

The University of Sydney

sydney.edu.au

Native grains from paddock to plate

Study of the economic, environmental and social sustainability of an ancient system in a modern context



THE UNIVERSITY OF
SYDNEY

Institute of
Agriculture



Executive summary

This project was about investigating the economic, environmental and social features of the ancient native grains food system of Aboriginal people in the modern world. It is complex, and cannot be achieved without a multidisciplinary approach.

But our conclusion?

It can be done.

Dr Ali Khoddami
(food chemist)

Anna Drake
(food science student)

Dr Angela Pattison
(agricultural scientist)

Callum Craigie
(Gomeri man and land management trainee)

Celine Badaoui
(food science student)

Dr Claudia Keitel
(environmental and food chemist)

Associate Professor Guy Roth
(agricultural scientist)

Dr Henry Leung
(business finance)

Ji Hun Lee
(food marketing student)

Dr Rebecca Cross
(human geographer)

Dr Shauna Phillips
(agricultural economist)

Associate Professor Tina Bell
(environmental scientist)

Foreword

It's time somebody did something like this with native grasses. It helps young people like me learn about the grasses my people used, what they were using and what they were eating, and how it collaborates with agriculture.

Now I really like learning and caring about plants and learning about what my people used to eat, or used to help cure the sick.

Callum Craigie
Gomeri

I have been told that it used to be possible to walk barefoot through the country. I couldn't imagine doing that now. Weeds or bare stony ground would turn me back. Food production in inland Australia has been based on careful management of native grasslands and open woodlands for thousands of years. This story is about Aboriginal people and their knowledge coming together with other knowledges to bring back culture, revitalise Country, and thinking deeply about how we produce food. Perhaps one day we can all walk barefoot again.

Angela Pattison
Project leader



Native grains from paddock to plate

Contents

1. The paddock to plate marketing chain	4
1.1 Sowing	5
1.2 Harvesting	9
1.3 Processing	10
1.4 Nutritional properties	12
1.5 Food properties	15
1.6 Marketing to consumers	17
2. Socio-cultural sustainability	19
3. The economic prospects of on-farm native grass production	26
4. Environmental sustainability	29
5. Farming systems context	33
6. Conclusion	35
Acknowledgements	36

Scope of the study

This research was based on the land, species and people currently residing on Gomeroi country, particularly near Narrabri, NSW and has also been guided by commercial production of grains and the social enterprise business model of Black Duck Foods on Yuin country. Whilst it focuses on one part of Australia, many of the principles will apply across the nation.

This summary contains observations, conclusions and recommendations for all members of the community. It is complemented by some short videos which can be found via our website:

- www.sydney.edu.au/science/our-research/research-areas/life-and-environmental-sciences/indigenous-grasslands-grain.html

A technical report containing methods and in depth results and discussion is in preparation, and several journal manuscripts based on aspects of this project are currently undergoing the peer-review process.



Note on language

This report avoids the phrase 'traditional crops' since 'traditional' could mean either native or introduced species, depending on your perspective. Gamilaraay language experts have recommended the following words:

- *Dhunbarrbila* = Lots of edible grain/seed in one place (similar to English 'grain crop'). Comes from *dhunbarr* (grass seed ready for grinding), which possibly comes from *dhun* (tail or hanging thing, as most native grain heads do when full of seed)
- *Dhuwarr* = Bread made from native grains.

The above words can be used for any grassland species that have the potential to produce food. The noun *guli* is used here specifically for native millet (*Panicum decompositum*) and *dhamu* for purslane/pigweed (*Portulaca oleracea*).

Where crop or crops is used, it is referring to introduced species grown as a monoculture such as wheat, rice, chickpea, or other staple food.

We recommend the above Gamilaraay terms be used more widely when referring to the grain produce from Gomeroi country. Healing of Country and people goes hand-in-hand with restoration of language, and will assist people of all cultural backgrounds to clearly communicate as we explore, reimagine and share together foods and food production systems.



We acknowledge the tradition of custodianship and law of the Country on which the University of Sydney campuses stand. We pay our respects to those who have cared and continue to care for Country.

1. Paddock-to-plate marketing chain

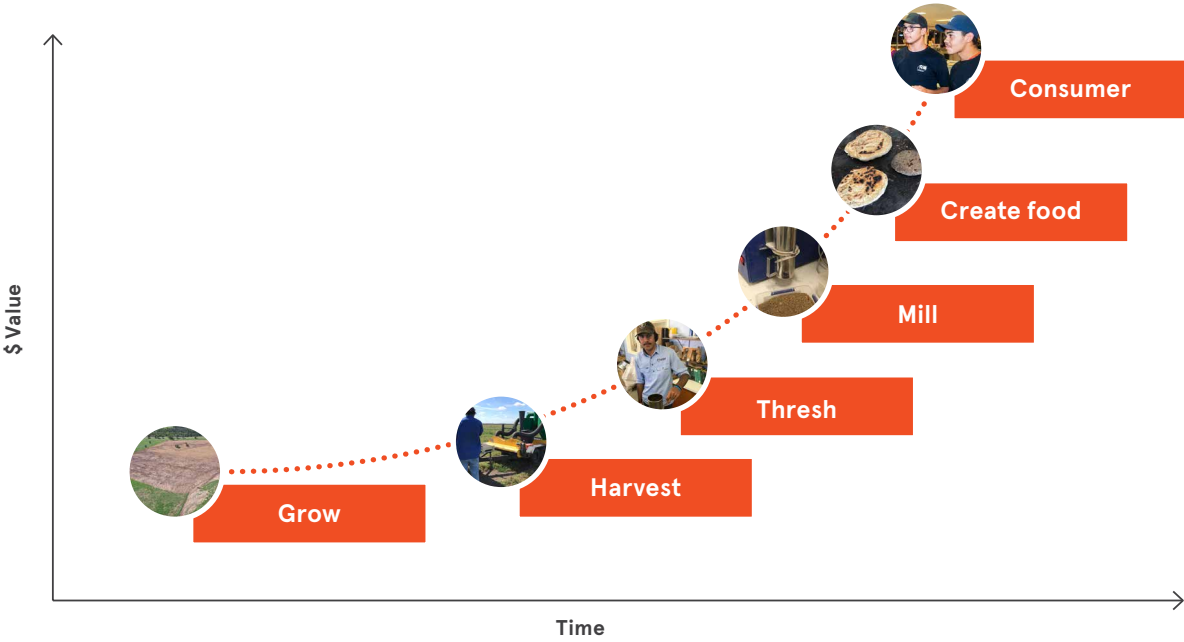
Grass seeds have always been a key source of food for people in the majority of climates around the world. They are quick to grow and can be stored for long periods of time. The species that are highest yielding, easiest to harvest and safe to eat have been domesticated. Wheat came out of the Middle East, rice from the tropics of Asia, sorghum from sub-Saharan Africa, maize from the Americas. Grain legumes and many other plants that grow in open fields have also been domesticated for their grain, such as chickpea and lentils.

Dhunbarr or native grains have been grown, harvested, processed and eaten for thousands of years on Gomeri country. There is some overlap between grain crops from overseas and dhunbarrbila – they grow in open fields, can be sown and mechanically harvested, can be cooked in similar ways and have broadly similar nutritional profiles (see Section 1.4 nutrition). There are also some key differences which need to be considered, mainly due to differences in their production chains up until this point.

As a generalisation, the dhunbarrbila to dhuwarr production chains were localised and the people involved knew each other. The people harvesting knew the people processing, and everyone shared in eating.

This system is quite different to the long and complex marketing chains in the modern world, where nutrients are exported from the land it is produced on in grain, and standardisation/product consistency is important as the end consumer doesn't know where, or from who, their grain came from.

Understanding this difference is key to deciding how to balance the economic, environmental and socio-cultural sustainability of a native grains operation. The decision may vary between groups and companies.



1.1 Growing



Hand harvesting of mitchell grass near Bellata, NW NSW.



Mechanical harvesting of mitchell grass near Bellata, NW NSW.

Native grasslands dominated large areas of Gomeri country before the arrival of Europeans and were one of the reasons cattle and sheep were brought to the region.

“I had never seen such rich pasturage in any other part of NSW. Still it supplied the bread of the natives; and these children of the soil were doing every thing in their power to assist me, whose wheels would probably bring the white man’s cattle into it.”

Sir Thomas L. Mitchell¹

Northwest NSW is now known for its fertile cropping soils. Almost all the native grasslands have been removed for either cropping or grazing, both of which changes the species mix from dhunbarrbila to either pasture mixes which maximise leaf matter for livestock, or high-yielding introduced grain crops. These crops have had significant plant breeding and farming research to increase their performance. Typical wheat yields in the region are 3 - 4 t/ha. Estimated dhunbarrbila yields are between 0.1 and 0.5 t/ha, depending on the species, rainfall and management

regime. This major difference in productivity significantly influences the potential economic returns from dhunbarrbila crops (see section 3). It also raises the possibility of using agronomy and plant breeding to improve yields, with appropriate consultation with traditional custodians.

