Divergent perceptions of the 'neo-Australian' forests of lowland eastern Madagascar: invasions, transitions, and livelihoods

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Abstract
Grevillea banksii (Proteaceae), a non-native shrubby tree, has in the past five decades expanded to cover hundreds of thousands of hectares in lowland eastern Madagascar, accompanied by other Australian and pan-tropical species, including *Melaleuca quinquenervia, Acacia mangium,* and *Eucalyptus spp*. We investigate contrasting perceptions of this new landscape with view to facilitate future management. Field research was based on 290 surveys, key informant interviews, and ecological inventories at six sites from Farafangana in the south to Fenerive Est in the north. After documenting the ecology and usage of grevillea, we analyse differing ways in which it can be perceived. Perceptions promoted by scientists and administrators include the contrasting ideas of beneficial landscape greening, rampant biological invasion, novel ecosystems, and forest transition. Perceptions held by local actors are highly determined by practical livelihood concerns. These local views are largely positive due to the major role of grevillea firewood and charcoal sales in livelihoods; however, context plays a major role and a number of disadvantages are perceived as well, including difficulty of removal, competition with crop and pasture land, and the respiratory health impacts of involvement in charcoal production. We conclude that policymakers and managers – in this case and in similar cases around the world – need to be more reflexive on the ways in which environmental problems are framed and to put those frames more in conversation with local people's experiences in order to productively resolve invasive species management dilemmas.

Keywords:
Perception, invasive species, *Grevillea banskii*, livelihoods, discursive framing, Madagascar

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1 **Introduction**

The rolling hills of lowland eastern Madagascar were once perceived as barren and burnt savannahs carved out of the rainforests that covered the region before human arrival, or as home to productive agro-forests of cash crops like cloves, vanilla, and pepper, and fruit trees like coconuts, mangos and litchi (Goodman and Benstead, 2003; Jolly et al., 1984). In the past five decades, however, vast expanses of what might be called "neo-Australian" forests have come to cover the same hills (Figure 1). Along a 1000 km littoral, stretching over 50 km inland, the landscape is frequently covered with scrubby, monospecific stands of non-native *Grevillea banksii*, and peppered here and there with fellow Australian introductions *Melaleuca quinquenervia, Acacia mangium,* and *Eucalyptus spp.*, among a smattering of other local and pan-tropical species.

This paper investigates how environmental managers might address these new landscapes. By environmental managers, we refer not only to government officials and forest agents, but also local farmers, entrepreneurs, development or conservation project staff, and scientists. We presume that management decisions will not only be based on data (like distribution maps, seed ecology, economic productivity), but also on how the landscape is perceived.

Farmers, labourers, local officials, entrepreneurs and other residents of the region perceive the landscape through daily experience (Shackleton et al., 2011; Ngorima and Shackleton 2018). Their perceptions of these landscapes are also shaped by interactions with ideas and discursive frames operating at higher levels of scale – national policies, regional environmental imaginaries, global discourses – that carry the authority of the people who promote them, like administrators and scientists (Baka, 2014; Forsyth, 2003; Harden, 2012; Bennett and van Sittert 2018). Such frames are sets of ideas, embodied in discourses, that allow people to give meaning to phenomena – to see them, to interpret their causality, and guide action (Seijo, 2009; Snow et al., 1986). Frames are a collective, interactive, sociological processes that interact with individual perceptions (Benford and Snow, 2000). The purpose of this paper is to describe, analyse, and compare different perceptions of Madagascar's neo-Australian grevillea forests – both those rooted in experience and those made possible by framings from national and international actors – in order to show their overlaps and differences and their implications on management.

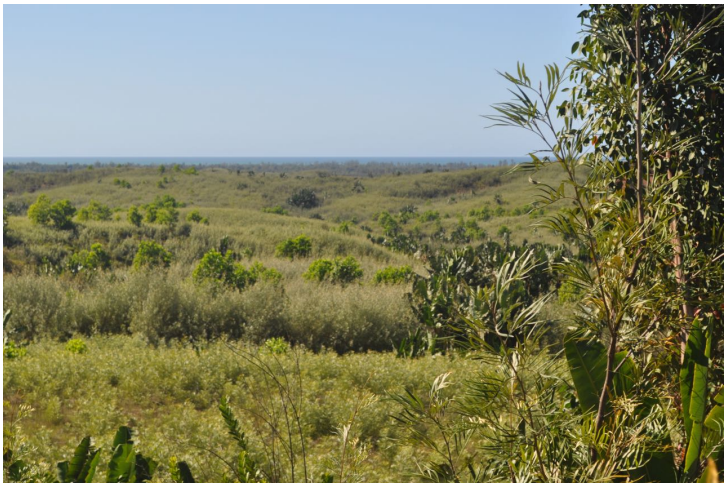

Figure 1. A neo-Australian landscape near Vatomandry, Madagascar dominated by non-native species from Australia. In the foreground and middleground, widespread *Grevillea banksii* is interspersed with *Acacia mangium*, and *Eucalyptus* spp.; in the distance one finds a coastal wetland of *Melaleuca quinquenervia*. Photo: CAK, 2014.

