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Aboriginal Translocations: The Intentional Propagation and Dispersal of Plants in Aboriginal Australia

J. L. Silcock[1]

Abstract. The prevalence and imperative of translocations for the conservation of plant species is increasing in response to habitat loss and degradation, plant diseases, and projected climate change. However, the intentional movement and nurture of plant species to increase their range and/or abundance has been practiced for millennia, encompassing species with food, medicinal, narcotic, and ceremonial values. While it is well documented that Australian Aboriginal people altered the composition and structure of vegetation communities through regular burning and engaged in complex food processing and storage, the extent to which they intentionally dispersed and propagated plants remains unclear. Here, I review the ethnographic, archaeological, biogeographic, and phylogenetic record relating to plant translocations in Aboriginal Australia. With the exception of re-planting of tubers after harvesting, the ethnographic record is characterized by sparse but detailed accounts of movement, planting, and/or nurture of important species, often involving ceremonial elements. Translocations encompassed assisted migrations, introductions and reinforcements, and spanned much of the continent and numerous life-forms and plant uses. The ethnographic record is fragmentary and often difficult to verify, and we will never know the full extent and nature of plant translocations in Aboriginal Australia. However, combined with biogeographic and, increasingly, phylogenetic insights, there is sufficient evidence to place modern translocations in a much older context of human-plant interactions. This allows for broader and more nuanced discussion around the practice and ethics of translocations, particularly in the context of assisted migrations in response to climate change, as well as re-evaluation of "natural" plant distributions in Australia.

Keywords: plant translocations, Indigenous, propagation, biogeography, Australia

Introduction

Plant translocation is defined as the intentional movement of material with the aim of increasing a species' geographic range and/or population size, and includes both augmentation of existing populations and establishment of new ones. It is a rapidly expanding field of conservation biology in response to the limits of in situ conservation for species that survive as much-reduced populations in highly fragmented and modified environments (Dalrymple et al. 2012; Godefroid et al. 2011). The importance of translocations will continue to grow in the face of continued habitat loss and degradation, disease, and projected climate change (Hancock and Gallagher 2014; Webber et al. 2011).

However, translocation of plants deemed important or valuable by societies is not a new phenomenon (Ford 1981; McNiven 2008). There are many examples globally of plant propagation either preceding or independent of, and not necessarily leading to, agriculture (Anderson 2005; Deur and Turner 2005; Hastorf 1998; Smith 2011). Numerous contemporary plant distributions spanning diverse environments are attributed to human nurture and transport over millennia (Balee 1989; Cowan and Smith 1993; Denevan 1992; Gremillion 1997; Shipek 1989; Watson and Kennedy 1991; Wickens 1982). These include not only important food plants but also those with medicinal, culinary, or narcotic properties and/or cultural and

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ceremonial meaning (Farrington and Urry 1985; Hammett 1997; Scarry and Steponaitis 1997).

Recent books concerning Aboriginal resource management and environmental impacts in Australia have been met with broad interest and stimulated debate beyond academic spheres (Gammage 2011; Pascoe 2014). It is well-documented that Aboriginal people altered the abundance of species through regular burning over millennia (Atchison 2009; Jones 1969; Yibarbuk et al. 2001). There is also evidence of extensive processing, storage of surplus grain, and irrigation (Allen 1974; Ashwin 1932; Harris 1984), including two regions that Gerritsen (2008) identifies as being engaged in "incipient agriculture" at the time of British colonization. However, the extent to which people intentionally dispersed and cultivated plants and, in doing so, increased the range and abundance of certain species, thus changing vegetation community composition, remains subject to debate.

Here I review the archaeological, ethnographic, biogeographic, and phylogenetic record relating to Aboriginal plant translocations. Specifically, I ask three questions: (1) Were plant propagules deliberately moved and planted and what type of translocations were practiced; (2) What types of plants were involved, in which regions, and for what purpose; and (3) What impact has this had on contemporary plant distributions? This review illuminates a poorly-documented aspect of Aboriginal plant management with implications for the ecological and ethical framework of modern translocation science, particularly assisted migrations in response to climate change, and our conception of "natural" species distributions in Australia.