Most native grain species are short-lived perennials, not annuals. This means:

- They take longer to produce the first crop, but then don't need to be resown every year.
- Once established, dhunbarrbila require significantly less inputs than other crops.
- The dhunbarrbila system copes better with drought than monoculture cropping, although weeds create risk particularly when rain returns
- The dhunbarrbila system may sequester more carbon than annual monoculture crops, depending on the plant vigour
- Weed control is more difficult, and generally requires more physical operations (more expensive/labour intensive/power) as opposed to chemical use
- Dhunbarrbila heads stagger their ripening over several weeks and may have multiple reproduction events in a year, thus requiring multiple harvests and specialised equipment
- Immature seed is mixed with mature seed at harvest

¹ Journal of an Expedition into the Interior of Tropical Australia In Search of a Route from Sydney to the Gulf of Carpentaria (1848)

Native grass species are not as vigorous as introduced pasture grasses and weed species. This means establishing them from a field containing a seed bank of introduced species, such as a previous pasture area, can be expensive and time consuming.

Further information on sowing, growing and harvesting native grasses can be found at <https://www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands/rangelands/publications-and-information/grassedup>.

What species can be used

This project investigated kangaroo grass (*Themeda australis*), mitchell grass (*Astrebla* spp.), QLD bluegrass (*Dichanthium sericeum*), native millet (*Panicum decompositum*), warrego grass (*Paspalidium jubiflorum*), arm grass/signal grass (*Urochloa distachya*), button grass (*Dactyloctenium radulans*), tall oat grass (*Themeda avenacea*), weeping grass (*Microlaena stipoides*) plus the non-grass species purslane/pigweed seed (*Portulaca oleracea*), old man salt bush seed (*Atriplex nummularia*), seed of several acacia species (*Acacia* spp.), kurrajong seed (*Brachychiton populneus*), quandong kernels (*Santalum acuminatum*) and spiny mat rush seed (*Lomandra longifolia*). This is a small subset of options, and several of these species have uses beyond flour products e.g. QLD Bluegrass as a stock feed, pigweed as a vegetable, quandong for its fruit and spiny mat rush for woven baskets.

The Agrifutures feasibility studies on grains¹ and legumes² have further information on species options.

Weeping grass has excellent production potential in its natural range and is easy to thresh and market, and is one of the first commercialised native grain species. However it is a cool temperate species and thus could only be produced in a small area in the eastern parts of Gomeri country.

Kangaroo grass has a wide distribution across the country, is a very hardy and fire-responsive species, and has been proven to produce healthy, edible grain. It has been famously mentioned in many accounts of Aboriginal grain production. However on Gomeri country, the quantity of seed produced per hectare is



Examples of grains, pods or kernels which have historically been used for food.

small, the grain is difficult to thresh compared to other species, and it has low to moderate grazing value.”³ It may be culturally significant to some groups, but is otherwise not recommended at this emerging stage of the native grains industry.

QLD bluegrass has an aromatic inflorescence but very small seed. It is unlikely this species will be suitable for a bulk grain market, although as a pasture it is well-suited to the region.³

Of the remaining species, the choice of which species to plant will depend on the intended end use e.g. human food only versus revegetation/pastures market, whether the grasses will also be grazed, soil type of the production area and the farm’s climatic region. Availability of seed may also be a consideration (see section 3 Economic feasibility).

Due to its ease of threshing, soil and climatic adaptability within Gomeri country, potential yields per hectare and favourable taste of the flour, guli (native millet) is one of the best options for a human-food only enterprise. Button grass or warrego grass may be better options depending on soil type, rainfall and other complementary enterprises such as grazing.

1 <https://www.agrifutures.com.au/product/native-grasses-make-new-products-a-review-of-current-and-past-uses-and-assessment-of-potential/>
 2 <https://www.agrifutures.com.au/related-projects/native-legumes-as-a-grain-crop-for-diversification-in-australia/>
 3 https://centralwest.ils.nsw.gov.au/_data/assets/pdf_file/0007/567628/native-grasses-guide.pdf

Of the non-grain species, several acacia species already have established markets⁴, and as legume they are able to increase the nitrogen content of the soil. However the field management and harvesting of shrubs or trees such as the acacias is quite different to grasses. Some implications of mixed shrub/grass plantings are discussed below.

Dhamu (purslane or pigweed) produces large amounts of highly nutritious seed (particularly high in omega-3 fatty acids) and has an established market in other countries where it is also naturally found such as China, India and the Middle East. It is the subject of further research within this project.

Several native legumes, spiny mat rush, nardoo, kurrajong seed and quandong kernels can play important roles in grassland/woodland ecosystems as well as providing edible seed. Further research into poisons and anti-nutritional factors needs to be conducted before these species can be considered for sale on the bulk grains market.

There is considerable genetic variation within all the grain-producing species. Selecting plants which produce more grain but maintain their role on Country is an easy way to increase food production. It may be possible to increase yields between 10 and 100%, or perhaps more, by combining plant selection with controlled sowings, fertilisation, and other agricultural techniques. However, increasing the seed of only these plants and replacing previous paddocks with these new cultivars is possible in monoculture fields but very difficult in polyculture fields (see next section). Plant selection and breeding should be explored with this in mind.

Recommendation

From a paddock to plate perspective (sustainably growing, harvesting, processing, selling and producing food), guli (native millet) has the most potential on Gomeri country.

Growing pure seed stands (monoculture)

Creating a near-monoculture dhunbarrbilla will produce a pure bag of grain that can be easily sold. To start such an enterprise will require:

- Weed-free field. This may mean scalping the soil surface, several years of weed control prior to planting, or planting into a field which has been cropped for several years under a good weed control regime. Any of these options will require heavy machinery e.g. tractors, spray rigs, and concurrent expertise; or funds to employ a contractor. Conversion of a current pasture or rangeland to a near-monoculture native grain without machinery or chemicals would take many years (at least 10) in the vast majority of Gomeri country due to weeds, historic overgrazing and lack of fire in recent history.
- Seed. Current cost of seed is usually between \$100 and \$600 per kg depending on species. Seed is generally sown between 5 and 10 kg/ha.
- Planting equipment. Species which germinate from naked seeds can be sown through a regular seeder. However the majority of native species have awns/hairs and thus require either specialised equipment or to be coated to make the seed smooth enough to flow through pipes.

Detailed descriptions of sowing and establishing native grasses can be found at:

- dpi.nsw.gov.au/agriculture/pastures-and-rangelands/native-pastures



Coated versus uncoated Mitchell grass to enable seed to flow smoothly through pipes.

4 https://anfab.org.au/main.asp?_=Wattleseed



Sowing a monoculture seed production field with coated Mitchell grass seed.



Indigenous Food Research Park field at Narrabri, shortly after a cool burn.

Alternative growing options (polyculture or opportunistic)

Monoculture production is not the best option for all groups due to environmental, cultural or start-up cost reasons. This project is investigating five other options.

- Mixed grazing + dhunbarrbila. Livestock are used to manage the biomass/weeds in winter and produce an additional economic output to the grain. This needs careful management to prevent overgrazing and is of lower environmental value than the below options, but higher than monocultures and has guaranteed economic return.
- Pasture cropping. Sowing a winter crop into dhunbarrbila may produce an additional economic return and provides winter biomass to compete with weeds. This will only work in some climatic zones and requires equipment to sow, maintain and harvest introduced crop species.
- Multi-species native plant production. Multiple edible plant species may be grown together in a field, such as rows of saltbush and acacia between grasses, or mixed stands of winter versus summer productive species. It reduces the potential for chemical weed control but creates diversity of economic options (in both yearly schedule and markets).
- Opportunistic harvest of existing native grain areas. There are remnant areas of native grasses across the region; some of which can be harvested as-is to produce a low value product (post-harvest separation is required). This may include harvesting remnant native vegetation on farms, travelling stock routes, or native pastures. A contract situation might be the best approach.

Food ecosystems. Traditional Aboriginal food systems did not confine a small number of species to a field. The land yielded multiple hand-harvested plant and animal species existing in a managed ecosystem.

The food ecosystem option is the most desirable in terms of environmental and social outcomes, but the most uncertain in economic returns. This is because of its complexity, such as the nitrogen-fixing non-food species growing intertwined with the grains, native fauna assisting turnover of soil, and larger animals assisting in the recycling of nutrients as well some providing meat. This system is highly complex, based on thousands of years of intimate knowledge of the species, soil and climate, and all food was hand-harvested. Whether it can be replicated in a modern context is challenging given the cost of labour, strict food quality demands of markets and the distance to consumers meaning shelf life is paramount. However there is as strong desire to create a dynamic long-term research site for this purpose.

Recommendation

Further research at the hectare scale occurs for all these options both on-farm and on Country.

1.2 Harvesting

Collection of the grain can take many forms depending on the species. Examples include:

1. Cutting and windrowing, or drying on screens. Piles may be dried out in the sun or burnt before collection.



Two different genotypes of purslane being dried in the summer sun before seed collection.

3. Small scale collection using blower vac or similar equipment, which partially mulches the material as it passes through the fan.



With its low habit and small smooth seed which easily sheds from the seed heads, button grass is efficiently collected using a blower vac.

2. Harvesting ripe heads using a brush or paddles attached to a vacuum. Ripe seed and trash is sucked into the collection bin as it drives through a field; green matter is only gently disturbed.



'Rosevale Reaper' grass seed harvester, which is towed behind a ute in an offset position. Similar equipment is suitable for small, odd-shaped or uneven paddocks.

