Third Edition

Harlan's Crops and Man

People, Plants and Their Domestication

H. Thomas Stalker
Marilyn L. Warburton
Jack R. Harlan

American Society of Agronomy | Crop Science Society of America

WILEY

Harlan's Crops and Man: People, Plants and Their Domestication

Harlan's Crops and Man: People, Plants and Their Domestication

Third Edition

H. Thomas Stalker, Marilyn L. Warburton, and Jack R. Harlan

American Society of Agronomy
Crop Science SOCIETY OF AMERICA
WILEY

Copublication by American Society of Agronomy, Inc., Crop Science Society of America, Inc., and John Wiley & Sons, Inc.

Editorial Correspondence:
American Society of Agronomy, Inc.
Crop Science Society of America, Inc.
5585 Guilford Road, Madison, WI 53711-58011, USA

agronomy.org
crops.org

Registered Offices:
John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA

For details of our global editorial offices, customer services, and more information about Wiley products, visit us at www.wiley.com.

Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some content that appears in standard print versions of this book may not be available in other formats.

Library of Congress Cataloging-in-Publication Data

Names: Stalker, H. T. (Harold Thomas), 1950– author. | Warburton, Marilyn L., author | Harlan, Jack R. (Jack Rodney), author.
Title: Harlan's crops and man : people, plants and their domestication / H. Thomas Stalker, Marilyn L. Warburton, and Jack R. Harlan.
Other titles: Crops and man
Description: Third edition. | Hoboken, NJ : John Wiley & Sons, Inc. ; Madison, WI : American Society of Agronomy, Inc. : Crop Science Society of America, Inc. : Soil Science Society of America, Inc., [2021] | Includes bibliographical references and index.
Identifiers: LCCN 2020026833 | ISBN 9780891186335 (hardback)
Subjects: LCSH: Crops–History. | Agriculture–History.
Classification: LCC SB71 .H3 2021 | DDC 633–dc23
LC record available at https://lccn.loc.gov/2020026833

doi:10.2135/harlancrops

Cover Design: Wiley
Cover Image: © ACSESS

Set in 9.5/12.5pt STIXTwoText by SPi Global, Pondicherry, India

10 9 8 7 6 5 4 3 2 1

Contents

Preface

Third Edition, 2021

Since the second edition of *Crops and Man* was published some 30 years ago, germplasm collections have expanded greatly, molecular genetics has taken root and is being used to answer age-old questions, and archaeological research has discovered many ancient plant and animal remains, uncovered new sites, and expanded our knowledge of the movement of man and his crops throughout the world. Many of the early studies are no longer possible to continue because hunter-gatherers have all but disappeared except in a few relatively isolated regions.

Crop plant evolution involves an understanding of human behavior, as well as extensive knowledge about plants, what happens to plants as man selects traits that he values, and the importance of these plants in varying societies. The process of evolution takes place over both time and space, and as Jack Harlan so eloquently points out, there is no one model or answer to all questions. In this edition, we made every effort to maintain the basic structure of the previous volumes, while updating information that has evolved during the past 30 years. Most of the original references are still used because evolution of particular plants and many theories have not changed, and the older literature presents the foundation for current work.

Jack Harlan did not formulate his theories and concepts by sitting in an office or library and daydreaming; he explored many regions of the world's centers of diversity. He collected more than 12,000 accessions of cereals, forages, legumes, trees, and fruits from more than 45 countries. Many of these have been extensively used as the sources for disease and insect resistances and to introduce genetic variability to modern production agriculture. He made taxonomic revisions of the genera *Cynodon* and *Sorghum* and studied the evolution of many other species, especially the cereals. He was also involved in archaeological research and had firsthand knowledge of ancient plant types.

Dr. Harlan formulated five concepts as related to crop plant evolution: first, the "Compilospecies" concept where related species intermate to form hybrid swarms with high levels of fitness and aggression, and which are able to expand their ecological range. Secondly, he understood the relationships between crops and companion weeds, and the importance of introgression to maintain diversity in a species. Third, Vavilov's Centers of Origins, which were more centers of diversity than origin, were revised into larger areas. Dr. Harlan recognized that not all crops had distinct centers and that the center of origin is not necessarily (and is more often not), the center of diversity. Fourth, he understood that the origin of crop domestication occurred for different reasons by various peoples and no one concept fits all situations. Thus, he developed a no-model model to incorporate the array of theories for crop domestication. Lastly, a natural classification of cultivated plants was proposed that consisted of gene pools rather than the classical method of morphological descriptions. This allows the thousands of variants of a crop to be lumped together into a single genetically and reproductively unified gene pool.

For his masterful accomplishments and service to the agriculture community, Dr. Harlan received many highly prestigious recognitions and awards, both nationally and internationally. His contributions have been recognized in symposia and in Europe a conference series named after him continues to bring together scientists to discuss topics in crop plant evolution.

Jack Harlan was a brilliant scientist and a true scholar. He stimulated all those who knew him to explore new avenues of learning and to never stop acquiring knowledge, not only in their specialty, but in related fields as well. Jack R. Harlan was my mentor, graduate advisor, and friend.

Harlan's use of the word "man" to describe all people was commonplace at the time of his writing. We have left this gender non-descript word use in our attempt to maintain the original flavor of his entertaining story style, and trust our readers understand we mean no disrespect.

