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Acacia exchanges: wattles, thorn trees, and the study of plant movements

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Abstract
Plants are frequently moved around the world, creating new regional landscapes and environmental imaginaries. Building on previous work in environmental history and geography, we develop a three-part approach to analyzing plant movements and apply it to trees from the *Acacia* genus (*sens. lat.*) exchanged between Australia and the rest of the world. First, we investigate the agents, circuits, and frequencies of acacia movements, including transoceanic transfers, regional diffusion, and ecological dispersal. Second, we trace bundles of knowledge or technology that accompany the acacias, highlighting how they help shape regional biogeographies. Finally, we analyze how different societies, with distinct economies, politics, and environmental sensibilities, receive introduced plants. This approach allows us to see transferred plants as active agents in region-forming processes, and to avoid normative tropes like 'miracle plants' or 'alien invasives'. The highlighted species include *A. colei*, *A. melanoxylon, A. mearnsii*, *A. farnesiana*, *A. nilotica*, *A. mangium*, and their close relatives.

Keywords
Acacia
Australia
Diffusion
Ecological imperialism
Environmental history
Forestry
Indian Ocean region
Invasive species
Plant transfers
Political ecology
Seed dispersal

Introduction

Throughout history, plant species have journeyed from place to place and across continents, changing natural landscapes and social relations. Many species have moved of their own accord, but many more have been transported through human agency. If Herodotus had repeated his travels around the Mediterranean in the 20th century, he would have been astonished to see the flora that most people now regard as typically Mediterranean: citrus trees brought by the Arabs from the Far East; cypresses from Persia; eucalypts and acacias from Australia; tomatoes, chili peppers, maize, potatoes, tobacco, cactus, and many more plants from various regions of North, Central, and South America (Braudel 1972, p. 548).

Much research in environmental history over the past decades has centered on how European colonialism transformed nature in every part of the world to serve its imperial interests. Naturalists, scientific institutions, and explorers transferred plants between distant lands to botanical gardens and commercial plantations (e.g. Brockway 1979; Grove 1995; Drayton 2000; Schiebinger & Swan 2005). Meanwhile, biologists have directed their research at introduced plants themselves, and how their seed dispersal strategies, competitive adaptations, and host environments allow them to become 'invasive'[1] (Cronk & Fuller 1995). These dual emphases of historians and biologists (Beinart & Middleton 2004) deflect attention from other relevant processes, like the diffusion of plants by anonymous carriers, the knowledges and technologies that are carried with them, and the differing sensibilities that shape the reception of these transplants in their new locations. These processes come together with the long-distance transfers of interest to historians and the ongoing dispersal processes of interest to biologists to make distinctive marks on regional identities, ways of life, and biogeographical landscapes.

Australia entered the intensifying global circuits of plant exchanges in the late eighteenth century. British settlement marked the beginning of what Crosby (1986) famously referred to as the 'biological expansion of Europe', a process where the expansion of wheat and livestock-based agriculture created a series of 'neo-Europes' in North and South America, southern Africa, New Zealand, and Australia. Yet ships also

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[1] While definitions of 'invasive plants' are contested (Colautti & MacIsaac 2004), key elements often include (a) non-local status or initial transportation through human agency, followed by (b) actual or potential widescale spread of reproductive offspring away from transported parent plants (Richardson & Pysek 2006; see also Cronk & Fuller 1995).

left Australia laden with specimens, seeds, and even potted plants. Tall gum trees, flowering wattles, and exotic banksias soon graced botanical gardens and landscapes around the world. Eucalypts and acacias were Australia's leading transoceanic emigrants, transplanted because their environmental characteristics could achieve a variety of social and ecological goals in warmer climate zones: afforestation, wood production, soil rehabilitation. Through the work of gardeners, farmers, and forestry agents, as well as birds, insects, and streams, these plants transformed their host environments just as other introduced species transformed Australian environments, perhaps even creating 'neo-Australias'.

Plant movements such as these have been both celebrated and vilified. Thomas Jefferson reputedly once said that the greatest service that could be rendered to any country was to add a useful plant to its culture (Juma 1989, p. 6). This spirit certainly prevailed following the sixteenth century 'Columbian exchange' (Crosby 1972) that introduced potatoes to Ireland, tomatoes to Italy, and maize to southern Africa, or in the nineteenth century when 'acclimatization' societies sought improve landscapes aesthetically and economically by introducing plants and animals from elsewhere, like oaks and trout to Australia, or eucalypts to Algeria (Lever 1992; Osborne 1994). Over the past half-century, however, concerns over safeguarding endemic biodiversity and fighting problematic pests have put many plant transfers in a negative light (Elton 1958; Cronk & Fuller 1995). In Australia, there is now a large body of environmental literature that points to the disruption caused by the introduction of non-native plants, animals and organisms (Rolls 1969; Low 2002).

Australia's current preoccupation with epic dramas of ecological assault by alien plants over native species is not unique, and reflects similar concerns and debates around the world (Holland & Olson 1989; McNeely 2001). These concerns have overridden previous celebration of plant transfers. We believe that characterizations of plant transfers as 'good', 'bad', or even as 'conflicts of interest' between good and bad (see de Wit et al. 2001) are unproductive, because they do not acknowledge that plant transfers are intricately bound up in the social context of the eras in which they occur, and in the specific ecologies and economies of places where they were introduced. Plant transfers are an integral part of the human process of regional differentiation, imbricated in daily life and livelihood practices, in development schemes and plans for betterment, and in emotional attachments to place.

Today's concern with the impacts of invasives on agriculture and conservation of endemic species or native habitats tends to ignore the complex and often versatile ways in which transferred plants – or literally, transplants – shape distinctive cultural and biogeographical landscapes. Plant movements involve diverse human and non-human actors, including transoceanic traders, seasonally migrating birds, enthusiastic gardeners, grazing animals, ants, insects, all moving in different circuits and directions. How and why transferred plants become part of regional landscapes, livelihoods, and sensibilities depends not only on how these different agents and circuits come together, but also on the knowledges, networks, and other organisms that travel with these plants into their new social environments and places of habitation. A more ecumenical approach to understanding plant movements would focus on three questions: first, by what agency and through which circuits do plants move and spread? Second, what kinds of things travel in a 'bundle' with these plants? Third, how is a transferred plant perceived and received in economic and political terms in its new home, how is it represented, and what kinds of feelings or sentiments does it evoke amongst its new human neighbors?

The following sections use these three questions to explore how different varieties of the plant genus *Acacia* (*sens. lat.*), have been exchanged between Australia and other regions of the world. We begin by examining the different ways in which environmental historians and geographers have described plant transfers between the 'New' and 'Old' worlds, and then go on to examine acacia exchanges between Australia and other regions by focusing on the agents and circuits involved, the 'bundled' travelers, and social reception of these plants in their new environments.

Studying plant movements

From prehistory to the present, people have moved plants and spread seeds from place to place in a variety of intentional and unintentional ways: by walking from one place to another, trading in plant products, sharing knowledge of plant uses, transporting plant stock, seeds, and cultivation practices (Ridley 1930; Sauer 1969; Holland & Olson 1989; Harlan 1992). For example, the grains eleusine and sorghum traveled from eastern Africa to India at least 4000 years ago (Achaya 1994); people who left the Malay archipelago over 1000 years ago and settled in Madagascar carried rice to their new home; tamarind was brought to northern Australia by Makassar fishermen; breadfruit was spread by Pacific Islanders to the places they visited and traded; citrus was brought by Arabs to southern Europe, and so on (Doran & Turnbull 1997).

