



**UNIT 2: FOOD AND
THE ENVIRONMENT**

L.21

**CARBON
FARMING**

Note to Teachers

Conventional farming contributes to global warming because of its dependence on petrochemicals for farm machinery, transportation, fertilizers, herbicides and pesticides. Although estimates differ, farms contribute roughly 10% of greenhouse gases. By eliminating petrochemical inputs and providing food for the local community, sustainable farming techniques can radically diminish greenhouse emission. Furthermore, agricultural practices called “carbon farming” can actively fix carbon in the soil. Lesson 21 examines the carbon cycle and the practices of carbon farming. In the process it questions a common assumption: that conventional farming is the only way that we can meet the food needs of the world’s population.

Damage to a fragile landscape caused by British farming practices has led Australian farmers to become leaders in carbon farming techniques. Australia may feel very far away to your students, so you may wish to stress the practices rather than the place. At the same time, students may benefit from remembering that conventional farming has caused considerable environmental damage worldwide. Americans, furthermore, are not always leaders in spearheading change to address environmental degradation. Additional context for carbon farming can be found in optional Lesson 21a.

Goals *In this lesson, students will*

- understand global problems posed by climate change.
- learn that farmers are developing methods to address the problem of greenhouse gas emissions caused by agriculture

Objectives

- Students will examine visual evidence of climate change to understand its impact around the world
- Students will review the carbon cycle and the sources of greenhouse gas emissions through a map and video.

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Please use this margin to notate how to best adapt this curriculum to your students.

Objectives CONT.

- Students will use a reading and/or presentation to study carbon farming practices and their consequences.

Materials

- Reading
- Computer with Internet access and projector.

INSTRUCTIONS

Part I: Evidence of Changes from Global Warming

1. Show students the set of slides included in the accompanying presentation. These photos illustrate the evidence of global warming, as witnessed by observers from around the world who contributed their photographs to a National Geographic Magazine campaign to record climate change. These photos represent a few of the photographs selected for publication by the editor.
2. As you move slowly through the slides, ask students to jot down what they notice about the consequences of climate change. Then share these observations with the full group.

Part II: The Cause of These Changes?

3. Ask students what they know about global warming. Once they have shared their ideas, show students Slide #8, a graphic that illustrates the “thermal blanket” that surrounds the earth.

Most of this blanket is water vapor, but it also contains carbon dioxide (CO₂), methane, nitrous oxide, and chlorofluorocarbons.

Since the industrial revolution, we have increased our production of these gasses, causing more heat to be trapped, which raises the earth’s temperature.

Burning fossil fuels such as oil and coal, which are rich in carbon, releases carbon dioxide (CO₂) into the atmosphere.

This state of affairs is the reason for which scientists, writers and politicians have emphasized the need to move to alternative forms of energy, such as wind and solar, which are renewable and do not release CO₂.

4. In order to understand why carbon dioxide is a problem, it is important to know more about carbon and the carbon cycle. Show students this video.

<http://ed.ted.com/lessons/the-carbon-cycle-nathaniel-manning>

Part III: Carbon Farming

5. Good news: good farming practices can directly address the emission of carbon into the atmosphere.

Divide students into groups of roughly three and distribute the attached handout.



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(10 minutes) Ask them to read it carefully, taking notes, annotating or highlighting—whatever your preferred method.

(10 minutes) Once students have read the handout, ask them to discuss their questions and understanding with the members of their group.

Open the floor for a full class discussion, beginning with their questions.

Some of this material will likely be familiar to students. At the same time, it refers to complex processes that are simplified here, in order to assure that the carbon cycle and climate change do not overwhelm a conversation about carbon farming.

Help students articulate what they do understand about the important ideas from this text, and work through their questions.

End the session, if you have time, by giving students a small sheet of paper on which they should record the “takeaway” insight they gained from today’s discussion.

Part IV: Cooking Lab

1. Return to the photo of the root systems of perennial grains. Remind students that the root systems enable plants to access soil moisture and nutrients and stabilize soil structure. If we want to promote the logic of carbon fixing and carbon farming, we want to promote the growth of perennial plants.

The grasses eaten by grazing animals tend to be perennials, but the plants that we have domesticated for our food are virtually all annuals.

One strategy being pursued to increase carbon farming is the development of successful perennial crops, such as wheat.