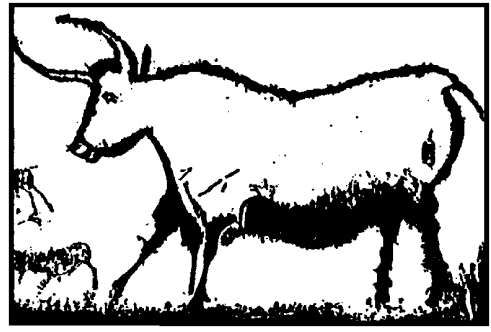
In this revision, we hope that young plant scientists will broaden their views of the world around them to better understand the evolution of humans and the plants that feed the world. The book does not present the genetics of speciation, polyploidy, or plant breeding. But rather, it is intended to present views of evolution through the personal experiences of Jack Harlan and set the foundations for patterns of crop diversity.

H. Thomas Stalker
Raleigh, North Carolina

1

Prologue

The Golden Age



First of all the immortals who dwell on Olympian homes brought into being the golden race of immortal men. These belonged to the time when Kronos ruled over heaven, and they lived like gods without care in their hearts, free and apart from labor and misery. Nor was the terror of old age on them, but always with youthful hands and feet they took their delight in festive pleasures apart from all evil; and they died as if going to sleep. Every good thing was theirs to enjoy: the grain-giving earth produced her fruits spontaneously, abundantly, freely; and they in complete satisfaction lived off their fields without any cares in blessed abundance.

Hesiod, eighth century BC
(Translated by R. M. Frazer, 1983)

Harlan's Crops and Man: People, Plants and Their Domestication, Third Edition.
H. Thomas Stalker, Marilyn L. Warburton, and Jack R. Harlan.

Published 2021 by John Wiley & Sons, Inc.
doi:10.2135/harlancrops

Crop Evolution

In this book, we shall be dealing with evolution. We shall try to describe the evolution of crop plants from their wild progenitors to fully domesticated races and the emergence of agricultural economies from preagricultural ones. We shall deal with the activities of man that shaped the evolution of crops and that influenced the shaping of crops as human societies evolved. Crops are artifacts made and molded by man as much as a flint arrowhead, a stone axe head, or a clay pot. On the other hand, man has become so utterly dependent on the plants he grows for food that, in a sense, the plants have "domesticated" *him*. A fully domesticated plant cannot survive without the aid of man, but only a minute fraction of the human population could survive without cultivated plants. Crops and man are mutually dependent and we shall attempt to describe how this intimate symbiosis evolved.

The word "*evolution*" means an opening out, an unfolding, a realization of potential as in the opening of a flower or the germination of a seed. It implies a gradual process rather than sudden or cataclysmic events, with each living thing being derived genetically from preceding living things. Evolution as a process means change with time and the changes may be relatively slow or rapid, the time relatively long or short. Thus, the differences brought about by evolution over time may be small or great. As we shall see, some cultivated plants differ very little, if at all, from their progenitors. The same can be said for the evolution of agricultural economies and the sociological changes that have occurred in the process of developing fully agricultural and industrial societies from hunting–gathering systems.

To develop a degree of understanding of what has happened and what agricultural systems mean to mankind, we need some sort of picture of what life was like before agriculture. We need to establish a baseline from which we can visualize the domestication of plants and the emergence of agriculture. What kinds of plants did man eat before today's crops were available? What did he know about plants, and what might have caused him to begin the process of domestication? The descriptions given here will necessarily be brief and sketchy, but will give an idea of the condition of man before he began to grow plants with the purpose of using them for food.

We also need to know something about man as a hunter to understand ourselves. Lee and DeVore (1968) have put it succinctly:

> Cultural Man has been on earth for some 2,000,000 years; for over 99% of this period he has lived as a hunter-gatherer. Only in this last 10,000 years has man begun to domesticate plants and animals, to

> use metals and to harness energy sources other than the human body.... Of the estimated 80,000,000,000 men who have ever lived out a life span on earth, over 90% have lived as hunters and gatherers; about 6% have lived by agriculture and the remaining few percent have lived in industrial societies. To date, the hunting way of life has been the most successful and persistent adaptation man has ever achieved.

As a matter of general education and self-understanding, it is important that we know something about this basic human adaptation. There are two general approaches to the problem: (a) we can study surviving nonagricultural societies and examine the ethnographic observations made within the last few centuries, or (b) we can attempt to interpret preagricultural life from the artifacts, refuse, and other clues left by ancient man and recovered by archaeological techniques. In this chapter, we shall deal primarily with the first approach but the archaeological record shall be touched on in later sections.

The Hunter-Gatherer Stereotype

Traditionally, agricultural people have looked down on hunting people who are described as "savage," "backward," "primitive," "ignorant," "indolent," "lazy," "wild," and "lacking in intelligence." Europeans applied the term "civilized tribes" to some eastern North American natives who lived in towns and cultivated plants, but these Native Americans themselves referred to the hunting tribes of the plains as "wild Indians." In Africa, farming groups that surround hunter-gatherers, ". . . did not merely assert their political dominance over the hunter-gatherers and ex-hunter-gatherers they encapsulated; they also treated them as inferiors, as people apart, stigmatized them and discriminated against them" (Woodburn, 1988, p. 37). Similar attitudes prevail in Asia, Oceania, and Tropical America. The prejudice is nearly universal.

The stereotype includes the idea that hunting–gathering people were always on the verge of starvation and that the pursuit of food took so much of their time and energy that there was not enough of either one left over to build more "advanced" cultures. Hunters were too nomadic to cultivate plants and too ignorant or unintelligent to understand the life cycles of plants. The idea of sowing or planting had never occurred to them and they lacked the intelligence to conceive of it. Hunters were concerned with animals and had no interest in plants. In the stereotype that developed, it

was generally agreed that the life of the hunter-gatherer was "nasty, brutish, and short," and that any study of such people would only reveal that they lived like animals, were of low intelligence, and were intellectually insensitive and incapable of "improvement."