1.3 Processing

Unlike grain from domesticated crops, which have been bred to separate easily from husk during the harvest process, dhunbarr need threshing and cleaning after harvest.

This project, along with anecdotal reports from growers and other researchers, has identified the purification of grain as the most significant barrier to the economic success of a dhunbarrbila food system.



Separation of the three unwanted parts is time consuming and labour intensive, even with the assistance of modern equipment. Research-scale threshers, sieves, grinders and polishers of various rubbing materials, apertures and speeds have been tested, finding that harvested samples of 1 kg often yielded less than 100g of marketable seed for species such as kangaroo grass and Mitchell grass. Button grass, native millet and purslane are the easiest to thresh, but as the seed is small they may contain soil grains of similar size which are difficult to mechanically separate. Weeping grass has high seed yield per kg harvested sample and still requires post-harvest threshing, but is one of the easier grains to thresh and due to large seed size is also easy to sieve. Mitchell grass, signal grass and warrego grass are particularly difficult to mechanically thresh. However, some people who have tried warrego grass without complete threshing (only extraneous trash removed) indicated they do not mind the grassy taste, suggesting the partially threshed product may be suitable for sale to certain consumers.

The use of fire to burn trash around seeds was central to processing many native grain species by Kamilaroi people. Water was also used to assist separation of tightly held trash from grain. Both fire and water are likely to also be used in the future production and marketing chain, however it has implications for the flavour, nutrition, functional properties and shelf life of the end product as well as the processing costs (some positive, some negative). Thus further research is required.



Results of threshing tall oat grass (*Themeda avenacea*). Field-collected seed on left, removal of awns and trash in the middle, then removal of lemmas and paleas to end up with the pure seed on the right.



Experimenting with non-fire threshing methods: hand crank grain mill on widest setting, motorised thresher, manual rubbing.

The next step in the production chain depends on the end product. Some form of milling or grinding is required to make bread. Roller milling, stone milling and wholemeal grinding each produce flours of various nutritional and functional properties.

Non-traditional methods of processing might also be applied, such as crushing to kibble or polishing like rice. Some methods may be preferred for cultural reasons. Whilst the technologies of grain processing and cooking which required refined metals e.g. boiling, stewing, brewing, were not present on the Australian continent until recently, they are likely to be part of the future of the industry. Consultation with Gomeri people is important to the wholistic success of such ventures.

Currently available industrial milling equipment can be used on native grains. Whilst research would reveal further improvements, this project recommends milling research as low priority relative to threshing. Grains Research and Development Corporation¹ have an excellent overview of flour milling and quality for wheat.



Rich brown wholemeal kangaroo grass flour produced using a lab-scale grinder with 8mm sieve.

Recommendation

Processes and equipment for efficient threshing and seed purification be developed as a matter of urgency to decrease production costs.

¹ https://grdc.com.au/_data/assets/pdf_file/0011/202421/grdcwheatquality.pdf

1.4 Nutritional profile

Aboriginal people have ground plant seeds into flour and mixed it with water to create a paste eaten raw or cooked over fire for thousands of years. Despite this, reliable records of why certain species of *dhunbarrbila* were used for food throughout history are sparse. Similarly, our knowledge about the nutritional and functional properties of native grains is incomplete.

Worldwide, indigenous grains have been found to have excellent nutritional composition, both in macronutrients for providing energy (as protein, lipids and carbohydrates) and micronutrients, such as antioxidants, vitamins and minerals. Protein content in grain is particularly important as it is a key nutritional component of the human diet. Proteins provide the building blocks (amino acids) for creating

muscles, bones, enzymes and hormones required for healthy functioning of the body. Lipids, a group of energy-rich compounds, are similarly important for a healthy nutrition. Lipids in native grains can be high in polyunsaturated fatty acids which are beneficial for cardiovascular health and brain health and development. Native grains have the potential to protect against nutritional disease such as diabetes as they contain large amounts of fibre and slowly digestible starch which improve digestion and support the growth of beneficial microbes living in our gut. They also contain significant amounts of minerals or micronutrients – iron, magnesium and zinc – and vitamins including thiamine and riboflavin.



Wholegrain flour of edible native seeds plus wheat (top left) showing the diversity of colour and texture.

We measured the nutritional composition of 17 species of native Australian plant seeds and compared them to commercial varieties of three types of wheat (durum, bread and biscuit wheat). For this, we analysed the flour produced by grinding native seeds for macronutrients (lipids, carbohydrates and proteins), micronutrients and energy content.

We also measured features of the grain itself, including moisture content and colour, which are important indicators for shelf-life and processing properties of the flour, and which influence the quality of the final food product. Where possible, we analysed the grain and flour from more than one source to get an idea of variability of nutritional properties within the species.

The nutritional information presented in the table opposite is a snapshot of key results. Mitchell grass, which had the highest amount of protein of all the species sampled, contained 55% more protein and two and a half times the amount of minerals than bread wheat. Kangaroo grass contained 40% more protein, and five times more minerals compared to bread wheat. Seed from other species were also rich in protein and minerals, as well as polyunsaturated and omega-3 fatty acids. All species of Acacia that were tested (Mulga wattle is given as an example) and Kurrajong were higher in protein (50% greater), and had twice the amount of minerals compared to bread wheat. Seed from all native plants tested were higher in polyunsaturated fats (between 72 and 92% of total fat) compared to bread wheat (65%). Purslane was particularly high in minerals compared to bread wheat (23 times higher) and omega-3 fatty acids (10 times higher). Finally, most species had high fibre content, but analysis was incomplete at publication of this report, so no results have been included.








Four species of native grain flour, showing the diversity of colour and particle size.



Johnny cakes, including pure dhunbarr and blended dhunbarr and wheat, cooking on a BBQ at Narrabri.

This table highlights the nutritional properties of four indigenous species compared to bread wheat. Each species represents a particularly high content of one or two of the nutritional compounds tested (i.e. proteins, minerals, and unsaturated and omega-3 fats).

Species	Appearance	Nutritional properties Quantity per 100 g
Bread wheat (<i>Triticum aestivum</i> 'Sunmate') – comparison species		Energy: 1634 kJ Protein: 14.6 g Total fats: 2.5 g saturated fats: 0.5 g unsaturated fats: 2 g Total carbohydrates: 69 g Total minerals: 1.8 g
Mitchell grass (<i>Astrelba lappacea</i>) – high in protein		Energy: 1676 kJ Protein: 21.6–23.7 g Total fats: 4.6 g saturated fats: 1 g unsaturated fats: 3.6 g Total carbohydrates: 57 g Total minerals: 4.5 g
Kangaroo grass (<i>Themeda australis</i>) – high in protein and minerals		Energy: 1819 kJ Protein: 19.8–21.7 g Total fats: 8.5 g saturated fats: 0.9 g unsaturated fats: 7.6 g Total carbohydrates: 52 g Total minerals: 9.6 g
Mulga wattle (<i>Acacia aneura</i>) – high in protein		Energy: 1962 kJ Protein: 23.6–25.9 g Total fats: 11 g saturated fats: 1.8 g unsaturated fats: 9.2 g Total carbohydrates: 51 g Total minerals: 4.3 g
Purslane (<i>Portulaca oleracea</i>) – high in minerals and unsaturated and omega-3 fats		Energy: 1544 kJ Protein: 11.8–12.9 g Total fats: 9.4 g saturated fats: 2 g unsaturated fats: 7.4 g omega-3 fats: 3.6 g Total carbohydrates: 29 g Total minerals: 41 g

Recommendation

Overall, native grains are more nutritious than wheat. They contain more protein and minerals compared to wheat, and some contain particularly high levels of unsaturated and omega-3 fats. Seed from a greater variety of sources needs to be analysed to understand the variability of nutritional content according to growing conditions. Additionally, more detailed analysis is needed of the composition and types of proteins, starch, minerals, vitamins and fibre.

1.5 Food properties

The English word 'bread' has been frequently used to describe the foods made from native grains, however the white leavened loaves known today are not a good comparator. The high fibre, gluten free and high mineral flours from dhunbarr make heavy, dark and flat loaves. Dhunbarr have also been mixed with other native plants and used as stuffing.

Native grains are very hard compared to wheat. Particle size index (PSI) for Australian milling-grade wheat typically ranges from 9 to 11. Preliminary findings for native grains suggest the particle size index is between 3.5 and 5 (lower PSI represents harder grain). This has implications for the way they break into smaller pieces when milled, and how much water they absorb during cooking.

Dhunbarr can be mixed with wheat flour in various quantities to improve the flavour and nutritional properties of bread with relatively small impact on texture, shelf life and cooking requirements. A mixture of dhunbarr flour (15%) and wheat flour (85%) was created for four species and the properties of the composite flour, dough, and leavened bread made from this mixture were tested. The qualities tested were texture (stickiness, hardness, cohesiveness, springiness and chewiness), bread loaf volume and density, crust and crumb colour, crumb size and water activity. These quality tests are indicators of shelf life and consumer acceptability of the products. All quality parameters were compared to dough and bread prepared from 100% wheat as well as gluten-free species marketed as 'ancient grains' – millet and quinoa. This information is relevant not only to bread but also other flour-based products, such as crackers and biscuits.