Everything from wheat and rye to oats and rice have perennial varieties, and Kernza wheat is an example of a perennial grain currently in development for human food.

Today, students will cook with one of the oldest wheat grains developed by the most ancient farmers. (Farro is actually an umbrella term for three kinds of grain: emmer, einkorn, and spelt wheats).

Cooking with farro evokes to the moment when we COULD have selected for the genetics that we now seek to develop: perennial crops that will facilitate carbon sequestration.

See attached recipe for Farro Salad with buttermilk dressing.



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BUTTERMILK FARRO SALAD

10 students

This recipe will make enough for each person plus a bit extra to taste. The farro can be cooked in advance and stored in an airtight container. If cooking the farro in the classroom, you will need to include a pot with a lid, burner, wooden spoon, sieve and trivet.

Equipment List

- 12 cutting boards
- 12 knives
- 8 peelers
- 2 small bowl, for dressing and for scallion garnish
- Whisk
- 2 medium compost bowls
- Large bowl
- Mixing spoon
- 2 wet measures
- 2, 1 tablespoon measuring spoons
- ¼ cup dry measure
- 3, 1-cup dry measure

Food Items

- 2 cloves garlic
- Fine grain salt
- 1 cup buttermilk
- ¼ cup cider vinegar
- ¼ cup olive oil
- ¼ cup dill, about 1 bunch
- 1 bunch scallions
- 1 Tbsp chopped thyme
- 1 small kohlrabi
- 2-3 medium carrots
- 2-3 small beets
- 4 cups cooked farro (about 2 cups uncooked)



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BUTTERMILK FARRO SALAD

YIELD: 8 servings

Ingredients

- 2 cloves garlic, minced
- 3 teaspoons fine grain salt
- 1 cup buttermilk
- ¼ cup apple cider vinegar
- ¼ cup olive oil
- ¼ cup dill, minced
- 1 bunch scallions, lower two thirds finely chopped
- 1 tablespoon chopped thyme
- 1 cup kohlrabi, about 1 small kohlrabi
- 1 cup carrots, 2-3 medium carrots
- 1 cup beets, 2-3 small beets
- 4 cups cooked farro (cooked according to directions on package)
- Chopped scallions for garnish

Directions

1. Combine the garlic and 1 teaspoon of salt on a cutting board. Mash into a paste using the flat side of your knife. Place in a medium bowl.
2. Add the buttermilk and vinegar to the bowl with garlic paste. Whisk together and let sit for 5 minutes or so. Gradually whisk in the olive oil and remaining salt, then whisk in the dill, scallions and thyme.
3. Peel and cut the kohlrabi, carrots and beets in a small dice.
4. In a large bowl, toss the kohlrabi, carrots and farro. Add 1 cup of the dressing and toss again.
5. Add beets and toss lightly. Let sit for 10 minutes.
6. Taste and adjust with more dressing and salt, if needed.
7. Sprinkle scallions over the top for garnish.



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Use the space below to note key ideas, themes, or surprising takeaways from the reading.