Occasionally, an unusually perceptive student of mankind tried to point out that hunting man might be as intelligent as anyone else; that he had a sensitive spiritual and religious outlook; that he was capable of high art; that his mythologies were worthy of serious consideration; and that he was, in fact, as one of us and belonged to the same species with all its weaknesses and potentialities. Such opinions were seldom taken very seriously until recent years. It has finally become apparent that no part of the stereotype is correct and that widely held presuppositions are all completely false and untenable. Our ancestors were not as stupid or as brutish as we wanted to believe.

In 1966, Richard B. Lee and Irven DeVore organized a symposium on Man the Hunter held at the University of Chicago and published in 1968. Lee reported on his studies of the San !Kung of the Dobe area, Botswana. Over a three-week period, Lee (1968) found that !Kung Bushmen spent 2.3, 1.9, and 3.2 days for the first, second, and third week, respectively, in subsistence activities. He wrote, "In all, the adults of the Dobe camp worked about 2 ½ days a week. Since the average working day was about 6 hr long, the fact emerges that !Kung Bushmen of Dobe, despite their harsh environment, devote from 12 to 19 hr a week to getting food."

Among the Bushmen, neither the children nor the aged are pressed into service. Children can help if they wish, but are not expected to contribute regularly to the work force until they are married. The aged are respected for their knowledge, experience, and legendary lore; and are cared for even when blind or lame or unable to contribute to the food-gathering activities. Neither nonproductive children nor the aged are considered a burden.

To the !Kung Bushman, the mongongo nut [*Schinziophyton rautanenii* (Schinz) Radcl.-Sm] is basically the staff of life. These nuts are available year-round and are remarkably nutritious (Table 1.1). The average daily per-capita consumption of 300 nuts weighs "only about 7.5 ounces (212.6 g) but contains the caloric equivalent of 2.5 pounds (1134 g) of cooked rice and the protein equivalent of 14 ounces (397 g) of lean beef" (Lee, 1968). Lee found the diet adequate, starvation unknown, the general health good, and longevity about as good as in modern industrial societies. The average of 2140 calories per person daily (Table 1.1) compares favorably to the 2015 USDA recommendations of 2400–3000 calories for an adult male and 1800–2400 calories for an adult female (https://health.gov/dietaryguidelines/2015/guidelines/appendix-2/).

Table 1.1 Diet of the !Kung Bushmen.

	Protein (g/day)	Calories per person per day	Percent caloric contribution of meat and vegetables
Meat	34.5	690	33
Mongongo nuts	56.7	1,260	67
Other vegetable foods	1.9	190	
Total	93.1	2,140	100

Source: Adapted from Lee (1968).

Sahlins (1968) came in with almost identical figures for subsistence activities of the Australian Aborigines he studied and elaborated on his term "original affluent society." One can be affluent, he said, either by having a great deal or by not wanting much. If one is consistently on the move and must carry all one's possessions, one does not want much. The Aborigines also appeared to be well fed and healthy, and enjoyed a great deal of leisure time.

Gatherers can obtain food in abundance even in the deserts of Australia and the Kalahari Desert of Africa. The rhythm of food-getting activities is almost identical between the Australian Aborigine and the !Kung Bushmen of southern Africa. The women and children are primarily involved in obtaining plant and small animal materials. Hunting is reserved for males at the age of puberty or older but is more of a sport than a necessity. Meat is a welcome addition to a rather dull diet but is seldom required in any abundance for adequate nutrition. Both males and females tend to work for 2 days and every third day is a holiday (Figure 1.1). Even during the days they work, only about 3–4 hr per day are employed to supply food for the entire group (Australian data presented by Sahlins, 1968).

Other reports at the symposium tended to support these general findings. A picture emerged of leisure, if not affluent societies, where the food supply was assured even under difficult environmental conditions and could be obtained from natural sources with little effort. The picture described did seem to fit the golden age of Hesiod or the Biblical Garden of Eden.

The publication of *Man the Hunter* was a surprise to many who believed some version of the hunter stereotype. The stimulation was enormous. Between 1968 and 1992, there were at least 12 international conferences on hunter-gatherers as a direct result, but not all were published. A few of the early conferences included ones published by Ingold et al. (1988a, 1988b) and by Schire (1984). In addition, one may cite Bicchieri

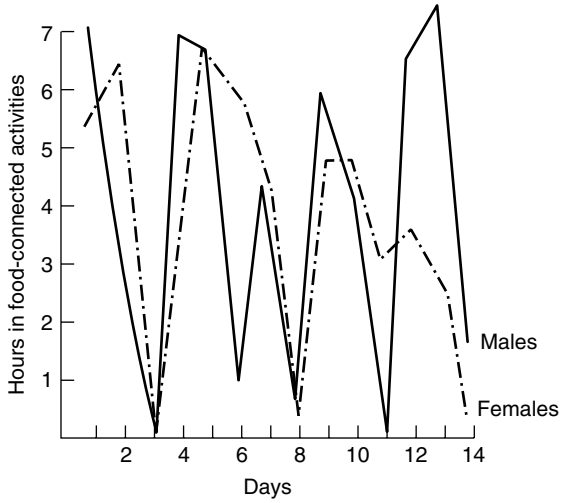


Figure 1.1 Food-gathering activities of the Australian Aborigines. *Source:* Adapted from Sahlins (1968).