To do so, we take a four-step approach. First, after outlining the research methods and based on the obtained results, we describe the case of the new grevillea-dominated forests of eastern Madagascar. Then, we investigate the experiential perceptions of different local actors. Next, we focus on the powerful analytical and discursive frames of officials and scientists and how they suggest different management interpretations. Finally, the discussion juxtaposes the two, showing how the diverse practical daily livelihood concerns of local residents overlap and differ in diverse ways from official and scientific discursive frames.

2. Study Area and Methods

Eastern Madagascar is characterized by a warm and humid tropical climate. Human land use over the past millennia has converted much of the pre-human lowland rainforest into fire-climax grasslands, crop fields, and agro-forests on a pioneer front extending inland from the coast (Agarwal et al., 2005; Zaehringer et al., 2015). Coastal sands and lagoons lead westwards to lowland hills that continue for 30 to 100 km, depending on the region, before reaching the highland escarpment, where one finds remnants of natural humid forests (green zones on Figure 2).

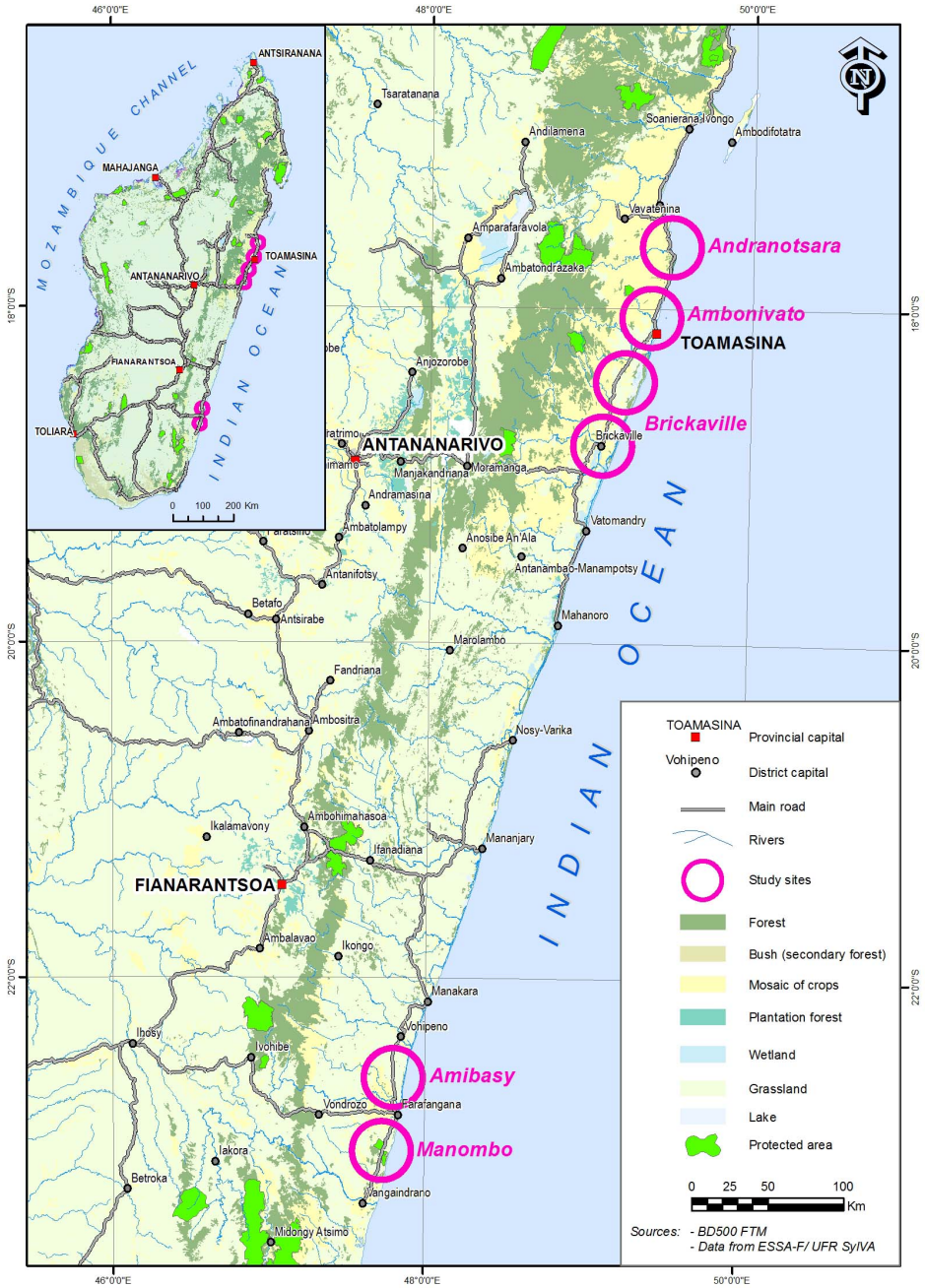

Figure 2. Location map of field sites.

