PART IV

GRASS

By

A. S. HITCHCOCK

Principal Botanist in Charge of Systematic Agrostology
United States Department of Agriculture
Custodian, Section of Grasses
United States National Museum
and

AGNES CHASE

Associate Botanist
United States Department of Agriculture

CHAPTER I

GRASSES THE BASIS OF CIVILIZATION

"He causeth the grass to grow for the cattle," says the Psalmist, and Moses promised the children of Israel, as their reward if they kept the commandments of God, that they should have "grass in their fields for their cattle." With the Prophets grass is the symbol of blessing and redemption—"in the habitation of dragons shall be grass," "the Lord shall give to everyone grass in the field." And the want of grass is the symbol of desolation, "the hay is withered away, the grass faileth." The theme of grazing runs all through Genesis and Exodus. But long before cattle were domesticated, primitive man, living largely on animals he could kill, was vitally concerned with grazing lands. He must have followed the herds of wild cattle and bison, the flocks of wild sheep and goats, as the North American Indian followed the herds of the American bison, or buffalo. An abundant supply of grass meant plenty of tender, juicy meat.

Grazing lands possess other plants than true grasses, but grasses are their most important constituent, because these plants withstand close and repeated grazing better than do other plants. In the grass leaf, consisting of two parts—sheath and blade—growth takes place at the base of the sheath and at the base of the blade (Fig. 36), instead of being diffused about equally throughout the leaf, as it is in clovers and other forage plants. When a clover leaf is bitten off, that is the end of it, but when a grass blade is bitten off, growth keeps on at the base and the blade is soon as long as ever. It is this growth from the base

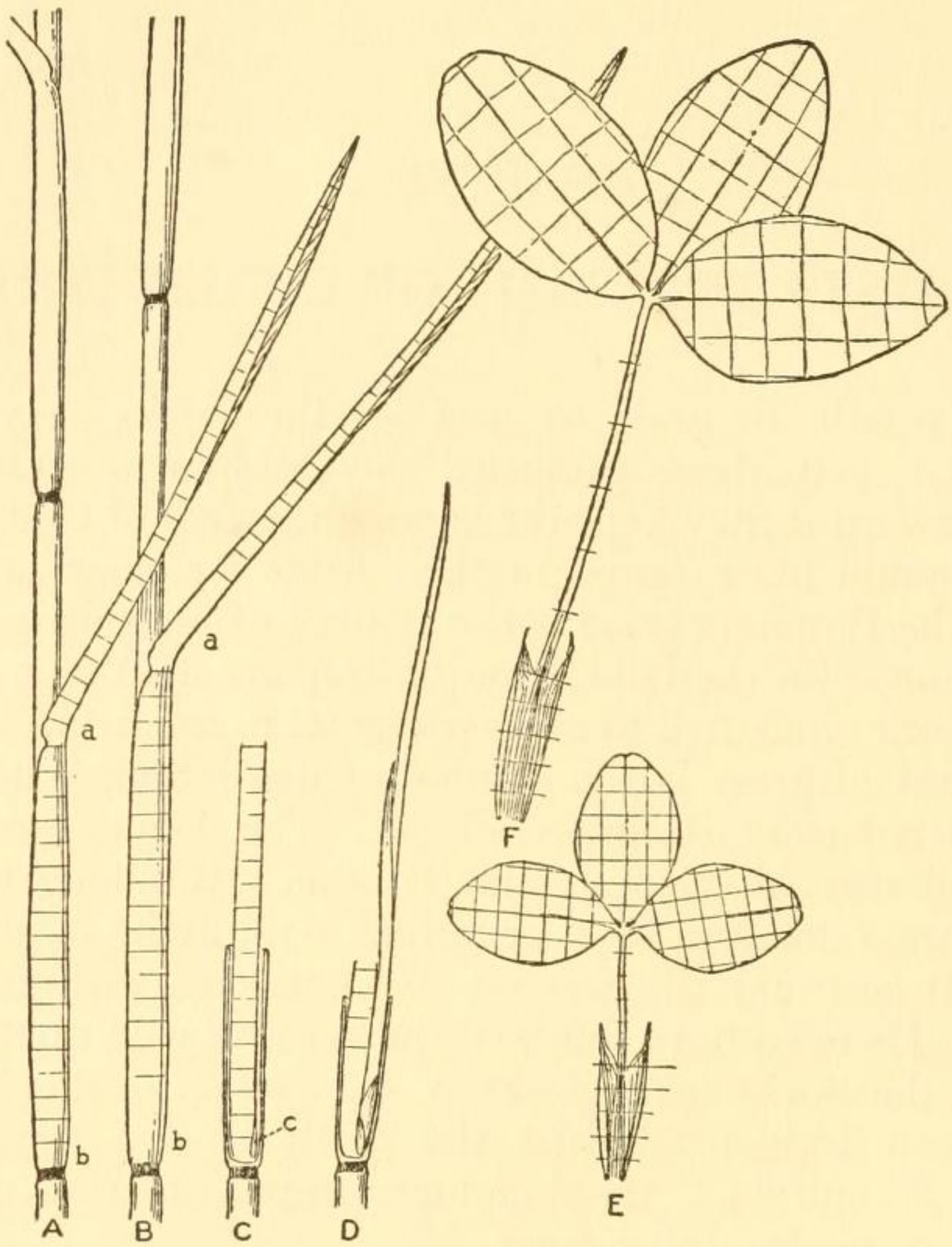


FIG. 36. Leaves of grass and of red clover marked to show areas of growth. A, grass leaf: a, base of blade; b, base of sheath. B, same leaf one week later, showing growth at a and b. C, base of culm in sheath; bud of potential branch shown at c. D, same one week later, showing growth at the base and the potential bud developed into a leafy shoot. E, leaf of red clover. F, same one week later, showing nearly uniform growth throughout, the greatest growth taking place in the petiole, the part of least value

(like human hair) that makes necessary repeated mowing of the lawn. Moreover, in a grass not only is the leaf renewed but the stem also. A grass stem is jointed, each joint bearing a leaf. In the axil of each leaf is a potential bud, which lies dormant so long as the main stem is growing. If, however, the main stem is grazed or cut off, the bud in the axil of the uppermost remaining leaf develops and replaces it. Grass is nature's nearest approach to an indestructible forage plant. So dominant are the grasses among grazing plants that the English word *grass*, which originally meant herbage in general, and from which is derived the verb *to graze*, has come to be applied particularly to the gramina, or "true grasses."

These true grasses seem to have appeared on the earth during Upper Cretaceous time, as their earliest fossil representatives have been found in formations laid down in this period. In the Eocene there was a notable expansion of the grass family, and in the Miocene it was well on its way to becoming one of the dominant types of plant life. Little Eohippus, of the Eocene, the great-great-grandfather of all the horses, and his descendants in the Oligocene, who have left their fossil remains in our Western States, had teeth for eating twigs and bark. During the Miocene our Great Plains were uplifted and became a vast grassland. The little browsing horse, no larger than a sheep, developed teeth for grazing, and, living on a grass diet through many generations, increased in size and swiftness until, when the Ice Age appeared, there were at least ten species of the genus, some as large as the domesticated horse of today and one even larger. The horse and the other graminivorous (or grazing) animals, the ancestors of our domestic live stock, really owe their development to grasses.

Man's first attempts to control his fate, to provide for future need instead of remaining the victim of droughts or other untoward circumstances, which were the beginnings of civilization, must have been on grasslands where

the young calves, lambs, and kids he caught and tamed could find forage. It was on grasslands, too, that primitive man, after he had reached the food-producing as distinguished from the food-gathering stage, developed most rapidly. The earliest known records of human culture are found in the Nile Valley and in southwestern Asia, open country of scanty rainfall. It is perhaps significant that the most primitive tribes of living men, the pygmies of Africa, New Guinea, and the Philippines, are found only in forested regions. Sheltered in the depths of the forest they have led their timid lives, so near the verge of starvation that they are relatively few and remain in the Stone Age to this day.

It was while the ice of the fourth Glacial Period covered most of Europe, some hundred thousand to five hundred thousand years ago, according to Breasted, that the earliest Nile dwellers slowly changed from hunters to breeders of flocks and tillers of the soil. Wheat, with ages of selective cultivation behind it, has been found in some of the oldest known graves in the world, in the Nile Valley. The stomachs of bodies from these early cemeteries contain husks of barley and of a kind of millet (*Echinochloa colonum*) no longer cultivated. In the Nile Valley the cultivation of grain seems to have preceded the grazing industry, but breeding of donkeys, sheep, and cattle was well established by 3500 B.C.

In Europe the hunters of the Old Stone Age advanced but slowly until the final retreat of the glaciers some seven to ten thousand years ago. But the domesticated or half domesticated animals of the Nile Valley and the eastern shores of the Mediterranean somehow found their way into Europe, following steppes and valleys until in time they reached the grassy Swiss uplands, where they were again domesticated by the Swiss lake dwellers.

For thousands of years the women of those early ages had gathered the seeds of wild grasses, crushed them between stones, and made cakes of them. At an early

period barley and wheat somehow reached these lake-dwellers, for these grains have been found in the remains of Swiss lake villages. Men as well as cattle must have wandered from the East, each generation going further west and carrying seed grain with them. With grain and cattle the Europeans of the Late Stone Age were able to advance rapidly from a life of hunting to one of settled communities of cultivators and cattle breeders. As in Egypt the two types of culture, growing of grain and cattle raising, both based on grasses, proceeded together, the prototype of modern farming.

In western Asia the hunter developed primarily into a cattle breeder, depending on the wild grasslands for forage, ever wandering in search of fresh pasture. When Abram and his family set out from Ur, between the Euphrates and the desert of Arabia, "to go into the land of Canaan," he was a herdsman, doubtless seeking new grazing lands. He followed up the valley of the Euphrates, far to the north, instead of striking across the desert to Canaan, and stopped at Haran (later called Charan) in upper Mesopotamia, a region of good pasture land. Later Abram wandered southward in the country bordering the Mediterranean, stopping where he found water and pasturage, until, when "there was a famine in the land," he drove his "sheep and oxen and he-asses and she-asses and camels" down into Egypt. In that fertile land Abram became "very rich," that is, his stock increased, until, on returning to Canaan with his nephew Lot, they had such vast droves of animals "the land was not able to bear them." And "there was strife between the herdsmen of Abram's cattle and the herdsmen of Lot's cattle," even as there was between the cattlemen of our Western States in the seventies and eighties of the last century. Later there was trouble with Abimelech over a well and more strife between herdsmen, and so the story of the patriarchs unfolds, always against a background of seeking grazing land and trying to hold it. Famine came in Isaac's

day and he sowed a field "and received in the same year an hundredfold." This is the first mention in the Bible of sowing, but what Isaac sowed we do not know. The first mention of grain is in the passage where Isaac, blessing Jacob by mistake for Esau, says, "God give thee . . . plenty of corn." This corn must have been wheat or barley, both of which were cultivated in Egypt and adjoining regions centuries earlier.

The Indo-Europeans, our own ancestors, were already herdsmen when, some forty-five hundred years ago, they began to spread from the great grassy steppes which lie east and northeast of the Caspian Sea. Tribe after tribe of these nomads wandered across Europe seeking pasture, until they reached the westernmost land, the British Isles. Besides cattle and sheep, these people had horses. Among the Hebrews and other Semitic tribes donkeys were used as beasts of burden and camels for riding. The early European tribes were horsemen, the great-great-grandfathers of our cowboys. As these tribes found promising land—the valley of the Danube, the plains of Hungary or Lombardy, the valley of the Rhone—they settled down, cultivating wheat and barley as well as raising livestock, just as American pioneers took up homesteads in the West. Middle and western Europe, being a land of mixed forest and relatively small stretches of open grassland, encouraged this settled life of farming and progressive civilization. The great grasslands to the north of the Black Sea and stretching far into Asia remained the home of nomads, who depended on wild pasture. As the tribes and their flocks increased they became ever more warlike, fighting with one another, and periodically—when there was a drought, probably, or when the grasslands were depleted by long overgrazing—moving out in vast hordes, overwhelming towns and agricultural settlements. The Scythians before the Christian era, and the Huns, Tatars, and Mongols, who later overran Europe, were such swarming nomads. Much of his-

tory is but the record of invasions of peoples seeking fresh grasslands.

Grasses were the innocent cause of trade wars, also, for caravans of camels or horses had to follow grasslands; and these trade routes were fought for, as sea routes and railways have been fought for in modern times.

Grasses and Old World Civilization

Although grazing was an advance over hunting it did not forward civilization as did the cultivation of grain, which compelled a settled abode. At the dawn of history the beginning of such cultivation was so far in the past that it had become a myth. In Egypt wheat was held to be the gift of Isis, in Greece, of Ceres. Our breakfast "cereals" commemorate the Greek myth to this day. From Egypt and adjoining Asia, the cradle of a civilization based on the cultivation and grazing of grasses, this culture slowly spread in all directions, reaching from China to the British Isles and down through Abyssinia to the tribes of East Africa, a culture built up on the economic foundation of grain fields and herds.

None of the cultivated races of wheat are known in the wild state. A wild form of emmer (*Triticum dicoccum*) was discovered in 1906 on Mount Hermon, in Palestine, and later in Moab, by Aaron Aaronsohn, and called *Triticum dicoccoides* by the German botanist, Koernicke. In 1910 it was found again in western Persia, in the Zagros Mountains. It seems fairly certain that this is the ancestor of cultivated wheat. In emmer and in its wild variety, the axis of the head breaks up, the grain remaining inclosed in the chaff. In cultivated wheat (Fig. 37) the axis does not break up and the grain can readily be freed from the chaff. This character must have been developed and fixed by selection, yet so long ago was it accomplished that the wheat found in the earliest known graves is free from chaff. Breasted states that the stomachs of mummies in these graves contain the chaff of barley, which,

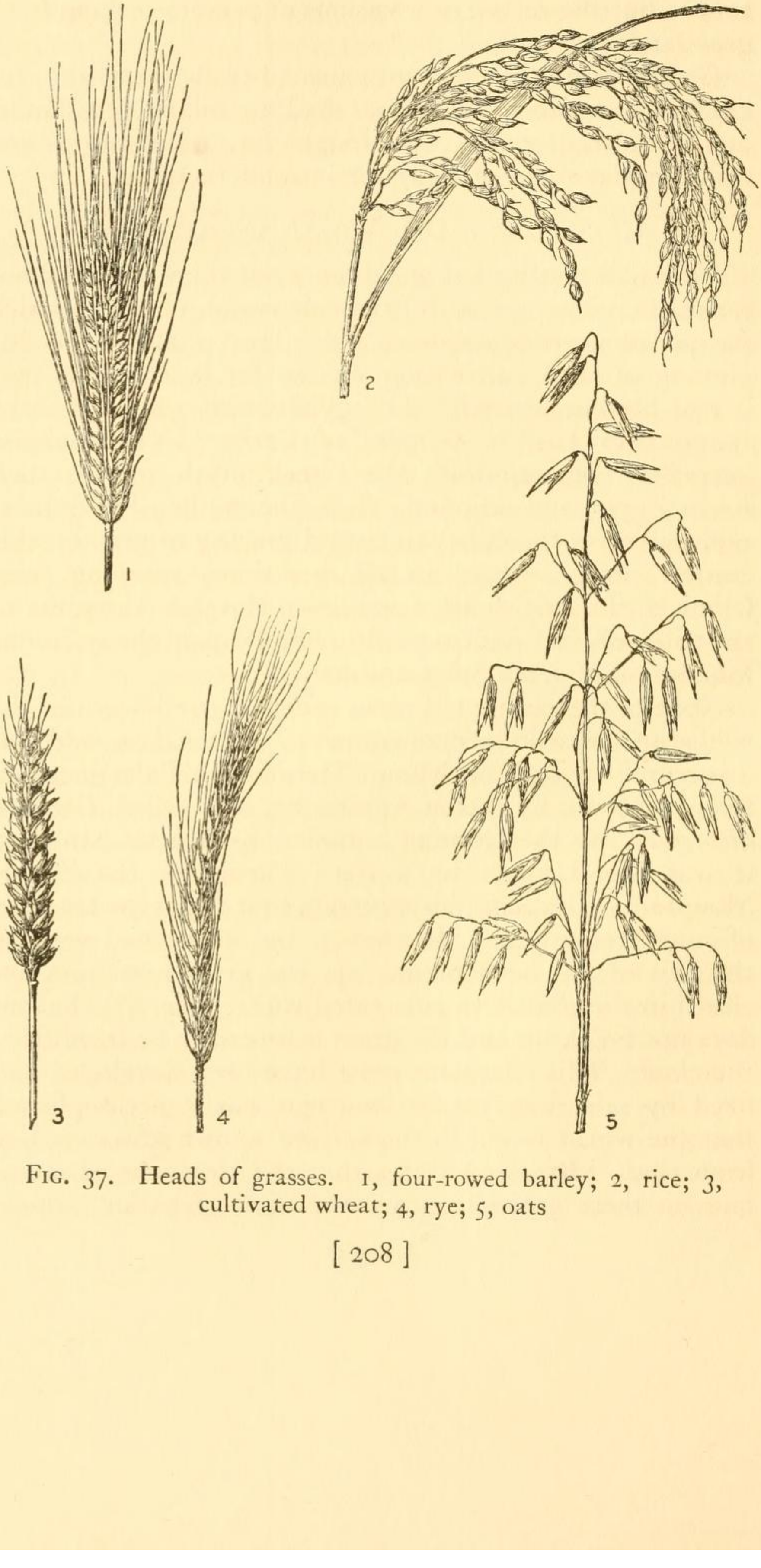


FIG. 37. Heads of grasses. 1, four-rowed barley; 2, rice; 3, cultivated wheat; 4, rye; 5, oats

being difficult to separate from the grain, was present in the bread. The chaff of wheat is not found in the stomachs, because it was readily removed from the grain.