(1972), *Hunters and Gatherers Today*; Dahlberg (1981), *Woman, the Gatherer*; Winterhalder and Smith (1981), *Hunter-gatherer Foraging Strategies*; Williams and Hunn (1982), *Resource Managers*: *North American and Australian Hunter-gatherers*; Koyama and Thomas (1982), *Affluent Foragers: Pacific Coasts East and West*; Price and Brown (1985), *Prehistoric Hunter-gatherers: The Emergence of Social and Cultural Complexity*; Harris and Hillman (1989), *Foraging and Farming: The Evolution of Plant Exploitation*; and such regional treatments as Hallam (1975), *Fire and Hearth: A Study of Aboriginal Usage and European Usurpation in Southwestern Australia*; Silberbauer (1981, p. 242), *Hunter and Habitat in the Central Kalahari Desert*; Riches (1982), *Northern Nomadic Hunter-gatherers*; Lee (1984), *The Dobe!Kung*; Akazawa and Aikens (1986), *Prehistoric Hunter-gatherers in Japan*; and there are many hundreds of additional research papers. There is now a vast amount of new material on the subject, but some of the oldest papers are still the most useful because observations were made before the hunter-gatherers were so restricted and encapsulated as they are now.

The biases of some of the investigators were often clear. Some set out to dispute the "affluent society" concept and others to support it. Some of the anthropologists were hung up on Marxist views of "history," since the egalitarian nature of most hunter-gatherer societies suggested Marx's view of communism: "No one starves unless all starve"; "no man need go hungry while another eats"; "rich and poor perish together," and so forth

(Lee, 1988). The quotes are from observers of Iroquois, Ainu, and Nuer, respectively, and seem to equate egalitarianism with hunger, which is probably not fair. Incidentally, Karl Marx took his model of basic communism from an agricultural Iroquois society, not from hunter-gatherers, who are not so likely to starve.

What do the new studies show? To no one's surprise, they show that the golden age was more golden for some than for others. Even a few examples of famine were found (Johnson & Earle, 1987, p. 374). Brian Hayden (1981) listed a number of tribes showing a continuum of work from "a few minutes per day" (Tanaina in Alaska) or 2 hr per day (Hadza in Tanzania) to "all day every day" or "too busy to visit relatives" (Birhor in India). Well, I have been too busy to visit relatives even when I wasn't doing much of anything. It also comes as no surprise that if processing and cooking time is added to collecting time, it takes longer to get a meal than some figures would suggest. Processing some foods is laborious and time-consuming. Grinding or pounding seeds into flour has always been drudgery, and boiling toxic foods in several changes of water takes a lot of time. Still, is watching a pot boil hard labor, especially if the kids make a game of picking up sticks to keep the fire going? And, of course, farmers must also process their food, too, so the addition of processing and cooking time does not necessarily change the comparison.

There are certain aspects of time and work that do not seem to receive due attention. Suppose you like your work? I always have, and have spent far more time at it than necessary for survival. Consider those men of industrial societies who spend endless hours cramped and freezing in a duck blind for little or no reward, or those who huddle in a shelter fishing through the ice in the middle of a Minnesota winter. The social aspects are what matter; after a few nips of whiskey, no one cares if the rod bends or not. I record two ethnographic notes from my own experience, both from farming societies, but the principles apply to anyone. Early one morning on a deserted road in Afghanistan, I came across a line of men dressed in colorful embroidered jackets, balloon pants, and pixie-toed shoes. They had two drums and were singing and dancing up and down with their sickles in the air. A group of women followed, shrouded in their chadors, but obviously enjoying the occasion. I stopped and asked in broken Farsee: "Is this a wedding celebration or something?" They looked surprised and said: "No, nothing. We are just going out to cut wheat." Harvest time is a good time of year even if it is hot and the "work" is hard. It is a time for socializing and, if the harvest is good, for celebrating.

A second observation was in eastern Turkey. My interpreter and I had seen a family harvesting a field and we stopped. He talked to the people

while I collected some samples. My interpreter later told me that he had commented to the farmer that he could harvest the field in half the time if he would use a scythe and cradle. The farmer looked at him in astonishment and said: "Then what would I do?" There is a certain amount of Parkinson's law in all these activities. One fills up the time available. What is the meaning of time if there is more of it than you know how to use? As for getting by with the least effort possible for survival, I do not think that is human nature. Sure, anyone can drink vin ordinaire, but why not work a little harder and drink Chateauneuf-du-Pape?

How do hunter-gatherers spend their leisure? Apparently they sleep a lot, but there are other diversions. Gambling is popular among many tribes; Woodburn (1970, p. 59) states that the Hadza people spend more time in gambling than in obtaining food. The most popular gambling stake is poisoned arrows. There are also music, dances, ritual and ceremony, rites of passage, playing cat's cradle, storytelling, creative arts, making useful and decorative articles, and similar activities. Life appears easy, but generally dull. Perhaps as a consequence there is a great deal of coming and going; the camp population is fluid and camps may be moved on the slightest pretext or for no reason at all. Understandably, there is a tendency to concentrate on the foods most easily obtained at a given time, and these are likely to change from season to season and, to some extent, from year to year. Groups of people in many gathering societies tend to be very fluid for that reason. When food is at maximum abundance, there is a tendency to gather in large bands. This is the season for rejoicing, celebrating, observing ancient tribal rituals, arranging marriages, and having naming ceremonies, coming of age ceremonies, and so on. The tribe is more fully represented at this time. During the most difficult season of the year, the people may break up into microbands to better exploit the gathering range and to avoid exhausting the food supply near the larger camps.

Many Australian Aborigines remain apart much of the yearly cycle even after becoming dependent on European agricultural–industrial systems. For most of the year they find jobs as ranch hands, laborers, mechanics, and so forth, but they may quit whatever they are doing, take off their store-bought clothes, and take a three-month "walkabout" during their traditionally festive season. Gathering is still easier than working at that time of year.

The study of hunting tribes that have survived long enough to have been observed by modern ethnographers is full of difficulties and pitfalls. Many tribes had become profoundly modified through contact with and by the pressures applied by agriculturalists. Some were reduced to the status of slaves or servants; others were restricted on reservations or their normal

ranges were constricted by pressures of stronger groups. The social and economic structures of many tribes were in an advanced stage of disintegration at the time of ethnographic description.

