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THE FERN ALLIES

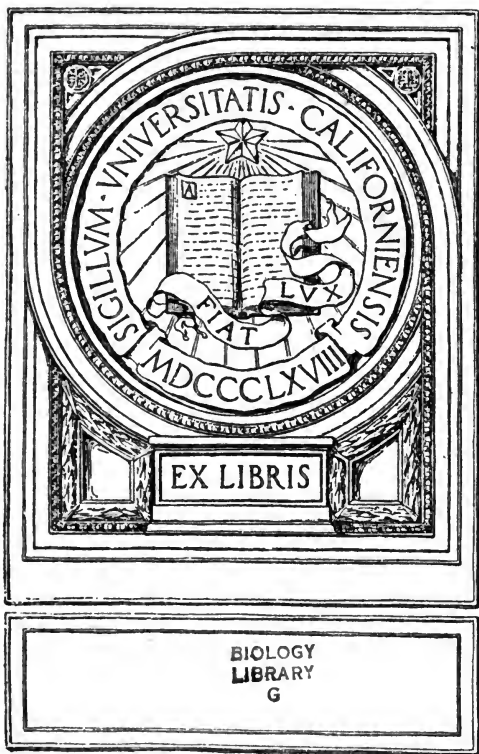
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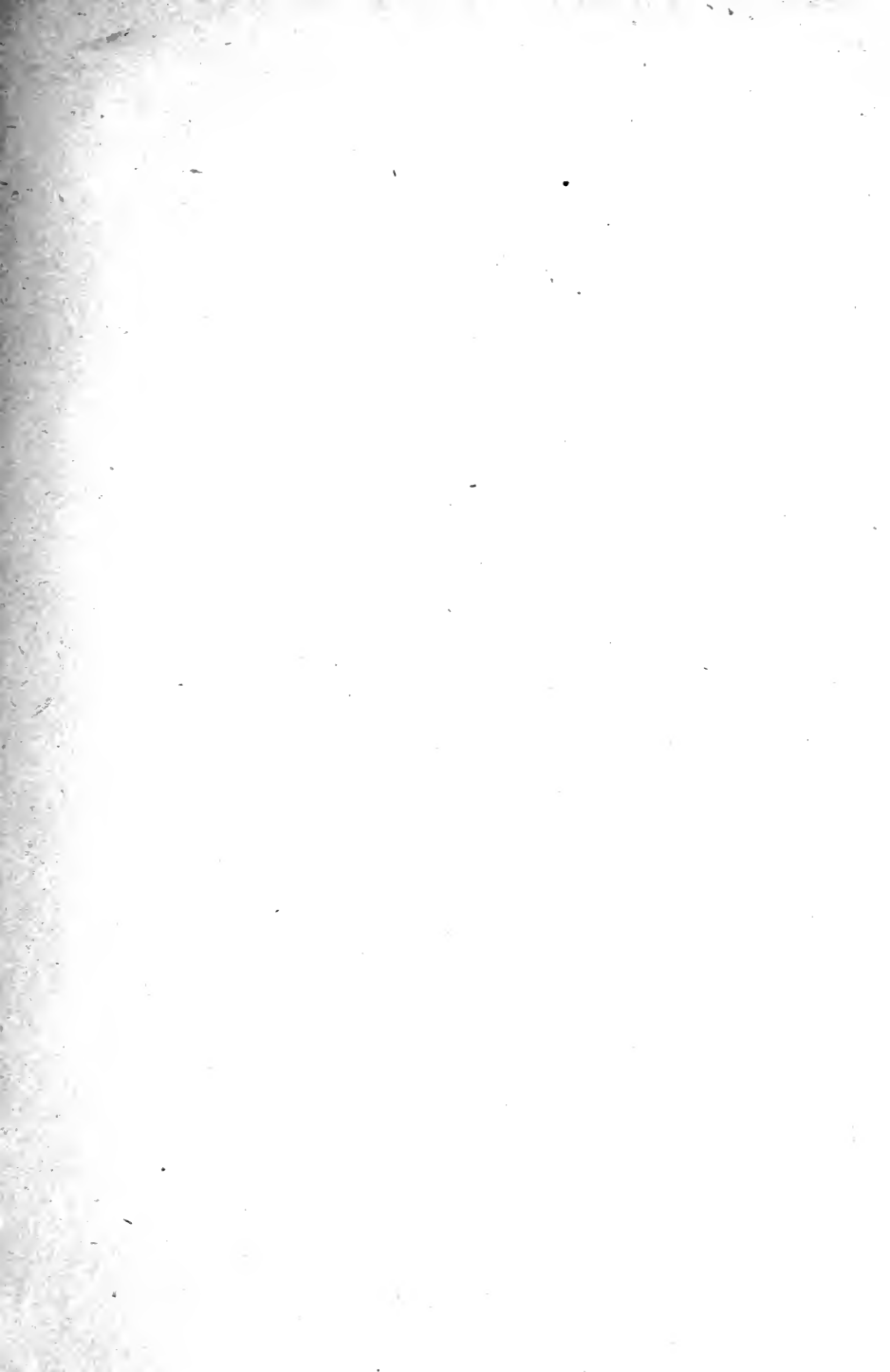


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THE FERN ALLIES.





PLATE I. COMMON SCOURING RUSH. *Equisetum hiemale*.

1914, BY FRANK L. A. STOKES COMPANY

THE FERN ALLIES

OF

North America North of Mexico

BY

WILLARD NELSON CLUTE

*Author of "A Flora of the Upper Susquehanna," "The Fern
Collector's Guide," "Our Ferns in their Haunts," etc.*

WITH MORE THAN ONE HUNDRED AND FIFTY

ILLUSTRATIONS BY

IDA MARTIN CLUTE



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This edition published in September, 1905.



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PREFACE

THE Fern Allies, by reason of their curious forms and often great abundance, seldom fail to attract the attention of the student of plants, but their identification has always proved more or less of a puzzle to beginners. Like the ferns, they bear neither flowers nor seeds, and at first glance seem to offer few points by which they may be distinguished. The species are usually included in botanical Manuals, but the necessarily brief and technical descriptions have tended to discourage rather than to aid the novice. In reality, however, most of the species are easily identified, and it is one of the purposes of this book to point out how this may be done.

No book has ever before been published in which one may find untechnical descriptions of our fern allies, nor one in which all the species have been figured; in fact a large number are figured for the first time in this book. Such illustrations as have hitherto appeared are scattered in various American and foreign books, often inaccessible, many of which, published long ago, are more or less inaccurate. It has been our aim, not only to illustrate every species, but to represent them correctly. The drawings have been made from typical specimens of the plants, and it is believed that many of the species will now be easily identified by merely comparing them with the illustrations.

In the text each species has been carefully described anew from authentic specimens, and all the known facts

in its life history added. Preceding the account of the species in each genus will be found a chapter on the group as a whole, followed by a Key to the species. In each group of species the best known is placed first, and those that follow are frequently compared with it. Many of these plants have received so little study from botanists that scarcely anything is known about them. In a further study of the life histories of these species the beginner will find a new and inviting field in which he will be a discoverer rather than a gleaner. I shall be glad to receive notes of this kind, and offer to identify any species that may prove troublesome, provided good herbarium specimens are sent me, accompanied by postage for reply. I cannot undertake to return such specimens, however.

Among technical works relating to the American species, first place must be given to Underwood's "Our Native Ferns and Their Allies," which includes brief descriptions of all but the most recently discovered species in North America north of Mexico. Dodge's "Ferns and Fern Allies of New England" contains somewhat more extended accounts of the New England species, with an excellent chapter on the identification of Isoetes and a list of the species arranged according to the time each fruits. Eastman's "New England Ferns and Their Common Allies," in which there are illustrations and untechnical descriptions of a few of the common species, completes the list of works devoted exclusively to the subject. Of foreign works, Baker's "Handbook of the Fern Allies," published in 1887, includes short descriptions of all the species in the world that were known at the time of publication. Some mention should also be made of "*The Fern Bulletin*," now in its

thirteenth volume, which enjoys the unique distinction of being the only publication in the world devoted to the ferns and fern allies. In past volumes it has published much regarding the haunts and habits of the plants, including descriptions of many new species and forms. A series of Fern Floras of the States is now being published, which gives lists of the ferns and fern allies in each State, with distribution and other notes added.

In the matter of nomenclature I have adopted a somewhat conservative treatment, preferring for the most part the names commonly used, since these will be most frequently found in other books. When they differ from others recently proposed, the latter are given also, and they have also been included in the Checklist of the species. It does not seem advisable, in a work of this kind, to follow the practice of radical botanists in treating a large number of forms as species. It is possible that some of these forms may be found to have characters of specific importance, but it will be less confusing to the beginner if they are still regarded as forms of the species from which they have been segregated.

These newly named forms have had to be recognized, however, and in giving them what I believe to be their rightful places a number of new combinations have unavoidably been made. In no other way has it seemed possible to indicate to beginners the various disguises under which certain plants are likely to be found in coming years. In the Checklist I have followed the plan of citing the authority for the species only, believing that the author of a new combination is not entitled to the prominence which a double citation of authorities confers.

Much valuable assistance in the preparation of this book has been given me by students of the fern allies. The source of many notes has been indicated in the text, but I am especially indebted to, and wish here to thank, Mr. S. B. Parish, Mr. A. J. Hill, Mr. C. H. Demetrio, Dr. C. B. Graves, Mr. J. B. Flett, Mr. Julian Reverchon, Prof. R. S. Cocks, Mr. Thomas Howell, Mr. M. L. Fernald, Mr. J. H. Ferriss, Miss E. Cannon, and Miss L. F. Kimball. Mr. Alvah A. Eaton, of the Ames Botanical Laboratory, whose studies of these plants have contributed so much to our knowledge, has rendered invaluable assistance by the loan of specimens, by sending many interesting notes, and by a critical reading of the proof. It is but fair to add, however, that in matters of nomenclature and the limitations of species I have not always followed his suggestions.

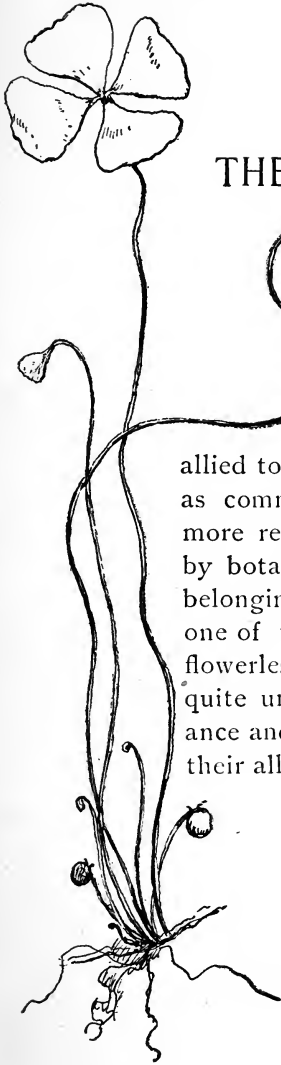
WILLARD N. CLUTE.

Joliet, Ill.,

February 27, 1905.

THE FERN ALLIES.





THE FERN ALLIES.

SINCE ferns are members of the vegetable kingdom, all plants are more or less allied to them, but the term Fern Allies, as commonly understood, has a much more restricted meaning. As regarded by botanists, the fern allies are plants belonging to certain families included in one of the great natural groups of the flowerless plants. The fern allies are quite unlike flowering plants in appearance and have little more resemblance to their allies, the ferns; but their structure and manner of fruiting show them to be closely related.

Botanists long ago divided the vegetable kingdom into two sub-kingdoms which they named respectively the *Phanerogamia*, or Flowering Plants, and the *Cryptogamia*, or Flowerless Plants. In this second division

were placed such diverse plants as the algæ, fungi, liverworts, mosses, and ferns. None of these ever bear flowers or produce seeds, but, aside from this, the various groups differ as much among themselves as the division as a whole differs from the flowering plants. The ferns and fern allies are the most highly developed of these plant families, and in structure are closely related to the simplest flowering plants. They, alone, have true roots and stems with tissues specialized for different functions. The presence of these specialized tissues—the so-called fibro-vascular system—has caused these plants to be called Vascular Cryptogams or Vascular Acrogens to distinguish them from the less-specialized mosses, algæ, etc., composing the Cellular Acrogens.

Modern botany still accepts these divisions, though the terms used to designate them have changed somewhat as they have become adjusted to our present ideas of nomenclature. We now usually speak of flowering plants as the *Spermatophyta*, and of the ferns and fern-like plants (the vascular acrogens) as the *Pteridophyta*. The mosses and liverworts are now the *Bryophyta*, and the rest of the cellular acrogens are spoken of as the *Thallophyta*. The fern allies, then, belong to the highest division of the flowerless plants, have stems in which there are woody tissues and ducts, and, in short, comprise all the *Pteridophyta* except the ferns themselves, as shown by the accompanying table of the orders represented in the North American Flora.

ORDERS AND FAMILIES OF THE NORTH AMERICAN
PTERIDOPHYTA.

SERIES I. — FERNS.

ORDER 1. — OPHIOGLOSSALES.

Family 1. — Ophioglossaceæ.

ORDER 2. — FILICALES.

*Family 1. — Hymenophyllaceæ.**Family 2. — Osmundaceæ.**Family 3. — Schizæaceæ.**Family 4. — Ceratopteridaceæ.**Family 5. — Polypodiaceæ.*

SERIES II. — FERN ALLIES.

ORDER 1. — SALVINIALES.

*Family 1. — Marsiliaceæ.**Family 2. — Salviniaceæ.*

ORDER 2. — EQUISETALES.

Family 1. — Equisetaceæ.

ORDER 3. — LYCOPODIALES.

*Family 1. — Lycopodiaceæ.**Family 2. — Psilotaceæ.**Family 3. — Selaginellaceæ.*

ORDER 4. — ISOETALES.

Family 1. — Isoetaceæ.

Like the ferns, the fern allies are reproduced by spores, which, germinating, form prothallia upon which the reproductive organs, the antheridia and archegonia, are borne. From the union of the contents of archegonia and antheridia, new plants are produced. The prothallia, however, are often quite unlike the familiar green, heart-shaped prothallia of the fern. Some are colourless, tuber-like, and develop underground instead of upon the surface in the usual way, and in some that develop above ground the prothallia are not heart-shaped and the antheridia and archegonia are on separate prothallia. The process of fertilization is essentially

the same in all, — a fusing of the contents of archegonia and antheridia.

The ferns are a strongly marked and easily recognized group of plants, but the fern allies have no such uniformity of appearance. Only the botanist, familiar with their manner of fruiting, would think of associating plants of such diverse habits and dissimilar forms. The club-mosses usually have trailing vine-like stems and tiny scale-like leaves; the selaginellas grow in moss-like tufts; the pepperworts have leaves resembling four-leaved clovers; the quillworts have very short trunks and grass-like leaves; while the scouring-rushes, at first glance, seem to have no leaves at all and to be chiefly remarkable for their development of stem. Nevertheless, all are practically alike in their manner of fruiting and in the structure of the plant body, and are therefore properly classed together.

The great diversity of leaf and stem in the fern allies is made necessary by the habitats of the plants. The club-mosses live on dry moors, in rocky wastes, or sandy swamps; the scouring-rushes in damp shades or standing water. The water-fern is found floating on the surface of quiet pools; the marsilias root beneath the water and send their leaves to the surface; while many of the quillworts pass their entire life at the bottom of rivers, lakes, and ponds.

As a whole, the fern allies are members of a decadent group, and the lack of close resemblances between the families is doubtless to be explained upon the supposition that many of the intergrading forms have died out. At present there are about seven hundred living species, or approximately one for every six species of ferns. In the remote past they were much greater in both num-

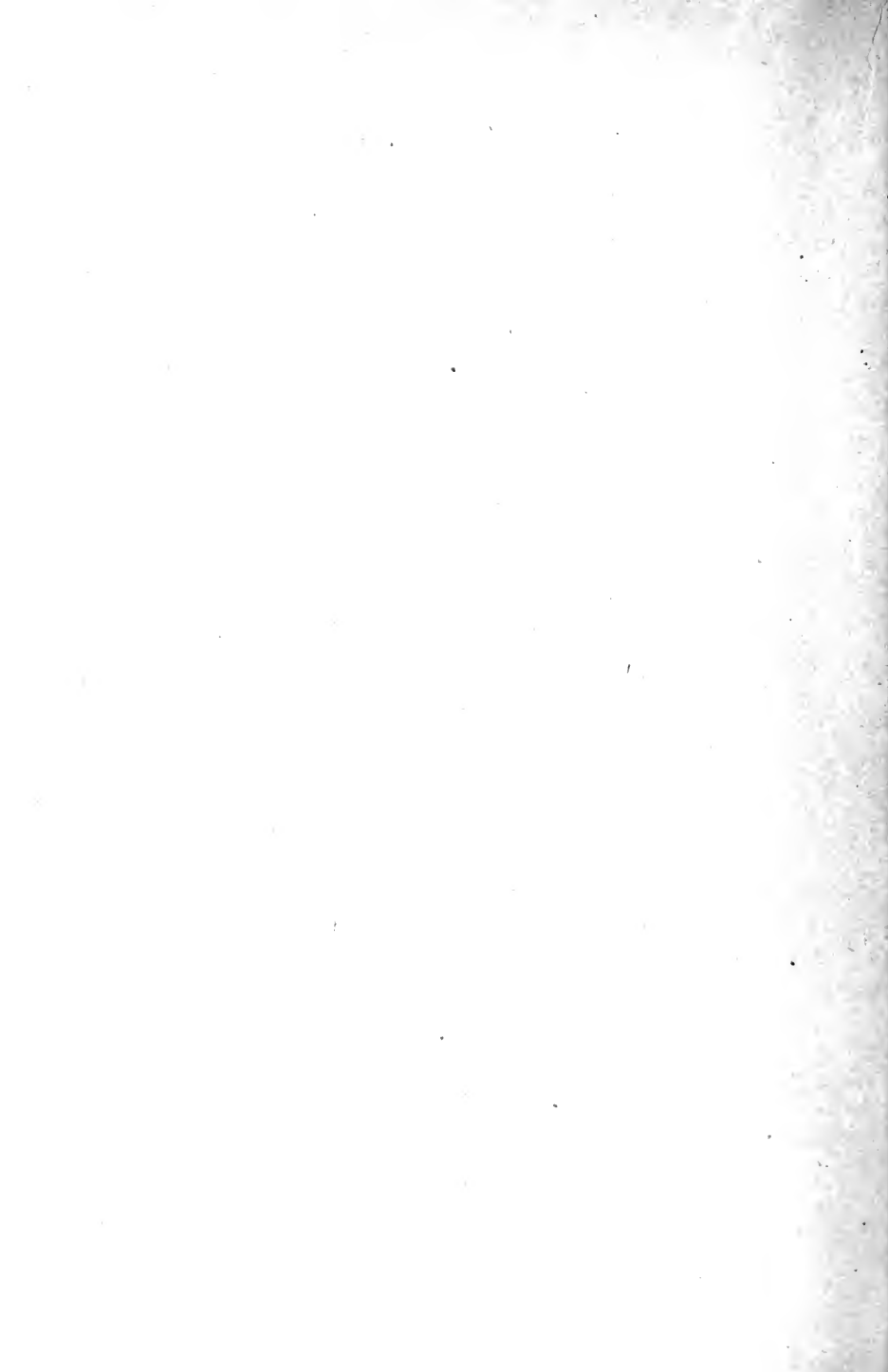
bers and importance. The prototypes of our lowly club-mosses and scouring-rushes — the lepidodendrons, sigillarias, and calamites — often equalled in size the forest trees of the present, and their remains form the greater part of the Coal Measures. It is reported that one of the Scottish coal beds consists almost entirely of the spores and spore-cases of some extinct *Lycopodium*. Of our modern genera, *Equisetum* dates from the Triassic Period; *Isoetes*, *Marsilia*, and *Pilularia* from the Tertiary; and *Lycopodium* from as far back as the Devonian Period.

With few exceptions the fern allies are not remarkable for either beauty or utility. Some of the club-mosses, under the more familiar names of running pine and trailing evergreen, are annually used in quantity for holiday decorations, and various species of *Selaginella* are cultivated for their graceful foliage. The spores of the club-mosses form the lycopodium of the pharmacist and have been used in the manufacture of fireworks, while the rough stems of the scouring-rushes were once valued for polishing and scouring.

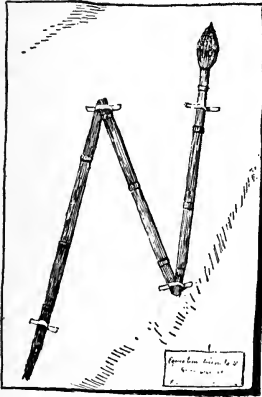
KEY TO THE FAMILIES OF THE FERN ALLIES.

- I. — Sporangia in terminal cones
 - Stems hollow, rush-like *Equisetaceæ*
- II. — Sporangia in the axils of the leaves or leaf-like bracts, often forming terminal spikes
 - Plants apparently stemless *Isoetaceæ*
 - Plants with evident stems
 - Spores of two sizes *Selaginellaceæ*
 - Spores all alike
 - Sporangia in spikes *Lycopodiaceæ*
 - Sporangia in clusters *Psilotaceæ*
- III. — Sporangia in berry-like sporocarps
 - Whole plant floating *Salviniaceæ*
 - Plant rooting in mud *Marsiliaceæ*

THE EQUISETACEÆ:
SCOURING-RUSHES AND HORSETAILS.



THE EQUISETACEÆ.



NOT inappropriately may the Scouring-Rushes be likened to the cacti, for, like them, their leaves are reduced to mere rudiments, and the stems perform all the offices usual to leaves. This, however, is not their only peculiarity. In their general structure they have little re-

semblance to other plants. The stems are jointed, hollow except at the joints, and noticeable for their lack of differentiation from the underground portion of the plant. From the farthest subterranean root-stock to the tip of the tallest shoot, the construction is essentially the same. It may be likened to a line of drain-pipe, each section of which fits into the slightly flaring top of the one below it. These hollow sections are grooved exteriorly with from three to fifty longitudinal grooves, varying in number with the species. These grooves are known as valliculæ and the intervening ridges as carinæ. Within the stem walls, and encircling the central hollow, there are usually found two other series of hollows,—one series beneath the valliculæ, and therefore called the vallicular canals; the other beneath the carinæ, and called

the carinal canals. These differ in size and shape with the species, and thus form excellent characters for their identification.

At the top of each joint in the stem there is a papery sheath which seems to form a socket into which the next joint above it fits. This sheath is toothed on its upper border, usually with as many teeth as there are ridges in the stem. From various indications it is evident that this sheath represents a circle of confluent but reduced and functionally useless leaves. Inside the sheath (that is, in the axils of the leaves) buds are formed,—a bud for each leaf,—and if these develop into branches they break out through the base of the sheath in regular whorls. In many species these buds always remain dormant unless the tip of the stem is injured, when a few near the tip may give rise to short branches.



Section of
Stem at
the Sheath.

Externally the stems are often coated with particles of siliceous matter in many curious patterns, such as rings, bands, granules, teeth, and rosettes; and, not infrequently, abundant siliceous particles may be found lining the central hollow. This siliceous coating gives a characteristic harshness to the stems of certain species, rendering them useful for polishing woodwork and other articles. The siliceous matter is usually most abundant on the carinæ, while the stomata—the minute openings for transpiration—are distributed along the valliculæ.

The rhizome or underground portion of the plant is often of considerable length, and spreads about in the earth from a few inches to several feet beneath the surface. The sheaths at the joints also contain buds, and

these, upon developing, become either secondary rootstocks pushing up toward the surface, or possibly aerial stems rising above it. From the base of these buds slender roots are produced. The sections of the rootstocks are covered with a tawny or blackish felt, which, like the root-hairs, doubtless assists in the work of food-absorption. The buds on the stems readily produce roots if covered with moist earth, while rootstocks exposed to the air soon produce stems. Since the plants are liable to be either covered with mud or washed from their places during freshets, it is a wise provision of Nature that stem and rootstock are so nearly interchangeable. In certain species the rootstock occasionally develops small round tubers. These resemble the rootstock in structure and may be assumed to be undeveloped branches of it. Their use is unknown, unless they may serve as a storehouse for surplus plant-food. Under certain circumstances they may possibly give rise to new plants.



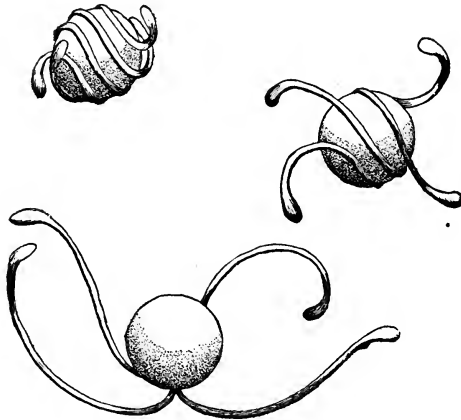
A Joint of the Stem.

The spores are always borne at the tips of the stems in cone-like spikes or catkins. These spikes consist of numerous, usually six-angled, plates attached to the stem by a central stalk, and bearing from five to nine little sacs or spore-cases on their margins. The sacs extend horizontally toward the centre of the cone, and only the angular plates to which they are attached are to be seen before maturity. When ripe the cone lengthens slightly, drawing the plates apart, the spore-cases open on the side next the stalk that bears them and the spores escape.



SPORE-CASES.

The spores are tiny globular, single-celled bodies, bright green in colour, and so small that single individuals cannot be distinguished without a lens. Each possesses two filiform appendages with enlarged ends,



SPORES, ENLARGED.

called elaters, which are attached to the equator of the spore by their middle, coiling spirally around it when moist and spreading out when dry. As the spore-case dries at maturity, the elaters uncoil and assist in liberating the

spores; and when the spores are free, they assist in floating them on the air. The elaters of several spores often become entangled, and the spores float away together, an advantageous arrangement, since the prothallia are dioecious and require more than one spore to reproduce a plant.

The spores contain chlorophyll, the green colouring-matter of plants, and lose their power of germinating within a few days after leaving the spore-case. When they lodge in a favourable place, they germinate in ten or twelve hours, and soon produce small green, lobed prothallia. It is said that the fresh spores will germinate readily if sown upon the surface of water. Although the spores are apparently all alike, some produce only

male and others only female prothallia. It is impossible, before germination, to discover which is which, and, since the male prothallium is always the smaller, it is conjectured that the difference in the sex may be due entirely to the amount of nourishment the prothallia are able to obtain, those well nourished becoming female and the others male. It is interesting to know that the cones of fossil species have been found so well preserved as to show that the ancestors of our present plants had spores of two kinds, like the modern selaginellas and isosetes.

The scouring-rushes range in height from a few inches to thirty feet, but the largest seldom exceed two inches in diameter, and the majority are rarely thicker than a lead pencil. In all, the rootstock at least is perennial, and in some the aerial stems last for several years. There are about twenty living species, most of them in temperate regions. During the Carboniferous Age they were most abundant, almost equalling the ferns in numbers. Though few in species now, they are abundant and widely distributed. North America contains representatives of more than half of all the species in the world.

The name *Equisetum* is from two Latin words meaning "horse" and "bristle," and was applied to these plants in allusion to the many slender branches of certain species, which render the plants not unlike the tail of a horse in appearance. In the order Equisetales there is but one living family, the Equisetaceæ, and in this family there is but the single genus *Equisetum*. The fossil species mostly belonged to the family Calamariæ. Many of them attained the size of trees.

KEY TO THE SPECIES OF EUISETUM.

SERIES I. — Evergreen species. Stems rough, seldom branched, catkins usually tipped with a hard point

Stems tall, stout, about as thick as a lead pencil

Sheaths dilated upward

Margins incurved, stems rough

E. Funstoni

Margins not incurved, stems smooth

E. levigatum

Sheaths not dilated upward

Old stems much branched *E. robustum*

Old stems seldom branched

Joints short. . . *E. hiemale*

Joints longer . . . *E. Ferrissii*

Stems slender, tufted

Six-angled, thread-like *E. scirpoides*

More than six-angled, larger *E. variegatum*

SERIES II. — Deciduous species. Rootstock only, perennial.

Stems smooth, usually branching, catkin

not tipped with a hard point

Fertile stems tawny or flesh-coloured when young

Not lasting through the summer

Plants stout, Western . . . *E. Telmateia*

Plants slender, mostly Eastern *E. arvense*

Lasting through the summer

Branches of sterile stems unbranched

E. pratense

Branches of sterile stems again branched

E. silvaticum

Fertile stems green like the sterile

Sheaths appressed . . . *E. fluviatile*

Sheaths looser

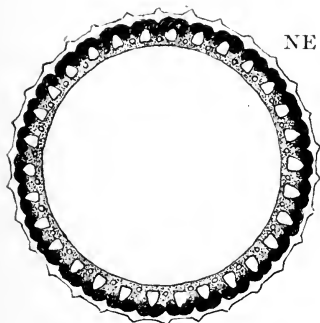
Spores perfect, abundant *E. palustre*

Spores imperfect, few *E. littorale*

THE EVERGREEN EQUISETUMS,
OR SCOURING-RUSHES.



THE SCOURING-RUSHES.



CROSS-SECTION OF STEM.

ONE of the most conspicuous differences among the equisetums is found in the duration of the aërial stems. In some species all traces of them above ground disappear soon after the first hard frost, while in others the stems not only endure at least one winter, but in the second season possess enough vitality to put forth new branches. It is singular, also, that the evergreen species should all resemble one another in external appearance more than they do the species with deciduous stems. To divide the genus upon the single character of perennial or deciduous stems would separate the species into two very natural groups. It has been proposed to make these two groups separate genera, though botanists at present usually include the two in the single genus *Equisetum*; the evergreen species, however, are placed in the sub-genus *Hippochætæ*.

The Common Scouring-Rush.

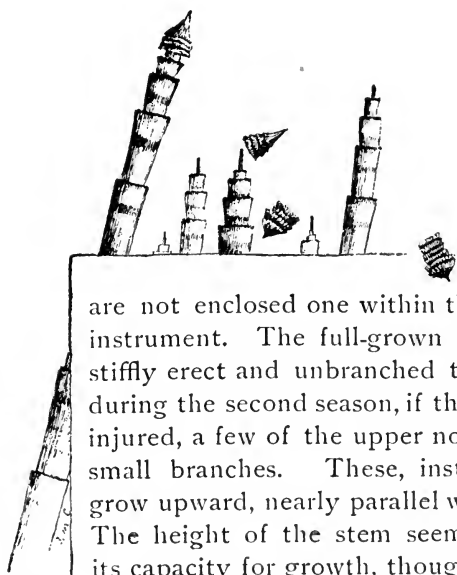
Undoubtedly the best known of the evergreen equisetums is the common scouring-rush (*Equisetum hiemale*). Its stiff unbranched stems of dark green, ringed at the

nodes with bands of black and ash-colour, are sufficient to attract the eye at any time of the year, but they are especially noticeable in winter, when, in the absence of other greenery, they become very conspicuous against a background of snow or withered leaves. It is a very gregarious species, and is seldom found except in little thickets that are very characteristic.

Early in spring the new stems make their appearance, arising from short branches of the underground portion of the plant. In appearance these budding stems suggest a closed telescope, being of full diameter, but with only the sheaths of the joints showing. Development consists

in the lengthening of the internodes, just as a telescope may be lengthened by drawing out the tube, though in the case of the plant the sections

are not enclosed one within the other, as in the instrument. The full-grown stems are usually stiffly erect and unbranched the first year; but during the second season, if the tip of the stem is injured, a few of the upper nodes may put forth small branches. These, instead of diverging, grow upward, nearly parallel with the main stem. The height of the stem seems limited only by its capacity for growth, though, since each joint is smaller than the one preceding it, there would come a time, theoretically, when no more joints could be produced. The tip of the stem is usually



YOUNG
STEMS.

winter-killed long before such a condition is reached. Mature stems seldom reach a height of more than four feet, or a diameter at base of half an inch.

A series of joints in the stem divide it into many sections, each three or four inches long. At the top of each section, or internode, there is a leaf-sheath a quarter of an inch or more long, fitting closely around the base of the next internode, and bearing on its summit numerous small triangular teeth which end in a long point. These teeth are jointed to the sheath and usually fall away at maturity, being noticeable only in very young stems. Often the tips coalesce in the bud, and, as the stem lengthens, they are carried upward on its summit in a compact mass resembling an old-fashioned candle-extinguisher or a Chinese pagoda.

Where the sheath joins the stem, there is a brown or blackish band, and a line of the same colour borders the outer edge. Between these the colour is purplish, greenish, or ashy white. The width of the black band and the colour between them varies with age and with the individual. In some specimens the bands always remain narrow, while in others they may broaden until the entire sheath is suffused with black. This latter is most common in old stems and in sheaths near the base. The marginal band is always the darker of the two, and in young specimens the second band is frequently missing, or is indicated only by a faint brown line. No species show the manner of jointing better than this. After the stem has been pulled apart it may be easily reconstructed on account of the nicety with which the ends of the internodes fit into the sheaths. At the nodes or joints the stem is solid, but cross-sections of the internodes show a very large central cavity occupying four fifths of

the stem, besides a series of small oval vallecular canals alternating with a series of still smaller carinal canals in the thin walls. Externally the stem bears from twenty to thirty or more narrow longitudinal grooves, the ridges between them being covered with many minute cross-bands of silex. Occasionally these bands break down in the centre, leaving a double row of silicious tubercles. The amount of silex in the outer coat varies, but usually it so completely covers the epidermis that the vegetable matter can be dissolved out by acids, leaving a complete outline of the stem in silex,—a sort of stone or glass skeleton.



COMMON
SCOURING-
RUSH.
*Equisetum
hiemale.*

The scouring-rush fruits in a yellowish, cone-like catkin at the apex of the stem. Occasionally, during the second summer, small cones may be produced at the tips of the short branches also. The terminal cone is ovate, about half an inch long, and ends in a short hard point. The principal fruiting-season is in May and June, though the cones, usually small and undeveloped, may be found at any time, and the plant fruits in a desultory way until October. Even in winter the compact little cones have fully-formed spores packed snugly away until a more propitious season. If one of these winter cones be split from tip to base with a sharp knife, and the cut surface be quickly examined with a lens, a most interesting sight will be revealed. From the gaps made in the delicate walls of the spore-cases, a lively crowd of spores come tumbling out, jostling one another in their haste and apparently

urged on by those behind. As each fat little spore reaches the open, it unfolds its elaters like four tiny wings and quickly sails out of the field. As long as the moisture in the tissues is evaporating they continue to come. To change the scene, one has only to dip his specimen into water or to breathe upon it. At once every elater is coiled. Even those spores just balanced on tip-toe as it were, ready for flight, decide to remain, and all seem trying to shrink into the smallest space possible. The change is due to the hygroscopic nature of the elaters, which coil in the presence of moisture. This characteristic ensures that the spores shall not set out on their travels until a fair day comes and the sailing is good, and also prevents the elaters from being folded again and the spores dropped until a moist interval, suitable for germination, occurs.

The rough and flinty exterior of this species makes it useful for scouring and polishing. It was once of prime importance in domestic affairs, being used for cleaning pots, pans, floors, and other woodwork. Cabinet-makers and others also found many uses for it, but with the advent of scouring-soaps and sandpaper it has gradually fallen into disuse. In our own country, a few Indians on the borders of civilization still use it for polishing the shafts of arrows and similar work. It is said to be occasionally used in the Old World also at the present day.

The names of "scouring-rush," "scrub-grass," "shave-grass," "polishing-rush," and "gunbright" all allude to its use in polishing, while the term "naked horsetail" has reference to the branchless nature of the stems. In some sections the slender jointed stems have suggested the name of "bamboo." "Joint-rush" and "joint-grass"

refer to the same appearance. The names "snake-weed" and "snake-rush" are probably derived from the fact that these plants often grow near water,—damp thickets and snakes being always popularly associated. The author has also heard the stems called "frogs' fishing-poles." The species has occasionally been called "smoke-weed" or "mountain-rush," but the reason for the application of these names is not apparent. "Horse-pipes" refers to the large size of this species. Smaller species are called "pipes" or "paddock-pipes," and the larger ones would naturally be called "horse-pipes," just as we speak of "horse-radish" "horse-fiddle," or "horse-chestnut." "Winter-rush" alludes to the fact that this is our commonest evergreen species. At the time of its use as a scouring-agent it was imported into England from Holland in large quantities, and in this way gained the name of "Dutch rush." It is stated that this species is often planted upon the dykes in Holland, its long branching rootstocks serving to prevent the soil from washing away.

Children often amuse themselves by placing the fresh stems on the rails of the street-car lines, and listening for the sharp reports caused by the air in the central cavity bursting through the walls of the stems as the car passes over them. The juices of the stem will also cause them to explode when thrown into the fire, and the medicine-men of various Indian tribes still make use of them in this way, in order that their popping may stimulate their patients to renewed vigour. The hollow joints of the stem may be made into a rude sort of Pan-pipe similar to those made from canes by the negroes of the South. According to an old writer it was thought that if cows fed upon this plant their teeth would drop out. It

may be added that cattle will not eat it if there is anything else to be had. The juice of the plant was once thought to be useful in nosebleed and as an application to wounds.

The scouring-rush is found throughout North America growing along streams, on the borders of swamps, and in other low grounds. It is able to exist, however, with much less moisture, and is frequently abundant along dry railway embankments and on gravelly banks. There is some variation in plants from different localities, the one here described being the form common to the North-eastern States. Its closely appressed sheaths and many-grooved stems are characters that usually serve to identify it. It is the most abundant of our evergreen species, and is also found in Europe and Asia, extending in a more or less broad belt around the earth in the North Temperate Zone. It appears to be absolutely unharmed by the cold. The water in the central hollow often freezes solid without hurt to the plant. In exposed situations the stems on the southern side turn a dingy brown in winter, but become green again on the approach of a milder season.

In the Mississippi Valley, and farther west, there is a form called *Equisetum hiemale intermedium* which has transverse bands of silex on the stems, looser, somewhat funnel-shaped green sheaths with a narrow black-and-white margin and deciduous or persistent teeth. It has often been collected for *Equisetum lævigatum*, which it resembles in many ways, especially in the funnel-shaped sheaths, but the internal structure is that of true *hiemale*. *Equisetum lævigatum* is also said to have annual stems, but there is still some doubt upon this subject. In some States, notably Nebraska, *Equisetum hiemale intermedium* is considered of some importance as a forage crop. No

less than ten named varieties of *Equisetum hiemale* have been reported from America. Many of these are mere ecological forms, of interest only to the systematist. Those wishing to study them will find a full account of all in volume XI of the *Fern Bulletin*.

The Great Scouring-Rush.

In the Southern and Western States the most abundant of the scouring-rushes is probably the great scouring-rush (*Equisetum robustum*), which is supposed to intergrade with the common scouring-rush and is by many considered only a variety of it. It is a strong and robust species, but except for its larger size it cannot be distinguished from *Equisetum hiemale* in a cursory examination. Mr. A. A. Eaton, who has carefully studied the genus, is convinced that this is only a well-marked race of the scouring-rush, but as it has always appeared in text-books as a separate species it will be so treated here. Mr. Eaton's view is probably the correct one, however.



Large Sheath.
Natural Size.

Aside from its larger size, the characteristics usually depended upon for separating *Equisetum robustum* from *Equisetum hiemale* are the greater number of grooves in the stem, the three-keeled ridges of the sheaths, and the single series of cross-bands of silex on the carinæ. *Equisetum hiemale* is supposed always to have obscurely four-keeled ridges in the sheaths, and two rows of silex tubercles on the carinæ, but any of the characteristics of the one may be matched by specimens of the other.

In favourable situations the stems of this species often reach a height of ten feet, and a diameter of half an inch or more at base, forming thickets similar to those of the common scouring-rush. In the warmer parts of its range the new shoots begin to make their appearance in March or earlier, and by the first week in April the fruiting cones may be obtained, though the stems have scarcely reached their maximum height at that period. During the first year the stems seldom branch, but early the next spring a large number of them put forth long wand-like branches from the upper joints. All authorities agree that this form rarely branches, but this is clearly a mistake. It produces branches much more freely than does *Equisetum hiemale*. In addition to the principal stems this species not infrequently produces several slender stems from each rootstock.

The sheaths are rather longer than those of *Equisetum hiemale*, and are pinkish ash-colour with rather narrow marginal and basal dark bands, the latter at first prominent and lighter in colour. The teeth are dark brown with tawny margins, elongated triangular in shape, with long tapering points, and usually remain in position until the stems are full grown or even longer. Those upon the branches do not fall off during the life of the stems.

The fruiting cones are from half an inch to an inch long and terminate in a sharp point as in the other species of this group. The fertile stems produce a single spike at the apex of the stem the first year, and the following season one or more smaller cones may develop on the ends of small branches, the terminal cone, of course, being absent. Like the common scouring-rush, the stem of this species is hollow for the greater part of



*Equisetum
Ferrissii.*
Section of
Stem,
Natural
Size.

its diameter, and the contained air causes a loud report when it is forced out under pressure.

The great scouring-rush is rare east of the Mississippi River except in the South. It has been reported, apparently upon good authority, from scattered stations in New Jersey, Pennsylvania, Maryland, Indiana, Illinois, and Michigan, and is the common form in the States bordering the Gulf. In the West it appears to be plentiful throughout, extending northward into British Columbia. It is said to occur in India also. The stems are as rough as those of the common species, and are still occasionally used for polishing by the Southern negroes. Being so nearly like *Equisetum hiemale* it shares with it the various common names.

The Slender Scouring-Rush.

The characters relied upon for the identification of the various *Equisetum* species, such as the number of grooves in the stem, the diameter of the stem, length of the joints, etc., make the variations a matter of easy mathematical demonstration. In making some investigations along this line, recently, the author was surprised to find that the extremes of variation in *Equisetum hiemale* are much less than is commonly supposed. Out of more than 250 stems selected at random, all but twenty-four were between $5/32$ and $8/32$ of an inch in diameter. The length between joints was between two and three inches in all but fifteen of the 230 specimens measured, while of 125 specimens in which the grooves were counted, all but thirteen had from twenty-four to thirty

grooves each. At the same time, an *Equisetum* was found near Joliet, Illinois, that differed so constantly in these characters that it was considered a new species and was named *Equisetum Ferrissi*. This species is principally distinguished by its tall, slender, pale-green stems with few grooves, and the exceedingly long sections between joints. More than fifty specimens, selected at random, were measured, and all but four were $\frac{4}{32}$ of an inch or less in diameter. The grooves were also fewer in number, only nine stems having more than fourteen grooves. The greatest difference of all, however, was in the length between joints. None of the internodes were as short as the average in *Equisetum hiemale*, and but fourteen were less than four inches long. The longest measured more than six and a half inches. This form may also be known by the appressed sheaths, which are green when young, but in age become chalky-white with a narrow black basal band encircling them obliquely. The teeth are two thirds the length of the sheaths, slender and deciduous, with a central streak of dark brown bordered by a wider hyaline margin. After the teeth have fallen, the border of the sheath becomes thickened, incurved, and dark brown in colour. The grooves between the leaves extend below the basal black band. The catkins, like those of the common scouring-rush, are tipped with a sharp point and are borne on a short pedicel. They ripen about the first of June, but many appear to be abortive and are to be found in the globular expansion formed by the topmost whorl of leaves.

The slender scouring-rush resembles *Equisetum hiemale intermedium*, but may be distinguished from it by the smoother, slenderer stems, by having fewer grooves in

the stem, and by the appressed sheaths and strongly apiculate catkin.

