Quantifying the Mulligan River Pituri, *Duboisia hopwoodii* ((F. Muell.) F.Muell.) (Solanaceae), Trade of Central Australia

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Research

Abstract

Pituri (*Duboisia hopwoodii* (F. Muell.) F. Muell.) (Solanaceae) is a narcotic shrub which grows in the parallel dune fields of the Simpson Desert of far south-western Queensland, Australia. The ethnographic literature points to an impressive scale of trade of **pituri** between Aboriginal groups across inland eastern Australia, and suggests total annual production of 2500-3000 kg of dried plant material. However, there has been no attempt to assess the feasibility of these figures, or investigate the number of **pituri** plants required to sustain such a scale of trade. We mapped the distribution and density of *D. hopwoodii* along four one km wide transects, totally 130 km in length. Our results suggest that the population of **pituri** west of the Mulligan River could number around 36,000 mature plants. Ninety randomly selected plants were measured, and the foliage of six of these was harvested and dried. Plants yielded between 0.15 and 6.68 kg of dry matter. Our 90 measured plants would have yielded around 155 kg of dried **pituri**. Therefore, between 1450 and 1740 plants would be required to sustain the purported level of trade and use. With knowledge of the location of dense **pituri** groves and highly efficient expeditions, harvesting this number of plants is feasible. However, numerous questions remain surrounding the ecological and ethnographic aspects of the **pituri** trade.

Introduction

Pituri (*Duboisia hopwoodii* (F. Muell.) F. Muell.) is a narcotic shrub from the family Solanaceae which grows in the extensive parallel dune fields of the north-eastern Simpson Desert on the Queensland-Northern Territory border. Although the species occurs across inland Australia, only plants from a relatively small, disjunct population west of the Mulligan River (Figure 1) were used and traded as a narcotic (Letnic & Keogh 2010). Other Australian species within the alkaloid-rich family Solanaceae, particularly numerous *Nicotiana* species, are also known as **pituri** in Central Australia (Latz 1995). In the present study, the term **pituri** refers only to *D. hopwoodii*, and the material prepared from this shrub. Ethnographic accounts identify Mulligan River **pituri** as a key commodity in the long distance exchange networks that operated east of Lake Eyre and the Simpson Desert dune field (McBryde 1987). These accounts suggest that more than one ton of dried **pituri** was traded on a quasi-annual basis. In this paper, we use new field data to determine the annual harvest rate of *D. hopwoodii* shrubs and the number of plants required to sustain such a scale of trade.

Colonial history

From the beginning of contact between the Aborigines and Europeans, **pituri** has inspired intense scientific and popular curiosity (Keogh 2011). Explorer Edmund Kennedy saw Aboriginal people using **pituri** on Cooper Creek below Windorah in September 1847 (Kennedy 1847:137). However, the report by Wills of being given “some stuff