The geographic distribution of surviving hunters results in a serious bias. By and large, hunters have survived where agriculture is unrewarding. We find them in the Kalahari Desert and adjacent dry savanna in southern Africa, in small pockets of tropical rain forest, in the frozen wastes of the Arctic, or in western North America, but there are no examples left in the more productive agricultural lands of the world.

At the time of European contact, the eastern forests and woodlands of North America were largely populated by native agriculturalists; the people living in the plains and westward mostly maintained hunting–gathering economies. There were enclaves of farmers, such as the Mandan on the Missouri River in North Dakota, and a highly sophisticated agriculture had developed in the Southwest USA where people practiced irrigation on a large scale and often lived in towns. Some farming was practiced along the Colorado River watershed and into southern California, but most of the California natives and other tribes of western North America lived by hunting, fishing, and gathering. A substantial body of information has been assembled about them, but we must remember that they did have contact with farming people and some of their cultural elements could have been borrowed.

Data for hunter-gatherers in South America have been accumulating during the late 20th and into the 21st centuries. In the review by Scheinsohn (2003), she indicates distinct areas occupied by hunter-gatherers in the grasslands of Argentina and southern Chile, farming communities in the highlands of western South America, and mixed hunter-gatherer and farming societies in more mid-to-low land areas of Bolivia, Brazil, and Venezuela by about 6000 BP (Before Present). There is some evidence of man in South America by at least 30,000 BP (Scheinsohn, 2003), and these peoples were certainly hunter-gatherers. The Bushman of southern Africa has been studied in some detail, but we know historically that they had long contact with the livestock-herding Hottentot and farming Bantu tribes. The Congo pygmies often spend part of each year with agricultural people. The Ainu of Japan have taken up some farming in the last century or so. Many of the hunter-gatherers of India are so constricted by agriculturalists that they have virtually become members of a nonfarming caste.

The Andaman Islanders succeeded in preserving a greater degree of isolation, partly by killing off strangers who landed or were shipwrecked on their shores. Still, we know they borrowed some customs from outsiders. Both pottery and pigs seem to have been introduced about 1500 AD

(Coon, 1971). It is even possible that they were agriculturalists when they arrived and abandoned the practice when they found it unnecessary.

Perhaps our most reliable data come from Australia. At the time of European contact in the early 19th century, there was an entire continent populated by an estimated 300,000 people without a single domesticated plant and no genuine agriculture. Although it is true that for some centuries before European contact there were Malayan traders visiting northern Australia on a fairly regular basis, there is little evidence that this resulted in significant changes in use of food resources and it did not induce the Aborigines to take up the cultivation of plants. The Torres Strait is also rather narrow and some contact with agricultural Melanesians occurred. That this would influence the whole of Australia very much seems doubtful.

I shall, therefore, rely more on ethnographic data from Australia than elsewhere, but will remind the reader that any reconstruction of a way of life of some thousands of years ago, based on a small, biased sample of living people, is full of hazards and sources of error. The earlier accounts may have more value than some of the later ones because the effects of European contact were rapid and profound.

Woodburn (1988) and in a series of papers, outlined an important distinction between immediate return strategies and delayed return strategies. The former live from day to day, or at most a few days at a time on current returns. Delayed return groups have longer-term goals; these include manufacturing of boats, nets, weirs, traps, and deadfalls, tending bee hives, the capture and keeping of animals to be eaten later, the replacement of the tops of yams at digging time, sowing of seeds, managing vegetation with fire, water spreading, irrigation, flooding of forests, arranged marriages, and so forth. The Australian Aborigines were delayed return strategists of great skill, and as such were closer to agriculturalists than to immediate return hunter-gatherers such as the Bushmen and Hadza. Great Basin and West Coast Native Americans and the Jomon of Japan were also delayed return strategists.

As more and more data have accumulated, a consensus has developed that present day and recent hunter-gatherers, whether of immediate or delayed return, have evolved in parallel with agriculturalists and no longer represent the original condition before agriculture. They are not the "pristine" hunger–gatherers of 10,000–12,000 years ago. In addition, the diversity among hunter-gatherers is such that no single model can represent them. There is not even a single model for Australia, let alone the other hunter-gatherers in the world. Our extensive field studies will not tell us all we want to know about preagricultural societies, but they are suggestive.

The oldest remains of *Homo sapiens* L. were left in Morocco about 315,000 years ago (Hublin et al., 2017a, 2017b), which is much older than previously

thought. Foley (1988) reserved the term "human" for anatomically modern man who appeared on earth as early as 100,000 years ago and as late as 30,000 years ago in some regions, but many intermediate fossil remains define the evolution within the genus *Homo*. However, early species of *Homo* were not "human." Late Pleistocene man was anatomically modern, but larger, heavier, and more sexually dimorphic. Foley suggests reduction in size and dimorphism was a response to a change in food procurement systems. With the extinction of many large mammals and general impoverishment of the fauna at the end of Pleistocene, men and women began to share more evenly in food procurement, and the broader spectrum of plants and animals exploited was accompanied by morphological changes in humans.

What Do Gatherers Eat?

Lee (1968) classified 58 tribes according to the percentage of dependence on hunting, fishing, or gathering. The data were taken from the Ethnographic Atlas (Murdock, 1967), but adjusted somewhat by transferring the pursuit of large sea mammals from fishing to hunting and shell-fishing from fishing to gathering. The food obtained by gathering is predominantly of plant origin. The class does include small animal foods such as mice, rats, lizards, eggs, insect grubs, and snails. Tortoise and shell-fishing is important to a few gathering tribes. In several cases where detailed analyses were made, however, plant foods contributed 60%–80% of the intake of gathering people.