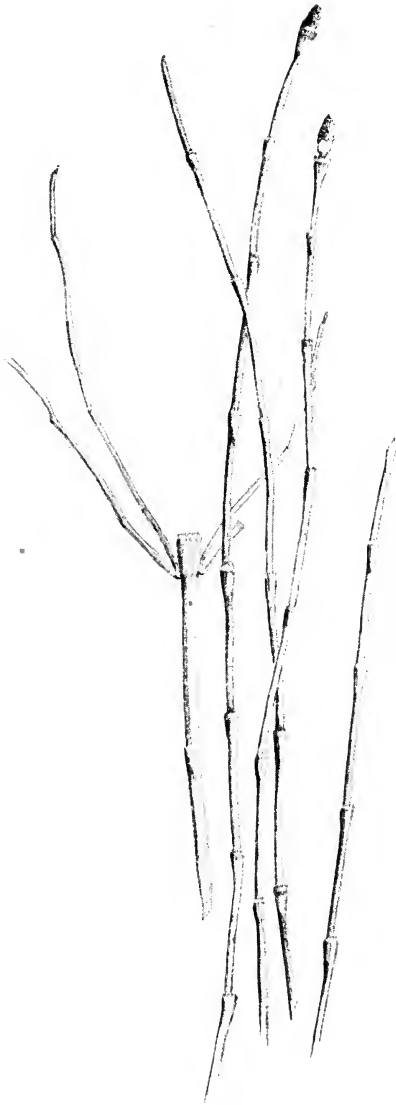
It is not known at present whether this form occurs elsewhere, or whether its existence at Joliet is unique. At the place where it was discovered it forms an extensive thicket, but this may have arisen by means of the spreading rootstock. Possibly the first plant was produced by a variant spore. If so, it is not likely to be found in other localities, and the question arises whether it is entitled to be called a species, or is more properly considered a form of *Equisetum hiemale*. From the modern viewpoint of evolution it might be thought an offshoot, by mutation, of the species mentioned. In form it appears to be more distinct than either *Equisetum hiemale robustum* or *Equisetum hiemale intermedium*; but should it turn out to be unworthy of specific rank it would still rank as a sub-species with the title of *Equisetum hiemale Ferrissi*.



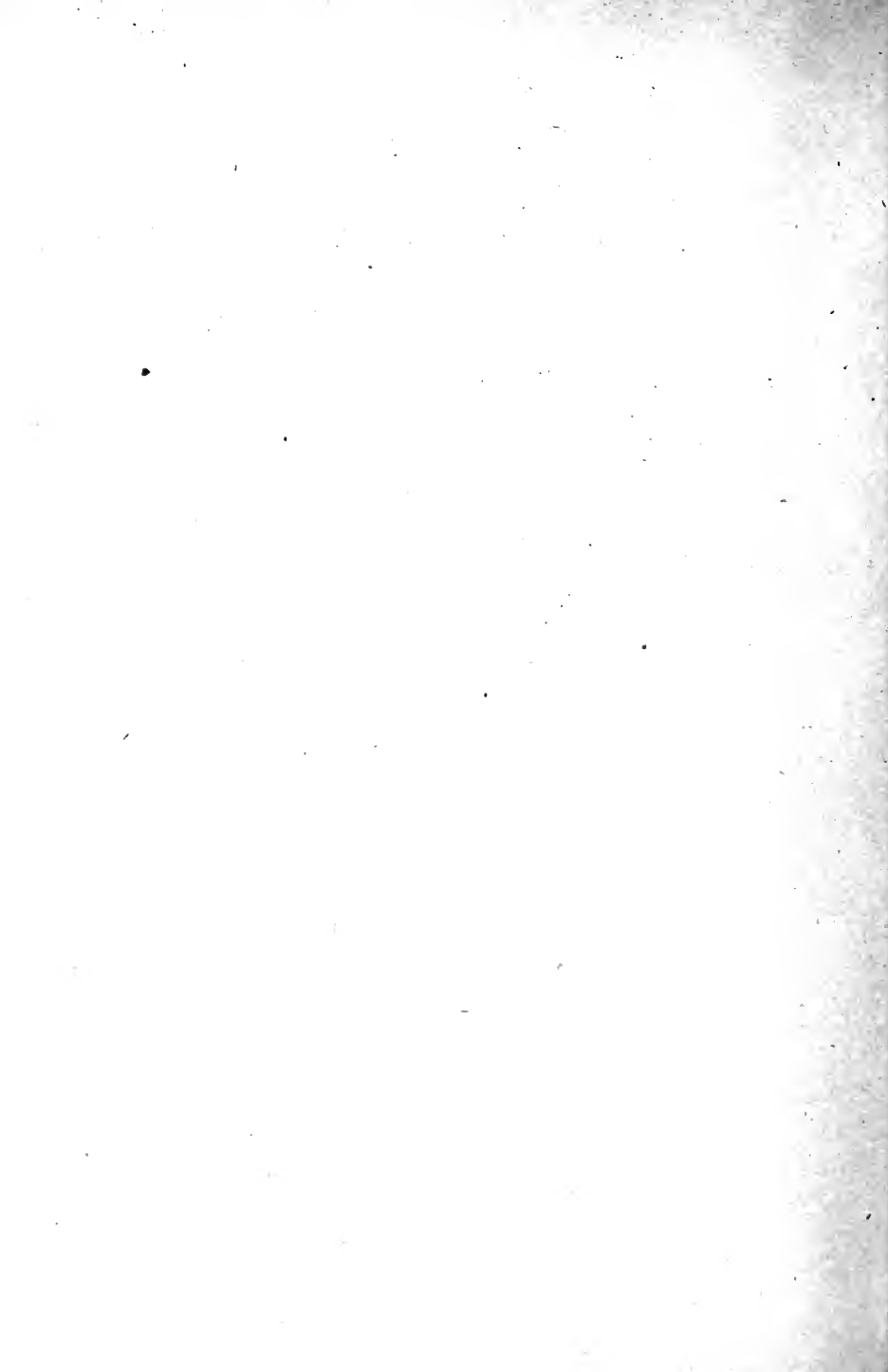
TIP OF
STEM EN-
LARGED.

The Smooth Scouring-Rush.

Typical specimens of the equisetums are not difficult to identify, but when one has a large series of a single species from different localities to deal with, the task becomes more perplexing than might be supposed, on account of the numerous variations presented; in fact, it is hinted that all the species in the section *Hippochate*, though distinct enough as to type, may be connected by intergrading forms. One of the most variable of these species is the smooth scouring-rush (*Equisetum lævigatum*). On the one hand it is linked to the common scouring-rush by the form known as *Equisetum hiemale*



SMOOTH SCOURING-RUSH.
Equisetum laevigatum.



intermedium, and on the other it intergrades almost imperceptibly with the smaller variegated scouring-rush.

In outward appearance the smooth scouring-rush is much like *Equisetum hiemale*, though usually shorter and slenderer and with less silex in the epidermis. Well-developed specimens may reach the height of four feet, but the average is probably less than twenty inches. The exterior is comparatively smooth and has from ten to thirty grooves. The sheaths are long, green, and dilated upward like a funnel, this last characteristic being one of its most distinguishing features. There seems to be some question as to whether or not the stems last through the winter. All its affinities are with the evergreen species, and it has always been called evergreen in the books, but Mr. Eaton, the latest monographer of the American species, has stated that the stems are annual, and that the species may be distinguished from *Equisetum hiemale* by this single peculiarity. Further observations on this point are desirable. The present lack is no doubt due to the fact that the species is rare in the Eastern States, where most of the studies of *Equisetum* have been made.

The stems of the smooth scouring-rush usually grow in tufts from the summit of the rootstock. They are slender and usually unbranched, though the more robust specimens may develop several ascending branches from near the base, especially if the tip be injured. In this it is the reverse of the common scouring rush, which, if it branches at all, does so near the tip of the stem. In colour the stems are pale green, and a cross-section shows a large central cavity with medium-sized vallicular canals, those under the carinæ being either smaller or absent. On the exterior the grooves are somewhat

rounded with or without cross-bands of silex. The sheaths are coloured like the stem, or occasionally paler, rarely with a black girdle at base. The leaves of the sheaths usually have a central ridge at base, which fades out as the apex is approached. The teeth are long and slender, silvery white in colour, with a narrow streak of dark brown down the middle. At maturity these teeth usually fall away, leaving the brownish bases, bordered with white, as a narrow brown and white margin to the sheath.



SHEATH OF
SMOOTH
SCOURING-
RUSH.

This species begins to fruit about the first of May, though the catkins may be found as late as midsummer. The late catkins are produced on secondary stems which spring from the base of the earlier ones. The cones are small, ovate or oblong, with the base often enclosed in the uppermost sheath, and the point at apex short or absent.

The range of the smooth scouring-rush, as usually defined, begins in New Jersey and spreads out in fan shape to the Pacific coast, the line of its southern limit passing through Louisiana and Texas, while the line on the north crosses Ohio and Wisconsin, and so on to British Columbia. In the East and South it is extremely rare, and there is a suspicion that the Eastern records are based on forms that are more properly referred to *Equisetum hiemale*. The form *Equisetum hiemale intermedium* closely resembles it, especially in the shape of the



Catkin of
Smooth
Scouring-
Rush.

sheaths, though in the latter these are shorter and paler, with a black basal girdle. *Equisetum levigatum* is found only in America, and is doubtless most common in the Middle West, where it is often used for forage. It prefers a moist soil, being usually found in sand or clay on the borders of streams. Many facts in its life history are as yet imperfectly known, and the beginner will find this a species worthy of further observation. Five American varieties of no especial importance have been described in the *Fern Bulletin*.

The Branched Equisetum.

Students who consult other works on the fern allies will find listed among the North American species two that are no longer regarded as members of our flora. These are *Equisetum ramosissimum* and *Equisetum Mexicanum*. The first was reported from British Columbia more than fifty years ago, but as it has never been rediscovered there, and the reported situation is far out of the plant's known range, it seems almost certain that some other species was mistaken for it. The second species, *Equisetum Mexicanum*, has frequently been reported from southern California, but here again the probabilities are that the identification is incorrect. Baker, in his "Hand-Book of the Fern Allies," considers *Equisetum Mexicanum* to be a form of the tropical *Equisetum giganteum*; and while it is possible that an occasional plant of this species may stray across our southwestern border, it is more probable that the California specimens belong to a different species. Since these plants have always been wrongly identified, it becomes necessary to give them a new name to distinguish them.

Mr. A. A. Eaton has therefore proposed the name of *Equisetum Funstoni*, in honour of General Funston, who in early life made several botanical expeditions into little-known regions, upon one of which he collected this species.

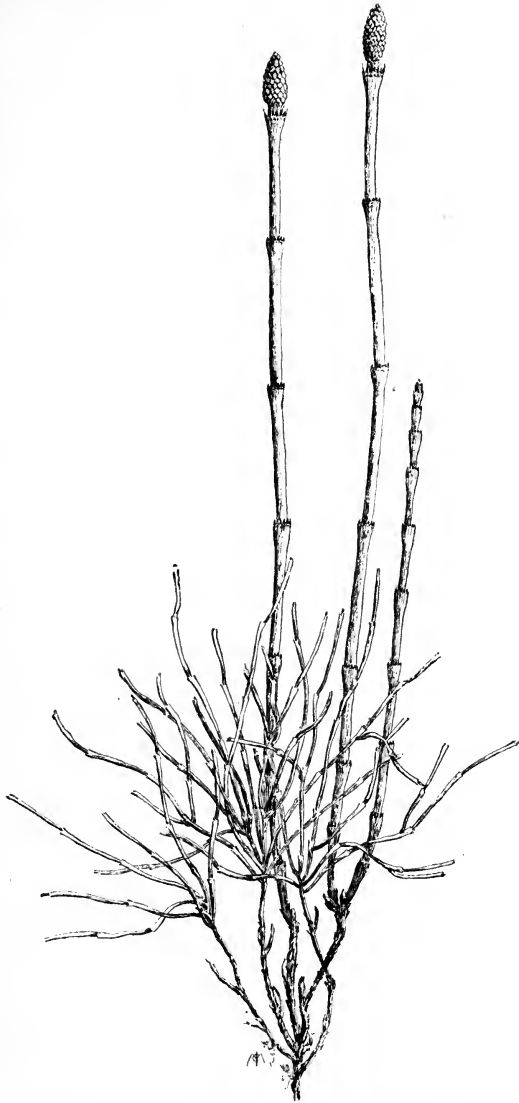
The branched scouring-rush is most like *Equisetum lævigatum*, but may be distinguished from it by its rougher stems and by the shape and make-up of the sheaths. In both species the sheaths are coloured like the stems, and both are dilated upward, but in *Equisetum Funstoni* the margin of the sheath, after the tips have fallen, turns inward, while in *Equisetum lævigatum* it does not. The leaves composing the sheaths of *Equisetum Funstoni* are somewhat separated at the apex. The stems of *Equisetum lævigatum* are also supposed to be annual, while those of *Equisetum Funstoni* last through the winter. This difference, however, may be accounted for by the warmer climate of the region inhabited by the latter. Both species



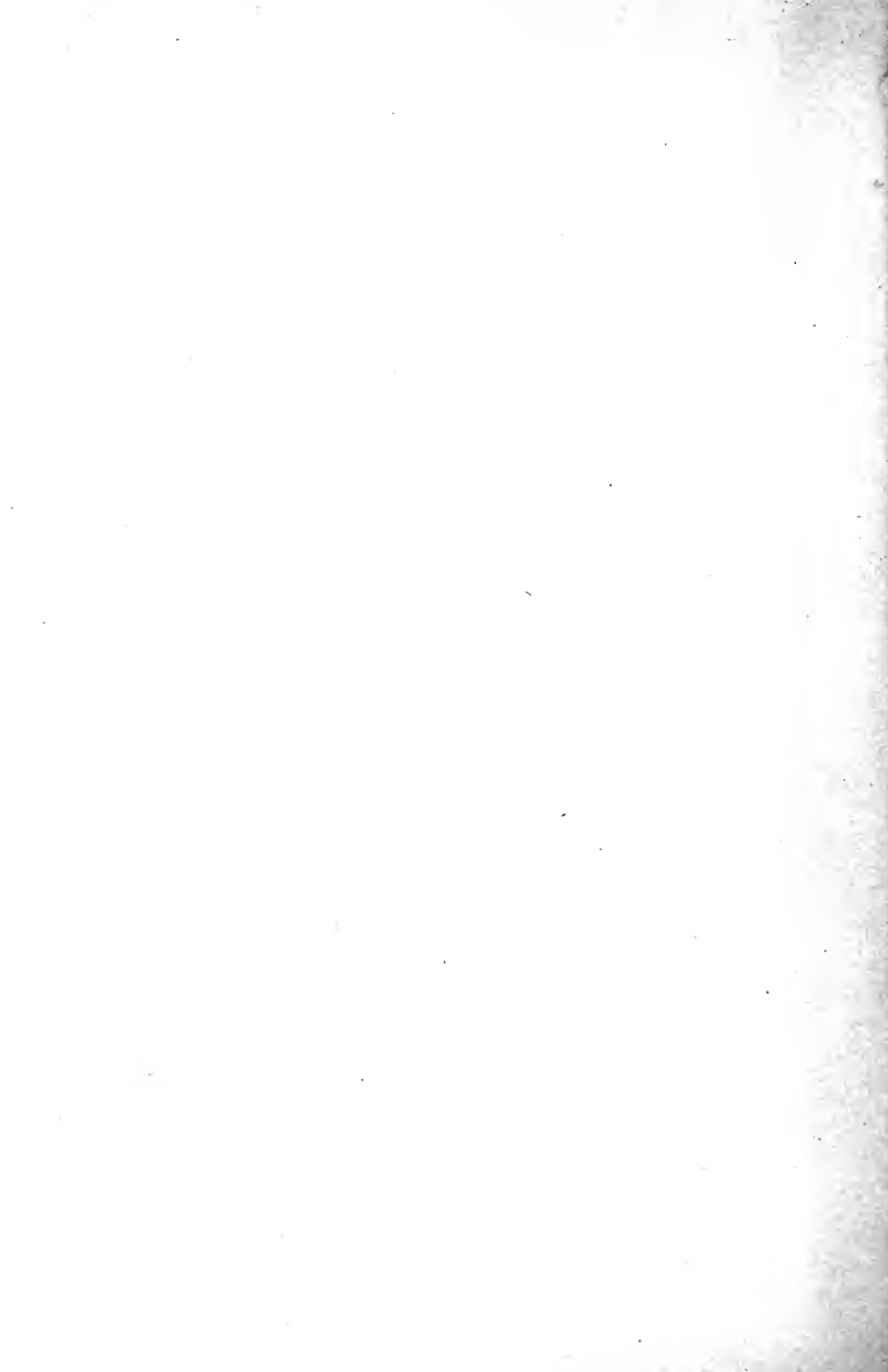
Sheath of
Equisetum
Funstoni.

are alike in having catkins lacking the apical point, though, curiously enough, they belong to a section in which the possession of such a point is one of the distinguishing features. It has been suggested that *Equisetum Funstoni* is but a form of the better-known *Equisetum lævigatum*. Whether this is true or not will necessitate further study of both plants in the field. Should it be proved to be a form of *Equisetum lævigatum*, it would be known as *Equisetum lævigatum Funstoni*, since the other was first named.

The new stems of the branched scouring-rush make their appearance early in the year, and by the middle of March are in fruit. At maturity they may reach a



BRANCHED EQUISETUM *Equisetum Funstoni.*



height of two feet or more, with a diameter of a quarter of an inch. They contain from ten to thirty grooves, the ridges somewhat rounded and usually rough with many cross-bands of silex. The sheaths are twice as long as they are wide, and are tipped with triangular, long-pointed teeth, most of which are torn off by the developing stems, the rest falling at maturity. The teeth are dark brown or black with a pale margin, and the bases, which remain attached to the sheaths, are slightly grooved in the centre. Each leaf has a low ridge extending lengthwise, and the upper margin, where it is separated from the others, is slightly raised. In cross-section more than four fifths of the stem is hollow, and both the carinal and vallecular canals are very small, or, occasionally, wanting.

Much remains to be observed regarding the development and duration of the stems of this species. Apparently the erect fruiting stems do not branch, at least not until after fruiting, but the sterile stems produce regular whorls of branches as they develop. There is also a form of the sterile stem, most noticeable in winter, which spreads flat on the ground and sends out a multitude of short, very slender branches from the base, forming dense mats. In this form the stems are about ten-angled, and the teeth are silvery white and persistent. It does not seem to be known whether the fertile and sterile stems last through the winter, but, reasoning from the analogy of related species, it may be assumed that they do.

The fruiting-catkins are among the largest produced by this group of plants, being about three quarters of an



Catkin of
Equisetum
Funstoni.

inch long and a third as broad. They are nearly ovate, with a rounded apex, and the base is either included in the uppermost sheath or raised above it on a short stem. In most specimens there is a cup-shaped sheath of the same colour as the catkin, closely appressed to the lowest whorl of sporophylls.

Equisetum Funstoni is a plant of the extreme Southwest. It is very abundant in southern California below about 1,500 feet altitude, and prefers moist sand, especially along streams, although it occasionally grows in soil so dry that the stems perish during the summer. In general appearance the species is so much like *Equisetum lævigatum* that it is easily mistaken for it. Four ecological forms have been named. It is interesting in this connection to note that there are but two other species of *Equisetum* in the world, named for botanists.

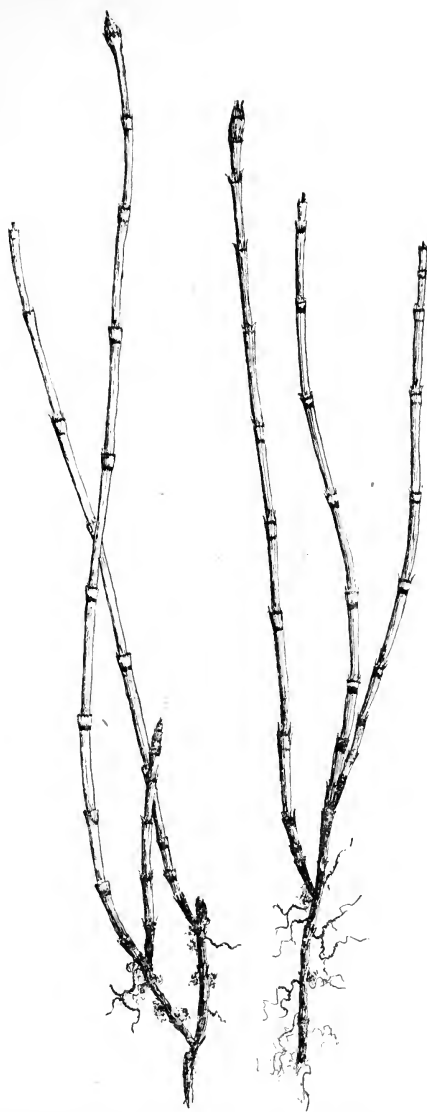
The Variegated Scouring-Rush.



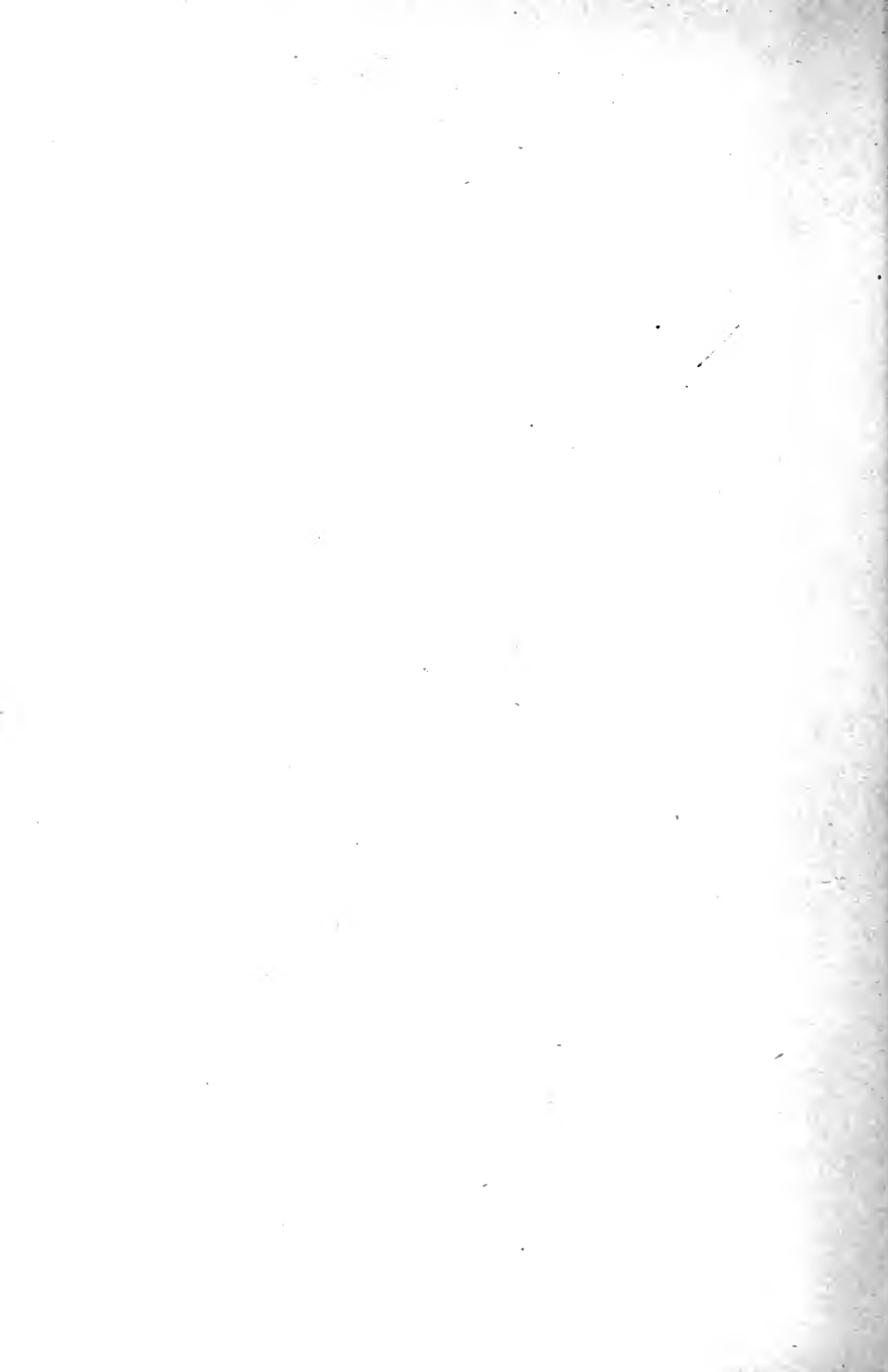
Sheath of
Equisetum
variegatum.

One familiar with the appearance of the smooth scouring-rush might easily mistake the variegated scouring-rush (*Equisetum variegatum*) for a small form of that species. Superficially they are much alike except in size and the markings of the sheaths, but a close examination will show many other points of difference. *Equisetum variegatum* is much the more widely distributed, and in America the habitats of the two do not overlap to any great extent.

The stems of this species grow in tufts from the apex of the rootstock, and reach a height of from six to twenty inches. They are slender, barely an eighth of an inch in diameter, and so



VARIEGATED SCOURING-RUSH. *Equisetum variegatum*.



weak that they often spread about in a half-recumbent position. Externally they are marked with from four to ten broad, rounded, or slightly two-angled ridges with still broader hollows between. A cross-section shows the central hollow to be about one third the total diameter, the vallecular canals to be relatively large and transversely oval, while the carinal canals are much smaller.

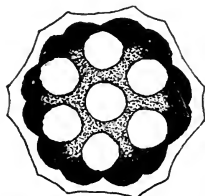
The sheaths are of moderate length, slightly dilated upward, and tipped with elongated, triangular, slender-pointed teeth with white margins which may or may not fall off at maturity. At the base of old stems the sheaths are jet black; higher up they are ash-colour with two black girdles, one at the base and one on the margin; while near the apex and in young stems they may be clear green with only a narrow blackish band on the margin. The leaves are four-ridged, the two middle ridges separated by a rather deep groove, this latter being considered an important point in identifying the species. The catkins are slightly ovate, half an inch or under in length, and tipped with a comparatively large point. After fruiting, the sporophylls often fall from the axis of the cone, which may persist in this condition for some time.



Catkin of
Equisetum
variegatum

The variegated scouring-rush is a lover of the North, and inhabits a zone encircling the earth from about the 42d parallel of north latitude to the Arctic Circle and beyond. In the southern part of its American range it has been reported from all the northern tier of States and from Illinois and Indiana. It has often been reported from the Southwestern States, but it is likely that in such cases *Equisetum laevigatum* may have been mistaken for it. It grows in

swamps, on wet rocks, and on the gravelly borders of streams, but, according to Eaton, seldom in sand. In Europe it has been reported as occurring in sandy places near the seashore. In the northern part of its range the



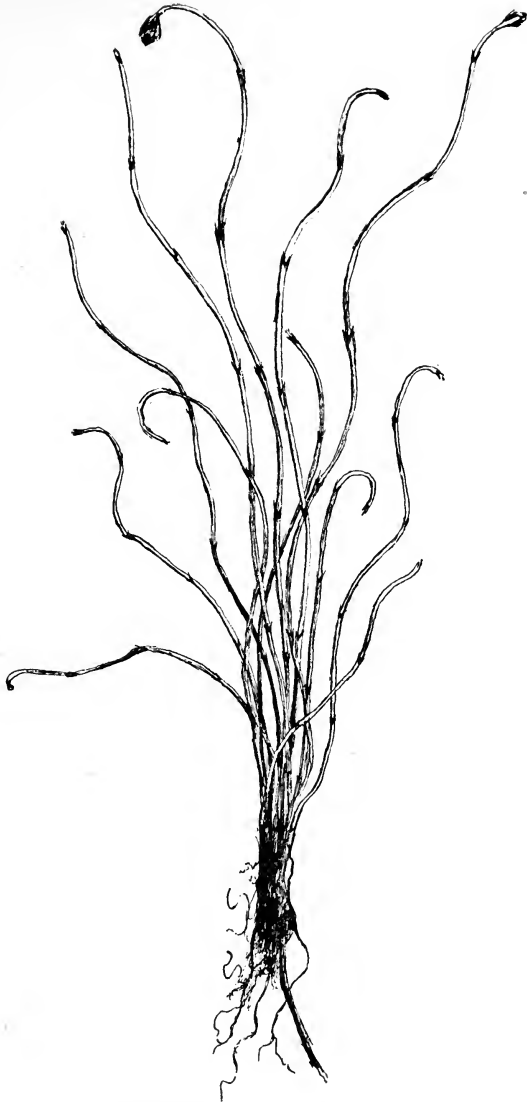
Cross Section of Stem.

stems possibly do not survive the winter, but farther south there is evidence that a majority, if not all, are evergreen. The specific name, *variegatum*, refers to the appearance given to the stem by the black sheaths. Four varieties have been named, of which *Alaskanum*, found from the State of Washington northward, is the most noteworthy. It is regarded by many as being a connecting link between this species and *Equisetum hiemale*.

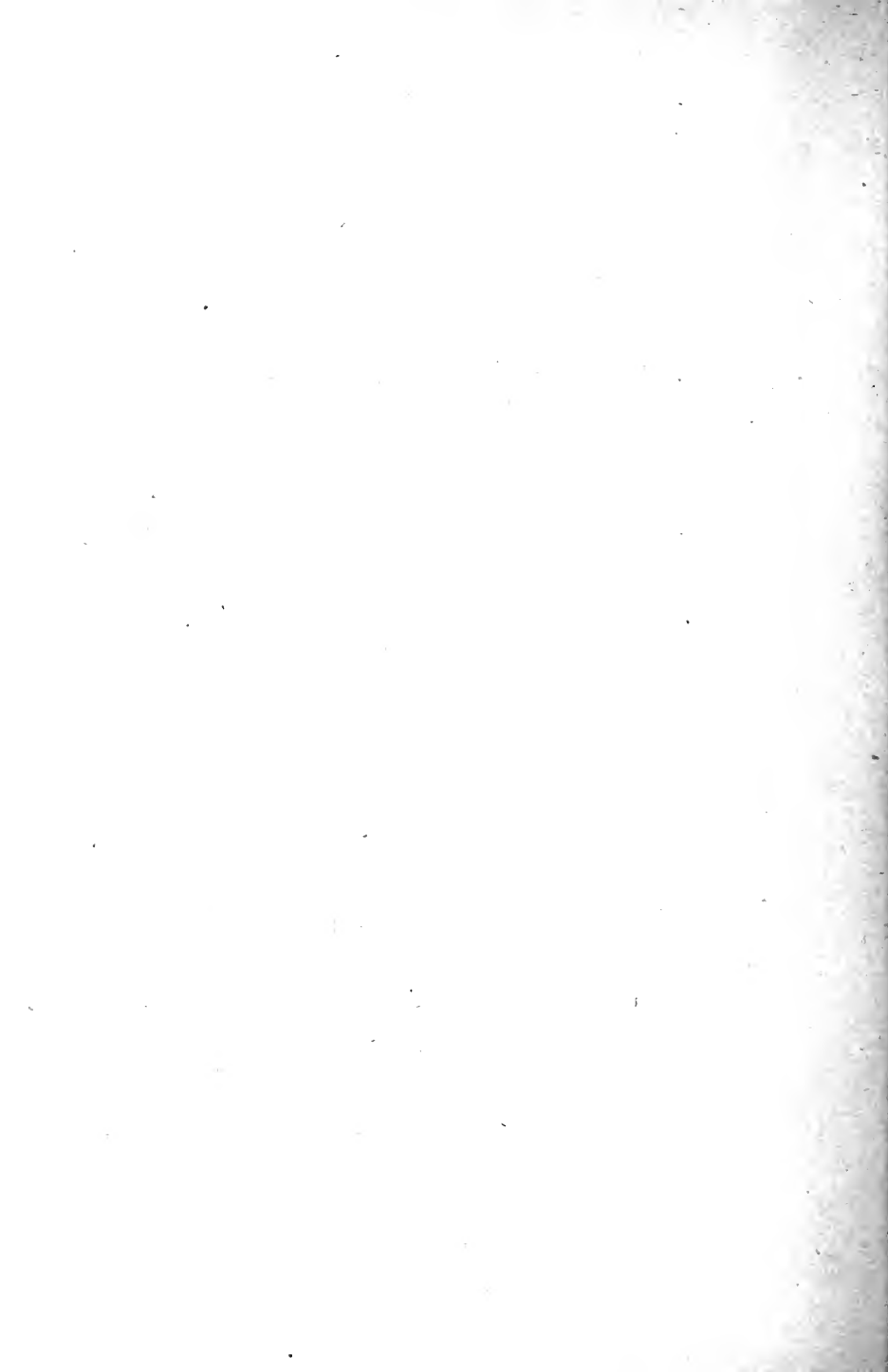
The Dwarf Scouring-Rush.

After puzzling over the minute differences that are often depended upon for separating the other species of *Equisetum*, it is refreshing to turn to one like the dwarf scouring-rush (*Equisetum scirpoides*) that is so distinct in form and so characteristic in appearance that even the beginner, finding it for the first time, has no doubt as to its identity. It is the smallest living species of *Equisetum*, and for this reason is often overlooked in regions where it is fairly common.

This species, though growing only in the colder parts of America, is an evergreen, and, like its relative, the common scouring-rush, carries many of its fruit-buds through the winter. Almost as soon as the snow has disappeared, the first catkins begin discharging their spores, and the plant continues to fruit through the summer.



DWARF SCOURING-RUSH. *Equisetum scirpoides*.



The greatest number of mature spikes will probably be found about the middle of April, making it one of the earliest fruiting species of *Equisetum*.

The stems grow in dense tufts, the longest barely reaching a height of ten inches, and are so slender as to be almost threadlike. They are often branched at base, but seldom so above, unless they become prostrate and covered with soil. The fertile stems are nearly erect, but the sterile are flexuous and bend over at the tip. When dried for the herbarium they often coil into circles or even double circles. The stem is six-angled, but there are only three leaves in the sheath. In all other species of *Equisetum* the number of leaves in the sheath and the number of angles in the stem are equal, and the apparent anomaly presented by this species is explained by the fact that in addition to the true ridges there is an equal number of false ridges over the vallecular canals. The ^{SHEATH.} three leaves are not joined together, and do not properly form a sheath, in this showing very clearly that the sheaths of the other species are formed of confluent leaves. The teeth are small, slender, black, with pale margins, and are not deciduous. The leaves have one deep central groove and two lighter lateral ones, making them four-keeled. In age, both leaves and sheaths become dark brown or black. Unlike all other equisetums, the stems of this species have no central hollow. The vallecular canals are comparatively large, and the carinal, though small, are present.



SHEATH.

The fruiting-spikes are scarcely larger than peppercorns and consist of about half a dozen small sporophylls on an axis tipped with a tiny black point. Many of the

embryo fruit-spikes seem never to become fully developed. The first spores are ripe at about the time the anemone and spring beauty are blooming.



CATKIN.

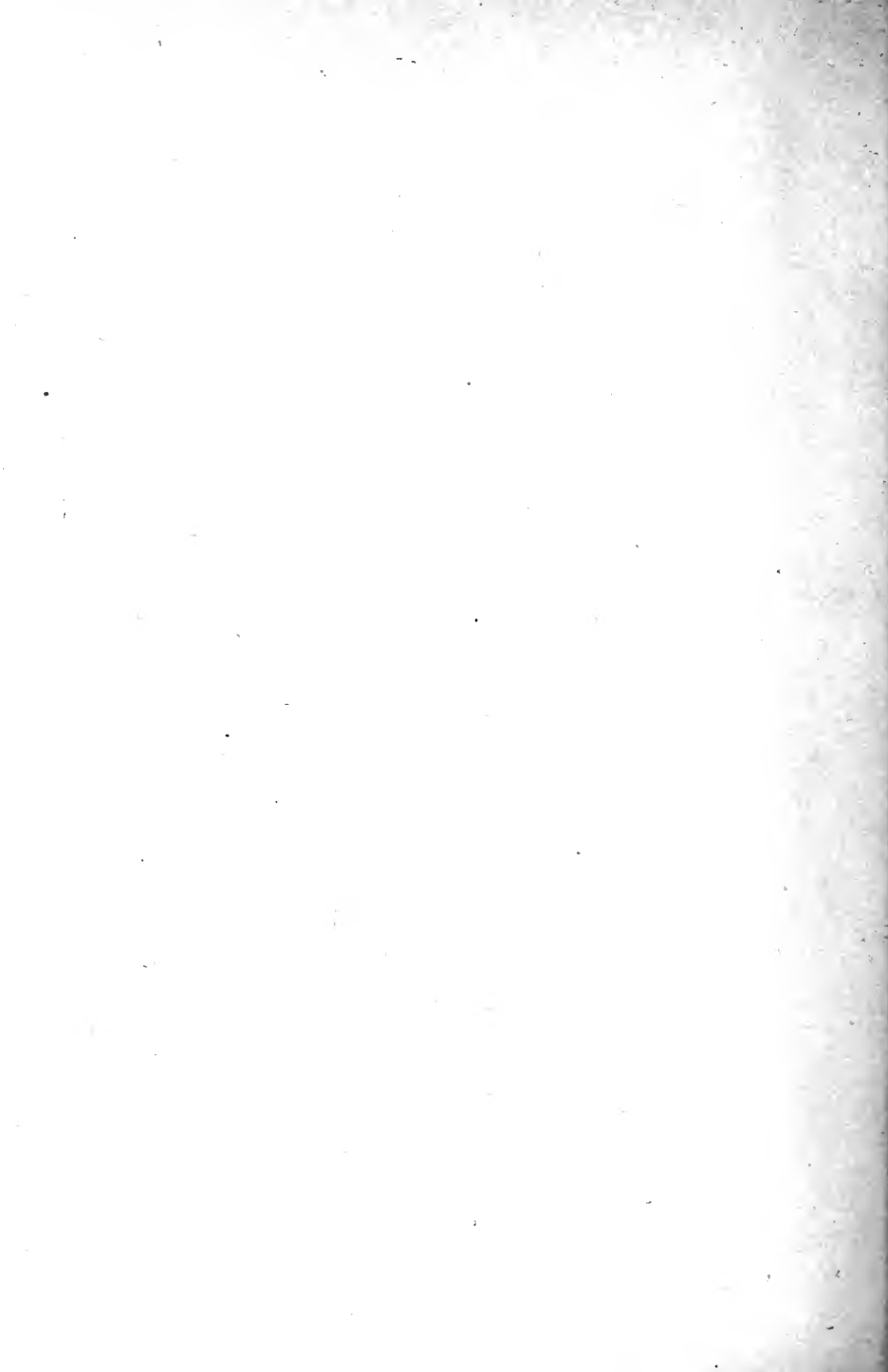
The dwarf scouring-rush is found from Greenland and Alaska south to Pennsylvania, Illinois, Nebraska, Montana, and British Columbia. It is also found in northern Europe and Asia. The stations on the southern limits of its range in America are widely separated, and the plant does not begin to become common until the northern boundary of the United States is reached.

A writer in the *Fern Bulletin* reports it as covering several acres in western Connecticut, and says of its habitat:

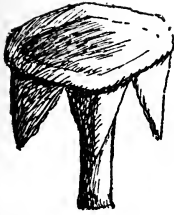
“It seems to favour moist, thickly wooded hillsides for the place of its abode, although Mr. Grout found it in a cold boggy meadow. The place where I first saw this plant is a steep hillside thickly grown up to hemlock and white pine. Underneath, the little *Taxus*, or ground hemlock, grows in abundance, and the twisted-stalk, showy orchis, red trillium, and round-leaved violet are its companions.”

It is also found on wooded banks, decayed logs, and among fine grasses, usually in forest regions. Since it so nearly resembles the grasses and sedges among which it grows, the best time to search for it is early in the year, before the other early vegetation has started up.

THE DECIDUOUS EQUISETUMS,
OR HORSETAILS.



THE HORSETAILS.



THE separation of the Equisetaceæ into two divisions, called respectively the Scouring-Rushes and the Horsetails, is at best but an arbitrary classification. The manner of growth, the structure of the stem, and the method of fruiting are the same in all, and they are therefore properly placed in a single genus. There are however, certain very noticeable characters by which even the novice may separate them into the groups mentioned, and in the popular mind they are usually so separated. As treated in this book, the horsetails will be considered as those species of *Equisetum* in which the stems die at the approach of winter and the fruiting-cones are without a terminal point. Their sterile stems also usually produce regular whorls of branches, and the fertile often do so. These form the section *Eucquisetum*, or *Equisetum* proper, of the systematist.

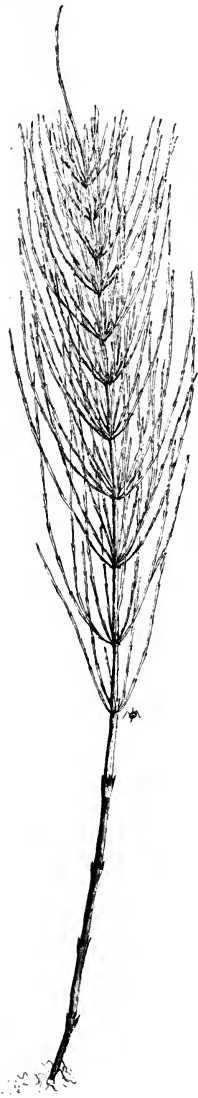
The Field Horsetail.

The field horsetail (*Equisetum arvense*) is without doubt the most abundant species of *Equisetum* in the world. Not only is it widely distributed, but wherever it grows it usually occurs in the greatest abundance. Normally a moisture-loving plant, it can adapt itself to

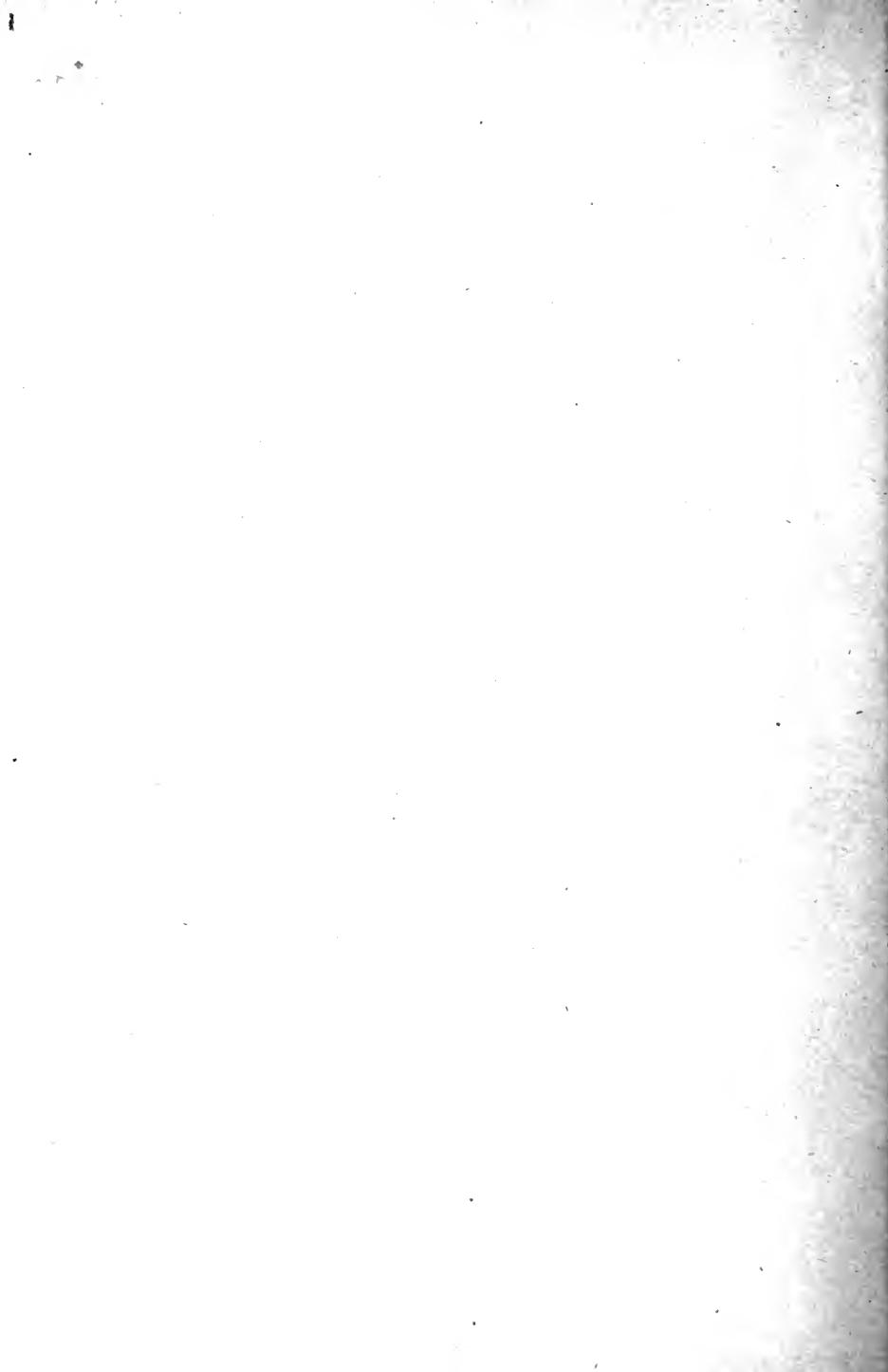
a wide variety of situations, and is often found in dry and sterile places in which few other plants can exist, such as dry roadsides and railway embankments. In the latter situation it thrives exceedingly well, and, though rooted in cinders, covers vast stretches of the surface with a pleasing mat of its yellowish-green sterile stems. All who have ever travelled a dozen miles on a railway in summer have doubtless seen this plant.