The narrow band of coastal plains and hills ranges from 0 to 300 meters altitude, with diverse largely sedimentary geology and alluvial soils. Twentieth century descriptions do not mention *Grevillea banksii*, emphasizing instead several main landscape components, the mosaic of which differs by region. These include (1) grasslands of pan-tropical species maintained by frequent anthropogenic fires, especially towards the less tropical south, some of these grasslands being savannah-like and featuring the native traveller's palm (*Ravenala madagascariensis*); (2) towards the interior there are secondary thickets and fallow slash-and-burn fields of diverse native and introduced species, including the naturalized *Rubus mollucanus*, *Psidium cattleyanum*, and *Solanum mauritianum* and many others (Kull et al., 2012; Pfund, 2000); and (3) agrarian landscapes of wet rice in valley bottom irrigated fields surrounded by orchards of introduced cultivars like litchi, cloves, coffee, mango, banana, breadfruit tree and other plants. Locally, particular soils may host other specific plant communities, such as heathlands, or the possibly native *Casuarina equisetifolia* on coastal sands (Goodman and Benstead, 2003; Jolly et al., 1984).

Nowadays, the landscapes of eastern Madagascar include large stands of *Grevillea banksia* (Figure 3), known as the 'dwarf silky oak' in its native Queensland (hereafter simply 'grevillea'). This

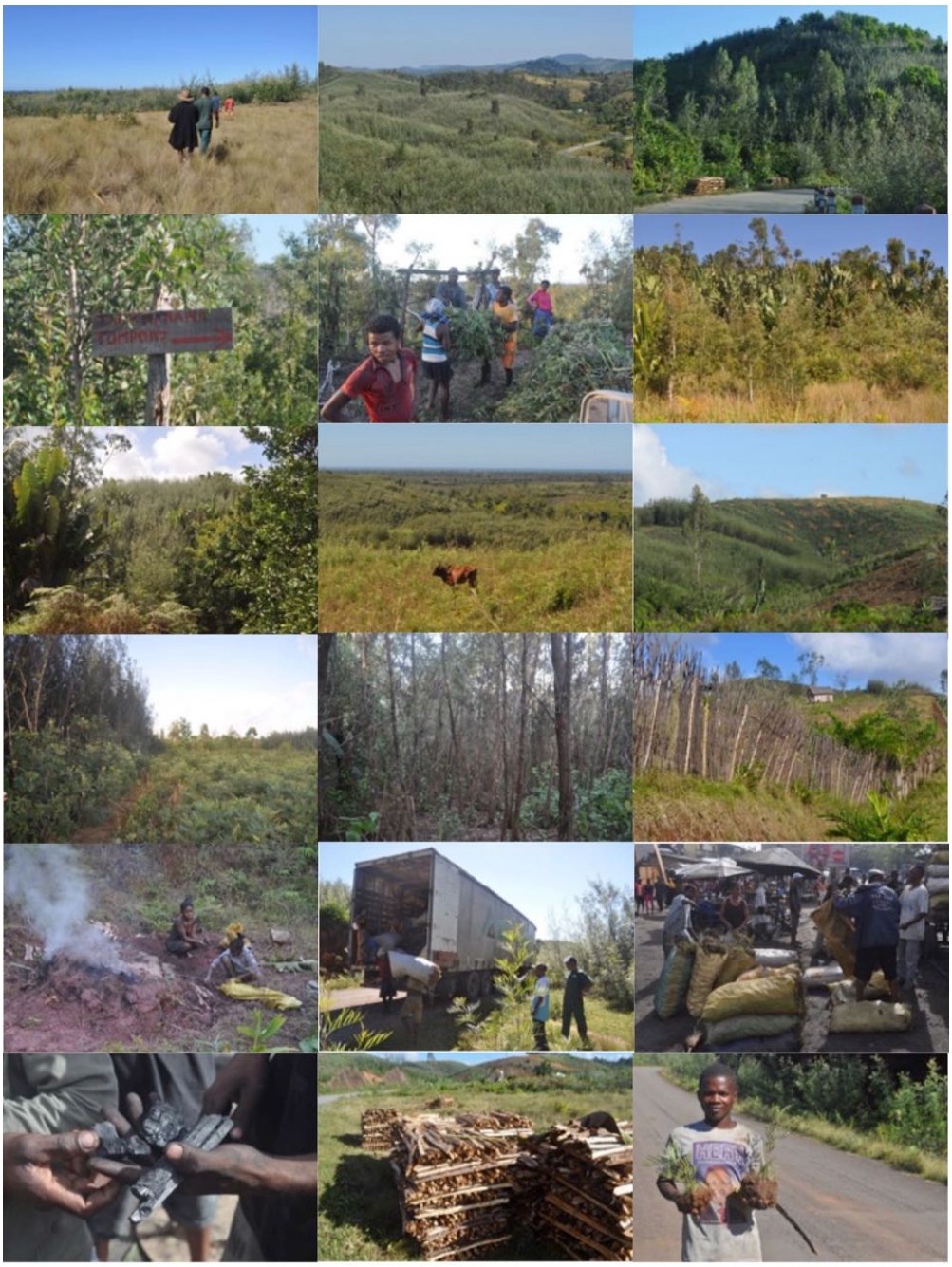

Figure 3. Collage of photos of neo-Australian landscapes in Madagascar and their uses. Row 1: landscapes near Vatomandry, including (left) grassland of type typically replaced by grevillea stands; (middle) dense even-age grevillea; (right) grevillea with *Acacia mangium* and eucalyptus. Row 2: Melaleuca landscapes: (left) private property sign; (middle) collectors selling harvest of leaves to essential oil buyers; (right) melaleuca in foreground with *Ravinala madagascariensis* and eucalyptus. Row 3: (left) agroforestry plots surrounded by grevillea; (middle) cow in former pasture landscape; (right) grevillea stand cleared to create litchi orchard near Vatomandry. Row 4: (left) mature and young stands of grevillea for fuel wood harvest; (middle) interior of tall grevillea stand; (right) grevillea fence poles. Row 5: The charcoal commodity chain: (left) charcoal over and women gleaning leftover coals; (middle) truck loading charcoal sacks; (right) roadside charcoal seller, Toamasina. Row 6: (left) comparing grevillea charcoal with large piece of eucalyptus charcoal; (middle) grevillea fire wood bundles for road side collection; (right) young man transporting grevillea seedlings. Photos by CAK except Row 3 right, by LGR.