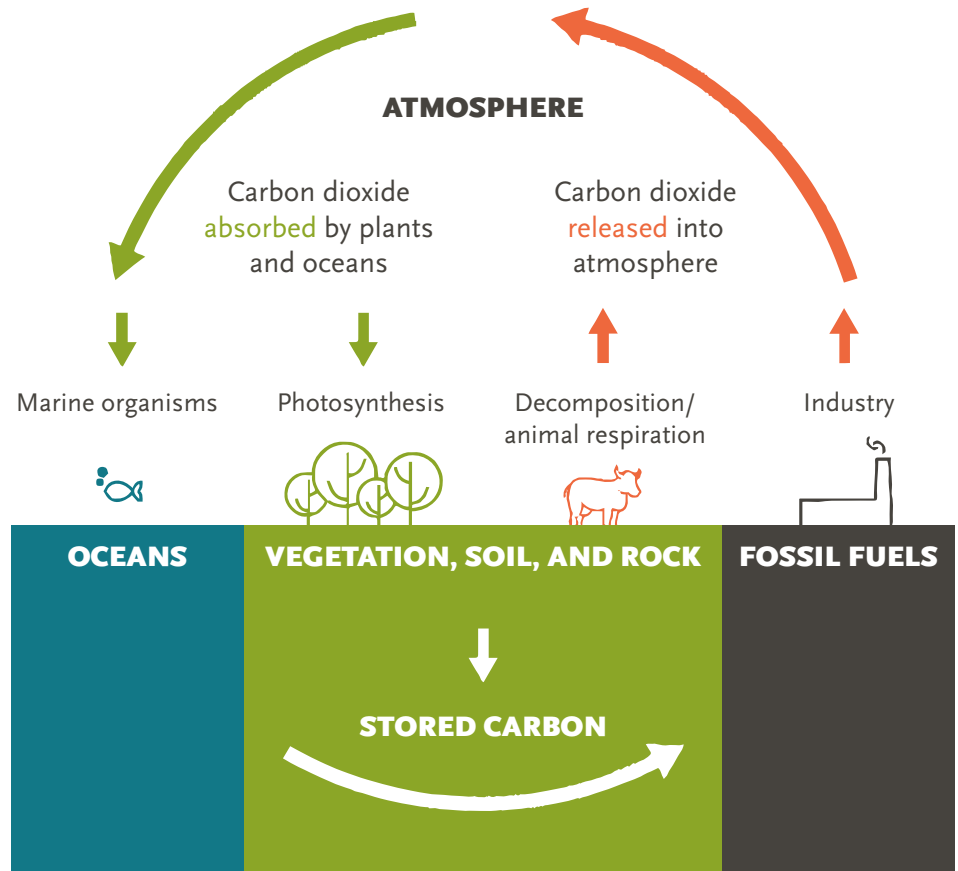
Handwriting practice lines for notes.

CARBON AND CARBON FARMING

One way to address global warming is to sequester or fix as much carbon into the soil as possible—to remove it from the atmosphere where it can increase global warming. This process is called “carbon farming.”

Carbon, let’s remember, is all around us!

- It is the fourth most common element in the universe and the second most abundant element in the human body. Life cannot exist without it.
- It exists in many forms because it can bind with other elements to create complex and stable compounds. Those long chains of compounds store a lot of energy and release a lot of energy when broken.
- Carbon is always moving in a cycle from air to land to air. This movement is called the carbon cycle.



1) The following discussion comes from Courtney White, *Grass, Soil, and Hope*, pp. 14-23, and 68-95.



CARBON FARMING



A no-till drill

<http://www.fao.org/ag/agp/agpc/doc/counprof/australia/australia.htm>



Pasture cropping

<http://www.pasturecropping.com/pasture-cropping>

In this cycle, carbon can be fixed into the soil in two ways. First, carbon was fixed in the soil through the LONG geologic process that created coal, oil, and natural gas from trees and other dead plants hundreds of millions of years ago. We cannot replace that carbon.

Carbon also enters the soil through plants.

- Photosynthesis transforms sunlight into chemical energy using carbon dioxide from the air and water from the soil. That process releases oxygen into the air and creates organic compounds used for plant growth.
- 30-40% of the carbon created by photosynthesis is expelled into the soil by a plant’s roots. It feeds the microorganisms that help to build healthy soil.
- The more photosynthesis ➡ the more carbon released by plant roots ➡ the more carbon enters the soil. When soil is healthy, it can store carbon for hundreds or even thousands of years!

Carbon Farming practices seek to remove as much CO₂ from the atmosphere as possible and sequester it in stable, healthy soil.

Australia is one place where carbon farming is popular, in part because farming practices brought by British colonists depleted the land’s dry soils of their carbon stocks.

One carbon farming technique is pasture cropping, which involves planting a crop in pasture land. Pasture cropping farmers use a drill to plant cereals like wheat or oats, early in the spring. Unlike tilling, which turns over the soil, the drill minimizes soil disturbance around pasture grasses that are dormant in cold weather.

Farmers then harvest the cereal crop before pasture grasses reach their peak growth.

The image to the left shows the green pasture grasses underneath the dried and brown stalks of the cereal crop. The harvester doesn’t cut the grasses. By harvesting the cereal crop, however, it does reduce competition, and therefore stimulates the growth of pasture grasses. These grasses feed the sheep and cattle that graze on the land.

Why is pasture cropping such a great idea?

- Pasture cropping yields two crops: grain and animal products
- In this practice, both the cereal crops and the grasses are feeding soil microorganisms, building up soil carbon, and improving fertility faster than the grasses could achieve alone.
- Pasture grasses are perennials—they have a multi-year life cycle. That means that they can develop much deeper root systems than annually planted crops. Deeper root systems create more stable soil and enable a plant to take advantage of nutrients found in much deeper soil.