The appearance of the fertile stems of this species is among the first signs of returning spring. They come almost before the grass has begun to green, often starting up in such numbers as to give a strong tinge of their own warm flesh-colour to the sunny slopes on which they grow. There is something very mushroom-like in the rapidity with which these fleshy stems mature when once they have started to develop, and the likeness is increased by the fact that, like the mushroom, they have no green in their composition.

The first stems are usually fully developed and showing their spores long before one has discovered that they have started. If one begins the season early enough, however, he may find just beneath the surface of the earth numerous buds in which the fruiting-cones are all complete and waiting for the first warm day to call them forth. Indeed, as early as midsummer of the preceding year these buds may be found. Just before growth commences they often measure an inch or more in length and half an inch in diameter. At this time the sheaths are also fully developed, and overlap one another like shingles on a roof, thus completely enclosing the catkin. Growth consists in the development of the internodes, and often proceeds at the rate of nearly two inches a day. At maturity they are from a few inches

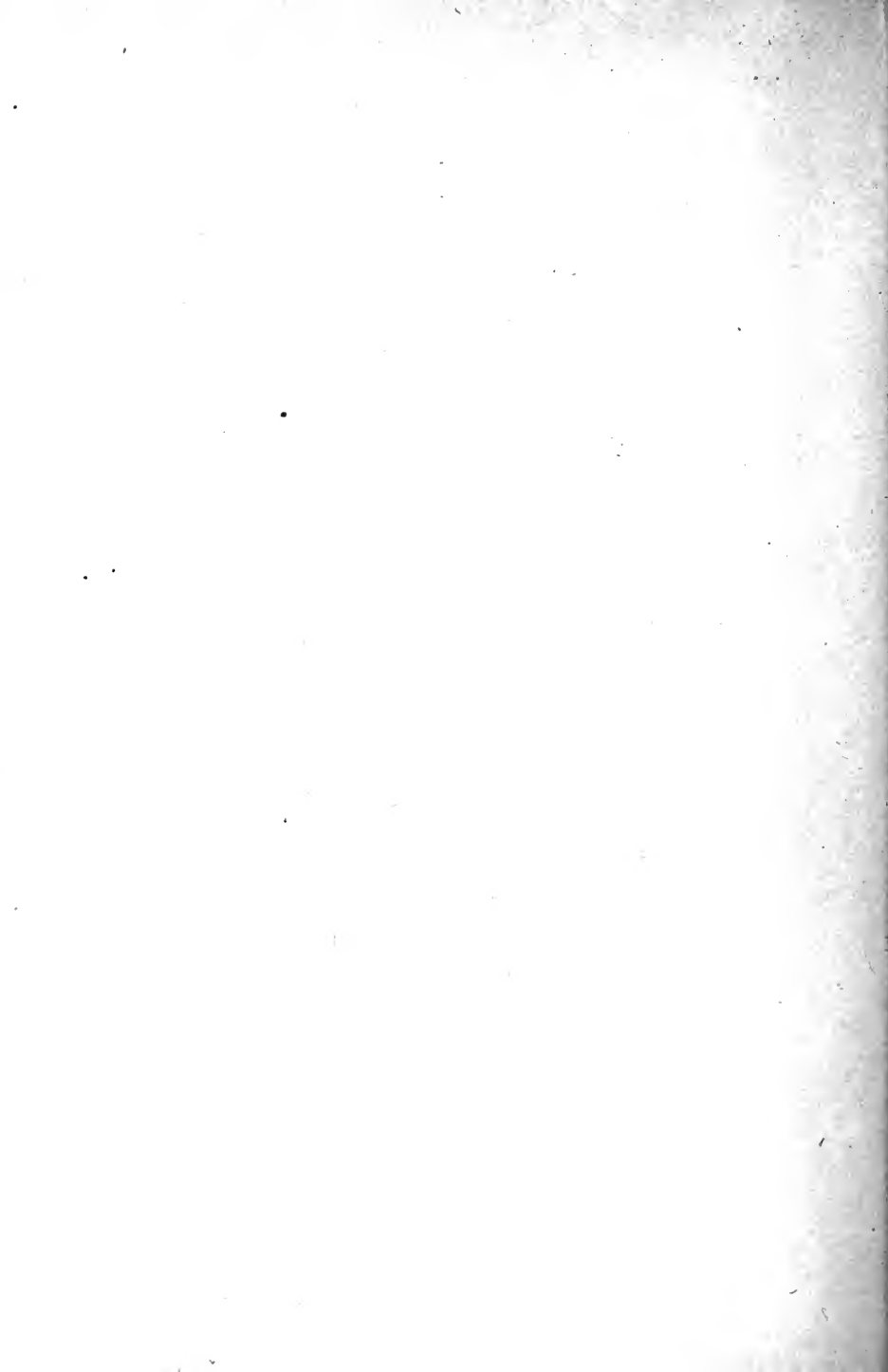


FIELD HORSETAIL. *Equisetum arvense*.
Sterile frond.





FIELD HORSETAIL. *Equisetum arvense*.
Fertile frond.



to a foot or more high, but less than a quarter of an inch in diameter. The earliest stems are to be found in dry sandy places; those growing in wet or clay soils develop much later.

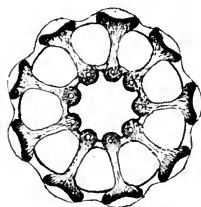
The full-grown fertile stems are most attractive objects, the yellowish sheaths with long, pointed, dark-brown teeth contrasting very prettily with the deep flesh-colour of the internodes. There are usually from six to ten of these sheaths on a stem, each nearly an inch in length and half an inch wide at the top, flaring upward like a funnel. The upper sheaths are usually largest. In the bud, the bases of these sheaths are deep yellow in colour.

The mature cones are yellowish-brown and frequently two inches in length. They are a third of an inch in diameter and much like those of the scouring-rush in appearance, except that they are softer and more catkin-like and lack the hard terminal point. The sporophylls, owing to the way they are placed in the cone, are usually six-sided, but there are often more than six sporangia, and the outer ends of these are plainly indicated by elevations on the outer surface of the sporophylls. The spores are produced in great abundance, and at the proper time the slightest jar will suffice to shake them out in grey-green clouds. By striking a ripe cone upon the back of the hand one may shake out a little heap of spores that under a simple lens may be seen suddenly to boil up, at the same time becoming lighter in colour. This is due to the uncoiling of the elaters as the moisture in them evaporates and the spores prepare to drift away on the wind.

Soon after the spores have been shed, the fertile stems wither and disappear. At the same time the sterile fronds begin to be noticed, springing from the small

buds at the top of the rootstock near the point where the fertile stem arises. The sterile stems are much taller than the fertile, in favourable circumstances reaching a height of three feet. Ordinarily they are from ten to fifteen inches high. The sheaths are shorter and narrower than those of the fertile stems, but, like them, are dilated upward. They are never so noticeable, being usually pale green in colour and tipped with slender dark-brown teeth. Toward the base of the stem the entire sheath may be dark brown.

In the section to which the field horsetail belongs, the structure and number of grooves in the stem and the arrangement of the sheaths play a less important part in the identification of the species than they do in the



Section of Stem.

Hippochaete. They are, however, not without value for this purpose. In the present species it may be noted that there are eight or more leaves in the sheath of the fertile stem, and about fifteen in that of the sterile one. Since there is usually one leaf for each groove of the stem, the number of the latter

is easily ascertained. The tips of the leaves of this species are not deciduous, and the central hollow of the stem occupies about one third of its diameter.

In what may be considered the normal plant, the stem is erect and bears about twenty whorls of slender branches, a whorl at each joint of the stem. Each whorl consists of a dozen or more simple, three-angled, ascending branches six inches or more long, making a bushy frond in which it is not difficult to fancy a likeness to the tail of a horse. Doubtless it was the appearance of this species that earned the common name for the

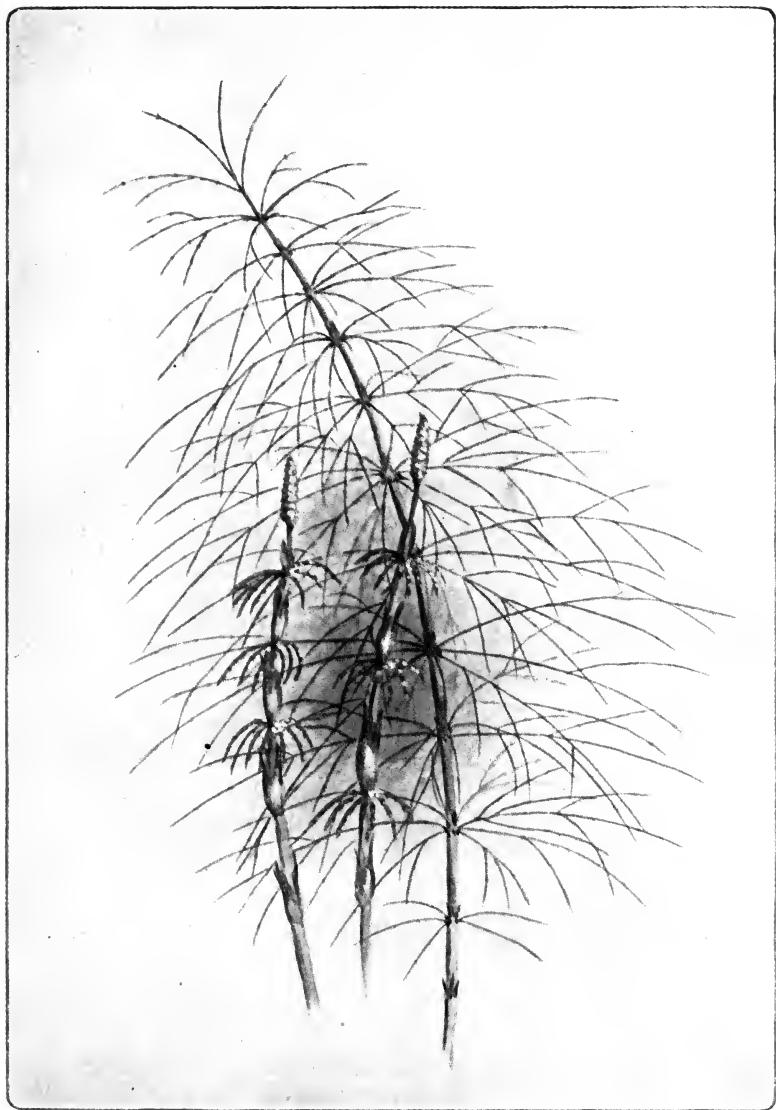
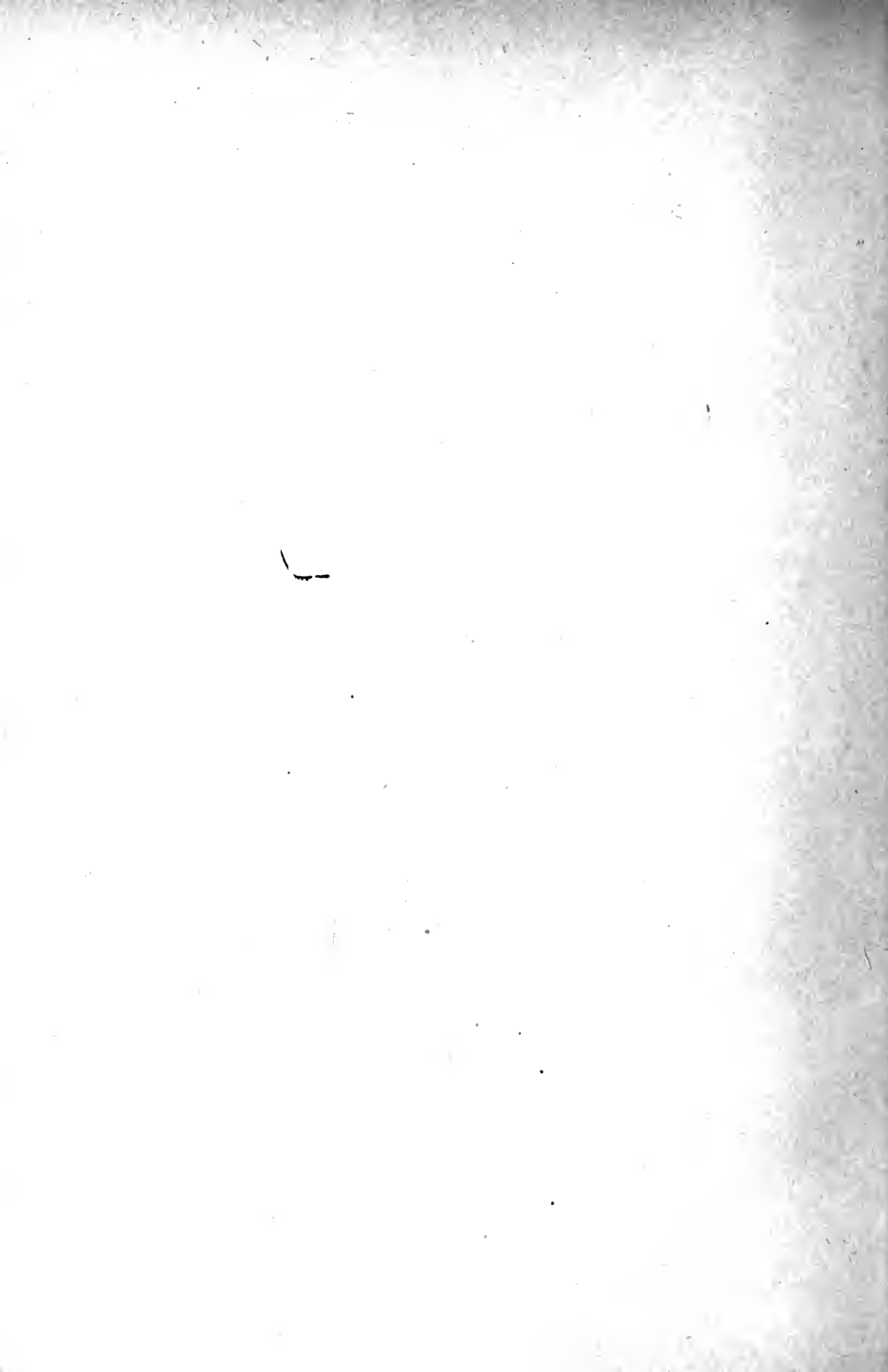


PLATE II. WOOD HORSETAIL. *Equisetum silvaticum*.

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group. The branches, as in the evergreen species, are produced from buds in the axils of the leaves in the sheath, and these, as they develop, burst through the base of the sheath instead of growing up out of it. The branches are, of course, jointed like the stems, with sheaths at the joints, and at their junction with the main stem each is surrounded with a dark-coloured sheath of its own which gives an additional girdle of colour to the joints of the main stem. In the ordinary plant a few of the lower nodes do not produce branches, while toward the tip the whorls of branches are successively shorter, forming a blunt-ended frond above which the stem continues for a short distance as a slender prolongation.

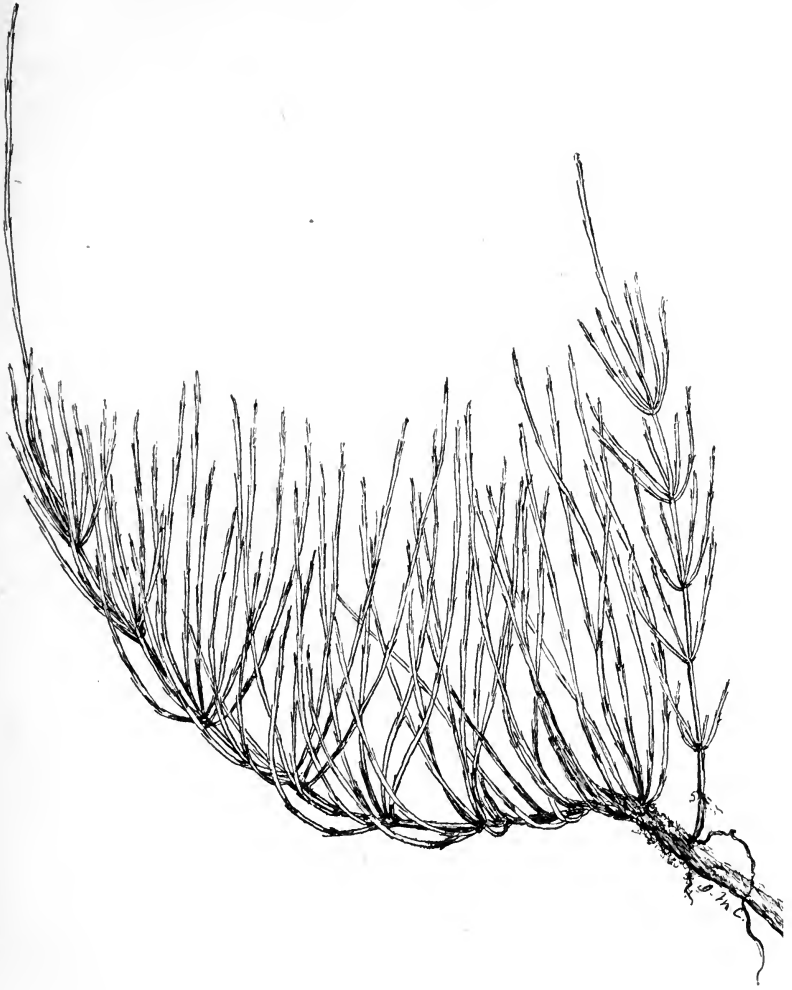
As might be expected of a plant growing under such diverse conditions of light, warmth, and moisture, there is great variation in the form of the sterile frond. Mr. A. A. Eaton has recorded no less than nine named forms in the *Fern Bulletin*. None of these seem fixed, and it is likely that all can be changed to the normal form by a change in the soil or surroundings. The erect form which we have taken as typical is mainly found in moist, rich, light soil in half shade. The next most noticeable form is named *decumbens*, and is characterized by the main stem spreading along the ground with only the tip erect. The short branches, however, are all erect, and this makes a peculiar one-sided form easy to recognize. It is common in exposed sterile soil and is usually to be found on railway embankments. In the form called *diffusum* there appears to be no central stem, the branches arising from the summit of the rootstock and spreading flat on the earth. This is often found along roadsides, and in other places, in the company of *decumbens*. *Pseudosylvaticum* is a form in which the branches

branch again, as they do in the wood horsetail. In these forms the branches have no central hollow, and many of them are more than three-angled.

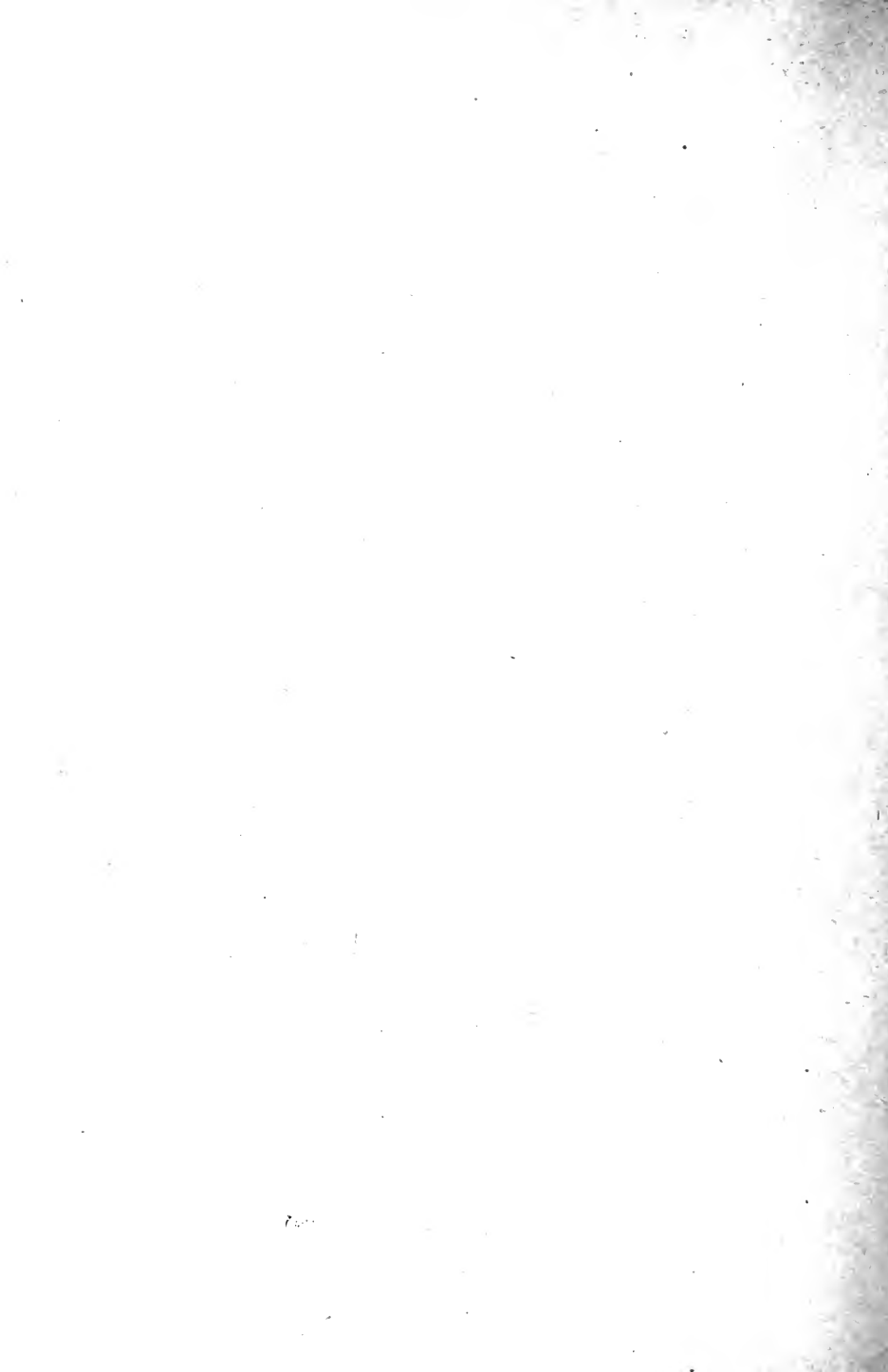
The fertile fronds seem little inclined to change with the changes of the sterile one. Occasionally, however, small catkins appear on the tips of sterile stems in early summer, forming the variety *campestre*. This is supposed to be due to a late spring frost cutting down the regular fertile fronds, and thus throwing a fruiting tendency into the sterile stems.

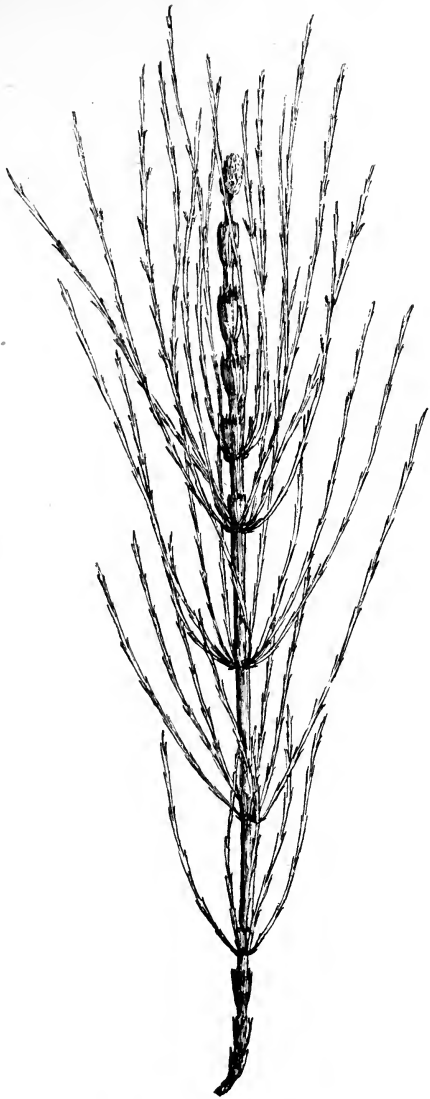
The main rootstock of this species is perennial, branching, and creeps extensively a foot or more below the surface of the earth. At short intervals secondary rootstocks are given off, and these go directly to the surface, there giving rise to both fertile and sterile fronds. The rootstocks are in all respects like the stems except that they lack the central hollow. The internodes of the secondary rootstocks are often heavily clothed with short, tawny felt, and at the nodes, as in the main rootstock, the usual sheaths occur. From the base of the buds in the axils of these sheaths the roots are produced. When the buds develop they produce rootstocks, though if exposed to the air they may take on the form and function of stems. They often remain dormant for an indefinite period, but will grow at once if needed in the economy of the plant.

The secondary rootstocks often bear at the nodes small rounded tubers as large as peas. These have the same structure as the rootstock, and are probably in the nature of arrested branches. More than a dozen of these tubers have been found on a twelve-inch section of secondary rootstock. It has been conjectured that these tubers act as storehouses of food upon which the plant can draw when the fronds are developing.

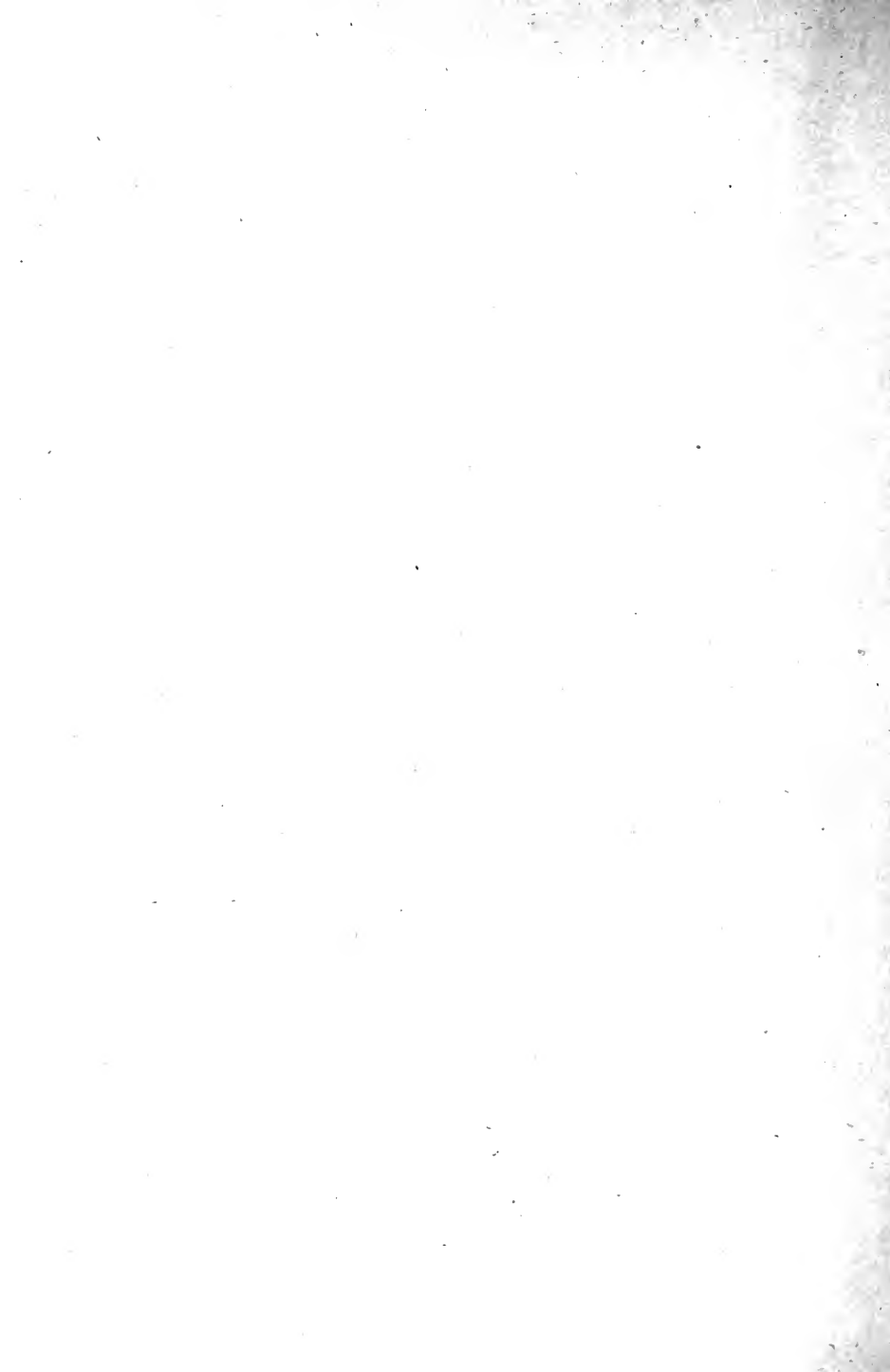


Equisetum arvense decumbens.



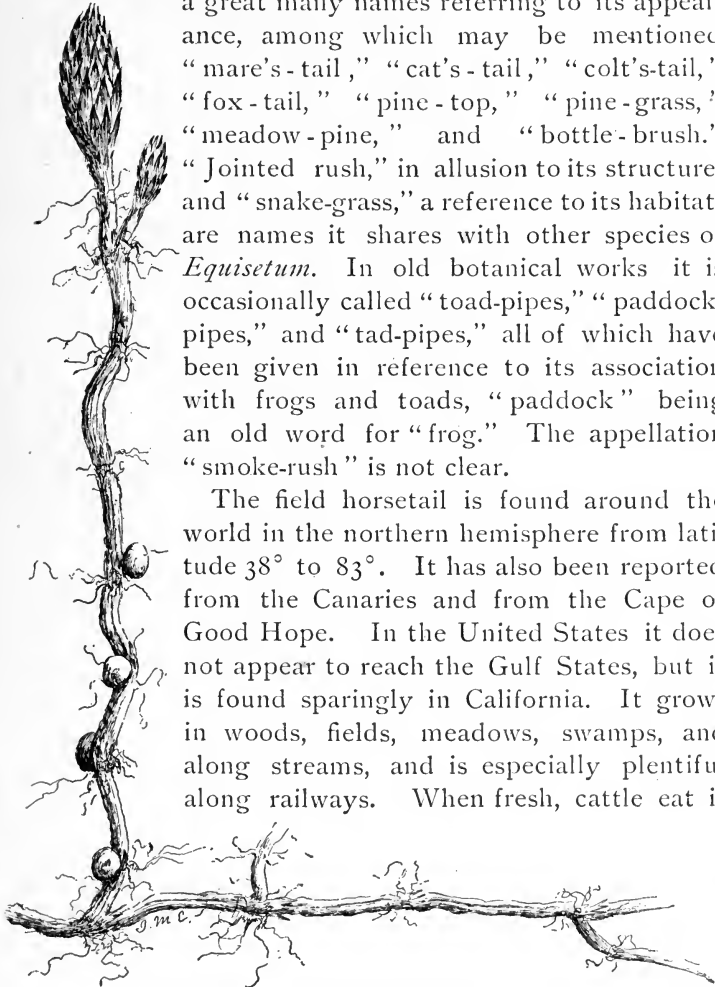


Equisetum arvense campestre.



In Great Britain this species is called "corn horsetail," on account of its abundance in grain fields. It has also a great many names referring to its appearance, among which may be mentioned "mare's-tail," "cat's-tail," "colt's-tail," "fox-tail," "pine-top," "pine-grass," "meadow-pine," and "bottle-brush." "Jointed rush," in allusion to its structure, and "snake-grass," a reference to its habitat, are names it shares with other species of *Equisetum*. In old botanical works it is occasionally called "toad-pipes," "paddock-pipes," and "tad-pipes," all of which have been given in reference to its association with frogs and toads, "paddock" being an old word for "frog." The appellation "smoke-rush" is not clear.

The field horsetail is found around the world in the northern hemisphere from latitude 38° to 83° . It has also been reported from the Canaries and from the Cape of Good Hope. In the United States it does not appear to reach the Gulf States, but it is found sparingly in California. It grows in woods, fields, meadows, swamps, and along streams, and is especially plentiful along railways. When fresh, cattle eat it



BUDS AND TUBERS OF FIELD HORSETAIL.

with impunity, though when cut with the hay it has been found to be quite poisonous to horses. At the first hard frost in autumn, the stems in exposed places perish, but where protected by vegetation they may exist for some time longer.

This species is so widely distributed that the cultivator of the fern allies seldom has to transplant it to his grounds; but if it be desired to make it grow, nothing is easier. A bit of the root-stock, planted almost anywhere, will soon produce one of its characteristic thickets. Once started, it is most tenacious of life, and if buried six feet or more in loose soil will ultimately come to the surface again.

The Ivory Horsetail.

It is a curious coincidence that the commonest species in both groups of *Equisetum* should each be related to a second species that very much resembles it except in size. The great scouring-rush is so near like the common one that it may be doubted whether the two are not forms of a single species; but in the case of the field horsetail and its gigantic counterpart no such uncertainty exists. The difference in size alone would almost be sufficient to distinguish them, for the sterile fronds of this giant species, the ivory horsetail (*Equisetum telmateia*), often reach a height of ten feet. Otherwise the two have many points of general resemblance, though none are sufficiently close to cause confusion in identifying them. Both are among the earliest of spring plants and are able to grow in a variety of situations, and the fertile fronds are sharply differentiated from the sterile, dying soon after the spores are shed. In view of these



IVORY HORSETAIL. *Equisetum telmateia*.
Fertile frond.



resemblances it is curious that the range of *Equisetum telmateia* in America should be restricted to a narrow strip of country on the Pacific coast, while *Equisetum arvense* is spread over nearly the whole continent. The two may thus sometimes grow in the same locality, but no intergrading forms have been found. When they grow in company, *Equisetum arvense* appears to be a week or more earlier than *Equisetum telmateia*. The time at which the fertile spikes appear depends somewhat on the locality. In California, according to Campbell, growth continues all winter, and the fertile fronds, developing gradually, spring up and spread their spores whenever they are ripe.

In British Columbia the fertile spikes are produced during the first warm days of spring, which occur about the middle of April. In a short time they have reached a height of from ten inches to two feet, with a diameter of an inch or more. The stems are therefore the heaviest of any species in the North Temperate Zone. They are reddish brown, contain thirty or more shallow grooves, and at the joints are encircled by the large, loose, light-brown sheaths, which, including the long, slender teeth, are nearly two inches in length. The catkins are two or three inches long, and three quarters of an inch thick, and consist of twenty or thirty whorls of sporophylls.

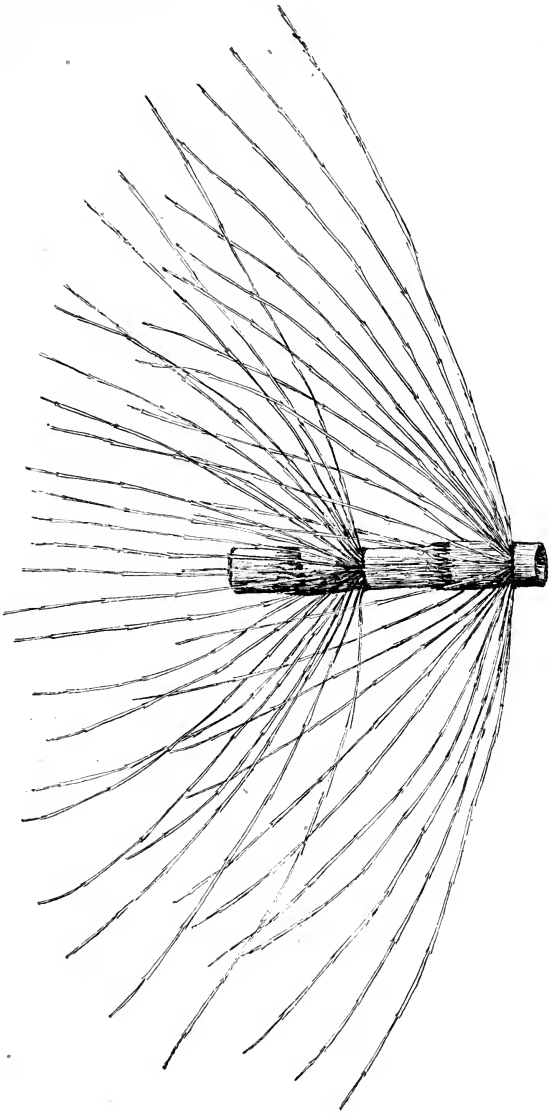
The sterile fronds appear as the spores are being shed. These are ordinarily about three feet high, though in favourable situations they may attain to more than thrice that height, in such cases being half supported by the shrubbery among which they grow. Often they grow in such masses that it is difficult to pass through them. When the stems appear, the branches are short and closely appressed, but later they spread out some-

what, as in the field horsetail. There are sometimes more than twenty whorls of these branches, and from twenty to forty branches in a whorl. Near the tip the whorls are rather close together; below, they are farther apart, and the lower third of the stem is naked. The average length of the branches is nearly six inches, but in some instances they are three times as long. The sterile stems are pure white, and the sheaths which closely invest them are pale green, with brown teeth. The common name of this species was given in allusion to the colour of these stems.

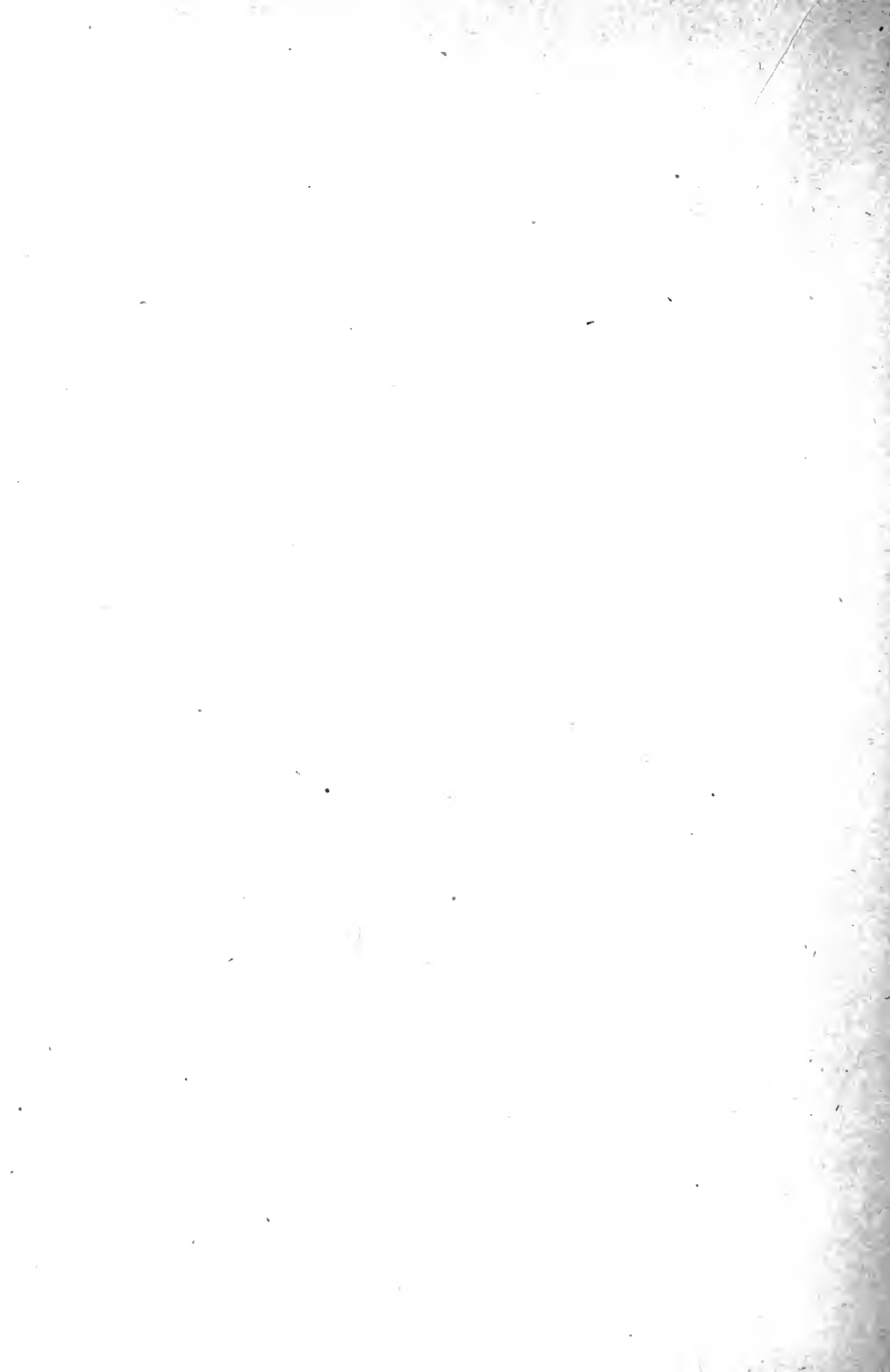
Although the ivory horsetail grows in regions where the earth is not penetrated very deeply by the frost, in the North, at least, its stems are strictly annual. The rootstock is similar to that of *Equisetum arvense*, though larger, and at the nodes it also bears numerous tubers which are as large as marbles. These tubers often occur in necklace-like strings, and show very plainly that they are the swollen internodes of the rhizome.

Like *Equisetum arvense*, this species has numerous varieties, mostly of an ecological nature. Late in the year one may find fruiting-cones on the ordinary green stems. In the case of similar cones on the normally sterile fronds of *Equisetum arvense*, it has been assumed that they have been caused by an injury to the fertile stems; but in Francis's "British Ferns" it is stated that the cones on *Equisetum telmateia* are caused by drought, and that with specimens grown in pots these cones may be produced at will by withholding water at the proper time.

Equisetum telmateia is well distributed in the Old World, being found from Ireland and Scotland to Siberia, Persia, and North Africa. In America it is



IVORY HORSETAIL. *Equisetum telmateia*,
Section of Sterile frond.



found at low altitudes along the coast from southern California to British Columbia and Alaska, being abundant in the central part of its range and the dominant *Equisetum* in British Columbia. According to Mr. A. J. Hill, the Indians are said to eat the fertile spikes. In addition to the usual common names, this plant is sometimes called the "great water horsetail" and the "mud horsetail," neither of which is very appropriate, at least in this country, where the plant grows in any soil, including railway embankments. The spores lose their vitality soon after they are shed, and this may perhaps account for its being less abundant than the field horsetail. The species seems to be rarely cultivated, though it ought to be a most desirable species for decorative planting.

The Shade Horsetail.

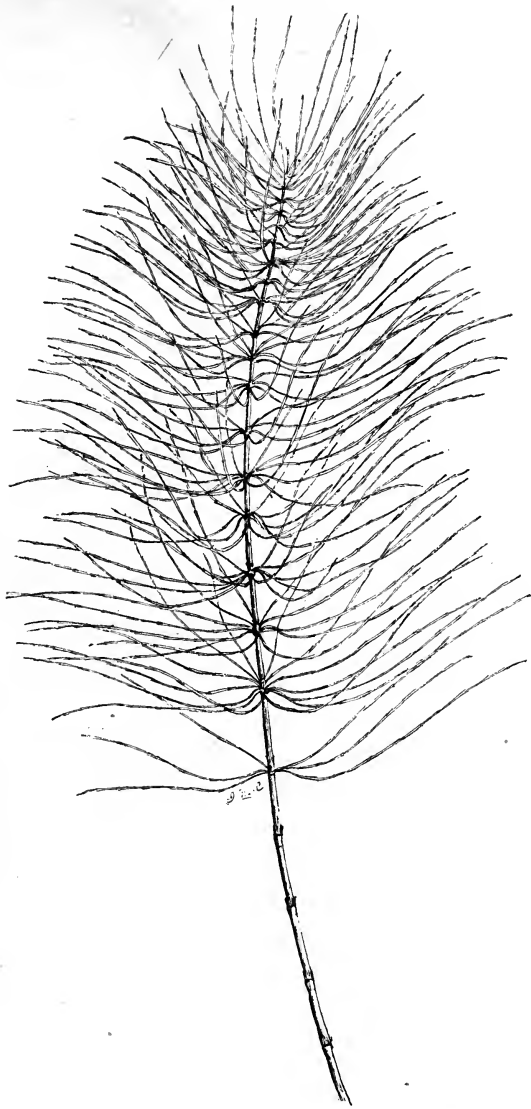
The American collector is likely to see little of the shade horsetail (*Equisetum pratense*), for its centre of distribution is in the far North. Only a few stations for it in the United States are known. It is possible, however, that when students become more familiar with this species it will be found to be more widely distributed. Its rather close resemblance to the field horsetail makes it easily overlooked by the novice.