The era of European exploration and colonialism increased the pace and distance of plant transfers. In particular, the linking of the Old and New Worlds unleashed a rapid exchange of plants, animals, and organisms both useful and damaging to the respective environments and societies (Crosby 1972). The great voyages of exploration of the 18th and 19th centuries corresponded with the escalation of scientific interest in tropical biology and geography. Brockway's (1979) classic work on global biological exchanges investigates the role of scientists and institutions, such as the Royal Botanic Gardens at Kew in England, in contributing to the expansion of British colonialism through the transfer of plants such as rubber, cinchona, and sisal across territorial possessions in the tropics. Many subsequent historical studies of plant transfers have elaborated on the role of botanical gardens, and disciplines such as economic botany and scientific forestry, in facilitating the movement of plants through colonial networks. By the beginning of the 20th century, botany and forestry were well established within colonial administrations around the globe; practitioners shared scientific ideas and information about the plants in their domains, recommending their transplanting for economic, climatic, and ornamental purposes (see Headrick 1988; Grove 1995; Bonneuil 1997; Griffiths & Robin 1997; McCracken 1997; Bourguet & Bonneuil 1999; Drayton 2000; Dovers *et al.* 2002; Beinart & Middleton 2004; Schiebinger and Swan 2005).

Crosby's important works *Columbian Exchange* (1972) and *Ecological Imperialism* (1986) examine plant transfers between the New and Old Worlds. The former text describes the rapid exchange and diffusion of useful plants across the Atlantic following the expansion of Spanish and Portuguese power in the Americas, and their subsequent spread into a variety of regional agricultural traditions. In *Ecological Imperialism* (1986), Crosby presents a more radical thesis on plant transfers, arguing that the success of European settler colonization in the temperate zones of the Americas, Africa, and the Antipodes was crucially dependent on the 'portmanteau biota' of plants, animals, and organisms that accompanied the settlers.

Crosby's 'ecological imperialism' thesis, however, overwhelms other regional and local processes of plant movement that may have occurred before, during, and after colonialism. Several scholars have argued the need to investigate multi-directional and/or non-imperial flows of environmental ideas and plant resources around the world

(Mackenzie 1997; McCracken 1997; Tyrrell 1999, p. 13). In their historical review of research on plant transfers, Beinart and Middleton (2004) argue that Crosby's thesis of an asymmetry in biota transfer favoring plants of European origin is 'impressionistic'. They note that for such analysis to succeed, it is necessary to establish legitimate spatial and temporal limits and to consider carefully what criteria to use in tallying invasions in different directions: i.e., should an introduced plant that is naturalized[2] and widespread across a region count more or less than a recent exotic invader limited to one site but showing signs of aggressive proliferation?

Beinart and Middleton (2004) outline a number of problems associated with historical studies of plant transfers. First is the tendency to prioritize the role of scientists and colonial institutions. They argue that one needs to look beyond famous explorers, naturalists, foresters, and botanic gardens as agents of transfer. While such individuals and institutions played key roles in some transfers, and dominate the written record, plants have long been moved by all kinds of people. For instance, the spread of crops through the Columbian Exchange (Crosby 1972) was mainly carried out by 'ordinary' farmers and traders. The slave trade across the Atlantic was a source of new plants in the Americas, including the unintentional transfer of African grasses as bedding material (Parsons 1972), and the intentional transfers of African rice as a food crop (Carney 2001, 2003). Even today, as international research organizations and corporations move plants and seeds around in the name of development or for monopoly profits, a large portion of plant flows is carried out by petty traders, peddlers, and households engaged in extensive networks of information and commodity exchange (e.g., Ban & Coomes 2004).

Second, Beinart and Middleton note that excessive emphasis on the initial transfer of plants often obscures the subsequent processes by which non-native plants are spread through regions. They stress the importance of recognizing natural agency in plant movements: many plants are very effective seed dispersers (Ridley 1930; Willson & Traveset 1992); some coastal species can disperse their seeds across oceans (Guppy 1917; Duvall 2006). Finally, Beinart and Middleton point out that the story of how a plant arrived in a new place does not explain why it succeeds (or fails) in a new environment (also see Robbins 2004). Success depends on plant characteristics, environmental factors

[2] 'Naturalization', in plant ecology, is when an introduced plant has established a self-reproducing population (Richardson & Pysek 2006).

and social reception. Using numerous examples of African farmers and new food plants, they show that a plant's utility plays a key role in social acceptance. Utility, however, is not the only factor influencing social reception of introduced plants. There are many cases that illustrate how people's views of introduced plants are shaped by cultural and political discourses that are continually redefined in the context of the times. For example, individual boosters played a key role in popularizing the planting of kudzu around the American South; now the plant is seen as a pest (Alderman 2004). Comaroff and Comaroff (2001) argue that efforts to define a new, post-Apartheid sense of nationhood in South Africa has been accompanied by an environmental discourse that represents Australian wattles as 'alien invaders' threatening the natural integrity and ecological security of the country.

Two additional studies highlight the importance of non-colonial or non-metropolitan centered circuits of plant transfer. Carney's (2001) *Black Rice* explores the role played by African slaves in the establishment of rice cultivation in the American South. She shows that slaves from West Africa were not merely 'work-hands' but also carriers of an entire rice culture with its associated production knowledge systems, technologies, and social structures. Tyrrell's *True Gardens of the Gods* (1999) investigates environmental exchanges between Australia and California from the mid-19th century to the 1930s. He focuses on the interactions between the two places during a period of frontier expansion, colonial settlement and changing environmental sensibilities. His study not only reveals the multi-directional character of transfers of environmental ideas, biota, and scientific and technological expertise, but also shows how changing social priorities and political-economic conditions, combined with the biological agency of transplants, gave rise to new environmental perspectives and conflicts of interest centered on introduced species.

The works of Tyrrell (1999) and Carney (2001, 2003) highlight an additional insight: that plant transfers need to be examined not just in terms of seeds and rootstock, but also in terms of the associated 'bundles' of knowledge regarding propagation and cultivation, pest management, and networks of commercialization. Many plant transfers have proven worthless due to the lack of associated knowledge bundles, which is why so many colonial botanical gardens and herbariums sought as much information as possible from collectors in the form of taxonomies, descriptions of locations where samples were collected, economic botany, and so on (Headrick 1988;

McCracken 1997; Schiebinger 2004). For instance, British experiments with tea cultivation in India routinely failed until they recruited Chinese experts to help propagate the plants and make them viable for production in plantations (Juma 1989). Portuguese colonizers transferred the plant *Cissampelos pareira* across their tropical territories in the mistaken belief that it was the source of a highly valued drug, *Pareira brava* (Ridley 1930). In other cases, introduced plants may spread vigorously in their new locations, and require control by pests that occur in their home ranges. Well-known examples of biological control include the introduction of *Cactoblastis* moths and *Cochineal* beetles to control *Opuntia* prickly pear cacti in Australia, South Africa, and Madagascar (Tyrrell 1999; Beinart & Middleton 2004).