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- Grazing animals control the growth of grasses while the cereals are growing, and control weeds. They thrive on pasture grasses, fertilize the soil with their manure, and trample dead and decaying organic matter on the surface of the soil.

Does pasture cropping work?

The farm of Colin Seis can serve as one example. There, Seis and the scientists he has worked with have documented

- substantial improvement in both quality and yields of crops and animal products
- a healthier overall ecosystem, as measured by the numbers and varieties of native grasses, birds, and wild animals
- significant increase in the soil microbial counts and soil nutrients – in other words, much more stable and healthy soil
- this soil can now hold 200% more water, even in an arid environment
- A 203% increase in soil carbon over ten years – a rapid transformation

Farming can and should be a key solution in the fight against global warming.





**UNIT 2: FOOD AND
THE ENVIRONMENT**

L.21a Preface

**THE CONTEXT
FOR CARBON
FARMING**

OPTIONAL LESSON

Note to Teachers

Carbon Farming is an extremely important development in agriculture. It is a way to restore degraded land and mitigate climate change. Advanced carbon farming techniques have been developed in Australia, where soils are often just a fraction of an inch thick. Australia, however, is far away and may feel very abstract to your students. The purpose of this optional lesson is to provide a historical context for the conversation about carbon farming—and to understand the exploitative power dynamics that carbon farming can help to correct.

Goals *In this lesson, students will*

- understand the need for changes in agricultural practice in Australia.
- learn the nutritional and environmental benefits of native plants.

Objectives

- Students will use a short video to introduce them to the culture and food supply of Australian Aboriginal peoples.
- Students will practice the skill of observation without judgment to assess that food system objectively.
- Students will use a series of questions to help them analyze a short text on food cultures before and following British colonization to understand the change to the food system and its environmental impact, and guide their discussion of it.

Materials

- Computer and projector and ability to stream a video
- Reading



THE CONTEXT FOR CARBON FARMING

Please use this margin to notate how to best adapt this curriculum to your students.

I. Introduction

1. Without too much introduction, show students the four minute video at <https://www.youtube.com/watch?v=SjIOoaifjxA>. Ask them to watch with an open mind and clear, sharp focus.
2. Ask students to write down what they notice. Ask them to use phrases like “I noticed” or “I observed” and emphasize that this exercise is about observation rather than evaluation.
3. Ask students to share what they have written. Please ask that they share only observations rather than assessments.

They may notice that the foods are profoundly different from those they typically eat.

They may notice how hard the women are working to find food.

They may notice that the landscape looks rather dry and somewhat barren.

4. Ask students to speculate on the following question: Did Australian Aboriginal peoples benefit from being able to shift to European foods like wheat bread?

II. Australia before and after British colonization

1. Distribute the following reading. Do a read around, ask students to read it silently, or divide the handout—whatever works best for your students.
2. Questions to consider:
 - What is the relationship between Aboriginal peoples and the natural world?
 - How would you describe the Aboriginal food system?
 - How did that food system change under British colonialism?
 - What were the effects on Aboriginal peoples and on the ecologies of Australia?
3. Divide students into small groups to discuss their responses to these questions, and then open a full class discussion to share with the larger class.
4. Ask students if they can predict the subject of their next class meeting.

There is no separate cooking lab associated with this lesson. A mutton dish, however, would be appropriate to the lesson.



THE CONTEXT FOR CARBON FARMING



Use the space below to note key ideas, themes, or surprising takeaways from the reading.

Handwriting lines for notes

A QUICK HISTORY OF AUSTRALIAN AGRICULTURE

PLEASE NOTE: This discussion may contain the names and images of Aboriginal and Torres Strait Islander people who are deceased. Avoiding reference by name is a mark of respect to the dead in Aboriginal tradition.

In 1688 the first Englishman to visit parts of Australia, William Dampier, saw nothing edible as he looked around him. So when the British came to colonize Australia, they were determined to bring everything they needed.¹ The consequences for the land and indigenous peoples of Australia were immense. The following discussion seeks to illustrate why.