Native grass flours produced darker breads with stronger, earthier flavours. Despite the deeper colour, the breads had similar functional properties. The addition of Dhunbarr flour at this concentration did not have a strong impact on the structure of the bread. All loaves were soft and springy, with a very similar texture to wheat bread. This showed that Dhunbarr flour can be incorporated into leavened wheat bread without adversely impacting the physical properties.



Guli (native millet) flour and quandong fruit cooked over hot coals at Tulladunna, Wee Waa.



Cooking johnny cakes (flatbreads) on the BBQ with blended wheat and dhunbarr flour.

Other options have been proposed for the use of various native grass and grain species, including as kibble, rolled grains, as a rice substitute, puffed grain, for oil or protein extraction, in sauces, as a coffee substitute, and to make beer. The ability to investigate these, and other food options, is hampered by the lack of raw product with which to experiment. The stories and traditions associated with dhunbarrbilla, and the role of Aboriginal people in developing these foods, should be considered when discussing new food products.

The next step in development of the paddock-to-plate chain is human taste testing (“sensory evaluation”) of products made by professional bakers and chefs. Creating the flavours and aromas which bring out the uniqueness of these species whilst maximising consumer acceptance is best done in partnerships between growers, the food industry, and researchers. The first step should be choosing the types of food products to trial based on knowledge of the market, rather than assumptions. The word ‘bread’ has been used to describe flame-grilled flour-based loaves for convenience, however mass-produced leavened breads not only bear little resemblance to dhuwarr, they may not be the best way to connect the dhunbarr story to modern consumers.



Bread made with 15% native millet (left), 15% weeping grass (middle) and 100% wheat (right).



Dhunbarr flours (top row) and non-native flours (bottom row).



Bread made with 15% quinoa (left), 15% acacia (middle) and 15% Warrego grass (right).

Recommendation

Dhunbarr flour can be blended with wheat at at least 15% in leavened bread without adverse effects on texture, whilst imparting unique flavours, colours and aromas. Partnerships with professional bakers, chefs and the food industry should investigate what food products are best made with native grains and flours, followed by sensory evaluation. This may include exploring different processing techniques, such as puffing, pre-cooking, roasting and rolling/flaking, which optimise sensory attributes.

1.6 Marketing to consumers

How much a consumer is willing to pay for a kilogram of dhunbarr forms the basis of business plans for the industry. Marketing foods with provenance and cultural branding can increase the end price, however they sometimes involve complex consumer behaviours (which may either be favourable or unfavourable towards cultural branding¹) and the type of food containing the dhunbarr plays a major role on price.

This project has begun the process of estimating the consumer price for dhunbarr by looking at the price of raw grains in supermarkets based on their nutritional value. This creates a baseline from which other factors which influence price of edible raw seed products in Australian retail stores can be built into future market research and modelling.

The notion that healthier foods are more expensive is well-established with the disparity of price between healthful and less healthful foods persistently expanding. This creates problems in food security especially to those without the resources to sustain a nutritious diet.

Most measures of nutritional quality focuses on total diets and not on single foods. This was due to a dogma that there were no good or bad foods, only bad diets with the common perception that “all foods can fit” to achieve a healthy diet. However, defining nutrient quality of individual foods may assist consumers in substituting healthier and more-nutrient dense options into their diets such as dhunbarr.

Data

Price data was obtained online from major retail chains such as Woolworths, Coles, Aldi and Harris Farm. Equally weighted pack sizes were used to control for the effect of bulk buying food products which may influence the retail price per weight.

The seed products that have been selected are unprocessed or minimally processed to ensure their nutritional properties have not been altered. Moreover, given the final cooked products from dhunbarr foods will vary, the research focused on grains sold in their raw form.

The seed products include wholemeal wheat flour, whole wheat grain, barley, oats, rolled oats, sunflower, pumpkin seeds, Khorasan wheat, spelt wheat grain, spelt wheat flour, rye, kibbled rye, kibbled wheat, linseed, triticale grain, rolled triticale, rice, brown rice, quinoa, chia seed, bulgur wheat, pearl barley, and sorghum.

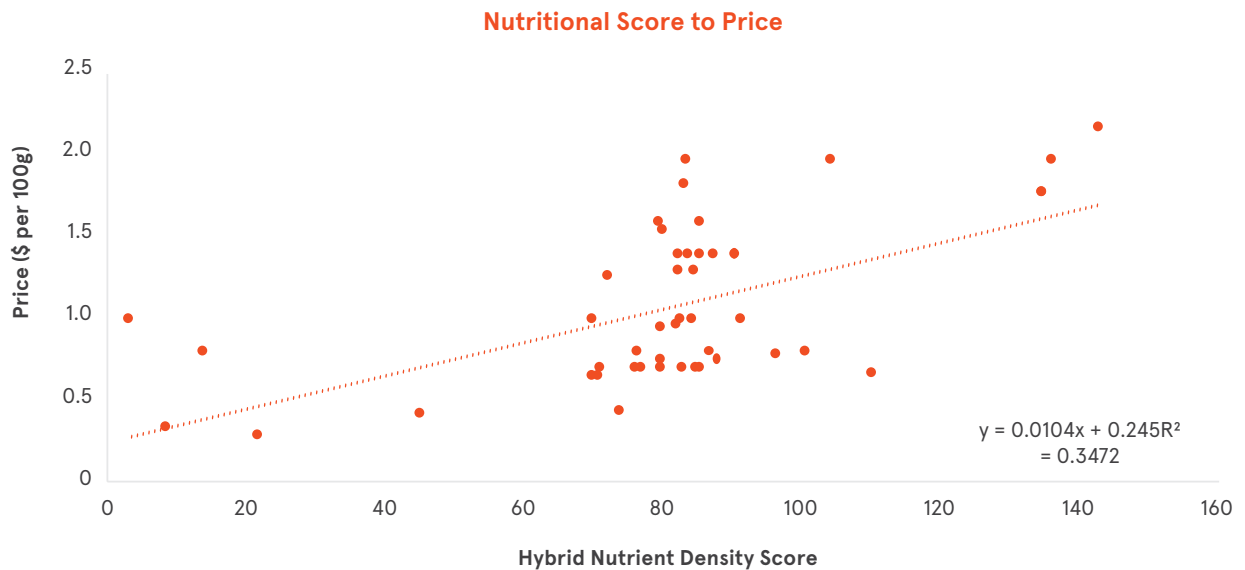
Further control variables were collected, including whether the seed product was gluten-free, ancient, organic as well as identification on the number of colour/s on the packaging.

A hybrid nutrient density score (HNDS) has been computed for each grain product. The HNDS is based on a combination of qualifying nutrients, or nutrients to encourage, such as protein, fibre, and a variety of vitamins and minerals, and on disqualifying nutrients, or nutrients to limit, typically saturated fat, sugars, and sodium.

¹ See John Newton's 'Oldest Foods on Earth'

Preliminary Results

This graph shows how much consumers are willing to pay for raw grains in supermarkets according to their real nutritional value.



Preliminary results (see graph above) reveal that consumers will generally pay more for nutrient-dense foods. However other properties also influenced price – for example, brown rice and black rice have very similar nutrient density scores (70 to 74), however price varied from \$0.42 to \$1.26 for 100g.

However, the current prices for bulk dhunbarr (equivalent to approximately \$10 to \$60 per 100g, section 1.1) far exceed the retail value for all products found in this preliminary analysis, regardless of HNDS.

From this point forward, and in-depth analysis on the effect of other characteristics of seed products that may relate to price will be conducted. They include whether the product is gluten-free, ancient or organic, the different marketing elements used on the packaging, and its Australian Health Star Rating.

Building on this, the impact of value adding on the price, particularly in the high-end markets, should be investigated. For example, what is the increase in value of the raw grain when it is milled then baked into a bread in a high-end restaurant? Both the price consumers will pay and the number of consumers willing to pay this price needs to be investigated.

Recommendation

As the price of dhunbarr far exceeds other nutritious grains, ways to decrease the price (likely through lowering costs of production) must be found. Alternatively, markets must be found which are willing to pay this high price e.g. high-end restaurants with interest in cultural, environmental or provenance branding.

2. Socio-cultural sustainability

It has been well documented by multiple authors (including Bruce Pascoe, Bill Gammage, Ralph Gerritson and Norman Tindale), that some Aboriginal nations relied on native grasses for grain production. These nations actively managed grasslands using cultural burning and harvested, stored and ground grains for flat-bread making. The Gomeroi (or Kamilaroi) nation was part of this Aboriginal grain-belt.

Due to colonisation, much knowledge, language and lore was fragmented, and in some cases lost, including knowledge on managing, producing and handling native grains. However, some knowledge has remained. Recent workshops and knowledge sharing days in Narrabri and Wee Waa have created opportunities for the communities to share some of this knowledge.

“You got to know that interconnectedness of everything that goes into that one piece of food....And when you know that, that’ll tell you where it comes from. And that’ll tell you who that mob is. That’ll tell you that Country. So that’ll tell you that language. So it can all speak for itself.”

Noel Butler, Native Grasses for Grains (NG4G) workshop

With a resurgent focus on native plants and products for sustainability and enterprise development, there is a clear lack of Indigenous engagement in and ownership of these value chains. Prominent Indigenous growers, like Bruce Pascoe and Clarence Slockee, as well as journalist Drew Rooke, explain;

“At the moment the bush food industry is massive, but when you look at how much money funnels back into Aboriginal communities and benefits Aboriginal people, it’s just such a small percentage that it’s f**king laughable.”

