NMML
OCCASIONAL PAPER

PERSPECTIVES IN
INDIAN DEVELOPMENT

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Plant Transfers, Bio-invasions and Biocultural Diversity: Perspectives from Africa

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Nehru Memorial Museum and Library
2014

NMML Occasional Paper

Published by

Nehru Memorial Museum and Library
Teen Murti House
New Delhi-110011

e-mail : ddnehrumemorial@gmail.com

ISBN : 978-93-83650-55-2

Price Rs. 100/-; US $ 10

Page setting & Printed by : A.D. Print Studio, 1749 B/6, Govind Puri Extn. Kalkaji, New Delhi - 110019. E-mail : studio.adprint@gmail.com

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Plant Transfers, Bio-invasions and Biocultural Diversity: Perspectives from Africa*

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Introduction

This paper talks about the history of prickly pear, an American cactus, in South Africa (Beinart and Wotshela, 2011). Prickly pear was, quintessentially, an unruly plant. The aim here is to generalize from this case and address a central issue in contemporary environmental history and conservation debates. How should we make judgements about, and evaluate, the rapidity of botanical change, plant transfers and the increasing evidence of bio-invasions. How do we balance, biodiversity conservation with a recognition that plant transfers—and species' transfers more generally—have been, and remain, part of dynamic

* Paper presented at a conference titled 'Unruly Environments: Ecologies of agency in the global era' at the Nehru Memorial Museum and Library, 13–14 February, 2014.

production systems that have historically underpinned human civilizations. Transferred plants have created incalculable value and are at the heart of many hybrid botanical and cultural landscapes, sometimes treasured, that are unlikely to be entirely reversed.

A linked set of problems concerns the language and concepts we use to understand such changes. Scientists tend to see unruly exotic plants as aliens, weeds and invaders. Should we seek a more neutral language? The term 'plant transfers' potentially provides a perspective different to the ideas of bio-invasion and ecological imperialism. Our language perhaps reflects our predispositions and influences our analyses: whether we are environmental protectionists and restorationists, or happy hybridists (Keulartz and van der Weele, 2008). This debate also raises questions about the meaning of biodiversity and the newer idea of biocultural diversity. The latter concept has been offered as a route by which certain forms of human agency can be more effectively inserted into the concept of biodiversity protection.

In discussing plant transfers and bio-invasions with respect to Africa, especially South Africa, the author is deliberately including cultivated crops, weeds, and plant invaders within the same frame of analysis because it is difficult to restrict species within these culturally constructed categories. Some examples are maize, prickly pear (*Opuntia ficus-indica*), and black wattle (*Acacia mearnsii*)—each offers a different perspective on the larger processes at work. Prickly pear and black wattle are particularly good plants with which to think about these problems because they crossed continents and they crossed boundaries of culture and race, of useful plant and pest, of crop, weed and invader. The attempt is tentatively to explore and connect different bodies of literature that are seldom adequately integrated and are sometimes at odds in their approach: environmental history; concerns in Africanist social sciences with the primacy of the poor and local knowledge; analysis of biocultural diversity; 'invasion science' (Richardson and Ricciardi 2013); and ecological economics, which has pioneered the increasingly powerful idea

of ecosystem services and their quantification. The latter two literatures tend to emphasise the environmental and economic costs of bio-invasions or plant transfers.

Plant transfers have been central to world history. They have been fundamental in demographic growth, great agrarian complexes, and in the expansion of settlement and empires, especially European empires of the last 500 years.

It is impossible to imagine the contemporary world without an understanding of the scale of plant transfers. In *Ecological Imperialism* (1986), Crosby suggested an asymmetrical plant exchange, both of crops and weeds, from the old world to the new, with Eurasia as the dominant plant power bloc. However, if Africa is considered as part of the old world, the evidence suggests a counter movement or washback between the Americas and Africa (Beinart and Middleton, 2004). Over the last three centuries sub-saharan Africa came to depend increasingly on American domesticates: maize, cassava/manioc, sweet potatoes, some beans and gourds, potatoes, tomatoes, tobacco, peanuts, cocoa, avocado, chili, peppers, agave, guava, pineapple, passion fruit as well as prickly pear.

True, sugar cane, plantains and bananas, tea, mango and citrus, which came from the east, are all major food or plantation crops. And this was not a one way movement: African rice, millet, sorghum, sesame, coffee and some grasses crossed to the Americas (Carney, 2001). But overall, it is almost certainly fair to say that plants of American origin, especially maize, were of greater importance in Africa than plants from the East, and that food plants from the Americas were more important to Africa than African plants to the Americas. Although many American food plants found their way to India, and chili transformed South Asian tastes, they were perhaps less significant in the sub-continent. Africa was a major loser in the Atlantic world as the victim of the slave trade, but gained in important ways from plant transfers that fed into African agriculture, African civilizations and African demographic strength.

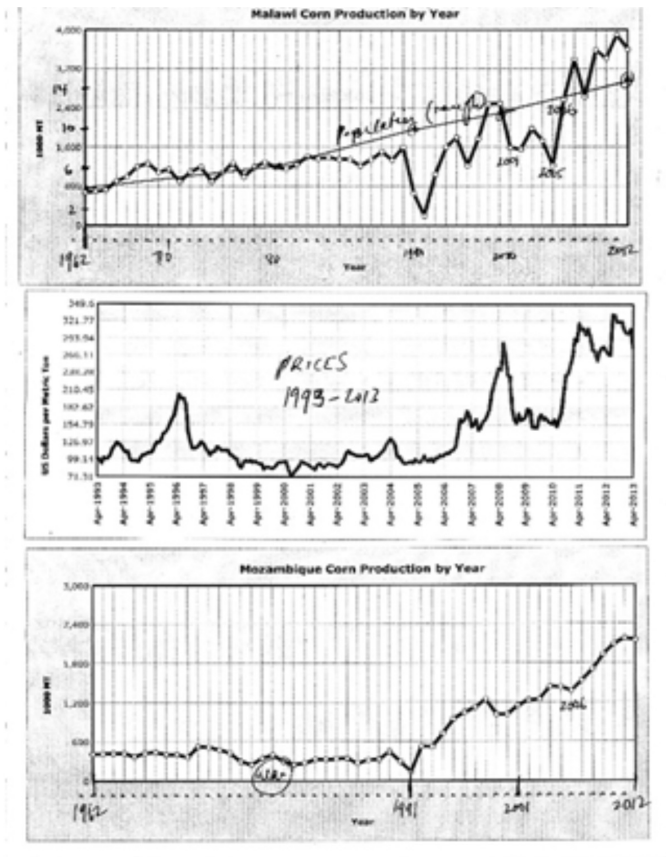
Crosby (1986) cited evidence for asymmetry in weed as well as food plant transfers. Out of about 500 farmland weeds in the United States, roughly 50 per cent were of Eurasian, largely European origin. But South Africa shows exactly the opposite pattern. Of the 47 main Declared Weeds noted in Henderson et al. (1987), at the time that Crosby wrote, 35 or 74 per cent were from the Americas, mostly south and central America. Only one of the nine worst alien invader trees was from Europe. We need to be cautious not only about asymmetrical plant flows, but also about the concept of ecological imperialism in respect of plants. Plant transfers were often related to colonialism but in the case of American plants in Africa both useful plants and weeds could flow without direct colonialism although imperial seaborne transport was central to such movements.