small tree in the Proteaceae family can grow rapidly up to 10 m in height, with alternate, simple leaves, deeply incised almost down to the central nerve, with long, linear lobes along each nerve. The variety found in Madagascar has creamy white flowers (other varieties with red flowers are popular ornamental plants worldwide). Grevillea has many characteristics of a pioneer species: it is heliophilic, and its seeds are wind and bird dispersed and respond well to fire (Le Bourgeois and Camou, 2006). The species had already been introduced at Ivoloina forest station by around 1950 as a potential reforestation species (Chauvet, 1968) and in erosion control trials near Lake Alaotra soon thereafter (Tassin, 1995), and was already naturalised and self-seeding near Lake Alaotra, Brickaville, and Vatomandry by the late 1960s (Chauvet, 1968). It was promoted and disseminated by government agents several times in multiple regions, notably in the 1980s, for the purpose of reforestation (Andriamiharimanana, 2011; Blaser et al., 1993). Today, villagers sometimes propagate seedlings or seeds themselves to establish charcoal woodlots.

Grevillea is now common among most of the eastern coastal lowlands of the island, from Maroantsetra in the northeast to Fort Dauphin in the southeast. It is also found in the northwest on the small islands of Nosy Komba and Nosy Sakatia (Rajoelison, 1987). Grevillea forests develop behind beaches, either on sand or dune cords, or broadly inland on lateritic soils (Rajoelison, 1995). On sandy and podzolic soils, as a result of frequent fires, stands of the native shrub *Phillipia* sp. disappeared in favour of a homogeneous grevillea forest around Ambila Lemaitso, Vatomandry and Mahanoro (Rajoelison, 2005).

Other elements of the current forest landscapes of eastern Madagascar (Figure 3) include the Australian *Melaleuca quinquenervia* (known as "niaouli"), introduced since at least 1914, with a few hundred hectares of plantations by the 1940s (Louvel, 1924, 1951) and now a widespread, sometimes invasive, feature in marshes and wetlands of the eastern lowlands (Eppley et al., 2015; Miandrimanana et al., 2014). Leaves of this tree are harvested for sale to commercial essential oil distilleries; Madagascar niaouli oil contributes perhaps up to a quarter of global supply (Ramanoelina et al., 2008). A more recent Australian introduction is *Acacia mangium*, a tropical broadleaf phyllodinous acacia popular in the forest industry of south east Asia. Introduced in the 1980s, seed selection activities took place with a dozen provenances in the 1990s at several research stations; the species has since shown invasive behaviour (Chaix and Ramamonjisoa, 2001; Kull et al., 2008). Seedlings are commonly distributed by diverse development, agroforestry, and mine rehabilitation projects.

This article is based on fieldwork conducted in July 2014, February through April 2016, and July 2016. Social and ecological work was conducted in six principle field sites spanning the eastern lowlands of Madagascar (Table 1, Figure 2). Each site was centred on a rural village or hamlet and its surrounding lands, covering 5 to 10 km^2. Within these six sites, multi-method techniques included forest inventories, key informant interviews, household surveys, and general observations. Forest inventories were made of tree and shrub species in 30 square plots in each site, with size classes >10cm, 5-10cm, and 0-5cm diameter in nested compartments of decreasing size (20x20m, 10x10m, 1x1m). In each site, ten plots were chosen with dense grevillea presence (defined as > 50 percent stems of that species), ten with light presence (<50 percent), and ten with no grevillea (Radaniela Andrianoro, 2016). Semi-structured key informant interviews were undertaken with local authorities, forest officials, forest reserve guides, and village elders; and informal discussions also took place with other village residents. The survey was administered to about 65 households in each site, representing a random sample of roughly 20 per cent of total households (with the exception of the two Brickaville sites where only 7 per cent were surveyed due to time constraints). The survey asked questions about local people's perceptions about grevillea, their uses of the tree and the ecosystem, and the socio-economic and revenue value of forest products for their livelihoods (Harimanana, 2016). In addition to the sites above, additional interviews and transect walks were undertaken in the region around Vatomandry, about 50km south of Brickaville.

Furthermore, interviews were conducted with firewood and charcoal sellers in regional towns. Fieldwork was complemented by the analysis of scientific and policy documents, both historical and recent, focused on forest dynamics in eastern Madagascar. Documents were qualitatively analysed for characterisations of grevillea and associated species, and to identify frames used to justify different interpretations of deforestation and afforestation dynamics.