Tales have been told of the germination of wheat found in Egyptian graves, and it has been claimed that the peculiar wheat with branched heads called "mummy wheat" was derived from such seed. These statements are not credited by scientists. It must have been an easy matter for a guide or other person to replenish the wheat in graves shown to travelers, and doubtless many a traveler was willing to pay well for a few grains of wheat from an ancient jar found in a grave with a mummy. But the so-called mummy wheat has not been found in Egyptian graves, and authorities agree that it did not exist in antiquity. Pharaoh's dream of seven ears of corn on one stalk suggests that the branched heads of wheat may have appeared as occasional sports since early times, though it was only in modern times that this form of wheat was fixed by selection and breeding. Certain varieties of Poulard wheats produce branched heads, especially in Alaska, as do some of our native wheat grasses, such as *Agropyron smithii*.

Barley was also cultivated in the New Stone Age, for it is found in Egyptian pottery jars dating from 4000 B.C. and in the remains of Swiss lake villages. The barley of antiquity was the six-rowed kind (*Hordeum hexastichon*) less commonly cultivated today than the four-rowed (*Hordeum vulgare*). The two-rowed (*Hordeum distichon*), also cultivated today, is the only form known to grow wild. The four-rowed barley appears to have been derived less anciently from *Hordeum spontaneum*, now growing wild from the Caucasus to Persia and Arabia.

Wheat reached China long before the Christian era, but rice is the more widely cultivated grain in eastern Asia. Rice was developed in the dim past, being cultivated before 3000 B.C. In an ancient Chinese ceremony five kinds of seed were planted, rice by the emperor himself, the other

four by princes of his family. Of the five, esteemed as the greatest gift to the race, four are grasses, rice, wheat, sorghum, and millet. The fifth is a legume, soya or soy bean. Rice was cultivated in India in very early times; thence it spread to Babylon, and finally, about a thousand years later, it reached Syria and Egypt. It also spread south and east throughout the Malay Archipelago. In the Philippines today as for ages past rice is cultivated on the terraced mountain sides, the terraces holding the rains and preventing erosion. In this conservation of soil Philippine culture is far in advance of our own wasteful methods, which have resulted in denuding vast areas of fertile top soil. There are forms of rice growing wild in southeastern Asia which probably represent the species from which the cultivated rice (*Oryza sativa*) was developed.

Rye came into cultivation far later than wheat, barley, and rice, probably about the beginning of the Christian era. It seems to have originated in a region farther north, somewhere in the Russian steppes of Europe or Asia. Unlike the earlier-known grains, rye will run wild and maintain itself under favorable conditions for a time. For this reason it is difficult to determine whether plants that have been found growing wild were really wild forms or descendants of cultivated rye.

The common oat (*Avena sativa*) is generally believed to have been derived from the wild oat (*Avena fatua*); the Algerian oat from *Avena sterilis*, and a few other varieties from *Avena barbata*, all three species native to the Mediterranean region. Oats were known to the ancient Greeks as weeds in grain fields, but appear to have been cultivated in middle Europe during the Bronze Age.

Sorghum (*Sorghum vulgare*) in various forms has been widely cultivated for ages; but, though long grown by Egyptians, it has not been found in the early tombs. A number of closely related species are native to east-central Africa. Sorghum was probably derived from one of

them, and introduced in prehistoric time into Egypt, whence it spread to India and China. In warm countries sorghum seeds so heavily that it is the staple food of millions of people, especially in Africa. Sweet sorghum (*Sorghum saccharatum*) also was probably derived from a central African species. It appears to have reached Egypt after the time of the Pharaohs and to have spread to Arabia, India, and China, where it is the *kao-liang*, or "great millet" of the Chinese. In the United States kafir, milo, and durra, forms of sorghum, are grown for seed and for forage. Broom-corn sorghum is grown for its great branching heads from which our brooms are made. Sweet or saccharine sorghum or sorgo is cultivated for the sweet juice extracted from the stem, which, boiled down, was the delicious sorghum molasses so commonly made by farmers of the Middle West a generation ago.

Several other species of grasses have been cultivated by primitive peoples for the seed, but are now largely replaced by wheat and other grains. Common millet (*Panicum miliaceum*), a native of Asia, probably reached Europe nearly as early as wheat and barley, for it is found in remains of Swiss lake dwellings. It has become naturalized in many temperate regions, including the United States. Italian or foxtail millet, with a multitude of derived forms, such as Hungarian millet and German millet, was also commonly cultivated in prehistoric times, apparently spreading westward from China, and reaching Switzerland in the Stone Age. Pearl millet (*Pennisetum glaucum*), another African grass, is grown in Africa and in tropical Asia for food. At maturity the smooth and shining grain bursts through its chaff, the long cylindrical spike being thick set with these "pearls." Coracan (*Eleusine coracana*), a native of India, teff (*Eragrostis abyssinica*), and fundi (*Digitaria exile*), natives of Africa, are also cultivated in tropical Asia and Africa but are unimportant compared to the grains.

Besides the grains, whose seeds furnish the breadstuffs

of the world, there is another grass which is the source of an important food, sugar. Sugar cane (*Saccharum officinarum*) is now cultivated in all tropical and sub-tropical regions of sufficient rainfall (Fig. 38). Compared with the grains its cultivation is relatively recent. Sugar cane seems to have originated in south-eastern Asia (New Guinea, according to to Brandes) and was grown in China a century or so before the Christian era, but was not known to Europe until the Middle Ages, when it was introduced by the Arabs into Sicily and the south of Spain. The ancients had to depend on honey for their sweetening; hence the ideal land, flowing with milk (having plenty of grass, that is) and honey. Sugar cane in cultivation rarely flowers and very rarely sets seed. Since the rich store of sugar in the stem would be used by the plant in the production of seed, the species has been artificially selected for sterility. Plant breeders occasionally succeed in securing seedlings, but sugar cane is propagated by planting joints of the cane, which root at the nodes and send up new stalks.

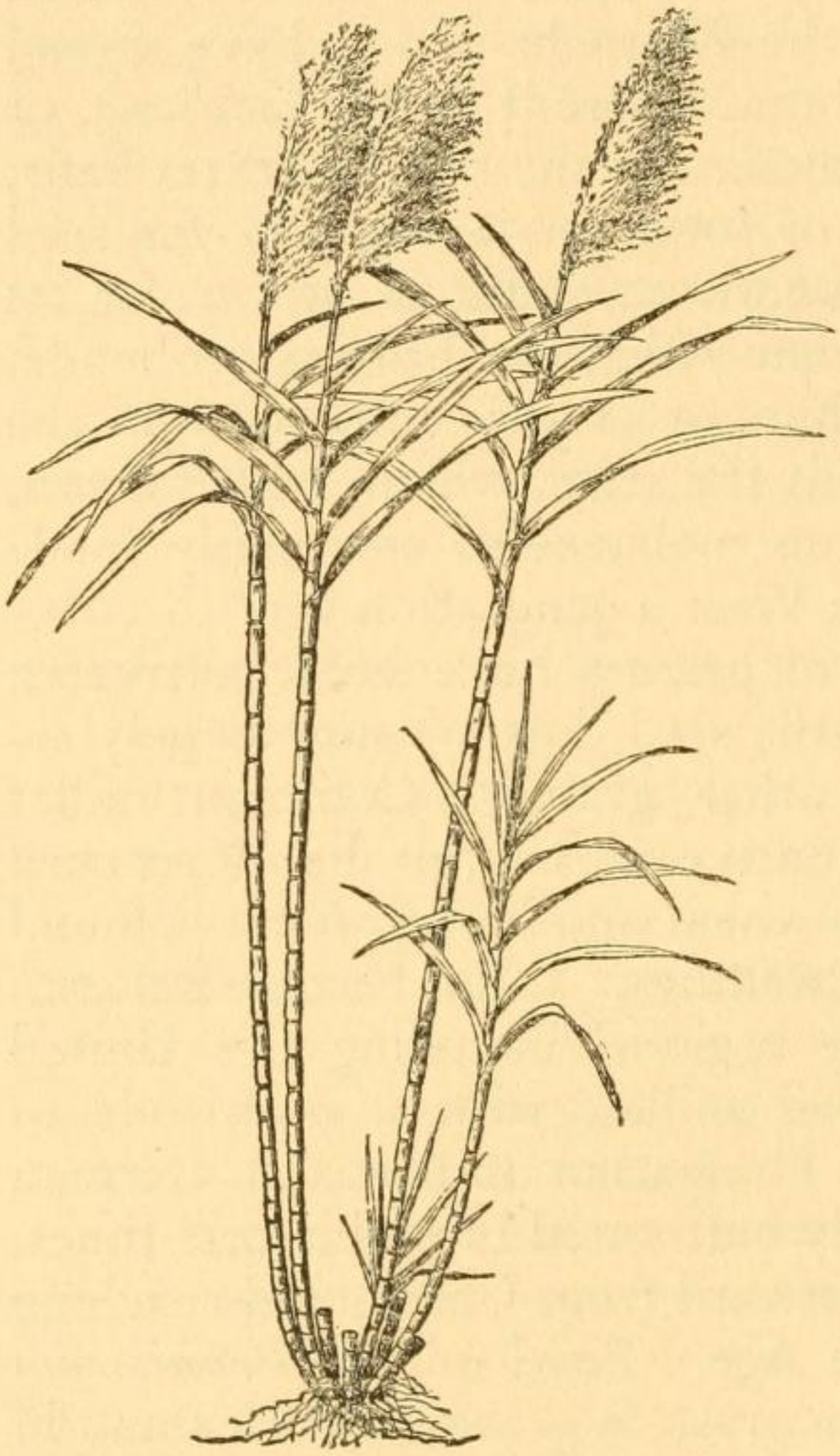
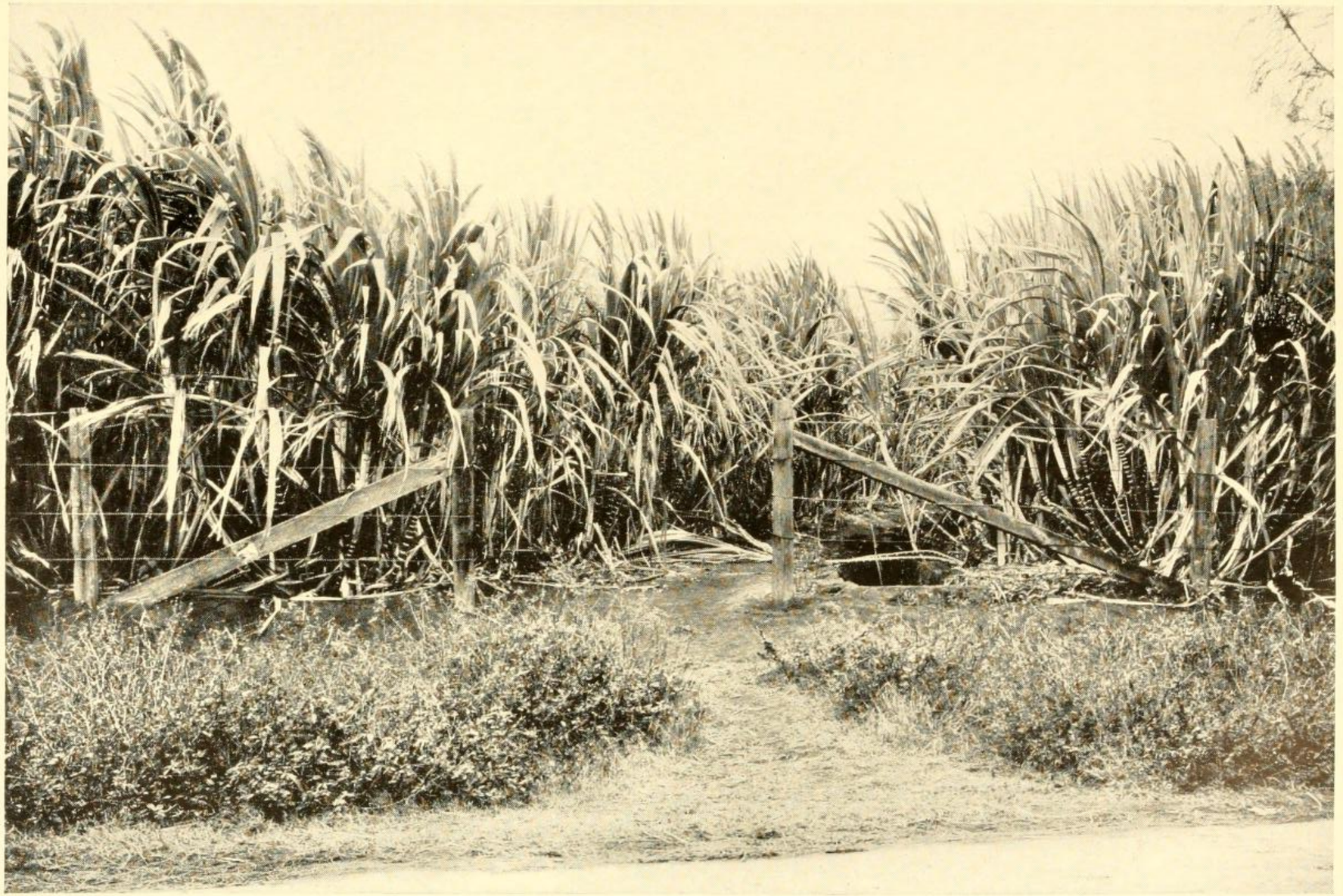


FIG. 38. Sugar cane



Field of sugar cane in the Hawaiian Islands. Photograph by Hitchcock

THE BASIS OF CIVILIZATION

Grasses and Amerindian Culture

The culture-nucleus, based on cultivation of grain and grazing, spread from Egypt and adjacent Asia throughout the Eastern Hemisphere, except Australia, which developed no civilization of its own. In America a second center of civilization arose, based on the cultivation of maize, which like that of wheat began so far back in antiquity that its origin is veiled in myth. To the American Indian maize was a gift of the gods. One of the legends is familiar to us—the one which relates how Hiawatha prayed that the lives of his people might not depend on hunting and fishing. In answer to his prayer came Mondamin, with whom Hiawatha wrestled mightily, whom he buried, and from whose grave, carefully tended according to Mondamin's instructions, sprang maize, a never failing food for the people. While Eurasia had wheat, barley, rice, and the other grains America had but one. When the white man arrived maize was cultivated from Central America south to Peru and north to Quebec. The Inca, Maya, Aztec, and Pueblo civilizations were based upon it, and it was cultivated by the North American Indians over much of what is now the United States. The hungry Pilgrim Fathers, we are told, found a buried hoard of Indian corn during their first terrible winter in the New World and thankfully stole it. But for this lucky find there would probably be fewer *Mayflower* descendants than there are today. The Indians taught the Pilgrims how to plant maize, or corn as it was called by the English settlers, fertilizing it by burying two fish in each hill.