Maize

Maize is not usually categorized amongst bio-invaders but it is important to think about the impact of this plant in relation to indigenous biodiversity. Introduced by Portuguese traders and slavers into Africa soon after it was initially encountered in the Americas, maize had particular value because it served both as a vegetable, after boiling or roasting, and as a grain that could be dried, stored and ground(Miracle, 1966; Crosby, 1972; McCann, 2005). Its covered cob provided protection against voracious birds and some insects. Maize yields in favourable conditions were relatively high, compared to the well-established sorghums and millets and the leaves and stalks were useful fodder.

McCann (2005) illustrates how maize was rapidly inserted into the agricultural repertoire of the Asante kingdom, which became perhaps the largest and most powerful in Africa, from the seventeenth century. The crop spread unevenly, initially slowly in some regions, but relentlessly. Despite its nutritional disadvantages—a lack of protein compared to sorghum or wheat—maize became the major food-crop in Africa during the twentieth century. The area under maize expanded from about 14 to 27 million ha between about 1960 and 2005. Yields have on

an average also increased and the output has more than doubled. Production is highest in South Africa, where, unusually in Africa, the bulk is grown on large commercial farms.



But since around 2006, smallholder maize production has surged in a number of southern African countries. Malawi took the lead through subsidizing 'starter packs' of seed, fertilizer and tools that helped to double output from an average of about 2 million tonnes per year in 1999–2003, and about 1.6 million tonnes in the famine years of 2001–5, to 3.6 million tonnes in 2009–13 (Chirwa and Dorward, 2013; indexmundi). A similar picture emerges from recent figures on Mozambique, Zambia and Tanzania. McCann (2005) estimated that people in Lesotho, Malawi and Zambia consume a higher proportion of maize in their diets, over 50 per cent, than anywhere else in the world. They

also devote a higher proportion of the land to it. Maize seems to many of its growers and consumers prototypically part of African life and culture. The same may be said of external observers: a map of the world typifying continents by their food represented Africa by maize and India by chili, both American plants (Wells, 1993: 8).

Map of the world through characteristic foods

Maize brought in its wake ecological and increasingly agro-ecological disadvantages. It displaced indigenous species where land was cleared. Monocropping gradually displaced mixed fields with beans and pumpkins. Maize cultivation prepares ground for weeds, can quickly exhaust soil and precipitate soil erosion. McCann (2005) argued that maize spread malaria—at least in Ethiopia, where this crop is gradually expanding its frontiers.

It is a matter of chance that maize does not become invasive. The heavy cob and seeds are not easily spread and the kernels are usually cooked or ground before eating. The reproductive

capacity of the seeds is also destroyed when consumed fresh by birds and animals. Seeds of opuntia species, by contrast, generally eaten uncooked in fruit, benefit from the digestive juices of animals. The fact that maize seldom invades land beyond the fields is a massive advantage, ecologically speaking, not generally recognized. But maize cultivation has probably, along with livestock, been one of the major causes of environmental change in Africa. Should we exclude maize from the category bio-invader simply because it is generally controlled by humans and does not spread beyond the fields? A bio-invader is usually defined as spreading through its own strategies of reproduction and survival, rather than human agency, but as we shall see, this is a fuzzy line of distinction. And should we not include humans themselves as bio-invaders—the most powerful bio-invaders of all?

Any environmental critique of maize, however, must be tempered by recognition that it is the preferred food source in many African countries, especially in southern, central and eastern Africa. Its spread has coincided with massive demographic growth in Africa, though it was not the direct cause of this.

Year	**1900**	**1960**	**2000 2011**
Global population 7 billion	1.6 billion	3 billion	6 billion
Africa's population 1 billion	130 million	274 million	800 million
Africa's population as percentage of global population	8%	9%	13% 14.3%

Africans largely welcomed and absorbed many American cultivars. Maize facilitated the slave trade, though it was never central in that era, and became one significant basis for large settler owned commercial farms in southern Africa. But overall American crops and useful plants advantaged African people, helped underpin pre-colonial power in some contexts, and bolstered subsistence, economic growth and demographic strength

in the twentieth century. Maize was not unruly or invasive in a narrowly defined sense, but it was environmentally transformative.

Weeds

What about the bio-invaders that meet the usual definitions more closely and need less human stewardship? Two key South African commentators reflected global literature in arguing:

> Human communities and natural ecosystems worldwide are under siege from a growing number of destructive invasive alien species (including disease organisms, agricultural weeds, and insect pests). These species erode natural capital, compromise ecosystem stability, and threaten economic productivity. The problem is growing in severity and geographic extent as global trade and travel accelerate. (Richardson and van Wilgen, 2005).

It is commonly argued that bio-invasions have an enormous economic as well as ecological impact. Pimentel et al. (2001) extrapolated from calculations for six countries to estimate the annual global toll at approximately $1.4 trillion. This total, popularized through a *Newsweek* article (Margolis, 2007), is reproduced in a number of other sources without critical comment(Keulartz and van der Weele, 2008). The figure, not dissimilar from that estimated for the cost of US bailouts in the first year of the banking crisis, was offered by a key scholar in the field, as part of a densely documented article, but it is conjecture or an educated guess. Much depends on definitions and Pimentel's discussion does not cover the benefits of species transfers.

Based on a conference held in Cape Town by the Global Invasive Species Programme, *The Great Reshuffling* (2001), ed Jeffrey A. McNeely, is unusually broad-ranging in its overall approach, allowing for different emphases in the papers. The editor notes that some species transfers can be beneficial to humans, but accepts that invasive alien species generally are not.