Clarence Slockee
Growth Industry¹

“I don’t want Australians to dispossess us a second time, by taking away our foods and the plants we domesticated all those years ago. I’m hoping they will remember where it came from and include Aboriginal people in the bounty that will flow from using Australian foods...you can’t eat our food if you can’t swallow our history.”

Bruce Pascoe
Swallowing our History²

“Remember (native foods) are imbued not just with tens of thousands of years of Aboriginal knowledge, spirituality and cultural heritage, but also the racism, frontier violence, theft of land and children, and massacres that have defined this continent’s more recent past.”

Drew Rooke
Growth Industry³

1 https://www.killyourdarlings.com.au/article/native-foods-and-white-australia/?fbclid=IwAR0Ev8Xb35KIS84OTVyXgoV9o_Fly86DsyOWMR4He7OEB4K1P2VkatBbE4

2 https://mattersjournal.com/stories/swallowingourhistory?format=amp&__twitter_impression=true&fbclid=IwAR1L_6Fqj8aipcVZe-U9Ev3uA0LwVOINudlulQTIN0vylzGLnb0s-rmpbqw

3 https://www.killyourdarlings.com.au/article/native-foods-and-white-australia/?fbclid=IwAR0Ev8Xb35KIS84OTVyXgoV9o_Fly86DsyOWMR4He7OEB4K1P2VkatBbE4

The need for Indigenous peoples to not only benefit, but to guide and direct research and enterprise development related to native foods, is paramount. This project has engaged with local Aboriginal communities, Gamilaraay knowledge-holders and Indigenous Elders and leaders beyond Gomerioi country. Via this engagement we aim to walk alongside Indigenous aspirations and have Indigenous viewpoints and aspirations guide the research.



Volunteers discussing Dhuwarr with representatives from five different Aboriginal communities from Gomerioi country, and representatives from Black Duck Foods on Yuin country (including Bruce Pascoe and Noel Butler), at Narrabri.



Volunteers preparing dough of various species and blends led by Aboriginal women from Wee Waa.

Alignment with community aspirations

The potential for a native grasses for grains enterprise to align with local community goals was explored through multiple discussions with representatives from the Narrabri and Wee Waa Local Aboriginal Land Councils (LALCs). Both LALCs have a strong focus on maintaining culture and language and have plans for using land/buildings they own/manage to achieve aspirations related to having a cultural/art centre, developing cultural awareness workshops, developing a native community garden, and developing places for tourism including hotel/restaurant.

For the Gomerioi traditional owners, igniting a native grasses industry is a way to:

- Sustainably use land owned/managed by Local Aboriginal Land Councils to generate income, jobs and training for community
- Enable community to take part in cultural practices of caring for Country including the use of cool-burns to manage grasslands
- Inspire the youth and integrate knowledge of native grasses into local school curriculum
- Develop Aboriginal-owned value chains from production to selling bakery products
- Begin healing Country and Mother Earth
- Encourage conventional farming to value native grasses and disrupt narrow and unsustainable conceptions of agriculture and grain production in Australia.

Reflections and recommendations

Aboriginal-run businesses are already operating on small scales e.g. Black Duck Foods on Yuin country.

Different communities may have different reasons for wanting to explore dhunbarr enterprise – community/culture over commercial profit, others will want both.

Opportunities

The Tulladunna Reserve presents a key place for experimenting with native grass regeneration. The reserve is co-managed with Wee Waa LALC and they see a strong opportunity for bringing back cultural burning and Indigenous land management via a native grasses project.



Cooking Johnny cakes/dhuwarr over hot coals at Tulladunna Reserve.

Narrabri LALC manages a piece of land backing onto the Namoi River which they currently lease out for grazing. While water on the property is a limitation, growing native grasses on this plot would align with their plans for developing a community garden on this site.

“We got to think about gender too, male and female. There’s a lot of Aboriginal families out there and they have to be included in the process of it all. This is where we need to our kids to be involved in this. One person don’t cover it.”

Bernadette Duncan, NG4G workshop

“We could certainly get volunteers from around here, we would make a community event of it and would share knowledge together.”

Narrabri LALC

Both LALCs expressed the following:

- **The need for community involvement:** LALCs understand that it may take time for this type of enterprise to become economically profitable, but that the range of non-economic co-benefits of pursuing this (see above in aspirations section) make the venture very worthwhile. The community would have to be involved in starting up a native grasses enterprise. It was also noted that there would be the possibility of generating income by selling seed to government, non-government and private entities; a strategy that is currently lucrative and would produce instant financial benefit for communities.
- **Collaboration between communities** was also suggested by some LALC members. In particular, some discussion focused on the strengths and weaknesses of different LALCs, for instance, Wee Waa LALC did not own (only manage) tracts of land suitable for commercial production of native grasses (they do manage a reserve, but there would have to be an agreement in place as this is a co-managed public reserve). In contrast, Narrabri LALC does own more suitable land. Due to this, the following was suggested;

“It would work best if we could partner with Narrabri LALC, that way, they could produce/harvest the grains and then perhaps we could process, package and post grains off, and that way we would be working together.”

Wee Waa LALC

Therefore, looking for options for communities to collaborate and strengthen their enterprises and share knowledge might be key in supporting early stage development of enterprises. Further to this, identifying value chains that link regional/rural Aboriginal communities to urban Aboriginal food producers and suppliers, as well as events like Blak Markets in La Perouse (<https://www.facebook.com/blakmarkets/>) would extend this collaboration beyond Gomerioi country and strengthen Aboriginal ownership over the whole value-chain. Further to the above points, both LALCs expressed that getting volunteers from community to initiate on-the-ground production and processing would be no problem;

- **Knowledge sharing** days are already facilitated by the LALCs, and a native grasses enterprise would add a new dimension to already existing, successful events;

“Our knowledge sharing days we’ve had, they’ve all been a really good success... we just have people come out and share their stories and just have a gathering there. Just like a big get together.”

Wee Waa LALC

Getting knowledge back into community, finding connections between existing knowledges and developing new knowledges together were seen as key benefits of a native grasses enterprise. Additionally, traditional owners expressed embeddedness of knowledge of native grasses in ecosystems, landscapes, peoples, cultures, language, lore and law;

“All of this is food, you need to know the story connected to the food. To do that you need access to your country, to your land, traditionally which is yours. And to be able to understand that, food like the kangaroo grass. We need to have this knowledge connected to the food because if you have the food then you got to know all the other plants that grow in connection with it...Then you know all the animals that are connected who need that and the birds and the insects. You got to know that interconnectedness of everything that goes into that one piece of food....And when you know that, that’ll tell you where it comes from. And that’ll tell you who that mob is. That’ll tell you that Country. So that’ll tell you that language. So it can all speak for itself. So we need the rights and we need

the opportunity for all our mob to be able to access our traditional lands, not be locked out. So we can get our elders and stuff with their knowledge... and take everybody back to those places, then we can start to learn all our connectedness about where we belong back to Mother Earth. And all that food that comes to her is what we need to survive. That’s how it’s been for 100,000 years and we’re sort of losing our way now which we all know, so we need to get that back.”

Noel Butler, NG4G workshop

A reinvigoration of local identity, particularly in the youth, through knowledge sharing was viewed as an empowering aspect. Working side-by-side with colonial food systems and environmental management structures was also viewed as important;

“So we need this greater acceptance of who we are and the knowledge we’ve got, we need that first, and then be allowed to be able to have access to re-strengthening that knowledge and sharing that with our mob and our people who are the keepers of Country, of the land, and work on that then with a side-by-side thing is what we say.”

Noel Butler, NG4G workshop

Furthermore, knowledge sharing with non-indigenous community members through a native grass enterprise was seen as an opportunity. Being able to educate and raise awareness in the wider community on the importance and value of native species and the role they play and can play in our socio-ecological systems was a key motivation for some community members.

- **Economic benefits:** The ability to generate profits and move towards economic self-sustainment was viewed as a key opportunity via a native grasses enterprise. LALCs expressed both the limitations and strengths of current funding models;

“The money the land council gets... it only employs one person, everyone else volunteers”

Wee Waa LALC

“Then another funding we’re going to have to renovate the building, gut it, we were down with the builder last week. The council builder, so they’re going to govern and do it the way we want it to be done. So ...we can sustain that but over here it’s nearly 12 thousand dollars a year, we’ve not got funding [for that].”

Wee Waa LALC

“We may not be able to generate a lot of income from this, but it would be great if we could get this going and teach the young ones so that they can be inspired and become native grass farmers one day”

Narrabri LALC



Baking Johnny cakes at Narrabri (left to right: Callum Craigie, Lyn Pascoe, Bruce Pascoe).



Knowledge sharing around native grains at Narrabri LALC.

- **Links into formal education:** Teaching the next generation and building their capacity for involvement in a native grass industry was a strong desire amongst all participants. Embedding knowledge and activities around native grasses and native foods in general into local school curricula across disciplines, including science, food tech and art was particularly expressed by members of the Narrabri LALC;

“In our local school, we have a community garden and they use the food in food tech. We could do the same with a patch of native grasses and we could use it to teach into lots of different subjects”

Narrabri LALC

Beyond the schooling environment, there were strong suggestions for embedding this knowledge and developing skills for this enterprise into local TAFE courses. Wee Waa LALC members specifically discussed the conservation certificate that some community members were currently completing at Moree TAFE. Other participants at workshops likewise expressed this opinion and saw education, skill-building and qualifications for community as key opportunities;

“I think we need better educational opportunities for our people as well so that our people can be involved in these activities”

Bruce Pascoe, NG4G workshop

Reflections and recommendations

There is opportunity and interest in connecting with Aboriginal businesses in Sydney to begin selling products on a very small scale.