Methods

Ethnographic sources, including explorer journals (spanning most of the nineteenth century), accounts of early European settlers, anthropological works, peer-reviewed articles, books, and monographs, were searched for references to deliberate Aboriginal transport and planting of propagules. In areas where traditional land management practices survive to various degrees, contemporary ethnographic evidence, as published in journal articles or through interviews with people working in these communities, was drawn upon. Species and types of plants that are known to be important in certain regions were searched for on the Web of Science and National Library of Australia "Trove" databases for references to deliberate manipulation of their distributions. The sources consulted were drawn as widely as possible from across the continent, but are unlikely to be comprehensive. For each translocation documented, information about location, plant life-form, uses/significance of the plant, type of translocation, evidence type, and reliability was collated (Table 1).

In this paper, I define translocation as the deliberate planting and nurture of plant propagules (including entire plants, vegetative parts, cuttings, and seeds) and follow the World Conservation Union Guidelines (IUCN 2013) to define four types of translocations: assisted migration, introduction, reintroduction, and reinforcement (Table 1). In situ nurture and protection of certain species, such as back-burning around stands of important trees and shrubs (Vigilante and Bowman 2004; Walsh 1990, 2008), protection of seedlings (Hynes and Chase 1982), and creation of favorable habitats for certain species through soil enhancement or irrigation (Barber and Jackson 2014; Veth and Walsh 1988), were not included unless they were part of deliberate planting. In some cases, in situ nurture occurred alongside translocations and this was noted. Incidental movements of plants with no evidence of translocation intent were not included. Six species mentioned in an ecological paper as having been potentially introduced to the Simpson Desert by Aboriginal people, but with no

Table 1. Information collated for each plant translocation documented by Aboriginal Australians.

Field	Description
Species	Scientific and common name; nomenclature follows the Australian Virtual Herbarium[1]
Biogeographic region	As per Thackway and Cresswell (1995)
Location	Coordinates in decimal degrees, where record related to a specific and identifiable locality
Lifeform	Tree, shrub, perennial herb (including tubers), annual herb, perennial grass, annual grass
Uses/significance	Food, materials, stimulant, ceremonial, unknown
Type of translocation	"Assisted migration" refers to movement of a species outside its apparent indigenous range; "Introduction" refers to the establishment of new populations within the range of the species; "Reintroduction" is the establishment of a population at a site where it formerly occurred; and "Reinforcement" is the planting of propagules into an existing population with the aim of increasing its abundance and/or viability (adapted from IUCN 2013)
Reference	Source of record
Type of evidence	Ethnographic, biogeographic, phylogenetic, and/or archaeological
Ethnographic source	Direct contemporary observation, first-hand historical observations, second-hand information, contemporary knowledge of Aboriginal people
Reliability	Ranked as high, medium, or low, as discussed in Methods

details provided (Buckley 1981), were not included.

Assessment of reliability was made through strength of evidence of deliberate translocation and whether there were corroborating lines of evidence. Where possible, the record was checked with relevant botanical and ethnographic experts in the region concerned. In general, a record was assigned high reliability where it was based on direct contemporary observations of translocation (either published or communicated through interviews with the author), where historical sources were verified by other lines of evidence, or for translocations documented in peer-reviewed phylogenetic studies. Moderate reliability generally involved contemporary knowledge or first-hand historical accounts of some movement and planting of propagules, but without definitive evidence of translocation and no corroborating biogeographic or phylogenetic evidence. The records assigned low reliability were second-hand information that appeared in general ethnographic or botanical works with no primary sources provided and biogeographic inferences without supporting ethnographic or phylogenetic evidence of translocation.

Results: The Evidence for Translocations in Aboriginal Australia

Overview of Aboriginal Translocations

Over 50 species were recorded as being deliberately translocated by Aboriginal Australians, including at least 20 trees and shrubs, 13 tuberous species (mostly yams), nine non-tuberous herbs, and seven grasses. The vast majority (43 species) were, and in some regions still are, important food species, while at least nine were valued for plant materials. At least 17 species had (or have) ceremonial or cultural importance, with translocations of these often occurring as part of a specific ceremony. Most species were subject to numerous types of translocations (Table 1; Supplementary Table 1). Introductions (i.e., the establishment of new populations within the known range of the species) were the most common type,

documented for 31 species. Reinforcement planting into existing populations, often accompanied by in situ nurture of plants and their habitats, were documented for 23 species, while assisted migrations into new areas outside the apparent indigenous range of the species were documented for 19. Ten records involve post-contact translocations, mostly of important food or ceremonial plants taken back to gardens to maintain connection with sites where they grow in the absence of regular visits.