Nevertheless, such species can be 'deeply woven into the fabric of modern life' (McNeely 2001: 7). Weeds, he accepts, are judged culturally and affect people differently. Such analyses complicate understandings of both invasions and costs.

With reference to South Africa, there were many invasives that seemed only to have costs, ecological and economic. American burrweed (*Xanthium spinosum*) was the first to be declared noxious in South Africa in the 1860s—it stuck in the wool of sheep, which was then the country's major export (Beinart, 2003). A recent example is the red water fern, *Azolla filiculoides*, which clogged dams, reservoirs and water systems (Hill, 1999). It has been countered by the American weevil, *Stenopelmus rufinasus,* collected in Florida, released in South Africa in 1997 and then transferred elsewhere on the continent.

But successful invaders could also serve as valuable self-spreaders. Mesquite or prosopis was deliberately introduced in the late nineteenth century as a fodder and shade plant in the driest pastoral districts of South Africa and was still being praised in the mid-twentieth century as 'probably amongst the most important fodder trees introduced into South Africa' (Loock, 1947). The pods have high nutritional value and the seeds, like those of prickly pear, survive ingestion so that livestock themselves spread the plant. Mesquite can also be pollarded to produce a valuable hard wood. But by the 1990s it had spread rampantly in some areas, displacing sparse indigenous vegetation (Hoffman et al. 1999: 143ff). Increasing commitment to biodiversity conservation turned environmentally-minded scientists against it. Although mesquite still had potential value, the costs were perceived to far outweigh any benefits and the conceptualization of environmental loss had changed.

Australian Saltbush (atriplex species) is now classified as a plant invader, but for most of the twentieth century it was semi-cultivated as a fodder for sheep in the semi-arid districts of South Africa (Beinart, 2003). It does not generally invade rapidly

and some farmers still feel that it enhances pastures. Livestock owners in these districts, as well as in the African communal areas, seldom grow significant quantities of fodder. Scientists would not generally consider fields of fodder, such as the protein-rich lucerne, as invasive. Yet in semi-arid areas fodder crops are hugely demanding of water and of course destroy indigenous species where they are planted. Saltbush, if considered a partially self-spreading crop, rather than a bio-invader, is in some respects a less environmentally-damaging plant.

Lantana, ubiquitous in India and Australia as well as South Africa, was probably introduced as a colourful hedging plant (Bhagwat et al. 2012). Lantana has become highly invasive on forest fringes, roadsides and in other spots where it competes effectively with local vegetation. Although its unripe berries are toxic to livestock, they are attractive to birds when ripe and birds in turn spread the plant that sustains them. Many indigenous birds and animals thrived on plant transfers, not least baboons and crows on prickly pear.

Prickly Pear

Opuntia ficus-indica was perhaps the best example of a useful self-spreader in South Africa. Prickly pear was planted but unlike maize, it spread largely through non-human agency. In some contexts, and in the eyes of different people, it could be a crop, a useful weed, or a damaging invader. It had significant economic value in nineteenth and early twentieth-century South Africa and to a lesser extent it still does (Beinart and Wotshela, 2011).

Opuntia species were amongst the earliest plants brought back from the Americas in the sixteenth century. The Spanish conquerors soon knew they were the source of cochineal, the rich red die used by the Aztecs, which became an important export from Mexico and was quickly absorbed into Europe cloth making and painting (Greenfield, 2011). By the eighteenth century opuntia had reached much of the Mediterranean littoral, the Canary Islands, the Cape and India. One species spread in southern

Madagascar from the late eighteenth century (Middleton, 2003), becoming the basis of a cattle economy in the arid south of the island.

Prickly pear, and especially *Opuntia ficus-indica*, the most common useful species, served multiple purposes such as hedging, fodder, food and medicine especially for poor rural communities. Plants were taken by settlers, from Cape Town to Graaff-Reinet, then at the eastern, pastoral margins of the Colony, in the 1760s and they spread with the intensification of white and black livestock farming. While initially transplanted by humans, by the mid-nineteenth century prickly pear was largely spread by birds and animals that ate the succulent fruit, or by torrents along the watercourses. Although the cladodes were too low in nutrients to provide a complete fodder, they were particularly useful in semi-arid districts and in droughts because of their high water content. Thorns were treated by chopping or burning. Livestock were already established in this part of South Africa and this exotic American plant became part of their diet. In the Americas, introduced livestock came to feed on this indigenous species.

Spineless varieties, some probably introduced in the eighteenth century and others imported from breeders in north Africa and California in the early twentieth century, were particularly valuable as a standing drought fodder because they needed no treatment. However, these had to be reproduced by cloning from cladodes. If reproduced from seed, most spineless plants reverted to thorny varieties. This was the general pattern as prickly pear became invasive in the second half of the nineteenth century. By the later decades of the nineteenth century, sweet, wild fruits—abundant in many central and eastern Cape districts—were collected free and widely eaten by people, both black and white. Some were sold to the towns. Prickly pear fruit beer became a favoured beverage for poor black people in districts where the plants thrived. The plant was also used for yeast, syrup and soap. Local knowledge and culture was expanded around an exotic.

Main area of prickly pear invasion in the cape

Untreated prickly pear can damage livestock and thickets can take over the best riverine soil. By the early twentieth century, agricultural officials and commercial farmers investing heavily in sheep for wool production, turned against the plant. In the 1930s, dense stands commanded about 1 million hectares and it was scattered through much of the country; in Australia, an estimated 10 million hectares was densely covered. State-sponsored biological eradication campaigns in both countries used cactoblastis moths and cochineal insects from Latin America to blast thickets away, initially with more success in Australia. In Madagascar, the unofficial introduction of cochineal insects decimated the plants, and the cattle that were dependent on them, causing a famine (Middleton, 2003).

In South Africa, this first major biological eradication campaign proceeded more slowly—and cost a great deal—but by 1980, the main species of prickly pear were reduced by about 90 per cent. The state engaged in prickly pear eradication not primarily to protect indigenous biodiversity, although it was sometimes called conservation, but to serve the economic interests of commercial livestock owners and—in the eyes of officials—the agrarian economy as a whole. Occasionally, some rough

figures were offered as to the costs, or potential future costs, of invasive prickly pear, generally based upon estimates of the costs of clearing it. But this was not systematically done, nor were the losses to poor people calculated. The decisions about eradication were made on the basis of observation, experience and the political clout of key landowners and officials. In fact, the interests around opuntia were complex because spineless varieties had been quite widely planted, and they too were threatened by a generalized biological campaign. Contrary to some arguments then and now (van Wilgen et al. 2001), spineless cactus, and even spiny prickly pear properly treated, might have increased grazing capacity (Beinart and Middleton, 2004).