Awareness needs to be increased around trademarking language and knowledge, and the use of intellectual property in research and development.

“Then pulling out those [species] that are the food banks or the possibility of our food production plants from different grasses and grains that grow in the different areas. Putting that or suggesting that that information gets put into curriculum at TAFE for people who we can employ for work, who are currently unemployed. So anywhere you can have a scheme that changes directly, they get the knowledge through horticulture courses on propagating or growing or planting and the farm techniques on that.”

Rhonda Ashby, NG4G workshop

“Then you get our people into it, then get a uni degree and go further, become the teachers... that way is employment for our people, keeping us in the industries that we want our people to work in alongside our own people and we’re starting to get somewhere...that takes all Aboriginal people off unemployment and improves our health. We can afford better housing, it gets rid of a lot of discrimination because we’re moving...all of us all together like we do, support each other, that’s how we survive. And it changes attitudes and it changes opportunities...it’s called sharing the love.”

Noel Butler, NG4G workshop

Potential barriers

- **What products to develop and will they meet consumer demands:** There were questions raised as to whether products derived from native grasses would be accepted by mainstream consumers; with the following question raised in all focus groups: do people really want to eat these grains? Beyond this, we discussed the potential for value-added products to be developed first, but exactly what types of products should be and where they should be sold was expressed as a point of uncertainty and a potential vulnerability in developing a native grains enterprise.
- **Knowledge of cultural burning:** To manage native grasses, there would need to be some trial and error embedded in practices. There is a need to bring back knowledge of cool burns and upskill the community in these practices. Wee Waa LALC in particular discussed an imperative to bring back this knowledge for caring for Country – for cultural purposes extending beyond enterprise development.
- **Different communities have different aspirations:** A key point that was iterated throughout discussions and evident in different community member responses, was a difference in objectives related to starting up a native grasses enterprise. For many, it would be fulfilling cultural and community aspirations, and the commercialisation of grasses was viewed as less important. For others, cultural aspirations were also important, but the potential to generate income from commercialisation was viewed as a key motivation – generating income from existing land and being able to manage that land in a way that cares for Country while being for profit and thus create employment opportunities was viewed as a win/win venture. The core purpose or motivation behind developing a native grass enterprise varied greatly and this needs to be taken into consideration.
- **Should native grass production adhere to conventional agriculture:** potential dhunbarrbilla systems were viewed differently by Indigenous communities and plant scientists/agronomists. While plant breeding and monocultural crops are viewed as the best way to produce grains for commercial purposes by maximising yields and efficiencies, Aboriginal community members expressed that their views for a native grass enterprise to include diverse grasslands, using plants that have not been bred or modified for production.

“We need to be careful not to go down that road where people want to make our grains bigger and bigger and bigger because the country can’t support it. And we have to respect 120,000 years of our history where the old people were very satisfied with what Mother Earth could give them and they worked with the earth rather than against the earth. It’s a really important principle for us to remember and to teach our kids so that we can resist this desire for plant scientists to create a new plant. We don’t want a new plant, we want our own plant. We want the plant that is good for Country.”

Bruce Pascoe, NG4G workshop

“Every plant is part of a community, if you take that plant away from their community it is like taking you away from your community, how would you feel?”

Uncle Len Waters

While this last point is not necessarily a barrier, it would mean that consumers would need to accept different mixes of seed in their products and that grain supply would not be regular or uniform.

“We want the employment, we want the recognition, we want the cultural and historical knowledge to be respected. We have to be really careful. There’s enormous amount of goodwill in the non-Aboriginal community but it often doesn’t translate into money for us or employment for us so we have to insist on it.”

Rhonda Ashby, NG4G workshop

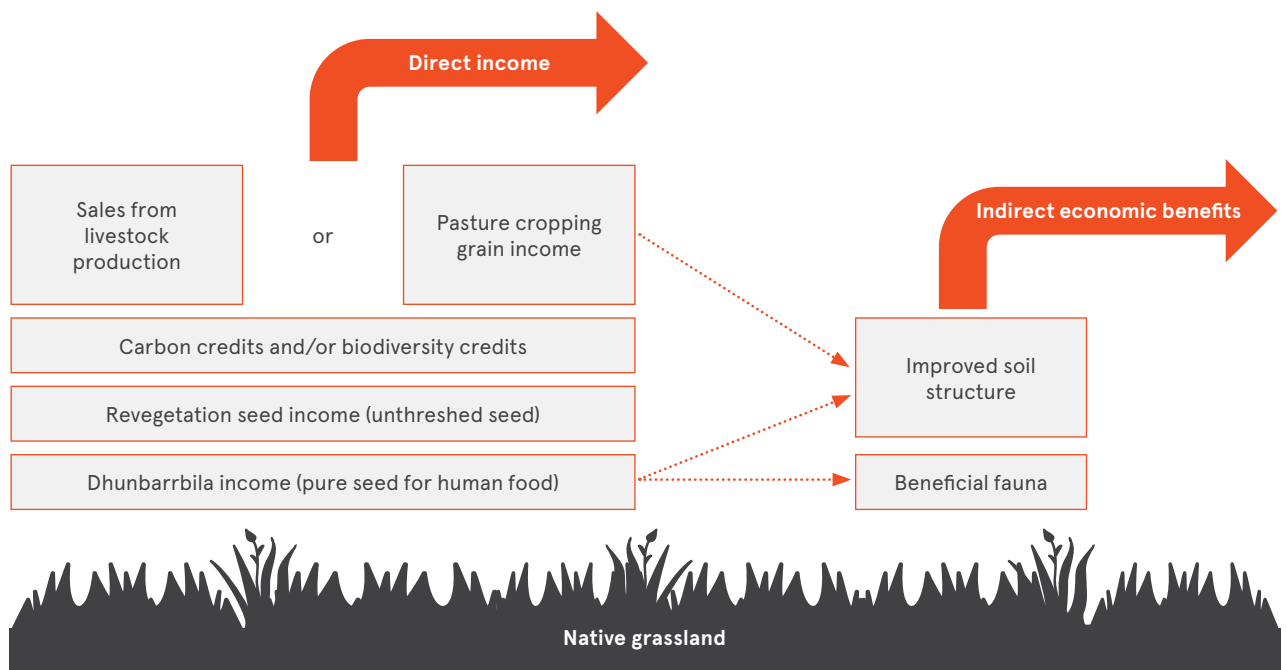
Reflections and recommendations

Native grasses as an industry may benefit communities and LALCs, the latter who are currently particularly reliant on external funding sources, provided the potential barriers above are discussed and addressed.

3. The economic prospects of on-farm native grass production

Over past decades there has been a growing interest in production of native grasses both for ecological purposes, productive purposes in farming and for developing and commercialising Indigenous foods and medicinal products. A mix of native grass species can be combined in a pasture and managed as a natural ecosystem. Native grass production on farm allows multiple outputs (vertical stacking): pasture cropping, grazing for livestock production, native grass seed sales, increased biodiversity, improved soil structure and carbon storage.

An illustration of vertical stacking. Each box represents a source of income, all based on a native grassland



Although nonarable farmland is often used for pasture that is a mix of exotic and native grasses (unimproved pasture), established native perennial pastures that are a mix of natives alone are rare on Gomerioi country. The practice of pasture cropping itself has been adopted by some farms but the percentage of cropping area under pasture cropping in Australia is about 1%, so the practice is not widespread.

For this project, to explore the economic possibilities of introducing native grass production in a whole-farm context, a representative farm model for the Narrabri region was built. The model mimics the farmer's decision problem: to maximise total gross margins on the farm what mix of crops, pasture and livestock can be produced with the available farm resources?

Along with production options of crops, cattle can be fattened on improved pasture, unimproved pasture (a mix of exotic and native grasses) or pure native pasture (a mix of QLD Bluegrass, Mitchell Grass and Native Millet). In this project field trials are being run on different management techniques for pure native grass production. A choice of management techniques was modelled that includes:

- cool burning
- grazing
- pasture cropping (with the crop faba beans)
- monoculture
- Kangaroo grass on the hilly timbered nonarable land

Flexible options for marketing native grass seed were also included in the modelling scenario. Native grass seed can be sold:

- unthreshed to the mine site rehabilitation and government revegetation markets
- to local Indigenous harvesters to use in Indigenous dhunbarrbila production enterprises, or
- as threshed grain for sale to the human consumption market.



Cattle grazing a typical open woodland pasture on Gomerioi country during the 2017-2020 drought.

Results

Across a range of rotations of the crops and pastures, the farm decision model indicates that native grass production would be included in the farm plan along with crops and cattle fattening. Preliminary findings indicate that areas of nonarable land could be devoted to native grass production by cool burning along with areas devoted to pasture cropping with local Indigenous harvest. Improved pasture produces the greatest amount of feed for the cattle, and native pasture the least. Results indicate that if improved pasture is incorporated in the crop rotation, cattle will be fattened on improved pasture alone and native grasses used for pasture crops and seed crops. Without improved pasture in a rotation, a combination of unimproved and native grass pastures is included in the plan to fatten the cattle, produce grass seed and pasture crop.