One of the important features in which this species differs from the field horsetail is found in the fertile shoots, which, after the spores have been shed, put forth whorls of branches from the nodes and thereafter behave in all respects like sterile stems. While this is true of the majority, other stems may be found that die as soon as the spores are shed, and the species is therefore usually described as having three kinds of fronds. The

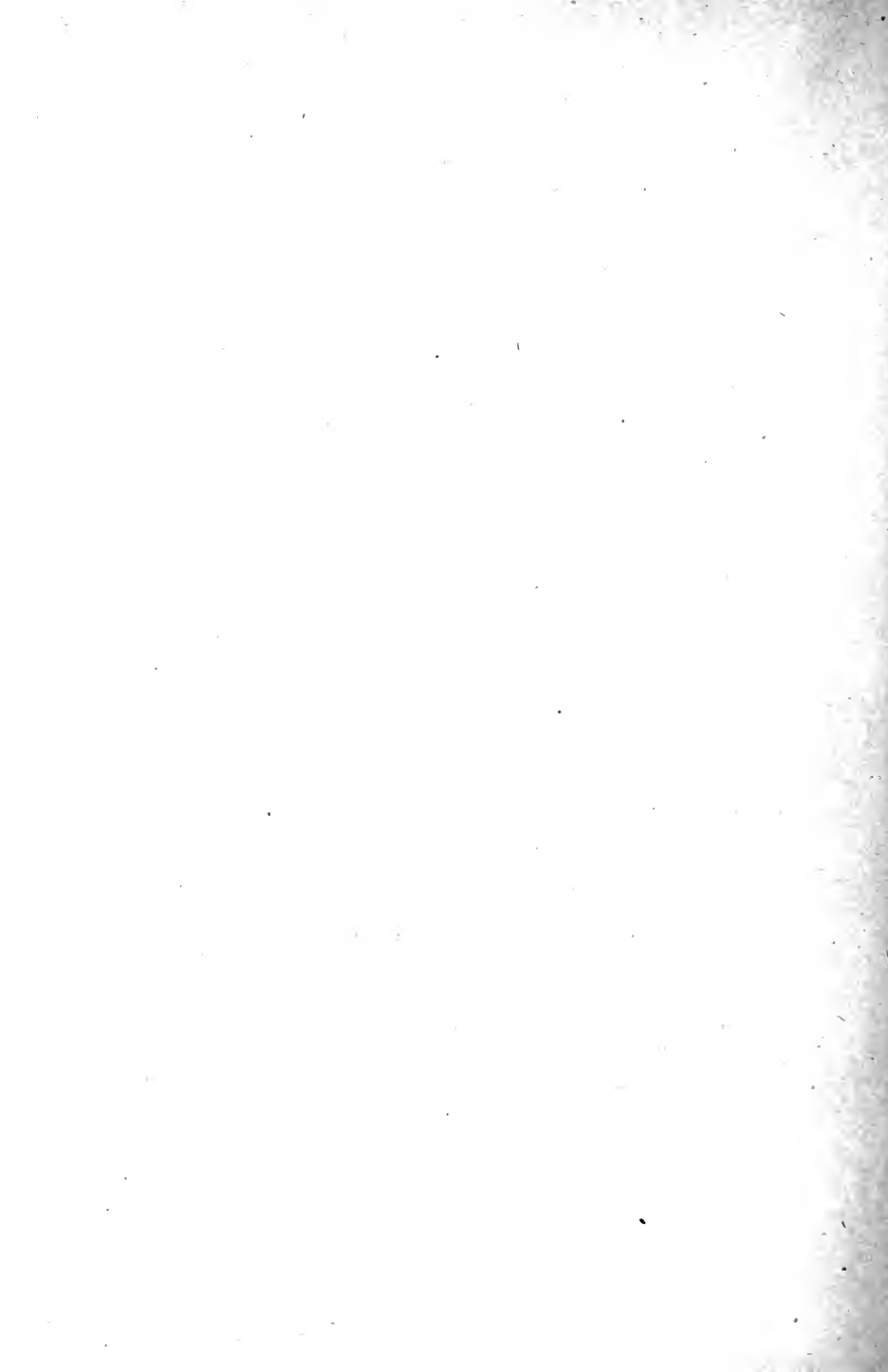
vegetative impulse seems to exist in different proportions in each one, some having so little that they do not survive the spring fruiting. It is interesting to know that the size of the sheaths varies with the kind of stem, being largest in the evanescent fertile stems, of medium size in those fruiting stems that later bear branches, and smallest in the wholly sterile ones. Before the fertile stems have produced branches, they are much like the fertile stems of the field horsetail, except that they are usually shorter, slenderer, paler in colour, and with less flaring sheaths. They have been described as sea green with pale sheaths tipped with long, pointed, white-margined brown teeth. The catkins are about cylindrical, an inch long, and a quarter as wide, and perish as soon as the spores are shed.

The sterile stems are erect, fifteen inches to two feet in height and very slender. They are white or pale green in colour and contain from eight to twenty grooves. Below, the stems are smooth, but toward the apex the ridges are thickly set with tooth-like projections of silex which are frequently large enough to be seen with the unaided eye. The sheaths closely encircle the stem, and are pale green, tipped with white-margined brown teeth similar to those of the fertile stems. In the upper two thirds of the frond, each node gives rise to a whorl of simple, jointed, three or more-angled branches. These are peculiar for having the joint nearest the stem short and bent sharply downward, while the rest of the branch is spreading or ascending. This character is one that the eye readily appreciates.

The shade horsetail is found in the North Temperate and Arctic Zones of both hemispheres. According to A. A. Eaton it ranges southward to New Jersey, Michigan,



SHADE HORSETAIL. *Equisetum pratense*.
Sterile frond.





SHADE HORSETAIL. *Equisetum pratense*.
Fertile frond.

Minnesota, and along the Rocky Mountains to Colorado. It has also been reported from Iowa. In Minnesota it is said to be common, but elsewhere in the United States it is very rare. From Alaska to the Hudson Bay region it appears to be plentiful. It is more abundant in the Old World than with us, growing in cultivated fields as well as in waste places, often so plentifully as to be considered a troublesome weed. Eaton observes that it must be common in the rye fields of Germany, since it is nearly always present in the straw in which German glass is packed for export.

In appearance and habitat this species stands so nearly midway between the field horsetail and the wood horsetail that the beginner might fancy it a hybrid between them, but students of the equisetums do not hold this view. The three forms of fronds, however, are of interest in showing in a single species the relationship between fertile and sterile shoots.

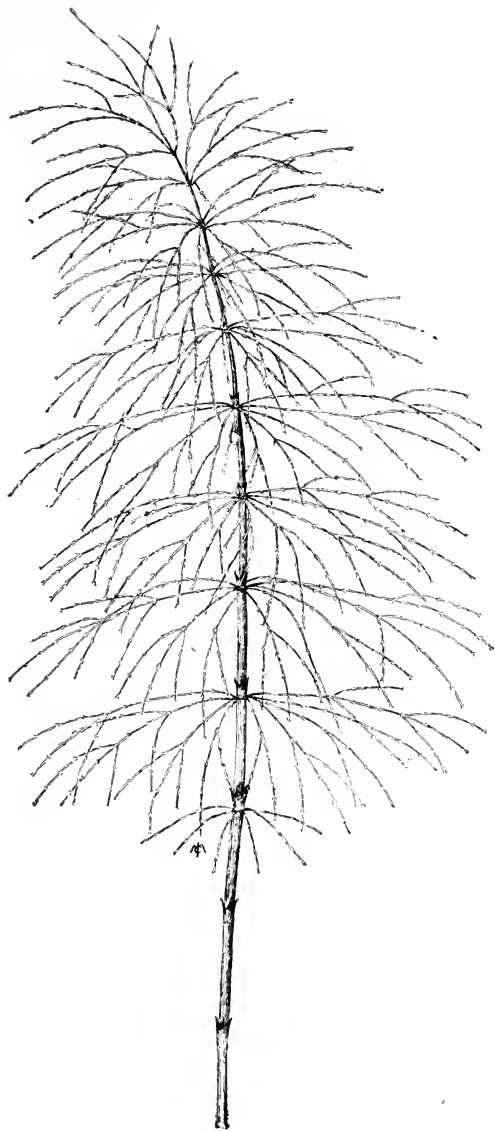
The Wood Horsetail.

In his book, "The Fern Garden," Shirley Hibbard characterizes the wood horsetail (*Equisetum silvaticum*) as "the most elegant of all the plants upon the face of the earth." This may seem like extravagant praise to those who have never chanced upon its graceful green spires reared in the shadows of some moist woodland; but to those who have, it will probably seem not much overdrawn. If not ready to admit its claim to be the most elegant of plants, they will scarcely deny that it is the handsomest of the equisetums and fully the equal of any other plant whose beauty depends entirely upon the outline and cutting of leaf and stem.

As in all species of *Equisetum* in which there is a marked difference between fertile and sterile fronds, the fertile are first to push up, appearing shortly after those of the field horsetail and in their early stages scarcely to be distinguished from them. There is, however, from the beginning, a greenish tinge to the stems, presaging their subsequent vegetative functions, while the sheaths, rather longer for their width than in *Equisetum arvense*, are tipped with long teeth of bright reddish brown. At first the sheaths are dilated upward, but they soon change to urn-shape on account of the swelling buds within. The fruiting cone is about an inch long and one third as wide. It is of the same general colour as the stem, and consists of the usual number of sporophylls borne above the topmost sheath on a pedicel two or three inches long.

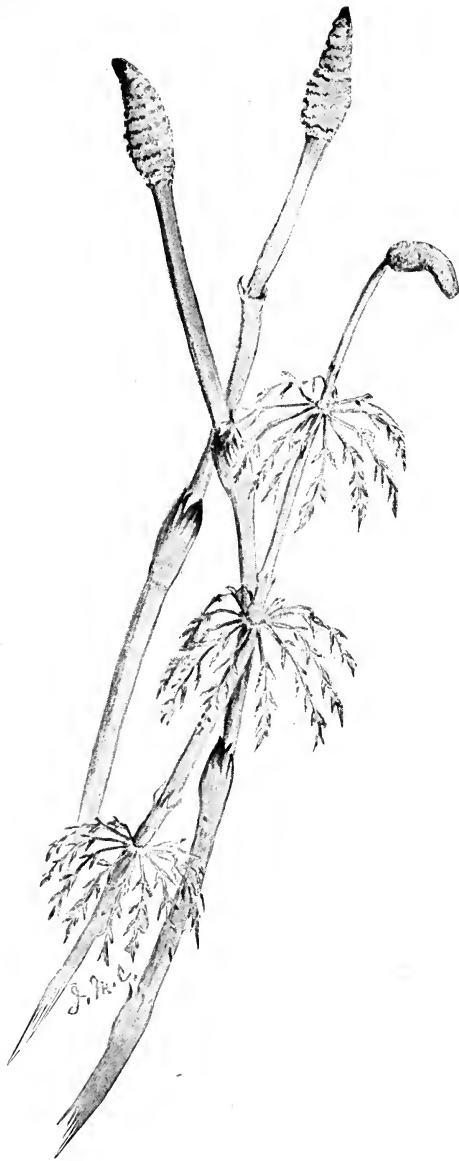
Before the spores are ripe, whorls of branches have begun to develop from the upper joints. Sometimes even the lowest whorl of sporophylls push out a few short branches. The fruiting parts usually wither as soon as the spores are shed, while the rest of the stem continues to develop branches and soon is hard to distinguish from the wholly sterile fronds, except that the sheaths are somewhat larger and the apex of the stem not so slender and tapering.

The sterile fronds closely follow the fertile, and when fully developed may reach a height of three feet. The stem is slender and has twelve to eighteen grooves, the ridges between being rough with small particles of silex, but never rough enough to be noticeable. The lower nodes do not produce branches, but above there is a whorl of branches at each node, the lowermost reaching a length of three to six inches, and the others gradually decreas-

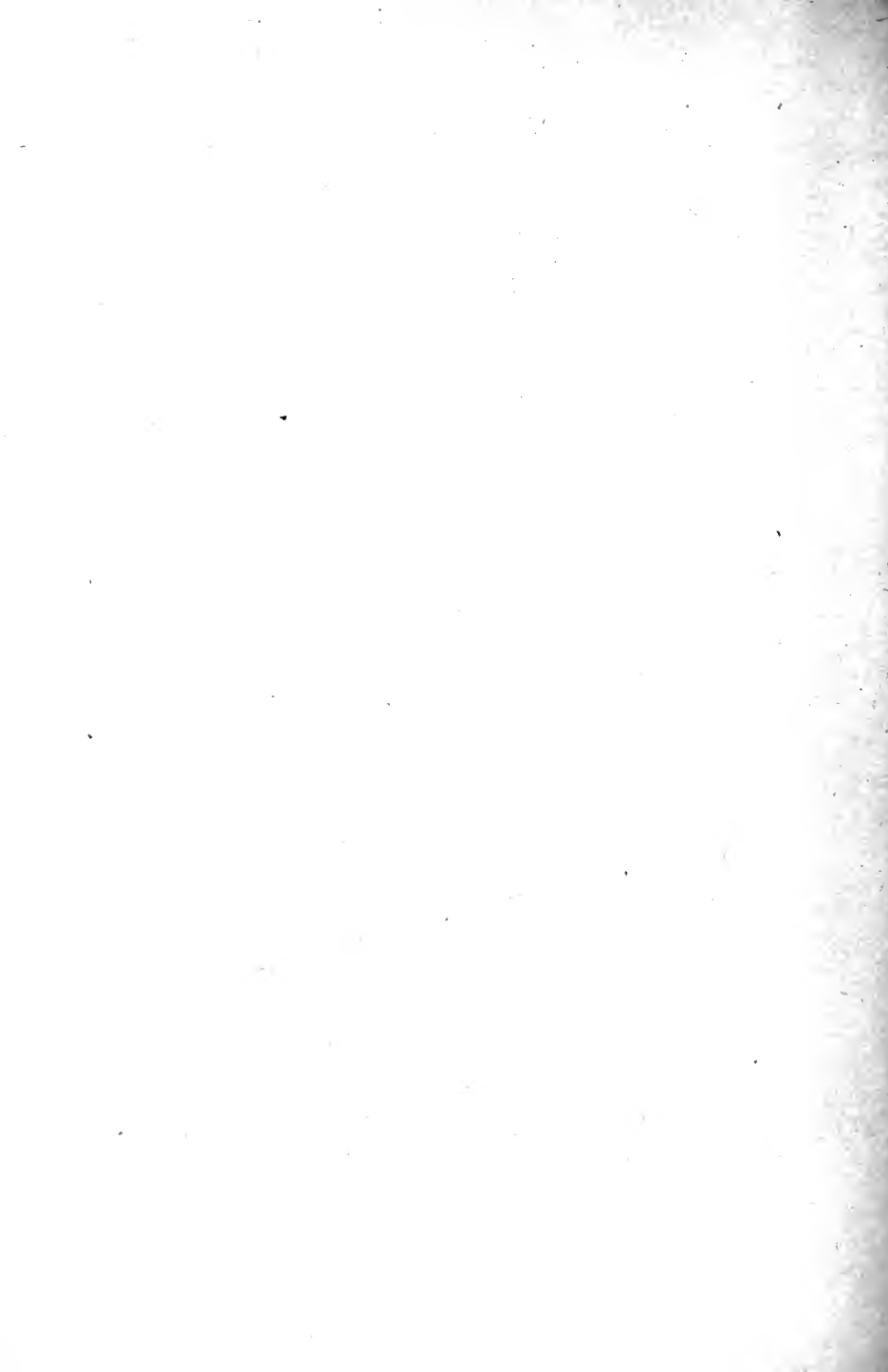


WOOD HORSETAIL. *Equisetum silvaticum*,
Sterile frond.





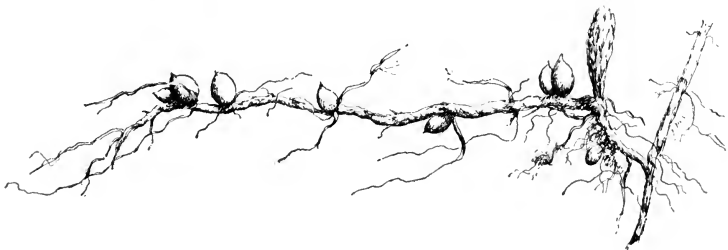
WOOD HORSETAIL. *Equisetum silvaticum*.
Fertile fronds.



ing in length to the apex of the frond. Occasionally, however, the branches at the apex are nearly as long as those below. The branches of each whorl spread out nearly horizontally, and each is again branched, the longest branchlets being nearest the stem. The effect produced is that of a series of circular green platforms diminishing in size upward, with the main stem as a central column. The fine and slender branchlets with drooping tips make the whole frond exceedingly delicate and graceful. This is the only species in the world in which the branches are again regularly branched. In some cases the secondary branches are also branched.

The rootstock of the wood horsetail is slenderer than that of *Equisetum arvense*; otherwise it much resembles it. The sheaths of the secondary rootstocks, however, are better developed, though the buds from which the fertile spikes are produced are smaller. The secondary rootstocks also bear tubers, though not so abundantly as does *Equisetum arvense* or *Equisetum telmateia*. These tubers are usually much larger than those of *Equisetum arvense* and are ovate instead of spherical.

The wood horsetail is found in America from Virginia, Michigan, Iowa, and Nebraska to the Arctic



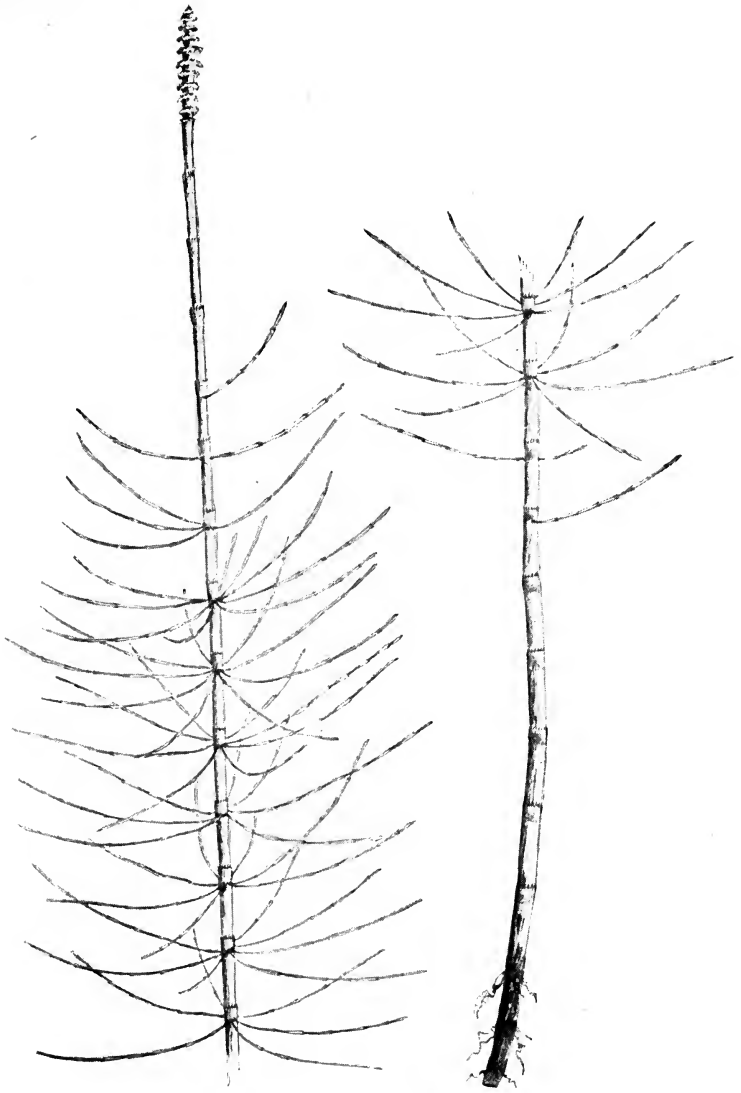
WOOD HORSETAIL BUDS AND TUBERS.

Circle, but apparently does not occur in the United States west of the Rocky Mountains. It is also found in the northern parts of both Europe and Asia. It delights in rich moist soil, its favourite haunts being deep woodlands and the banks of shaded streams. It is rarely if ever found in fields, though it may persist in pastures and swamps for some time after the sheltering trees have been removed. Like the field horsetail, it is sometimes called "bottle-brush" in allusion to its fronds. It has the reputation of fruiting sparingly, and the fruiting-spikes are certainly not so abundant as those of other species when the plant grows in deep shade, though in exposed positions they may always be found in season. Plants that extend their bounds by rootstocks or bulbs usually produce few seeds or spores, and our plant seems to be no exception to the rule. According to Withering, horses are fond of this species, and in the north of Europe it is said to be sometimes preserved for winter fodder.

The wood horsetail readily adapts itself to a life in the fern garden if given a fat soil and plenty of shade and moisture. It spreads nearly as rapidly as the field horsetail and presents a far more attractive appearance. It may also be grown in the greenhouse. In such situations the rootstocks, being prevented from following their inclination to spread about, send up great numbers of the graceful, emerald-green fronds that are the delight of all who see them.

The Water Horsetail.

Of all our American equisetums the water horsetail (*Equisetum fluviatile*) is undoubtedly first to start into growth each spring, but, owing to the length of stem it



WATER HORSETAIL. *Equisetum fluviatile.*



produces before fruiting, it does not put forth its catkins until several other species have shed their spores. As its name implies, this species is usually found in several inches of water, and the rootstock, lying in the unfrozen mud, early feels the vernal impulse and starts the young stems upward soon after the ice has disappeared and while yet the meadow grasses are brown and sere. These developing stems are most striking objects, being ringed at close intervals with many circles of the black saw-like teeth of the sheaths. Sometimes as many as thirty circles of teeth may be found on the stem before it has pushed above the surface of the water. Growth, as in the other species, is principally a matter of lengthening internodes.

About the last week in May, in the southern part of its range, the stems that are to produce the spores develop a fruiting-catkin an inch or more in length and a third as thick. Fertile fronds are ordinarily not abundant, but it is said that a period of drouth will greatly increase their numbers. As soon as the spores are shed, this catkin withers, but from the sheaths of the stem that bears it slender branches have been developing, and these, lasting through the season, make the stems look so much like the regularly sterile ones that they cannot be distinguished from them at first glance. Since the production of spores is a heavy draft upon the vigour of the stem, the fertile fronds are usually overtopped by the others, which often reach a height of five feet or more.

There is no uniformity in the manner of branching, as in most other species, but each stem is likely to vary the pattern somewhat. In general, however, the lowest ten or twelve joints are unbranched, then come several

whorls of simple branches which grow successively shorter upward, ceasing entirely six inches or a foot below the apex, which thus extends above the bushy portion as a slender whip-like prolongation. The lowest branches are often a foot or more in length and seem more in the nature of secondary stems. Usually the branches are much shorter and are disposed in regular horizontal whorls, though often, especially toward the apex of the stem, the symmetry of the whorls is destroyed by the failure of certain branches to develop. It is not uncommon, also, for both fertile and sterile stems to be entirely without branches, in which event they might be mistaken for forms of the common scouring-rush. In branched forms the lowest branches may occasionally put forth a few branchlets, but usually the branches are simple.

The stems of this species are smooth and contain from ten to thirty shallow grooves which are not very prominent in the living plant, but become more marked in the dried specimens. The sheaths are like the stem in colour, about as broad as long, and closely appressed to it. The teeth, separated from one another by rounded sinuses, are short, sharp, and nearly black in colour. According to A. A. Eaton, the number of grooves in the stem and the number of leaves in the sheath increase upward, so that the upper joints often contain a third more than those below. The stem is hollow for about four fifths of its diameter, none of our other species equalling it in this respect. The carinal canals are apparently always present, but the vallicular are often wanting in growing stems, though very prominent in older ones. The rootstock, which is about as thick as the stem, is also hollow. It is usually not very deep in

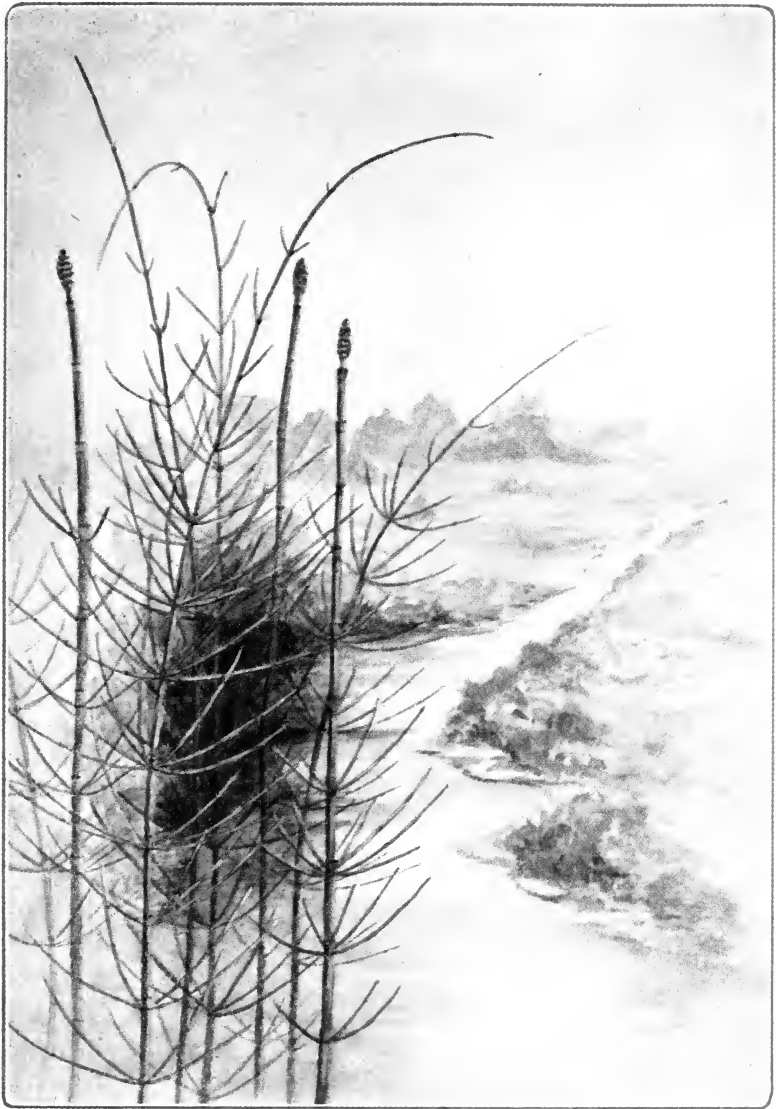
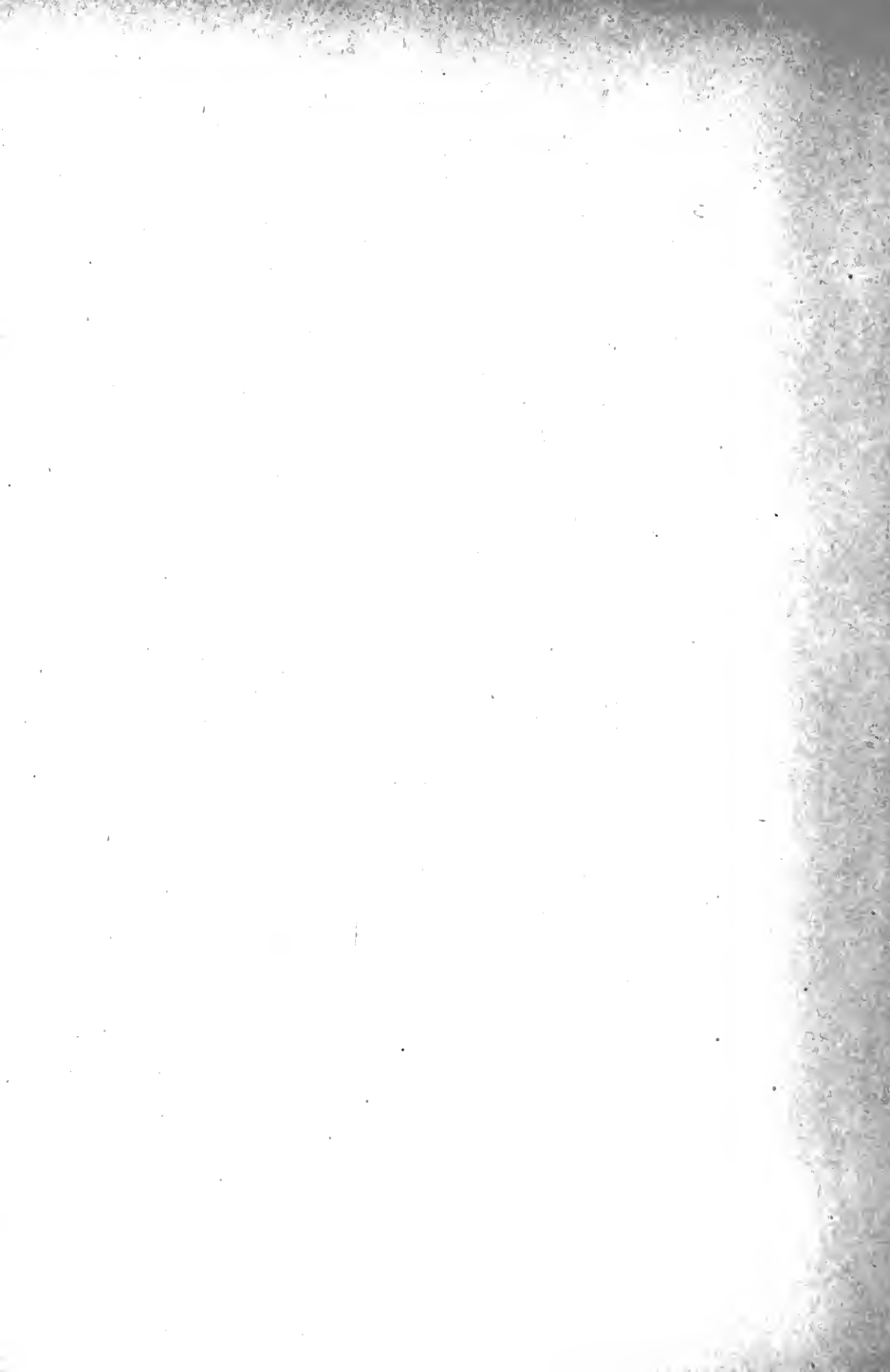
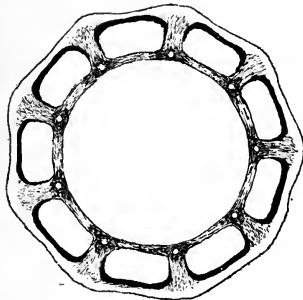


PLATE III. WATER HORSETAIL. *Equisetum fluviatile*.

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the soil, perhaps because the overlying water makes it unnecessary by keeping out the frost. As the aërial stems rise through the mud, they send out roots from the basal joints, and it is probable that if the entire stem was buried in the mud it would promptly take up the offices of a rootstock. Branches of the rootstock sometimes produce tubers which are described as "about the size of a nutmeg, but shaped like a fig." Half a dozen have been found on a single branch.



SECTION OF STEM.

Half a dozen have been found on a single branch.

This species has very little silica in its outer coat and is one of the smoothest of the equisetums. It is readily eaten by cattle, and is said to be fed to cows in Sweden to increase the flow of milk. In Lapland, reindeer eat it even when dried, though they will not touch hay, and Linnæus recommended that it be gathered and preserved with reindeer-moss for winter use. When abundant it is occasionally cut for hay in America. According to Haller, the Romans were accustomed to eat it. Muskrats are very fond of the young stems and often work much havoc among them just as they are pushing up to the surface of the water.

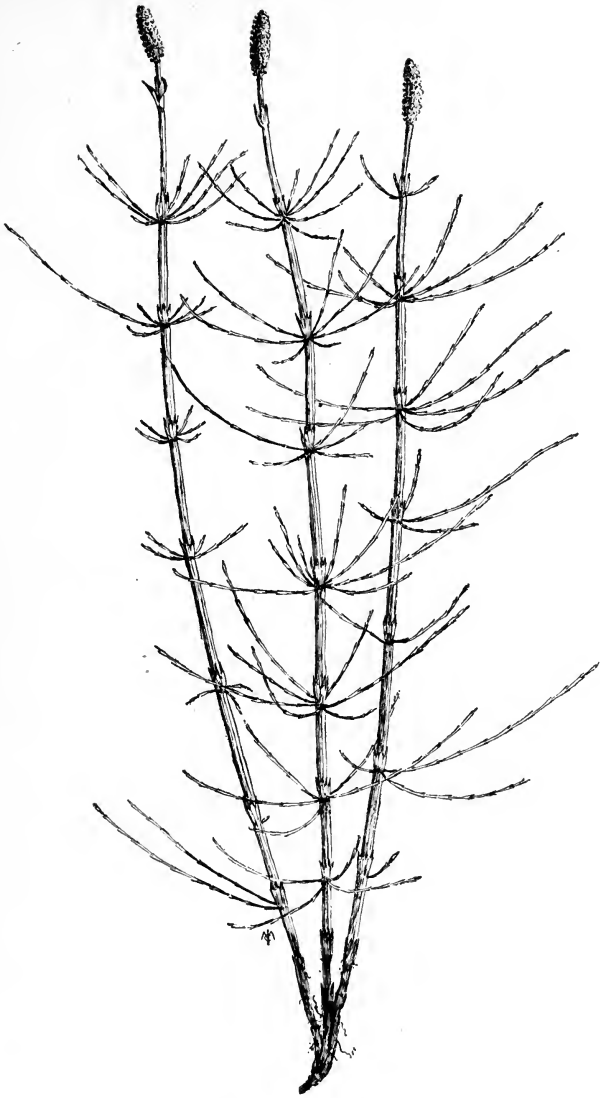
The water horsetail extends from Virginia, Kansas, and Washington to the far North, being not uncommon in the northern United States, though not always present in what appear to be favourable locations for it. While it prefers to grow in several inches of water and is commonly found in the quiet reaches of shallow, slow-moving streams or on the margins of lakes and ponds, it

is often found in mud or moist sand and gravel at mid-summer, owing to the lessening of the water by drouth. Along certain rivers it forms a continuous border for miles, almost to the complete exclusion of other plants. It occurs also in northern Europe and Asia, belting the earth in a zone nearly a thousand miles wide. It is a polymorphic species and in some of its disguises is hard to identify. Its irregular branching and appressed sheaths are most characteristic features. It is so much like the marsh horsetail and the shore horsetail in appearance that the novice may have trouble in distinguishing between them, but since this is the only one of the trio that is abundant it is safe to give it the benefit of any doubt that may arise.

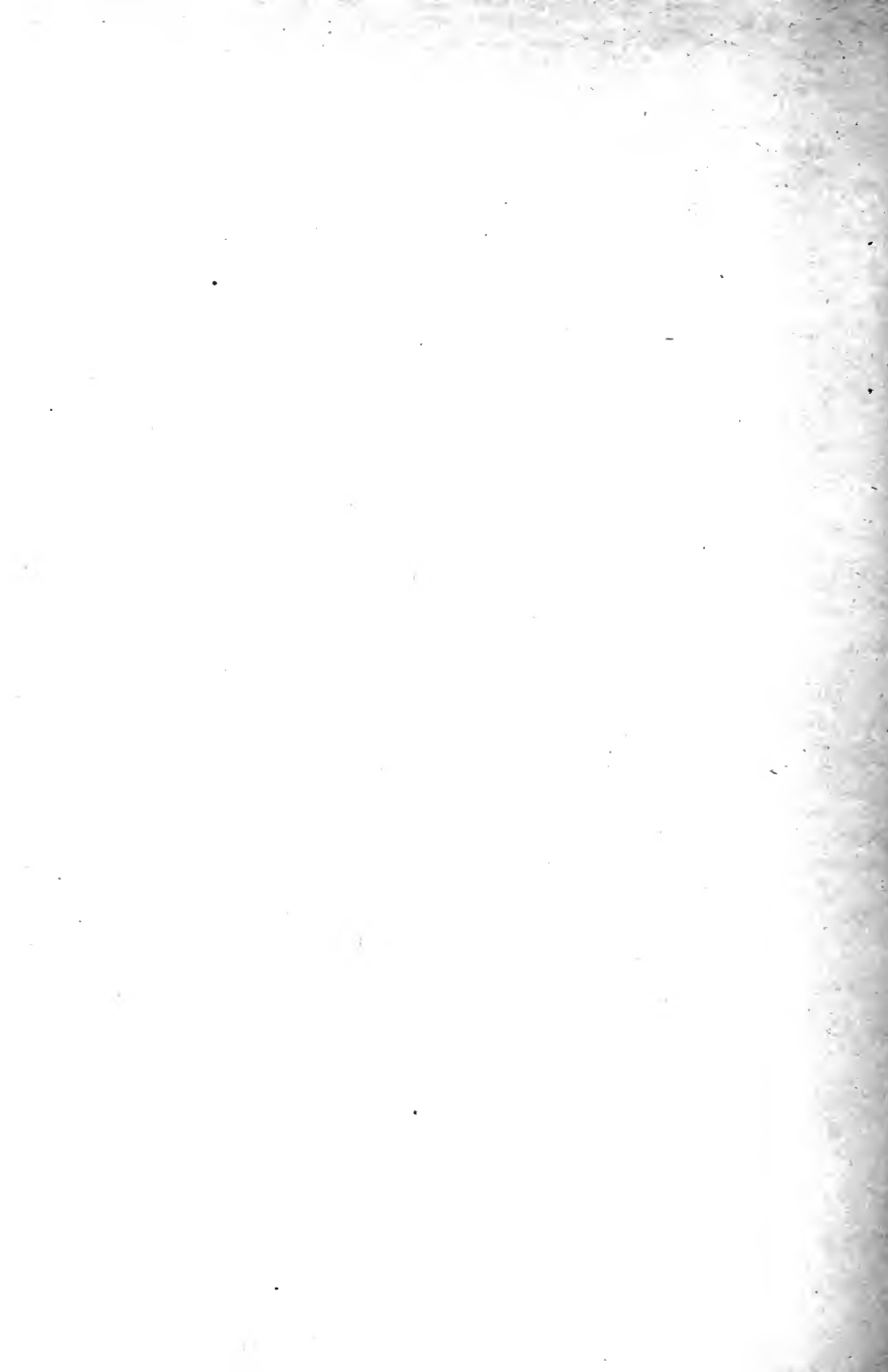
In many books the species is called *Equisetum limosum*, but *fluviatile* is the older name. This difference in age, however, well illustrates the small differences that govern the work of botanists. The name *fluviatile* stands just before *limosum* in "Species Plantarum" and is, therefore, older by the mere length of time it takes for the printer to set a line of type; and yet this is held sufficient to make the one for ever right and the other for ever wrong. *Limosum* is now used to characterize the nearly unbranched form. Among its common names are "mud horsetail," "joint-grass," and "paddock-pipes." The last name is also given to *Equisetum arvense*, but is more appropriately applied to this species, since it is found in the places beloved of "paddocks," as frogs were commonly called.

The Marsh Horsetail.

At first glance it is possible to mistake the marsh horsetail (*Equisetum palustre*) for the water horsetail,



MARSH HORSETAIL. *Equisetum palustre.*



but the fact that *Equisetum palustre* is rare in the settled parts of America will save the collector from making many mistakes of this kind. Should he by chance collect the rarer species, he will discover, by comparing it with the other, that there are many small though important points of difference. Although the two are so much alike in habitat and structure, the stems of *Equisetum palustre* are more deeply grooved and have a smaller central hollow, the sheaths are dilated upward, and the rootstock is solid, all of which are the exact opposites of the conditions that prevail in the water horsetail.

The marsh horsetail is a smaller species than *Equisetum fluviatile*, seldom reaching a height of two feet, and, though delighting in rich moist soil, is not so frequently found growing in the water. The stem is slender and often branched from the very base, producing regular whorls of short branches. Occasionally the basal branches may be much longer—perhaps two thirds the length of the main stem—and may be borne half erect like secondary stems. Fertile and sterile stems are much alike, except that in the one the main stem is terminated by a catkin, and in the other the apex ends in a slender unbranched tip.

The catkins are unusually large for the size of the plant, being an inch or more long and about a third as wide. They are borne above the last whorl of branches on slender pedicels an inch or more long, and, as is the rule among horsetails, perish as soon as the spores have been dispersed. The species begins to fruit early in summer, and a succession of new stems may often prolong the season into autumn, though the greatest number of catkins will be found early in the year. Sometimes

the long basal branches, or a few of those near the tip, may bear small cones of fruit also.

The sheaths in both fertile and sterile fronds are longer than broad, greenish in colour, with rather loose black teeth bordered with white margins. They invest the stem quite loosely, being dilated upward. The leaves are convex, grooved in the middle at the apex, and strongly keeled below.

The stems have from five to twelve broad, deep grooves, the ridges separating them being narrower, sharply elevated, and rounded on the back. These grooves are fewer in number than in *Equisetum fluviatile* and in fresh specimens are much more prominent. When dried for the herbarium the difference is not so marked. The branches usually contain fewer angles than the stem, and their sheaths are also green and dilated. The central cavity of the stem occupies about one sixth of the diameter, a character which alone is sufficient to distinguish it from *Equisetum fluviatile*. Carinal and vallecular canals are also present. Although so much like the water horsetail, it occasionally produces forms that are very much like varieties of *Equisetum arvense*, and the likeness is heightened by the similarity of the internal structure of the stem.

The marsh horsetail has been reported from all the New England States except Rhode Island, and from Illinois and Washington. In none of these States is it abundant or extensively distributed, and in many the record rests upon a single locality. It is more plentiful in British America, extending to Alaska and Hudson Bay. It grows among grasses in damp meadows, in moist woodlands, and in open swamps. Dr. C. B. Graves has found it in Connecticut in meadows sub-



A Form of *Equisetum littorale*.

ject to frequent overflow. It occasionally forms thickets, as the other species do, but appears not to be as gregarious as some. In the colder parts of the Old World the plant is more plentiful, but becomes rare in southern Europe. Mr. A. A. Eaton notes in the *Fern Bulletin* that the Indians of Alaska make baskets of the rootstocks of some species of *Equisetum* and concludes that this is the one used.

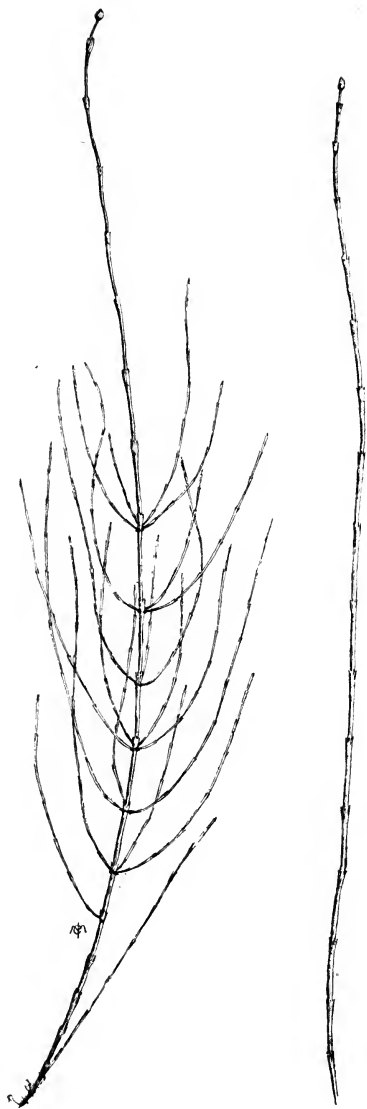
The Shore Horsetail.

Many botanists are inclined to question the right of the shore horsetail (*Equisetum littorale*) to be called a distinct species. It presents a most perplexing series of forms and appears never to be twice alike. Now it is tall and abundantly branched, like *Equisetum fluviatile*; again it may be prostrate or decumbent, like forms of *Equisetum arvense*; and at other times may simulate *Equisetum silvaticum* or *Equisetum palustre*. The sheaths may be appressed or dilated, the central cavity may occupy one-half or two-thirds the diameter of the stem, and the stem itself may be either branched or simple. Still more remarkable, the spores are abortive and have no elaters, this being the only form of *Equisetum* having this latter characteristic. All these differences seem best explained by the theory that the forms given the name of *Equisetum littorale* are really hybrids between some other species, and while the author accepts this theory the form is here treated as a species in order not to confuse the novice, who will find it listed as a species in all other American works.