The Aboriginal translocation record spans 38 of Australia's 89 biogeographic regions across all major climate zones. The Mediterranean southwest, tropical north, and Western and Simpson Deserts stand out as having relatively high numbers of translocations documented, and all encompass three types of translocation, including assisted migration (Figure 1). Large parts of south-central South Australia, central Queensland, and central New South Wales have no reliable records of deliberate translocations, despite being the subject of much ethnobotanical work by Philip Clarke (South Australia; see Clarke 2014 and references therein) and having a detailed explorer record that was comprehensively reviewed by the author (central Queensland and New South Wales; see Silcock et al. 2013).

Forty-seven records were found in ethnographic literature and/or contemporary knowledge, although six of these are very difficult to verify and were ranked as low reliability (see Methods). Eleven ethnographic records were supported

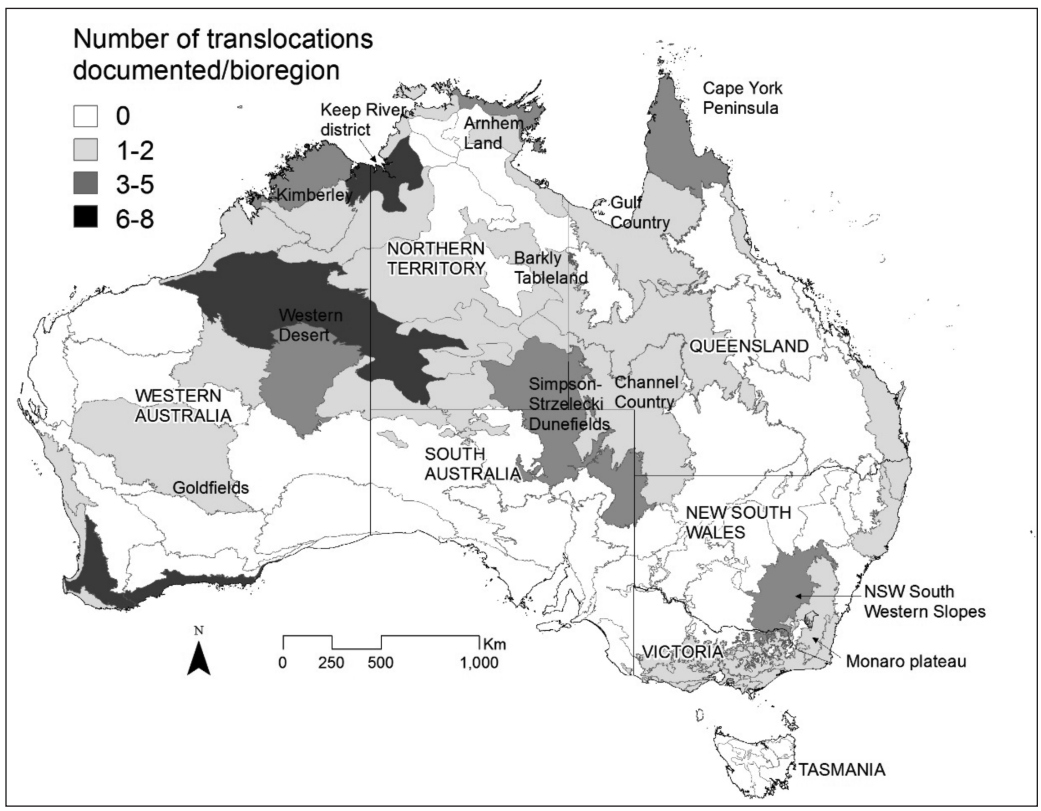

Figure 1. Number of Aboriginal translocations documented by biogeographic region, Australia. State names and specific locations mentioned in the text are identified. Records ranked as being of low verifiability are not included on the map, but do appear in Supplementary Table 1.

by biogeographic, phylogenetic, and/or archaeological evidence. There were biogeographic inferences of translocations for seven species with no supporting ethnographic evidence, and five of these were considered to have low reliability.