Although no specific studies were done on how prickly pear displaced indigenous species at the time of the biological campaign, eradication was undoubtedly beneficial to indigenous biodiversity. Equally, it had major costs for poor rural people. Prickly pear is no longer as significant a supplement to the income of poor people. Although the fruit is quite widely eaten and brewed in the limited number of districts where it is still available, usage is declining because collecting and processing it is time-consuming. Tastes—particularly in alcohol—are also changing.

Over the last couple of decades, expert opinion on prickly pear has partly shifted, reflecting political change in South Africa. Brutsch and Zimmermann argued in 1993 that the success of eradication opened the way for new initiatives in utilization. The plants are unlikely to erupt again because they are held in check by cactoblastis and cochineal insects. But all species of opuntia remain 'weeds and invader plants', legally speaking, under the Conservation of Agricultural Resources Act (1983) and it is illegal to handle or spread them. Eradication is still required by landowners. The arguments against opuntia are now based on a new environmentalism that prioritizes biodiversity and water conservation, rather than sheep-farmers' interests. In fact the Act is not enforced but private landowners and the government Working for Water campaign continue to eradicate opuntia.

Shackleton et al. (2007) suggest that local benefits are often underestimated in discussions of the costs of invasive or alien species, where calculations are done in relation to ecosystems at a national or regional level. The value of useful invasive plants such as prickly pear should be given greater weightage when balanced against their environmental costs (Shackleton et al. 2011). In a survey of fruit sellers around Grahamstown, they confirmed that prickly pear provided supplementary income, especially in poorer households that had no wage earners, even though this was not usually the preferred way of earning income. The supply of fruit is an added benefit; in one village surveyed, few were sold but domestic consumption was high. These distributional questions should be taken into account in assessing the costs and benefits of exotics.

Prickly pear penetrated rural lives and remains part of local economy and folklore. Historically, at least, we could compare its cultural significance to that of vineyards in the western Cape. The comparison gains greater strength if, as in the case of maize, the concept of invasiveness is expanded to cover crops. Opuntia migrated globally, and has generally played a similar role as food for the poor and fodder for their animals. The Palestinian term for the fruit, Sabra, was adopted by Israelis for early Jewish

settlers, conceived as prickly on the outside but sweet on the inside. It is said that you could long identify the old, pre-1948 Palestinian settlements by the remnants of prickly pear hedges. Opuntia have long been important in the semi-arid parts of north-east Africa, particularly in Ethiopia and Eritrea. In Eritrea, expatriates were called beles, after the fruit, because they returned in the summer when it was widely harvested and sold.

Black wattle

Black wattle (*Acacia mearnsii*) was introduced to Natal from Australia for tanning and timber in the nineteenth century (Sherry 1971; Carruthers and Robin, 2010; Bennet, 2011). Grown in commercial plantations and government woodlots in African areas, foresters specifically encouraged its use as firewood and building poles to protect indigenous trees. Black wattle was so successful that plantations peaked at over 250,000 ha in the 1950s and 1960s and South Africa exported wattle bark for tanning back to Australia. Its value as a commercial product was enhanced by dual use: bark for tanning and the trunks for poles. In recent decades, the tree has been used increasingly for wood chip and paper manufacturing (Griffin, 2011).

African smallholders on communal lands planted black wattle around their homesteads as a quick-growing source of timber, fuel and shade in higher rainfall districts east of the Drakensberg. It was resistant to fire, could be pollarded, and also spread itself, diminishing the need for systematic planting. Black wattle was at one time ubiquitous as a household agroforestry crop in parts of the eastern Cape, KwaZulu-Natal and Mpumalanga. No calculation has been made of the scale of smallholder tree stocks but by the end of the twentieth century plantations covered about 130,000 ha and an estimated 2.5 million ha had been partially invaded (de Wit et al. 2001). Black wattle is interesting for the same reasons as prickly pear—it creates havoc around our categories and is, in the words of scientists, a 'conflict of interest' species. It has attracted academic analysis in South Africa and is one of the few species for which a systematic cost benefit analysis has been attempted.

Black wattle around Transkeian homestead

de Wit et al. (2001) argue that black wattle has overwhelming economic and environmental costs which manifest themselves in significant negative impacts on water resources, biodiversity, and the stability and integrity of riparian ecosystems.

Annual Costs (de Wit et al, 2001)	**Annual Benefits**
Decline in water supply $1.4 billion US dollars	Plantation production $363 million
	Building Materials and other use $21 million
	Firewood $143 million
Total: $1.4 billion + ecological costs of loss of displaced species	**Total: $527 million**

They calculated the economic value of water flow lost to black wattle in Kwazulu-Natal at $1.4 billion a year. The focus on costing water loss was related to South Africa's Working for Water programme, a major and innovative public works campaign,

supported by ecological and economic arguments, to eradicate invasive species. The ANC government was open to these arguments partly because Working for Water provided employment for poor people. de Wit et al. (2001) were aware of the importance of black wattle not only for plantation production but for rural households. They conducted household surveys and assigned quite generous values to economic benefits in construction of rural dwellings, for which poles were used as a framework, and especially to the value of firewood. But they still emerged with costs that far outweighed the benefits. The calculation seems to justify eradication. Cost-benefit analysis is not the only approach to biodiversity protection but let us pursue this logic. Although these authors set new standards in environmental cost-benefit analysis in South Africa, there are potential problems with this calculation.

Ecosystem services calculations, which have become increasingly important in contemporary biodiversity debates, force attention on economic as well as ecological losses. They enable conservationists to debate on potentially equal terms with hard-headed global policy makers. But in this case, firstly, de Wit et al. tend to make the assumption that the provision of ecosystem services is dependent only on indigenous vegetation. Secondly, it seems that the sum assigned to water assumes that it is fully commodified and costed as if it was all used in a reticulated commercial system downstream. Thirdly, they do not allow for water absorption by the indigenous vegetation that would (in the best scenario) have replaced black wattle. In sum, the value of water lost may have been considerably less.