Cumulatively, the recent advances in historical studies of plant movements provide a new sensitivity to and awareness of non-colonial or non-metropolitan circuits of transfer. They emphasize the importance of associated 'bundles' that are carried with the plants. They recognize the different ways in which plants establish and spread in new ecological and sociopolitical contexts. Finally, they demonstrate the value of transnational frameworks of analysis (White 1999). Our analytical approach for studying acacia exchanges between Australia and other regions of the world builds on these advances. In order to understand how acacia transfers have shaped distinctive regional landscapes in Australia and around the world, we focus on: 1) the different processes through which acacias have been moved, 2) the different 'bundles' of knowledge, technologies, and pests that have accompanied these acacia species to their new locations; and 3) the diverse ways in which the acacias have been 'received' or 'accepted' into the regional economies, cultural practices and environmental imaginaries of their new human neighbors.

Each of these themes is accompanied by a set of related questions. With respect to the **movement** of acacia species, we ask: by what means, or 'agency', are plants moving, through what sorts of networks or circuits, over what distances, and with what frequency? These questions lead us to develop three broad categories that distinguish between different kinds of movement: transfer, diffusion, and dispersal. We use the term 'transfers' to represent the transoceanic movements of plant genetic material by human agents such as naturalists, scientific organizations, or traders; these long-distance movements are less frequent and often less significant in terms of regional landscape outcomes. 'Diffusion' represents the spread of plants from person to person, through agents such as forestry companies, development agencies, commercial nurseries, or by individual farmers and gardeners. We use this term consciously, because it recalls the rich geographic literature on diffusion of cultural practices, techniques, and innovations (Sauer 1969; Gregory 2000). 'Dispersal' is used in its ecological sense to encompass the process of plant spread by natural forces, insects, and animals (Ridley 1930; Willson & Traveset 1992); i.e., ants rolling seeds from one place to another, wind-and water-borne transmission, or birds and herbivores transporting seeds in their gut. The different ways in which these kinds of movements come together in space and time shapes distinctive regional characteristics and biogeographical landscapes.

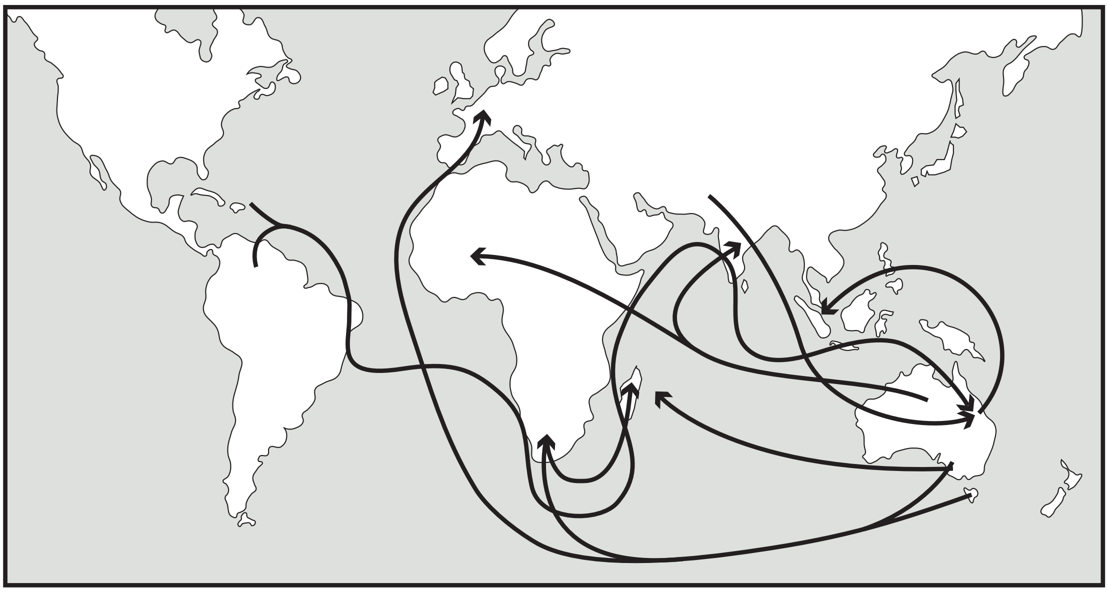
With respect to ***bundled movement***, we ask: What kinds of things move with a plant to a new place, preceding, accompanying, or following it on its journey? The 'bundles', depending on the type of human agency involved, may include knowledge of a plant's cultivation and use, linkages to markets for the plant's products, or even pathogens and pests that can control the plant. The ways in which these 'bundles' are formed become key sociopolitical and ecological factors that shape the different outcomes and uses of plants in different regions. Regarding ***social reception***, we ask: how do regionally distinct economies, politics, and environmental imaginaries shape their society's relationship to an introduced plant? Social perceptions of the plant and the feelings it evokes, whether in terms of utility, aesthetics, emotions, or sensibilities of affection or belonging, evolve over time, and influence the plant's presence and place in the regional landscape.

The following sections of this paper use these themes to understand the regional outcomes of acacia exchanges between Australia and the world. We focus on six groupings of acacia species that have either been moved into or out of Australia: cool climate wattles like *A. mearnsii* and *A. dealbata*; the blackwood tree, *A. melanoxylon*; tropical forestry species like *A. mangium*, *A. crassicarpa,* and *A. auriculiformis*; arid zone revegetation trees like *A. colei* and *A. cowleana*; the mimosa bush or cassie, *A. farnesiana*; and the prickly acacia, *A. nilotica* (Table 1; Figure 1).

Table 1: The six case studies

Name	*Description*	*From*	*To*	*Chief agents of movement*		
				Trans-ocean	*Regional*	*Local*
Outbound from Australia						
cool-climate wattles e.g. *A. dealbata* and *A. mearnsii*	feathery leaved 2-30m trees	south-eastern Australia	worldwide; esp. Indian Ocean rim, Brazil, China & Mediterranean	Br. & Fr. colonial naturalists, botanists, 'nurserymen'	government agents; private foresters; garden industry	tree planters (gov't and private); water, ants, livestock, wind
A. melanoxylon	tree with phyllodinous leaves	south-eastern Australia	worldwide; polyploid found on Réunion called *A. heterophylla*	perhaps petrels in case of Réunion Is.; elsewhere Br. botanists; foresters	foresters, garden industry	water, birds, wind, foresters, gardeners
tropical acacias e.g. *A. mangium, A. crassicarpa, A. auriculiformis*	broadleafed phyllodinous trees	northern Australia, New Guinea, and nearby islands	most tropical zones, with massive plantations in South East Asia	foresters and technical agents	foresters (government and commercial)	foresters, farmers, birds, wind
arid zone acacias, e.g. *A. colei, A. cowleana*	mostly 4-5m shrubs	sand plains and creeks in deserts of Australia	West Africa, southern India	foresters and technical agents	government foresters and technical agents	foresters, farmers, ants, wind
Inbound to Australia						
A. farnesiana	many-branched and thorny small tree or shrub	central and southern America	worldwide; found across northern Australia	perhaps Sp., Port., or Dutch colonial actors	ocean currents; traders; planters, farmers	planters, water, livestock, wind
A. nilotica	feathery leaved and thorny tree, commonly 4-5 m but up to 10 m	across Africa and Middle East to India; subsp. *indica* native to drier zones of south Asia	worldwide; subsp. *indica* to Queensland, Somalia, West Timor	Br. colonial 'economic botanists'	government agents; farmers	farmers, water, livestock, wind

Figure 1: Simplified map of transoceanic movements of the six case studies.