The Archaeological Record

Little archaeological evidence has been found for most Aboriginal plant management activities, including translocations (Beck et al. 1989; Denham et al. 2009b; Harris 1984; Smith 2011). Balme and Beck (1996) conjecture that soil mounds widely observed in southeastern Australia may have been gardens, most likely for the cultivation of edible tubers. The occurrence of these soil mounds overlaps with the distribution of *murnong* (*Micoseris lanceolata*), but they also occur in areas where tuberous lilies, ferns, and wetland sedges are abundant. Such mounds have been widely documented and numerous uses proposed (Clarke 2008; Etheridge 1893; Hallam 1975), but only Batey (in Frankel 1982) and Thomas (1906) directly observed the creation and use of mounds for growing plants in Victoria and Western Australia, respectively. To date, only these southern "yam gardens" and a stone arrangement in the Western Australian Goldfields region (Figure 1; discussed below) provide archaeological evidence of translocations.

The Ethnographic Record

The majority of records of translocations come from the ethnographic record. While Australian explorers and early settlers frequently described fields in the wild that resembled "stubble paddocks," with piles of grass or earth turned over for miles (e.g., Gregory 1884; Mitchell 1847; Sturt 2001 [1849]), direct accounts of deliberate translocation of plant species are rare. Most references to translocations were found in anthropological works and contemporary ecological knowledge (Table 1; Supplementary Table 1).

The re-planting of sections of tubers (including yams, lilies, sedges, legumes, ground orchids, and numerous other plant groups) after harvesting is documented throughout Australia and is by far the most well-known and widely-practiced example of translocation. This practice encompasses reinforcement of populations and, in some cases, introductions to new areas, and has been reported from Cape York (Campbell 1965; Hynes and Chase 1982; McConnel 1957), central and western Victoria (Batey n.d.; Pascoe 2014), Arnhem Land (Blake et al. 1998; Chaloupka 1993; Russell-Smith et al. 1997; Specht 1958), the Keep River area (Head et al. 2002), the Kimberley (Crawford 1982), and along the southwestern coast of Australia (Gregory and Gregory 1884; Hallam 1975; Figure 1). Re-planting of tubers does not seem to have been practiced inland, although they were widely utilized as a food source (Latz 1995; O'Connell et al. 1983; Veth and Walsh 1988), and harvesting techniques and management practices probably enhanced dispersal and reproduction (Ens et al. 2017; Walsh 1990). Yen (1989) notes the planting of bush sweet potatoes (*Ipomoea costata* and *I. polpha*) in an unspecified part of the Western Deserts, but this is impossible to verify and is only corroborated by Kimber's record of post-contact planting of a tuber discussed below.

First-hand accounts of deliberate translocation of other types of plants are sparse but frequently detailed. Perhaps the most remarkable comes from Dame Mary Gilmore (1865–1962), who, as a child, observed "more or less extensive planting of seeds by the lubras" after a fire on the plains in Wiradjuri country of the New South Wales South Western Slopes (Gilmore 1934:221; Figure 1). Fresh seed capsules were collected from unburnt shrubs and planted where burnt ones stood, while a "heavy kind" of grass seed was collected, processed, and the best grains planted into the burnt area. She recalled:

> How I remember the grass planting so well is that being a child I thought all seed was the kind wanted, and gathered ripe and unripe, and chiefly the sort that rolls on sickle-shaped terminal. This, I was told, was not what was required, that the wind would plant this; that it was what did not run, and then catch in the earth, that had to be planted by hand. (1934:221–222)

She also described people replanting seeds to replace what they ate, preparing the soil by lighting a small fire first. She recounted a specific tale of re-planting the "ground-berry" (possibly *Eremophila debilis*), involving selection of the biggest seeds. Gilmore concluded that "the natives had a knowledge of their own in regard to conditions of soil, shade and moisture in relation to seed" (1934:222). She also described what appears to be systematic cross-fertilization of the fruit-bearing quandong tree (*Santalum acuminatum*):

> When a grove is in flower they brought branches from another grove to fertilise the blossom. One of the places where I saw this done was at Yarrengerry… Earlier I had seen it done near what is now Bethnungra. Often I saw the twigs left on the ground under the trees to show that the work had been done and need not be repeated. Whether the branches were used merely to fertilise, or whether to introduce an unrelated strain, I do not know. I heard my father explain it to my mother, but…I was only a child…. (1934:222–223)