The value of wattle to rural households at the time was extrapolated from a survey. The population of KwaZulu-Natal province in 2001 was 9.4 million with about 46 per cent counted as urban—roughly 5 million rural people or say 800,000 households. We have no idea how many used black wattle for hut frameworks at the time and it was not the only species used for building. But I suspect the figure of $21 million is an underestimate because it does not fully take into account the costs

of purchasing such timber elsewhere, or replacing it with other materials such as concrete blocks. Moreover, timber cropped up everywhere in fences, hurdles, sledges and grain containers. In respect of firewood, we should consider that if African women had to rely on less convenient sources, they would have to walk and carry loads further. The value of women's labour is not included in the calculation of the costs that might be incurred to rural households if black wattle was eradicated. At the South African minimum wage of R4,50 in 2001, two four-hour firewood journeys per week would have cost R36 per household in labour per week or around US$250 million for KwaZulu-Natal. Alternatively, the expense of alternative fuel sources would have to be taken into account. Rethinking the nature of costs and benefits in this way evens up the balance.

There are a number of additional elements that could be brought into the equation. Black wattle is good firewood, but in its live state it is also resistant to fire that periodically sweeps the communal grazing lands in the dry winters. The advantage of such semi-invasives to poor rural people who are often strapped for time was that they needed little cultivation. Black wattle spread on the commonages and thus even families without household tree-stocks could gain access to firewood. Black wattle trees are, in a sense, efficient plants, and this helps to explain why they, alongside some species of eucalyptus and pine, were planted and used by poor people in these rural districts where landholding is still largely communal.

Moreover, if Australian acacias and eucalyptus had not been available there may have been (as the early twentieth-century foresters feared) an even greater impact on South Africa's limited but highly diverse indigenous forest resources. So black wattle has displaced some indigenous vegetation around water courses and inhabited areas but potentially saved some indigenous forests. And how should we assign an aesthetic value of the more traditionalist villages with their dispersed thatched huts built with timber frames? (Unfortunately my perception of beauty is not shared by most rural African people who are moving away from these building styles.)

As in the case of prickly pear, careful attention should be paid to distributional issues. Black wattle may reduce water supplies as a whole. But who would benefit from the water saved by their eradication? The calculation above considers this largely from the vantage point of downstream urban and industrial needs. These are certainly important in a country where the majority of people, including black people, live in cities, towns, and dense settlements. Yet the upstream rural communities in KwaZulu-Natal, Eastern Cape and Mpumalanga are amongst the poorest. It is possible to conceptualize black wattle and other usable plants as storing water for them. Water resources are a national issue but as in the case of prickly pear, eradication would impact most on the poor.

Costs and Benefits of Black Wattle recalculated

Costs	**Benefits**
Decline in water supply – somewhat less than $1.4 billion US dollars	Plantation production $363 million
	Building Materials and other use $200 million
	Firewood $143 million
Total: About $1 billion + ecological costs of loss of displaced species	Women's labour $250 million
	Total: About $1 billion + ecological benefit of saving indigenous forest + value of semitraditional cultural landscape + medicinal value + welfare costs for loss of resources to poor

Research over the last decade at the village level confirms the value of black wattle to rural communities. An evaluation by

de Neergaard et al. (2005) of black wattle eradication in the Working for Water programme in KwaZulu-Natal noted that

> Whilst the programme provides an income to thousands of families in rural areas, it may also be jeopardising the livelihoods of the same communities. The wattle is an important resource for village households; virtually all households used it as their primary heat source and for building materials. Other uses included medicine extraction and 20% of the interviewed households gained income from selling firewood.

Additionally Aitken, Rangan and Kull (2009) note the importance of small-scale charcoal production from alien acacias in Mpumalanga.

Shackleton et al. (2007), interviewing in an Eastern Cape African village, heard both positive and more negative responses: people tended to see black wattle as more invasive than prickly pear and some understood it to be alien whereas most saw prickly pear as local. Nearly all of those interviewed used it for firewood and building and about 60 per cent preferred it for these purposes. The other 40 per cent would have used indigenous, often harder, wood that burnt more slowly and lasted longer, but access was difficult. Some saw invasive thickets as a cost, both because they diminished pastureland and provided a haven for vagrants. Yet the majority of local African people did not regard it as a pest. Merron (2010:84) argues that white landowners around the Baviaanskloof World Heritage Site were more hostile to invasive black wattle but found the costs of eradication too high without government assistance. They did not consider Working for Water successful in the control of aliens; it was 'just providing jobs'.

Indigeneity and Biodiversity

Literature on ecosystems services tends to conjure very high values for indigenous ecosystems. This is an inventive and important intervention in a world of limited resources and in the face of global forces that prioritize exploitation of nature. The

argument is not against such calculations nor one against environmental regulation and protection. Such calculations are actually potentially exciting in rethinking environmental and economic history. Did the ubiquitous indigenous *Acacia karoo*, which was valuable in holding soil along stream banks, as well as for goat fodder and firewood, provide more wealth to South Africa over the long term than diamonds? This plant could also become invasive but the process is generally described as bush encroachment and not invasion because it is indigenous. If, as suggested above, ecosystem services can be provided by exotics, could we argue that prickly pear was as valuable as some indigenous species (and more valuable than diamonds)? In addition to all its value for people, the plant was also used to control soil erosion. But it is being suggested that quantification should be used carefully, and the distribution of cost and benefit highlighted, especially where arguments are deployed to restrict usage by poor people who rely on the alien species.

The concept of biodiversity protection is central to discussions about ecosystem services. The author's limited acquaintance with the literature suggests that analysis of biodiversity focuses largely on relatively undisturbed environments. In preparation for the International Year of Biodiversity (2010) Pavan Sukhdev, lead author of 'The Economics of Ecosystems and Biodiversity' (TEEB) project, argued in *Nature* (2009) that ecosystem services are most beneficial to poor people—especially in relation to their access to public or common goods. Bio-invasions were at the heart of his discussion of degradation and environmental costs. He seemed to work with a rather purist or nativist concept of biodiversity—a world of value without plant transfers. The UNEP report, *Dead Planet Living Planet* (Nelleman, 2010) seems also to focus on the value of indigenous biodiversity. These arguments are echoed in the South African context. In *Diversity and Distributions* (Van Wilgen et al., 2011), 'make the link between environmental protection and the well-being of poor people, who rely more heavily on ecosystem services and who often bear the brunt of the impacts brought about by invasive alien species.' However,

we cannot assume that historically speaking poor people favoured indigenous plants or derived more value from them. This is almost certainly not the case for most African communities and our research on prickly pear suggested that they may not share the same concept of indigenous species as scientists.