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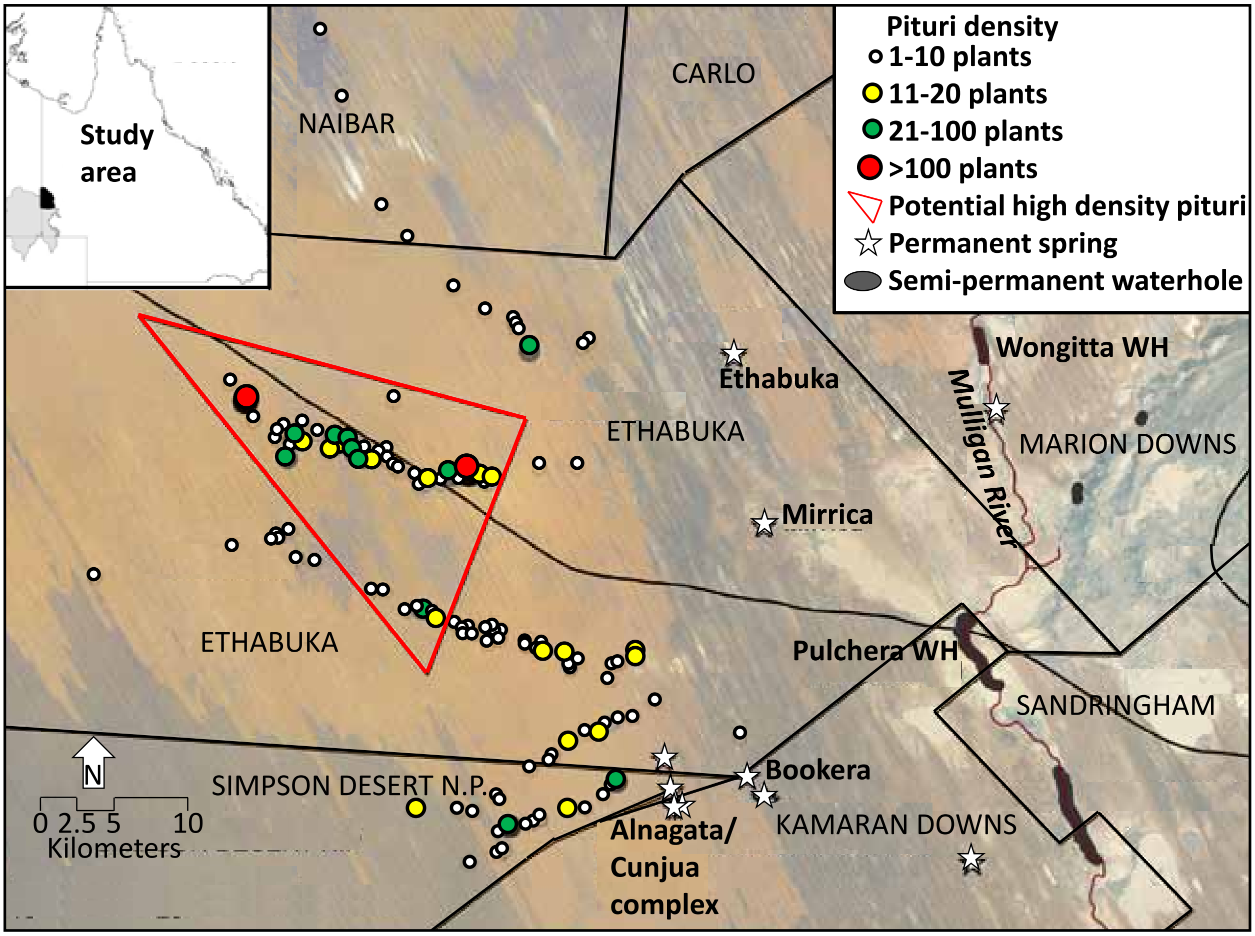

Figure 1. Study area of the Ethabuka Reserve and Carlo Station adjoin the Queensland-Northern Territory border, Australia, where the alluvial plains of the Mulligan River merge with the Simpson dunefields. Mapped *Duboisia hopwoodii* (F.Muell.) F.Muell. populations are shown with current property and paddock boundaries, and permanent and semi-permanent waters. **Pituri** density refers to groves of plants where no individual is separated by >200 m. Base imagery provided by SPOT (Astrium GEO-Information Services, Canberra, Australia).

they called **bedgery** or **pedgery**" in 1861 (Wills 1863:283) brought the narcotic into the public consciousness. It was reported to produce a "voluptuous, dreamy sensation" (Bancroft 1879:7). By 1872 chemists in London, Edinburgh and Paris were running tests on samples of the prepared drug collected by Brisbane physician Joseph Bancroft. In four papers presented through the 1870s, Bancroft described various aspects of **pituri**, including its preparation, pharmacology and high value to Aboriginal people, who "give anything they possess for it" (Bancroft 1878:8).

Despite this growing interest and knowledge, Europeans had difficulty identifying the source of **pituri**. Most samples obtained were of dried, prepared plant material. Not only did it grow in a remote and inaccessible habitat, Aboriginal people refused to reveal its location. It was not until 1876 that explorer William Hodgkinson, who had tried **pituri** during Howitt's 1861 Burke and Wills Relief Expedition, located the plant *in situ*. While he was camped on the Mulligan River west of present-day Bedourie, local people brought him prepared **pituri**, but refused to take him to the location where it grew. He took a local man hostage in a vain attempt to be shown the location of the groves – the fabled **Peecheringa**. Hodgkinson finally stumbled upon the plant, a sand hill shrub to 1-2 m high, on 17th August east of Twin Hills (-23°19'S, 138°16'E) (Hodgkinson 1877). From the late 1870s, **pituri** became more prominent in the European imagination. References appeared in numerous popular and scientific accounts of inland Australia, including the surveyors Bedford (1886, 1887), Cornish (1880) and Winnecke (1884), ethnographer W.E. Roth (1897), grazier-naturalist Alice Duncan-Kemp (1934) and many bush correspondents to the Queenslander (e.g., Brown 1879, Eglington 1881, Potjostler 1878).