Table 1. Principal field sites, from north to south

Nearest town	Commune rurale	Location	Coordinates
Fenerive-Est	Ampasimbe Onibe	Mahatsara I ("*Andranotsara*")	17°38'S 49°29'E
Toamasina	Antetezambaro	Ambonivato (in and around *Ivoloina Forestry Station*)	18°03'S 49°21'E
Brickaville	Ampahatany	Tanambao	18°47'S 49°08'E
	Brickaville	Befamoa	18°49'S 49°05'E
Farafangana	Ankarana	Amibasy	22°36'S 47°48'E
	Amporoforo	Manombo, (east of *Manombo Special Reserve*)	23°00'S 47°45'E

3. Forest inventory results

Our ecological surveys provided previously unknown scientific information to characterize the vegetation of these new types of landscapes for which we analyse divergent perceptions below. They showed that stands of grevillea were frequently associated with other woody species, including fruit trees, but in stands with relatively low species richness and diversity. Four woody species were found in all five field sites in association with grevillea: *Ambora purpurea, Eucalyptus camaldulensis, Psidium cattleyanum*, and *Ravenala madagascariensis*. A further nine species were found in two or more field sites (*Acacia mangium, Campylospermum obtusifolium, Cinnamomum zeylanicum, Eucalyptus robusta, Macaranga obovata, Melaleuca quinquenervia. Pinus kesiya, Streblus dimepate*, and *Strychnos spinosa*). The total number of woody species identified in the different sites was 46, in 24 families (Radaniela Andrianoro, 2016). Grevillea was found at densities often approaching 40,000 plants/ha, largely of specimens with diameter under 6 cm. Wood volume varied between 35 and 328 m^3/ha, with the highest values in less-exploited Ambonivato field site (a forest station), where older trees with diameter >15 cm were often bent or fallen. Many of the dense stands of grevillea elsewhere are even-aged with an open canopy reaching typically to 7-8 m height; the tallest specimen was 15 m tall, found in a less dense stand.

4. Local actor perspectives

The comment by one interviewee that grevillea "is like gold" sums up many first-order perspectives by rural village residents up and down the east coast. They perceive grevillea as representing a great source of revenue without major opportunity costs in terms of labour or land, as the tree is self-propagating and grows over formerly open lands.

The primary usage of grevillea in Madagascar is as firewood and charcoal (Figure 3). It can produce 15 to 18 m^3/ha/year (Blaser et al., 1993). The heating value is medium and the wood is not rich in ash (0,42% of dry wood) (Rajoelison, 1987) meaning it is a decent source of woodfuel, though eucalyptus remains a superior choice. Eight of nine village leaders, and 70 % of the nearly 300 villagers surveyed cited the utility of the tree for wood fuel and associated revenues. It also serves as a hedge, ornamental, fencing material, or shrub fallow. Its flowers are melliferous. Table 2 summarizes different perceptions of the ecosystem services and other characteristics of the tree.

	'Common' villagers (n=256)	**Village elders** (*zokiolona*, n=18)	**Village leaders** (chef *fokontany*, n=9)
Source of wood fuel	179 (70%)	9 (50%)	8 (89%)
Source of revenue	77 (30%)	5 (28%)	3 (33%)
Soil fertilization	74 (29%)	6 (33%)	3 (33%)
Quick growth	49 (19%)	4 (22%)	5 (56%)
Revegetation of denuded areas	36 (14%)	4 (22%)	2 (22%)
Apiculture (honey)	33 (13%)	3 (17%)	3 (33%)
Aids food crop production	33 (13%)	6 (33%)	2 (22%)
Easy to light as wood fuel (green or dry)	31 (12%)	2 (11%)	2 (22%)
Eliminates weeds	26 (10%)	2 (11%)	
Good quality wood fuel	13 (5%)	1(6%)	
Associated trees grow well and straight	13 (5%)		
Purify and cool air	10 (4%)		
Sweet edible flowers	10 (4%)		
Habitat for birds that were absent	5 (2%)	1 (6%)	
Shade	8 (3%)		

Table 2. Perceptions of the characteristics of and ecosystem services provided by *Grevillea banksii* stands across the study sites (number and percentage of actor group mentioning each). List includes only categories with responses >2%.

Diverse informants across the study sites told us of a boom in grevillea charcoal exploitation in the present decade. The major cities of the east coast (notably Toamasina) had previously relied more on eucalyptus charcoal trucked from major plantations in the highlands. Entrepreneurs have jumped on the opportunity to exploit closer resources with lower costs, and many consumers have switched to grevillea charcoal. Eucalyptus charcoal still commands a premium price, as it burns longer; the perceived advantage of grevillea is that it lights easily, even when wet.

The economic benefits of the tree are substantiated by our surveys, which found that money earned from grevillea wood fuel production formed a significant revenue for 41 per cent of villagers, with average monthly income from this activity reaching 182,000 MGA ($60) (Table 3). This activity frequently complements other revenues from activities like rice farming, livestock, fishing, preparing and selling dry fish, serving as a school teacher, running a small shop, or wage labour. Producers earn from 1500 to 5000 MGA per large sack of charcoal, and 250 to 600 MGA for simply a bundle of firewood. Along the commodity chain, local collectors, regional collectors, transporters, loaders, and merchants earn their percentage. The price to consumers per sack varies from 3000 to 7000 MGA. Several elders, who stated that theft levels have dropped as people have more basic revenue from grevillea, substantiated the contribution of grevillea to livelihoods anecdotally.