In his *List of Foods Used in Africa*, Jardin (1967) compiled an extensive and complex list of species. I have attempted to remove cultivated plants and introductions and reduce the synonymy as much as possible. There still remain more than 1,400 species that could be grouped into classes as follows:

Grass seeds approximately 60 spp.
Legumes approximately 50 spp.
Roots and tubers approximately 90 spp.
Oil seeds approximately 60 spp.
Fruits and nuts >550 spp.
Vegetables and spices >600 spp.
Total >1410 spp.

Most of Jardin's reports concerned agricultural tribes and only a small fraction of the list represented foods of gatherers. This suggests that (a) many more species have been gathered from the wild than have ever been domesticated, (b) even after agriculture is fully developed, gathering wild

plant foods is still a worthwhile effort, and (c) wild plant resources are of the same general kinds as domesticated plant resources. See also Fox and Young (1982) for southern Africa.

Yanovsky (1936) in his *Food Plants of the North American Indians* lists 1112 species of 444 genera belonging to 120 families. About 10% of these are crops or imported weeds; the rest are native American plants. The bulk of the plants listed were gathered by nonagricultural tribes. Fernald and Kinsey (1943) listed about 1000 species for eastern North America alone. Plants gathered in Central and South America have not been conveniently compiled, but the number of species is very large. A partial listing is given by Lévi-Strauss (1950) in *The Use of Wild Plants in Tropical South America*.

Our most reliable information again might come from Australian areas where agriculture was not practiced and where none of the plants had been domesticated. Lists compiled by Cribb and Cribb (1975), Irvine (1957), Levitt (1981), and Maiden (1889), are of help here, although no list is complete; there are problems of identification and synonymy, and many of the early ethnographic records contain native names because the observers were not botanists and could not identify the plants. Even so, Australians were recorded as having gathered and used over 400 species belonging to 250 or more genera.

Some observations are grouped below according to general kinds of plant food resources.

Grass Seeds (Potential Cereals)

Seeds of wild grasses have long been an important source of food and are still harvested on a large scale in some regions. A.C. Gregory (1886) commented:

> On Cooper's Creek (Australia), the natives reap a Panicum grass. Fields of 1000 acres (405 ha) are there met with growing this cereal. The natives cut it down by means of stone knives, cutting down the stalk half way, beat out the seed, leaving the straw which is often met with in large heaps; they winnow by tossing seed and husk in the air, the wind carrying away the husks. The grinding into meal is done by means of two stones—a large irregular slab and a small cannon-ball-like one; the seed is laid on the former and ground, sometimes dry and at others with water into a meal.

Stickney (1896) described methods of the wild rice (*Zizania palustris* L.) harvest by the Ojibwa of Wisconsin late in the 19th century:

> Two women, working together in a canoe, took a large ball of cedar bark twine and tied up sheaves just below the panicles when the seed was in the milk stage. Later, they went back when the seed was ripe and beat the sheaves over the canoe. Each woman knew her own bundles and the right of ownership was scrupulously respected. Sometimes sheaves were not previously prepared and the woman in the back would pole slowly forward while the other reached out with a curved stick and bent a bunch of stalks over the canoe and hit them with a straight stick held in the other hand. About a gill is attached at each blow. When the canoe became heavily laden in the front, the women exchanged implements as they kept their places and the canoe was poled back in the opposite direction. When the canoe was fully loaded and low in the water it was beached and the wild rice removed. The wild rice was dried in the sun or on a platform over a fire. Dehulling was done by men who placed the seed in a skin bag and treaded it in a pit dug in the soil. Dehulled seed was stored in bark boxes or large skin bags; sometimes so much seed was stored that it lasted until the next harvest.

Wild races of common Asian rice (*Oryza sativa* L.) were once harvested on a considerable scale in northern Australia (Bancroft, 1884):

> The wild rice of the Carpenteria swamps (*Oryza sativa*), however, needs to be carefully cleaned from its spiny chaff, which may be done by rubbing in wooden troughs. This must be the most important grass-food in Australia, being little inferior to cultivated grain. The plant grows six feet (1.8 m) high, and produces a good crop even in the latitude of Brisbane. The "paddy" is black with long awns. It is interesting, in Australia, to find one of the original sources of a cereal that has been cultivated in Asia for thousands of years.

The wild races are still harvested in India despite the cultivation of domesticated forms for six or seven millennia (Roy, 1921):

> In the Central Provinces the Gonds and Dhimars harvest this rice by tying the plants together into clumps and thus preventing the grains from falling. These grains have also got a certain demand in the market as they are often used by devout Hindus in these parts on fast days besides being sold to the poorer classes.

Burkill (1935) makes a similar observation:

> The poor do not ignore it (wild rice), but tying the awns together before maturity save the grain for themselves, or they collect the fallen grain, which is made an easier process by the length of the awns.

Ping-Ti Ho (1969) documented the harvesting of wild rice over much of southern and central China during a span of an entire millennium. One report, dated 874 AD, from Ts'angchou, Hopei Province, to the emperor may be paraphrased: "Wild rice ripened in an area of more than 200,000 mu (13,000 ha), much to the benefit of the poor of local and neighboring counties" (Ho, 1969). It is to be noted that rice had been a major crop in China for over 6000 years at the date of this report, but that the gathering of seeds of wild rice was still worth the effort.