Ethnography and pharmacology

Leaves and small stems of *D. hopwoodii* shrubs were harvested in early March and artificially cured in heated sand in pits (Aiston 1937, Gason 1882, Hodgkinson 1877) – a drying process that took about 2 hours and which arrested the enzyme action that normally degraded the nicotine level. The dried leaves and stems were then broken up and packed into small semi-circular net bags made from plant material (probably native flax, *Cullen* sp. (Roth 1904:9)), each containing around 1.4 kg (Gason 1882) and often painted with bands of red and yellow ochre. During use the dried material was mixed with *Acacia* ash and chewed into a ball, and was used as both a stimulant and analgesic (Watson *et al*. 1983). The active agent is the alkaloid nicotine, present in Mulligan River **pituri** at levels ranging from 2.4-5 % (more than twice the content of commercial cigarettes or of the *Nicotiana gossei* Domin, bush tobacco, used in Central Australia). Chemical analysis shows that in Central and Western Australia, *D. hopwoodii* is toxic because of the level of D-nor-nicotine, a much more powerful alkaloid, which is only found in low levels in Mulligan River **pituri** (Watson *et al*. 1983). This explains why only Mulligan River *D. hopwoodii* was exploited as a narcotic and widely traded. The species was also used in Central Australia, but primarily to poison waterholes to stupefy emus during hunting (Latz 1995).

The scale of trade in **pituri**, recorded between 1860 and 1880, was impressive. Aboriginal groups in the Cooper Creek area – including the Diyari, Wangkangurru and Yandruwantha – mounted annual expeditions involving a round-trip of 800-1200 km to obtain supplies of **pituri** (Aiston 1937, Gason 1882, Horne & Aiston 1924, Howitt 1904, Smyth 1878). Some **pituri** was also traded northwards from the Mulligan for 300-400 km to groups outside the desert along the Flinders and Gregory rivers (Roth 1897, Watson 1983). And the word **pijiri**, originally a Pitta Pitta word from the upper Mulligan, appears to have followed the trade downstream (Clarke 2008:55). Gason, who witnessed the last of the traditional **pituri** expeditions, estimated that each man returned fully loaded with 30-32 kg of dried **pituri** (70 lb) – and this is loosely corroborated by other sources (e.g., Aiston 1937, Howitt 1904).

A note on the veracity of Gason's observations is warranted at this point. Mounted Constable Samuel Gason was uniquely placed to see the **pituri** trade system in operation, as a police trooper stationed at Lake Hope on Cooper Creek between 1865 and 1871 just as pastoralists and missionaries were moving into this district (Jones 2007). He witnessed at first-hand the return of expeditions carrying **pituri** from the north, and the departure south of the red ochre expeditions. He is known to have been a reliable observer and his estimates of the scale of trade in red ochre are corroborated by a series of independent accounts of the red ochre expeditions between 1864 and 1890. Reports of group size range from 50-56 to 70-80 men, with estimates of the average load of ochre ranging from 23-45 kg per man (Howitt 1891, 1904:712, Jones 2007, Masey 1882). Therefore, Gason's estimates of the weight of individual loads of **pituri** are likely to be accurate. The main uncertainty surrounds the size of **pituri** expeditions as Gason does not directly record how many men were involved. However, the ethnographic context suggests that 30-50 men is likely to have been the minimum required for safe passage of these trading parties, and it is relevant that this is at the lower end of the scale reported for red ochre expeditions.

Assuming each man was carrying 30-32 kg of dried **pituri**, and there were 30-50 men per expedition (see above), we have taken 900-1600 kg of dried **pituri** per annum as a reliable estimate of the Cooper Creek trade, and 2500-3000 kg as a working estimate of the overall production of **pituri**. These figures include some allowance for supply of **pituri** to meet local demand and also trade to the north. As there is no hard data on local consumption or trade to the north, we have roughly doubled our Cooper Creek figures to 2500-3000 kg, on the assumption that local and regional consumption would be at least a similar order of magnitude as that to the south. This leaves the question of just how many *D. hopwoodii* plants this represents. It also raises questions about the ability of the **pituri** groves to sustain this level of harvesting. In this paper we provide some further quantitative data to answer these questions.