Acacia exchanges and Australia

The genus *Acacia*[3], native around the tropical and sub-tropical world (but not to Europe), has traveled extensively around the world at most latitudes between 35° north and 40° south. Part of the pea family (*Fabaceae*), most acacias blossom with numerous small creamy or golden balls or cylinders of flowers and have leguminous pods. Many species are thorny and have bipinnate feathery leaves, but some species, particularly Australasian ones, have no thorns and flattened stalks called phyllodes that look like simple leaves. Like other leguminous trees, acacias form symbiotic associations with root-nodule bacteria that fix nitrogen into the soil. Over 1350 species of acacia exist around the world. About 185 are endemic to the Americas, 150 to Africa, and 95 to Asia and the Pacific. Nearly 1000 are native to Australia (Brockwell *et al.* 2005; Maslin 2001).

Despite their wide distribution across most continents, hundreds of acacias have been transported to new habitats, and several have become well established. For instance, plantations of Australian black and silver wattles cling to South Africa's escarpments, while India's *A. nilotica* covers vast rangelands in tropical Queensland. Based on a survey of one database of acacia species[4], at least 8 taxa, or 2 percent, of non-Australian acacias, have established self-sustaining populations in Australia, while at least 12 Australian taxa (or 1 percent) have naturalized overseas. The six groupings of acacia species that have been transferred into or out of Australia (Table 1) offer a useful illustration of the different ways in which the movement of plants, their associated bundles, and social receptivity come together to shape distinctive regional economies and landscapes.

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[3] We refer to Acacia as a single genus, e.g. *Acacia sens. lat.* In 2005 the International Botanical Congress defined a new 'type species' for *Acacia*, the Australian *A. penninervis*. This was a key step in a proposed splitting of the genus into five separate genera, as it would allow most of the species (particularly those home to Australia) to keep the name *Acacia*. The remaining 400 species would fall into four proposed new genera: *Vachellia* (including *A. nilotica* and *A. farnesiana*), *Senegalia*, *Acaciella*, and *"Mariosousa"*. Despite this decision there is not yet full agreement, and the name *Acacia* is still widely used for all subgenera (Maslin & Orchard 2006).

[4] Areas of origin and introduction summarized from alphabetical species lists at www.worldwidewattle.com/speciesgallery (last accessed 12 April 2007; see also Maslin 2001). Only transcontinental naturalizations noted. The data are problematic at best, as there are many lacunae. Australian exports are particularly underrepresented (pers. comm. B. Maslin, April 2007).

Acacia movements

Acacia transfers

Each of the six acacia groupings was transferred across oceans, though in different eras and by different agents. The earliest was *A. farnesiana*, a many-branched and thorny small tree with a large home range in the Americas between Texas and Bolivia. It is now found from the Mediterranean rim to southern Africa, on all the shores of the Indian Ocean, and across the Pacific. Few people in these places realize that it was once a new arrival. Over a century ago, however, Anglo-Indian official and amateur botanist George Birdwood vouched for its New World origins:

> It is described as a native Chilian plant by Molina, in the 16th century, from which date it is gradually traced through a succession of writers eastward, in Italy, the Morea and Greek Islands, in the gardens of Egypt and Arabia, and in Western India. From Buenos Ayres, it was carried by Europeans into Louisiana, and as far north as Charleston, and again by Europeans it was carried from America westward to Tahiti and the Philippines, to Timor and Java, and apparently to Burmah and the Coromandel coast of India. It has now overspread all India. Everywhere its name seems to be derived from its exquisite "aroma," and as the Greek writers do not refer to this, its overwhelming characteristic, I accepted it as a plant of exclusively American origin, and one of the most delightful gifts of the old world to the new [sic]. (Birdwood 1896: 467).

The most plausible transfer agents for this plant are the ships of 16th century colonial powers Portugal and Spain.[5] Seeds were passed from port to port because of the tree's attractive, perfumed flowers and other uses in the production of fodder, dye, glues, and tannins (Duke 1981). By the time Britain explored the interior of its new colony Australia, the tree was already widespread (Bean 2007). It likely crossed to northern Australia from colonial outposts in the East Indies, carried by Portuguese explorers (McIntyre 1982), Makassar traders, or ocean currents (Ridley 1930).

In contrast, the transfers of Australia's cool-climate wattles relied on the colonial botanical networks of the 18th and 19th century. Britain and France, inspired by the scientific revolution, moved plants with enthusiasm (and with detailed records). Research ships from both countries collected acacias, among many plants, on their visits to southeastern Australia in the late 1700s and early 1800s. Such effort was not restricted to government-sponsored ships; private English nurserymen Lee & Kennedy had customers for Australian plants by 1788 and in 1790 sent a collector of their own to

[5] Some Portuguese claim that their explorers – who may have been the first Europeans to visit Australia (McIntyre 1982) – brought Australian trees to Iberia (Zacharin 1978).

Sydney (Zacharin 1978). The new plants were catalogued into the registers of scientific botany, and through the efforts of gardening enthusiasts like Empress Josephine, these novelties graced greenhouses and gardens around Europe (Hamilton 1999).

In the mid-19th century, botanical gardens transferred increasing volumes of plants for scientific research, colonial economic ventures, and landscape improvement. Often in conjunction with botanical gardens, 'acclimatization' societies sought to introduce plants (and animals) to new climates. Ferdinand von Mueller, director of the Melbourne Botanic Gardens and leading member of the Acclimatisation Society of Victoria, tirelessly promoted Australian plants overseas (Naudin & von Mueller 1887). As a result of these networks, British and French botanists began cultivating several Australian acacias (including the cool-climate wattles and *A. melanoxylon*) in their gardens; they were present in Cape Town by the 1850s. They were promoted for landscape improvements around the Mediterranean basin and in California, and as economically useful trees in the Indian subcontinent and South Africa (Osborne 1994; Tyrrell 1999).

A. nilotica, previously called *A. arabica*, also crossed the oceans on colonial circuits. This thorny tree was well known by the economic botanists of the late 1800s as a source of many useful products, such as gums and resins, dyes and tans (from the bark, pods, seeds, leaves, and gum), fibers, medicinal products (seeds), and food (gum and seeds) (e.g., Mukharji 1887). Several agents have been suggested for its introduction to Queensland. In 1887, its seeds were sent to the Brisbane Acclimatisation Society from the Botanic Gardens in Saharanpur, northwest India (ASQ 1887). In inland Queensland, some people claim that soldiers returning from the Boer Wars – or, alternatively, the Anglo-Afghan Wars – carried back seeds, or that relatives in Rhodesia sent seeds.[6]

In the past five decades, the networks of a variety of scientific-industrial-developmental agencies have served a key role in transoceanic transfer of many plants. These include the UN's Food and Agriculture Organization, the World Agroforestry Centre (ICRAF), and national research and development cooperation organizations. For example, the French *Centre Technique Forestier Tropical* made collections of dry zone Australian acacias in the 1970s and 1980s. Australian agencies such as the CSIRO (and its Australian Tree Seed Centre) and the development-oriented Australian Centre for International Agricultural Research (ACIAR) are heavily involved in the collection,

[6] Interviews in Julia Creek, Hughenden, and Richmond areas by A. Egan and A. Weyman, April 2007.

testing, and promotion of various species, particularly the tropical acacias (Turnbull 1987; Doran & Turnbull 1997; Midgley & Turnbull 2003).