As always, many questions arise in research. This model assumes requirements for native grass establishment and management are understood and that markets for native grass seeds function well. However, these markets are known to be fragmented, with poor information flows. Demand is inconsistent, but potentially large, arising from mine site rehabilitation, government and local community regeneration projects, and for food and medicinal products. Supply is erratic and there are only a few fully commercialised sellers, and some semi-commercialised small producers of seed. Native grass seed is currently expensive, but this would change as more supply comes into the market. Drivers in the research of how much native grass pasture is produced are the price of native grass seeds, the yield of seeds from the native grasses and the price of faba beans. Across a range of values for these prices and yields, native grass pastures remained in the farm plan.

The environmental benefits of production with an ecosystem approach of a mix of native grasses are likely to be substantial. Compared to introduced grass species, if native grasses store more carbon underground than exotic grasses there might be greater soil stabilization with the native grasses. Similarly, depending on the way the field is operated, it may also be a haven for wildlife, increase on-farm biodiversity, or preserve endangered habitat or species. Moving forward with data from field trials, the farm model will be extended to incorporate the potential for farmers to generate carbon credits for soil organic carbon or other credits for environmental outcomes.

At a broader industry scale, the issue of provenance arises in all native seed markets for revegetation projects and will be crucial for sustainable commercialisation of food and medicinal products. There is no established industry body for native seeds that deals with issues of provenance, seed viability and related production practice issues. Provenance is a mixture of culture, Country and environment. Indigenous Australians possess a history and understanding of native grass management and production so are best placed to establish and control a representative body for the native seed industry.

Reflections and recommendations

Incorporation of a dhunbarrbila enterprise is an economically viable part of a farm under certain circumstances. This includes making decisions on the uses of arable versus non-arable land, or improved versus non-improved pasture, as well as vertical stacking of activities such as pasture cropping with native grain production. Native seed production brings with it the possibility of linking with local Indigenous dhunbarrbila businesses. However, many challenges and opportunities exist in native seed markets.

4. Environmental sustainability

Environmental sustainability has a number of definitions, but the essence of the concept is that it encompasses habits and practices where humans interact with their natural environment in a way that natural resources are not degraded or diminished.

According to the definition proposed by the United Nations, practices that provide for environmental sustainability are those that support the long-term quality of the environment for the needs of future generations.

Modern industrial agricultural systems produce food and other commodities in large quantities with the quality and at the price required for economic markets. However, when poor agricultural practices are used in these large industrialised systems, it causes harm to the environment. For example, tillage and fallow practices can lead to degradation of soil quality, depletion of soil water and can pose a risk for contamination of surrounding land and waterways with runoff of chemical residues.



Cool burn on the native grains production area at Llara, March 2020. Cool burns are used on Gomerai country to manage native grasslands without chemicals or tillage.

Sustainable agriculture seeks to minimise the impact of farming on the environment. This is done by using cultivation methods that reduce water use and soil disturbance, limit dependence on fertilisers, promote carbon and nutrient cycling and lessen the need for pest and weed control. Additional benefits such as increasing biodiversity, carbon sequestration, improved water infiltration into soil and reducing crop disease are also possible to achieve.

“When you have a look at what’s happening to our land, the salination and the land degradation, what we’re doing, we’re still going and going ahead even with just the animals. We’ve already destroyed to extinction more species than every other country in the world. It’s a shocking result and that’s happened in 230 years.”

Noel Butler, NG4G workshop

Growing and using native plant species in an agricultural or horticultural setting is a valuable way of using the environment in a productive and balanced way. As an illustration of this point, because many native Australian plants are perennials – meaning that they live for more than one or two years – soil disturbance associated with tilling and sowing is reduced for dhunbarrbila. Having plant cover for long periods of time will also protect soil surfaces by reducing water and wind erosion.

Many plants that occur naturally in Australia have adapted to low nutrient soils and are often adversely affected if they have high nutrient inputs. Dhunbarrbila therefore require fewer nutrient inputs as fertilisers.

The same principle applies for the use of water resources by perennial native plants. Much of Australia has low, seasonally-available rainfall. Native plants have adapted to these conditions in many ways including root systems with tap roots that can access deep soil water reserves and shallow roots that take advantage of periodic rainfall events. Other adaptations include reduced growth, and therefore lower water use, during the dry season and possession of a multitude of specialised features that are plant versions of ‘water-saving devices’.

As an example, old man saltbush (*Atriplex nummularia*), one of the species investigated in this project, occurs naturally in low rainfall and arid areas. This species has a dimorphic root system with both deep tap roots and surface roots coupled with hairy leaves that help reduce water loss. A closely related species, bladder saltbush (*Atriplex vesicularia*) produces a fruit that is surrounded by tissue impregnated with a soluble salt. For seeds to germinate, about 50 mm of rainfall is needed to leach, or remove, this restrictive salt.



Saltbushes (*Atriplex* spp.) are common on Gomerai country.

As a consequence of low water and nutrient requirements, some native crops may take longer to become established and have slower growth rates than traditional crops. Appropriate management practices are needed to allow for slower rates of growth.

Not all native species can grow on limited resources – many types of mitchell grass (*Astrebula* spp.) have high water requirements and sowing is recommended when there is plenty of soil moisture available. Similarly, weeping grass (*Microlaena stipoides*), an important forage grass for livestock, grows well in soil with high fertility.



Mitchell grass on deep cracking clay soil near Bellata.

The key to using native plants in sustainable agriculture is to use species that are local to the area. This means that they will be able to cope with water and nutrient limitations (or excesses) and be adjusted to the seasonal conditions and regional soil types.

Understanding the conditions needed for establishment and growth of potential native cropping species is essential for putting them into an agricultural setting. In our studies using seed from a range of native grasses, including guli, we have tested pre-germination treatments – heat, aerosol smoke or soluble compounds in smoke – that can be applied in a relatively natural way (e.g. burning prepared areas). We found that exposing seed to smoke and the compounds in smoke ('seed starter') had the greatest germination success.

We also found that method of collection, harvest and storage has a role in germination success. For example seed of kangaroo grass (*Themeda australis*) collected from different localities in New South Wales and Victoria and harvested by different methods (e.g. manually collected from naturally occurring populations or machine harvested from cultivated plots) had different responses to germination treatments (see graph). Further studies are being done to try to tease apart the relative importance of each of these variables.

Under controlled conditions in the laboratory, different grass species had diverse germination success (see table). Regardless of the treatment applied (heat, smoke or exposure to soluble compounds in ash), many species responded in the same way with consistently high proportions of seed germinating (e.g. *Dichanthium sericeum*) through to very poor germination (e.g. *Eulalia aurea*, *Poa labillardieri*, *Eriachne obtusa*). Seed from different populations of *Themeda australis* and *Cymbopogon obectus* showed variable germination success even within the same species.

Reflections and recommendations

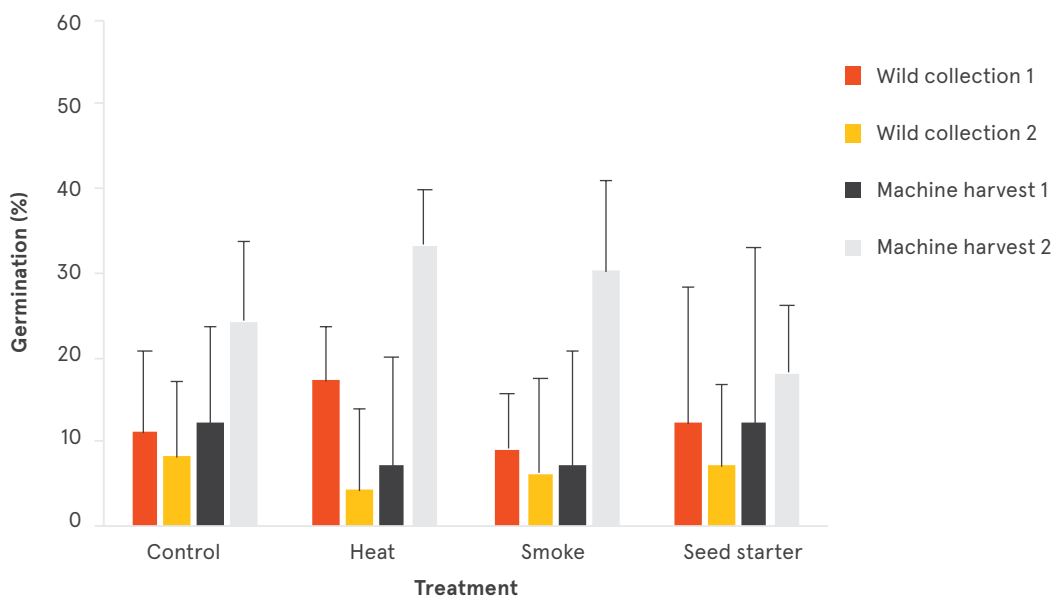
There is a great deal of basic ecology and physiology of native grassland species and dhunbarrbila systems that we do not know yet know making this a rich 'field' for future research.



Successful germination of kangaroo grass seed under experimental conditions.