The cases taken up in this paper may be unusual on a global scale, although casual observation in recent trips to Kenya suggest that the densely settled slopes of Mt Kenya are also covered with useful aliens and the street nurseries of Nairobi are dispersing a wide range of exotics. Clearly plant transfers can be damaging to indigenous biodiversity, even if they become part of a well-managed environment. But Michael Soule (1990: 235) argued some years ago that 'a policy of blanket opposition to exotics will become more expensive, more irrational, and finally counterproductive as the trickle becomes a flood. Only the most offensive exotics will be eliminated in the future'. He spoke as a dedicated but pragmatic conservation biologist and suggested that they would increasingly have to study recombinant, or hybrid, ecology with reference to much of the world.

Few take the extreme position that as all biomes are subject to continuous natural changes over the long term, and as all environments are inevitably shaped by humans, we should simply live with what we have—prioritizing human requirements. But nativist or purist concepts of biodiversity have limited spatial applicability, often lack a historical dimension and fail to cater for the actual diversity of plant species in most inhabited regions of the world. One recent calculation suggests only 25 per cent of the 'terrestrial biosphere' remained wild in 2000—and even this may depend on a generous definition of wild (Ellis, et al. 2010). There may be little choice but to 'concentrate on managing and co-existing with exotics and controlling the worst cases of invasiveness' (Soule, 1990). South Africa has over 7,000 introduced species. Much of Britain is irredeemably hybrid.

Variations on this more pragmatic position are increasingly articulated by scientists. Bhagwat et al. (2012) suggest that 'our

long-term view of Lantana invasion across three continents suggests that the future management of invasive species will require an adaptive management approach to their invasion. Policymakers will need to find innovative and diverse approaches to such adaptive management whilst being prepared to embrace the novel ecosystems that invasive species create'.

Such an approach has implications for concepts of biodiversity. In *The Great Reshuffling* (2001), Parker argued that continental, if not local, landscapes can absorb new species without losing the old, and in that sense exotic or alien plants can increase biodiversity. Thomas (2013) asserts in *Nature* that 'the response of people who find themselves "invaded" by such "displaced" species is often irrational. Deliberate persecution of the new—just because it is new—is no longer sustainable in a world of rapid global change'. This is a strange article, written emphatically, with little discussion of well-established literature that his arguments cut across. Scientific work sometimes lacks such discursive strategies of presentation. He also argues that new species can increase ecological diversity. Farmlands and cities, for example, provide new habitats suitable for exotics and can increase the number of species in a region; some alien plants become native or hybridize.

Our approach to biodiversity in the book on *Prickly Pear* (Beinart and Wotshela, 2011) raises similar issues. Do we need to redefine the term so that it fully covers the hybrid environments that characterize most of the settled parts of the world? In many respects these rather relativist ideas about biodiversity run parallel with earlier, typically Africanist or subaltern arguments that put people first, prioritize the interests of the poor and tend to be critical of exclusive conservation strategies (Guyer and Richards, 1996). It is important to qualify such approaches. Firstly, it has been argued in recent papers that Africanists should reconsider their generally very critical gaze at science and conservation (Beinart, Brown and Gilfoyle, 2009). Secondly, we need to keep in mind the big picture of massive destruction to indigenous nature on a global scale. What are the limits to pragmatism?

Thirdly, while they recognize to some degree the need for a practical approach, Richardson and Ricciardi (2013) argue that non-native species are much more likely to have deleterious ecological impacts and cause extinctions. In their passionate defence of invasion sciences, they marshall evidence to support this well-established point and confirm the likelihood that bio-invasions will cause 'lethal stressors on biodiversity'. Fourthly, we need to think like historians about the very recent past and future as well as the more distant past. The use of plants in rural society is not static.

Barbed wire is replacing plants for hedging (Beinart and Wotshela, 2011), especially in denser, peri-urban settlements and even in rural areas. Rural electrification over the last couple of decades is gradually changing the demand for fuel. de Wit et al. (2001) suggested that electrification, as an alternative to firewood, would remove the need for invasive, thirsty Australian trees, and was thus potentially the route to conserving water. While the cost of electrical goods remains a major barrier to the diverse use of electricity, slowly rising incomes and shifting ideas of modernity in the rural areas are opening the way for new power sources. Similarly, building materials are changing. The wattle and daub circular, thatched hut, or rondavel, ubiquitous for a century (but not before), for which most materials could be sourced locally, is fading. Even in traditionalist rural villages, an increasing proportion of structures are rectangular and built with materials such as mud or TATU (soil-cement) bricks, concrete blocks, and corrugated metal roofs (Fay, 2011 and personal observation).

van Wilgen suggests that black wattle may now be spreading more rapidly because of the decline in harvesting and that in those areas where it is well-established, it reproduces more quickly than it can be used. The plant is particularly difficult to eradicate because its seeds remain fertile in the ground for long periods. With respect to prickly pear, relatively successful biological eradication from the 1930s to 1980s diminished accessibility in many rural districts. This, together with commodification of rural lifestyles, has diminished use of this all-purpose plant. Although

the fruit is still very popular in parts of the country, and beer is still brewed, it is no longer central to poor rural communities. Processing is labour-intensive and fewer people make beer, jam and syrup. Manufactured alcohol is widely available and, driven in part by advertising, reshaping consumption even for the rural and small town poor.