Methods

Study area

The Simpson Desert is the largest sand ridge desert in the world, covering 200,000 km^2 and comprising adjacent portions of the Northern Territory, South Australia and Queensland (Gibson & Cole 1988). Dune fields comprise 73% of the Desert, and are its most distinctive feature (Purdie 1984). Individual dunes range from 10 to 35 m high and reach up to 200 km in length, running parallel with each other in a north-north-west/south-south-east direction. While the slopes are stable with vegetation cover, the crests may be mobile and sculpted daily by wind. Ethabuka Reserve and Carlo Station adjoin the Queensland-Northern Territory border, where the alluvial plains of the Mulligan River merge with the Simpson dune fields (Figure 1). Rainfall is extremely variable, both in and between years, although there is a pronounced wet season, with most rain falling between December and March (Letnic 2004). Average rainfall at Carlo Station is 200 mm, falling to 150 mm at Ethabuka. Summer temperatures are extremely hot, while short winters are characterized by warm days and cool nights. Field work for this study was preceded by a period of exceptional rainfall, with Bedourie (100 km to the east of Ethabuka) recording 410 mm from January to July 2010, compared to the long-term average of 130 mm for this period.

Survey and harvesting

Pituri is known to occur from the southern portion of Carlo through Ethabuka into the northern Simpson Desert National Park, with outlying stands on Cravens Peak and

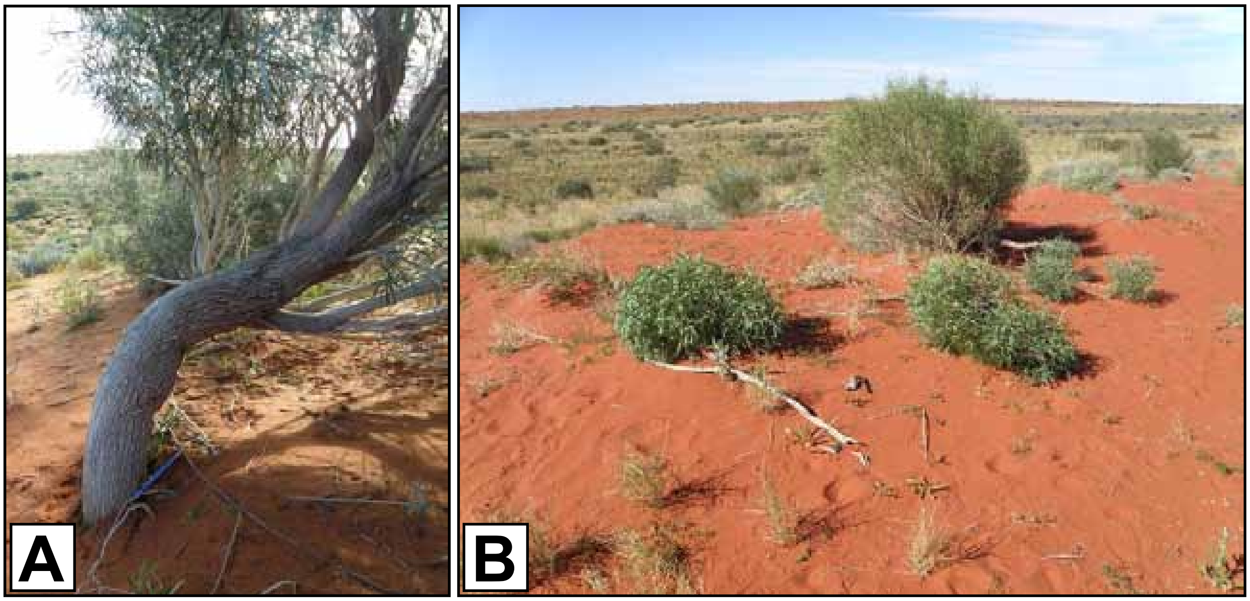

Figure 2. **A**) *Duboisia hopwoodii* (F. Muell.) F. Muell. stem (basal area measured at 5 cm above ground; **B**) mature plant surrounded by suckers (note runner in foreground). Ethabuka, Australia.