Since the varieties of the shore horsetail most often resemble specimens of *Equisetum fluviatile* and *Equise-*

tum arvense, it has been conjectured that these species are its parents. In both structure and habit it is about halfway between the two, and in some localities a series of intergrading forms could be selected, leading almost imperceptibly from one to the other. The strongest point made against the theory of the hybridizing of these two species is the fact that they do not fruit at the same time, but in reality this may be indirect evidence in its favour. *Equisetum* prothallia may live for some months if unfertilized, giving ample opportunity for crossing between species that do not fruit at the same time, while the infrequency of such an occurrence would account for the rarity of the hybrid form. Since in all the *Equiseta* the sexes are on separate prothalli, it would be a much easier matter to prove or disprove this theory than it would be in the case of ferns where both sexes are on the same prothallium.

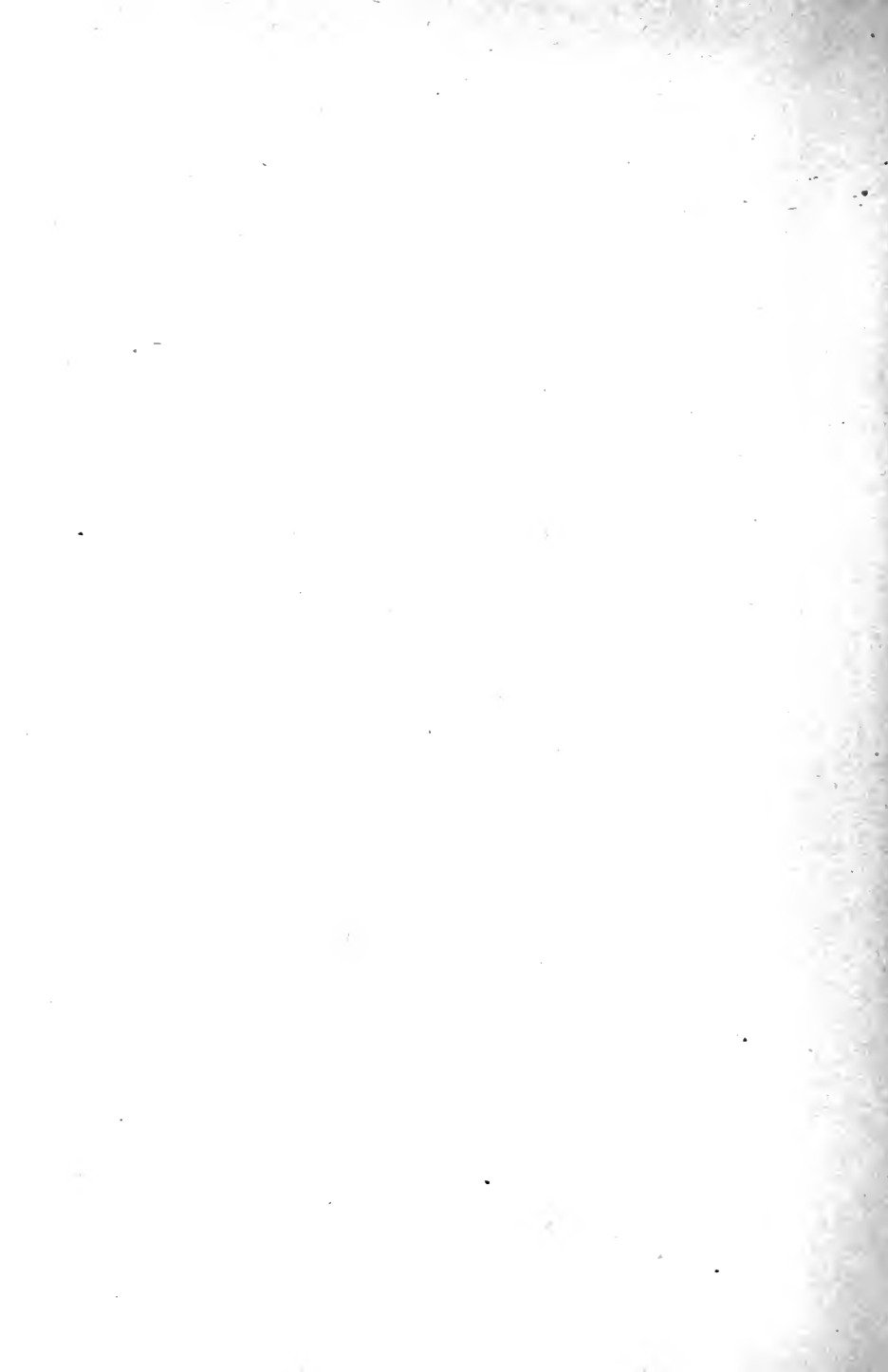
As commonly described, *Equisetum littorale* is three feet or less in height, usually erect, with slender stems containing from six to twenty grooves. In some specimens the stems are unbranched, in others branched only in the lower part, and in still others branches occur nearly to the top. In all, the upper nodes are prolonged into a whip-like tip which in fruiting specimens bears a small fruit-cone. Usually the stems with cones are not branched as much as the others. At the base of the stem the sheaths are dark in colour; above, they are green with short, narrow, dark-coloured teeth bordered with white. The sheaths may be appressed near the base of the stem, but beyond they usually widen out. The catkins are borne on very slender pedicels and often do not become much larger than pepper-corns, though occasionally they may attain a length of half an inch.



FORMS OF SHORE HORSETAIL. *Equisetum littorale*.

The sporophylls do not draw apart at maturity, as in other species; but this is of no consequence, since the spores will not germinate.

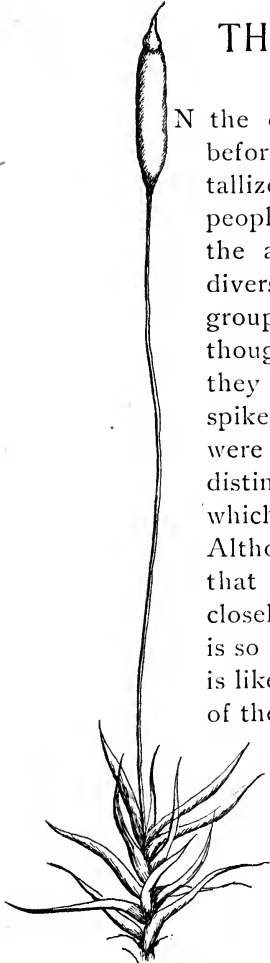
The range of *Equisetum littorale* is given as from New Jersey and Pennsylvania to Minnesota and northward. It is only occasionally found, but, where present at all, often occurs in great abundance notwithstanding the abortive spores, since it spreads rapidly by means of its rootstocks. Mr. Eaton notes that along the lower Merimac River the plant is so abundant as to be cut for hay under the name of "joint-grass." It prefers a drier location than does *Equisetum fluviatile*, but both may be found together. According to Mr. Eaton the two species may readily be distinguished in the field by a section of the stem just below the joints. In stems of *Equisetum littorale* the cross-section presents a star-like opening, while that of *Equisetum fluviatile* is larger and circular. In *Equisetum littorale* the vallicular canals are always present, but they are absent in *Equisetum fluviatile* except in large or old stems. It is easily distinguished from *Equisetum fluviatile*, however, by the fact that the sheaths are never so closely appressed to the stem, the grooves of the stem are fewer and deeper, and the central hollow is not so large. The shore horsetail is also found in the Old World, extending from England to France, Austria, Russia, and Scandinavia.



THE LYCOPODIACEÆ, OR CLUB-
MOSSES.

THE LYCOPODIACEÆ.

IN the early days of plant study, long before the art of simplifying had crystallized into the science of botany, people had very hazy ideas regarding the affinities of plants, and the most diverse were often placed in the same group. The Lycopodiaceæ were then thought to be mosses, but the fact that they bear their spores in club-shaped spikes did not escape notice, and they were accordingly called club-mosses to distinguish them from the true mosses, which bear their spores in capsules. Although everyone nowadays knows that the club-mosses are not very closely related to the mosses, the name is so convenient and descriptive that it is likely always to be used in speaking of them.



A moss Capsule.

In appearance the club-mosses are as different from the scouring-rushes as one could well imagine. The most noticeable characteristics of the scouring-rushes are the great development of stem and the small functionless leaves, while the club-mosses are remark-

able for their leaves, which, though small, are so numerous as often to make it easier to infer the presence of a stem than actually to see it.

In our species of *Lycopodium* there is nothing that can be called a rootstock, unless we are inclined to call the main axis a combination of rootstock and stem. In some species this axis is above ground and covered on all sides with the leaves; in others it is beneath the surface or buried in the *débris* that covers the forest floor; and in still others it creeps upon the surface of the earth with roots on the under surface and leaves on the upper. In all, it may send out roots whenever it comes in contact with the earth. It is noticeable, however, that there is only one growing end to this axis, and that the other is more rootlike in appearance. As the stem continues to add to its length at the growing end, it as slowly dies at the other, and thus the plants year by year move slowly forward, and, though rooted in the soil, no individual plant occupies quite the same position for two successive seasons. Indeed, although the life of the plant has continued uninterruptedly, it may be fairly questioned whether after some years it is the same individual. The leaves are not the same, the roots and stem are not the same, and it does not occupy the same place in the woodland.

In some species the main axis reaches a length of ten or fifteen feet; in others, less than half as many inches. It usually takes a course parallel to the surface of the earth and occasionally sends out secondary stems that are exactly like it in growth and function. From all these stems spring the short upright branches that form the noticeable part of the plant. The leaves are small and pointed, with a distinct midrib, which, however, does

not extend to the apex. They are arranged on the stem and branches in from four to sixteen rows, the number depending upon the species. These numerous short leaves, mostly standing out from the stem, make many species look exceedingly like mosses, especially when not in fruit; but even then they may be distinguished from mosses by the fact that their stems contain pronounced fibro-vascular bundles, while those of the mosses do not.

The lycopodiums are among the latest of the fern allies to fruit. Some in the northern States do not shed their spores until late in October. The spore-cases are always borne at or near the tips of the branches. In one type they are in the axils of unchanged leaves; in another the leaves are more or less reduced and yellow in colour, forming cone-like spikes which in some species are borne above the



Sporophyll and
Spore-case.



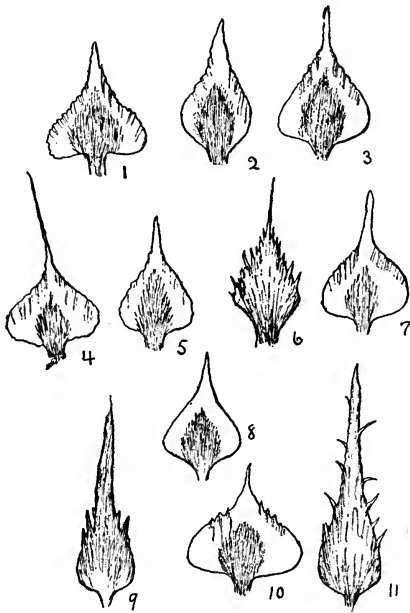
A Fruiting-
spike.

foliage leaves on slender stems. The sporangia or spore-cases, one in the axil of each leaf, are one-celled kidney-shaped structures with thin tough walls. The spores are very abundant, and bright yellow in colour. Undeveloped spore-cases are often found above and below the zone of fruitful sporangia.

The prothallium of *Lycopodium* is still imperfectly known. In the species in which it has been studied it usually consists of a cylindrical mass of pale cells either wholly or partly underground and bearing both male and female elements. These pale prothallia, lacking the green colouring-matter of ordinary plants, cannot secure

their food as other plants do, and so have set up a partnership with a fungus which is always present and aids in the work. The prothallia of certain exotic species living on trees are slender, much-branched structures and are saprophytic, that is, they live, like the mushrooms,

upon the decayed vegetable matter in their vicinity. Because of this associated fungus it is a difficult matter to grow the prothallia of the Lycopodiaceæ, and that of many species has never been seen. Further observations of these structures are very much to be desired. It is suggested that the prothallia might be raised by infesting them with spores of the fungus. This might possibly be done by watering the spores with water in which the roots of the lycopodiums have



SPOROPHYLLS OF LYCOPODIUM.

1. *L. complanatum*. 2. *L. alpinum*. 3. *L. sabinæ-folium*. 4. *L. clavatum*. 5. *L. Sitchense*. 6. *L. cernuum*. 7. *L. annotinum*. 8. *L. Carolinianum*. 9. *L. inundatum*. 10. *L. obscurum*. 11. *L. alopecuroides*.

been soaking. This theory is being put to a practical test, but the experiments have not progressed far enough to have the results included here.

In all flowering plants, and in nearly all others, the

roots, penetrating the earth, give off rootlets here and there as conditions require ; but in the *Lycopodiums* the roots branch dichotomously, dividing into two equal branches which may again divide in the same way. The roots do not seem to have any special point on the stem from which to grow, but develop on any part that touches the soil.

There are about a hundred species of *Lycopodium* known at present. The majority are found in the warmer regions of the world, where they often grow on the branches of trees, many feet from the ground. Other species clamber over the vegetation like the climbing ferns. Our species are all low and inconspicuous plants, keeping close to the earth on moors or in swamps, woodlands, and thickets. Some are very hardy, electing to grow in barren rocky wastes on the very edge of the world, as it were. They are often found in the greatest abundance on rough mountain-tops or bordering the roadsides in elevated districts. Some extend northward to the Arctic Circle and beyond. All our species are perennial, and not only are the leaves of most of them evergreen, but many appear to last for several years.

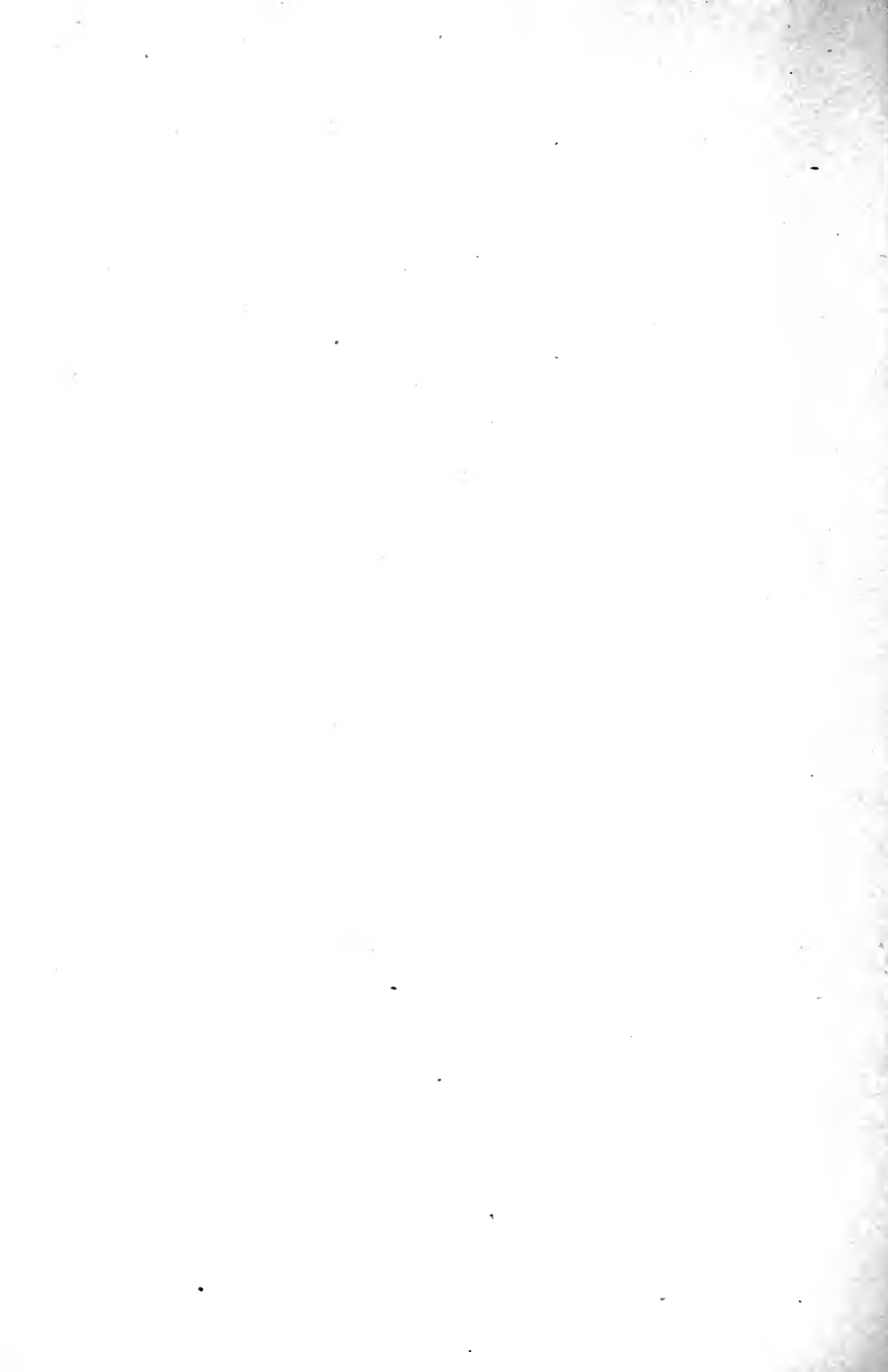
The lycopodiums of the present are mere remnants of the race. During the Coal Period they were most luxuriant, and the various forms attained the height of trees. Of these the lepidodendrons and sigillarias are well known, while the roots of other species were once erroneously referred to a genus called *Stigmara*. The spore-cases of some of these old lycopodiums have been so carefully preserved by nature that their structure may still be discerned. It is a curious fact that the ancient species were heterosporous, with two kinds of spores like *Isoetes* and *Selaginella*, while living lycopodiums have spores all alike.

The club-mosses are probably the best known of the fern allies. During the winter holidays, great quantities of certain species are used in festoons, wreaths, and other decorations. The steadily increasing demand for such greenery is pushing several of the more decorative species to the verge of extinction, since they reproduce very slowly. The spores of some species form an important article of commerce, and, under the name of lycopodium powder, may be found in any drug store. They contain more than half their bulk in oil, and, if sprinkled in the flame of a candle, may be seen to ignite with a flash. They have been extensively used in fireworks under the names of vegetable brimstone and vegetable sulphur. If sprinkled thickly over the surface of a glass of water, one may plunge his finger to the bottom without its being wetted. Their chief value to the druggist is for dusting pill-boxes, to keep the pills from sticking together. Various species of *Lycopodium* have been used in dyeing, and some are emetic, but their medicinal effects are too violent to entitle them to a place among drugs of the present. Most species are also more or less astringent.

The word *Lycopodium* comes from two Latin words meaning "wolf" and "foot," but the reason for its application to these plants is not apparent unless it is in allusion to the habit they have of growing in wild and inhospitable regions where only the foot of the wolf is likely to tread.

KEY TO THE LYCOPODIUMS.

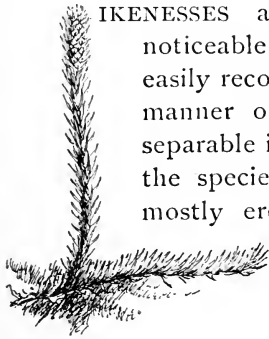
- I. — Sporangia in the axils of ordinary leaves
Leaves flat. Lowland species *L. lucidulum*
Leaves curved upward. Mountain species *L. selago*
- II. — Sporangia in cone-like spikes
Sterile stems prostrate ; fertile, erect, unbranched
Prostrate stems usually branched *L. alopecuroides*
Prostrate stems short, seldom branched
Rooting throughout *L. Carolinianum*
Rooting at base and tip only *L. inundatum*
Fertile and sterile stems erect ; rootstock creeping
Cones closely sessile
Averaging an inch or more long *L. obscurum*
Averaging less than an inch long
L. annotinum
Averaging less than half an inch long
L. cernuum
Cones apparently stalked
Branches about four-sided *L. alpinum*
Branches round
Leaves bristle-tipped, $\frac{1}{4}$ inch long
L. clavatum
Leaves not bristle-tipped, shorter
L. Sitchense
Branches flattened
Cones two to four, peduncle long, stout
L. complanatum
Cones one to three, peduncle short, slender
L. sabinæfolium



THE TRAILING LYCOPODIUMS.



THE TRAILING LYCOPODIUMS.



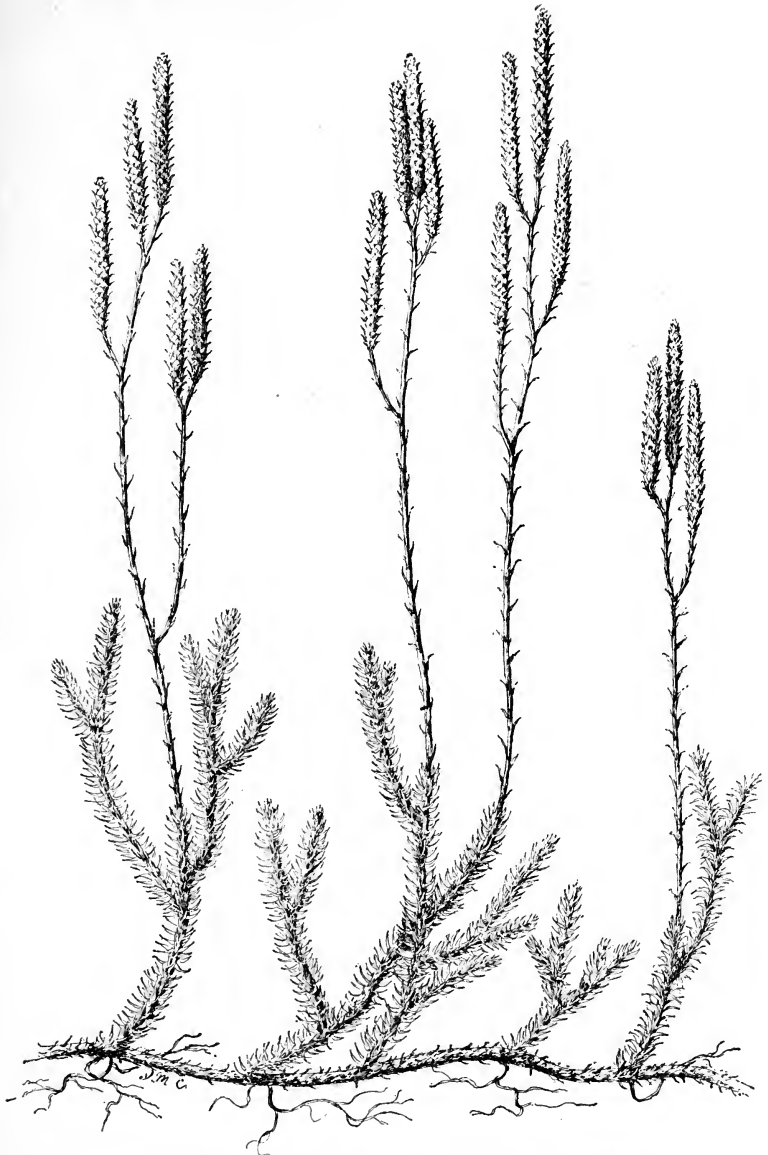
LIKENESSES among the club-mosses are so noticeable that any member of the group is easily recognized. Certain differences in the manner of growth, however, make them separable into two groups, in one of which the species are small and the plant body mostly erect or decumbent, while in the other the plants are larger and the principal stems long and trailing. These latter are the species that figure in our holiday decorations, and as most of them are well known in consequence, and are also common and widely distributed, they will be discussed in this first of two sections devoted to the club mosses.

The Common Club-Moss.

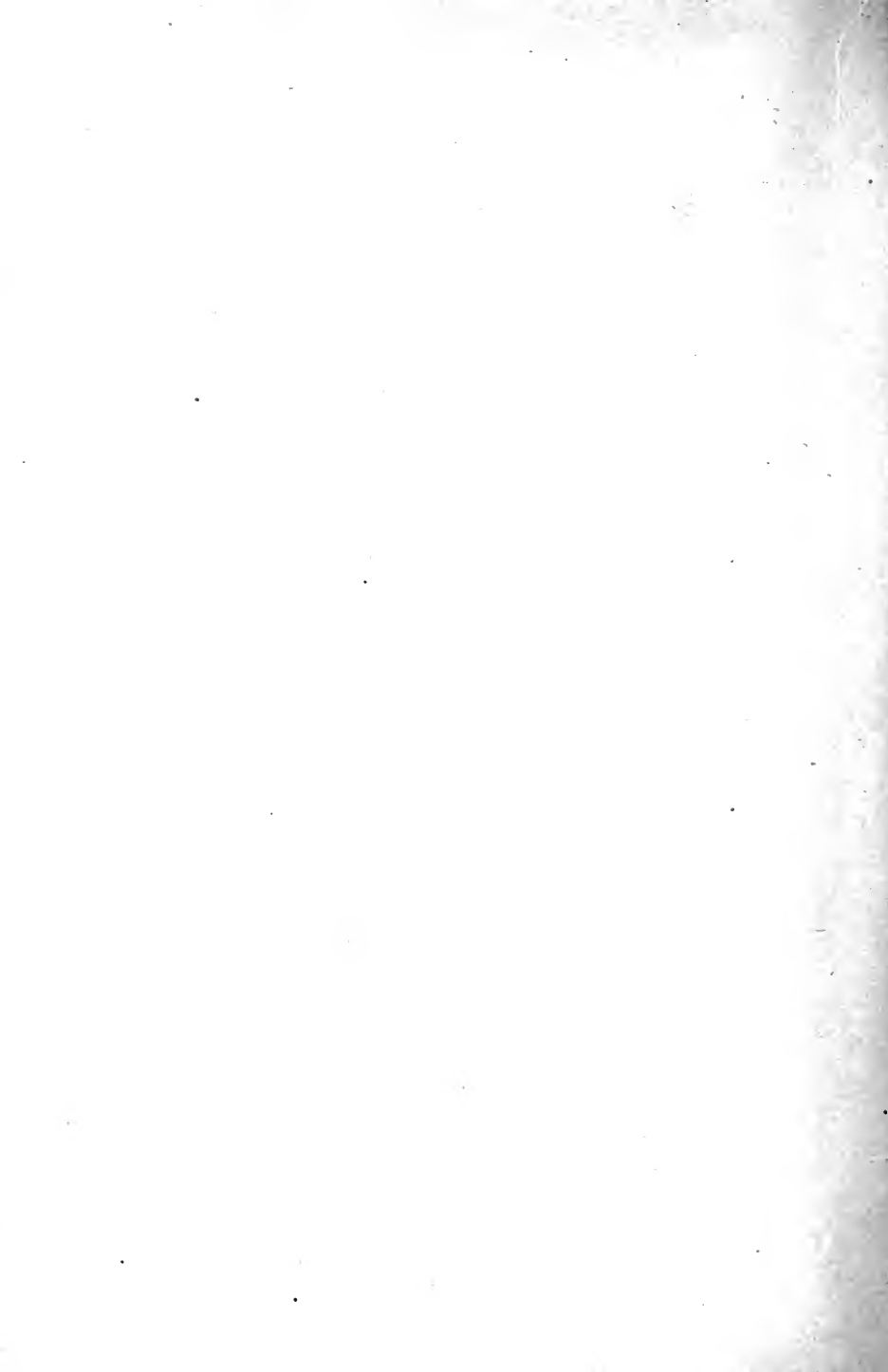
One seldom goes far in the scrubby uplands without coming upon the long, dark-green stems and yellow spikes of the common club-moss (*Lycopodium clavatum*), which delights to grow close to the earth and half hidden by the surrounding vegetation. In sunny thickets, however, it is often so abundant as completely to carpet the ground for many yards with its interlacing stems, and it is everywhere one of the most abundant species of its genus.

The main stem often reaches a length of ten feet or more, though it is usually much shorter. At the growing end it is usually above ground and covered on all sides with the green leaves; at the opposite end it is more or less hidden under an accumulation of dead vegetation, and the stems and leaves are yellowish. Here and there, throughout its length, single, stout, cord-like roots are given off, which extend downward until they enter the soil, where they usually branch once or twice. Frequently this main stem is branched, and these branches, like the axis from which they spring, maintain a course parallel with the earth. At short intervals along these stems other branches are produced which extend upward. During the first year they are from one to three inches long and are simple, but at the next growing-season they add more to their length and at the same time put out short side branches. This continues for several years until the older branches are several times branched, with occasional roots springing from the portions nearest the earth. There is thus a regular gradation from the short simple branches at the growing tip of the stem, less than a year old, to the larger much-divided branches at the other extreme which have outlasted several seasons.

The leaves are evergreen and persist for several years. They are arranged on stem and branches in about eight longitudinal rows, and so close in the rows as to overlap. They are about a quarter of an inch long, very narrow, and each ends in a long soft bristle. On account of the angle at which they are set on the stem, the branches appear about half an inch in diameter. The edges of the branch leaves are entire or occasionally toothed; those on the main stems have larger teeth.



COMMON CLUB-MOSS. *Lycopodium clavatum*.



The old leaves are dark green in colour, but the new growth is light silvery green and very noticeable in early summer. Owing to a slight constriction at the place where each season's growth begins, it is very easy to ascertain the age of each branch by counting the constrictions.

About midsummer the plant begins to put up its fruiting parts. These are simply transformed branches, and often indicate the relationship by producing one or more sterile branchlets instead of the usual cones of spores. The fruiting-spikes are always borne at the tips of branches of the previous year, in the position that sterile branches hold on other branch-tips of equal age. The fruiting peduncles are most abundant on the older parts of the plant, but any branch that is more than a year old may produce them. Sometimes in a distance of a single foot along the main stem there will be a dozen or more peduncles, each with three or four strobiles, or fruit-cones, at the summit.

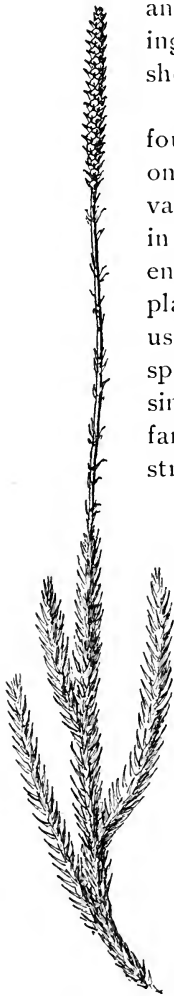
The stalks or peduncles are from three to eight inches in length, the average being about five inches. They are nearly of the same diameter as the stem, but, owing to the absence of leaves, appear much slenderer. They are clothed with appressed bracts like the leaves in outline, but which are smaller and at maturity are yellowish in colour. The strobiles are from one to three inches long, thicker than the peduncle, and consist of a great number of close-set, little ovate or heart-shaped sporophylls with thin ragged edges and soft bristle tips, each covering a yellow kidney-shaped spore-case. The spores are bright yellow and are produced in prodigious quantities. They are ripe in early autumn. The lycopodium powder of the shops is composed of the spores of this

species, the supply coming mostly from Sweden, Russia, and Switzerland. It is obtained by gathering the spikes just before the spores are shed, and collecting the powder in papers.

Occasionally a form of this species is found in which there is but one strobile on each peduncle. This has been named variety *monostachyon*. It is usually found in dryish situations, and its form is apparently due to a lack of some of the normal plant's requirements. While the variety usually produces but one strobile to each spike, it is possible to find plants with single strobiles near the growing end, and, farther back, peduncles bearing two or more strobiles.

This plant is one of those in greatest demand for holiday decorations, and the demand for it has made it rare in many localities. Fortunately, owing to its manner of rooting, the whole plant is seldom pulled up, and the fragments left behind may ultimately produce thrifty plants, so that it is likely to be a long time before it entirely disappears from a locality.

This is the club-moss *par excellence*, as its specific name indicates. In America, however, it is better known as "ground-pine," "running-pine," or "trailing Christmas green." Among Old World names for it may be mentioned "fox-tail," "stag-horn," "buck-horn,"



Lycopodium clavatum
monostachyon.

“buck grass,” and “wolf’s claw,” all of which doubtless have reference to the manner in which the branches grow. In Cornwall it is known as “good-luck.” Other names applied to it in various localities are “coral evergreen,” “running-moss,” “snake-moss,” “toad-tail,” and “lamb’s-tail.” The plant has strong astringent properties, and was once used in medicine. In Sweden the stems are woven into doormats and the plant is known as “matte-grass.” It seems to have been the custom for holiday parties in the Old World to trim their hats with the stems of the club-moss. The Swedes especially are mentioned in this connection, and Wordsworth alluded to the custom in the following lines :

“Or with that plant which in our dale
We call stag’s-horn or fox’s-tail
Their rusty hats they trim.
And thus as happy as the day
These shepherds wear the time away.”

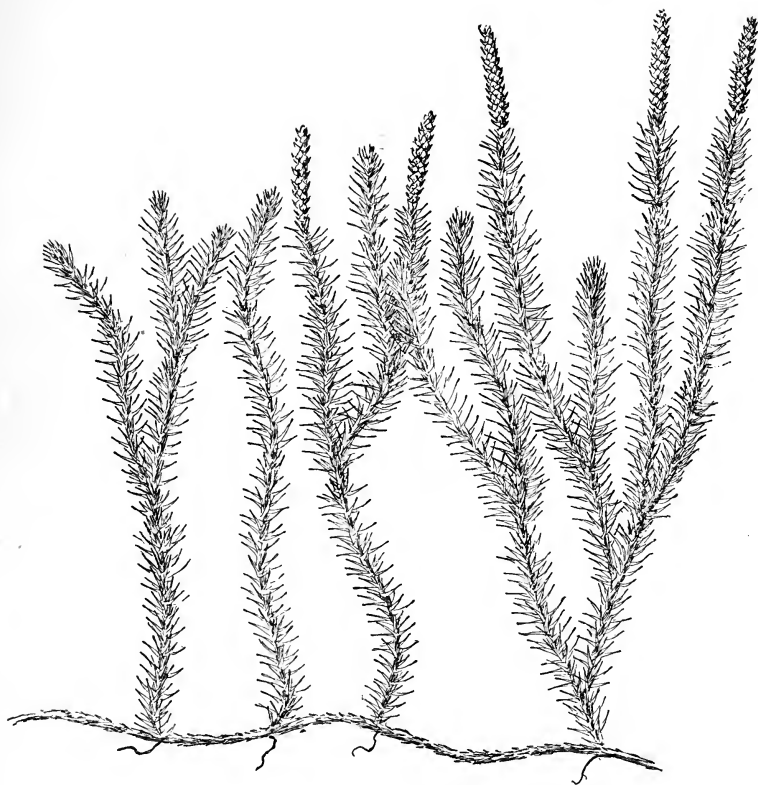
This species is one of the most widely distributed of its genus. It is common in the Arctic and Sub-Arctic regions of both Hemispheres, and has also been reported from tropical America, Brazil, Cape of Good Hope, Madagascar, India, Java, New Guinea, the Hawaiian Islands, and eastern Asia. As might be expected, there is considerable difference in the appearance of specimens from the extremes of its range, and it is a question whether they are all varieties of one species or a series of closely related species. Many, of course, have been described as separate species. The author has collected specimens in the American tropics, which are almost exactly like our common form except that they are more luxuriant and have longer peduncles. In North America it ranges from the Arctic Circle southward to Oregon, Iowa,

Michigan, Pennsylvania, and New Jersey. It also occurs in the mountains of North Carolina. In the southern part of its range it may be expected only in the elevated regions. Further extensions of its range are likely to be made when these have been thoroughly explored. Its habitat may be described as upland woods, but it is found in many exposed places and often grows in old fields and pastures. Its abundance makes it one of the first species likely to be found by the novice.

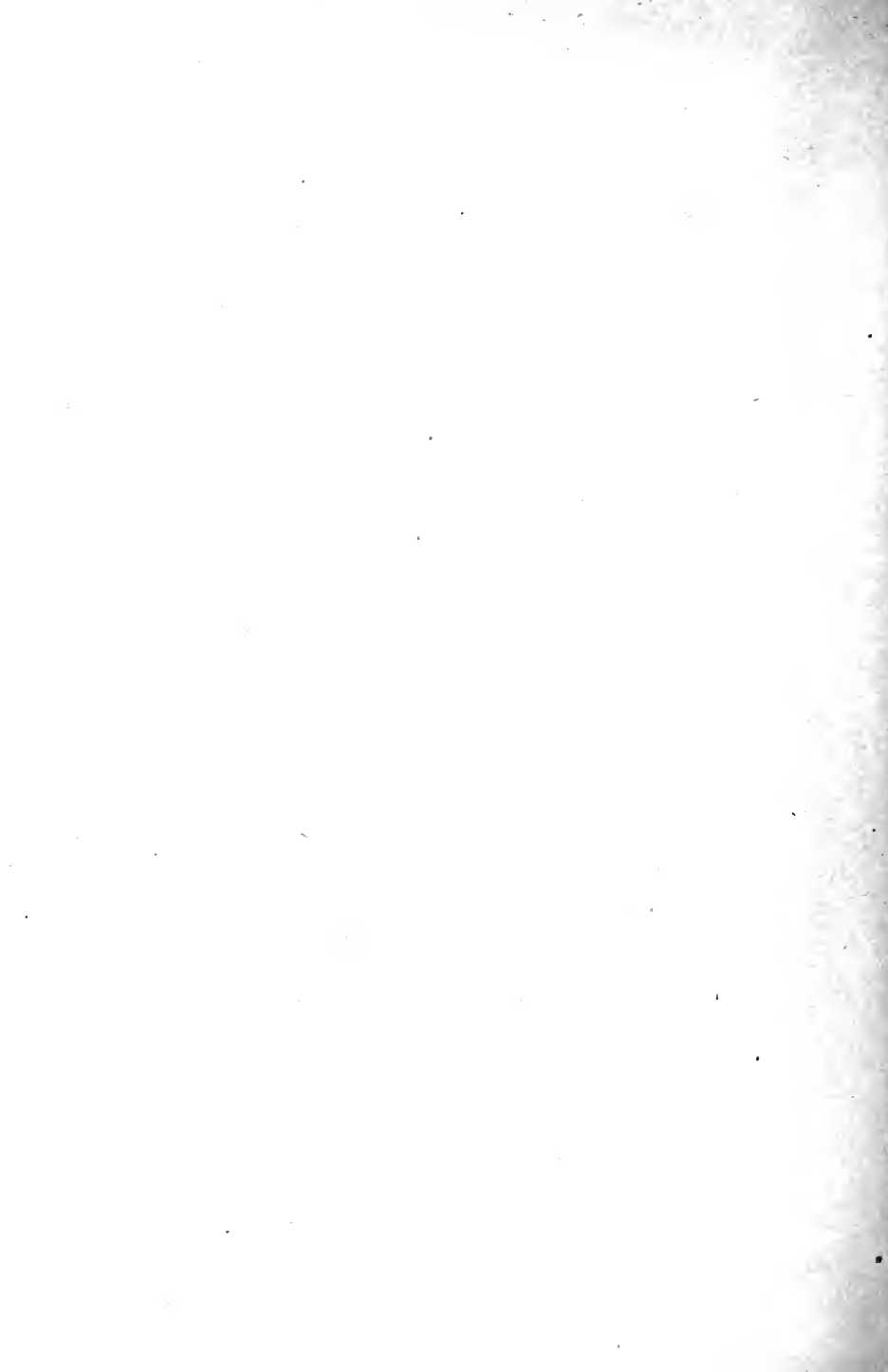
The Stiff Club-Moss.

If, while collecting in the haunts of the common club-moss, one should come upon a plant closely resembling that species except that the fruiting-cones are sessile on the ends of the branches, he may feel sure he has discovered the stiff club-moss (*Lycopodium annotinum*). This is seldom so abundant as its better-known relative, but it is by no means rare in the elevated parts of the northern United States and Canada.

The species is like *Lycopodium clavatum* in so many habits and superficial features that, with the exception of the manner of fruiting, one description would almost serve for both. The main stem may be said to come nearer our idea of a rootstock, being yellowish for most of its length, less leafy, and somewhat more deeply buried in the *débris* of the forest floor. In length it ranges from three to six feet or more, and the upright branches are usually simple the first season. The second season they branch or continue to increase in length, finally reaching a height of twelve inches in robust specimens, and often three or four times forked. The branches appear to arise dichotomously, and are more nearly erect than in the common club-moss.



STIFF CLUB-MOSS. *Lycopodium annotinum*.



The leaves are about a quarter of an inch long, somewhat firmer than those of *Lycopodium clavatum*, and are arranged on stem and branches in from five to eight rows. They are narrowly lanceolate with toothed margins, and end in an acute point without a bristle. At the ends of the branches the tips of the leaves point upward, but below this they are more spreading. As the new season's growth springs from the midst of the erect leaves, there are, in consequence, alternating zones on the branches in which the leaves are spreading or appressed, each appressed zone marking the ending of one season's growth and the beginning of another. From this circumstance the plant is called the "interrupted club-moss" in the Old World. The zones are most noticeable in specimens growing in exposed places. According to Moore's "British Ferns," old branches, after fruiting, bend over, take root, and start new rootstocks, but there appears to be need for further observation on this point before the statement is accepted.

The chief distinguishing feature of this species is found in the strobiles or fruit-cones. They are half an inch to an inch or more long, about one fourth as wide, and are borne singly on the tips of the branches with no sign of the peduncle so noticeable in *Lycopodium clavatum*. They are, as usual, made up of a great many small, closely assembled sporophylls, yellow in colour when ripe, and broadly heart-shaped with an irregular margin and slender tip. Each subtends a kidney-shaped spore-case filled with pale yellow spores which are ripe in late August or September.

In the far North, and on mountain tops in milder regions, there is a form of this species called variety *pungens*. It is characterized by its thicker, shorter, sharper leaves

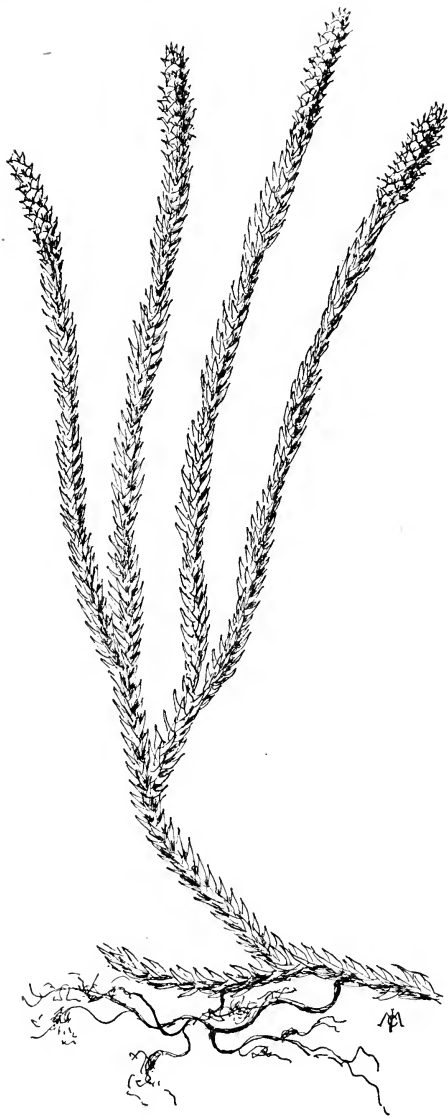
set closer on the branches and nearly appressed to them. The zones marking the beginning of each season's growth are also very clearly marked. It is in all ways a more compact plant than the type, the differences, without doubt, being due to the cold and exposure to which it is subjected.

The stiff club-moss is found from Washington to Colorado, Minnesota, Michigan, and New Jersey to Alaska and Greenland, appearing to be very common in suitable places in British America. It also occurs in the colder parts of the Old World and in the Himalayas. It loves the moist, shady woodlands, and is seldom plentiful in the dry and exposed places in which *Lycopodium clavatum* thrives.