Table 3 (next page). Selection of livelihood activities ranked by their monthly revenue in thousands of MGA. Based on questionnaire administered to 256 villagers, 18 elders, 9 village leaders, and 7 park agents. In 2016, 3000 MGA was worth about 1 USD.

Livelihood activity	Mean monthly revenue (1000 MGA)
Carpentry	412
Trade of dried fish	300
Broom making	287
Salaried work / park employee	230
Trade in liquor	199
Employee at quarry	186
Exploitation of *Grevillea*	182
Fishing	179
Running small shop	153
School teacher	150
Manual day labour	103
Sale of agricultural products	100
Animal husbandry	96
Rice cultivation	77
Artisanal production (basketry, etc.)	49
Honey production	40

In addition to selling wood for charcoal, people found grevillea useful for other livelihood needs (see Table 2). They frequently stated that grevillea stands loosen up, fertilize, and humidify the soil, and reduce the presence of weeds like *Andropogon gryllus*, facilitating later cropping on those plots. Some people cultivated fruit trees (coconut, litchi, mango, breadfruit), spices (cloves, vanilla, pepper) and timber trees (*Eucalyptus* spp.*, Acacia mangium*) in association with grevillea, and asserted that the quick growing grevillea served as nurse trees for the cash crops and served to encourage straight boles for the timber trees. They also appreciated the contribution of grevillea flowers to honey production. In a few cases, people used the species as minor construction wood due to its availability, but the wood quality is mediocre and needs frequent replacement. People also mentioned environmental services such as revegetation of denuded areas, air purity, return of birds to the landscape, and rainfall regulation.

The people we surveyed also cited disadvantages. First, it was mentioned that grevillea is difficult to remove, as it re-sprouts from cut stumps and roots and the seeds grow prolifically after burning. Second, the species occupies a lot of space, reducing land available for other activities, such as the expansion of agriculture. Third, the species competes with food crops, notably hill rice and cassava, necessitating costly weeding. Fourth, some people cited negative impacts on soil (three times less than those who stated the contrary). Fifth, some cited the respiratory health impacts of producing and transporting grevillea charcoal. Sixth, there was a perception by a dozen interviewees that the increased tree cover could lead to insecurity, providing cover for aggression or violence.

Finally, the spread of the tree reduces pasturelands, affecting those farmers who previously relied on common pasture and, in one village, a household who made its livelihoods from the collection of grass to make brooms. Indeed, informants explained that the spread of grevillea forests has been accompanied by transformations in land tenure arrangements. Open grassland areas, previously used as grazing commonage, have increasingly been claimed and titled by village members or urban charcoal entrepreneurs. This is also the case for orchards of fruit trees like litchi and stands of melaleuca in sandy wetland areas.

In our surveys, we asked respondents to reflect on their perceptions of grevillea in the past ("when you were 10 years old") and today. Their responses indicated that perceptions of grevillea have gone from passive (ignorance, negligence) in the past to positive (interesting, utility). Perceptions differed somewhat by case study site, dependent upon the local context. In some sites, people

historically had easier access to other wood sources, whether natural or plantation trees like eucalyptus or melaleuca, and have come to rely more on grevillea now. Some sites have closer access to transportation for marketing grevillea wood fuel. The southern sites around Farafangana differed in that grevillea expansion was somewhat more recent, in that urban wood fuel market demand is smaller, and in the fact that the area holds more open grasslands with a larger cattle-raising pastoral tradition. As a result, there were more complaints about the loss of pasture here. Some respondents told stories of people complaining to government forest agents or even ripping out grevillea seedlings that had been planted by those agents.

Local perceptions of the neo-Australian forests were dominated by practical concerns over earning a living and daily life in these landscapes, in contrast to the more categorical and abstract perceptions shaped by the administrative and scientific perspectives (next section). When asked whether there were any problematic invasive species to which they would like to draw our attention (described in local dialect as new plants that are expanding quickly and causing problems), numerous interviewees stated that for them, grevillea was not a problem, it was *Acacia mangium* which best met that definition, particularly because it shaded out clove trees and rendered soils underneath hard and sterile.

5. Powerful frames of analysis about these landscapes

How managers perceive these landscapes can be influenced not only by local perceptions, but also by discursive and analytical framings from national and international political and scientific actors. Here we review several such frames. The first two are prominent and evident in the words and documents of regional and national environmental actors, as well as in scientific documents. The latter are new framings currently limited to scientific discourse, but which could also influence how the landscapes are approached by managers.

5.1. Greening barren lands for environment and development

The first, probably most common frame sees grevillea as playing an essential role in greening barren lands. Such trees, in this framing, must be encouraged for environmental reasons and for their role in supplying natural resources for rural livelihoods and development. This perspective has long been the dominant way in which grevillea has been seen, and indeed is the reason for its introduction and dissemination. It is based on two main ideas that echo dominant environmental narratives commonly evoked in Madagascar (Kull, 2004). First, it evokes the problem of historical and current deforestation in Madagascar and its consequences for soil degradation and biodiversity loss. Second, it justifies the need for new or substitute trees as means to deflect deforestation pressure on remnant natural forests and as productive resources for socio-economic development.