Glenormiston to the north. Three 30 x 1 km transects, selected to pass through areas of known **pituri** occurrence, were walked on Carlo, Ethabuka and Simpson Desert National Park in June and July 2010, with a string of pack camels provided by Australian Desert Expeditions. An additional 40 km transect was walked in August 2011. All **pituri** plants encountered were marked using a GPS and mapped in ArcGIS9.3. The number of plants and suckers (<50 cm tall) were counted, habitat recorded and density of plants per hectare estimated. Additional opportunistic surveys were done between April 2009 and July 2010. The height, width and breadth of 90 randomly-selected plants were measured to calculate foliage volume. Basal area was measured at 5 cm above ground (Figure 2A). Each stem was measured separately. Abundance of flowers and buds on each plant were recorded. A 60 km transect on foot with pack camels directly to the northwest of the present study area did not encounter any *D. hopwoodii* plants and suggests their northern limit of distribution in the dune field is latitude 23°30'S.

The root-suckering habit of *D. hopwoodii* rendered it difficult and sometimes impossible to delineate what constituted an individual plant (Figure 2B). Root suckers could

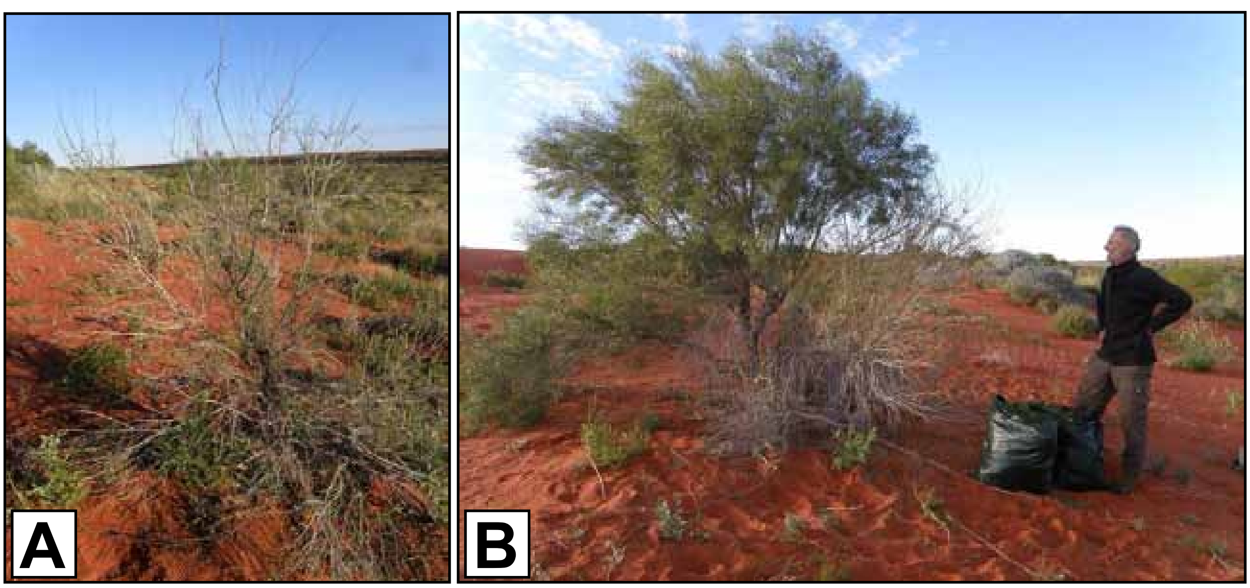

Figure 3. A) Estimated 90%; and, B) 40% harvest of **pituri** (*Duboisia hopwoodii* (F. Muell.) F. Muell.), Ethabuka, Australia, July 2010.

Figure 4. *Duboisia hopwoodii* (F. Muell.) F. Muell. flowering profusely, Ethabuka, Australia, July 2010.

sometimes be traced to a plant >50 m away. Plants on different sand mounds and thus forming recognizable above-ground units or ramets were measured as separate individuals (Cornelissen *et al*. 2003). Those on the same mound of accumulated sand were measured as a single plant. Any plant <50 cm tall was recorded as a sucker. It is likely that some 'individuals' measured were actually suckers of a larger adult plant. Nevertheless, this methodology allowed the size of plants to be accurately related to dry matter yield.