Maize (Fig. 39) has never been found growing wild, and it is singularly unadapted to maintaining itself without cultivation. No species growing wild is at all similar to maize. There are wild species related to each of the Old World grains, from which the cultivated form has probably arisen; but maize (*Zea mays*) is the only known species in its genus. The genus most nearly related to it is

Euchlaena, to which belongs teosinte, a native of Mexico, occasionally cultivated for forage.

Collins, who has made careful studies of maize and its crosses and also of teosinte, is of the opinion that maize originated as a hybrid between teosinte and an unknown and extinct species resembling pod corn.

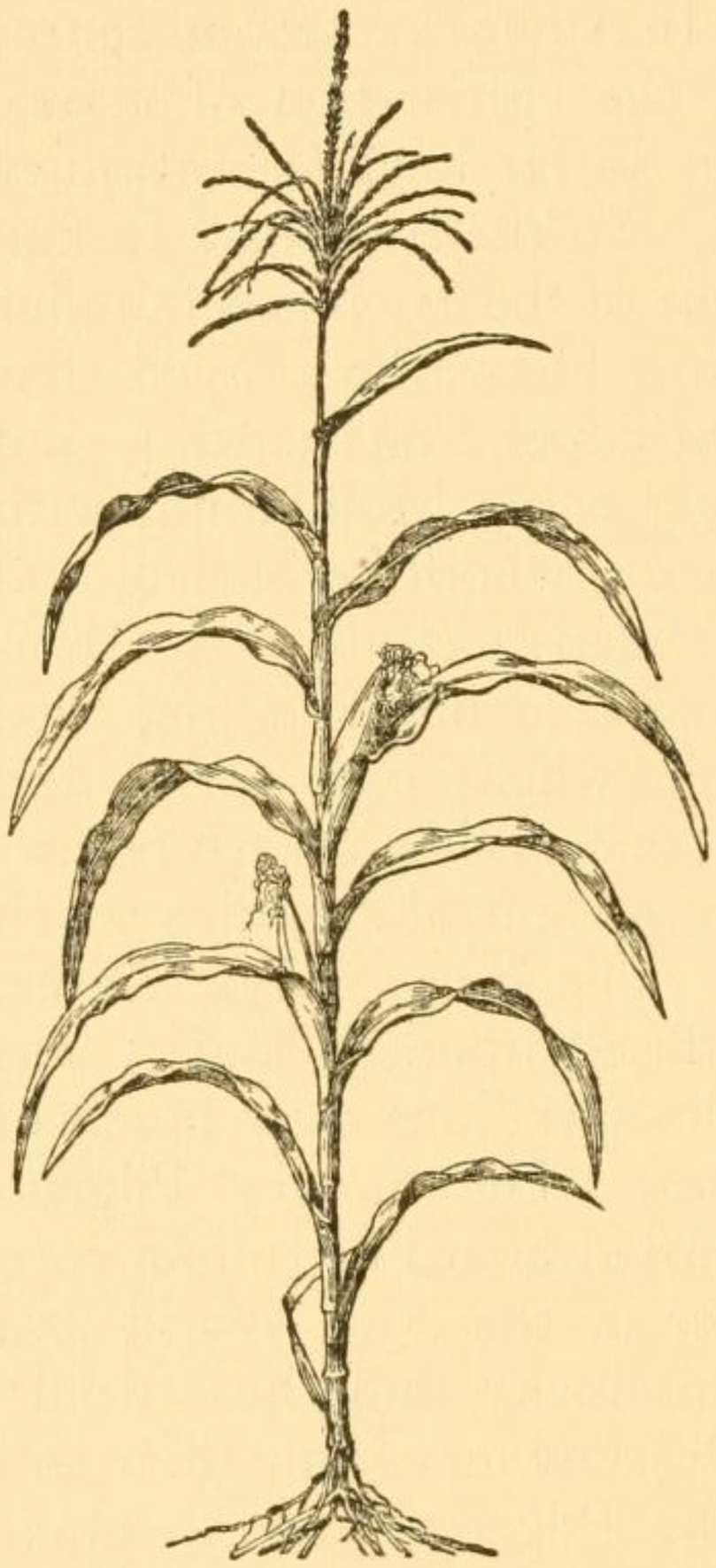
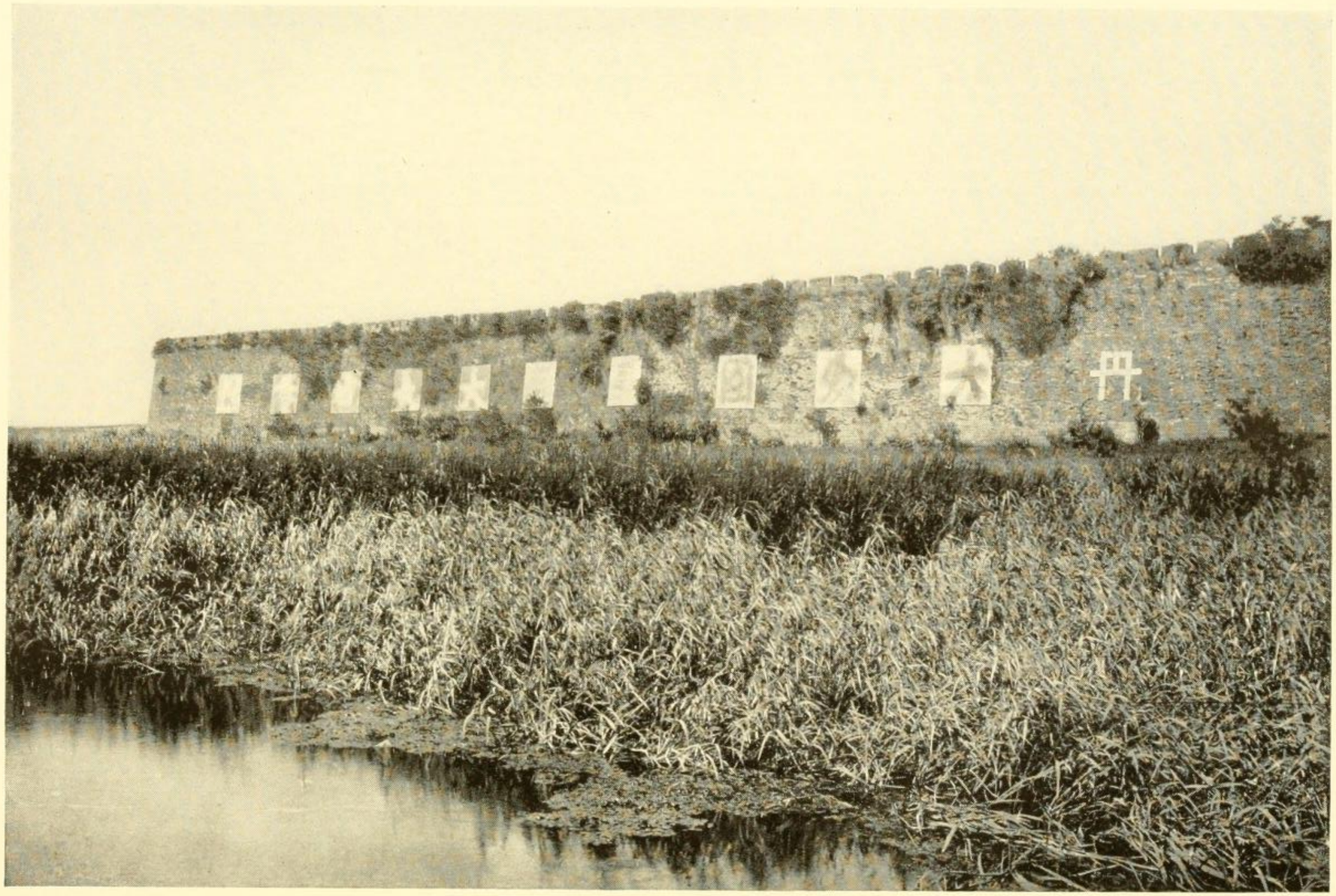


Fig. 39. Maize or Indian corn

Maize is the most highly specialized grass in the world; and it was the American Indian who, by artificial selection through thousands of years before the coming of the white man, produced this marvel of plant-breeding.

In the Old World the primitive agriculturist had domestic animals. The American Indian cultivated grain but had no cattle. The American bison, or so-called buffalo, is distantly related to the ancestors of domestic cattle, and in the mountains were wild sheep and goats; but these American animals for some reason were never domesticated. In South America the llama and alpaca were domesticated as beasts of burden, greatly inferior to the horse or donkey, and as sources of wool, but nowhere did the Indians have milk cattle. Though the horse originated in America, it became extinct on this continent before or during the Glacial Epoch and was unknown to the Indians until introduced by the Spaniards.

Herd of pack llamas traveling in the Andes, Peru (elevation 14,000 feet). Photograph by Hitchcock



Chinese Indian rice (*Zizania latifolia*) bordering a stream just outside the walls of Nanking. The lower part of the stem is used as a vegetable. The placards on the wall are advertisements. Photograph by Hitchcock

The Indians of the Great Lakes had besides maize another grain in the aquatic grass called wild rice, or Indian rice (*Zizania aquatica*). Down to our own day the Indians have gathered the wild rice, the women going about in canoes and tying together the heads of as many of the plants as could be gathered in the arms. These tied heads were left to ripen, when the women returned and, holding the tied heads over their canoes, beat out the grain. From two to three thousand bushels a year have been gathered in this way. Today Indian rice is an expensive dainty, served with game on the table of the epicure. In China the young shoots of a perennial species of *Zizania* are used as a potherb.

All the grains, to which man owes his civilization, are annual grasses, that is, the plant bears one crop of seed and dies. Perennial plants live over the winter or the dry season by means of underground parts that remain alive but dormant. Such plants usually bear fewer seed of less viability than do annuals, which must depend upon their seed for survival. An annual that failed to bear good seed would become extinct. Primitive man, or woman, rather, gathering seeds of grasses to add to the food supply, naturally took those of annuals, which were larger and more abundant. Annuals, being short-lived, produce seed within a few months after planting, while perennials seldom bear seed the first year. Naturally, then, it was annuals that were chosen for cultivation.

CHAPTER II

GRASSES THE BASIS OF WEALTH

So long as man depended on the chase there was danger of famine. By domesticating animals he greatly lessened this danger; but in a prolonged drought the grass would fail and the cattle perish, as has so often happened in our own Southwest. The cultivation of grain afforded a much more certain insurance against famine, for the grain could be stored from one harvest to another or for many years. The shrewd Joseph stored surplus grain for seven fat years; and then in the seven lean years that followed reduced the Egyptians to serfs by selling them back the grain they had raised and he had stored.

Grasses are the greatest single source of wealth in the world; for bread is in truth the staff of life, even if man does not live by bread alone. The prominent place the grass family occupies in the economic life of the world may be shown by a few statistics from the census reports on the value of farm crops in the United States.

The total value of farm crops for 1927 was more than nine billion dollars. Of this more than two billion, or nearly one-fourth of the whole, is credited to maize (corn). The next most valuable single crop is not a grass, but cotton, worth, fiber and seed, one and a half billion dollars. The third most valuable crop is grass, in the form of hay, the wild and tame together being valued at one and a third billions. Wheat, barley, oats, and rye together are valued at one and two-thirds billions. In round numbers the grass family, not even including rice, sugar cane, millets, crops of grass seed, and other lesser

items, accounts for five billion dollars of the total of nine billions, that is, more than all other crops, cotton, tobacco, fruits, and the rest, taken together.

Our agricultural statistics do not give the value of pasture, but in the aggregate it must reach an enormous figure. Every farm has its pasture land and vast areas in our Western States furnish forage, largely of grasses, to grazing animals. A large part of the value of dairy products and of beef and mutton must be credited to grasses. The proportional value of the grass family in agriculture is about the same throughout the world, rice and sugar cane being the most important in the tropical regions. The chief food plants of the world are the grains, legumes (beans, peas, lentils), potatoes, bananas and plantains, cassava, yams, breadfruit, taro, and the sago palm. Except among some primitive peoples the grains furnish the principal food, the others being supplementary.

Besides our daily bread, wheat bread or corn pone, knackbrod or bannocks, schwarzbrod or macaroni, rice or cakes of millet or sorghum, the grains furnish other important food products. Maize, the one native American grain, is a host in itself, giving us delicious sweet corn, pop corn, corn flakes, cornstarch, hominy, glucose, corn syrup, and a palatable oil besides. This oil, "Mazola," is obtained from the germ in the kernel of corn, a bushel of corn yielding about a pound of oil. As a by-product the germ yields a rubber substitute, the "red-rubber" now in common use as erasers, rings for fruit jars, sponges, and spongy rubber soap dishes and bath mats. Dextrin obtained from cornstarch has replaced gum arabic as the basis of mucilage. According to Slosson "more than a hundred different commercial products are now made from corn, not counting cob pipes." Cornstalks, formerly a waste product of huge proportions, are now coming into use as a source of cellulose and promise to be of especial value in the production of paper and of wall board. A corncob stone, called maizolith, has recently been de-

veloped. It can be worked and polished and used for such purposes as are now supplied by hard rubber and bakelite. Corn is also a source of alcohol. As Slosson further says, "This was, in fact, one of the earliest misuses to which corn was put, and before the war put a stop to it 34,000,000 bushels went to the making of whiskey in the United States every year, not counting the moonshiners' output. . . . The output of alcohol, denatured for industrial purposes, is more than three times what it was before the war."

Rye and barley are used extensively in making fermented and distilled beverages, and in the Orient a wine is made from rice. Much of the commercial vinegar is made from malt liquor, the alcohol being converted into acetic acid (the acid of vinegar) by means of ferments.

The juice extracted from the stems of sugar cane is concentrated until the sugar (sucrose) crystallizes and can be separated from the molasses. In earlier days the sugar was only partly extracted from the juice and the molasses, still rich in sugar, was an important by-product. Much of the molasses was used in the production of rum. With modern methods the separation of sugar is so nearly complete that the residue has little value. The bagasse, or crushed cane from which the juice has been extracted, is now being used in the manufacture of wall boards.

Range and Pasture

Besides supplying us with our daily bread, the grasses, by providing a large part of the forage of grazing animals, indirectly supply us with dairy products, beef and mutton, wool, leather, and horsepower. And, since hogs and poultry are fed largely on maize, ham and eggs are also secondary products of the grasses.

