle woodlots in the charcoal-producing Antsampandrano region.

Invasive wattles

Madagascar's non-native wattles are invasive in the sense that they are extending beyond their planted range and displacing other plant communities. Even Drouhard (1922), who favored wattles, noted their tendency to invade. The longevity and fire tolerance of their seeds, their ability to sprout in diverse soils, their quick growth, and the susceptibility of seeds to dispersal (by humans, cat-

TABLE 2 How do wattles compare? Comparison of highland tree characteristics. (Source: authors' observations 1992–2006)

Tree types	Species	Status	Availability	Uses
Wattles	*Acacia dealbata*, *A. mearnsii*, and *A. decurrens*	Naturalized, non-native	Widespread	See Table 1
Pines	Especially *Pinus khasya* and *P. patula*	Naturalized, non-native	Widespread	Major source of construction wood, also fuelwood
Eucalypts	Especially *Eucalyptus robusta*, *E. grandis*	Cultivated, non-native	Widespread	Major source of charcoal and construction wood, also fuelwood
Other introduced trees	eg *Cupressus, Aurucaria, Casuarina*…	Cultivated, non-native	Rare	Decorative, construction wood, fuelwood
Fruit trees	Apple, orange, peach, guava, avocado, etc	Cultivated, non-native	Common near homes	Fruit
Sacred grove trees	eg *Ficus*, *Dracaena*	Domesticated native	Rare, near historic settlement sites	Decorative, fruit, construction wood, fuelwood
Tapia woodlands	Especially *Uapaca bojeri*	Endemic	Certain regions only	Fuelwood, fruit, silkworm fodder, medicinal
Native forest trees	eg *Harungana madagascariensis*, *Agarista salicifolia*	Native	Isolated sites mainly near escarpment	Construction wood, fuelwood, medicinal

tle, ants, wind, and streams) are evident in their wide distribution in the highlands (Figure 1). A review of introduced and invasive plants in Madagascar (Binggeli 2003) lists *A. dealbata* as a key problem plant, based on its world status as highly invasive. *A. mearnsii* has a smaller distribution for historical reasons, but could still cause trouble: it has escaped from Sahambavy into nearby Ranomafana National Park (cf Lowe et al 2000; de Neergaard et al 2005).

Despite this, officials at the Ministry of Environment, Forests, and Water show no concern about wattle as an invasive (interviews, 2006). Indeed, forestry legislation does not distinguish between endemic and introduced species, and there are no policies about invasive plants. Concern and action since colonial days have centered on obviously harmful plants, like water hyacinths and prickly pears, and the "recent worldwide awakening of concern for invasives is not mirrored in Madagascar" (Binggeli 2003, p 257). As Binggeli notes, there is little ecological research on the impact of most introduced species. Foresters and government officials perceive the benefits of wattles to be much higher than any costs, particularly given their usefulness. Indeed, among these policymakers, the goal of reforesting the biodiversity-poor highlands for watershed protection, soil conservation, and fuelwood supplies is more important than worrying about the native or introduced status of trees (interviews, 2006). In this context, quick growth and spread is a positive attribute. For farmers as well, wattles are a resounding benefit (Table 1). Only 2 complaints arose in the interviews: hay fever associated with wattle pollen, and the difficulty of plowing land cleared of wattles.

Conclusion

Madagascar's wattle forests are invasive, multifunctional, and 'scrubby.' This situation owes its genesis to the specific ecological character of these introduced Australian trees (fast growth, adaptation to poor soils, self-reproduction and spread, and fire ecology), to their perceived usefulness (to the colonial economy, to foresters and other government officials, and to today's poor farmers), to high demand for products that wattles can supply (like fuelwood), to forest service regulations that are looser for wattles than other species, and to tree tenure rules that protect cultivated trees as opposed to 'wild' ones.

The planting, spread, harvesting, and control of wattles is shaped by ecology, regional economies, prevailing environmental ideas, and state and local institutions. If any of these factors changes, the wattle landscape will probably also change. For example, *A. mearnsii* was cultivated in upland Réunion in a fallow rotation with an export crop of geranium. When the geranium market collapsed, the wattle became invasive (Tassin and Balent 2004). In Madagascar, the end of the steam locomotive era may have unleashed the wattle invasion.

Given today's focus on sustainable development, particularly in places like Madagascar that are both poor and have prized but endangered environments, the presence of wattles presents a paradox. Wattles were economically important in the past as fuelwood and tannins. They are perceived as economically important today, both directly to rural livelihoods and indirectly in terms of watershed protection. Will they be so in the future? What if rising incomes one day permit rural Malagasy to use non-biomass energy sources? Reduced demand for wattles and other trees might allow them to grow and multiply, barring excessive bushfires. Forest cover (albeit non-native) might expand as an outcome of economic development.

Such an expansion of wattles was welcomed—even greatly encouraged—in the past, as environmental concerns in the highlands focused on soil and watershed protection through hillslope revegetation. In the future, however, official concern with 'alien invasives' could grow. Efforts may then be made to classify the wattles as weeds, and programs established to eradicate them, as in South Africa (de Neergaard et al 2005). Alternatively, perhaps expanding nitrogen-fixing wattle forests might serve to help re-establish some endemic trees in the highlands, creating a hybrid biodiversity (Carrière et al 2005).