On the other side of the continent, an elderly Martu man in the Western Desert (Figure 1) described how, before summer rain, bush tomato (*Solanum diversifolium*) seed was scattered on burnt places near camp sites (Walsh 1990). In Western Australia, Thomas (1906:113) described the pre-contact cultivation of purslane or *munyeroo* (*Portulaca* species) as "well established fact. It is grown like mellons [sic] on slightly raised mounds…," while Hyam (1939) stated that bunya pine (*Araucaria bidwillii*) nuts were sometimes deliberately planted in southeast Queensland. Both these species are highly-valued, the former as a staple desert food (Latz 1995:249–250) and the latter for large triennial feasts (Evans 2002). However, these isolated historic reports of deliberate planting are difficult to verify and were ranked as having low reliability, as they are made within generalized works and no sources are provided.

Plant translocations and ceremony were frequently intertwined, in what could be broadly viewed as "increase ceremonies" (Gerritsen 2008). In the Western Australian Goldfields region (Figure 1), people created a stone arrangement above a claypan to celebrate the sowing into claypan cracks and collection of seed from the samphire *kurumi* (*Tecticornia arborea*), which was used to make a superior damper (Dix and Lofgren 1974). The Wongkanguru people of the southern Simpson Desert broadcast seed of the *wirra* tree (*Acacia salicina*), the ash of which was mixed with the narcotic leaves of pituri (*Duboisia hopwoodii*), and staple food yelka (*Cyperus bulbosus*) during ceremonies after or preceding rainfall (Horne and Aiston 1924). The ceremonial performances associated with the broadcast of the latter were celebrations of mythological hero Jelkabalubaluru (Reuther, in Kimber 1984) and the final lines of the accompanying song translated as "plant plant root grow" (Aiston 1930:49).

These are all examples of reinforcement plantings, where propagules were planted to augment existing populations. However, there are sufficient records to suggest that deliberate introduction into areas outside a species' natural range was not an uncommon type of Aboriginal translocation. Alice Duncan-Kemp (1901–1988) grew up on a remote station in Queensland's Channel Country (Figure 1), and witnessed many

traditional ceremonies, including the Katoora ceremony, where:

> From their woven dilly bags the gins sprinkled seed food over the ground… Katoora or barley grass seed [probably *Astrebla pectinata*] lay in little hillocks, already swelling and creeping to repeated applications of water which the gins poured on them to make "wunjee aal the same walkabout" (grass to grow). (Duncan-Kemp 1934:146–147)

According to Duncan-Kemp (1934: 147), the katoora seed was "gathered from the coarse barley-grass of downs country" and obtained "by barter from the Kalkadoon, Goa, and Pitta Pitta tribes of the Winton and Boulia district [and]…passed down in reed or grass wrappings." Further west, Walter Smith (also known as Walter Perula and Wati Yuritja), a fully initiated bushman of Arabana and Welsh descent, recounted how, in the Simpson Desert (Figure 1), a type of grass seed used for making flour was broadcast by hand and lightly covered with soil:

> They chuck a little bit there [at favorable camp sites or soaks]. Not much, you know, wouldn't be a handful. [They] chuck a little bit, spread it you see—one seed there, one seed there… they chuck a bit of dirt on, not too much though. And soon as the first rain comes…it will grow then. (in Kimber 1984:16)

It seems that quite large amounts of seed were involved, with Smith remembering dividing about 50 pounds (23 kg) with a friend and rolling it up in his swag to transport. People from the eastern Northern Territory and northern South Australia would routinely take bags of seed from important species to areas where they did not occur, as gifts and trade items (Kimber 1984). The accounts of Duncan-Kemp and Smith concur with contemporary oral accounts from this region describing long-distance expeditions, which included "grass seeds in bags" as one of the traded items (Gerritsen 2008; McBryde 1987). Similarly, Martu people in the Western Desert have stated that seeds and fruits of food plants were exchanged at social events and through trade practices (Walsh 1990).