I have observed other species of rice, *O. barthii* A. Chev. and *O. longistaminata* A. Chev. & Roehr., that are regularly harvested in Africa, sometimes in sufficient abundance to appear in the markets. The Africans sometimes also tie wild rice into clumps before harvest (Harlan, 1989). Claude Lévi-Strauss (1950) reports the harvesting of *O. subulata* Nees [syn. *Rhynchoryza subulata* (Nees) Baill.] in Uruguay, Rio Grande do Sul, and the marshes of the upper Paraguay and Guaporé Rivers in South America. He also reports the technique of binding before harvest:

> The Tupí-Cawahíb of the upper Madeira River gather the seeds of an unidentified wild grass that grows in the forest, and to facilitate the harvest they tie together several stems before they are ripe, so that the seeds of several plants fall on the same spot and pile up in small heaps.

Panicum has been a favorite grass seed of gatherers the world over. In North America, *P. capillare* L., *P. obtusum* Kunth [syn. *Hopia obtusa* (Kunth) Zuloaga & Morrone], and *P. urvilleanum* Kunth have been listed as harvested in the wild (Yanovsky, 1936), and *P. hirticaule* J. Presl var (syn. *P. sonorum* Beal) was domesticated in Mexico (Gentry, 1942; Nabhan & deWet, 1984). Seven species are listed for Africa (Jardin, 1967), with the most important being *P. laetum* Kunth and *P. turgidum* Forssk. Four species are recorded for Australia, with *P. decompositum* R. Br. occurring in 1000-ha fields. Two species, *P. miliaceum* L. and *P. antidotale* Retz. were domesticated in Eurasia and India, respectively. It appears that food gatherers are attracted to similar plants.

At least five wild species of *Sporobolus* were harvested in North America, three in Africa, and three in Australia. Species of *Eragrostis* were gathered in North America, Australia, and Africa. For Africa, six wild species are listed and one was domesticated as a cereal, *Eragrostis tef* (*Zuccagni*) Trotter in Ethopia. *Eleusine* and *Dactyloctenium* were harvested in Australia, India, and Africa with one species (*E. coracana L. Gaertn.*) being

Table 1.2 Analysis of wild and cultivated wheats.

	Ether extract (%)	Crude fiber (%)	Crude protein (%)	NFE (%)[a]
Wild einkorn	2.64	2.33	22.83	60.04
Modern wheat	1.50	1.33	10.79	75.01

Source: Adapted from Harlan (1967).
[a]Nitrogen-free extract or carbohydrates other than fiber.

domesticated. Species of Digitaria were harvested in Australia, India, Africa, and Europe. Digitaria exilis (Kippist) Stapf and D. iburua Stapf were domesticated in Africa, D. cruciate Nees ex Hoff. f. in India, and common crabgrass [D. sanguinalis (L.) Scop.] was cultivated as a cereal in central Europe until the 19th century without actually being domesticated (Körnicke, 1985). The differences between cultivation and domestication will be discussed in Chapter 3.

Mannagrass [*Glyceria fluitans* (L.) R. Br.] was harvested in substantial quantities from the marshes of central and eastern Europe as late as 1925 (Szafer, 1966). The seed was even exported from the port of Danzig to countries around the Baltic. Yanovsky (1936) reports that the same species was harvested by Native Americans in Utah, Nevada, and Oregon. Wild oats (*Avena barbata* Pott ex Link and *A. fatua* L.) were harvested by the Pormo tribe in California after these weedy plants had been introduced from the Mediterranean (Gifford, 1967). As late as 100 years ago, wild grass seeds were harvested on a commercial scale in central Africa and exported by camel caravans into the desert and other food deficit areas (Harlan, 1989).

I once studied the amount of grain that could be harvested from wild einkorn wheat (*Triticum monococcum* L. subsp. *boeoticum*) in Turkey (Harlan, 1967). I found no difficulty in collecting over 2 kg of head material or the equivalent of 1 kg of clean grain per hour. On analysis, the grain contained about 23% protein as compared to about 11% for modern cultivated wheat (Table 1.2).

In all, Jardin (1967) lists about 60 species of wild grasses that have been harvested for their seeds in Africa within recent decades. Yanovsky (1936) lists approximately 38 for North America, and Irvine (1957) and others mention about 25 for Australia. The exact number cannot be given because of problems with synonyms and identification. Relatively little is known about wild grass harvesting in Europe and Asia although *Oryza, Panicum, Digitaria,* and *Glyceria* have been mentioned.

Legumes (Potential Pulses)

Gathering peoples are evidently attracted to Leguminosae of various kinds. Whole pods may be used, as well as seeds only, pods only, or even the tissues inside the pods surrounding the seeds. Some legumes have edible tubers and others have leaves or young shoots suitable for pot-herbs. Not infrequently the material harvested is poisonous and must be detoxified before use. Poisonous materials can be used for stunning fish, stupefying emus, or making poison arrows.

As with the Gramineae, certain genera appear frequently on plant lists and several distinct species of a given genus may be used in different parts of the world. Genera with wide distributions may be very widely used. For example, many species of Acacia are exploited in Australia, several are used in Africa and Asia, but only a few are used in the Americas. More species of *Prosopis* (mesquite) are used in the Americas, however, than in Africa, Asia, and Australia. Different species of *Canavalia* are harvested in Central and South America and in Southeast Asia and Australia. *Vigna* and *Dolichos* are widely exploited in Africa, Asia, and Australia while several species of *Phaseolus* are harvested in the Americas. *Tephrosia* spp. have been used for fish poisons on five continents.

Root and Tuber Plants

Roots, tubers, rhizomes, and bulbs have been widely harvested for untold millennia. The choice depends more on what is abundant and available than anything else. The genus *Dioscorea* is very large and includes about 600 species distributed throughout the warmer parts of the world. Many produce tubers that are edible or rendered edible after detoxification. About 30 species are harvested in the wild in Africa (Jardin, 1967) and several have been domesticated. Wild yam harvests are important in India, Southeast Asia, the South Pacific, Australia, and tropical America.