Applying smoke treatment to seed to promote germination.



Germination response (%) of kangaroo grass to four treatments (Control – no treatment; Heat – heated in an oven at 60°C for 2 minutes; Smoke – exposed to smoke from burnt eucalyptus leaves for 10 minutes; Seed starter – seed soaked in solution made from commercially available product) after 21 days.

Table right: Germination success (%) of a range of grass species. The value provided is the greatest proportion of seed germinated among the four treatments applied (Control – no treatment; Heat – heated in an oven at 60°C for 2 minutes; Smoke – exposed to smoke from burnt eucalyptus leaves for 10 minutes; Ash leachate – seed soaked in solution made from mixing ash in water) after 30 days. ND indicates that there was no significant difference in germination among treatments; for three species there was a significant difference detected.

Grass species	Germination (%)	Treatment
<i>Dichanthium sericeum</i>	97	ND
<i>Heteropogon contortus</i>	60	ND
<i>Joycea pallida</i>	48	ND
<i>Cymbopogon refractus</i>	48	Ash leachate > Control = Heat
<i>Panicum decompositum</i>	47	ND
<i>Digitaria brownii</i>	42	Control > Smoke
<i>Austrostipa scabra</i>	39	ND
<i>Heteropogon triticeus</i>	22	ND
<i>Themeda australis</i> (Population 1)	21	ND
<i>Themeda australis</i> (Population 2)	6	ND
<i>Paspalidium distans</i>	18	Smoke > Heat
<i>Cymbopogon obectus</i> (Population 1)	16	ND
<i>Cymbopogon obectus</i> (Population 2)	5	ND
<i>Austroanthonia</i> sp.	12	ND
<i>Eulalia aurea</i>	3	ND
<i>Poa labillardieri</i>	2	ND
<i>Eriachne obtusa</i>	1	ND

5. Farming systems context

Gomeroi country contains some of the richest cropping soils in Eastern Australia. The millions of hectares of deep cracking clays, relatively flat country cut by slow-flowing rivers, and access to good quality ground water support a range of agricultural activities, including irrigated cropping, extensive dryland cropping and livestock grazing.

This region has a reputation around the world for producing high quality grain, much of which is exported. Wheat, cotton, chickpea, barley, sorghum and canola are amongst the common crops in the area. Underpinning these enterprises have been significant investments in research and development both overseas and in Australia. The 'Green Revolution' of the mid-20th Century and work at local research stations such as the I.A. Watson Grains Research Centre in Narrabri and the Australian Cotton Research Centre in Wee Waa, have greatly increased the yield potential and profitability of crops on Gomeroi country.

These crops produce significantly more grains per hectare than native species (section 1.1). This same trend is true for the biomass production of many introduced pasture species compared to native species. With the world population set to reach 9

billion people over the next few decades, research is continuing to focus on ways to meet the demand for safe, sustainably-produced food and fibre from the same amount of land as is currently available. The alternative would be to clear more land. This is the context into which dhunbarrbila enterprises would enter the agriculture industry.

Almost all land managers on Gomeroi country have areas of native vegetation, usually grassland or open woodland, on their properties. It is usually unmanaged or minimally managed with stock.

As part of this project, the views of local non-Aboriginal land managers toward dhunbarrbila as a potential enterprise were sought in both formal and informal interviews.

Dhunbarrbila is generally believed to be a good option to make non-arable land produce income. This would provide land managers with the resources to do things like remove weeds, revegetate creek lines and better control feral animals. This improves the environmental sustainability of their properties, with both tangible and intangible benefits to elsewhere on the farm.



Aerial image of The University of Sydney's Narrabri campus and research farms. The coloured farm boundaries illustrate typical examples of mixed cropping and livestock properties on Gomeroi country.

However, most land managers did not consider dhunbarrbila enterprises likely to be more profitable than current cropping rotations. This was based on farmers perceptions of the costs of production and farm-gate price relative to cereal-legume rotations or irrigated crops. Hence they believed dhunbarrbila would only be suited to non-arable land.

“A lot of croppers around here have some hilly country that they don’t use for cropping, so that could be used for native grass production. I think they would be interested in making a bit of cash out of their unimproved areas although these are also used for grazing in mixed farming systems”

Agronomists workshop

It was also considered unable to produce a marketable commodity unless grown as a monoculture

“Agronomically, you would want to grow these grasses as a monoculture and because they don’t yield much grain, so they would also need some selection and plant-breeding I would think”

Agronomists workshop



Inspecting native-dominant pasture on a hillside in late summer, with a low-lying cropping paddock in fallow in the background.

The direct experience of this project, as well as informal discussions with those in the grains and cotton industries, is that dhunbarrbila enterprises can be a distraction from core farm business for large cropping (particularly irrigated cropping) enterprises. A contract or leasing arrangement for managing dhunbarrbila enterprises within larger farms e.g. in ‘back paddocks’ or along creeklines, or on crown land e.g. stock routes, was suggested in some form by several land managers.

The rise of regenerative agriculture (transforming marginal land back to native grasses, using the seed bank and grazing to stimulate growth and diversity) was not mentioned directly within the consultation done for this project on Gomerioi country, however some growers in the district are known to practice regenerative agriculture methods. Similarly, pasture cropping/no kill cropping or multi species cropping were also not mentioned. The fact it was not mentioned suggests there is potential for native grains research to incorporate education of regenerative agriculture principles when describing the ways native grasses can be incorporated on to farms in the region (section 1.1).

Conclusion

Many non-Aboriginal land managers on Gomerioi country are interested in the potential benefits of dhunbarrbila for non-arable parts of their properties. There is potential for leasing or contract harvesting (possibly by Aboriginal-owned businesses) to drive the uptake of dhunbarrbila enterprises on farms.

6. Conclusion

By looking at the economic, environmental and socio-cultural aspects of the dhuwarr production system from the paddock to the plate, several areas for further research and development were identified. The highest priority areas, all of which relate to the economic sustainability of the system, are development of an efficient threshing and cleaning process for food-grade seed, market research into how much consumers would be willing to pay for the final product (and the size of this market) and improvements in the efficiency of native grains markets.

The next priority for research is food product development. Of the 17 species surveyed, those likely to have the greatest nutritional benefit are Mitchell grass, kangaroo grass, purslane and acacias e.g. mulga. However the appropriate food product to use these in may not be bread, particularly for the species high in fatty acids. Furthermore, food product development should be done as a partnership between producers, chefs and Aboriginal communities, as the species that are the most marketable/nutritious are not necessarily the same ones that grow well or are well known in communities, and vice versa. Native millet is a good example.

In addition, quantification of the environmental benefits of the system, including carbon sequestration, biodiversity benefits or preservation of threatened species or habitats should be quantified with real field data for the six growing methods listed in section 1.1. This data can be used to make policy recommendations to governments, as well as in economic modelling.

The socio-cultural sustainability of the system has the right building blocks, provided Gomeroi people are given the resources (land, equipment, skills and market connections) to participate in the industry as it emerges. This will include consideration of appropriate business models, and ways to collaborate between land holders of all cultural backgrounds to take advantage of areas of land which can be easily used for dhunbarrbilla production.

This project also found that apart from threshing and cleaning operations, the knowledge, processes and equipment already exist for producing both the raw product and high quality foods in a modern environment.

Finally, we conclude that despite the challenges, the scope for a dhunbarrbilla on Gomeroi country (NW NSW) for people of all cultural backgrounds is positive, and brings excellent opportunities for rejuvenation of country.

Acknowledgements

Financial support for this project has been provided by the Australian Government's National Landcare Program and the University of Sydney.



National
Landcare
Program



THE UNIVERSITY OF
SYDNEY
—
Institute of
Agriculture



The people and organisations who are supporting this project in-kind with time, skills, resources are incredible and too numerous to mention. The below are a subset who contributed to this report specifically; thank you for your engagement.

Kamilaroi elders, community members and Lands Councils

- Rhonda Ashby
- Bernadette Duncan
- Steven Booby
- Lynn Trindall
- Narrabri Local Aboriginal Lands Council and community members
- Wee Waa Local Aboriginal Lands Council and community members
- Mungindi Local Aboriginal Lands Council

Black Duck Foods

- Bruce Pascoe, Noel Butler and team
- Chris Andrew

TAFE NSW

- Tony Meppem

The University of Sydney - staff

- Jaime Gongora
- John Bateman
- Kieran Shephard
- Peter Bell
- Emma Pavey
- David Gallacher
- Team at the DVC-ISS office

The University of Sydney - students

- Tracy Leung
- Jenifer Jenifer
- Sophie Fowler
- Sam Padgett
- Sebastian Pietz

Industry partners

- David Carr, Stringybark Ecological
- Steve Field and Lorena Ruiz Talonia, Field's Environmental Solutions
- Colin Seis, 'Winona'
- Graham Hand, Stipa
- Lee Mosionek, Australian Grain Technologies
- Drew Penberthy and Mitch Cuell, Penagcon
- John Duncombe, 'Fairview'

NSW Local Land Services

- Milton Lewis
- Luke Raveneau

University of New England

- Wal Whalley
- Boyd Wright



www.sydney.edu.au/science/our-research/research-areas/life-and-environmental-sciences/indigenous-grasslands-grain.html

Narrabri reception: (02) 6799 2200