The dynamics of change are probably shifting the balance of costs and benefits. Fifty, even as recent as twenty years ago the arguments for protecting access by poor people to ready supplies of these alien plants were probably overwhelming. However, the economic advantages of particular plants can diminish (or increase) because of changes in usage and technology. It is very difficult to follow such moving targets in cost-benefit analysis, especially when the information being inputted is so imperfect: no one really knows how many households overall use prickly pear and black wattle, or how much water would be saved if they were replaced by indigenous vegetation. Such a calculation would also have to take into account reports of bush encroachment by indigenous species in many parts of South Africa—another moving target that would also require estimates of water consumption for a number of different species. Bush encroachment in some areas may be caused by changing land use such as game-farming and the decline in smallholder cultivation of arable fields; the area of maize is retracting rather than expanding in the former homelands. Elsewhere, climate change may favour bush as against grass (Bond, 2014). Moreover, as long as the costs of eradication are disproportionately borne by poor people, the arguments against it must surely be strong. Eradication can be expensive, long-term and often very difficult; this was not included in the cost-benefit analysis undertaken for black wattle by de Wit et al. (2001)

Technologies of eradication, however, have been refined by deployment of biological strategies. Perhaps 106 agents, mainly insects, have been introduced into South Africa over the last century (Hoffman, 2014a). They can be much cheaper and more effective than mechanical or chemical strategies, but they imply

total eradication. In the case of prickly pear, biological controls were fairly successful, although they required extensive mechanical backup and had less impact on some of the most troublesome (non-useful) opuntia species, such as jointed cactus (*O. aurantiaca*). Key experts in this field have long seen the position of *O. ficus-indica* as stable with dense thickets restricted to a few small zones in coastal districts of the Eastern Cape and overall incidence down to perhaps 10 per cent of its height (Brutsch and Zimmerman, 1993). By chance rather than intention, enough fruit is available for some usage and distribution. The option of planting cultivated varieties of spineless cactus remains although these have to be carefully protected against the introduced insects.

Biological control of Australian acacias may also provide a partial solution to the complex conflicts of interest around the plant. Plantation owners and rural communities do not want established trees wiped out, if that were indeed a possibility. But selective biological strategies that control seed reproduction might offer a compromise. Five species of seed-eating weevils had been introduced to South Africa by 2011 (van Wilgen et al. 2011) with limited impact. Most promising has been *Dasineura rubiformis*, an Australian midge or gall fly that attacks flowers and stops the formation of seeds. This has been distributed to numerous sites in the provinces where black wattle and other Australian acacias are most invasive—Kwa Zulu-Natal, the Western Cape and the Eastern Cape(Hoffman, 2014b). Bio-control of seeding could stop new invasions without harming existing trees.

Biological strategies involve the transfer of insect species, but protagonists argue that testing is sufficiently sophisticated to render risks minimal.While potential for bio-control of invaders is exciting, success is unpredictable and research has tended to concentrate on a relatively limited range of species. An interesting question from the perspective of this discussion is whether transfer of alien insects on this scale represents an addition or diminution to biodiversity.

Human interventions, based largely on perceptions of the economic cost of plant transfers, have begun to shift rates of invasion. Perceptions of aesthetic value also change. Peter Coates's *Strangers on the Land* (2006), dealing largely with the United States, is replete with such examples. In South Africa the American jacaranda was planted along city streets and valued for its shade and flowers. Pretoria was called jacaranda city. Now the tree is cited as an invader because it can spread along sensitive water courses. Some environmentalists are even turning against the European oaks in Stellenbosch, grown since the seventeenth century. The Western Cape's extraordinary fynbos, a uniquely diverse biome, has been massively damaged by agriculture, urban development and invasives (particularly pines, Australian acacias and eucalypts), and is rightly being championed. Comaroff and Comaroff (2001) have seen an analogy between moral panics about alien people and alien plants in the rapidly changing context of post-apartheid South Africa, sparked by a serious urban fire in Cape Town in 2000. But the major dynamic in favour of fynbos has probably been a longer term rise of ecological and conservationist thinking and a slowly growing appreciation of indigenous vegetation. Ecotourism is another vehicle for celebrating indigenous plants, which are promoted through botanical gardens such as the much-visited Kirstenbosch, and consciously connected to Western Cape history and identity.

Biodiversity and Biocultural diversity

How do we think our way out of these dilemmas and in particular how should we think about plants that some see as unruly, out of place, environmentally destructive and costly? Coates (2006: 152–5) has charted some of cultural and historical debates about nativism in the US. Aside from demonstrating the historical fluidity of ideas, he suggests that we move beyond the loaded, emotive, sometimes anthropomorphic and militaristic words that scientists have come up with for plant transfers: invader, bioinvasion, alien, colonizer, and pest. Kull and Rangan (2008) also argue against introducing moral elements into the debate. Defenders of more hybrid or pragmatic positions are reluctant to see all botanical change as degradation and deploy

terms such as multi-horticulturalist or write of cosmopolitan, recombinant, hybrid or novel ecologies and ecosystems.

It would also be valuable to clarify the different understandings of biodiversity that seem to be emerging. Biodiversity is a relatively new term, which gained traction in the 1980s and has since become ubiquitous in scientific and popular language. In certain respects it is a quantitative concept that includes measures of a different ecological characteristics: the number of plant species in a specific area, the number of all species, the abundance of each species, the number of indigenous species, and the number of endemic species. Increasingly it seems to be used in a totalizing way to include overall genetic and molecular diversity—although it is difficult to understand the implications of this shift. The concept also seems to include implicit qualitative ideas such as concerns about extinction and about indigeneity. Critically, the question arises as to which are the most important measures and qualitative elements. Nativist approaches are suspected to be overwhelmingly dominant in scientific circles, privilege the indigenous and endemic. Pragmatic or hybridist approaches might be more interested in the overall number of species or new opportunities for endangered species. We heard at the conference on Unruly Environments (Delhi, 2014), for example, of tigers adapting to the ecology of Australian wattle thickets in India because they provided shelter for small mammals. Some gorillas in Africa have taken a liking to eucalyptus gum. Issues of scale are also important in this debate. Alien plants and invasives can diminish the number of species at a local level where they come to dominate, while increasing it at a regional or continental level.

So much of the debate concerns threats to, and declines in, biodiversity, that it seems important to establish which version of the concept is being deployed. As a corollary, calculations of ecosystem services can be affected by the value, or otherwise, assigned to transferred plants. More flexible approaches to analysing biodiversity recognize the scale of species transfers, particularly in the densely settled and agrarian areas that occupy so much of the world's surface. Academic fields such as crop

ecology and agroecology (the latter usually more concerned with mixed smallholdings) have certainly opened up investigation of hybrid agrarian environments. We need to have concepts that enable the study (and evaluation) of all plant ensembles and environments: from rich, relatively pristine, tropical forests and fynbos, to the hybrid diversity of smallholdings and gardens, to more restricted zones such as maize fields, prickly pear thickets, and streams invaded by black wattle. The term cultural landscape is often used to talk about settled areas, but tends to refer to managed, even manicured, environments that include buildings and gardens, rather than the more ragged unruly landscapes characteristic of many urban and agrarian contexts.