Multifunctional invasive forests present a challenge to sustainable development. They are central to many rural livelihoods, but may not remain so in the future. They provide crucial environmental services, but may displace endemic biodiversity. Should the wattles be combated, and if so, how should this be done without impoverishing rural resource users? In the context of Madagascar's poverty, the choice should probably be made by the families who earn their meager livelihoods from the land. To them, *zavatra sarobidy ny môza,* the wattles are not pests but something precious.

ACKNOWLEDGMENTS

Research for this article was funded by the Australian Research Council and by the Anne U. White Fund (Association of American Geographers). The authors thank F. Lehoux, H. Razafimampanana, B. McConnell, G. Rambeloarisoa, ESSA-Forêts, Bibliothèque Historique de CIRAD, E. Sutherland, C. Thorburn, and M. & K. Freudenberger for their help.

HISTORICAL SOURCES

Archives Nationales (Antananarivo, Madagascar): D3supp, D76supp, VI.J.46, VI.J.45, VI.J.50, H832.
Archives d'Outre Mer (Aix-en-Provence, France): Mad-ggm/2d/5, Mad-ggm/4d/4, Mad-ggm/5d/18.

AUTHORS

Christian A. Kull and Haripriya Rangan
School of Geography and Environmental Science, Monash University, Melbourne, VIC 3800, Australia.
christian.kull@arts.monash.edu (C.A.K.);
haripriya.rangan@arts.monash.edu (H.R.)

Jacques Tassin
CIRAD [Centre de coopération internationale en recherche agronomique pour le développement], UPR 37, Campus de Baillarguet, 34398 Montpellier Cedex 5, France.
jacques.tassin@cirad.fr

REFERENCES

Bertrand A. 2001. La vache laitière et le sac de charbon. *Bois et Forêts des Tropiques* 269(3):43–47.
Binggeli P. 2003. Introduced and invasive plants. *In:* Goodman SM, Benstead JP, editors. *Natural History of Madagascar*. Chicago, IL: University of Chicago Press, pp 257–268.
Blaser J, Rajoelison G, Tsiza G, Rajemison M, Rabevohitra R, Randrianjafy H, Razafindrianilana N, Rakotovao G, Comtet S. 1993. Choix des essences pour la sylviculture à Madagascar. *Akon'ny Ala* 12–13:1–166.
Carle G. 1928. Nouvelles observations sur la culture des plantes à tanin à Madagascar. *Revue de Botanique Appliquée* 8:53–58.
Carrière SM, Andrianotahiananahary H, Ranaivoarivelo N, Randriamalala J. 2005. Savoirs et usages des recrus post-agricoles du pays betsileo: valorisation d'une biodiversité oubliée à Madagascar. *VertigO* 6(1):1–14.
Chauvet B. 1968. *Inventaire des espèces forestières introduites à Madagascar*. Antananarivo, Madagascar: École supérieure des sciences agronomiques and University of Tananarive.
de Neergaard A, Saarnak C, Hill T, Khanyile M, Berzosa AM, Birch-Thomsen T. 2005. Australian wattle species in the Drakensberg region of South Africa: An invasive alien or a natural resource? *Agricultural Systems* 85(2):216–233.
Drouhard E. 1922. Situation actuelle des reboisements en mimosas de la région du Vakinankaratra. *Bulletin Économique de Madagascar* 2/3:141–150/255–257.
François E. 1925. La culture des Acacias à tanin à Madagascar. *Revue de Botanique Appliquée* 5:348–358/436–442.
Gade DW, Perkins-Belgram AN. 1986. Woodfuels, reforestation and ecodevelopment in highland Madagascar. *GeoJournal* 12(4):365–374.
Kull CA. 2004. *Isle of Fire.* Chicago, IL: University of Chicago Press.
Louvel M. 1951. L'Etat actuel des reboisements à Madagascar. *Revue de Botanique Appliquée* 31:185–196.
Lowe S, Browne M, Boudjelas S, De Poorter M. 2000. *100 of the World's Worst Invasive Alien Species: A selection from the Global Invasive Species Database.* Auckland, New Zealand: Invasive Species Specialist Group.
McConnell WJ, Sweeney SP. 2005. Challenges of forest governance in Madagascar. *Geographical Journal* 171(2):223–238.
Midgley SJ, Turnbull JW. 2003. Domestication and use of Australian acacias: Case studies of five important species. *Australian Systematic Botany* 16:89–102.
ONE [Office National pour l'Environnement], Instat [Institut National de la Statistique de Madagascar]. 1994. *Rapport sur l'état de l'environnement à Madagascar.* Antananarivo, Madagascar: UNDP [United Nations Development Programme] and World Bank.
Rakoto Ramiarantsoa H. 1993. *Ligneux et terroir d'altitude dans le Vakinankaratra.* Antananarivo, Madagascar: FOFIFA [Centre National de la Recherche Appliquée au Développement Rural]. Available from authors of this article.
Rakoto Ramiarantsoa H. 1995. *Chair de la terre, œil de l'eau.* Paris, France: ORSTOM [Office de la recherche scientifique et technique outre-mer].
Sherry SP. 1971. *The Black Wattle.* Pietermaritzburg, South Africa: University of Natal Press.
Tassin J, Balent G. 2004. Le diagnostique d'invasion d'une essence forestière en milieu rural: exemple d'*Acacia mearnsii* à la Réunion. *Revue Forestière Française* 56(2):132–142.
Uhart E. 1962. Les reboisements et le développement de Madagascar. *Bois et Forêts des Tropiques* 83:15–29.