Transoceanic transfers of acacias are repeated, not singular, events. The competing stories of *A. nilotica*'s introduction to Australia may all be based in truth.[7] In many cases, first introductions are not the source of modern-day populations. Southern France's silver wattles may date to seed imports in the mid-1800s, not to seeds sent to Mediterranean gardens by Empress Josephine's generosity fifty years earlier (Muller 2004). Many plants may have arrived in new places not directly from their place of origin, but from other transoceanic 'staging posts'. For example, France was a key staging post for eucalypts sent to Portugal, Ethiopia, and Chile (Zacharin 1978) and for acacias sent around the Mediterranean; South African plantations are the source of most of the 20th century spread of *A. mearnsii* around the word (Sherry 1971). The seeds for Australian acacias introduced to Madagascar's experimental arboreta in the 1950s came not just from Australia, but also from France, Morocco, and South Africa (Chauvet 1968).

Diffusion

The diffusion of the black wattle, *A. mearnsii*, outside the largely 'botanical' circuits of transfer was due to its economic usefulness as a source of woodfuel and construction wood, as a quick reforestation tree, and most importantly, as a source of tannin. Its bark is an excellent source of vegetal tannins. For much of the 19th century, Australia exported tens of thousands of tons of tanbark, chiefly to Britain where it was much sought after by the leather industry. By the 1870s people were expressing concern about overexploitation (Maiden 1890; Hillis 1989; Milligan 1994). As a result, officials across the British Empire, together with settlers and private investors, promoted the cultivation of the black wattle in their colonies. As a result, the tree provided woodfuel and tannins along the East African railways, woodfuel in the tea plantations of Sri Lanka and the southern Indian mountains, and timber and tannins in Natal and the Cape (Sukumar *et al.* 1995; Castro 1996; Midgley & Turnbull 2003).

Natal's wattle-planting farmers and private investors were aided by incentives like free seeds and grants from a government worried over the country's lack of self-

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7 While genetic analysis points to a South Asian origin for a wide sample of Queensland's prickly acacias (Wardrill et al. 2005), isolated stands may have grown from southern African seeds.

sufficiency in wood products (Hillis 1989; Witt 2005). By the 1950s, South Africa had the world's largest plantations of black wattle, extending over 360,000 hectares. Although the area of wattle plantations has since shrunk to about 120,000 hectares (Figure 2), they continue to support an important industry that exports wattle products globally: pulp to Japan and, ironically, tannin extract to Australia (Milligan 1994; Midgley and Turnbull 2003).

The silver wattle (*A. dealbata*) was also promoted by government agents and diffused by farmers as a quick-growing source of poles and fuel wood, not just in South Africa (Witt 2005), but also in highland Madagascar. French administrators introduced this tree here around 1900. District administrators encouraged colonists to plant some on their lands for soil conservation and fuel wood. In the 1910s, when the railway was built, the fuel needs of the wood-burning steam locomotives inspired everybody from government agents, to settlers, to Malagasy farmers to grow the tree for sale (Kull et al. 2007).

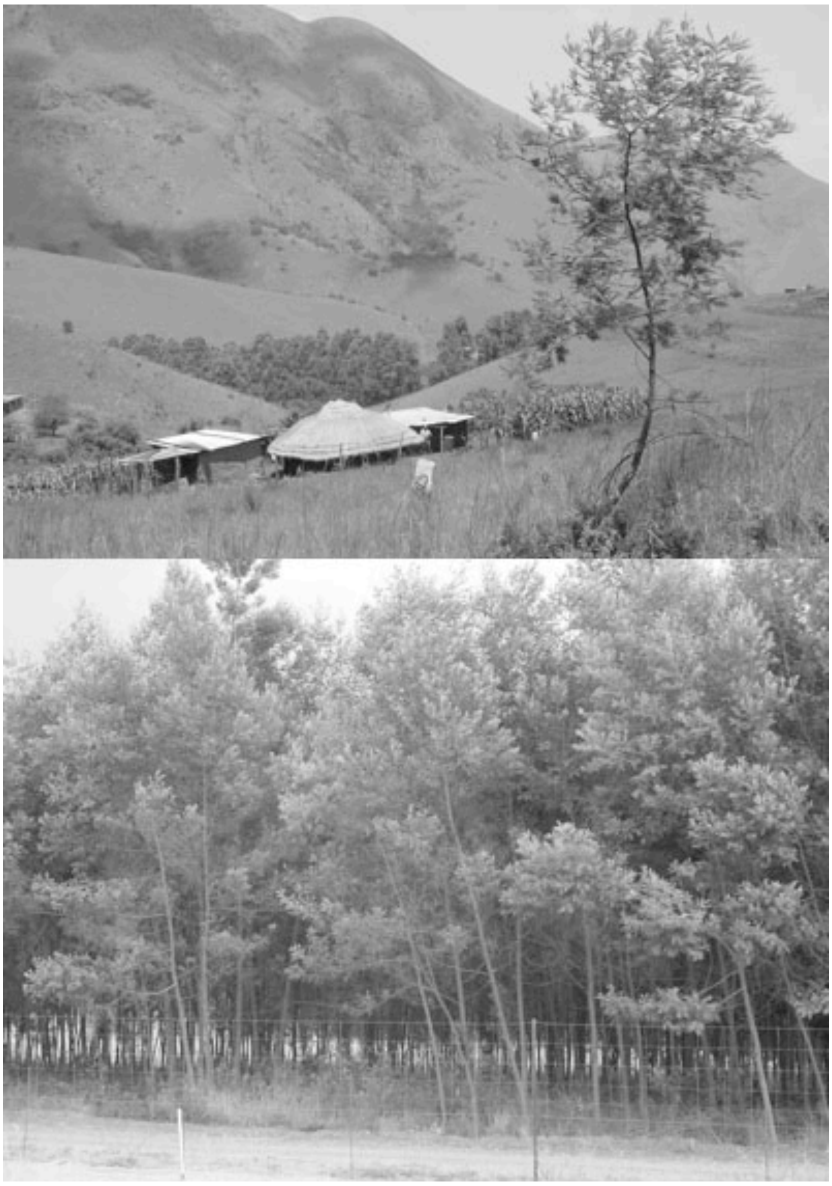

Figure 2: *A. mearnsii* in South Africa: a farm stand and commercial plantation in southeastern Mpumalanga province.