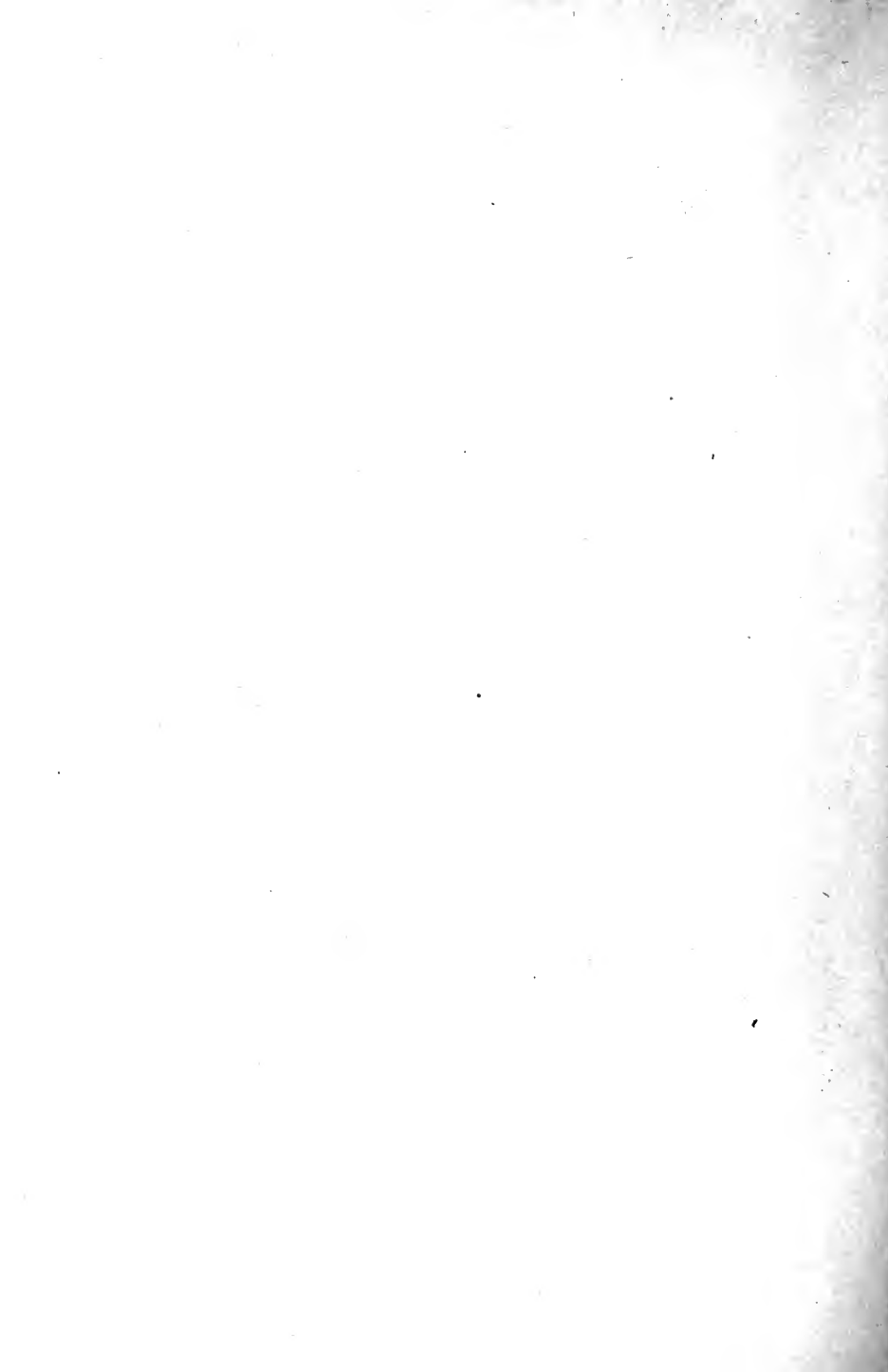
The Ground-Pine.

Although several lycopodiums are more pine-like in appearance, the name of ground-pine is most often applied to the plant known to the botanist as *Lycopodium complanatum*. It would require a lively imagination to detect in this species any resemblance to the pine, for the flat branches form little horizontal fans and semi-circles quite unlike pine needles or branches. By whatever name called, however, it is a distinct and easily recognized species, while its abundance, varied habitat, and extended distribution make it well known to collectors.

Like the common club-moss, the ground-pine has a long running main stem or rootstock which may reach a length of eight or ten feet. It creeps along close to the earth, or an inch or two below the surface, and at intervals sends down its single cord-like roots. The branches are erect, those of the season being from two to five

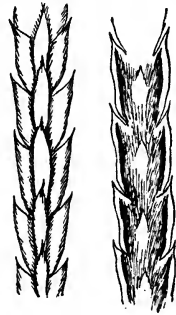


Lycopodium annotinum pungens.



inches long and consisting of a short main branch terminating in a bud-like point with a pair of opposite fan-like lateral branches just below it. These lateral branches fork four or five times near the base, or, occasionally, nearer the tips, the terminal branchlets being from half an inch to two inches long and spreading out horizontally in flat semi-circles. Occasionally there is a single lateral branch near the base of the main stem. The following year the bud-like point carries the main branch upward a few inches more, and there produces another pair of similar forking lateral branches. This process may be repeated for several years in succession, resulting in main stems a foot in height. The lower lateral branchlets also lengthen more or less in subsequent seasons by additions to the tips, the new growth being very noticeable at midsummer by reason of its lighter colour. These lateral branches may also send up short branches like the main one the second season, such branches arising from the point where the branchlets are given off. The branchlets of our common plant are flattened in a plane parallel to the earth, and have a very distinct upper and lower side, or, in other words, they are dorsi-ventral. The upper surface is also darker green.

In the matter of leaves this species differs greatly from most of our native club-mosses. First of all, owing to the dorsi-ventral branchlets, there are two kinds of leaves arranged in four rows. Extending lengthwise of the branchlets on the under side is a row of very short pointed leaves; in a similar row on the upper or dorsal side is a series of

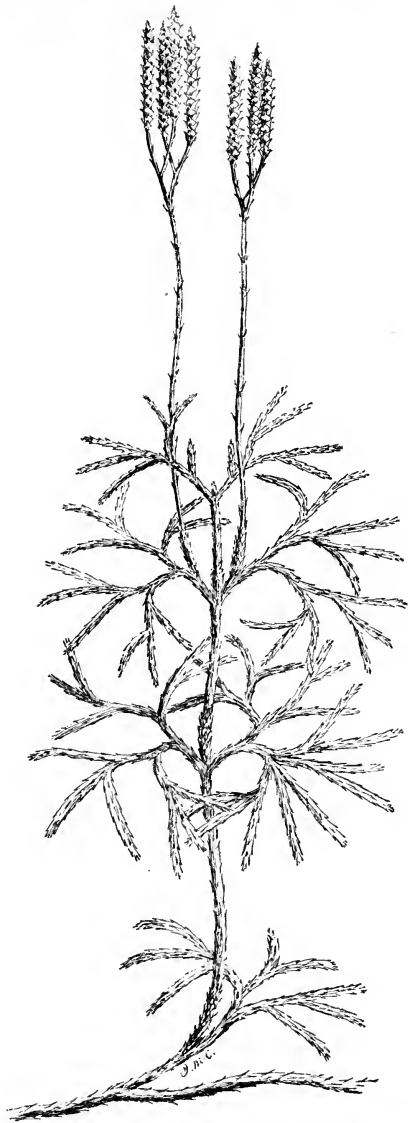


Upper and under surface of Branchlet.

larger leaves with tips closely appressed ; while on each edge of the branchlets, and most noticeable from above, is another row of the large leaves with slender spreading tips. The largest of these leaves are often not an eighth of an inch long, but their bases, being broad and decurrent, form a tiny lateral wing to the branchlets. The leaves on the main stem usually have narrower bases.

The fruit-spikes are an inch or more long and are borne on slender yellowish peduncles three or four inches in length. These are produced from near the tips of the main branches, two or three peduncles from each branch, and from their position are apparently transformed lateral branches. At the apex each peduncle forks, and each fork immediately forks again, thus giving rise to four cones of fruit. Occasionally there are one or two more fruit-cones, but four is the usual number. The peduncles are sparsely clothed with slender, nearly appressed scales, and the cones consist of large numbers of white-margined, heart-shaped scales with broad bases and slender tips, each covering a kidney-shaped spore-case in its axil. The spores are very numerous and are ripe about August or September. Like those of *Lycopodium clavatum*, they are gathered in quantity and have a commercial value. In most club-mosses, after a branch has once borne fruit, it commonly does not fruit again, but in this species it is not unusual for new branchlets and new fruit-spikes to be produced for two or perhaps more successive seasons.

This species was named *complanatum* by Linnæus, and until recently our well-known plant has been called by that name. It would seem, however, that the branchlets in the Linnæan specimens were less inclined to spread horizontally, and from this circumstance Mr. M.

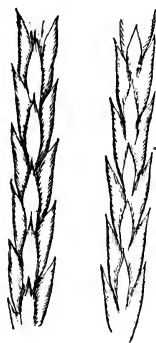


GROUND-PINE. *Lycopodium complanatum*,



L. Fernald thinks our plant should have a different name. He has recently proposed to call it variety *flabeliforme*. There seems to be good reason for thinking that the Linnæan plant is represented in our far North, or, rather, that our plant with spreading fan-shaped branches tends to bear these branches erect as one proceeds northward.

Growing with the common ground-pine, and seldom distinguished from it by the novice, may often be found specimens in which the branchlets are more erect and in which the under row of leaves scarcely differs in size from the upper and lateral rows. This has usually been regarded as a fairly distinct variety or species named *chamæcyparissus*. In contradistinction to the type, the main stem is quite like a rootstock, being pale, slender, and buried several inches in the earth. The foliage is often lighter in colour, and the branchlets also more inclined to lengthen at the tips the second season than in *Lycopodium complanatum*, and while they are not spreading they are more or less flattened, as in the other. The fruiting parts are exactly like those of *Lycopodium complanatum* but are said to ripen their spores two or three weeks earlier. This latter feature, however, seems to depend entirely upon the soil and surroundings of the plant. *Chamæcyparissus* is rarely if ever found growing alone, and the invariable proximity of specimens of *Lycopodium complanatum* suggests that it is only a strong and well-marked form, due, perhaps, to the main stem being accidentally covered with earth. Intergrad-

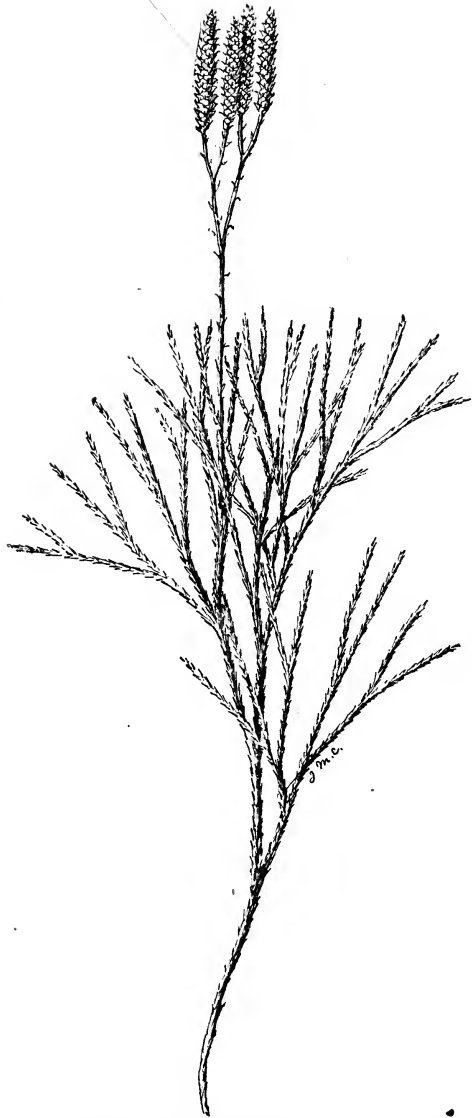


Lycopodium complanatum chamæcyparissus.
Upper and under surface of Branchlet.

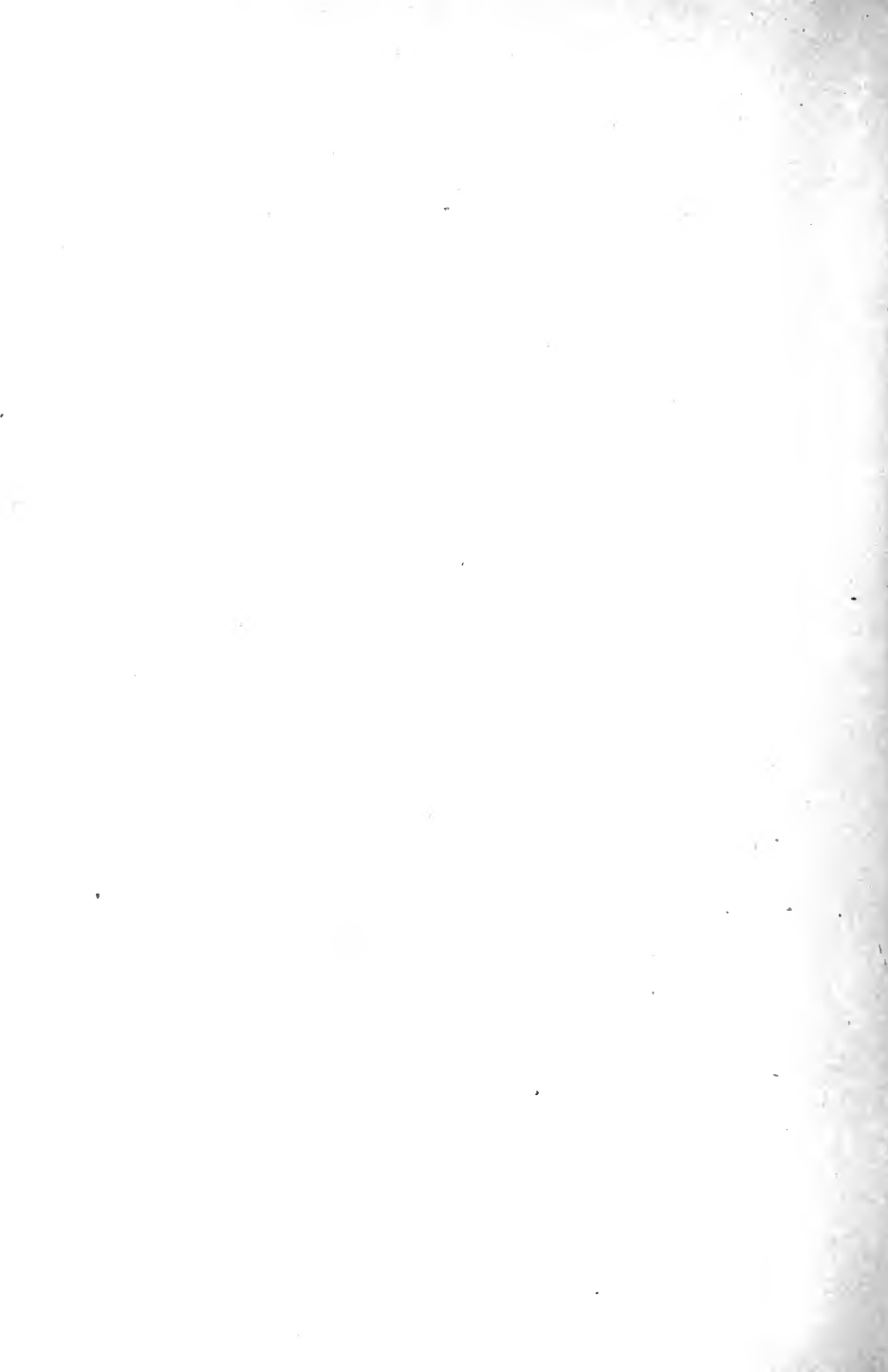
ing forms often occur. Since this form has always been known in American publications as *Lycopodium complanatum chamaecyparissus*, it is called by this name here to avoid confusing the beginner. An older name for it has been recently unearthed, and if one is inclined to call it a separate species it should be named *Lycopodium tristachyon*. Those who consider it a variety or form should call it *Lycopodium complanatum tristachyon*. The difficulty experienced in raising lycopodiums from spores prevents the application of a fairly decisive test of the distinctness of these two forms. If it could be shown that from the spores of one form the other may also be produced, we would be warranted in thinking them forms of the one species.

Lycopodium complanatum, like the common club-moss, is occasionally found with fruiting-peduncles bearing a single strobile each. This form has been described as the variety *Wibbei*. It may be expected in localities where the type abounds, usually in the more sterile and uncongenial surroundings.

This species is used in great quantities for decorations. It is said that the trade in Christmas greens began in New Jersey with this plant more than half a century ago. The State is still prominent in the business, though the demand long ago became so great that other sources of supply had to be found. At present the supply is drawn from the States about the headwaters of the Mississippi, more than two hundred tons being gathered each year from a single State. The price realized is about \$75 a ton. In consequence of the annual raids made upon it, the plant is rapidly becoming rare, but small patches of it are still to be found in most localities, while in some remote regions it still carpets



Lycopodium complanatum chamæcyparissus.



the ground to the exclusion of all else. Because of its use in decorations it is probably oftener seen than any other species.

Among its common names are "trailing Christmas green," "running-pine," "ground-cedar," and "festoon ground-pine." It shares the name of "creeping jenny," with the common club-moss, and is also known as "hog-bed" and "liberty." Occasionally it is called "princess pine," but this name belongs by right to one of the heathworts.

The ground-pine is found in the North Temperate Zone of both Hemispheres and has been reported from Madeira, the Azores, Madagascar, Java, Sumatra, New Guinea, and other tropical islands. It is also found in the Andes. Some of the forms from tropical countries are very different in appearance from ours and will doubtless some day be considered distinct species. In North America the plant ranges from the mountains of Georgia to Labrador, Iowa, Washington, and Alaska. In the United States the greater part if not all of the plants belong to the variety *flabelliforme*. As Canada is reached it fades gradually into the type. The range of the variety *chamæcyparissus* is usually given as from Maine to Georgia and Minnesota, but it will probably be found to be coextensive with that of the type when it is better known. The plant loves moist, shady woodlands, but may also be found in thickets and pastures, and along roadsides, often in dry situations, especially in upland regions.

The Ground-Fir.

In the northern parts of our continent there grows a species of *Lycopodium* that much resembles *Lycopodium*

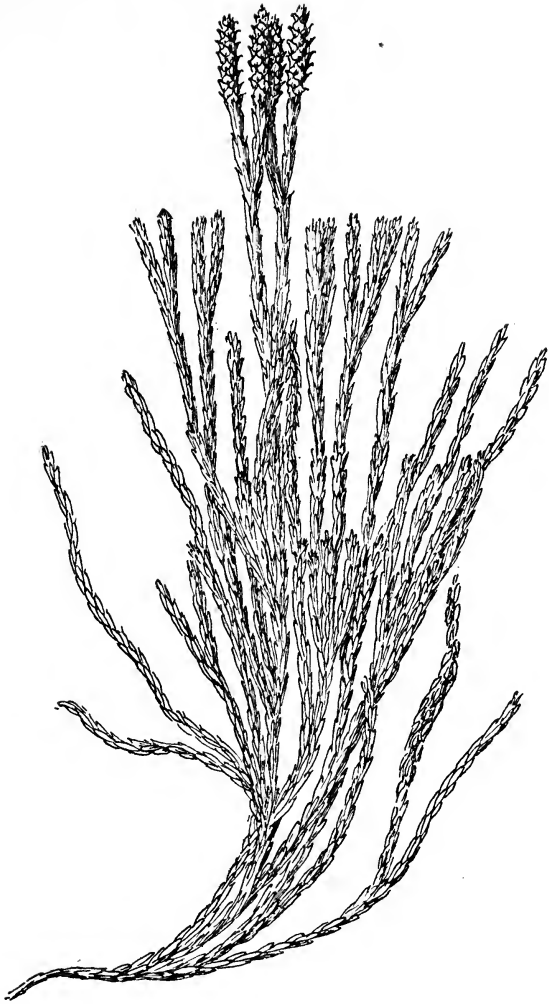
complanatum in general appearance, and which is assumed by some to be connected with it by the form called *Lycopodium complanatum chamæcyparissus*. While it is possible that *chamæcyparissus* may represent part of the line along which its evolution proceeded, it is certainly a distinct species now. Botanists know it by the name of *Lycopodium alpinum*, and the general public speak of it as the ground-fir.

The ground-fir resembles its congeners in having a long and creeping main stem, close to the earth, from which at short intervals it sends up short, erect branches that fork repeatedly, forming dense, flat-topped clusters. As in the other species, the branchlets add to their length the second and perhaps subsequent seasons, the new growth usually again forking. The leaves are about an eighth of an inch long, broadly lanceolate, pointed, and decurrent. They are dark green in colour, thick, rounded on the outer surface, and closely appressed to the branches, along which they are arranged in four rows. Owing to this arrangement of the leaves, the branchlets appear four-sided.

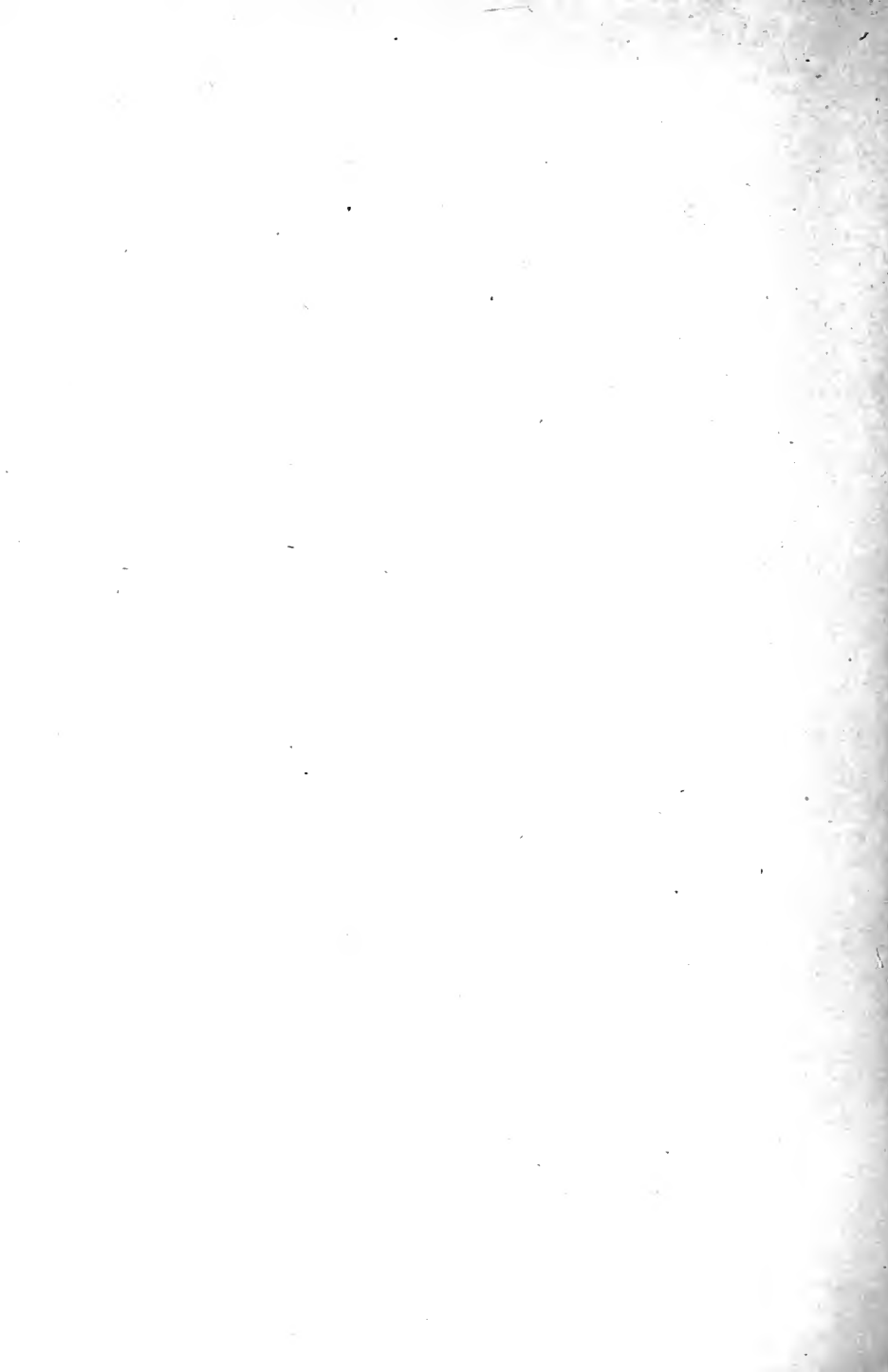


Branch of
Lycopodium
alpinum.

The fruiting parts are raised above the flat-topped clusters of branchlets on very short peduncles which are manifestly continuations of the main branches, and which resemble the branchlets except that they are less leafy and the leaves are somewhat narrower. The peduncles usually fork once near the spikes, and the leaves gradually merge into the short-pointed, toothed, and broadly heart-shaped sporophylls of the spike. The spikes are from half an inch to an inch long, cylindrical, and become yellow-brown with reflexed sporophylls when aged. The peduncle appears



GROUND FIR. *Lycopodium alpinum*.



to remain green. Among the majority of botanists it is customary to call this peduncle a branchlet, and this species is therefore described as having sessile spikes, but these spikes are not sessile in the sense that those of *Lycopodium annotinum* are. In the other species it is evident that the peduncles are transformed branches, and since the branchlets that bear the spikes in this species differ in a few slight particulars from those that bear only foliage leaves, it is as reasonable to call them peduncles as branches.

In the Old World this species is sometimes known as "heath cypress." It was once used in dyeing woollen goods a pale yellow, the process being simply to boil the goods in water with the plant and some leaves of the bog whortleberry.

Lycopodium alpinum as now understood ranges from British Columbia to the Arctic Circle, being common in Alaska and Greenland. It is also found in the North Temperate Zone of the Old World, extending southward into the more elevated portions of Germany, Switzerland, and Spain. It delights in the open spots in mountainous country, but in the colder parts of its range may be found on grassy moors near sea-level.

The Savin-Leaved Club-Moss.

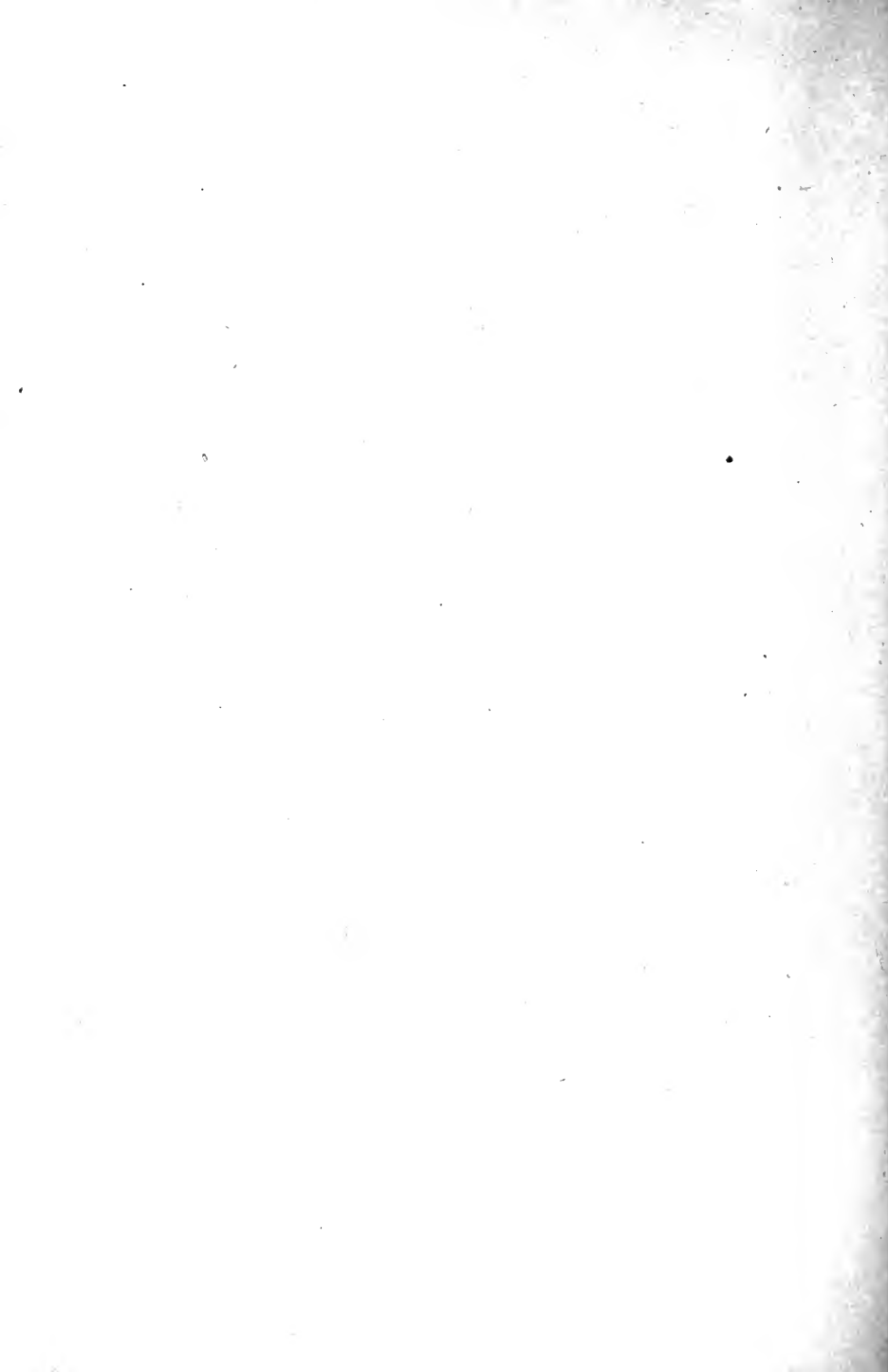
The several forms or species of *Lycopodium* growing in the northern part of North America have given botanists no end of trouble in working out their proper relationships. They are all more or less like *Lycopodium complanatum*, and it was once the custom of students to refer them all to this species, just as the novice would be inclined to do at present. It was less than ten years

ago that the tendency to call *Lycopodium complanatum chamaecyparissus* a distinct species began, and a still shorter interval has elapsed since Mr. Fernald pointed out the differences between the real *Lycopodium complanatum* and our common form. *Lycopodium alpinum*, while much like these in general appearance, has always had some standing in botanical circles as a distinct species, though even in several editions of "Our Native Ferns" Professor Underwood has suggested the possibility of its being another form of *Lycopodium complanatum*. In the same way the savin-leaved club-moss (*Lycopodium sabinæfolium*) has often been thought to be a form of *Lycopodium alpinum*. All these, however, are now believed by many to be separate species. There is no doubt that they are all closely allied to *Lycopodium complanatum*,—they might properly be called the *Lycopodium complanatum* group; but with a series of each before him even the novice would have no trouble in distinguishing between them. Whether the differences they present are of specific value depends upon the view-point of the student. The forms were all named long ago, and are not therefore new segregates, but the tendency in the past has been to ignore them as species.

The savin-leaved club-moss may be distinguished from its nearest of kin, *Lycopodium alpinum*, by the fact that, while the leaves are in four rows as in that species, the branchlets do not usually appear to be so much flattened. This is probably due to the fact that the leaves of *Lycopodium sabinæfolium* are slightly longer and slenderer, and not so closely appressed to the stem. The whole plant is slenderer than *Lycopodium alpinum*, but it has the same trailing habit and manner of growth.



SAVIN-LEAVED CLUB-MOSS. *Lycopodium sabinæfolium*.



The most striking difference between these two species, however, is found in the fruiting portions. In *Lycopodium alpinum* they are raised somewhat above the foliage on thick branch-like stalks with appressed leaves, but in the present form they are borne on slender peduncles two or three inches long, which bear only scattered, slender, spreading leaves. In *Lycopodium alpinum* there may be some doubts as to whether there is any peduncle at all to the catkins; but no doubt whatever exists regarding their occurrence in *Lycopodium sabinæ-folium*. The spikes are an inch or less in length, slender, and the whorls of leaves on the peduncles below the spike have the odd trick of producing sporangia. When the spores are ripe the sporophylls are usually reflexed as in *Lycopodium alpinum*. The catkins are usually borne singly, but there are occasionally two or three together. Like *Lycopodium complanatum*, the old branches produce new branchlets and new catkins for at least two years in succession.



Branch of
Lycopodium
sabinæ-folium.

The savin-leaved club-moss is named for its resemblance to the juniper (*Juniperus sabina*). Its range is given as from Prince Edward Island, northern New England, and Ontario, northward. In geographical position it lies between *Lycopodium complanatum* and *Lycopodium alpinum*, and the three may not improbably represent three strongly marked races of the same species. It is of interest to note that while *Lycopodium alpinum* ranges around the globe in high latitudes, *Lycopodium sabinæ-folium* is not found in the Old World, although there is a variety much like it in Japan called *Lycopodium Nikoense*.

Lycopodium Sitchense.

Half a century ago Ruprecht described a species of club-moss from the northern part of North America, to which he gave the name of *Lycopodium Sitchense*. Until recently little attention has been paid to this plant, because it has always been considered a variety of *Lycopodium sabinæfolium*. It differs from that species as at present considered in having shorter main stems, and shorter, slenderer branches and branchlets which form flat-topped tufts of green after the manner of *Lycopodium alpinum*. The branches are not dorsi-ventrally flattened, and according to Underwood the leaves are arranged on the stem in five rows.

Lycopodium Sitchense is the smallest and most delicate of all our trailing species. The main stems are often less than a foot long and creep on the surface or just beneath it. Its leaves are very slender, about an eighth of an inch long, and thickly set on the branches, from which they stand out in a way that faintly suggests the leaves of *Lycopodium obscurum*. As in all the other trailing lycopodiums, the main branches continue to add new branchlets for several years.



Branch of
Lycopodium
Sitchense.

The catkins are from half an inch to an inch long and an eighth of an inch in diameter, and are borne on slender peduncles or are occasionally sessile on the ends of the branches. Most descriptions of this species record the peduncle as less than half an inch long; but specimens collected in the Province of Quebec by M. L. Fernald have peduncles nearly two inches long, and this feature seems to be not



Lycopodium Sitchense.



uncommon. When peduncles occur, they are sparingly clothed with slender bracts that are nearly like the leaves in shape and size. In many cases but a single cone is borne on the peduncle, but in the majority the peduncle forks near the summit, each fork ending in a cone. At maturity the sporophylls appear to be reflexed.

Lycopodium Sitchense is found in the United States in Maine, New York, Idaho, and Washington, and extends northward to Labrador and Alaska. It has not been half a dozen years since its claims to specific distinction have been seriously considered, and therefore comparatively little is known about it. It will doubtless be found to be more abundant in the northern tier of States than it has thus far been found to be. Owing to its northern habitat it is likely to occur upon mountain tops only in the southern parts of its range.

The Tree Club-Moss.

It is not the tree-like proportions of the tree club-moss (*Lycopodium obscurum*) that have suggested its common name, but rather its habit of growth and general appearance. The upright stems are so much like miniature pine trees that any one finding the plant for the first time is likely to identify it by associating its appearance with the idea suggested by the common name.

The tree-like aspect of this species is heightened by the fact that the main stem is deeply underground, and the branches arising at some distance from one another seem to be different plants instead of several branches of one individual. Of all our lycopodiums, this species has a main stem that is most like a rootstock, being slender,

pale in colour, sparsely clothed with yellowish scale-like leaves, and sending out roots abundantly. It creeps extensively, but seldom becomes as long as the stems of those species that are wholly above ground.

The principal branches rise from two to five inches above the earth before producing branchlets, and are covered with many rows of curved, slender leaves each about an eighth of an inch long, but decurrent upon the branches in such a way as to appear much longer. Each main branch produces from five to eight alternate lateral branches, the lowest of which are largest and again branched two or three times before the final branchlets are produced. The branchlets are from half an inch to two inches long, thickly set with slender, almost linear, pointed leaves arranged in four rows.

Like the other common lycopodiums this species continues to add to the length of the branches for several years, during which the main branches continue to rise and put forth other lateral branches. The first year these latter are simple or slightly forked at the tips, and the next year the new growth springs from these tips, some producing one and some two branches. During the winter the leaves become a light yellow-green in colour, and the new growth, being dark green with silvery tips, is very noticeable. Branchlets as well as branches are crowded, half erect, and in old specimens form compact tree-like forms nearly a foot high.

The spikes of fruit are borne singly on the tips of the old branches, often as many as fifteen spikes on a single main branch, though the number is usually much less. The spikes are cylindrical, from half an inch to two inches or more in length, and an eighth of an inch in diameter. The sporophylls or scales of the spike are

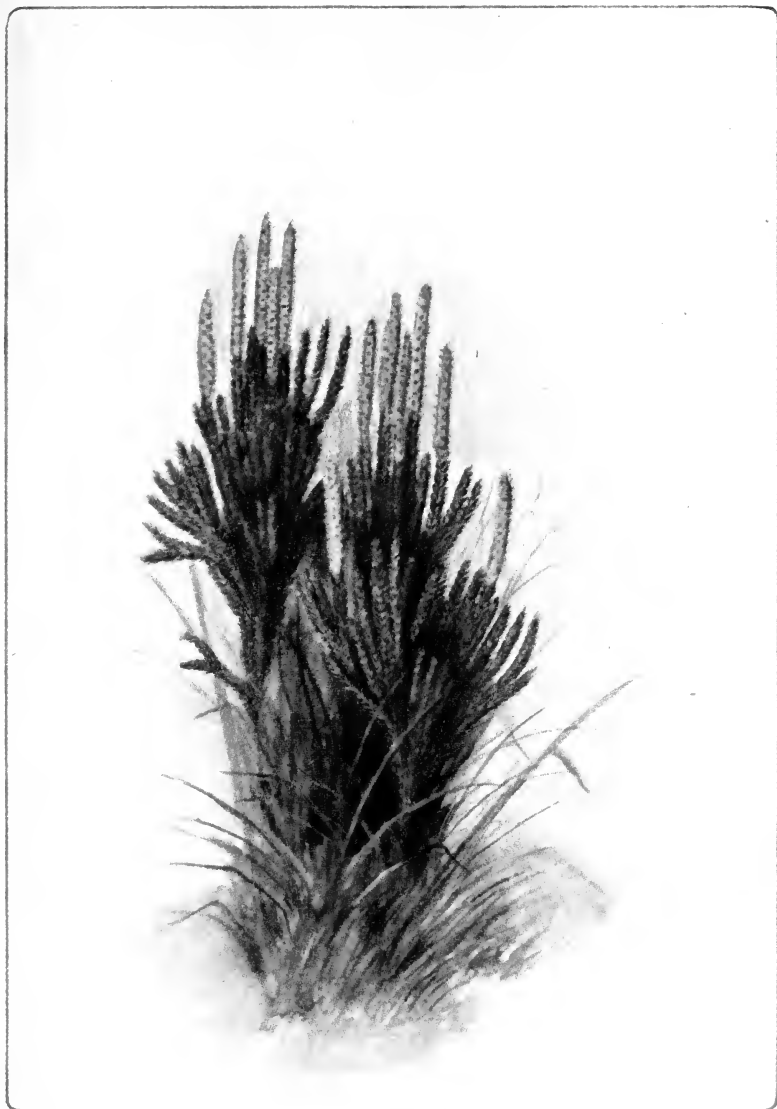
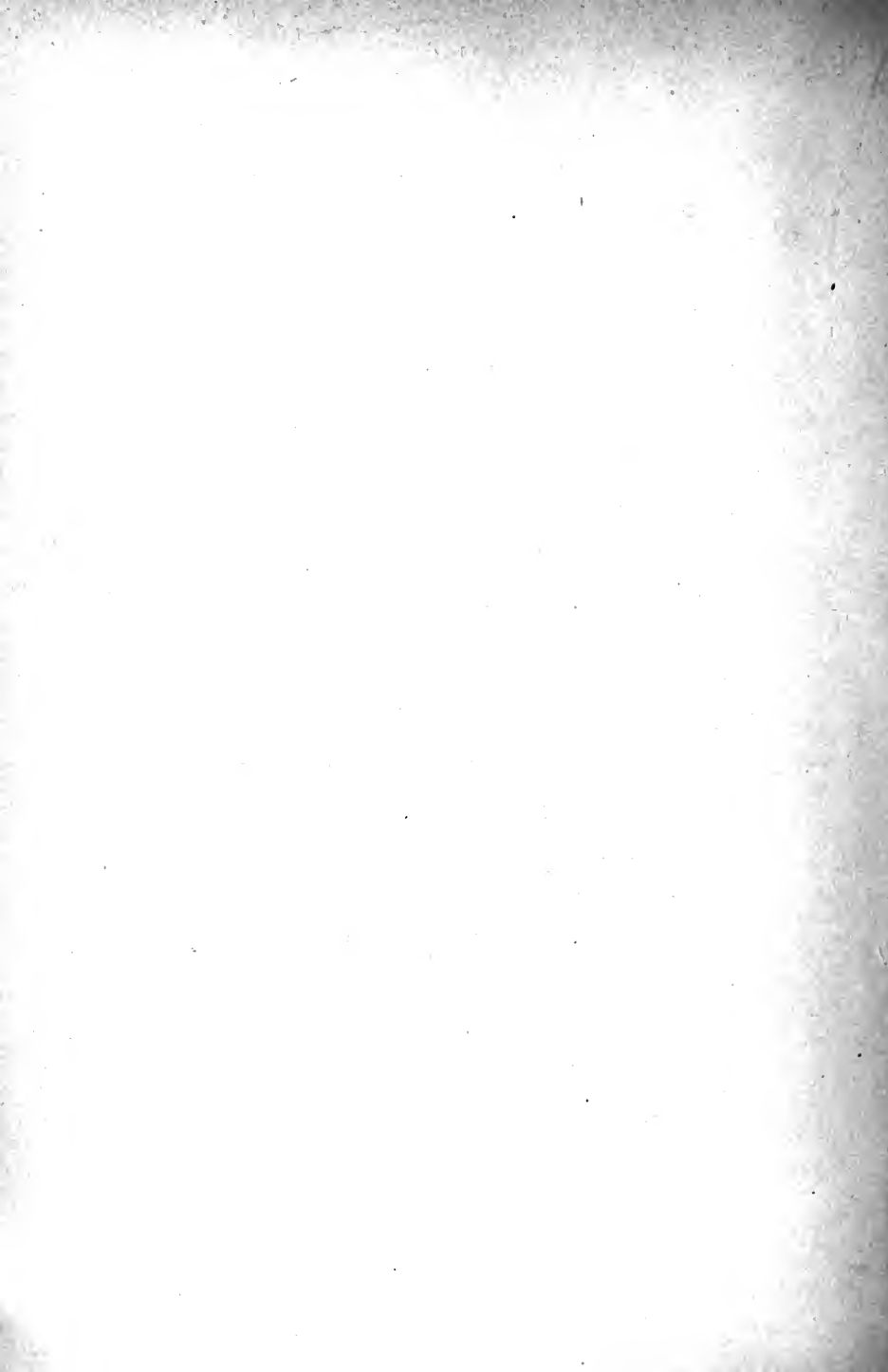


PLATE IV. TREE CLUB-MOSS. *Lycopodium obscurum.*

SCIENCE GHT, 1-15, BY FREDERICK A. STOKES COMPANY



broadly heart-shaped, with a slender tip, and closely overlap. Occasionally the spikes are prolonged into leafy branches above, showing unmistakably the relationship of spikes of fruit to the ordinary branches. The spores are ripe about September, though many ripen later.

Lycopodium obscurum ranges from Newfoundland to North Carolina, Tennessee, Minnesota, and Montana. It is found in southern Canada and extends northward along the Pacific to Alaska. It prefers moist, shady woods, and is one of the common species of the Eastern States. None of our other species resemble it very closely, which makes it a plant easy to identify. This is another of the species used for holiday decorations and is known as "bunch evergreen" or "crowfoot."

The Stag-Horn Club-Moss.