Can the concepts of biodiversity and bio-invasions also fully include the human role? Biologically, humans have been one of the most successful mammals, spreading relentlessly from their initial east African core—a truly invasive species. Compared to other species they also have a deeper environmental bootprint. Scientific approaches to biodiversity find it difficult to include these central issues, because they inevitably require economic, social and cultural analysis of human environmental impacts. But following Guyer and Richards (1996), writing from a typically Africanist perspective, it seems essential to introduce a social and cultural dimension into debates about biodiversity.

The concept of biocultural diversity may be useful to get at some of these complexities. It was possibly used first in the early 1990s by Darrel Posey (1999) in connection with Latin America. An ethno-entomologist and an activist for indigenous people, his intention was to capture the 'inextricable link between biological and cultural diversity'. His motive was to champion indigenous knowledge and to argue that in key parts of the world, such as the Amazon, biodiversity could only be conserved if indigenous people were protected because of their knowledge, their skills, and their long historical experience of living in some kind of balance with nature. Protecting cultural diversity would be the surest way of conserving biodiversity.

The idea was further developed in attempts to map biocultural diversity on a global scale; language was used as the main proxy for culture (Maffi 2001). Loh and Harmon (2005) tried to quantify zones of high indigenous natural and linguistic biocultural diversity. These included the Amazon, central Africa from Nigeria to Tanzania, and Southeast Asia/Papua New Guinea. They pointed to areas of highly diverse indigenous cultures as the heartlands of global biodiversity. This wave of scholarship attempted to demonstrate that biological and cultural diversity often coincided, and were strongly interlinked, possibly even constitutive of each other, although it could find no clear causal connection. Protagonists see such indexes of biocultural diversity as having both theoretical value and practical implications for guiding strategic priorities in the conservation of biocultural diversity.

Reviewing the literature, Michelle Cocks (2006) suggested that the term has largely been applied to 'indigenous, traditional' people and to positive linkages between cultural diversity and biodiversity. She argues that it should be adapted further to apply more generally, so that it can cater for rapid social change and a more fluid idea of culture. Her case studies, however, still largely cover the changing use of indigenous plants in South Africa, showing both their centrality in rural African cultural life and their significance in a more commodified context—for example, as part of a commercial trade in medicinal plants.

For historians there are deeper problems with the concept of biocultural diversity as it is generally deployed. For example, one study (Gorenflo et al. 2012) suggests that the Western Cape and Western Australia, though high in plant diversity, evince low cultural diversity, with only a few languages. This tentative attempt at mapping (as in the case of others) is a historical and has discounted the diversity of languages before colonization. Any discussion of a relationship between biodiversity and cultural diversity, even a coincidence between them, needs to be deeply historical because the making or protection of biodiversity is a very long term process. Such approaches also underestimate the diversity of languages and culture in the present; there are

certainly more than three languages spoken in Cape Town. The use of language as a proxy for cultural diversity also breaks down with respect to recent historical periods or the present. To say that all Brazilians who speak Portuguese are members of a single cultural group, particularly with respect to their environmental impact and conservationist tendencies is unconvincing and highly problematic at the empirical level. And the evidence from Africa suggests that we cannot assume that all poor rural people, even if they do speak diverse languages, prefer indigenous plants or instinctively conserve their local environments.

Biocultural diversity is a valuable idea for campaigning precisely because it privileges protection of the indigenous, whether culture or nature. But this version of biocultural diversity fails to deal adequately with cultural as well as environmental change and hybridity; in other words, it cannot effectively incorporate most of the world's societies and environments. For biocultural diversity to work as a more general concept, it should include a far more fluid notion of culture and a capacity to cater for historical and environmental change. It would need to include more flexible ideas about human use of plants—the whole range of plants that are valued, tolerated or rejected by people, as well as those that intrude themselves, whether exotic or indigenous. We need an idea in which the reproductive and survival strategies of natural species, such as invasive plants, can also be recognized in interaction with human agency and culture. (The author is not arguing for plant agency, or at least the meaning of the word in this context should be differentiated from human agency.)

Such an approach to biocultural diversity, which implicitly accepts—and perhaps legitimizes—hybrid ecologies, does not necessarily get us off the hook concerning the protection of indigenous biodiversity. It is vital to recognize distinctive biomes, characteristic of different areas, many under threat. We should not jettison a concept of environmental degradation nor diminish the problem of indigenous biodiversity loss. My approach therefore implies a strong argument for spatial differentiation and managed protected spaces. Cultural landscapes should also be

acknowledged for their beauty and value—as recognized in world heritage sites—including their exotic vegetation.

Loh and Harmon (2005: 231–2) write:

> Biocultural diversity may be thought of as the sum total of the world's differences, no matter what their origin. It includes biological diversity at all its levels, from genes to populations to species to ecosystems; cultural diversity in all its manifestations (including linguistic diversity), ranging from individual ideas to entire cultures; and, importantly, the interactions among all of these.

This is an extraordinarily ambitious agenda, but it is not quite what they try to do in their article. The author's argument is analogous and also essentially a totalizing approach to environmental history. Perhaps a single concept such as biocultural diversity cannot carry all of this freight and will effectively lose any incisiveness if it becomes too all-embracing.

One alternative is a more descriptive environmental history that attempts to map the complexity of change and to evaluate it both in social and environmental terms. This could provide space for analysing the value of plant transfers, as well as understanding why some plants are seen to become invasive and unruly, and why perceptions about this process change. Scientists, especially those specializing in ecology and bio-invasions, often feel strongly about this issue and have been successful in influencing popular discourse as well as policy. While Richardson and Ricciardi (2013) make a scientific and economic defence of the dangers of bio-invasion, Larson (2007) feels that scientists in this field should have the courage of their convictions, advocate 'socially engaged research' and be open about their commitment to eradication. He advocates a moral and political approach to biodiversity, just as Darryl Posey and others were protagonists of a political approach to biocultural diversity.

It is valuable that scientists recognize the instability of concepts such as biodiversity, their significance as political ideas and the scope for disagreement about what they mean. As noted above an entirely relativist or human-centred approach and acceptance of the enormous value of conservationist strategies is not being advocated here. The concern is to develop a workable concept of biodiversity that can be applied to hybrid environments, as well more complex approaches to valuing the vegetation that characterizes them. This could perhaps be contained in an expanded idea of bio-cultural diversity—although it will be very difficult to pin this down as a researchable idea. A looser, totalizing approach rooted in environmental history is perhaps more comfortable for historians, who will also disagree amongst themselves about the balance between human priorities and those of environmental and biodiversity conservation.

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