Aboriginal Food Culture

Once part of the supercontinent Gondwanaland, the soils of Australia are ancient and, due to its relative isolation, home to unique flora and fauna, wide geological variety and dramatically different climatic conditions across the landmass. Twenty percent of the continent is desert, and Australia is the driest continent after Antarctica. Like other early European explorers, when William Dampier first arrived he failed to recognize the wide variety of foods available to Aboriginal peoples and the practices of land management by which they farmed, reared animals, created fish farms, hunted and gathered.²

According to many scholars, Australian indigenous peoples may have the oldest actively practiced culture in the world. It dates back at least 50,000 years, but may be as old as 65,000 years. Part of that culture is the set of spiritual beliefs called the Dreaming. The stories of the Dreaming tell that Ancestor spirits took the form of humans and moved across the earth, creating animals, plants, rocks, and other components of the land. They also established the relationships between their creations—between people and the land, for example, and between people and other animals.

Once the ancestor spirits had created everything on the land, they turned themselves into parts of that land: trees, rocks, stars, watering holes, etc. As a result, the places the Ancestor spirits inhabited became sacred. Because Aboriginal peoples have always held the land to be sacred, they have always worked to protect and conserve it. As one Aboriginal elder, Tom Dystra put it, “We cultivated our land, but in a way different from the white man. We endeavoured to live with the land; they seemed to live off it. I was taught to preserve, never to destroy.”³

1) John Newton, “Before the Boats” in *The Oldest Foods on Earth*, Kindle Edition (Sydney: NewSouth Publishing, 2016).
2) John Newton, “Before the Boats.”
3) Copyright 2017 by Australian Government, “Australian Indigenous Cultural Heritage,” <http://www.australia.gov.au/about-australia/australian-story/austn-indigenous-cultural-heritage> (accessed 7 December 2017).



THE CONTEXT FOR CARBON FARMING



A witchety grub



Warrigal greens



Wattleseed



Convicts leaving for Australia

<https://www.smithsonianmag.com/history/the-never-ending-hunt-for-utopia-17296251/>

Aboriginal peoples hunted and gathered, but they also managed the land. They practiced localized burning to clear woodland, called “fire stick farming.” Scientists have shown that this type of burning increases biodiversity of both plants and animals.⁴ That biodiversity served the indigenous peoples well. In the Western Desert, they had a seasonal variety of 150 foods and in the tropical north, 750. (Writer John Newton contrasts these numbers with the 50-100 foods consumed by the average European Australian.⁵)

An Aboriginal elder, Margaret-Mary Turner, inventoried the foods of the Eastern Arrernte people. She grouped the foods into five categories: honey-like foods, foods from plants, edible seeds, foods from animals, and water. Aboriginal peoples consumed mostly foods unfamiliar to us, such as the goanna, witchetty grub, native spinach known as warrigal, bush banana, wattleseeds, and sandpaper fig. Many of these plants and animals are found nowhere else on earth.⁶

Not only is the Aboriginal diet extremely diverse, but it is also remarkably healthy. Many of their foods are extraordinarily high in nutrients.

Why is that? Scientists argue that plants survive better in extreme environments when they have elevated levels of compounds. And the wild foods on which Aboriginal peoples have depended have 6-20 times the “antioxidants, anti-inflammatories, vitamin C, enzyme regulators, even mineral content and nutritional density” of cultivated plants.⁷

British Colonial Agriculture

In 1788 the First Fleets of British settlers arrived to create a penal colony in Australia. They brought with them both their eating habits—a diet based on meat, flour, sugar, and tea—and their agricultural practices. Domesticated animals were among the many provisions they brought with them. Three months after the arrival of the First Fleets, livestock in the fledgling settlement consisted of “seven horses, seven cattle, 29 sheep, 74 pigs, five rabbits, 18 turkeys, 29 geese, 35 ducks, and 209 fowls.” Even so, the earliest colonists had a difficult time establishing themselves, and kangaroo meat was a key part of the colonists’ diet. Yet from the beginning, Europeans dismissed indigenous foods as “primitive.”⁸

The colony expanded throughout the nineteenth century, taking lands where Aboriginal peoples had farmed, hunted, and gathered. Land was offered to ex-convicts and then to other settlers. Until the twentieth century, most of that land was used to graze sheep and cattle. By 1860, there were 1.2 million acres of land being used for agriculture, and 25 million head of sheep and cattle.⁹

Immigrants to Australia cultivated wheat, barley, and corn, but also common European vegetables such as carrots, potatoes, lettuce, onions, and peas. They also planted European fruit trees. The labor force to work these farms was comprised of individuals who were forced into this work against their will,

4) Bird, R. Bliege et al., “The ‘Fire Stick Farming’ Hypothesis” *Proceedings of the National Academy of Science, U.S.A.*, September 30: 105 (39), 14796-14801, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2567447/> (accessed December 7, 2017).