Evidence for this perspective is widespread. French colonial efforts to establish a forest service, with forest stations and tree nurseries, were widely justified with reference to protecting remaining forests and soils and providing forest resources to the colony (Kull, 2004). Such efforts did not falter after independence, with tree planting days, community tree planting efforts, and a succession of forestry-oriented projects working to introduce, test, and propagate new species (Chaix and Ramamonjisoa, 2001; Gade and Perkins-Belgram, 1986; Kull et al., 2007; Tassin et al., 2009). A major soil erosion program in the 1950s promoted several exotic trees in an effort to revegetate 'barren' lands (Tassin, 1995); efforts in the 1990s and 2000s to expand the national seed bank for reforestation were couched in similar terms (Chaix and Ramamonjisoa, 2001).

Descriptions of grevillea and other species in the publications of foresters and others demonstrate the importance of this perspective. Chauvet (1968, p. 31) writes that it is an excellent "*espèce d'embroussaillement*", or species for 'bushing up', which succeeds on poor soils and which multiplies by itself, once established. Melaleuca was introduced as a 'reforestation species' in the lagoons of the eastern littoral. Working for a Swiss forestry project, Sutter (1990, p. 29) catalogued

forest species and mentions grevillea with the following statement [authors' translation]: "Again under the goal of soil protection and revegetation of degraded lands, one must underline the potential for rapid spread and multiplication of *Grevillea banksii*, notably after a fire".

Such framings of the importance of greening barren lands carry power, in that they are linked to government agents, foreign-funded projects, and scientists. Diverse interlocutors told us of the idea of aerial seeding of grevillea. While this was never actually carried out, the feasibility of the idea was indeed investigated in the 1980s (Rajoelison, 1987). Our interviews with directors of local nature reserves and forestry stations reflected this discursive frame, as they expressed a general appreciation of the grevillea landscapes as a reversal of historical degradation.

5.2 Biological invasion

A second frame is that of invasion biology, commonly taken up by environmental managers focused on biodiversity conservation (Simberloff, 2013). This perspective tends to view non-native species that spread on their own as a potential threat to ecological integrity as well as potentially noxious pests with economic or health consequences. While Madagascar has a century-long history of concern with and struggle over 'phytosanitary' pests (Decary, 1965; Middleton, 1999; Perrier de la Bâthie, 1928), the specific framing as 'invasive species' is more recent (Kull et al., 2014) and only partially applied to grevillea.

Due to its wide presence, grevillea was incorporated in early reviews of invasive species on the island (e.g., Binggeli, 2003; Tassin et al., 2009), and addressed again at the first scientific meeting on invasive species held on the island (Lehavana, 2012; Lisan, 2014), implying a need for management. Tassin et al. (2009) list grevillea as one of 21 forestry species with a high invasion risk. While the country's 2012 *State of the Environment* report mentions invasive species, grevillea does not figure among the 17 species of animal and plants mentioned (Ministère de l'Environnement et des Forêts, 2012). Government reports on eastern Madagascar are also inconsistent: a 2006 report mentions invasive species frequently, highlighting problems with fish and water hyacinth in particular, but only mentions grevillea positively in the context of reforestation efforts (ONE, 2006); in contrast a later report cites grevillea as an invasive species (ONE, 2008). Little invasion biology research exists on grevillea; an exception is Andrianandrasana et al. (2014) which found that grevillea significantly inhibited soil microbial activity in a small patch of native forest, disturbing micorrhyzal- and nitrogen-fixing symbioses. They also determined that the species developed cluster roots to cope with sites of degraded soils and that it locally enhanced soil phosphatase activity. They interpret their results as demonstrating that grevillea is a threat to the regeneration of native forest species. Indeed, due to its conversion of grassland into monospecific stands, grevillea could be seen as a 'transformer species', an invasive species causing a regime shift in the character of ecosystems over substantial areas (Richardson et al., 2000).

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Several different management implications could flow from an invasion biology perspective on grevillea, including restricting seed movement, monitoring, control measures, or eradication if feasible. Because the species has been deemed invasive elsewhere, in particular on the island of Hawai'i and in a small area of Réunion Island (Le Bourgeois and Camou, 2006), as well as in KwaZulu-Natal (invasives.org.za, accessed 24.04.2018) its much vaster presence, and its rapid spread in Madagascar could warrant such approaches. Given its widespread presence, eradication is not an option; however, environmental managers may opt for locally bounded efforts at control or eradication, for instance in nature reserves where the presence of grevillea has been signalled. This is already the case at the Manombo Special Reserve adjacent to one of our case studies (park agents complained of the labour effort involved). Another approach for widespread invaders is biological control, through the identification and release of host-specific insects or pathogens (Wilson et al., 2011), but given the initial research costs, perceived revegetation benefits, and the plant's economic value this would undoubtedly be controversial in the near term (Lehavana, 2012).

5.3 Novel ecosystems

Two other possible discursive framings of the grevillea situation emerge from the scientific literature but are as yet marginal in policymaker and manager circles. One is the idea of 'novel ecosystems' (Hobbs and al., 2014). This idea pushes ecologists to investigate and value emerging ecosystems that are combinations of native and non-native species, heavily influenced by humans but not necessarily managed by them (Marris, 2009). This perspective is implied in some studies looking at the role of invasive plants as habitat for endemic animals in Madagascar (e.g., Eppley et al., 2015; Gérard et al., 2015). The management implications of looking at the neo-Australian forests as novel ecosystems might lead to welcoming them because they restore a certain level and type of ecological functionality to a previously degraded, fire-climax grassland landscape. Research would be needed on different aspects of this functionality on new forms of ecological interactions, such as a possible role for grevillea in aiding the establishment of endemic forest species or serving as habitat for endemic wildlife.