Similar efforts were expended by officials in Queensland to diffuse a different acacia, *A. nilotica*, for a different economic sector: the wool industry. The Department of Agriculture and Stock recommended the tree's cultivation in the western rangelands beginning in the 1920s. It was touted for providing shade and for the protein rich fodder in its seed pods. As a result, this thorn tree was widely planted, around homesteads and wells, with seeds scattered from horseback (Mackey 1996, 1998). The Department of Primary Industries continued to promote its use until the 1980s, making seeds widely available through extension agents and fairs, encouraging pastoralists to plant them on their stations.

Diffusion also occurs outside the circuits of state agents and their partnerships. Farmers, harvesters, and gardeners are important agents of diffusion, collecting seeds and moving them, whether for sustenance or aesthetics. Aboriginals Australians long harvested large quantities of certain acacia seeds for consumption, which in combination with certain fire practices may have altered the trees' distribution (David 2002). The blooms of many Australian acacias make them popular decorative trees. For example, the cool-climate wattles and *A. melanoxylon*, among others, are common in the streets of towns from California to the Mediterranean. The early spread of *A. nilotica* in coastal Queensland was also linked to gardeners – within decades of arrival, plantings by town councils and private individuals had made it a widespread ornamental and shade tree in coastal regions (Mackey 1996).

Economic entrepreneurs are also key agents operating independent of the state. Local entrepreneurs have developed essential oil industries around *A. farnesiana* in southern France, Uttar Pradesh, and the Punjab (Duke 1981), encouraging the trees' planting and diffusion. Perfumes are also extracted from *A. dealbata*, supporting a profitable cut flower industry in the Côte d'Azur – where it has become naturalized and invasive (Muller 2004; Roland 2005) – and in India's Nilgiri Hills.

Dispersal

Acacia seed dispersal occurs through both abiotic and biotic agents. Wind can blow seeds meters from their source; water may wash seeds further. The seed pods of *A. farnesiana*, which stay closed at maturity, can float on ocean currents for up to 600 km (Ridley 1930; see also Guppy 1917; Duvall 2006). As far as biotic dispersal, Australian acacias tend to be either ant or bird dispersed (O'Dowd & Gill 1986; Table 1). Réunion's 'mountain tamarind' (*A. heterophylla*), a valuable hardwood tree, may be the result of bird dispersal from Australia. DNA analysis shows that *A. heterophylla* contains four copies of a single *A. melanoxylon* genome (Coulaud et al. 1995), implying that this plant found its way across 8000 km of ocean to the highlands of an isolated, recent volcanic island. How it did so is unknown; it is plausible, however, that petrels flying from Australia carried the seeds in their guts.[8] Ungulates, with their habit of eating acacia seed pods, also serve as dispersal agents. In South Africa, elephants are known to spread seeds of introduced *A. melanoxylon* and *A. decurrens* (a close relative of the black and silver wattles) (Ridley 1930). Livestock such as camel play a key role in dispersal, particularly of *A. farnesiana* and *A. nilotica*.

A. nilotica's spread in Queensland demonstrates the combined effects of different dispersal agents and their relationship to broader regional and historical trends and characteristics. The tree has been particularly successful in colonizing the Mitchell grasslands, dominated by *Astrebla* grasses and cracking clay soils. Here, because the tree is at the drier end of its range, it has expanded along watercourses, bore holes and irrigation ditches, spreading rapidly during particularly wet years (during the 1950s, 1974-76, and 1990-91). A crash in world wool prices in the 1970s led to the replacement of sheep (a poor dispersal agent) with cattle (an effective dispersal agent), which further spread the tree (Mackey 1996; Spies & March 2004; N. March pers. comm. 2006).

Transfer + Diffusion + Dispersal

Acacias have moved widely, through numerous circuits and agents. Formal government institutions are strongly implicated in the longer-distance, transoceanic movement of many (but not all) acacias; they are also key actors at the regional level. As the distance of movement decreases, the frequency tends to increase, as does the diversity of vectors and of circuits of exchange. Attention to the full range of agency and circuits of plant movements allows for a better understanding how certain plants become imbricated in regional geographies in specific ways. For acacia movements out of Australia, for example, British or French naturalists' expeditions form a captivating yet insufficient preface to a longer and more complicated story. The wattles' success in places like South

[8] Jacques Tassin, CIRAD Montpellier (pers. comm. 18 Oct. 2006).

Africa have as much to do with the quotidian spreading of seeds by farmers, elephants, or river waters, each operating within a specific regional social and environmental context.

Acacia bundles

Future economic profits motivated economic botanists to circulate detailed lists of plants and their uses through colonial networks in the 1800s. Knowledge of the utility of the fast-growing *A. mearnsii* for tannin, poles, and woodfuel (e.g. Maiden 1890) encouraged the tree's diffusion around the British Empire, and, once in place, knowledge of its cultivation facilitated its spread (Castro 1996; Midgley & Turnbull 2003). Conversely, poor knowledge impeded its spread in at least one place. In the 1920s, the French colony of Madagascar sought to compete with the South African tanbark industry. Unfortunately, however, there was confusion among French planters between species, particularly *A. dealbata* (already widely present, but poor in tannins), *A. decurrens*, and *A. mearnsii* (the best tannin species). As a result, five crucial years were lost due to misplaced planting efforts, impeding the growth of this industry (Kull et al. 2007), a fate sealed by the 1929 recession (Witt 2005). Only a few thousand hectares of plantations were established, and they never succeeded in competing with South Africa's vast plantations.

In some cases, commercial actors overlap with governmental agencies in bringing silvicultural techniques, improved seed stock (through provenance testing), processing technologies, and commercialization networks to new places. The Australasian tropical acacias illustrate this process. Fast-growing broadleaf trees like *A. crassicarpia*, *A. mangium*, and *A. auriculiformis* have gained important roles as commercial plantation species over the past thirty years. Interest was sparked by the introduction of *A. mangium* to Malaysia in 1966 for commercial forestry purposes.[9] *A. mangium* is a large shady tree, tolerant of acidic soils, and ideal for moist, tropical environments. It is mainly used for paper pulp, though its timber is also regarded as being of good quality. Malaysia and Indonesia now have nearly 850,000 ha of commercial plantations of this tree. CSIRO's Australian Tree Seed Centre and the ACIAR played key roles in collecting, testing, and

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[9] *A. auriculiformis* had already been planted widely beyond its native range, with initial cultivation by foresters in Malaysia and Thailand in the 1930s (it is now cultivated across tropical Asia, from India to China, for fuel, ornamental purposes, minor construction, and re-vegetation). *A. crassicarpa* was poorly understood before the 1980s, but subsequent research by Australian government agencies has made it another popular plantation and reforestation species.

promoting these trees; through these networks and international agencies like ICRAF and the FAO the trees have spread around the globe, from Tanzania to the Dominican Republic (Rocheleau *et al.* 2001; Midgley & Turnbull 2003).