5) John Newton, “Before the Boats.”

6) A lists and descriptions of those foods and their nutritional value can be found online, including at <https://www.mbantua.com.au/bush-tucker/>, https://www.survival.org.au/bushfood_all.php, and <https://www.mcd.com.au/product-categories/australian-native-foods/>.

7) John Newton, “Homegrown Marvels” in *The Oldest Foods on Earth, Kindle Edition* (Sydney: NewSouth Publishing, 2016).

8) Copyright 2017 by Australian government, “Australian farming and agriculture—grazing and cropping,” <http://www.australia.gov.au/about-australia/australian-story/austn-farming-and-agriculture> (accessed December 7, 2017).

9) Australian government, “Australian farming and agriculture.”



L.21a

Reading

THE CONTEXT FOR CARBON FARMING



A Chinese market gardener

<http://www.migrationheritage.nsw.gov.au/exhibition/waterfromthewells/chinese-market-gardeners/index.html>

including convicts, indentured servants, and Aboriginal peoples. In addition, by 1850, Chinese migrants began to set up market gardens and, by the turn of the twentieth century, were growing the majority of vegetables in Western Australia.

No longer in possession of the land that had provided for their livelihood, few Aboriginal peoples could live and eat as they had for millennia. By 1890, in fact, the Australian government was rationing flour, sugar and other goods to Aboriginal peoples, severely limiting their diet and nutrition. When anthropologist W.E.H. Stanner began living among Aboriginal peoples and writing about them in the 1930s, he described them as “badly undernourished... Many of them are short of essential proteins, fats, mineral salts, and vitamins.”¹⁰ Given the incredibly high diversity and nutrition that characterized the pre-colonial Aboriginal diet, this observation is particularly striking.

The imposition of an English diet on Aboriginal peoples severely diminished the quality of their nutrition and, consequently, their health. The colonization of Australia by the British had an equally damaging impact on the land. The British attitude toward the land in Australia was expressed clearly in 1861, when the Acclimatisation Society of Victoria stated that “none of the native plants was worthy of cultivation, that none of the native animals neither provided decent game nor were worthy of domestication, and that the native birds sang nowhere nearly as sweetly as those back home.” So the British imported everything from rabbits and foxes, to trout and carp, privet and bamboo—all of which caused serious environmental problems.¹¹

The British also imported, into very different ecological environments of the colony, agricultural practices that evolved in the heavy, rich soils of northern Europe. Heavy tilling, over-grazing on fragile lands, and—by the 1890s—the introduction of phosphate and nitrogen to enhance soil fertility were practices that led to problems of deforestation, soil compaction and degradation, erosion, and high salinity (salt levels) that reduced the fertility of the land.

For example, the Murray-Darling Basin in southeastern Australia, which occupies the “fourth-largest river system in the world,” produces about one-third of the country’s food. Imported European agricultural practices have devastated the basin’s natural fertility. Sheep and cattle are raised there, as well as wheat. Fruits and vegetables rely on heavy irrigation. In that region, agriculture has “cleared native vegetation, dammed rivers, irrigated semi-arid lands, and introduced invasive plants and animals. Today, ‘the soils in the basin are nutrient deficient,... thin and easily flood-damaged; increasing acidity and rising salty water tables are severe problems. The evidence is abundant: the relentless desire to impose an alien food culture and agriculture regime on the continent has left it dangerously depleted.’”¹²

British colonization exploited both Australia’s native peoples and its landscape. The Australian government has recognized the damage British colonization wreaked on native cultures, and in 1998 it created National Sorry Day, a day to recognize and mourn government policies that threatened indigenous culture. Healing the land has been a slow and difficult process, but promising new approaches to undoing such damage in Australia and elsewhere are beginning to gain popularity.

10) John Newton, “A Disastrous Change in Diet” in *The Oldest Foods on Earth*, Kindle Edition (Sydney: NewSouth Publishing, 2016).

11) John Newton, “They brought their own” in *The Oldest Foods on Earth*, Kindle Edition (Sydney: NewSouth Publishing, 2016).

12) John Newton, “They brought their own.”