To the southeast of the Wiradjuri country, written about by Mary Gilmore, the oral history of the Ngarigo people of the Monaro plateau reveals translocations along Songline tracks. Elder Rod Mason recounted that when the old women walked these paths, they carried seeds of their favorite food and resource plants, which would be sown and nurtured at their chosen, often spiritually significant, camping places (Massy 2017). This practice accounts for the biogeographically "out of place" ancient *kurrajong* (*Brachychiton populneus*) surviving in Charles Massy's homestead garden, which still shows signs of harvesting of bark and wood. Mason said that originally there would have been a grove of trees marking an important ceremony place (Massy 2017:29).

Contemporary Noongar elders of southwestern Australia report the transport of seeds of various resource species, including *Hakea*, *Banksia*, *Exocarpos*, and *Platysace* species (Lullfitz et al. 2017), a practice which is also noted in the ethnographic record (Grey 1841; Hassell 1975). Several Songlines (Dreaming tracks) recorded in northeastern New South Wales describe deliberate movements of seeds of the rainforest riparian tree black bean or *bugam* (*Catanospermum australe*), which probably explain its contemporary distribution (Rossetto et al. 2017). Women on the Barkly Tableland continue to translocate water lilies (*Nymphaea* species) to waterholes where they are not present (Kate van Wezel, personal communication, September 2016); the cessation of this practice in some areas of northern Australia may explain why lilies are no longer found in places where they "always" were (Rose 1988).

On the frontier, exchange of seeds sometimes transcended cultures and encompassed non-native species. For example, a date palm (*Phoenix dactylifera*) seed gifted to Aboriginal people in the Gulf Country by "Afghans" was planted and became regarded as a special tree due to its links with the past (Martin and Trigger 2015). Deliberate translocations in the post-contact era have been done to maintain connection with important Dreaming (Creation) sites or patches of country that are no longer visited regularly. On a bush trip in the 1990s, Biddy Simon, a senior Murinpatha woman of the Keep River district in northern Western Australia, not only replanted yams after harvesting, but took bulbils of bitter yam (*Dioscorea bulbifera*) back to her garden to grow (Head et al. 2002). Her garden also featured other plants collected from the bush, including *Typhonium* lilies and Leichhardt tree (*Nauclea orientalis*) seedlings; she remembered where and when these plants were collected and they provided connection to certain places. Biddy's plantings were not restricted to her garden. During two visits to remote springs, she tried to find the place where she had planted a type of round yam she called *mindal* while on holiday when she was about 13, some 40 years earlier; Head et al. (2002) observed that she was "quite cross" at not being able to find it.

Kimber (1976) documented four examples of Central Australian Walpiri and Pintubi men transplanting ceremonially significant, useful, or beautiful plants to their communities (Supplementary Table 1). Martu people also reported that, after contact with Europeans, their relatives spread seed of introduced bitter melon (*Citrullus lanatus*) and buffel grass (*Cenchrus ciliaris*) along the Rudall River in the Western Desert, although this is difficult to verify (Walsh 1990). Native tobacco or *mingkulpa* (*Nicotiana gossei*) is tended and encouraged in Central Australia through fire management and seeds are sometimes scattered to encourage germination, but it is uncertain whether this is a post-contact practice (Latz 1995). It has been introduced to garden plots in some Western Desert communities (Boyd Wright, personal communication, December 2017). In recent times, Alyawarr people in the central-eastern Northern Territory have deliberately established colonies of bush tomatoes (*Solanum chippendalei*) south of their natural range by scattering seeds near their camp sites, but the antiquity of this practice is not known (Latz 1995).

Biogeographic and Phylogenetic Insights

Translocation of at least 18 species is inferred from the biogeographic record, and over half of these are supported by ethnographic and/or phylogenetic evidence. The most common forms of biogeographic evidence of Aboriginal translocations are unusual disjunct occurrences or high concentrations of important species. Jones and Meehan (1989) proposed the existence of an "experimental horticultural province" encompassing northern Australia prior to rising sea levels isolating the continent in the early Holocene, which may explain the occurrence of common New Guinea domesticates such as taro (*Colocasia esculenta*) and bananas (*Musa acuminata*) in northern Australia. Assisted migrations may also explain the spread of some rainforest plants from New Guinea into northern Australia more than 10,000 years ago (Bean 2007; Denham et al. 2009a).