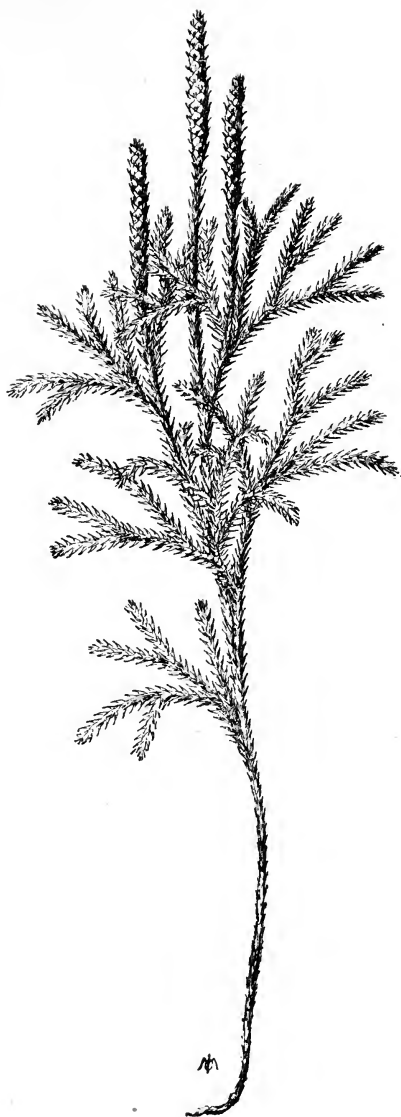
Nearly all the club-mosses in our flora are lovers of the north, and become rare as soon as warmer regions are reached. This probably accounts for the fact that the great State of California has not a single species of *Lycopodium* within its borders. The Gulf States fare somewhat better, though their species are not of northern origin, but instead are northward extensions of tropical species.

The rarest of the tropical club-mosses within our boundaries is the stag-horn club-moss (*Lycopodium cerinum*), which barely reaches the southern parts of Mississippi, Alabama, and Georgia, but is more frequent in Florida. In general habit it is like the tree club-moss except that the rootstock or main stem is seldom subter-

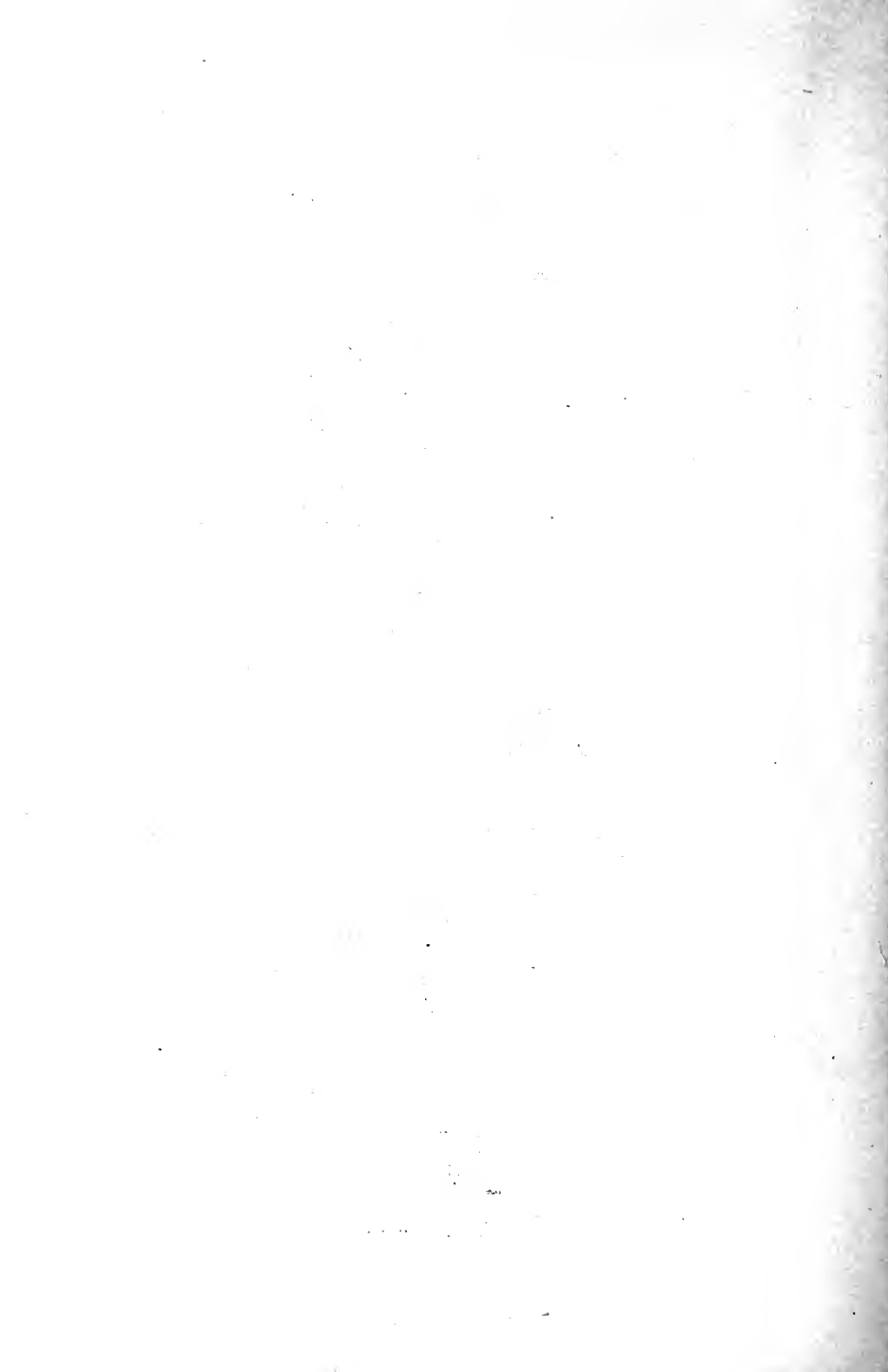
ranean. The aerial branches with us reach a height of fifteen inches to two feet and are erect or ascending. At short intervals they give off whorls of spreading lateral branches that are five or six inches long and branch again repeatedly. There are thus formed several nearly level circles of green about the main branches, after the manner of the wood horsetail. Should the main branches become decumbent at base, the lateral branches, near the earth, may lengthen and become secondary rootstocks. The main stems and branches bear large numbers of spreading leaves an eighth of an inch or more long, but so slender that the stems never seem to be heavily clothed. The branchlets bear great numbers of similar, though shorter, spreading leaves, which give the plant a soft and airy appearance.

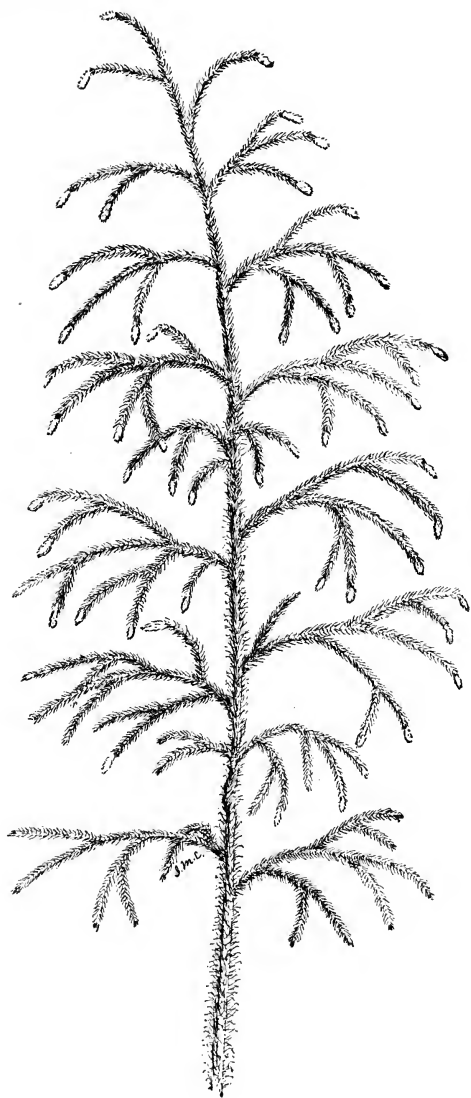
The catkins are very small, often no more than an eighth of an inch long, and are borne at the ends of the branchlets, from which they droop slightly. The sporophylls are ovate, tapering to a slender point, with finely ciliate margins. The plants are very fruitful, and the tall stems, with their circular whorls of branches covered thickly with the small cones, make a very attractive picture.

Lycopodium cernuum is pre-eminently a tropical species. It is found around the world in warm latitudes, and extends to Japan, Cape Colony, and New Zealand. As might be supposed, the specimens from the United States are undersized plants. In favourable situations it often grows to the height of six feet or more, half supported by the vegetation in its vicinity. The cones may also reach a length of nearly an inch. In our region the plant may be looked for on moist, half-shaded banks, but in the tropics it occasionally grows in drier situations.



TREE CLUB-MOSS. *Lycopodium obscurum.*

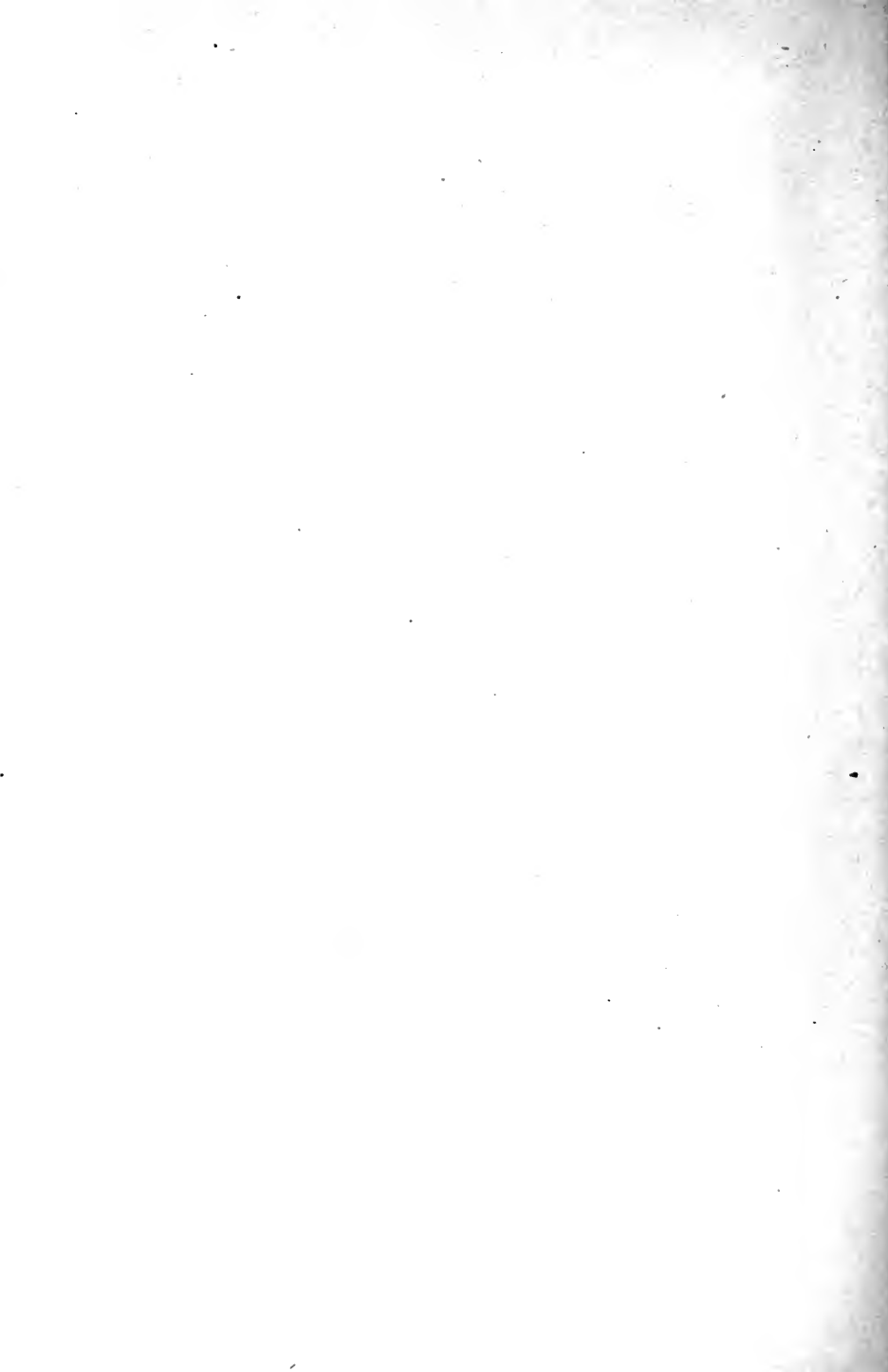




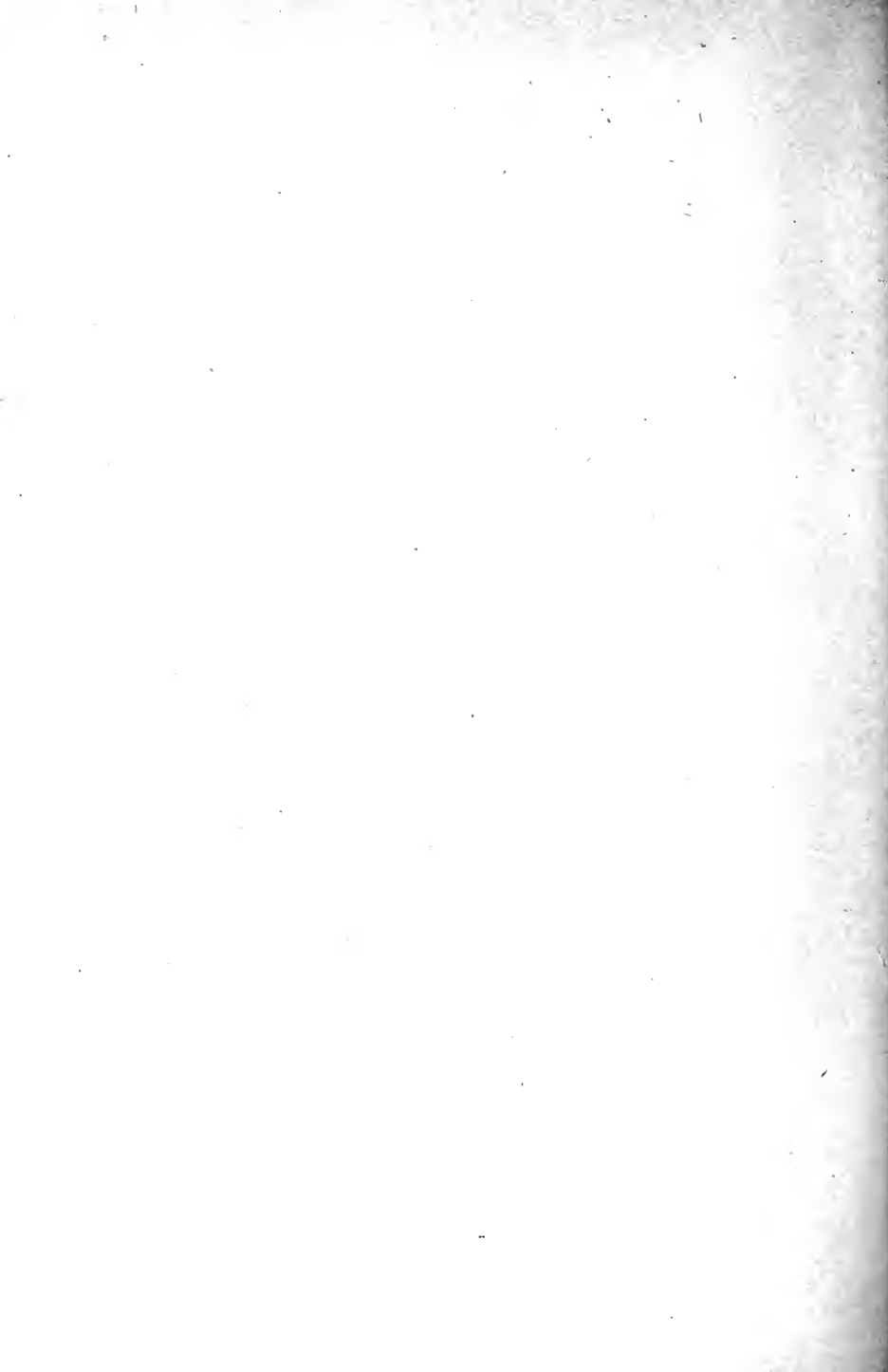
STAG-HORN CLUB-MOSS. *Lycopodium cernuum.*

It is probable that it will yet be found Louisiana, Texas and California.

The name of stag-horn club-moss, or stag-horn moss, has doubtless been given this species in allusion to the branches, which have considerable resemblance to the antlers of the deer. The plant does well in cultivation and is common in conservatories.



THE ERECT OR DECUMBENT
LYCOPODIUMS.



THE ERECT OR DECUMBENT LYCOPODIUMS.



CRITERS on the fern allies usually place the lycopodiums of the world in four distinct sub-genera, but the plants are all so much alike that no botanist ever thinks of considering any of these divisions as separate genera. The species to be presently treated come from three of these sub-genera, and so do not form a natural group; but since all of them lack the long trailing stems of the other species it will be convenient to consider them together.

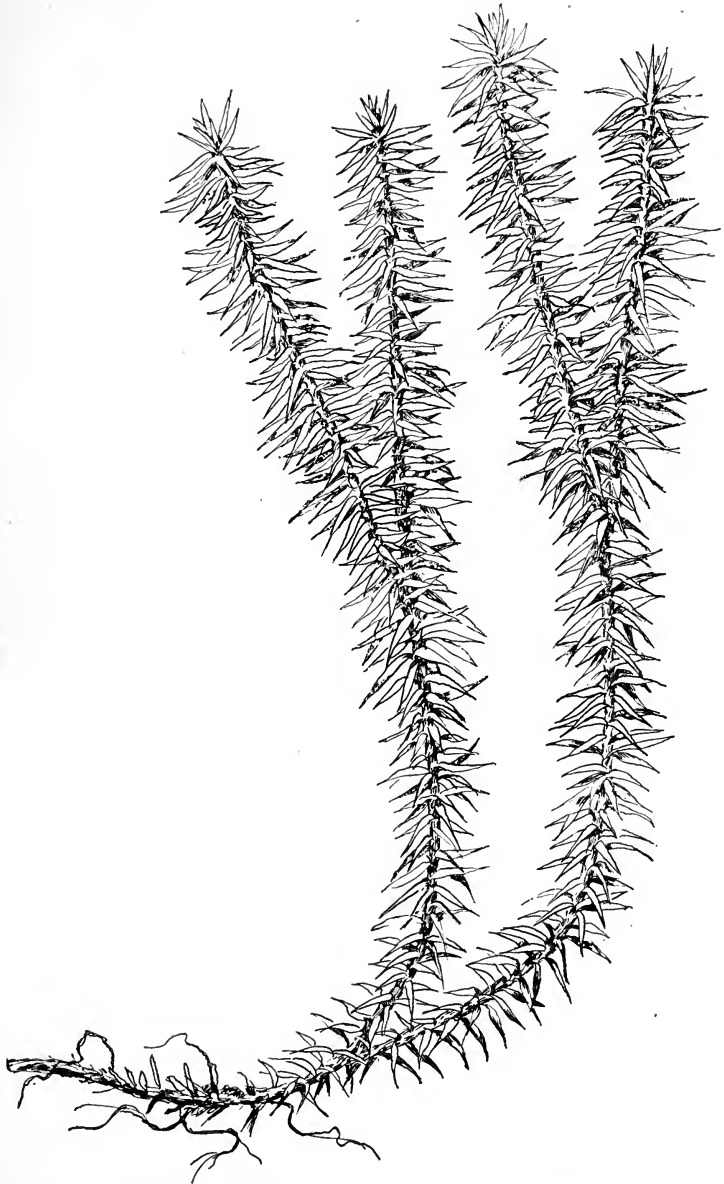
The Shining Club-Moss.

On deeply shaded hillsides, where the soil is rich and moist, one may often discover the dark-green and glossy stems of the shining club-moss (*Lycopodium lucidulum*). To such localities the plant clings persistently in spite of the falling leaves and shifting particles of soil that constantly tend to bury it. Year after year its growing tips struggle

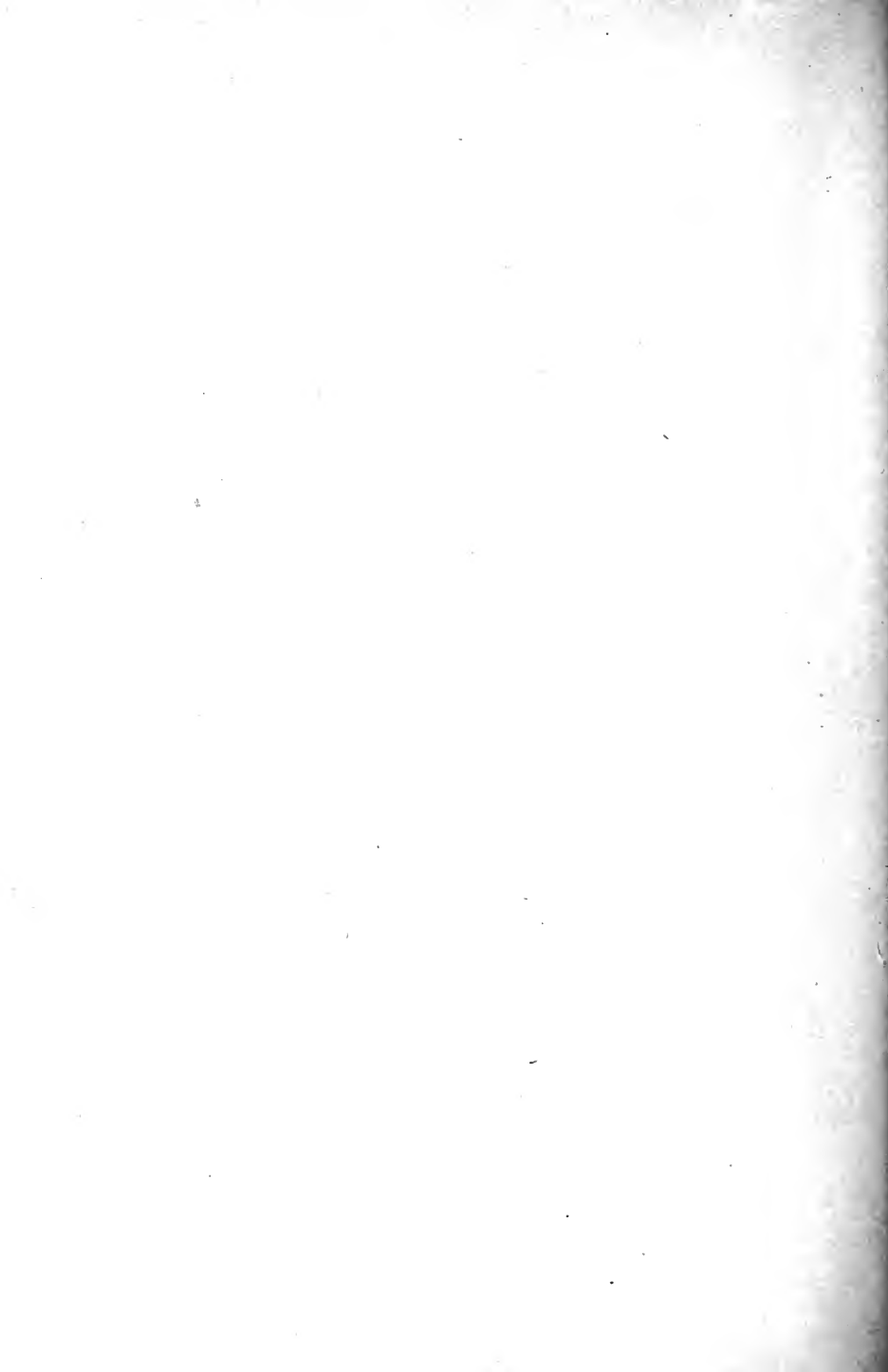
upward, and as regularly the parts at the other extreme disappear beneath an accumulation of *débris*. It is exceedingly rare to find a specimen that is not thus half buried, and in which many of the basal leaves are not yellow and dead in consequence.

The stems of this species are constructed on a plan somewhat different from that of the trailing species. There is neither rootstock nor main stem in the usual sense, but instead, the whole plant may be likened to one of the primary branches of *Lycopodium clavatum*. When the young plant begins growth, there is at first a single short stem. At length this forks at the apex into two equal branches, and these, after lengthening from one to several inches, fork like the original stem, this process continuing yearly during the life of the plant. The stems do not fork every year, but may continue for several seasons simply adding to their length. Growth proceeds very slowly, often not more than an inch a year. The stems attempt to grow erect, but after some years the weight causes the stem to become decumbent at base, and it then begins to decay. In the meantime, at intervals along the old stem, strong roots have been sent down into the soil, and when this decay has reached the first fork there are thus formed two separate plants where there was but one originally. Subsequently these two become four, and so on, a single plant ultimately giving rise to a whole colony. The living plants are often five or six times forked, but the majority fork only two or three times.

The leaves are about a quarter of an inch long, narrowly lanceolate or oblanceolate and sharp-pointed, the outer third of each leaf bearing a few scattered teeth on the margins. They are thickly set on all sides of the



SHINING CLUB-MOSS. *Lycopodium lucidulum*.



stem and stand out nearly at right angles to it, except those at the tips of the stems, which are erect. The new and spreading growth, springing from the midst of the erect leaves, marks the stem with regular zones of spreading and appressed leaves, by which the age of the plant may be told. On old parts of the stem, the leaves are usually reflexed. The leaves, though short, are the largest borne by any North American species, and are further distinguished by their very firm texture and dark-green colour.

The spores are borne in kidney-shaped sporangia, one of which is found in the axil of each of the ordinary spreading leaves near the tips of the stems. This in appearance is a wide departure from the usual way of fruiting, but when one considers that the difference is simply that in fruiting the leaves are not changed in shape and colour, a fundamental resemblance is easily seen. One other difference marks the fruiting of this species,—the ends of the fruiting-branches continue to grow, and the new leaves of one year become the spore-bearing leaves of the following season. Thus each stem has in time several zones of sporangia. In some cases there



Sporangia.

are at least six of these zones. The sporangia are bright yellow, and quite noticeable among the green leaves, but the spores do not appear to be very abundant. The empty spore-cases often remain upon the stems for years.

In addition to the ordinary means of reproduction by spores and the less common multiplication by the division of the stem, this species produces numerous small bulblets that are capable of forming new plants.

These are found above or below the zones of sporangia and issue from the same part of the leaf that the sporangia do. Each bulblet is borne on a six-bracted stalk barely a quarter of an inch long, much as the seed-pod is borne in flowering plants. The bulblets are about as long as their stalks and appear as two cotyledon-like scales. Stalk and bulblet have been likened to small plump dustpans. They may be found in their prime



A Bulblet.

about midsummer, and by early autumn they have dropped from their stalks and begun to form new plants. They may be easily found by searching beneath the old plants. The stalks upon which the bulblets are borne usually continue for a

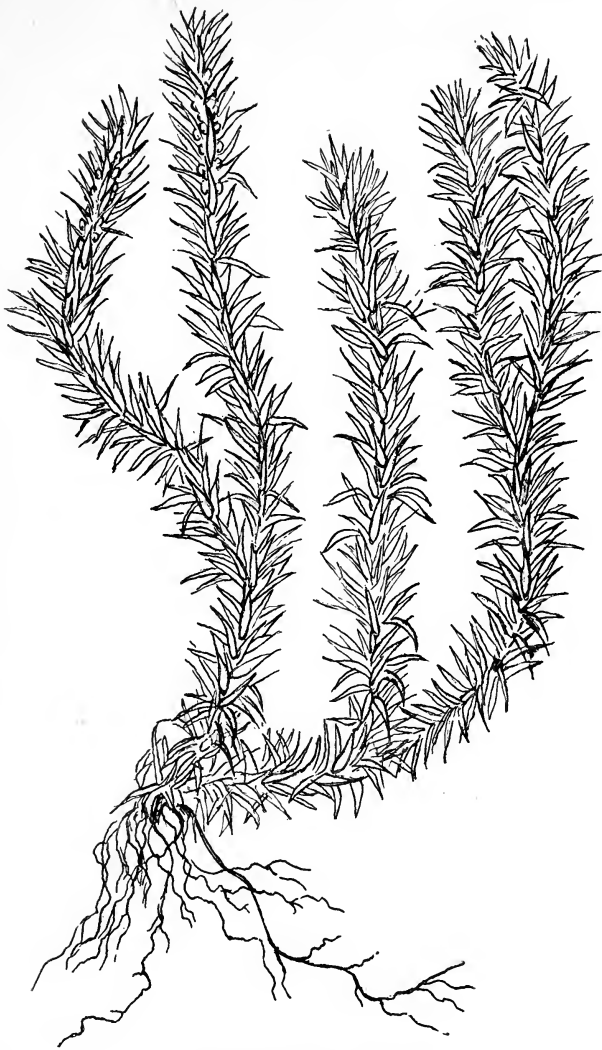


A Single Spore-case.

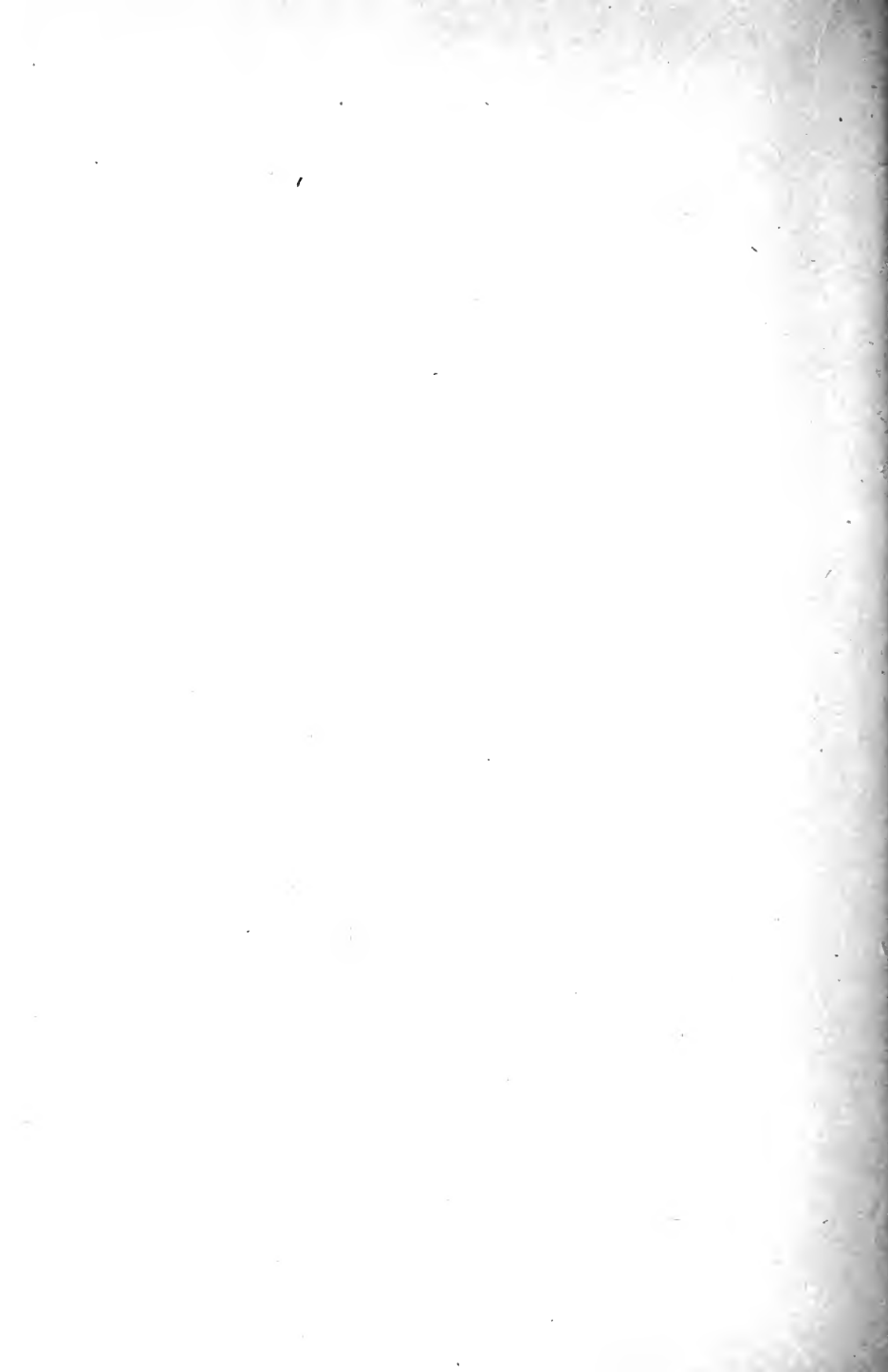
long time on the plants and may often be found in herbarium specimens.

This species is sometimes called the "hemlock club-moss," from the resemblance of its shiny leaves to those of the hemlock tree (*Tsuga Canadensis*). It is also called "swamp evergreen," in allusion to the moist places in which it loves to dwell. It is extremely tenacious of life. Specimens have been known to continue growth for a year or more when placed in a vase of water in the house. Most of the club-mosses are very difficult to transplant, but this species takes readily to cultivation.

A variety of club-moss has recently been described by Professors Lloyd and Underwood, that differs from this species only in being shorter and thicker and with slightly narrower leaves. It grows in the same manner as does the better-known plant, produces the same kind



Lycopodium porophyllum.



of bulblets, and appears upon examination to be merely a depauperate form of *Lycopodium lucidulum*. This view of the matter is fully borne out by the habitat of the plant, for it is described as growing only on sandstone rocks. It is only to be expected that this moisture-loving species, germinating upon a dry sandstone rock, would fail to come to its full luxuriance if it lived at all. It has been described as *Lycopodium porophilum*, but seems scarcely worthy of even subspecific rank. It would more properly be called *Lycopodium lucidulum porophilum*.

Its range is given as from Wisconsin to Indiana, Kentucky, and Alabama, always on sandstone rocks. The discoverer of the Kentucky station for this plant, Miss Sadie F. Price, author of "The Fern Collector's Hand Book and Herbarium," has furnished the author with specimens of this form and with the drawing which faces page 110. She writes that she collected it for a dwarf form of *Lycopodium lucidulum* and that when growing it looks like an unthrifty specimen of that species.

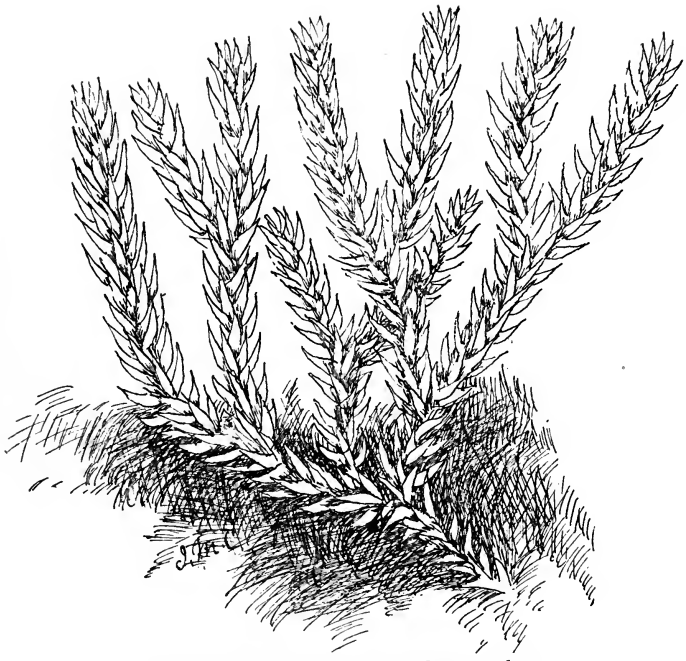
Lycopodium lucidulum ranges from Newfoundland to South Carolina, Alabama, Iowa, and Minnesota. Mr. J. B. Flett has recently discovered specimens in Washington that have been referred to this species, but owing to the fact that the leaves are thinner, with bluntish tips and fewer teeth, it has been named forma *occidentale*. *Lycopodium lucidulum* is also reported from Japan, China, and the Himalayas. It does not seem to be known in Europe, though the so-called variety *patens* of *Lycopodium selago* almost exactly matches our plant. Its favourite haunt is a cool springy bank in the dense shade of coniferous trees, though it may also be found

in drier situations. It rarely forms large patches, but is seldom absent from suitable localities throughout its range.

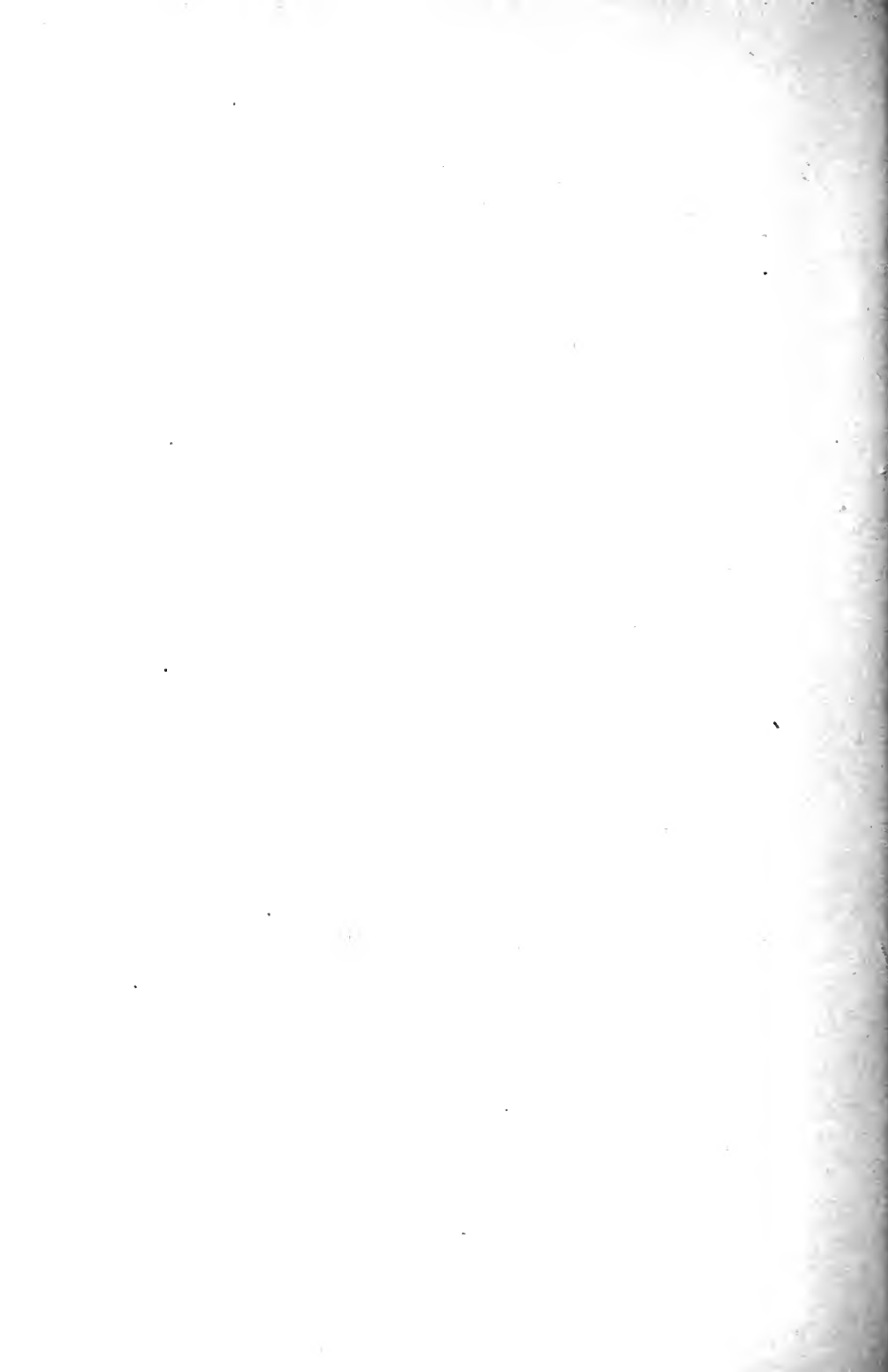
The Fir Club-Moss.

The fir club-moss (*Lycopodium selago*) is very much like the shining club-moss in general appearance; but the collector will not often mistake typical specimens, for the reason that they rarely grow in company. In the United States, the fir club-moss is a plant of high mountain summits, and is not plentiful until British America is reached. It is a shorter plant than *Lycopodium lucidulum* and seldom reaches a height of more than six inches. The stem forks several times, producing close, flat-topped tufts of branches that are usually erect, but in old or thrifty stems may become decumbent. Each year the branches add to their length, though, owing to the short seasons in its haunts, the annual additions are not very great. The leaves are a little more than an eighth of an inch long, crowded, narrowly lanceolate with a rather broad base, and are arranged upon the branches in about eight rows. They are somewhat concave on the upper side and curve upward toward the apex of the stem. In typical plants the edges of the leaves are entire and the apex is sharp-pointed.

The sporangia are borne in the axils of the leaves as in *Lycopodium lucidulum*, but although they are no smaller than in that species they are not as conspicuous, owing to the upward-curving leaves. They are also less numerous. The sporangia are not found on stems less than one season old, and, since they persist for some time,



FIR CLUB-MOSS. *Lycopodium selago*.



several zones of sporangia may be found on a single stem. This species also produces gemmæ or bulblets in profusion, and propagation by that means is probably more common than by spores.

Until recently no doubts were entertained as to the specific distinctness of *Lycopodium lucidulum* and *Lycopodium selago*, but it has recently been asserted that as one passes downward from the mountain haunts of *Lycopodium selago* he may find forms of it that gradually merge into *Lycopodium lucidulum*. It is therefore suggested that *Lycopodium selago* is only a mountain form of our common species. It is also noticeable that in Europe, where *Lycopodium selago* is common and *Lycopodium lucidulum* unknown, there is a variety with spreading, toothed leaves that appears to be very close to, if not identical with, our *Lycopodium lucidulum*. Some botanists are inclined to lay stress upon the fact that in *Lycopodium lucidulum* the zones of leaves are alternately appressed or spreading, while in *Lycopodium selago* they are all appressed or at least ascending; but it can easily be shown that the alternating zones of *Lycopodium lucidulum* are due to longer periods of growth, the spreading leaves being produced at the height of the season. If only a few leaves were produced each year, they would undoubtedly be ascending. Should further studies prove the truth of the theory that the plants called *Lycopodium lucidulum* and *Lycopodium selago* are but extreme types of one species, a reërrangement of names will be necessary. *Lycopodium selago*, having been named first, would retain its name, while the other would become *Lycopodium selago lucidulum*.

This species was once valued for its medicinal qualities. It was occasionally used as an emetic and cathar-

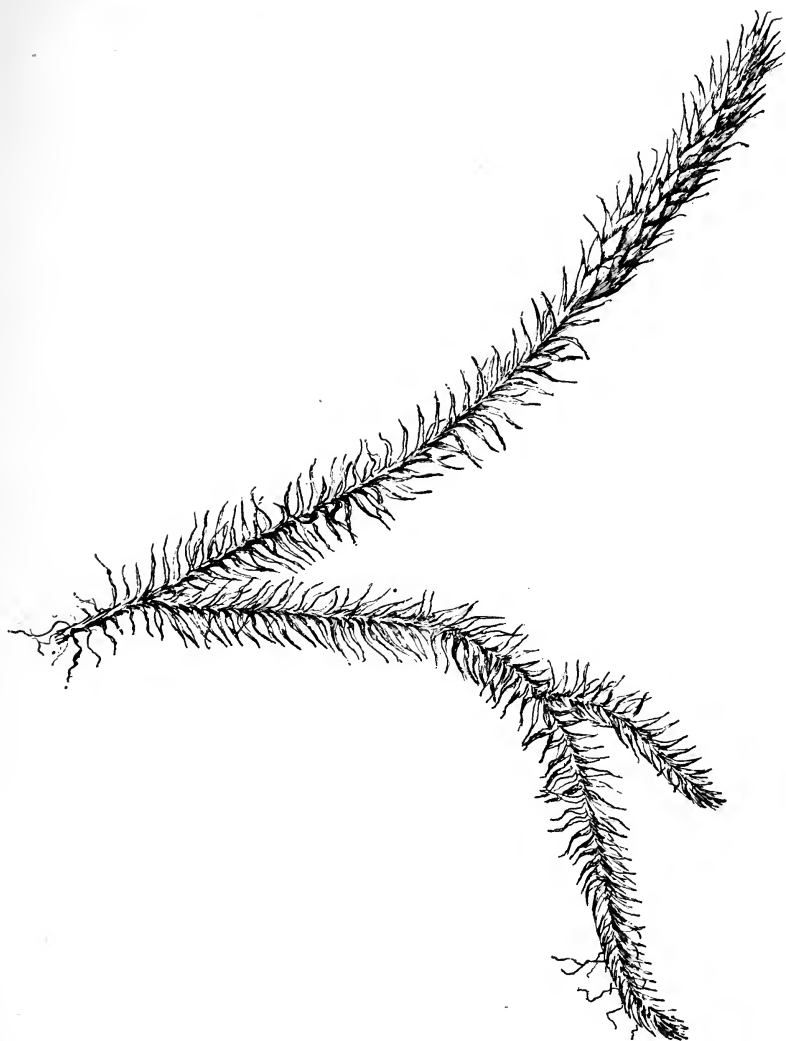
tic, but it is too powerful to be safe. According to Moore's "British Ferns" it was also used in the form of an ointment as a counter-irritant. A decoction of the stems is said to be used in Sweden to destroy vermin on cattle. Like other species, this plant has been used for dyeing and for fixing the colour of woollen goods. In Ireland it is known as "Virgin Mary's furze," and in Cornwall as "good-luck." According to M. W. Gorman the natives of Alaska use the stems to produce a kind of intoxication.