Tubers and rhizomes of the Araceae are widely harvested in the tropics and a few are found in the more temperate zones. Bulbs of the Liliaceae are popular where they occur. Yanovsky (1936) lists about 90 species belonging to the lily family (Liliaceae) that supplied food for North American natives. No less than 17 species of wild onion (*Allium*) were listed, and even the death camus *Zygadenus* was eaten after suitable detoxification. Tuberous legumes in the genera *Solanum, Ipomoea, Nymphaea,* and *Eleocharis* have been widely harvested, and *Cyperus rotundus* L. has supplied food in North America, Africa, Asia, Australia, and Europe.

Oil Plants

Most gatherers had periodic access to animal fats, but sources of vegetable oil were also sought. In the wetter tropics, the fruits of various palms (Palmaceae) were especially attractive. The African oil palm (*Elaeis*

guineensis Jacq.) is still exploited in the wild as is its counterpart in South America [*E. guineensis* Jacq. (syn. *E. melanococca* Gaertn.)]. Other palms also supply oil in quantity including, of course, the coconut (*Cocos nucifera* L.). Seeds of Compositae, Cruciferae, and Cucurbitaceae are harvested on every continent, partly for their oil content. Many nuts and some fruits are high in oil and are still harvested in the wild. Some familiar ones are *Aleurites* (Candlenut or tung-oil tree), *Persea* (avocado), *Theobroma* (cacao), *Pistacea* (pistachio), *Olea* (olive), and *Butyrospermum* (shea butter tree or karité). Several species of *Sesamum* and *Linum* are harvested for their oily seeds.

Fruits and Nuts

Long lists of fruits and nuts can be compiled, but it is not necessary to go into much detail here. We need only point out that the same patterns prevail as for grass seeds, legumes, and oil plants in that different species of the same genera are exploited almost everywhere they occur. In temperate zones, for example, species of walnut (*Juglans*), hickory (*Carya*), hazelnut (*Corylus*), chestnut (*Castanea*), beech (*Betula*), oak (*Quercus*), hawthorn (*Crataegus*), hackberry (*Celtis*), plum-cherry (*Prunus*), bramblefruits (*Rubus*), grape (*Vitis*), elderberry (*Sambucus*), pine-nuts (*Pinus*), and others were popular with gatherers in Europe, Asia, North America, Africa, and Australia. In the tropics, some of the popular genera were (and are) *Ficus*, *Citrus*, *Musa*, *Syzygium*, *Pandanus*, *Spondias*, *Adansonia*, *Artocarpus*, *Annona*, and *Carica*. If a plant appeals to one gathering tribe, a similar plant is probably used by another tribe, even on another continent.

Vegetables

Because the same general pattern is operative, it might be worthwhile to call attention to repetitive patterns in two families whose produce appeals to gatherers.

Solanaceae. The genus *Solanum* is found on every continent and includes several hundred species. About 15 species are gathered for food in Africa, 9 are listed for North America, and several are found in South America, India, and Australia. Some must be detoxified before being eaten. The fruits are the parts eaten in most cases, but leaves may be used as pot-herbs and a number of species have edible tubers. *Physalis* is another genus widely exploited with at least 10 species gathered in North America plus others in South America, Africa, Europe, Asia, and Australia. Species of wild *Capsicum, Cyphomandra,* and *Lycopersicon* were gathered in the Americas. The genus *Nicotiana* was a favorite of gathering tribes in the Americas and Australia. Several distinct species were involved and they were utilized almost wherever they occurred. In the Americas, the tobaccos were both

chewed and smoked, while it was a masticatory only in Australia. Lime of some sort was often mixed with the quid. *Datura* was used as a drug, medicine, or hallucinogen in both eastern and western hemispheres.

Cucurbitaceae. Plants of this family were often attractive to gathering peoples and in some cases were very important because of their abundance. In Australia, Maiden (1889) observed that *Cucumis trigonus* Roxb. was sometimes "growing in such abundance that the whole country seemed strewed with the fruit." In southern Africa, the landscape may be almost cluttered with wild watermelon [*Citrullus colocynthis* (L.) Schrad.] where it may serve as the only source of water for man and animals alike over extended periods of the dry season (Story, 1958). Tropical *Cucumis* and *Mamordica* species are still gathered in the wild in Africa and Asia. The genus *Cucurbita* is confined to the Americas and was extensively exploited by the Native Americans; several species were domesticated. The white-flowered bottle gourd [*Lagenaria siceraria* (Molina) Standl.] has been widely exploited, primarily for the hard shells of the fruits which make excellent containers. Its use has been recorded in the Americas, Africa, Asia, Europe, and Australia, but its distribution as a wild plant is not well known. The fruits of the Australian races are said to be purgative or even poisonous according to Maiden (1889) but are eaten by the Aborigines after being processed. The fruits of some domesticated races may be eaten when young without special precautions. *Luffa* is also widely used in Asia and Africa as a vegetable or medicine, but is a fish poison in Australia (Palmer, 1883).

Summary

Finally, we might return to the plants gathered by Australian Aborigines as, perhaps, representing a most authentic selection by surviving nonagricultural peoples. A short list of genera that include one or more species harvested in the wild by native Australians is given in Table 1.3. I have attempted to indicate where species of each genus are harvested in the wild in addition to Australia. It seems evident from these data and the foregoing discussion that gatherers exploit about the same range of plants wherever they find them.

It is not surprising, therefore, to find independent domestications of different species of the same genus, and if the genus is widespread, the different domesticates may have originated in different continents. Examples of such vicarious domestications occur in the following genera, among others:

1) Mesoamerica and South America—*Amaranthus, Annona, Canavalia, Capsicum, Carica, Chenopodium, Cucurbita, Gossypium, Opuntia, Pachyrrhizus, Phaseolus,* and *Physalis*;