High concentrations of edible fruit trees are found near old campsites in northern Australia (Hynes and Chase 1982; Jones 1975), including consistently on old shell mounds (Cribb et al. 1988). The important food plants desert raisin (*Solanum centrale*) and dillon bush (*Nitraria billardierei*) are commonly found in abundance near old campsites in central and southern Australia, respectively (Gerritsen 2008; Clarke 2008). The deliberate translocation of these species is difficult to verify from the biogeographic record alone, and the reliability of these records is ranked as low.

Recent studies combining ethnographic and phylogenetic data have more reliably demonstrated deliberate human-mediated dispersal of trees in northern and eastern Australia. Research using genetic and linguistic data points to humans as the most likely dispersal vector of baobab (*Adansonia gregorii*) trees in northwestern Australia, with the authors concluding that ancient humans significantly influenced its geographic distribution (Rangan et al. 2015). Rossetto et al. (2017) validated anthropogenic records of recent human-mediated dispersal of the edible nut-bearing riparian rainforest tree black bean (*Castanospermum australe*) in northeastern New South Wales by demonstrating genomic homogeneity across multiple catchments and extensively dissected topography.

Numerous recent phylogenetic studies from southwestern Australia show, to varying degrees, intraspecific DNA variation consistent with human dispersal hypotheses (Lullfitz et al. 2017). In particular, the distributions of important food plants, such as the tubers *youck* or Ravensthorpe radish (*Platysace deflexa*) and *P. trachymenioides,* and the zamia palm *djerri* (*Macrozamia dyeri*), seem likely to have been manipulated by people, although it is difficult to say whether this was via deliberate translocation or encouragement of in situ populations (Hopper and Lambers 2014; Lullfitz et al. 2017). There is an outlying occurrence of the important food and material shrub feather-leaved banksia (*Banksia brownii*) on the Vancouver Peninsula in southern Western Australia, next to an Aboriginal campsite. Given the unusual habitat, and with all other populations much further inland, there is some support for human agency in the establishment of this isolated population (David Coates, personal communication, March 2017).

The Central Australian cabbage palm (*Livistona mariae*) is separated from its nearest relative by 1000 km, but close genetic affinities and relatively recent divergence time bring a relictual origin into question (Kondo et al. 2012). The estimated divergence time overlaps with human movements into Central Australia and, as the palm is known to be a source of food and materials, Aboriginal dispersal is put forward as a possible mechanism (Bowman et al. 2015; Kondo et al. 2012). Human agency has also been suggested to account for the isolated groves of cabbage-tree palm (*L. australis*) on the southeastern Victorian coast (Hyam 1939). These studies and observations mean that human agency cannot be ruled out to explain other isolated occurrences of *Livistona* palms, notably the extremely disjunct and "remarkable" population of Millstream fan-palm (*L. alfredii*) on Cape Range in Western Australia (Humphreys et al. 1990).

Discussion: Extent, Distribution, and Implications of Aboriginal Translocations

The ethnographic record contains by far the most evidence for Aboriginal translocations, despite being fragmentary and prone to overlooking brief and inconspicuous practices, like small-scale plantings (Clarke 2003; Denham 2008; Gerritsen 2008; Gott 1983). As in other Indigenous societies, the plant management of Aboriginal people looked very different to European models. Land management practices closely followed natural processes and were often not recognized or understood by early European observers (Campbell 1965; Fowler and Lepofsky 2011; Gerritsen 2008; Lepofsky 1999). Very few explorer and early traveler journals contain observations of deliberate movements or plantings; most accounts are from people who lived among Aboriginal people for lengthy periods.

Most records are single but often detailed first-hand accounts, which are difficult to verify. Nevertheless, taken together, there is indisputable evidence that Aboriginal plant translocations spanned a wide variety of regions, habitats, and life-forms (Figure 1; Supplementary Table 1). The most frequently documented practice was the reinforcement of existing popu-

lations of important food plants through replanting of tubers in coastal areas and seeds of trees, shrubs, and grasses throughout Australia. Deliberate introductions and assisted migrations to new areas occurred through travel and trade networks, mostly in northern and central-eastern Australia.