The range is the modern equivalent of the grasslands of our remote nomad ancestors. It is unfenced public land upon which the cattle and sheep of several stockmen graze in common, the cattle being separated at a yearly round-up according to their brands, the calves being branded

with the mark borne by the cows they claim as mothers. Our Western States were once immensely rich in good range land, but the best of the land has now been settled and brought under cultivation. But, even so, the acreage upon which livestock is grazed exceeds that under cultivation. The figures for 1920 were 293,794,000 acres cultivated and 350,000,000 acres used for grazing.

The range lands lie almost entirely west of the 100th meridian and comprise the vast semiarid region, with an average annual rainfall of less than twenty inches. This land, covered with the hardy and nutritious buffalo grass and grama grasses (Fig. 40), the wheat grasses, bromes, porcupine grasses and numerous other native species, affords excellent grazing. Dry farming is feasible on part of it but stock grazing appears to be the most economical use to which it can be put. Until the end of the last century the Federal Government allowed stockmen uncontrolled use of the public domain. As a result rolling hills knee-deep in grass were reduced to bare knobs, deeply gullied, their fine soil eroded and blown over the land in blinding dust storms; and vast natural pastures of grama grass were despoiled of their palatable and valuable forage and given over to worthless plants or left denuded and

FIG. 40. Tuft of grama grass, an important range grass

subject to erosion. When more stock than the land can support are grazed upon it, the hungry animals not only devour the good forage so completely that no plants are allowed to seed and so replenish the range, but also, in extreme cases, paw the plants and eat them to the very roots. The unpalatable plants and those covered with spines are avoided by the cattle, hence these worthless plants bear seed and replace the good forage. When we read of the wars of the Hebrews and the neighboring tribes in the light of the history of our western range lands we are impressed with the fact that overgrazing changed the Promised Land of plenty to a land of want. "He turneth a fruitful land into barrenness for the wickedness of them that dwell therein," says the Psalmist. Substitute ignorance for wickedness and it is literally true.

One of the great achievements of the United States Department of Agriculture has been the study of grazing problems, and the working out of a system of licensed use of grazing lands. Much of the public range is now under the control of the Forest Service. Permits are issued to stockmen which limit the stock to the number which the range can bear without injury, and are so timed as to permit the plants to set seed, thus restocking the depleted range. The wars and invasions of the ancient nomads were due to the fact that they were ignorant of range management, as, indeed, are many peoples today. Great areas of the once luxuriant campos of parts of Brazil are now denuded and badly eroded from long-continued overgrazing.

Pasture is grassland brought under control. In former times villages had pasture land in common, where the cattle of the villagers grazed under the care of a few children. The "commons" or "greens" of English villages and our own Boston Common were originally such public pastures. Now that townspeople no longer keep cows our "commons" have become parks, and pastures are parts of privately owned farms. Until very recently improve-

ment of pastures has not kept pace with other improvements in farm management. "Only the fact that grass will stand an almost incredible amount of abuse has prevented its utter destruction. Relegated to land too rough to till, neglected by the farmer, abused by the grazier,

FIG. 41. Kentucky blue grass

permanent pastures still furnish one-third the feed consumed by domestic animals," as a writer in the *Rural New Yorker* truly says.

Blue grass or Kentucky blue grass (Fig. 41) is the standard pasture grass for the humid region of the United

States, while Bermuda grass (Fig. 42) is the standard pasture grass for the Southern States. Both these grasses are sod formers, with tough rhizomes or rootstocks forming a close turf that withstands grazing and the trampling of hoofs. Both were early introduced from Europe, the

FIG. 42. Bermuda grass, showing habit of growth

blue grass from north Europe, and Bermuda from the Mediterranean (Kentucky and Bermuda both being misnomers).

In regions of snowbound winters pastures provide forage for but part of the year, and additional feed must be stored for winter. Such feed in the form of hay is cut from meadows, cultivated or wild. In the United States the hay from wild grass, once of major importance, is decreasing rapidly as more and more land is brought under cultivation.

Until the last century or so forage grasses were not cultivated in the sense of sowing seed of a single species. The first forage grass to be cultivated was English rye grass (*Lolium perenne*), which came into use in England about 250 years ago. Other grasses came into use later, until at the present time about fifty species are cultivated for

meadow or pasture, several of them to but a limited extent. Although most of these species are cultivated in the United States only a few are of prime importance.

Timothy (Fig. 43, left) is the foremost meadow grass for the Northeastern States and for the humid regions of

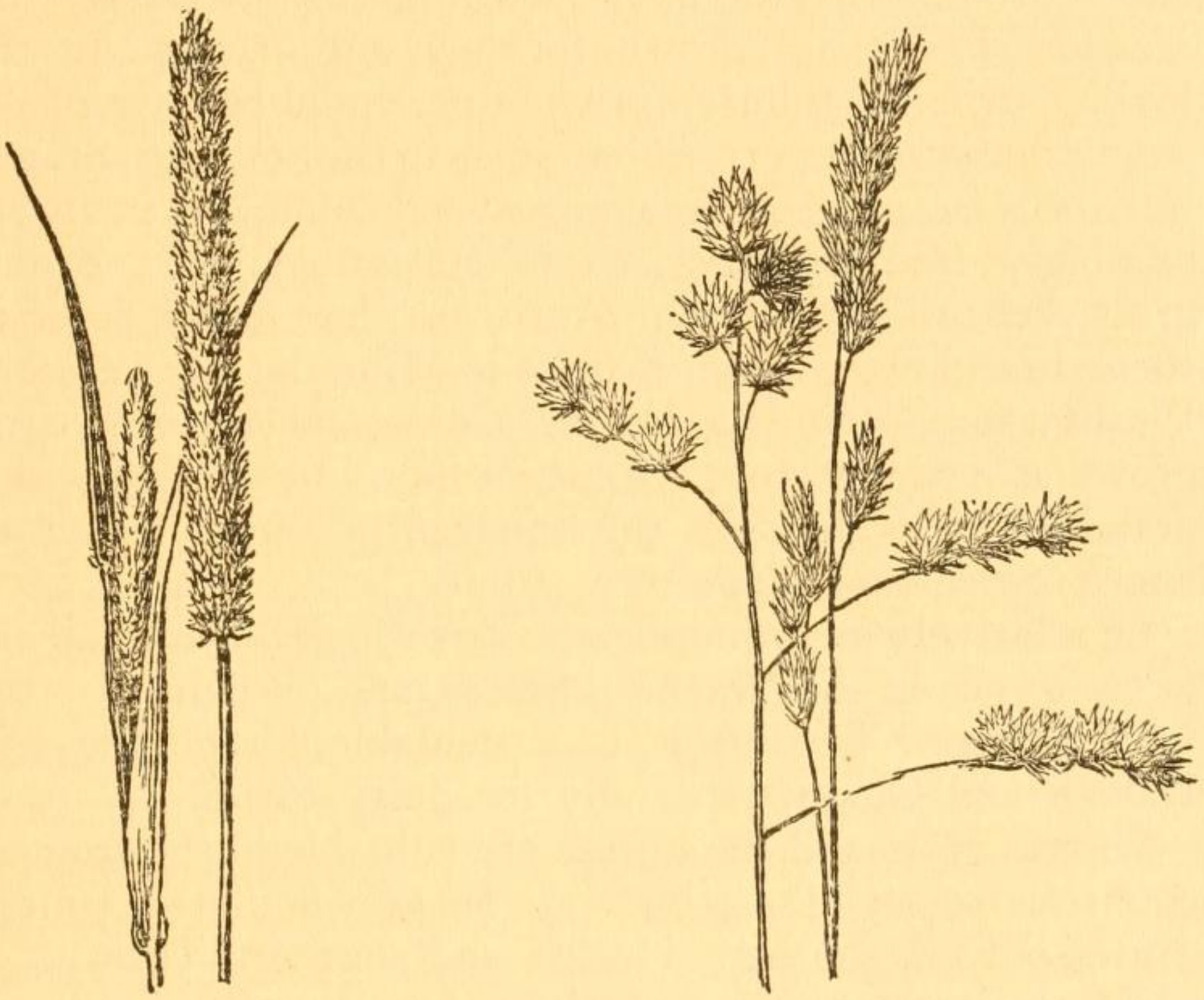


FIG. 43. Heads of timothy (left) and orchard grass (right)

the Northwest. It is the standard hay upon the market, that by which other hay is measured. Timothy was one of the earliest grasses to be cultivated for hay in this country and at once became dominant. It is not more nutritious than many other grasses, but its cheap and reliable seed recommend it to growers. The timothy seed is borne in a compact head and does not shatter easily when gathered. The whole crop ripens at approximately the same time and the heads are borne at a fairly uniform height, which make the seed crop easy to harvest. These qualities

combine to produce low-priced seed. The hay itself is easily grown and harvested, it cures well and is palatable and nutritious.

A few other grasses are important in certain areas, but none compare with blue grass and Bermuda for pasture and with timothy for hay. Redtop, orchard grass, and meadow fescue are grown for hay and pasture in the humid regions. Johnson grass, a perennial relative of the sorghums, is an important hay grass in the Southern States, but, because of its very aggressive rhizomes, it is an exceedingly troublesome weed in cultivated soil. Brome grass, because it is drought-resistant, has found favor in the semiarid region from Kansas to Minnesota and eastern Washington. On the Pacific Coast, wheat and oats, grown as a winter crop, are cut for hay. In California this grain hay is valued in the thirteenth census report at nearly twice that made from alfalfa.

Of relatively minor importance are rye grass, and tall oat grass, grown in the Northern States, and paspalum, in the Gulf States. The latter is a valuable forage grass in Hawaii and Guam, especially for dairy cattle.

Guinea grass and Pará grass are valuable in the tropical countries south of us, but can be grown in the United States only in southern Florida and southern Texas.

Forage is preserved not only as hay, but also as silage, which is prepared by packing the freshly cut forage, mostly maize stalks, leaves, and ears, in an air-tight receptacle called a silo. The mass ferments a little, becoming a mild forage sauerkraut, readily eaten by cattle.

In tropical countries, where the climate is not suited to haymaking, soiling, that is, the feeding of freshly cut forage to animals in inclosures, is commonly practised. A donkey trudging toward town almost hidden beneath a load of green grass is a frequent sight in the American Tropics. Soiling is also adapted to intensive farming, especially dairying, because large leafy grasses and legumes that would not endure trampling by stock can be grown,

which yield a larger amount of feed per acre than does pasture. But the amount of labor involved in soiling makes its cost prohibitive in most parts of this country. Teosinte, the wild grass most nearly related to maize, is grown for soiling in parts of Louisiana, where it yields an enormous amount of forage.

All these cultivated grasses are foreigners, mostly natives of Europe. Paspalum and teosinte come from the American Tropics. Only one of the fifty species cultivated in the United States is a native of this country. This is slender wheat grass (*Agropyron tenerum*), which is cultivated for hay to a very limited extent in the Northwestern States. Our prairies, plains, and upland meadows support numerous native species that are palatable and nutritious, but none of them has been found adapted to cultivation. This is due principally to the high cost of their seed. The grasses which best withstand grazing are sod formers. Perennials as a whole produce fewer and less viable seed than do annuals, and sod-forming grasses particularly, spreading vegetatively, do not produce large seed crops. Timothy, as stated before, is exceptional and is the preeminent meadow grass.

The United States Department of Agriculture and our State experiment stations have been for forty years testing grasses from all parts of the world, but the results are surprisingly small. Brome grass or Hungarian brome (*Bromus inermis*) is a comparatively recent introduction from Europe, where it had already come into cultivation. Rhodes grass (*Chloris gayana*), from Africa, gives promise for the irrigated regions of the Southwest.

The desire for miracles in grasses as in other things leads dealers occasionally to offer "mortgage-raisers" and the like, which turn out to be no better nor as good as grasses already in use. "Billion-dollar grass," widely advertised some years ago, is a variety of our common barnyard grass (*Echinochloa crusgalli*). The rich well-watered soil required for its growth would produce a far more valuable

crop of timothy. A so-called "Peruvian winter grass" is being sold at an enormous price, entirely out of proportion to its value. It is a variety of *Phalaris tuberosa* having rhizomes, was described from Australia, where it was introduced from Europe, and has been experimentally grown in California.

The grasses now grown in the humid region and in irrigated areas in this country are well suited to them. It is the ranchmen of the Southwest who are hoping for some grass that will make two blades grow where none grow now on their arid and semiarid acres, especially those depleted by overgrazing; for stockmen have impoverished their own as well as public lands by this practice. In a dry year in western Texas or in New Mexico one may hear a ranchman, holding on to his too numerous and starving cattle in the hope of rain, bitterly complain: "It's funny the Department of Agriculture can't find some grass that will grow on this land." The fact is that the best possible grass for that land did grow there until destroyed by overstocking. No grass, and certainly no other kind of forage—for grasses are the most long-suffering of all forage plants—can grow where it is grazed to its roots.

Land Building

Along our North Atlantic Coast and at the south end of Lake Michigan are great hills of sand, piled up by wind and wave. These sand dunes, unless held by vegetation, travel inland, a thin layer of the upper, driest sand blowing up the windward side and sliding down the lee side, the dune advancing from a few inches to a few feet in a year. The great dune at Cape Henry, Virginia, is thus moving and is burying a cypress swamp. One may walk down the lee side of the dune through the tops of cypress trees sticking out of the sand and come into the still unburied swamp. Where the land back of a dune is valuable, as on the Massachusetts coast and at the head of Lake Michigan, the advancing dunes cause great loss.

Dwarf Indian rice (*Zizania aquatica angustifolia*) on the margin of Lake Champlain, converting marsh into meadow. Photograph by Hitchcock

Spartina Townsendii building land outside a dike in the Netherlands. Photograph by Prof. F. W. Oliver, of London

Several species of grasses having strong rhizomes flourish on these wind-swept sands and serve to bind them. The principal species is beach grass or marram-grass (*Ammophila breviligulata*) (Fig. 44). When unusually severe winter storms or destruction by man make a break in the protecting zone of this grass a "blow-out" is likely to develop, which rapidly opens great gaps in the barren dunes, permitting the sand to sweep inland, covering towns and farm lands. The attempt of real-estate men to "clear away the sand hills" in order to develop summer resorts on the coast has had disastrous effects in places. It would be as safe to clear away the dikes on the coast of Holland.