The involvement of governmental agencies in transferring silvicultural knowledge and techniques to new places is due not just to commercial interests, but also to broader concerns for environmental protection, economic development and livelihood generation. A unique case illustrates this. A number of dry-zone Australian acacias, including *A. colei*, were planted in the Sahel during the 1970s and 1980s when global concern about desertification was at its peak. The fast growing, drought tolerant trees were introduced by the French agency *Centre Technique Forestier Tropical* to provide woodfuel, create windbreaks against sandstorms, and provide animal fodder (Cossalter 1986). Later, an Australian forester in Niger realized that the high-yielding, nutritious, easily collected seeds from some of these species could be promoted to supplement local diets. That is, Aboriginal "bush tucker" knowledge about the food uses of indigenous plants (Isaacs 1987) could follow the trees to western Africa. As a result, in the 1990s, the CSIRO, in conjunction with development projects, put considerable effort into this idea, sponsoring community-based seed collections, field trials, and a visit by two Aboriginal women to Niger to share their knowledge of acacia seed use and preparation. Today, more than 55 villages in Niger grow Australian acacias and harvest the seeds for food. Similar efforts have also been made in Tamil Nadu, India, where the same acacias had previously been planted for afforestation (Harwood 1994; Bennett 1995; Harwood *et al.* 1999; Rinaudo *et al.* 2002).

Once introduced plants become well established, and particularly when they become 'too' successful, concerns particular to the economies and environmental policies of particular countries may inspire further bundled transfers. For example, when plants come to be regarded as pests, officials sometimes seek to import the plants' own parasitic insects or pathogens to help control them. Both South Africa and Australia have sent scientists overseas to search for possible biocontrol agents for introduced acacias. South African scientists have imported six weevils, four wasps, one fly, and two pathogens from Australia to control problematic wattles (Sheppard et al. 2006). Australians, in turn, have expended considerable effort to control *A. nilotica*, relying on networks inherited from the days of the British Empire. From 1979 to 1984, Queensland's Department of Lands established a project at the Commonwealth Institute of Biological Control in Rawalpindi, Pakistan, to find potential natural enemies of *A. nilotica*. In 1989, an entomologist was sent to Kenya for two years of further research on control agents in a different part of *A. nilotica*'s range. Surveys were also conducted out of South Africa in 1991 and 1997, and a field station established there from 1999 to 2003, based at the Plant Protection Research Institute near Pretoria. Each potential biocontrol insect was then exposed to 70 or 80 species of Australian acacias to ensure that the insects would only affect the targeted tree. Six insects have passed the test and been released in Queensland, starting with the beetle *Bruchidius sahlbergi* in 1982 through to the latest, the caterpillar *Cometaster pyrula* in 2004 (Figure 3). So far, the releases have had minimal impact (Mackay 1998; March 2000; B. Palmer and J. Marohasy, pers. comm.).

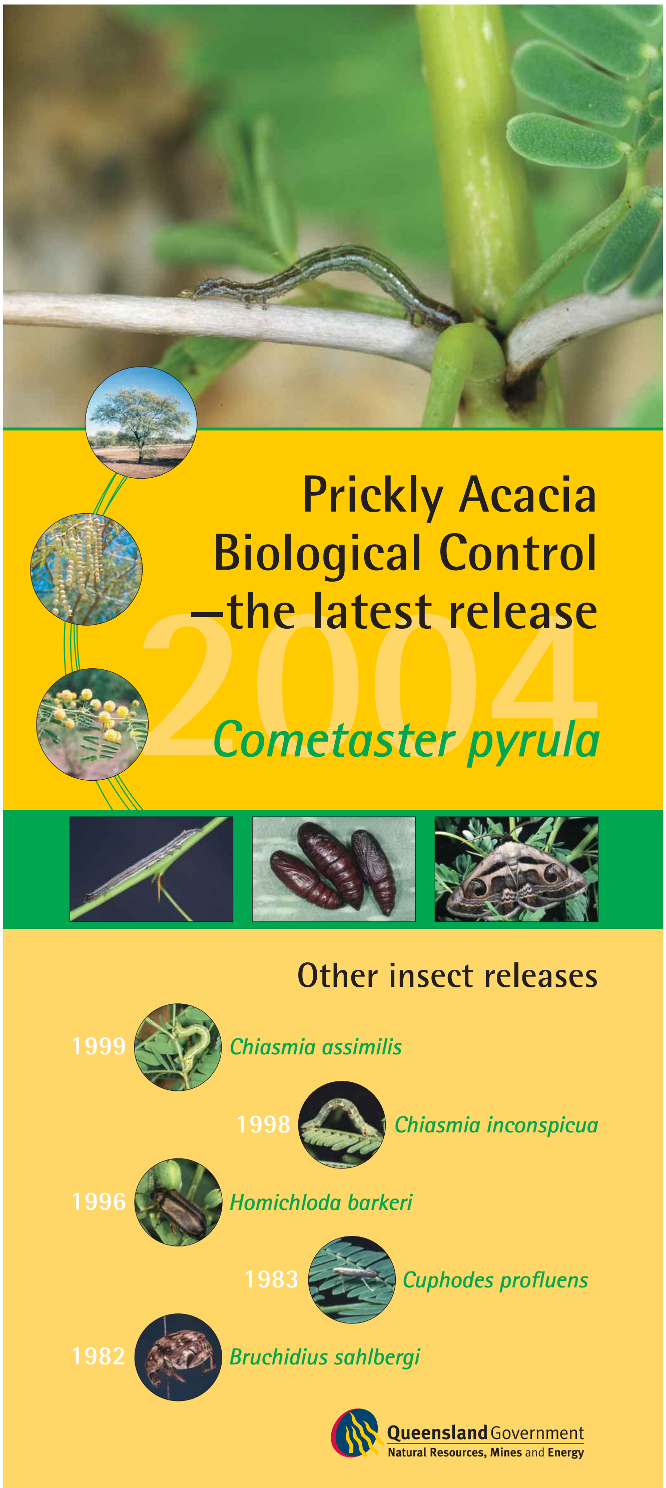

Figure 3. Pamphlet for biocontrol efforts of *A. nilotica* in Australia (reproduced with permission of Queensland Government, Alan Fletscher Research Station).

Social reception of acacias

Cool-climate wattles have been incorporated into the regional economies and landscape aesthetics of southern France and Madagascar. The 'mimosas' of southern France[10] are celebrated, widely planted, and seen as part of the regional identity of the Côte d'Azur. *A. dealbata* is central to a niche industry for cut flowers and perfume extracts, and the towns around Bormes-les-Mimosas hold annual festivals when the trees produce their golden blossoms (Roland 2005). In Madagascar's highlands the same acacias have entered the popular imagination through their omnipresent September blooms, celebrated in an annual 'Fête des Mimosas' in the city of Ambatolampy and in a widely known love song[11]. Here, officials have encouraged the planting of trees like wattles for over 100 years, arguing that they protect watersheds and stem environmental degradation in the barren highlands. Farmers now rely on them for woodfuel, for field fertilization, minor construction uses, and many other functions (Kull *et al.* 2007).

In both places, ecologists and environmental managers recognize the wattles as invasive, yet the social priority for action remains low (Muller 2004; Sheppard *et al.* 2006; Kull *et al.* 2007). This contrasts sharply with the reception of the same trees in South Africa. Here, endemic acacias such as the thorn trees and fever trees shading safari camps are celebrated, but introduced acacias are condemned as pests, despite their major economic role in the pulp and tannin industries. Self-reproducing populations of wattles have emerged outside plantations and spread onto grasslands and alongside streams (Figure 2). Although some poor rural communities make use of the wattles for poles and fuel (de Neergaard *et al.* 2005), the official view is that outside plantations these are alien invasive species threatening scarce water resources and biodiversity (de Wit *et al.* 2001). This prevalent discourse became glaringly evident when wildfires hit Western Cape, and elites blamed the fires, in the first instance, on alien vegetation (Comaroff & Comaroff 2001). Wattles and other introduced plants are alleged to have reduced water runoff by 7

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[10] There are some 20 species and hybrids of Australian acacias in southern France (Roland 2005), several of which have established self-reproducing populations outside gardens.