Movements of plants by Aboriginal people were—and continue to be—founded on intimate knowledge of species biology, life history, habitat requirements, and horticulture (Chase 1989). The practices described by Mary Gilmore in New South Wales—cross-fertilization, soil preparation, selection of the best seeds, replacement plantings—have much in common with contemporary conservation translocations. There are few other observations of translocations from this region, and Gilmore's romanticized and sometimes embellished portrayals of Aboriginal life have been noted (Tsokhas 1998; Walker 1991). However, the accounts of Walter Smith and Alice Duncan-Kemp, and contemporary knowledge recorded from western, northern, and southeastern Australia, show the depth of botanical knowledge that existed across the continent and a willingness to trade and experiment with seed sowing. Stories of ancestors teaching people about selecting and sowing seeds are common throughout much of Australia and show a detailed knowledge of propagation practices (e.g., Howitt 1904; Kimber 1984; Veth et al. 2017).

Much of this knowledge, including of what translocations were undertaken and their legacies in terms of species distribution and abundance, remains undocumented and ecologists often overlook or underestimate the role of human agency in dispersal of plant species (Bean 2007). Many important plant species in central and northern Australia have broad natural distributions, in which they are abundant over large areas, meaning that biogeographic evidence of translocations is scant. The lack of archaeological evidence of plant-management activities is recognized in other countries and may be partly due to lack of concerted research effort to date, as well as the often "light footprint" of such activities, particularly where they mimic natural processes (Deur and Turner 2005; Fowler and Lepofsky 2011; Lepofsky and Lertzman 2008). Compounding this, the destruction of many ancient "gardens," food production systems, and stories associated with them was rapid, through earthworks, livestock, and cultural decimation (Pascoe 2014).

There seems little doubt that many more of the estimated 20,000 vascular flora species known to have been used directly by Aboriginal people (Ens et al. 2017) were translocated than are documented. There are many regions without any evidence of deliberate movement and nurture, while documented translocations are concentrated in areas where there has been long-term anthropological and ethnobotanical studies, which have typically involved in-depth engagement with older people. This suggests fertile ground for research in under-represented areas, but the contemporary ethnographic knowledge sourced in northern and southwestern Australia no longer exists in many other parts of Australia. Emerging studies using molecular and genomic techniques have revealed, or in some cases validated, the ethnographic record of human-mediated dispersal (Bowman et al. 2015; Rangan et al. 2015; Rossetto et al. 2017), but have so far only been undertaken for four species.

Concluding Comments

Although biodiversity conservation as we define it today was not an explicit objective, the goals of Aboriginal translocations would appear broadly similar to present-day conservation initiatives: to create and maintain populations of important and valued plants. Success of translocations can only be evaluated after many years of monitoring—up to several decades, depending upon generation time of the species—and it is too early to judge

for the majority of contemporary conservation translocations (Menges 2008; Pavlik 1996). However, it seems that numerous Aboriginal translocations over the past 50,000 years have indeed been successful and manifest today as unusual distributions of some species. This is no doubt due to factors which underpin modern translocation success, including detailed knowledge of species biology and habitat preferences and learning from failed "experiments" (Dalrymple et al. 2012; Turner and Berkes 2006).

There is a burgeoning body of literature on the ethics and philosophy of moving plants (e.g., Albrecht et al. 2013; Sandler 2010; Thomas 2011). This debate is not a new one (Winston et al. 2014) but will intensify as assisted migrations outside a species' natural range are increasingly proposed in attempts to conserve species under anthropogenic climate change scenarios. Against this backdrop, we must acknowledge that people have been promoting growth and survival of certain species and transporting them beyond their "natural" range for thousands of years. Given the swift and violent dispossession of Aboriginal people by European settlers across much of the continent (e.g., Bottoms 2013; Watson 1998), the collation of the archaeological, biogeographic, phylogenetic, and ethnographic record provides valuable and unique insights to a long, complex, but often poorly-documented, history of plant management. Modern conservation and restoration practices, including translocation, are the latest chapter in an ongoing, dynamic, and ancient history of human-plant interactions (Hoffman and Rick 2018). Combined with emerging evidence from phylogenetic studies, the ethnographic record challenges our conceptions of "natural" species distributions in Australia and has contemporary relevance for cultural heritage, land management, and biodiversity conservation, including "novel" strategies like translocation.

Notes

[1] Available online at avh.chah.org.au.

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