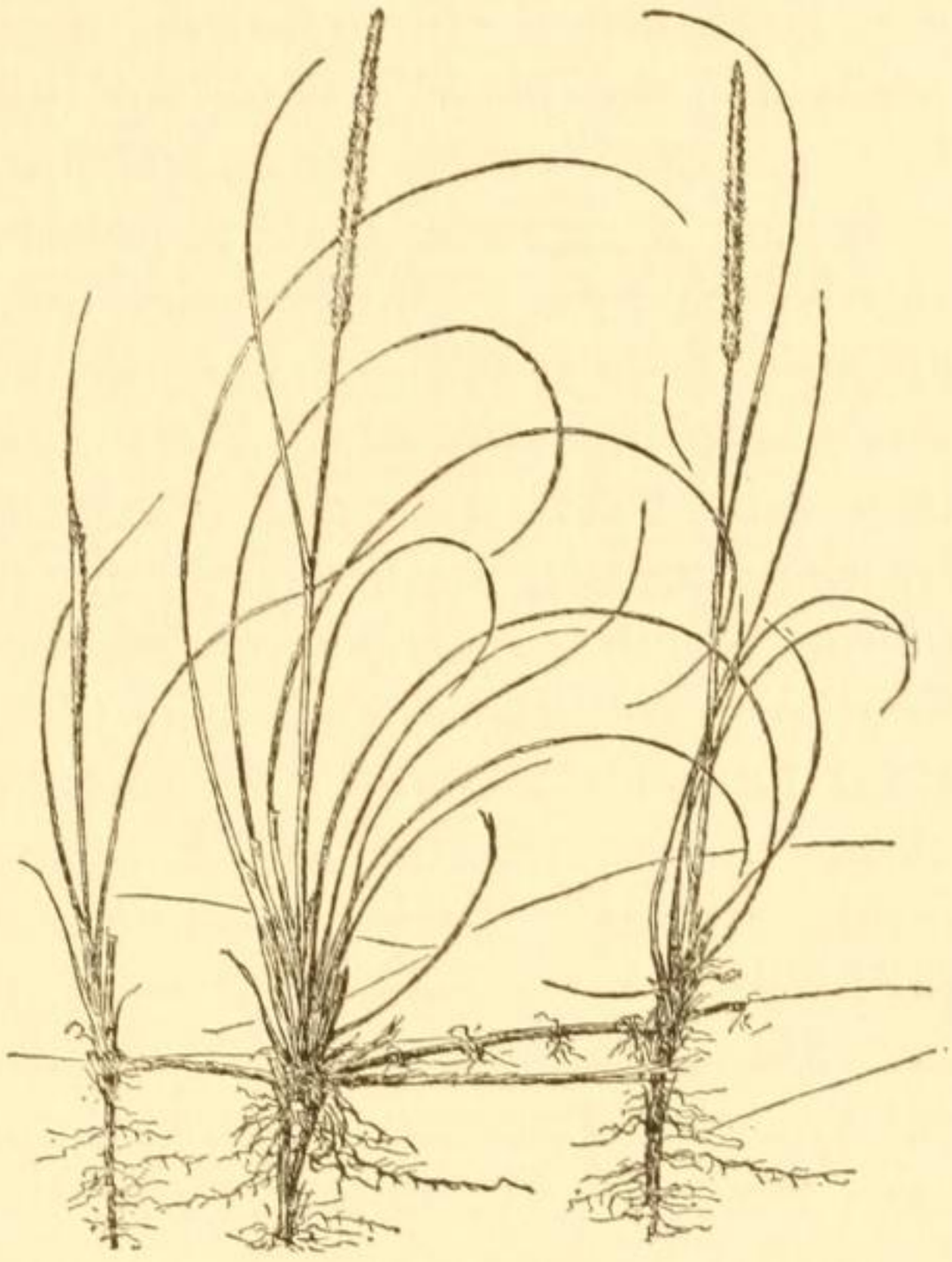


FIG. 44. Beach grass, showing habit of growth which makes it an excellent sand binder

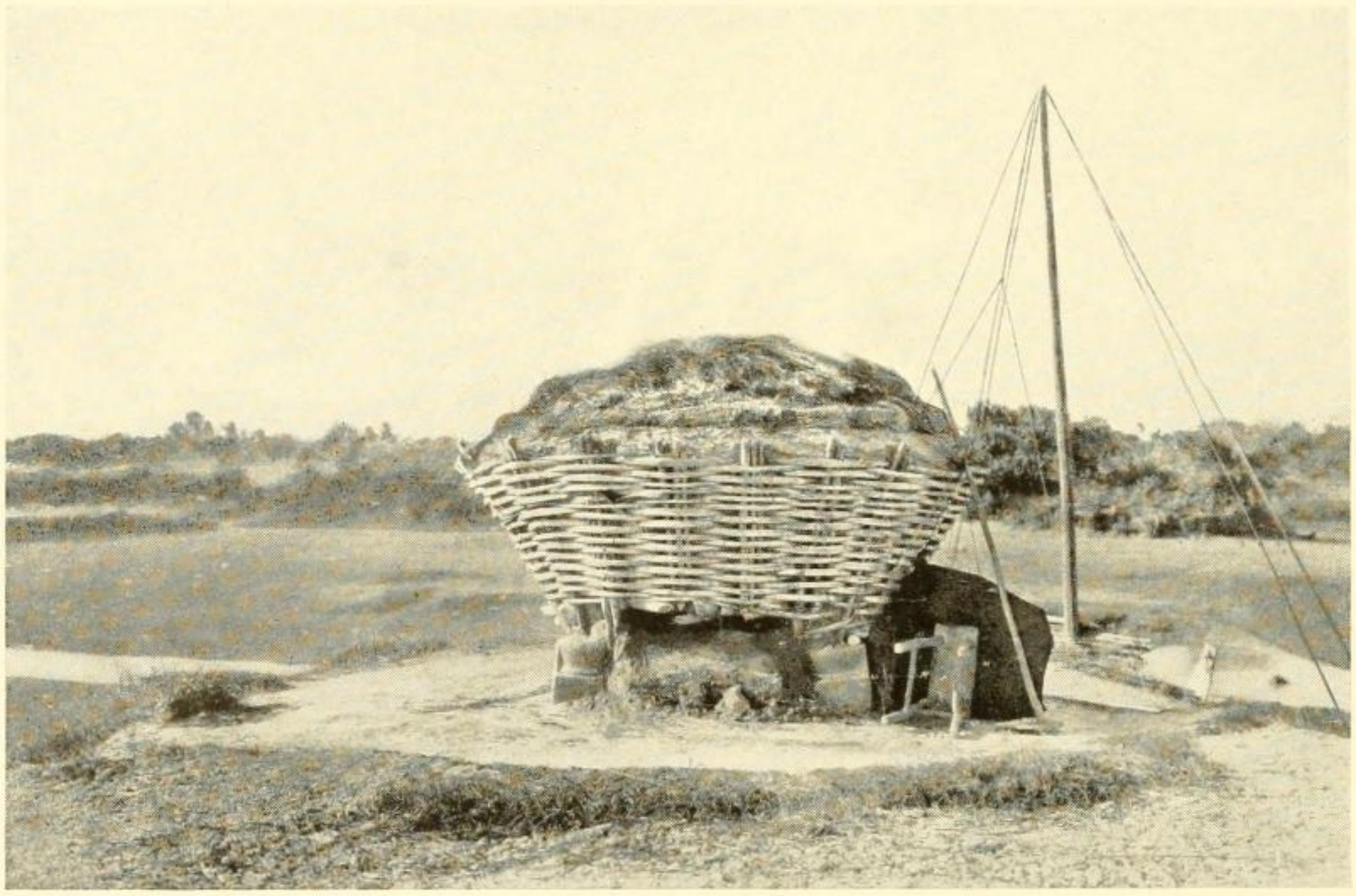
In Denmark, Holland, and along the Baltic, barrier dunes are under the care of the government. Areas of bare sand are planted with beach grass (*Ammophila arenaria*, closely allied to our own species) and accidental breaks are replanted.

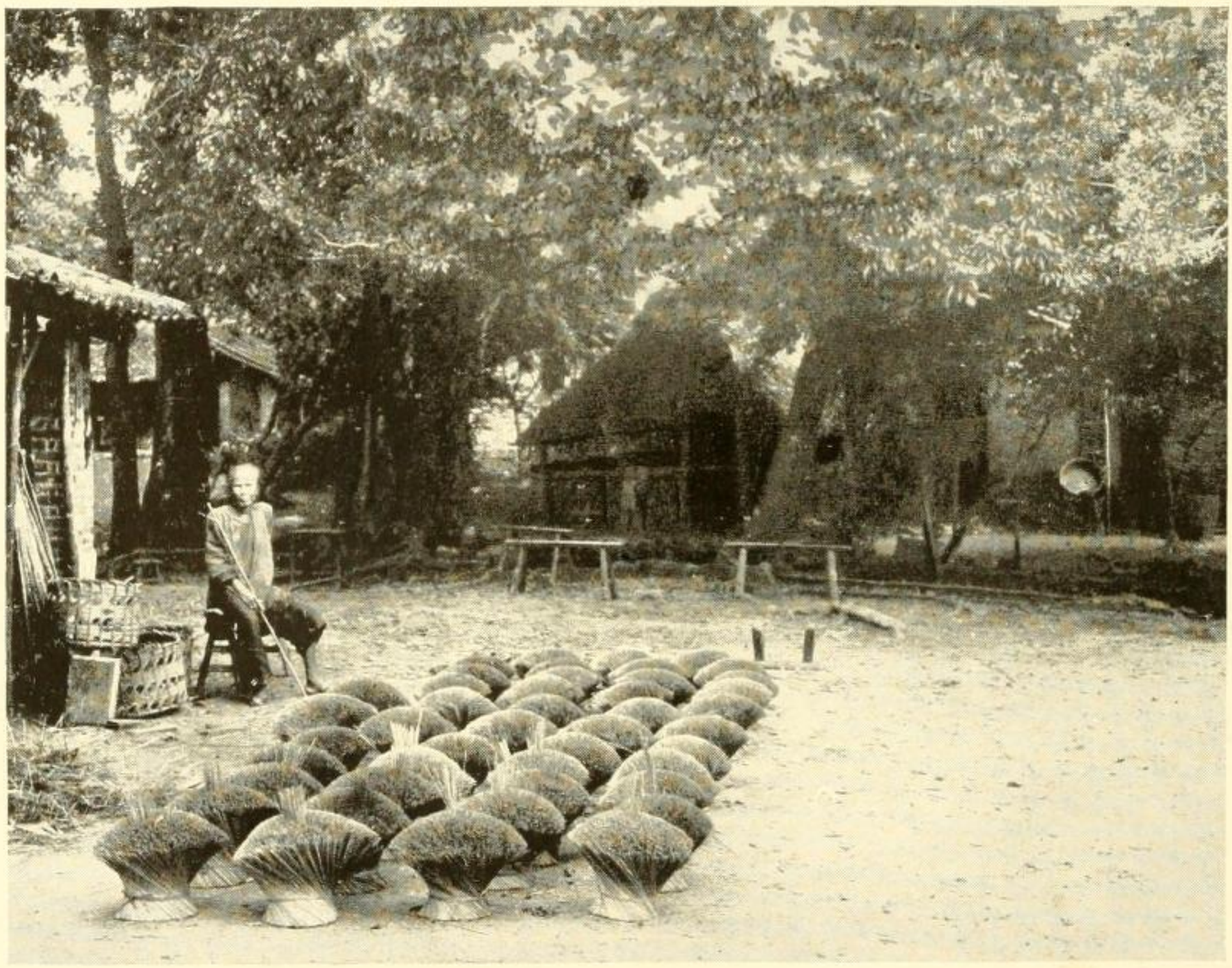
All marsh grasses are slowly building up meadow land. On mud flats and tidal estuaries such as those in the Gulf of St. Lawrence, Chesapeake Bay, and San Francisco Bay, species of cord grass (*Spartina alterniflora*, *S. cynosuroides*, *S. foliosa*, *S. patens*, and others) are building up

dry land. These grasses thrive in the soft mud submerged at high tide, their stout rhizomes forming a dense firm network ever pushing seaward. The coarse grass impedes the oncoming waves, protecting the shore while causing the water to drop its burden of silt, thus building up the floor until it becomes, first, marsh meadow, then dry land, when the *Spartina* dies out, leaving the land ready for the plow. This land building by *Spartina* has been going on along our coasts for ages, and it is going on today on a gigantic scale along the English Channel and the North Sea. The traveler on a ship entering Southampton today will see vast green meadows of *Spartina* stretching into the sea. Fifty years ago these were only bare mud flats. *Spartina Townsendii*, called "rice grass" by the English, a species closely related to *S. alterniflora* of the North American coasts, was first observed on the Southampton salt marshes in 1870. It now occupies the tidal flats for a stretch of one hundred and fifty miles along the south coast of England. "These bottomless muds, though they stood empty of vegetation . . . probably for thousands of years, found no plant capable of solving the problems of invasion and establishment till *Spartina Townsendii* came and made light of the task," says Prof. F. W. Oliver. On the French coast of the English Channel *Spartina Townsendii* now occupies the tidal flats along the Baie de la Seine, and has appeared near the Strait of Dover. A few years ago this grass was planted on the tidal flats on the east coast of England to protect the sea walls of Essex.

Cuttings of this grass have been sent to Ireland, the Netherlands, and Germany for reclamation work, which has proved especially successful in the Netherlands. (Plate 44.) In 1924 the grass was planted on the tidal mud of the Sloe, opening into the West Scheldt, and later along the East Scheldt also. The plants were set outside the dikes in rows at right angles to them. The force of the tide was thus divided and conquered, where crosswise

A clump of bamboo in China. Photograph by Hitchcock





Uses of grasses in China

Upper: A lime kiln on the island of Hainan, China, the wall of which is bamboo. Lower: Joss sticks of split bamboo drying in the sun, Canton.
Photographs by Hitchcock

plantings might have been uprooted and washed away. The tufts are spreading and filling in the spaces between them, soon to form a solid meadow and later arable land, thus within five years accomplishing the reclamation of miles of land which, left to nature, would take twenty years or more.

Other Uses of Grasses

The bamboos (Plate 45), the largest of the grasses, are of vast importance in the regions in which they grow, especially from Japan to India and Malaysia. The larger kinds reach a height of a hundred feet and are six to ten or twelve inches thick below, tapering to the summit. The culms or stems are very strong and are used in building houses and bridges. When the stems are split, flattened out, and the partitions at the joints removed they make very durable boards, a foot or more wide, for floors and walls. Rafts and floats are made of the hollow stems closed at the joints by air-tight partitions. With the partitions removed bamboo stems furnish water pipes or conduits. Sections of the stem closed at one end by the partition form convenient vessels for holding water. Much of the furniture, and many of the utensils and implements used by the Malays are made wholly or in part of bamboo. Slender bamboo stems are familiar to us in the form of fishing rods and walking canes. Shoots of *Bambusa Beecheyana* and other species of bamboo are a choice vegetable in the Orient and an expensive dainty in this country.