Six plants, spanning the range of size classes encountered during the survey, were harvested by hand. Only stems and foliage were taken, to best approximate the traditional harvesting method (Hodgkinson 1877, Johnston & Cleland 1933). A visually estimated 90% of each plant was harvested (Figure 3A), with the exception of one extremely large plant, where only a 40% harvest was achieved after two person hours (Figure 3B). Harvested material was packaged into paper bags and placed in drying ovens at 100°C for three days, by which time all moisture had been removed. The dry foliage was then weighed and dry matter yield (assuming a 100% harvest) was calculated for each plant.

Results

Density, distribution and population size

In total, 1620 plants and a further 570 suckers were mapped, mostly growing on the unconsolidated crests, saddles and upper slopes of high sand dunes in association with typical dune crest flora, including *Grevillea stenobotrya* F. Muell, *Eremophila willsii* F. Muell. subsp. *integrifolia* (Ewart) Chinnock, *Scaevola* species, *Dicrastylis costelloi* F.M. Bailey, *Goodenia cycloptera* R. Br., *Chamaesyce myrtoides* (Boiss.) D.C. Hassall, *Crotalaria eremaea* F. Muell, *Acacia ligulata* A. Cunn. ex Benth., and *Zygochloa paradoxa* (R. Br.) S.T. Blake. Nearly all plants over 50 cm tall were flowering and/or budding profusely (Figure 4). No plants were observed with fruits. Populations of **pituri** were found on a total of 110 dunes. Plants typically grew in small groups of 2-8 plants, and less commonly in groves of 20-60 plants

Figure 5. Section of dune supporting 270 individual *Duboisia hopwoodii* (F. Muell.) F. Muell. plants and 185 suckers (<50 cm) over 2.5 km along dune.

spanning a couple of hectares along a dune. Two dunes supporting more than 100 plants within a 500 m area were found, including one with 270 plants and 185 suckers spread over 2.5 km of dune crest and saddle (Figure 5).

The area of maximum *D. hopwoodii* density, encompassing these two dunes as well as smaller groves on nearly every dune crossed, occurred along a 20 km line west-north-west of the Ethabuka homestead (Figure 1). Assuming we could detect **pituri** for 500 m either side on a dunecrest (a reasonable assumption, given its conspicuous appearance), this equates to 20 km^2 surveyed. Within this area, 800 plants were mapped, or 40 per km^2. Our mapping suggests that this density extends for at least 20 x 15 km or 300 km^2, meaning that there would be 12,000 'individuals' within this zone of maximum density. The remainder of the area traversed was characterized by scattered groups of one to ten plants, with occasional larger groves, with a total of 770 plants mapped over 80 km walked (i.e., 9.6 plants/km^2). Our knowledge and interviews with surrounding land managers suggests that this zone of low density **pituri** probably covers an area of 2500 km^2, meaning that it may support 24,000 plants, albeit patchily distributed. This gives us a very rough population estimate of 36,000 'individuals', plus many thousands of small suckers. *D. hopwoodii* has not been recorded in surveys on the Northern Territory side of the dunefields (Gibson & Cole 1988).

Yields

The six plants harvested yielded between 0.15 and 6.68 kg of dry matter (Table 1). Both basal area and foliage volume were good predictors of yield (R^2 = 0.9957 and 0.987, respectively). Basal area was used to write a regression equation to predict yield for the other 84 plants measured (y = a + bx, where y = yield, a = intercept (-0.186), b = slope (0.024) and x = measured basal area). Using this equation, our 90 randomly-selected measured plants would yield around 155 kg of dry plant material. As discussed above, the ethnographic literature suggests an annual trade of between 900 and 1600 kg of dried **pituri** per annum. Our yield calculations and basal area measurements indicate that between 520 and 930 plants would be required to sustain the Cooper Creek trade, assuming a 100% harvest of each individual. The estimated total annual production of 2500-3000 kg of dried **pituri** would have required harvesting between 1450 and 1740 plants.

Table 1. Dry matter yields from six *Duboisia hopwoodii* (F. Muell.) F. Muell. harvested on Ethabuka, Australia, July 2010.