5.4 Forest transitions

Another scientific framing not so common in policymaking circles is the idea of a 'forest transition'. Researchers have noted that forest cover in many industrial economies have recovered after previous deforestation (Mather, 1992); interest has subsequently focused on whether such transitions may be occurring in tropical developing countries as their economies modernize (de Jong et al., 2017; Rudel, 2002). One challenge is that this framing tends to emphasize forest area over the character of forests, so exotic or plantation forests tend to be counted as a part of a forest transition. The spread of exotic pines, eucalypts, and acacias in Madagascar's highlands has, for instance, been analysed as a forest transition by researchers (McConnell et al., 2015). In Vietnam, government environmental managers have latched on to the forest transition idea to celebrate the country's expanded forest cover, yet in doing so obfuscating continuing deforestation of natural forest, leakage of timber demand across the border to Laos, and inclusion of large-scale monoculture plantations in forest statistics (Li et al., 2017; McElwee, 2016).

The grevillea forests of eastern Madagascar could be framed as a forest transition, as their expansion is increasing forest area in a region that was historically deforested. This case could furthermore make an important contribution to forest transition theory, for while scientists have identified a number of 'pathways' of forest transitions (de Jong et al., 2017; Rudel et al., 2005) none of these pathways places any emphasis on the agency of the plants themselves in leading to forest growth. Based on the grevillea case, one could propose an 'invasion pathway' for forest transitions in which the dispersal and colonization capability of a new species plays a major role. Of course, this is not to negate the human role in introducing, propagating, and creating the conditions for invasion (Kueffer, 2017), but it highlights that humans are not the only causal factors of interest.

The management implication of this forest transition perspective is to reinforce policies to encourage such trees in the landscape. It echoes the widely-held ideas of 'regreening' a barren, deforested landscape. Such a point of view is strongly reflected in the *National Strategy for Forest Landscape Restoration and Green Infrastructure* adopted by Madagascar in February 2017. However, the initial project documents of this strategy do not mention using grevillea for forest landscape restoration despite the obvious potential to do so.

6. Discussion and Conclusion

In this paper, we have sought to describe the neo-Australian landscapes of eastern Madagascar and to identify the main ways in which these landscapes are perceived by the people who live in them and framed by national and international policy-makers, managers, and scientists. For rural residents, perceptions are dominated by the practical experience of living with these plants and their

livelihood implications. They are currently largely positive, given the strong contribution of the trees to rural revenues, particularly in the past decade. However, this positive perception is tempered at times with practical concerns, primarily about keeping the widespread plant in check. These perceptions may evolve in the future, whether due to ecological change (such as continued spread of grevillea), social change (such as reduced markets for wood fuel following adoption of gas cook stoves), or a combination of the two (Kull and Tassin, 2012; Shackleton et al., 2007; Bennett and van Sittert, 2018).

Local perspectives overlap, but only in part, with frames that policy-makers and scientists use to describe cases like this of rapid, woody vegetation spread. The 're-greening' perspective has long dominated policy discourse in Madagascar and sought to produce exactly the kinds of landscapes that grevillea's spread is creating, but it has not tended to pay attention to the sometimes complex, and very contextual social and ecological dynamics surrounding the new forests which emerged in our interviews with rural residents. The 'biological invasion' perspective is a newer way to describe the phenomenon that has gained importance in policy circles. However, given the livelihood importance of the tree, any attempts to reduce or 'manage' the invasion would potentially have major livelihood repercussions (even if people also identified negative aspects to the presence of grevillea) and perhaps political repercussions. The 'novel ecosystems' and 'forest transitions' perspectives can reinforce certain aspects of the 're-greening' perspective that place value on new tree cover, but again say little about the consequences of these landscapes for specific local ecological and social contexts.

Policymakers, researchers, and managers need to be more reflexive on how they frame discussions and decisions about the spread of new plant species, and to put those frames more in conversation with local people's experiences in order to productively resolve management dilemmas. As other authors note in this special issue, two-way engagement with stakeholders has the potential to fundamentally reframe as well as facilitate invasive species management in productive ways (Bach et al., 2018; Crowley et al., 2018; Shackleton et al., 2018). In the case of Madagascar's neo-Australian forests if the 'biological invasion' framing begins to supersede the 're-greening' framing among policymakers, then the scene will be set for what researchers working on similar situations elsewhere have called a conflict of interest over the management of alien species (Estévez et al., 2015; Kannan et al., 2016; Shackleton et al., 2011; Zengeya et al., 2017). Indeed, one commentator working for a biodiversity conservation organisation has already framed the grevillea situation as a conflict of interest (Lehavana, 2012). Given the widespread extent of grevillea, perhaps more realistic and productive frame for management and governance might be one of 'living with weeds' (Head and Atchison, 2015) that does not impose a authoritative framing but seeks to interactively, flexibly, and inclusively develop a shared, responsible and pragmatic practices.

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8. References

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