Grasses are an important source of fiber for paper making and cordage. England annually imports more than two hundred thousand tons of esparto grass (*Lygeum spartum* and *Stipa tenacissima*) from Spain and North Africa for paper making. Species of *Spartina* are used for cordage and the roots of *Epicampes macroura*, a Mexican grass, make the stout "fiber" scrubbing brushes now on the market. Brooms are made of the seed heads of

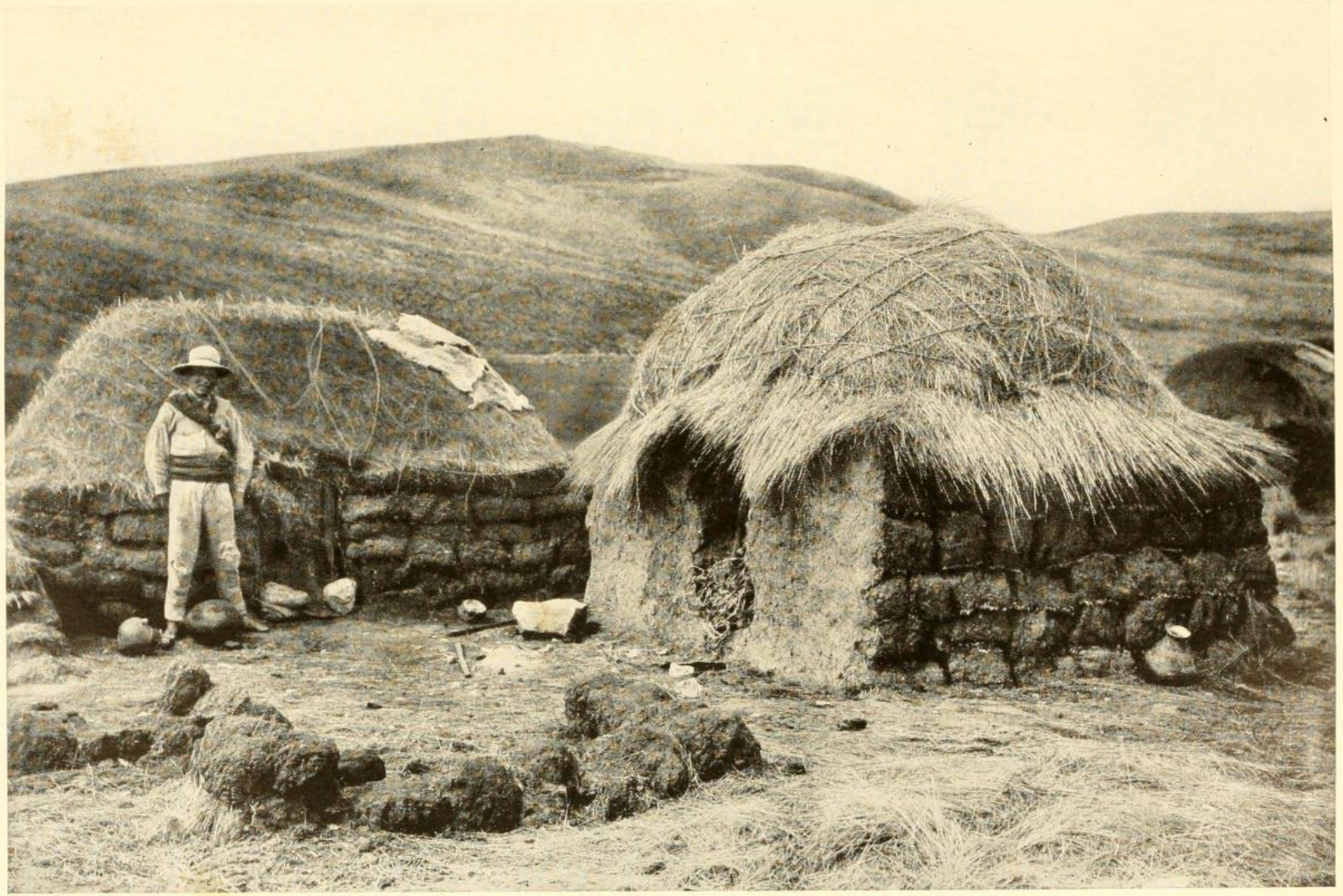
"broom corn," a kind of sorghum. Rice straw is used for matting and oat straw for straw hats. Leghorn hats are made of a kind of wheat straw cut young and bleached.

Tons of essential oils used in perfumeries are extracted annually from Asiatic grasses related to our broom sedge. A few of them are cultivated throughout the Tropics. One of them, citronella grass, is the source of the "fly dope" used by fishermen and campers as less unbearable than mosquitoes and black flies.

The resourceful pioneers who first settled the treeless regions of our Western States made grasses take the place of timber, building their houses of blocks of sod piled up into thick walls, which defied the blizzards of winter and the heat of summer. The sod house was to the pioneer of the plains what the log cabin was to the pioneer in wooded country. Today in the Andes the sheep herder builds his hut of sod and roofs it with ichu grass (Plate 47). The poor peasant in China uses grass for fuel to cook his meager dinner.

Injurious Grasses

The grass family, like many other fine families, includes a few vicious members. There are the weedy crab grass, couch grass, and the like, that cost the gardener and cultivator much labor, but they are troublesome only in being too hardy, and in coming where they are not wanted. The villains of the grass family are those that carry spears and daggers and use them without mercy (Figs. 45 and 46). Our native ruffians are bad enough, but a group of assassins from the Mediterranean join in their nefarious work. The native sand burs (species of *Cenchrus*) with their little balls covered with spines as sharp as needles, are troublesome to man and beast. The ripe spikelets of *Heteropogon contortus*, a relative of the broom sedges, have sharp barbed spears at one end and a stout twisted appendage at the other. The spear catches in the wool of passing sheep and the appendage untwists



Sheep herders' huts in the high Andes, Peru (13,000 feet). The walls are of sod. The roof, of ichu grass (*Stipa ichu*), is held down by ropes. Photograph by Hitchcock

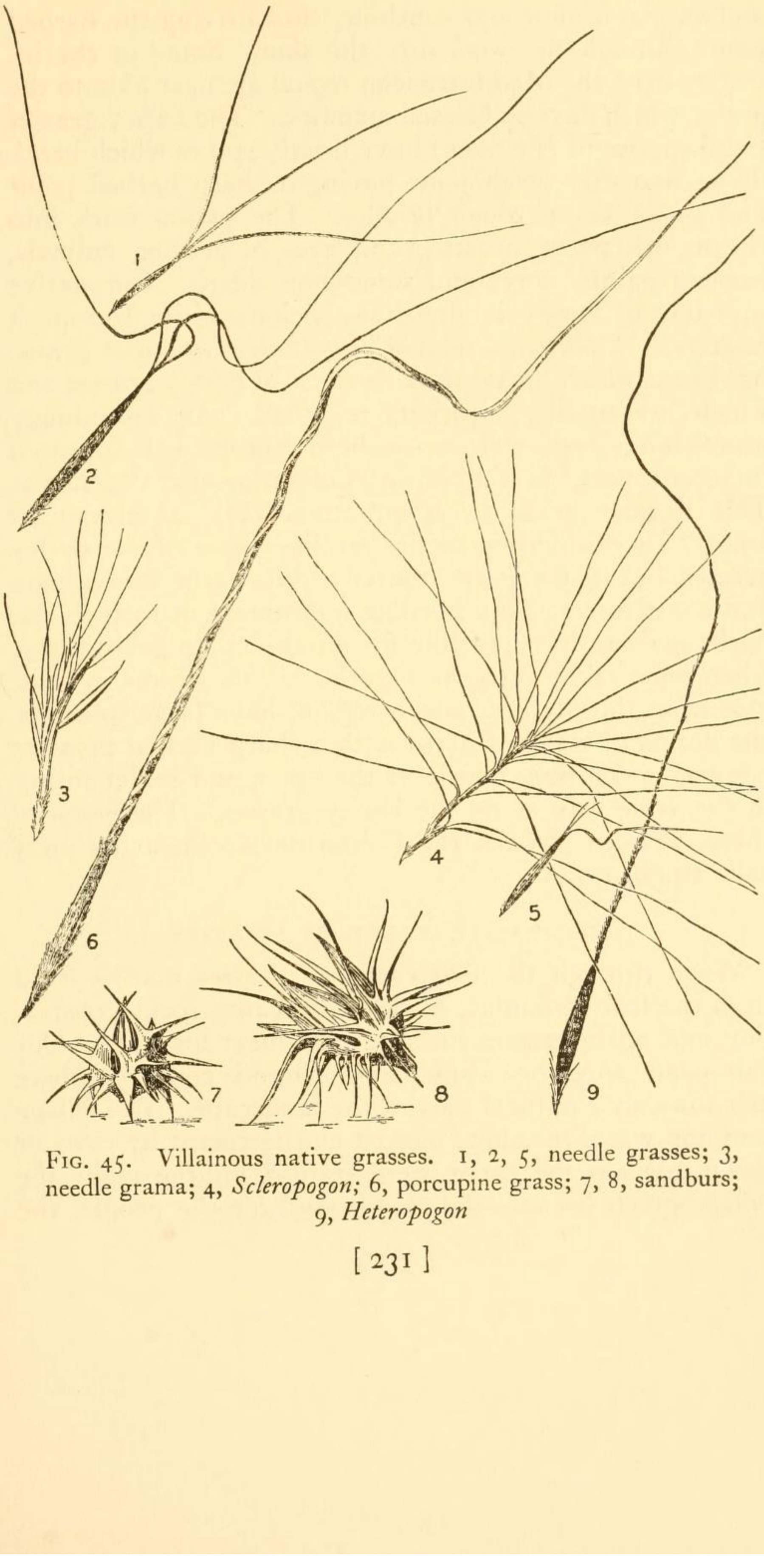


FIG. 45. Villainous native grasses. 1, 2, 5, needle grasses; 3, needle grama; 4, *Scleropogon;* 6, porcupine grass; 7, 8, sandburs; 9, *Heteropogon*

and twists, in dew and sunshine, thus driving the barbed point through the wool into the skin. Some of the invaders from the Mediterranean region are near akin to the grains which have so blessed mankind. The barley grasses (wild species of *Hordeum*) have bristly spikes which break up at maturity, each joint having a sharp barbed point and six or seven rough bristles. The points work into the mouth parts, nostrils, and eyes of grazing animals, causing painful sores and sometimes death. Our native squirrel-tail barley is almost as vicious as its European relatives. *Sitanion*, a related but wholly American genus, has heads which break up as do those of barley grasses and which are equally injurious to stock. An exceedingly unwelcome invader from southern Europe has appeared in recent years in California, Colorado, and Oklahoma. This is goat grass (*Aegilops triuncialis*), a relative of wheat. Its murderous tactics are like those of the barley grasses, but its joints are stouter and its barbs are stronger and constitute a really horrible instrument of torture, the barbs making it impossible for an animal to get rid of it when once taken into the mouth. A few brome grasses, also from the Mediterranean region, have large spikelets, the florets of which disjoint with a sharp barbed point at one end and a long bristle at the other, and inflict injury in the same way as do the barley grasses. The worst of these, *Bromus rigidus*, the California stockmen feelingly call "ripgut grass."

Decorative Value of Grasses

When through the cultivation of grasses man is freed from the fear of famine, his love of beauty seeks satisfaction and again grasses in large part meet his need. Our European ancestors came from humid country where meadows are a natural part of the landscape. The village common was a meadow, mowed and fertilized by cows or sheep. When the cattle were stabled for the night the village green became the playground for the people, the

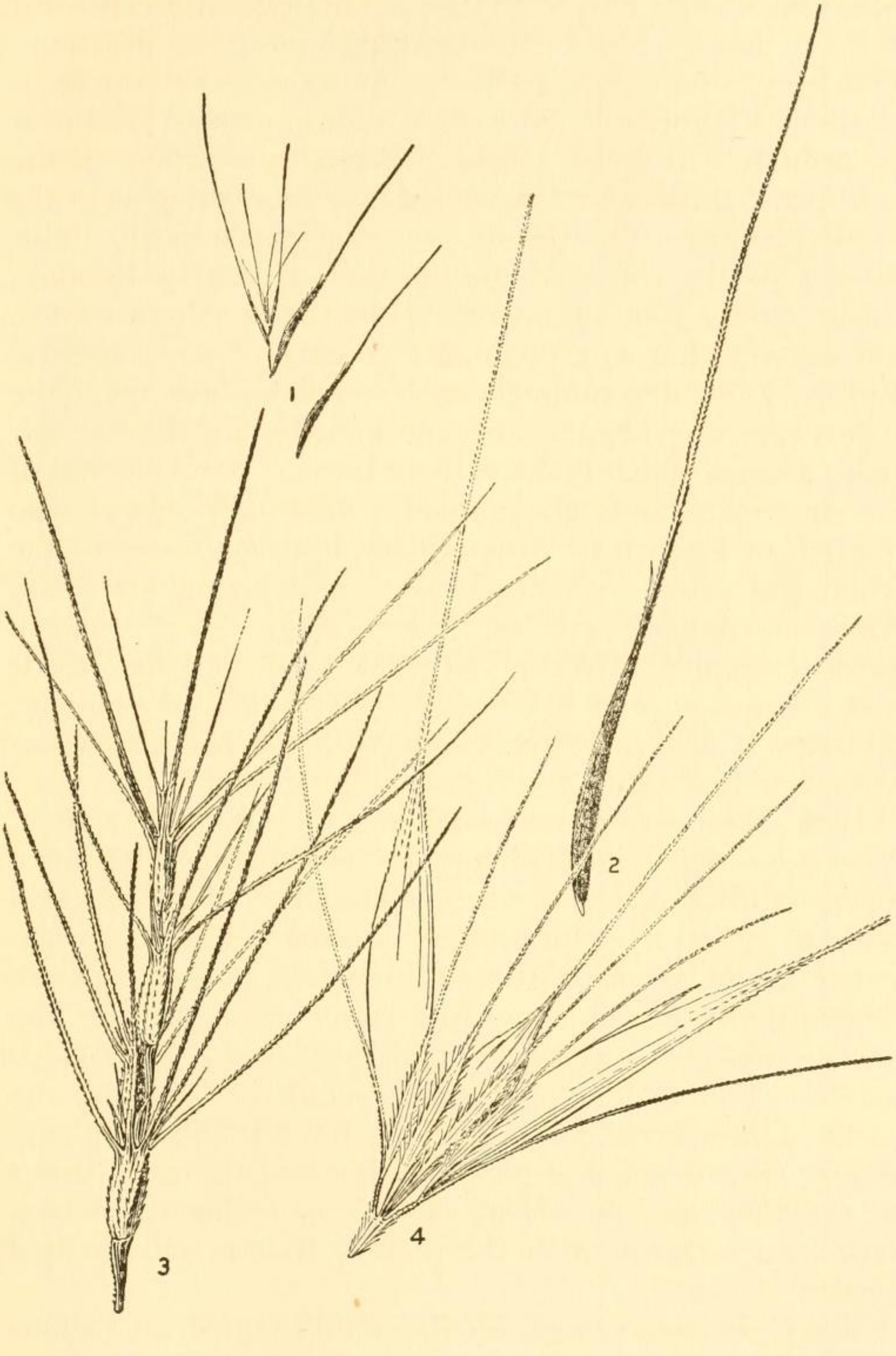
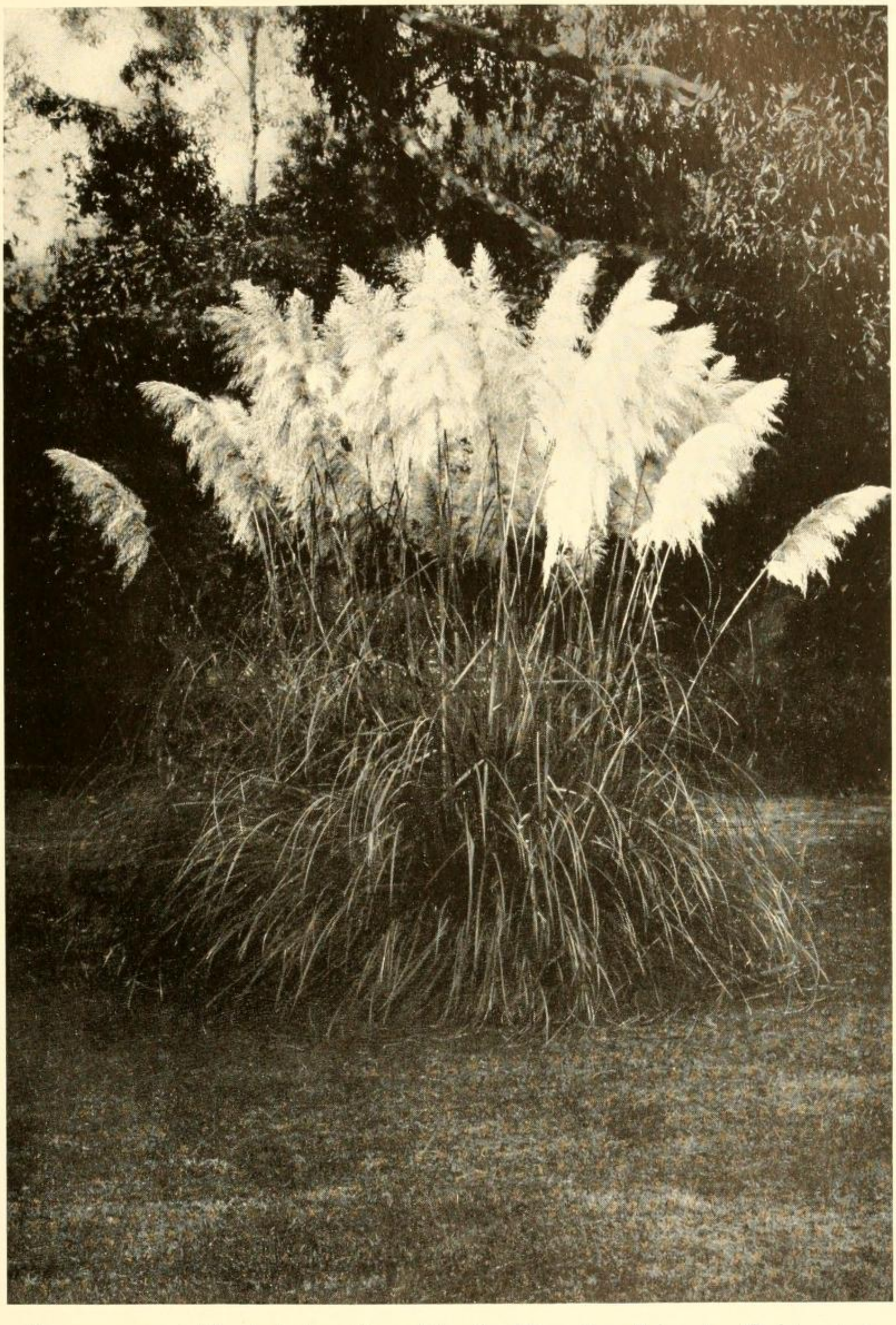


FIG. 46. Villainous introduced grasses. 1, soft chess; 2, ripgut; 3, goat grass; 4, wall barley

place for dances and festivities. The love of greensward is born in us. Most of our parks have more grassland than woods or flower gardens. As soon as an American acquires a home of his own with a bit of ground around it he attempts to make a lawn. Probably nowhere in the world is so much effort expended in lawn making as in the United States. The results are often pathetically indifferent, partly through ignorance, but largely because, except in the cool humid regions of the Northern States, our country has not the moist climate of our ancestral Europe. Our dry summers with scorching heat favor the plains type of grasses, coarse and bunchy, not the fine soft turfy grasses which make velvety lawns. A tale is told of an American landscape gardener visiting England who begged an English gardener to tell him the secret of the wonderful lawns in that country, and giving him good American money for the information. The English gardener replied, "Well, you plow it up and fertilize it and sow grass, then in a few years you plow that under, and sow it again. After you have kept that up two or three hundred years you'll have a good lawn."