[11] "Mimosa" by Dama, who has been called Madagascar's Bob Dylan and was elected to the national assembly in the late 1990s. The song talks of two lovers declaring their love through wattle flowers and scents, of their dream of building a wattle home, and of seeking solace in the beauty of a grove of blooming wattles.

Figure 4: Roadside signs for invasive species control in Australia and South Africa.

percent (Le Maitre et al. 2002). In response, in 1995 the government launched a large-scale employment generation program called *Working for Water*, paying poor workers in rural areas to rip wayward wattles and other water-guzzling 'alien invasive' species out of the ground (Figure 4).

Like South Africa, Australia celebrates its endemic acacias (the golden wattle *A. pycnantha* is the national flower and inspiration for the green and gold colors of its sporting teams) and classifies introduced acacias as pests – in particular *A. nilotica*, the 'prickly acacia'. This tree was originally seen as a boon for the grazing economy, for at low densities it increased stock productivity by providing shade and fodder. However, diffusion and dispersal of the species' seeds increased both its density and its range; it is now found in some 7 million hectares. A victim of its success, it is now widely reviled by government agencies, resource managers, and scientists. Dense thickets of *A. nilotica* reduce grass production, restrict access to pasture and water, and increase costs of mustering cattle. The Queensland state government declared the plant "noxious" in 1957, and it is now one of twenty plants officially deemed "Weeds of National Significance", with funding and action plans to match (Mackey 1996; Spies & March 2004; March pers. comm. 2006; Figure 5).

Figure 5: Steven Reddie surveys his property cleared of *A. nilotica* in outback Queensland (photo: Weyman, A.)

Interestingly, another introduced acacia populating vast stretches of northern Australia, *A. farnesiana*, gets a different social reception, at least in legal terms. Because *A. farnesiana* was present before British settlement, this tree is not classified as an exotic (Bean 2007). Aboriginals use its thorns as a tool, and are known to have eaten the seeds (Isaacs 1987); pastoralists have long tolerated it as drought forage. Biologists and environmental managers, however, condemn the tree for invading native ecosystems and aim to place it among a rogues gallery of prickle bushes, including *A. nilotica*, slated for control (Spies & March 2004). As a result, *A. farnesiana* has a borderline status like the dingo, which people introduced from Asia some 5000 years ago (Trigger 2006). Neither fully native nor obviously alien, these species highlight the importance in today's world of changing sensibilities of 'belonging' in determining a plants social reception.

The social reception of plants is contingent on a dynamic mix of regionally differentiated utilitarian, environmental, and ideological forces. Useful plants that are 'well-behaved' (i.e., grow well and either stay put or spread quickly, depending on the context), regardless of origin, are better tolerated than problematic weeds. Specific environmental conditions in different places – shaped by geography and the legacies of human actions – govern the opportunities and constraints on introduced plants, which in turn elicit different human reactions. Different ideologies specific to different places at different times are reflected in attitudes towards plants. Today, ex-British settler colonies arguably lead the way in agitating strongly against 'invasive aliens', in particular South Africa with its concern over water resources and Australia with its iconic invading rabbits and cane toads. Meanwhile, the Francophone or Lusophone worlds appears to pay much less heed to similar issues (e.g., Muller 2004, p. 4). These differences, rooted as much in regional economies as in social perceptions, continue to shape the role of introduced trees in particular landscapes.

Conclusion

These 'acacia exchanges' highlight the diversity of plant movements – before, during, and after colonialism – and the multiple agencies involved. We can only speculate the kinds of seed transfers undertaken in the vibrant Indian Ocean trade of the middle ages. Later waves of European colonial agents – expedition botanists, priests, sailors, traders, settlers, administrators, and their cargo – moved plants, intentionally and otherwise. The Portuguese linked Brazil to Angola, Mozambique, Goa, and Timor; two centuries later the English traveled their own circuits. Over the past five decades, new institutions played key roles in moving plants, ranging from the garden plant industry to international research and development agencies (e.g. Léon 1974). After each transfer, local and regional agents of dispersal and diffusion – ants, birds, water, and wind, as well as farmers, cattle, settlers, and gardeners – conditioned the kind of biogeographical landscapes that emerged.

The 'bundles' of information, knowledge, and technologies that accompanied the acacias further shaped their role in regional landscapes. These bundles were determined by the place-making efforts of different institutions and individuals in various places, linked to concerns ranging from commercial speculation to environmental management. The result, whether predictable or not, was a distinct regional economic and ecological outcome. How else is it possible that villagers in Niger today might eat more *A. colei* seeds than Aboriginal residents of central Australia, or that tall, uniform stands of *A. mangium* cover far much more terrain in southeast Asia than their wild brethren in Australia?

Our stories of wattle-swapping show how the metaphor of 'ecological imperialism', implying an epic tragedy of unidirectional conquest, control, and destruction of indigenous vegetation, is insufficient in capturing the versatile ways in which the acacias are incorporated into regional economies and identities, or how they become labeled as invading aliens and targeted for eradication. Australian acacias have been 'naturalized' not just ecologically, but also socially through daily use in crop fields, gardens, and markets in places as varied as the Côte d'Azur, Kwa-Zulu Natal, the Nilgiri Hills, and the Malagasy highlands. With time, people become attuned to plants' seasonal cycles, to their uses, and to their advantages and disadvantages. Some are beautiful, some are helpful, some are profitable, and some are pests that damage economic, ecological, or cultural landscape values. Such direct experience and associated emotions interact with broader discourses of particular times and places – like ideas of economic advancement or national purity. The outcomes are regionally particular perceptions of introduced plants, and different receptions in different places.

Analyzing plant movements in terms of the above themes of investigation – the agents and circuits of movement, the accompanying bundles, and the context of social reception – allows us to see plant movements as not simply a list of 'bad' alien invaders exotic to a particular locality, nor as a celebration of 'good' miracle plants. Instead, it allows us to appreciate wandering plants as active agents in region-forming processes. In particular, it focuses our attention on the how plant introductions both shape and are shaped by distinct regional convergences of ecology, livelihoods, politics, and ideology. Landscapes of introduced acacias – whether dreaded plantation wattles in upland South Africa, celebrated garden mimosas in southern France, or confounding thorn trees in outback Australia – are linked by the plants and ideas they have exchanged, but distinguished by their local outcomes. We are currently in an age where indigeneity and environmental purity are highly valued, and so metaphors of 'ecological imperialism' (Crosby 1986) and 'feral futures' (Low 2002) for describing non-native plants and their movements seem persuasive. A broader view, one that seeks to understand how and why a plant becomes imbricated in regional landscapes and how human sensibilities emerge in concert with the plant, replaces these parochial tropes with a more ecumenical vision.

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