Population & plant ID	Basal area (cm^2)	Foliage volume (m^2)	Actual yield (kg)	Projected yield (100% harvest, kg)†
396 B	3.80	0.63	0.13	0.15
386 F	23.75	5.10	0.31	0.35
445 C	28.26	3.36	0.47	0.52
446 A	83.60	12.94	1.46	1.63
396 O	91.45	20.46	1.65	1.83
397 D	283.39	56.40	2.67	6.68

† 90% of all plants were harvested, so the projected harvest = (100/90) X actual yield; only 40% of plant 397D was harvested, so actual yield = (100/40) X actual yield.

Discussion

The density of plants along our narrow transect through a representative area of habitat in the southern portion of Ethabuka shows that **pituri** is certainly present in the numbers necessary to sustain the scale of trade documented by Gason. Even if **pituri** was only harvested in this zone of maximum density, which at a conservative estimate encompasses 12,000 plants (see above), each plant would only have to be harvested at an interval of every 7-8 years. Thus the scale of **pituri** trade recounted in the ethnographic literature is ecologically feasible. If all or most groves were visited across the species' range, including the relatively accessible groves close to the Alnagata Spring complex, the interval between harvesting for each plant extends to about 20 years.

Gason (1882) noted that within four months of a **pituri** expedition, the Dieri had exhausted their supplies, presumably through demand-sharing and exchange as well as use. This could suggest that the **pituri** harvest was regulated by the productive capacity of the groves, rather than based on anticipated demand. The number of able-bodied men that could be gathered for an expedition may also have been a limiting factor, particularly during dry times when foraging for food would have consumed most available time and energy. Our results suggest that the limit of trade was probably imposed by the practical and time constraints involved in harvesting and transporting the plant material. Assuming that approximately 1300 kg of plant material was harvested for the Cooper Creek trade, 750 plants would have been harvested. Based on our harvesting effort, it takes about one person hour to harvest an average-sized plant. If the 750 harvesting hours were shared by 40 men, this would mean 19 hours of harvesting per man. This is probably five solid work days, when travel time between the groves is taken into account. Using the estimated 2500-3000 kg total production, around 1600 plants would have been harvested, equating to 40 hours per man, and probably approaching 10 work days.

The nearest reliable waters to the large **pituri** groves are the small but permanent springs that emanate from the Great Artesian Basin (Fensham & Fairfax 2003). Alnagata and Cunja Spring complexes are 20 km to the south-east, with travel mostly along swales to reach the eastern edge of **pituri** country, while Ethabuka Spring is 20 km to the east, over mostly well-spaced dunes and wide swales. The large semi-permanent waterholes of the Mulligan, including Pulchera, Tiribilkie and Wongitta (Silcock 2009) are about 30 km east of the margin of **pituri** country (Figure 1). To harvest the requisite amount of **pituri** and return to reliable water for processing would be at least a week-long expedition in the hot, waterless dune fields. With detailed knowledge of the location of **pituri** groves and a large group of harvesters, this is certainly feasible. However, the operation must have been highly organized and efficient, perhaps only targeting those areas where **pituri** density was highest. It would seem uneconomical to visit the outlying groves of 4-20 plants on Carlo and the northern section of Ethabuka. We note, however, that kangaroo skin water bags were used in this region (Anonymous 1885) and this may have given more flexibility in travel than the distribution of water alone would suggest.

While this study has quantified some aspects of the **pituri** trade, numerous questions remain. Our plants were harvested after an exceptionally wet period (see Methods), which may have led to higher leaf production. Thus our yield estimates should be viewed as being towards the maximum expected in any season. From an ecological perspective, it would be instructive to know how quickly plants can recover after harvesting, as this would determine the intervening period between harvests for each grove. It is well documented that Aboriginal people manage resources to ensure their persistence, and presumably they had fine-tuned the optimum harvesting regime, including the amount taken from each plant. There has been some speculation as to the effects of burning on **pituri** suckering and leaf production (Watson 1983). **Pituri** certainly suckers following disturbance such as herbivore browsing or fire, and produces vigorous green shoots (pers. obs.). This raises the possibility that plants were burned after harvesting to promote new growth. If so, it is possible that in the absence of regular disturbance through harvesting followed by burning, the **pituri** groves have declined in abundance and vigor over the past century. Future field experiments trialling different combinations of harvesting and burning could shed light on these questions.

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