It takes knowledge and work and time to make a lawn, especially in a region of hot dry summers. The home gardener often makes conditions already unfavorable still more so by terracing his ground with the sterile earth excavated for his house, lifting the surface a foot or more higher than natural above the water table, so that the grass roots can not reach the moisture below. By copious watering he induces the grass to spread its roots near the surface; the scorching sun dries the top soil and the plants suffer. Shrubbery and perennial borders are much easier to establish and maintain, though some lawn is necessary as a foreground in the picture that a well-planned garden makes.

The chief lawn grasses for the humid temperate regions are Kentucky blue grass (*Poa pratensis*) and certain species of bent grasses (*Agrostis*), such as creeping bent, col-



Pampas grass (*Cortaderia selloana*) in the Hawaiian Islands. Cultivated for ornament. Photograph by Hitchcock

onial bent, velvet bent, and brown bent. Where these grasses thrive, beautiful lawns may be established by preparing the soil and planting good seed. "The custom of applying a layer of vegetation, part grass and part a miscellaneous collection of weeds, to a soil consisting of the refuse from building operations will never give satisfactory results. Such a lawn is a permanent source of regret and no amount of faithful watering can materially improve it." In the Southern States Bermuda grass (*Cynodon dactylon*) is extensively used for lawns.

The growing popularity of golf, which serves to mitigate the strain of urban life, has created a demand for good turf grasses. Golf, like our ancestors, came from humid Europe, where grazed meadow land offered natural golf grounds. Much time and money are being devoted to golf greens, and many experiments are being carried on in the hope of improving them. When the best grasses for different regions have been found and the best methods of treatment have been worked out, the home gardener can appropriate the knowledge to the bettering of his lawn.

A number of grasses are cultivated as ornamentals. Great clumps of plume grass (*Erianthus Ravennae*), giant reed (*Arundo donax*), pampas grass (*Cortaderia Selloana*, Plate 48) and eulalia (*Miscanthus sinensis*) are often seen in our parks and public squares. Eulalia, however, is an aggressive weed, spreading rapidly, and its cultivation should be discouraged. Fountain grass (*Pennisetum Ruppelii*), with slender pale-pink panicles, is commonly used, though not to the best advantage, as a border for circular beds of cannas.

In warm countries the bamboos are planted in parks and gardens. One of the most beautiful sights on earth is the bamboo grove in the botanical garden at Rio de Janeiro. Even at Kew Gardens, near London, a charming bamboo garden flourishes with hardy shrubby and dwarf species.

In this country we have a large number of beautiful

native grasses that deserve to be cultivated as ornamentals. One of the loveliest is the broad-leaved uniola (*Uniola latifolia*), which grows in low woods from Pennsylvania to eastern Kansas and southward (Fig. 47). Though a woodland grass it flourishes in open sunlight and takes

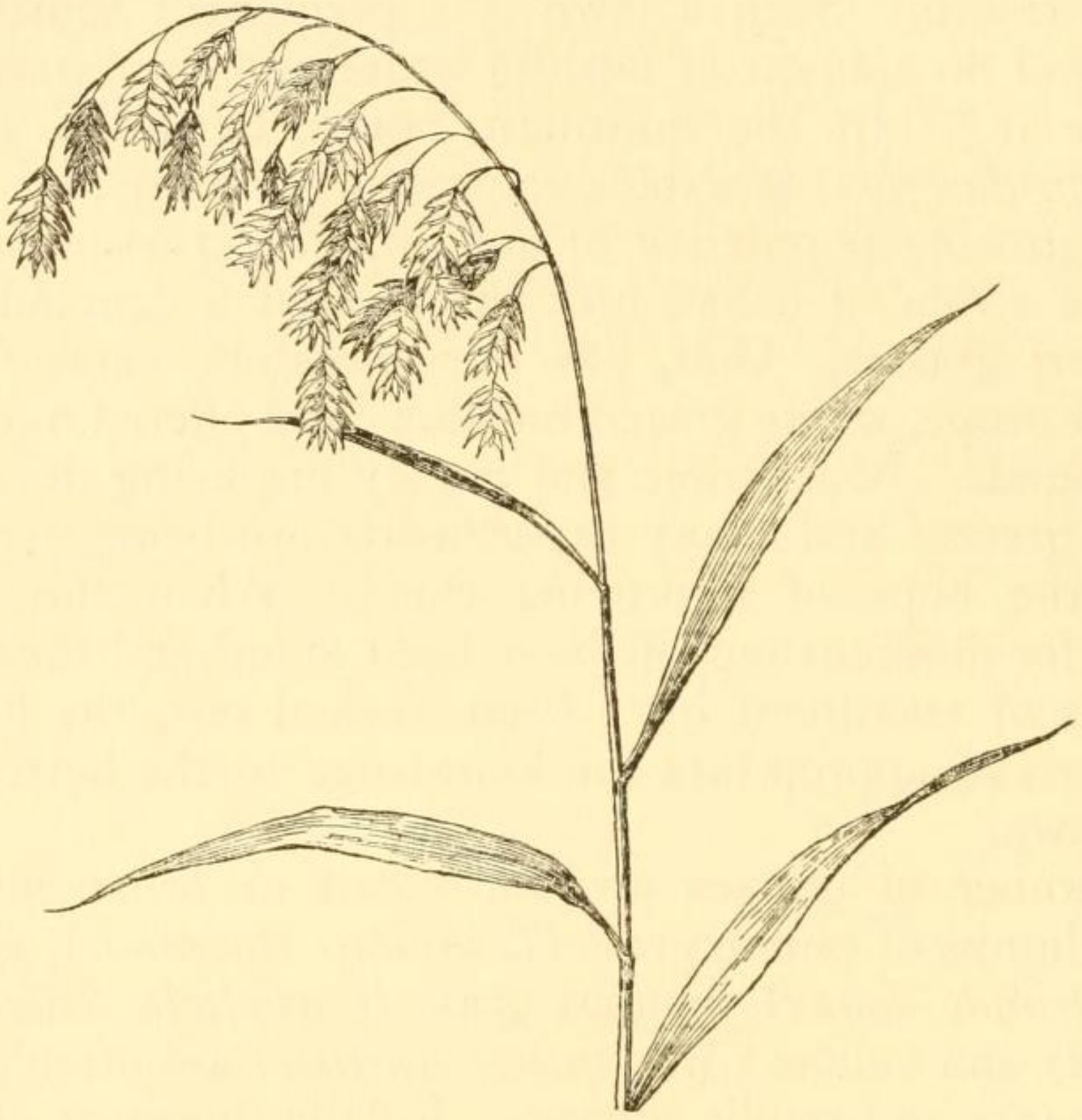


FIG. 47. Broadleaf *Uniola*

readily to domestication. The graceful clumps, with stems three to four feet tall, broad-spreading leaves, and drooping panicles of large very flat spikelets, are charming in a perennial border, or in shaded ground under tall trees. A few stems with their graceful panicles in a slender vase, or a greater number arranged in a standard in a flat bowl are very decorative in the house.

Any of the broad-leaved panic grasses (*Panicum clandestinum*, *P. latifolium*, *P. Boscii* or *P. commutatum*) pro-

duce good foliage effects. In spring and early summer their stems are simple, but by midsummer they begin to branch, and by September they look like miniature shrubby bamboos, quite Japanese in effect.

In the Rocky Mountain region and westward are several melic grasses (*Melica spectabilis*, *M. bulbosa*, *M. stricta* and others) with large spikelets of purple or bronze and pale green, as lovely as any flower. Bottle-brush grass (*Hystrix patula*), a woodland species of the eastern half of the United States, is already cultivated to some extent, but deserves wider use. A few of these grasses under a spreading tree, with their slender gray stems, curving leaves and swaying heads of horizontally spreading, long-awned spikelets, suggest a dance of wood nymphs. These and many other beautiful grasses of woods and prairie are as ready to gladden our gardens, if we give them place, as are wrens and bluebirds when we provide nesting boxes and water for them.

CHAPTER III

THE PLACE OF GRASSES IN THE PLANT WORLD

ALTHOUGH grasses have so important a place in the life of mankind—indeed, "All flesh *is* grass"—they are the least noticed of flowering plants. They seem to be taken for granted, like air and sunlight, and the general run of people never give them a thought. Many do not even know that grasses are flowering plants. Their flowers are very small and are mostly hidden by the bracts of the spikelet; but they are as truly flowers as are the gorgeous blooms of the lilies, to which they are not so remotely related. The flowers of grasses are borne on tiny specialized jointed branches, each flower inclosed in two bracts, and with two empty bracts at the base of the branch. This minute branch, with its bracts and flowers, is called the spikelet (little spike). The typical arrangement is really quite simple. In Figure 48, at the left, is a diagram of a flowering branch with leaves and flowers arranged as are the bracts and flowers of a grass spikelet; in the middle is a diagram of a spikelet for comparison (the bracts spread to show the flowers); and at the right is a spikelet of brome grass. It will be seen that the spikelet is a specialized leafy flowering branch, the branch jointed as are the stems of all grasses, and the flowers two-ranked, as are the leaves.

The essential organs of any flower are the stamens and pistil. A stamen consists of an anther, which contains the pollen, and the slender stalk which bears it; the pistil consists of the ovary, which contains the ovules, and the

stigma, which receives the pollen and is usually borne on a relatively stout stalk. When the pollen (usually of a different individual of the species) falls on the stigma it germinates and sends its contents, in a minute tube which pushes down through the style, to the ovules, fer-

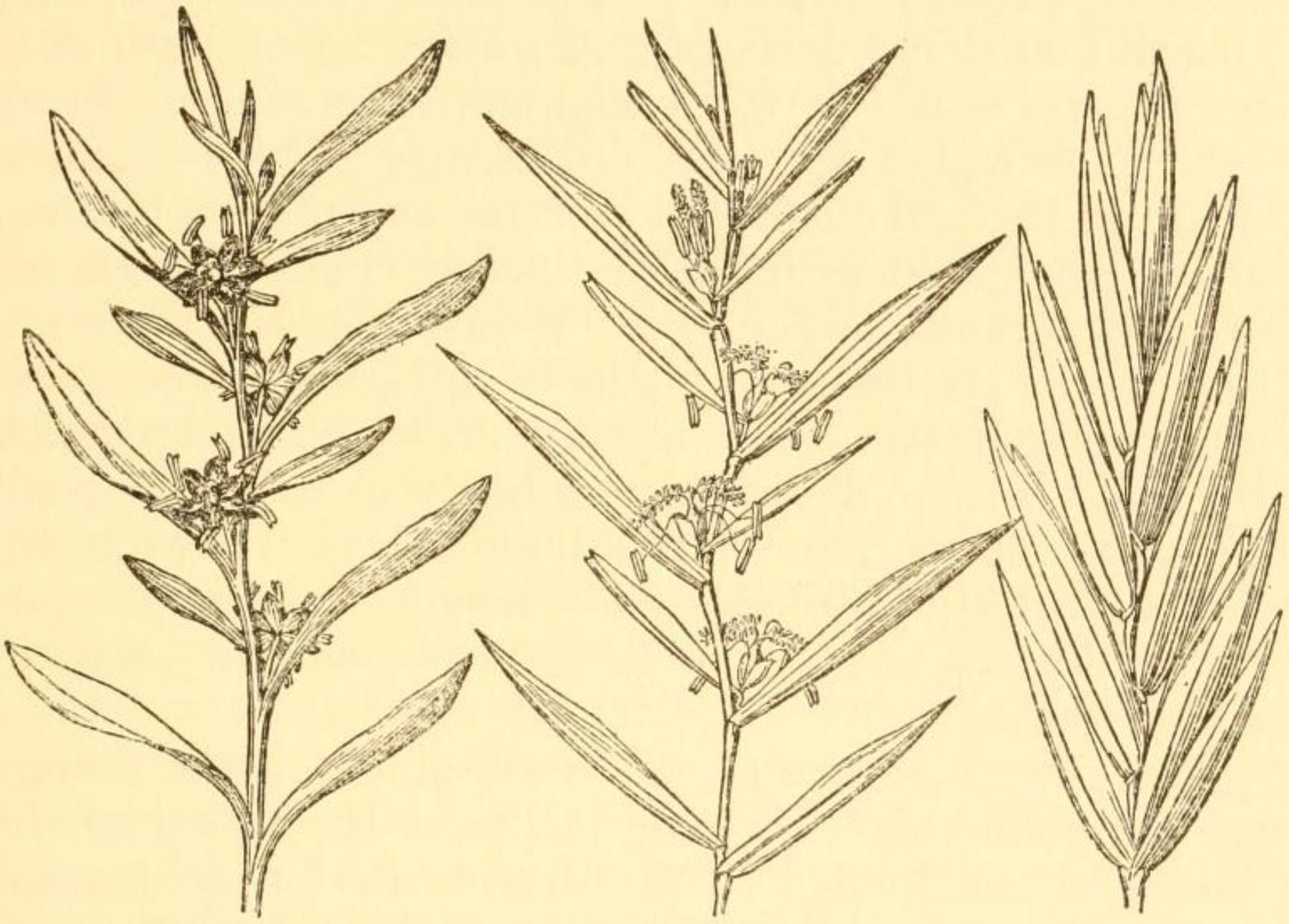


FIG. 48. Left, diagram of a branch of an ordinary flowering plant, with leaves and flowers arranged as are the bracts and flowers of a grass spikelet; center, diagram of a grass spikelet with the bracts spread to show the flowers; right, a spikelet of brome grass

tilizing them. The matured fertilized ovules are the seeds. The foregoing is true of all flowering plants. In showy flowers, like the lily or the rose, the essential organs are surrounded by a brightly colored perianth or by petals. These showy accessories protect the essential organs in the bud and at blooming time attract insects, which carry pollen from one flower to another, cross-fertilizing them. The essential organs of the grass flower are protected by the bracts which inclose them (the lemma and

palea). The abundant pollen is carried by the wind; hence, having no need to attract insects, grass flowers have only a rudimentary perianth, consisting of minute organs called lodicules, which swell up at flowering time and force open the lemma and palea, allowing the stamens and the feathery stigmas to protrude. It is a common observation that a stalk of maize standing by itself does not usually bear a perfect ear of corn; sometimes it bears only a cob with a few scattered kernels. This is because the wind blows the pollen to one side and the silk receives little. In a field of maize the pollen is effective except on the windward border. Even if the flowers are perfect—that is, the stamens and pistils in the same flower—as is usual with grasses, there is some arrangement by which the pollen of one flower is more likely to reach the pistil of another flower than it is to fall directly on its own pistil. For example, the anthers usually dangle on slender threads below the stigmas, hence the pollen is blown away to another flower.

There are many cases, however, in which the flowers are self-pollinated. In some plants at least some of the flowers are so hidden in the sheaths that they can not open and cross-fertilization is impossible.

Grass spikelets are of many forms, but all are built on the same general plan, and they are borne in heads of various shapes and sizes. In wheat, barley, and rye the spikelets are borne directly on the main axis, on opposite sides, forming spikes. In oats, brome grasses and Kentucky blue grass the spikelets, each on a little stem, are borne on the branches of a panicle. In timothy the long cylindric head is really a dense panicle, the spikelets crowded on the numerous very short branches. In Bermuda grass, *Spartina*, grama grasses, and the like, the spikelets are borne on one side of the axis, forming a one-sided spike. In broom sedges, sorghums, sugar cane, and their relatives, the axis or branches of the inflorescence break up, the joints remaining attached to the mature

spikelet and aiding in the protection or dissemination of the seed.

In maize, wild rice, buffalo grass, and some other grasses, the flowers are unisexual, the stamens and pistils being borne in separate spikelets. In maize the staminate spikelets are borne in a terminal panicle (the tassel), and the pistillate spikelets in rows on a compound axis (the cob), which is on a short leafy branch (the leaves being the husks) in the axil of a leaf. The "silk" of the ear of corn consists of the numerous long styles with stigmas along their sides. In wild rice the pistillate spikelets are borne on the erect upper branches of a large panicle and the staminate spikelets hang from the spreading lower branches.

Classification of Grasses

There are such multitudes of different kinds of plants (of grasses alone there are about six hundred genera) that it is necessary to classify them in order to put our knowledge of them in usable order. This classification is based on genetic relationship, a sort of family tree. The plants occupying the earth today are the survivors of millions of generations. Countless forms have become extinct, some of them leaving impressions in the rocks or in coal measures (fossils), but most of them leaving no record. The relationship between some plants is obvious, the apple and the pear, peas and beans, the walnuts and hickories, for example. In these cases we assume that their common ancestor is not so very far in the past, a mere hundred thousand years or so. Somewhere in the buried past were the intermediates, the connecting links, between the most diverse of flowering plants. If the history of all plants were known, the living species would be found connected by lines of blood relationship running back millions of years.

The unit of classification of plants is the species, which is a group of individuals closely resembling each other and

capable of freely interbreeding. Species that are evidently related are grouped together in a genus. The black oak, white oak, burr oak, and shingle oak, are different species of one genus, *Quercus*. Related genera are grouped in families and families in classes. For convenience in recording our knowledge concerning plants these genera and species are given Latin names. This custom was adopted in the days when Latin was the language of learning, when English, German, Swedish, or French university professors alike gave their lectures in Latin. It is continued today because, so far as the names of plants go, Latin is still an international language. What we call barley, the Germans, Gerste, the French, orge, in Latin is *Hordeum vulgare*, and plantsmen of all countries use that name. The chief advantage of the system of Latin names, however, is that these names indicate the relationship of plants. All species of a genus have the same generic name. Kentucky blue grass and all its kind are Poa, *Poa pratensis*, *P. trivialis*, *P. annua*, *P. Sandbergii*, and the like. The common names of these —Kentucky blue grass, rough meadow-grass, spear-grass, little bunch-grass, respectively—give no clue to their relationship. Knowing *Poa pratensis* anyone familiar with the Latin names of grasses, hearing of any grass named Poa, has an idea of what it is like; it is something like *Poa pratensis*.

Grasses, together with sedges, rushes, lilies, and other families, belong in the class of monocotyledons, characterized by an embryo having a single seed leaf (cotyledon) and by stems having woody fibers not in layers but distributed through them (as seen in the cornstalk). Anyone will have observed that sprouting corn, rye, and other grasses send up a single leaf first, whereas squash, radishes, morning glories (which belong to the class of dicotyledons) have a pair of opposite seed leaves. The grasses form a highly specialized family of about six hundred genera, with a greater number of species than any other family,

except the orchids and composites (asters, dandelions, thistles, and the like).

Grasses have been so successful in the struggle for existence that they have a wider range than any other family, occupying all parts of the earth, and exceeding any other in the number of individuals. They reach the limits of vegetation, except for some lichens and algae, in the polar regions and on mountain tops. They are the dominant vegetation in arid regions, sand dunes, salt marshes, and in other places where conditions of plant life are exceedingly severe. Grasses range in height from less than an inch, full grown, to more than a hundred feet. Bamboos, the largest of grasses, form extensive forests and jungles. In the mountains of tropical America and Africa bamboos occupy a zone above timber line and below the short-grass areas of the alpine regions. Some bamboos have developed a climbing habit. Their slender stems push up through the jungle along trails or streams until they reach the sunlight. Whorls of branches then develop which rest on the tops of the trees or shrubs and support the main stem, which continues to grow and to branch repeatedly until the plant forms a lacy curtain hanging from the tree tops. One of the loveliest sights in the West Indies and other parts of the American Tropics are these curtains of bamboos on mountain side or stream bank. Grasses love sunlight, hence only in dense forests are they scarce. A few broad-leaved species carpet the forest floor in the Tropics, and bamboos and others climb out into the sunlight.

The greatest number of species of grasses are found in the savannas of the Tropics, but the greatest number of individuals are found in temperate and cold countries. In the Arctic and Antarctic regions grasses compose about a fourth of all the species. The grasslands of Alaska and northern British America support great herds of caribou and reindeer. On all the great mountain systems of the world grasses are the dominant plants above timber line.

The great grass areas of the world are our own Great Plains, stretching from the Mexican plateau to the Arctic tundra; the semiarid llanos of Venezuela; the campos of central and southern Brazil; the pampas of Uruguay and Argentina; the steppes of Russia and western Asia; the plains of Siberia, Mongolia, and China; the "sud" or elephant-grass regions bordering the upper Nile, the veldt of arid and semiarid South and East Africa, which supports the great game animals made familiar to us by moving pictures, and the steppes and savannas of Australia. In such areas the grasses had their origin and have reached their greatest specialization.

Visitors to Mariposa Grove, California, are told that the big trees (*Sequoia gigantea*) are the oldest living things; and in some of our museums are to be seen cross-sections of *Sequoia* with the annual rings marked at intervals, showing how thick the trunk was at the time of Christ, at the discovery of America, and at other outstanding dates. It seems very probable that individuals of some perennial grasses may be quite as old as the big trees. Some marsh grasses, like *Spartina*, and prairie grasses, such as buffalo grass (Fig. 49), a dominant plant of the Great Plains, propagate by stolons or rhizomes, forming colonies over large areas. Such plants are not only perennial, they are practically immortal. Clumps of *Spartina* in our coastal marshes may be branches of plants that grew from seed thousands of years ago; and much of the buffalo grass which today forms continuous turf for many miles is probably part of the very plants that took possession of the plains as they dried after the retreat of the glaciers.

Bunch grasses, such as the grama grasses, often leave a record of their gradual advance. The bunch grows by accretion at the periphery, where successive stems arise, there being no room for new stems within the bunch. After a few years the center of the bunch dies, but the periphery continues to advance until the colony assumes the form of a ring. Such "fairy rings" are common on

Sheep feeding on the high plains of the Andes, Peru (13,000 feet). The bunch grass is ichu, common in the high Andes. Photograph by Hitchcock

the plains and in semiarid regions. Eventually the ring, which sometimes becomes as much as a hundred feet in diameter, breaks up into segments, but it can still be traced by the circle of segments, which finally form the beginnings of new rings. The increase in diameter of a

FIG. 49. Buffalo grass, pistillate and staminate plants spreading indefinitely by stolons

bunch may be only a fraction of an inch each year, hence a large fairy ring represents the growth of hundreds or even of thousands of years.

Such vigorous vegetative propagation enables grasses to hold their ground once they have taken possession. Their world-wide dispersal, however, is due to the numerous devices they have developed for the dissemination of their seeds.

Seeds of water grasses may be carried in mud on the feet of water birds. Some are inclosed in air-tight coverings that enable them to float. Darwin made an experiment which shows how widely seed may be carried by water, fishes, and birds combined. He threw seed of barnyard grass into a stream, then caught a fish from the stream and fed it to a stork. He planted the droppings of the stork and barnyard grass came up.

More grass seeds are scattered by the wind than by any

other method. People who have lived in the country have seen tumble weeds, roughly spherical in outline, rolling before the wind, scattering seeds as they go. Many grasses scatter their seeds in this way. Tickle grass and witch grass are familiar examples. The diffusely branched panicle breaks away at maturity and is whisked hither and yon, often piling up in fence corners. One of the characteristic grasses of the Great Plains, *Schedonnardus paniculatus*, bears its flowers on slender branches along a narrow central axis. At flowering time the axis may be only ten or fifteen centimeters long, but the whole inflorescence continues to grow until at maturity it is a loose spirally coiled affair as much as fifty centimeters long, which breaks away and rolls before the wind.

The commonest device for dissemination by the wind is an attached tuft of silky or cottony hairs. The seeds of the common reed (*Phragmites communis*), an ancient and world-wide species, of plume grasses (*Erianthus*), broom sedges (*Andropogon virginicus* and its relatives), and many others float in the air like thistledown, and are carried far and wide by the wind.

Some grasses secure dissemination of their seed by barbed spines and spears that catch on the hair of animals. Most needle grasses (*Aristida*), porcupine grasses (*Stipa*), and others that steal rides in this way do no harm to their involuntary carriers, but some, like sand burs, barley grasses, and certain brome grasses are at times injurious. In one of the needle grasses, *Aristida longiseta*, commonly called dogtown grass because it grows in the loose soil thrown up around the burrows of prairie dogs, the seed is borne in a little needle-pointed spear with three slender divergent bristles as much as ten centimeters long instead of a shaft. The weight is so distributed that, as the little contrivance is borne through the air the point is directed forward, ready to strike into any animal in its way and thus secure further transportation. At maturity whole swarms of these seed bodies go scurrying across the plains.

Seeds, especially of annual grasses, are produced in far greater number than can find place to grow. They fall by chance in all sorts of places and all perish save the relatively few that fall in unoccupied spots that meet their requirements of moisture, temperature, and soil. A seed contains a minute plant, the embryo, which was formed while the seed was still attached to the mother plant. Germination is a continuation of the growth which was interrupted during the period of dispersal. While dormant most seeds are dry and the seed coat is resistant to moisture, thus preserving the contents. During germination the seed coat swells and allows moisture to enter the seed. The embryo sends out a little root in one direction and a little stem in the other. The grain or kernel of the maize well illustrates these processes because the seed is large and the changes can be easily followed. The nourishment for the embryo is stored mostly as starch, which is insoluble in water and can not be used directly by the young plant. During germination the starch is converted into soluble sugar, which can be transported by the juices of the little plant. This sugar supplies food for the seedling until it is able to get water from the soil through its developing roots and until its leaves turn green, ready to manufacture its nourishment from the air by means of the sunlight.

The mechanics of germination in the maize seed are interesting. If the seed lies exposed on a moist surface it merely puts forth a root and a stem. If, however, the seed is buried in the soil the stem would have difficulty in passing up through the soil as the tender tip would be injured. The shoot does not bend and elbow its way up as do peas and squashes and other dicotyledons, but goes straight up, the growing parts, one little leaf rolled up inside another, being contained in a tight pointed sheath, closed at the tip. This sheath (technically the coleoptile) elongates, pushing upward through the soil until it reaches the surface, when its tip breaks and the

shoot pushes through. There is, of course, a limit to which this sheath will reach. In most kinds of maize it can grow not more than about ten centimeters, though there is a Mexican variety that can grow to the enormous length of twenty-five centimeters.

There are one hundred and forty-seven genera of grasses in the United States and about fifteen hundred species, composing ten to twelve per cent of the entire flora. The grasses of the world have been arranged according to their relationships into fourteen tribes, of which all but one are represented in the United States. The more important are the following.

Bamboo tribe, including woody grasses, the most primitive known. Primitive grasses are those in which there is the least difference between the vegetative and the flowering parts of the plant. Our only native bamboos are the large and small canes (*Arundinaria macrosperma* and *A. tecta*) which form the canebrakes of the Southern States.

Fescue tribe, including fescues, bromes, blue grasses, orchard grass, the common reed, pampas grass and other relatively unspecialized grasses.

Barley tribe, including wheat, barley, rye, and our native wheat grasses. The spikelets are borne on opposite sides of a simple rachis.

Oat tribe, including oats and tall oat grass. The spikelets are borne in panicles. This tribe is especially well developed in South Africa.

Timothy tribe, including timothy, bent grasses, needle grasses (*Aristida*), and others having one-flowered spikelets in panicles.

Grama tribe, including grama grass, Bermuda grass, buffalo grass, *Spartina*, and others with spikelets borne in one-sided spikes.

Canary-grass tribe, including the fragrant vanilla grass or holy grass, sweet vernal grass, reed-canary grass, an important constituent of wild hay, and canary grass, which furnishes canary seed.

Rice tribe, a small group of which rice is the only important member.

Indian rice tribe, aquatic grasses with unisexual spikelets, including our wild or Indian rice.

Millet tribe, containing highly specialized grasses, including two very large genera, *Panicum* (of which the common European millet is a species) and *Paspalum*. It also includes crab grasses, barnyard grass, foxtail millet, pearl millet, and the vexatious sand bur. This tribe is best developed in the Tropics and warm temperate regions.

Sorghum tribe, containing more highly specialized grasses, including the great genus *Andropogon* (to which belong the broom sedges), sorghum, sugar cane, and the cultivated eulalia. The tribe is largely tropical.

Maize tribe, including maize or Indian corn, the most highly specialized of grasses, teosinte, and Job's tears.

Darwin says that a traveler should be a botanist, as the landscape is so largely composed of plants. To know them adds to the traveler's enjoyment. Both the stay-at-home and the traveler could add to their enjoyment of landscape or garden by some acquaintance with grasses, which are not so difficult to study as is generally supposed. An illustrated work on the genera of grasses of the United States can be purchased from the Superintendent of Documents.[1]

[1] Hitchcock, A. S. Genera of Grasses of the United States. U. S. Dept. Agr. Bull. 772. Supt. Doc., Govt. Ptg. Office, price 60 cents.

SELECTED BIBLIOGRAPHY

Chase, Agnes. First book of grasses; the structure of grasses explained for beginners. New York, 1922.

Hitchcock, Albert S. A text-book of grasses, with especial reference to the economic species of the United States. New York, 1914.

—— The genera of grasses of the United States, with especial reference to the economic species. U. S. Dept. of Agr. Bull. 772. Washington, 1920.