In the United States, *Lycopodium selago* is found from North Carolina to Maine, Michigan, and Washington, but only in the higher mountains. It extends to Alaska and Greenland, being most plentiful and growing nearly at sea-level in these northern countries. It is abundant in northern Europe and Asia, and has been reported from Australia, New Zealand, and Antarctic America. Many forms of it are reported from the tropics, but these are probably distinct species.

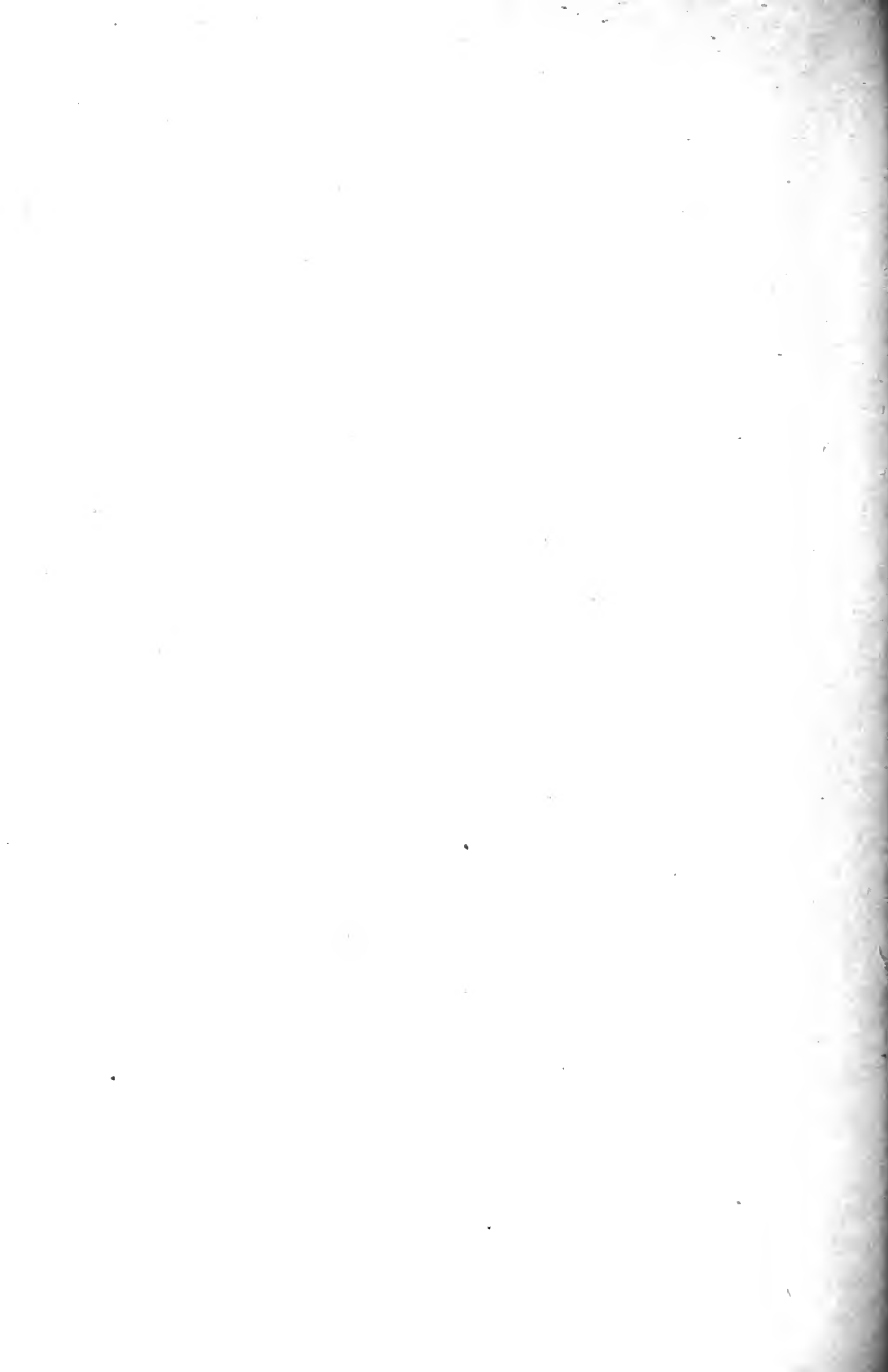
The Bog Club-Moss.

The club-mosses with which the average collector is most familiar delight in moist spots in woodland, on mountain side, or on moor, but the bog club-moss (*Lycopodium inundatum*) is so fond of moisture that it frequently grows in beds of sphagnum close to the trembling boggy margins of our small lakes and ponds, its habitat alone being often sufficient to identify it.

The stems of this species present still another departure from the more familiar club-moss form. They are slender and threadlike, from two to eight inches long, and are rooted near the base, beyond which they usually



BOG CLUB-MOSS. *Lycopodium inundatum*,
(Twice natural size.)



rise clear of the earth, bending over in the form of an arch to root again at the tip. The plant is therefore as truly a walking club-moss as *Camptosorus rhizophyllus* is a walking fern. In the smaller specimens the stems commonly do not branch, but in the larger ones two or three short branches may be produced, each of which roots at the tip like the main stem. Indeed, this is their only means of continuing existence, for at the end of the growing season the older parts of the plant die, leaving these vigorous, bud-like tips, filled with plant-food, as so many points from which new stems may be produced the following year.

The leaves are from an eighth to a quarter of an inch long, linear, entire, with broad bases and pointed tips, and are closely crowded on all parts of the stem, though owing to its horizontal position those on the under side turn upward, so that all appear to grow from the upper side. The fruiting parts are at the tips of separate stems which are much like the main stems except that they are stiffly erect. They are quite short, usually under five inches high, and spring from the older parts of the main stem. They are clothed with leaves similar to those on the other parts of the plant, but less spreading, and there is usually but one fruit-stem to a plant. The cone of fruit is from a quarter of an inch to two inches long and about twice the diameter of the stem. There is no sharp line marking the separation between stem-leaves and sporophylls, one almost imperceptibly merging into the other. Typical sporophylls are broad and rounded at base, toothed above, and suddenly narrowed to a long slender tip; but, near the base of the spike, sporangia are borne by the ordinary linear stem-leaves. The sporangia approach globose in shape, and

though but one is borne in the axil of each sporophyll they are numerous enough to make the spike the heaviest part of the plant. The spores are ripe in late autumn.

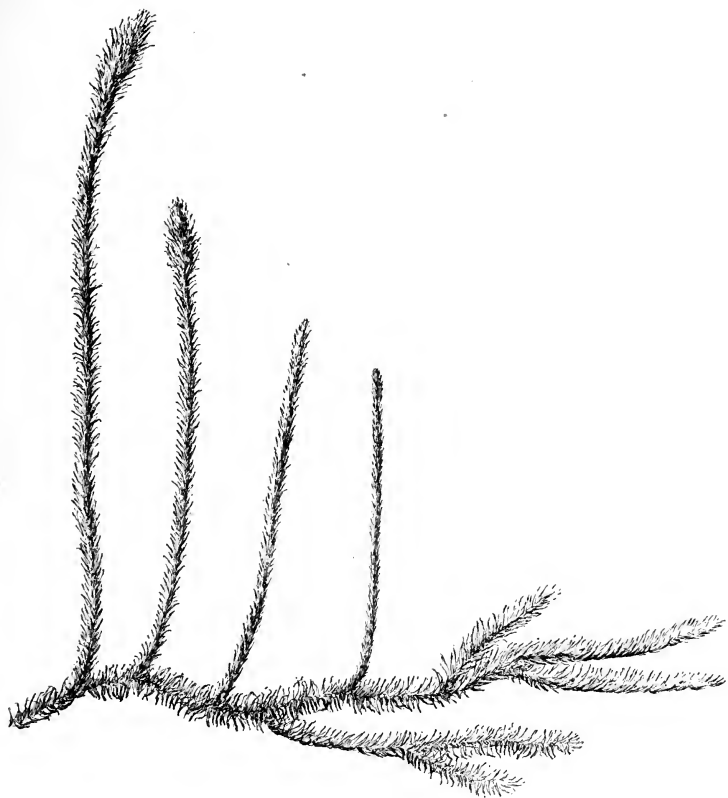
A larger form of this plant, with slender branching stems and slightly longer leaves, has been named the variety *Bigelovii*. According to Baker's "Fern Allies" the fertile stems of this are sometimes a foot long, with a spike six inches in length. It is the author's opinion, however, that a form of the closely related *Lycopodium alopecuroides* has been wrongly identified as this form. He has seen no specimens of the so-called variety *Bigelovii* that were not more properly placed elsewhere.

In localities where the bog club-moss is undisturbed, the plants frequently form "fairy rings" like those formed by various fungi. The rings are due to the creeping habit of the plant, which tends to carry the tips slowly outward from the centre, which is left vacant by the dying of the older parts. Where the progress is unobstructed, the circles continue to enlarge for many years.

The bog club-moss is a northern plant, being plentiful in Labrador and Alaska, and extending southward to New Jersey, Pennsylvania, Illinois, and Washington. It is also a common species in the north of Europe. It is seldom found except in swampy ground, and is considered rather rare in the United States. After the Carolina club-moss it is our smallest species. It is possible to find fruiting specimens less than two inches long.

The Fox-Tail Club-Moss.

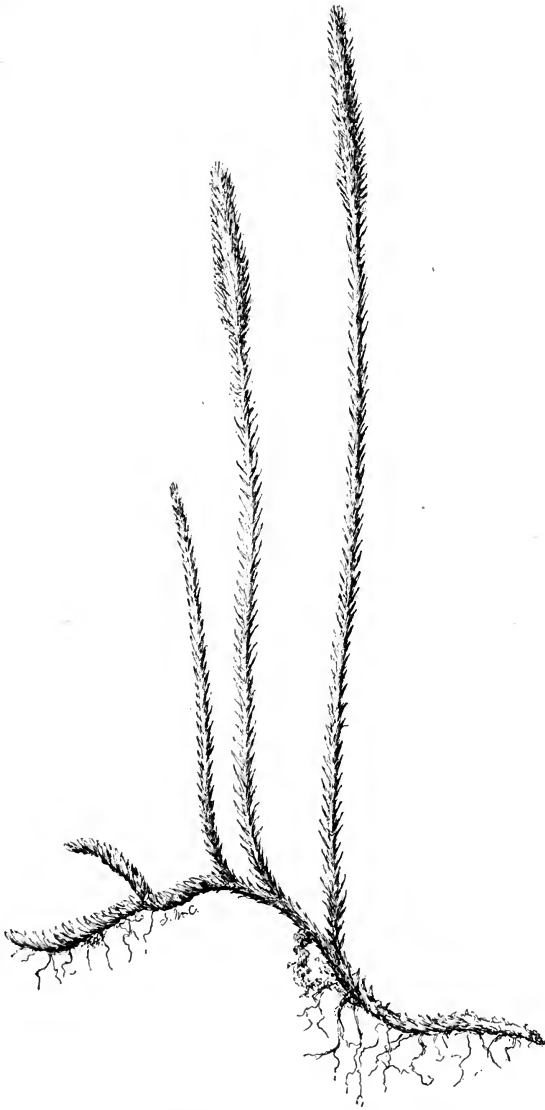
Just as the bog club-moss begins to be rare southward, another species appears which resembles it so closely



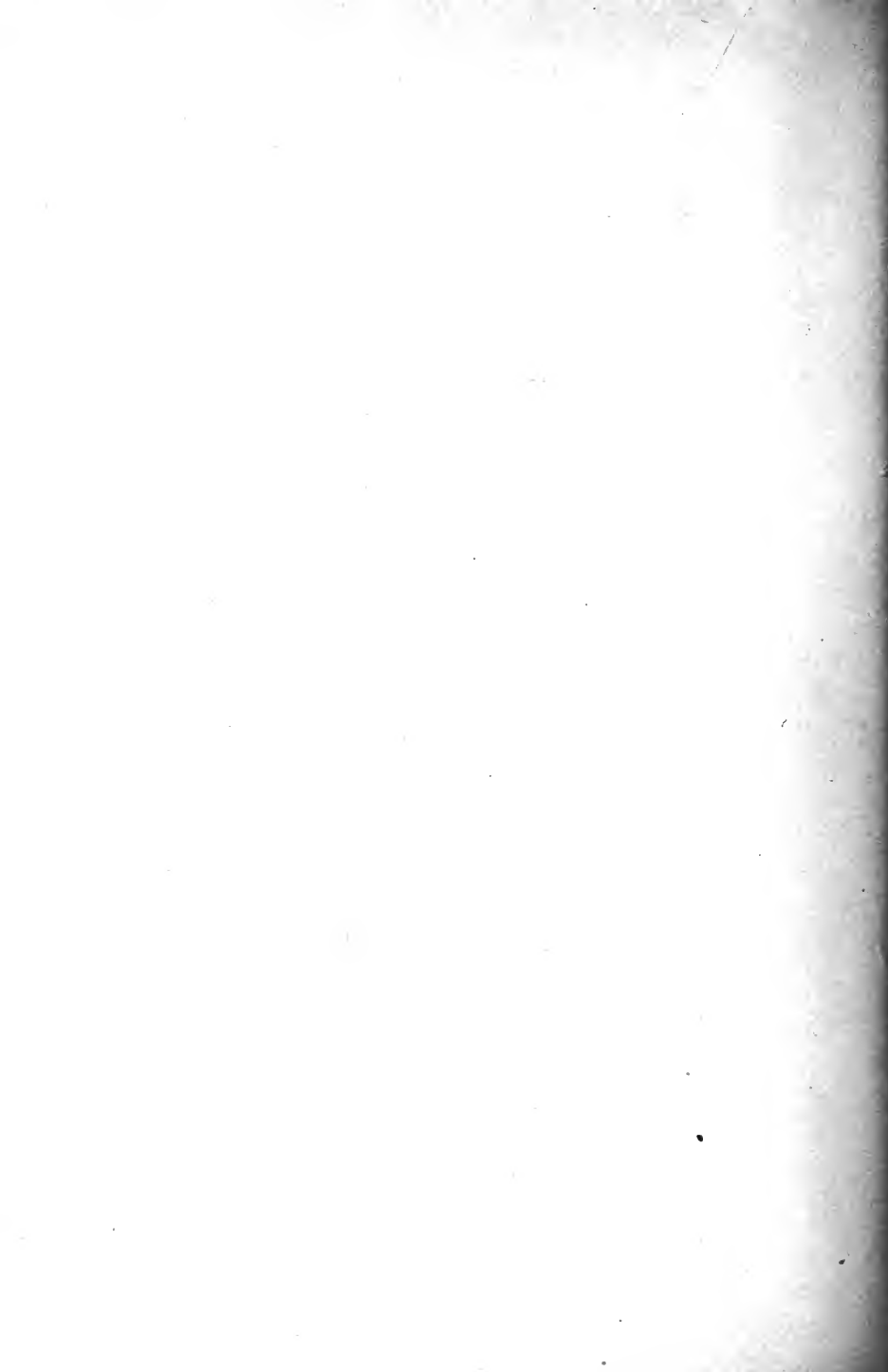
FOX-TAIL CLUB-MOSS.

Lycopodium alopecuroides. One-third natural size.





Lycopodium alopecuroides adpressum.



that the novice might be excused if he should think it a gigantic specimen of the northern plant. This new species is the fox-tail club-moss (*Lycopodium alopecuroides*), a plant which reaches its best development in the Southern States, but which in the northern part of its range is still so robust that the single characteristic of size is nearly enough to distinguish it.

The sterile stems of *Lycopodium alopecuroides* are from ten inches to two feet long. In small specimens they may arch as do those of *Lycopodium inundatum*, but in the larger plants they are likely to be simply trailing. The main stems are about an eighth of an inch in diameter and give off several lateral branches, the more vigorous of which may branch again. The stems root most abundantly near the tips, but may also produce slender roots wherever they come in contact with the soil.

The leaves are a quarter of an inch or more in length and are produced thickly on all sides of the stem, but those from the under surface grow upward and appear as if produced from the sides. They are narrowly linear, spreading, with the tips pointed, and the margins bearing an occasional slender tooth.

The fruiting stems are erect, a foot or more high, and are clothed with appressed or spreading leaves like those of the sterile parts. The spore-bearing area is from one to four inches long, and about one third thicker than the stem which bears it. The sporophylls are much like the ordinary leaves, but longer and with more teeth. The spores ripen very late in the year, often not until the end of October in the north. Unlike *Lycopodium inundatum*, a single plant often produces several fertile stems, as well as certain additional upright stems that are manifestly in the nature of fertile stems, but

which never come to fruition. These latter are borne on the branches or on the newer parts of the main stem, and are doubtless produced too late in the season to be fruitful. In exposed places throughout its range there is found growing with the type a form that by some has been considered a species and named *Lycopodium adpressum*. It differs from the type in being somewhat smaller, with shorter, thicker, less spreading leaves, and with slender fruiting-stems clothed with appressed leaves in shape like those of the sterile stems. The fruit-spikes are from one to four inches long, and about twice the diameter of the stems that support them, the sporophylls being rather broader at base than in the type. Owing to the appressed leaves, the fruiting parts are more distinct and cone-like than those of the type. The spores are produced in great abundance. Several fertile stems are usually produced on each plant, and the upright sterile stems noticeable in the typical *Lycopodium alopecuroides* are also plentiful. All the characteristics in which this form differs from typical plants are such as might be produced by an unusual amount of light and heat, and the exposed situations in which the plants grow seem fully to account for this appearance. Under these circumstances it seems better to call this a sub-species and to name it *Lycopodium alopecuroides adpressum*. Although this form has always been known by the name of *adpressum*, whether treated as a species or as a variety, it has recently been proposed to change it to *Chapmani*, because the name *adpressum* was earlier applied to another plant. If considered as a variety, our plant would now be called *Lycopodium alopecuroides Chapmani*.

A curious form of *adpressum* was found on Staten

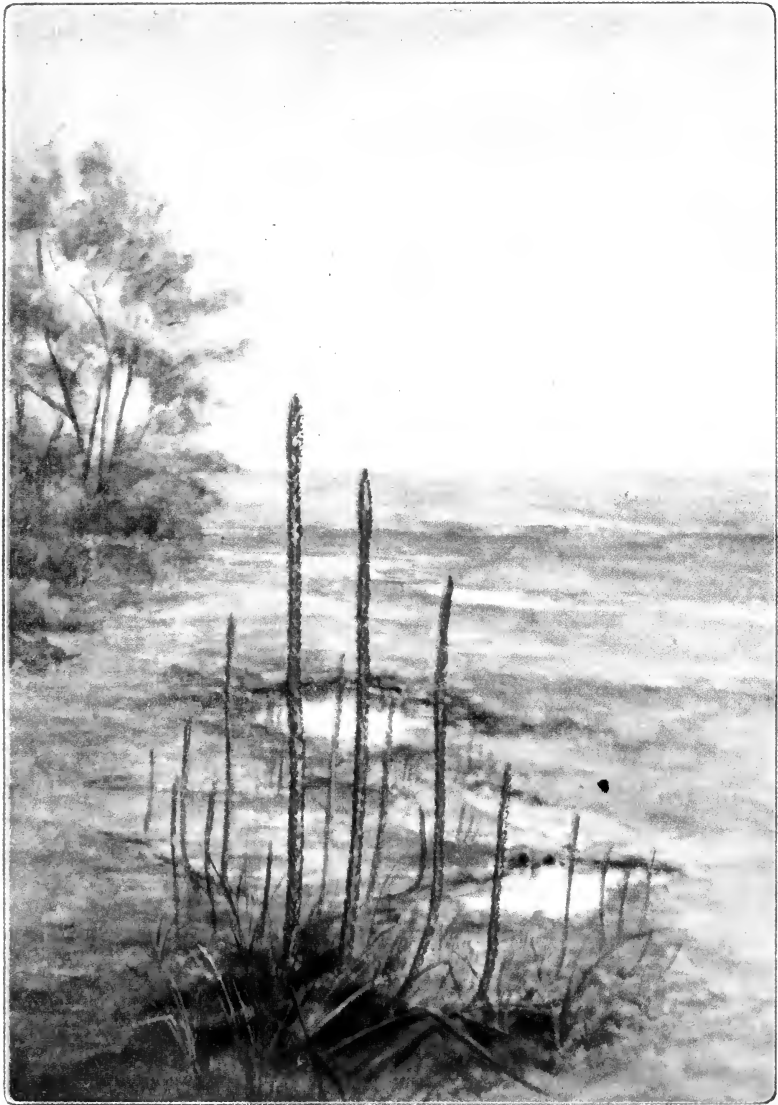
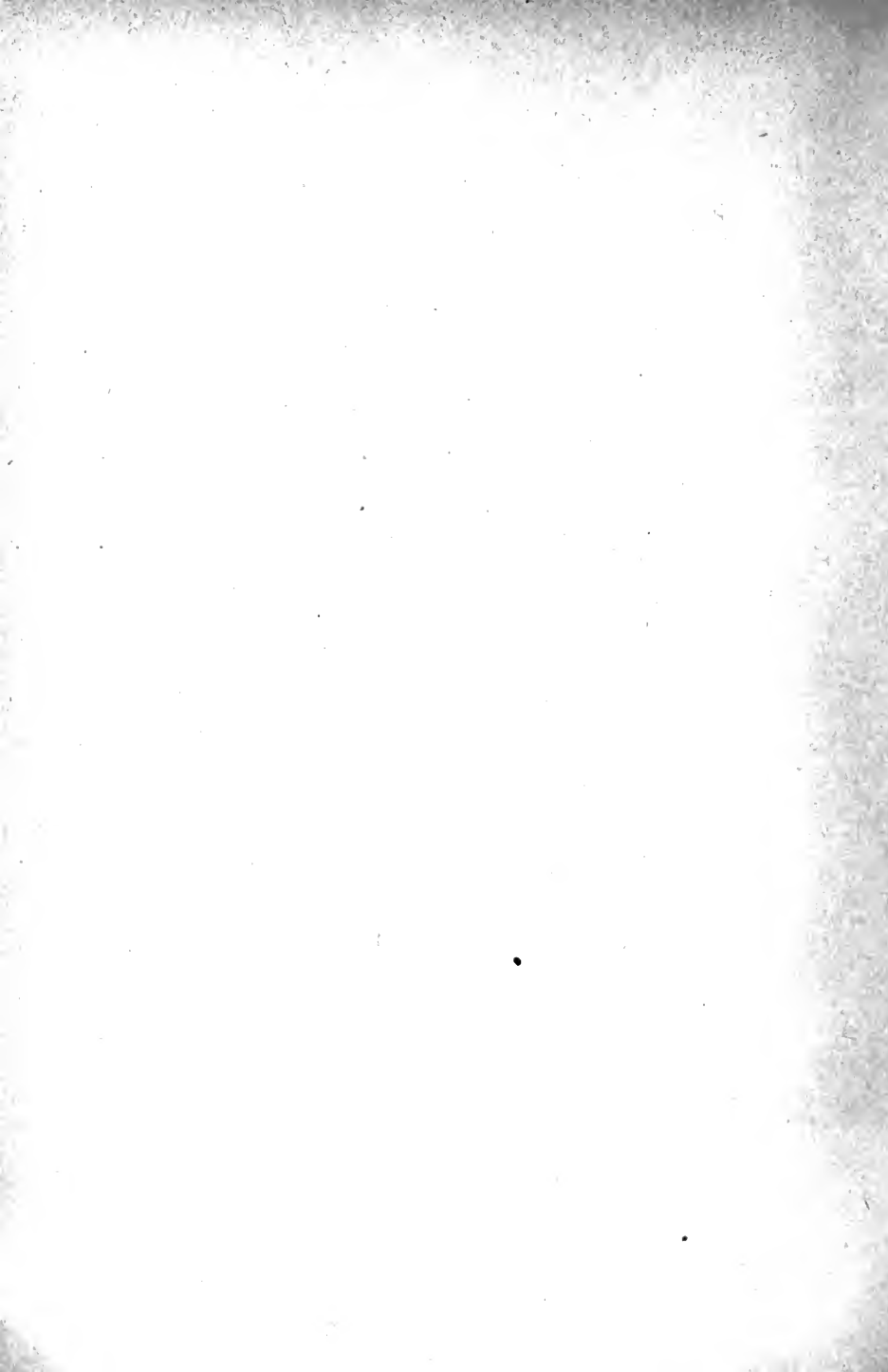


PLATE V. LYCOPODIUM ALOPECUROIDES ADPRESSUM.

THE PHOTOGRAPH BY FREDERICK ALLEN COLEMAN



Island, New York, by W. H. McDonald, who named it *polyclavatum*. It is like ordinary *adpressum* with the exception that the fertile stems each bear from two to six short branches, some of which produce fruit cones while others are sterile.

Still another form of *Lycopodium alopecuroides* is occasionally considered a distinct species and called *Lycopodium pinnatum*. It is a slender plant, growing in wet places, and derives its specific name from the supposition that its stems are pinnately branched. It is certain, however, that while the stems may appear pinnate they are not really so, and that this is simply a more branched form of the species. Aside from this character the stem is long and slender, and the leaves are inclined to stand out at right angles to the stem, this being due to the watery habitat the form affects.

Lycopodium alopecuroides is essentially a tropical plant and within our limits is confined rather closely to the Atlantic and Gulf coasts. In South America it is said to extend to Monte Video. The typical form extends northward to Long Island, where it was first discovered by the author near Babylon. The form *pinnatum* is a luxuriant phase of the plant found only in watery situations in the Gulf States. *Lycopodium alopecuroides adpressum* extends to the coast of Massachusetts and is the commonest form from New Jersey to Virginia. The plant is a lover of the swampy sand-barrens and often covers large areas. So far as known, both the species and varieties are absent from the interior of the continent.

The various disguises of this plant have always been a puzzle to botanists. It was first described as a variety of *Lycopodium inundatum*, and when the forms were discovered they too were named as varieties. There is

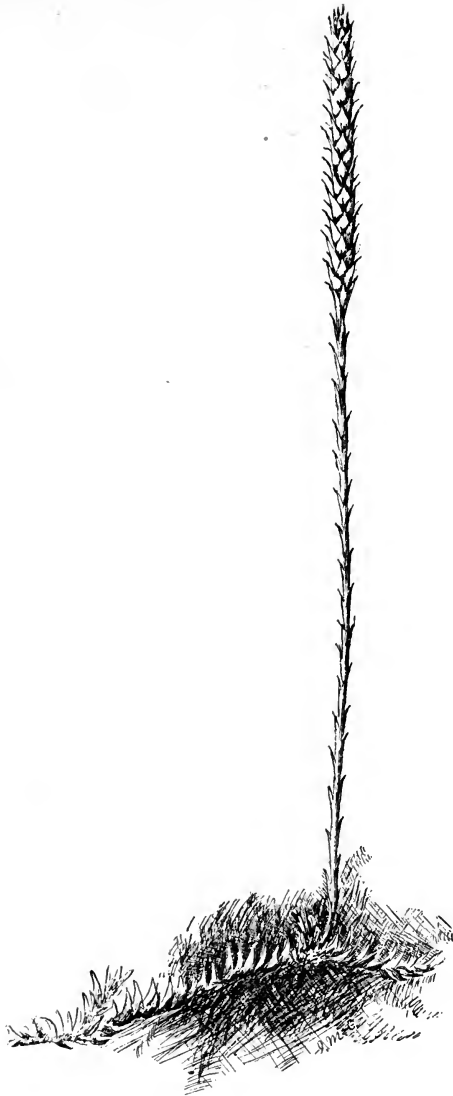
no doubt, however, that it is distinct from *Lycopodium inundatum*. The common name of "fox-tail club-moss" has been given this species in allusion to the bushy spike of fruit like a fox's tail.

The Carolina Club-Moss.

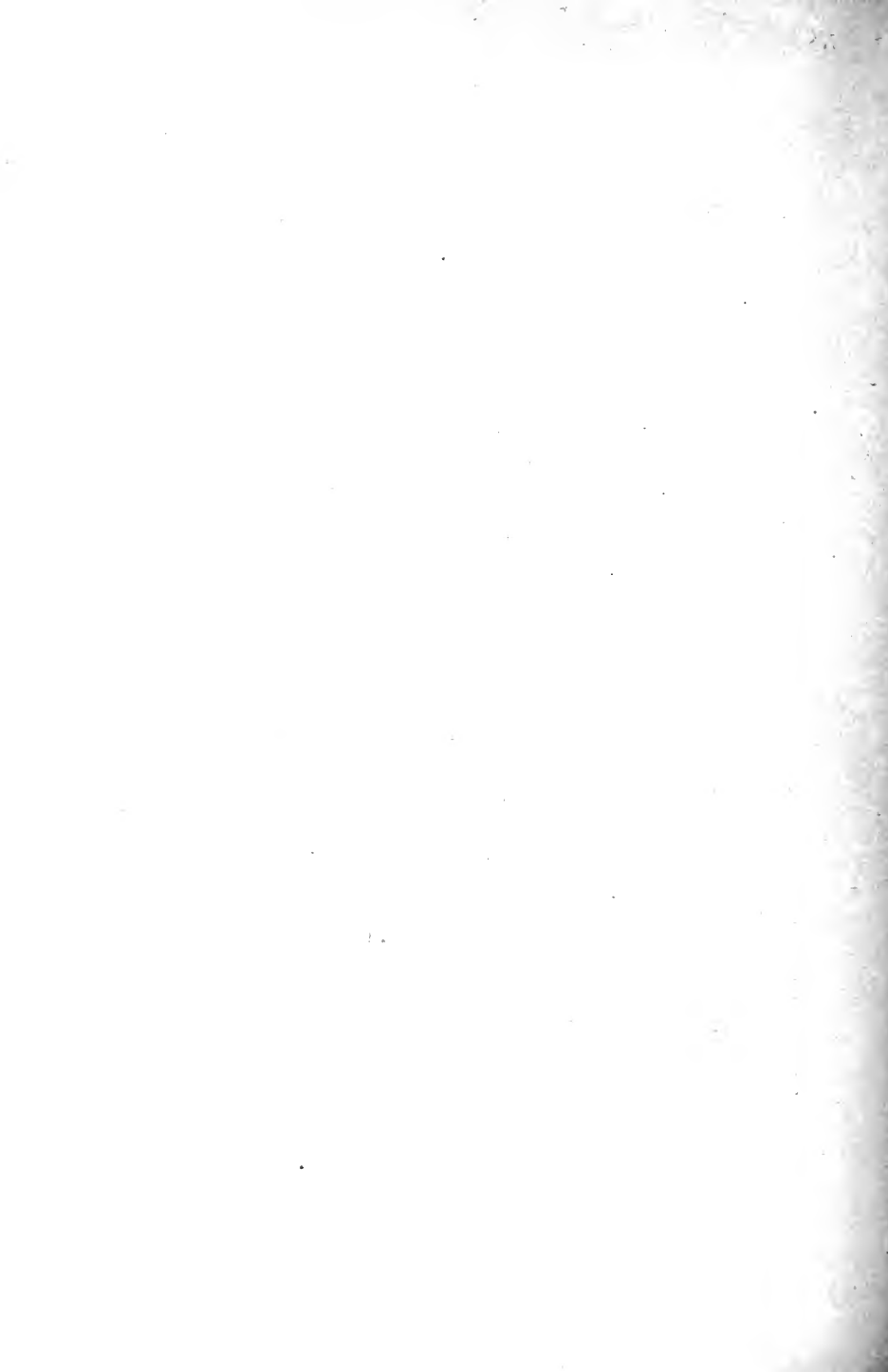
The Carolina club-moss (*Lycopodium Carolinianum*) is one of the most diminutive of its race, and its claims to being the smallest North American species could not be contested with any prospects of success by any save the bog club-moss. In the northern part of its range, at least, it is clearly entitled to the honour, and it is only when we include the more robust plants of the South that any doubts arise.

The sterile stems of this species are from one to four inches long and are appressed to the earth, clinging so closely by means of numerous roots that the plant can scarcely be got up entire without the use of knife or trowel. Owing to their position the stems are markedly dorsi-ventral, and the leaves are of two sorts, the larger often a quarter of an inch long, borne on the sides of the stem and spreading; the others awl-shaped and borne on the upper side of the stem. The large leaves are ovate-lanceolate with a broad base, entire margins, and pointed apex. In these, one side is longer than the other, causing them to curve sidewise and throwing the tiny midrib a little to one side of the middle. Although so short, the stems usually produce one or two small spreading branches.

The fruiting-stems, of which there appears to be but one to a plant, no matter how robust the specimen, rise from the older portion and often reach a height of ten



CAROLINA CLUB-MOSS. *Lycopodium Carolinianum*.

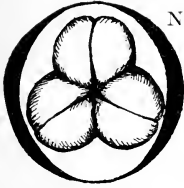


or twelve inches,—several times the length of the sterile stems. They are very slender, but are stiffly erect and sparsely clothed with small, linear, appressed, long-pointed leaves. At the top is borne the single cone, consisting of many close-set, yellow sporophylls, each subtending a roundish spore-case. The sporophylls are broad and rounded, with spreading tips, and the cone is about three times the diameter of the stem or peduncle. In the northern part of its range the fertile stems are usually short, and the cones are from half an inch to an inch long. In the South the stems are taller, and the fruiting portion often three or four inches long, though not much thicker than in the Northern plant.

The Carolina club-moss is found from central New Jersey south to Florida and Louisiana, so far as known, only near the coast. It delights in open sandy swamps in the pine-barrens, and in its New Jersey haunt is frequently a neighbour of that rare little fern, *Schizæa pusilla*. It is not found in Europe, but according to Baker's "Handbook of the Fern Allies" it occurs in Ceylon, Hong Kong, New Guinea, Tasmania, and the Cape of Good Hope. It is also reported to occur in South America as far south as Brazil. It is probable that many of these forms will ultimately turn out to be different species. Some are described as having stems a foot long. In the tropics, forms referred to *Lycopodium Carolinianum* sometimes bear tubercles on the sterile stems.

THE PSILOTACEÆ.

THE PSILOTACEÆ.



ONE of the most curious of all the fern allies, and one of the rarest in our flora, is that relative of the lycopodiums which botanists call *Psilotum triquetrum*. This, in fact, is often considered as one of the Lycopodiaceæ, and in many books will be found included as one of the four genera supposed to belong to that family; but the typical *Psilotum* form is so different from that of *Lycopodium* that in the opinion of modern botanists we are warranted in placing the species in a separate family which has been named the Psilotaceæ. In this family, as now recognised, there is the single genus *Psilotum*, and in this genus less than half a dozen species. Baker's "Fern Allies" names but two species and several varieties. Others are inclined to give some of the most pronounced of these varieties specific rank, but in any event the genus will always remain with very few species. The family being so small, a description of our single species will suffice for an account of the whole family.

Like many of its relatives among tropical lycopodiums, our species (*Psilotum triquetrum*) is epiphytic and usually grows on the trunks of trees, though it is occasionally found upon the earth, on fallen logs, or the like. The mature plant has no true roots, from which it is conjectured that it is a saprophyte, like the mushrooms,

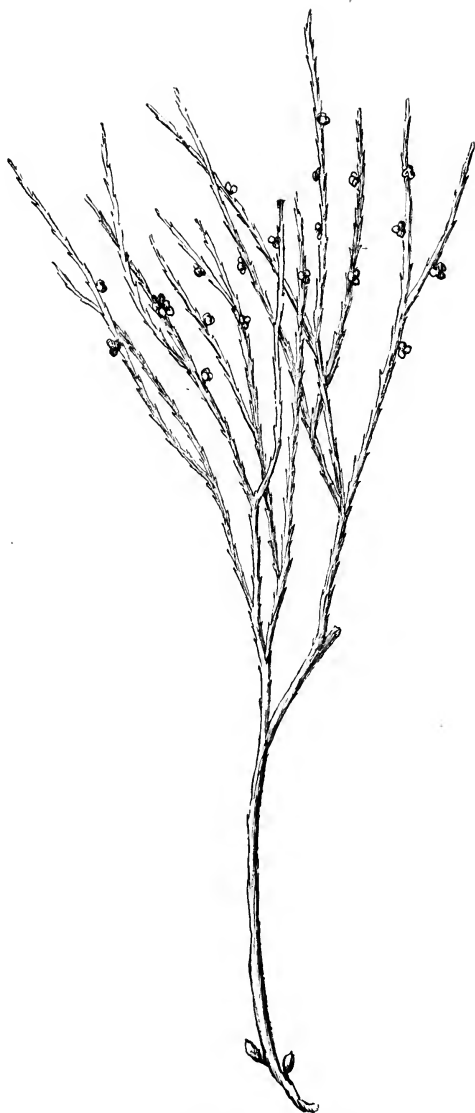
absorbing its nourishment from decaying plant tissues by means of its root-like rhizomes. These rhizomes are curious structures consisting of a great number of cord-like organs that form a tangled mass from six inches to a foot or more in extent. From various parts of the rhizome the stems rise to a height of twelve inches or more, at the top forking repeatedly to form the fan-shaped branches. The base of the main stem is about one tenth of an inch in diameter and is three-angled, and the branchlets are three-winged. The leaves are reduced to tiny linear scales less than one twelfth of an inch long, and, though scattered along the angles of the stems and branches, are so inconspicuous that the plant always appears to be leafless.



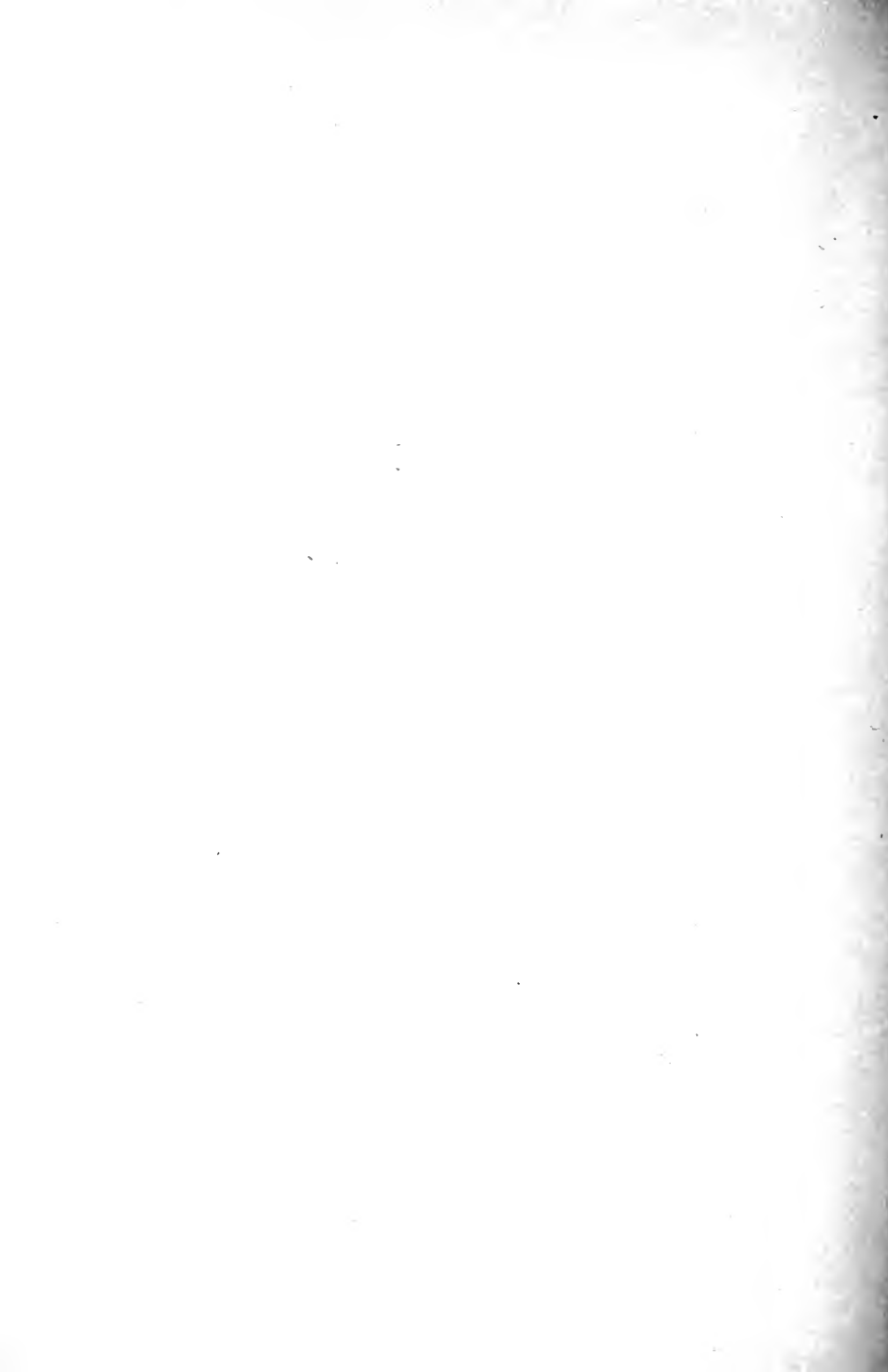
Synangia of
Psilotum.

The sporangia occur singly along the branchlets, each small leathery spore-case held in a slight hollow of the stem by a forked sporophyll which looks like a pair of the stem leaves. The spore-cases are globular or top-shaped, three-lobed, three-celled affairs, opening at the top, when ripe, by three tiny oblong slits. Spore-cases of this type are often called synangia. From their appearance they have been likened to tiny apple-dumplings.

Although the spore-cases are produced in abundance and the spores are numerous, the plant has additional means of reproduction. When it grows in soil, it may send out certain slender subterranean shoots which produce a great many buds or bulblets by which the plant multiplies rapidly. Occasionally these buds may remain dormant for a long time. The prothallia of this species is unknown.



Psilotum triquetrum.



The range of *Psilotum triquetrum* is from northern Florida southward. The species was once reported from South Carolina, but some doubt may be entertained as to its existence there at present. In central Florida it is not uncommon, usually growing on the palmetto, and it is probable that it may yet be discovered in other of the Gulf States near the coast. It is widely spread in the tropics, extending quite around the world and reaching Japan and New Zealand. It has long been known under the specific name of *triquetrum* in allusion to its three-angled branches, but recent works occasionally list it as *Psilotum nudum*. Campbell, in his "Mosses and Ferns," is inclined to add to the Psilotaceæ the genus *Tmesipteris*, which contains a single species growing in New Zealand. Other authors place this with the Lycopodiaceæ. No fossil plants have yet been found that can with certainty be referred to the Psilotaceæ, though various specimens from the Coal Measures are commonly regarded as belonging to this family.

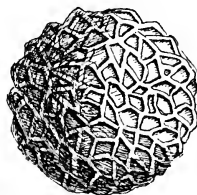


THE SELAGINELLACEÆ, OR DWARF
CLUB-MOSSES.

THE SELAGINELLACEÆ.



IN the time of Linnæus the plants that are now referred to the genus *Selaginella* were thought to be true club-mosses, and such species as were then known will be found in old botanical works in the genus *Lycopodium*. There is, however, this important difference between them. In the lycopodiums the spore-cases bear many spores all of the same size and appearance, which produce prothallia of one kind, while in *Selaginella* the lower spore-cases in the fruit-spikes each bear about four large spores called megaspores, while the spore-cases higher up in the spike bear great numbers of smaller spores called microspores. When the microspores germinate they form very reduced prothallia bearing only antheridia, and are therefore called male prothallia; while the megaspores produce larger prothallia with only archegonia, and hence are called female prothallia. Both sorts of prothallia begin to develop before the spores have left the sporangia, but even after the spores have fallen, the prothallia, unlike those of most of the ferns and fern allies, never leave the spores. When the prothallium in the megaspore has nearly attained its growth, the thick



Megaspore of *Selaginella rupestris*. (Much enlarged.)

and rough walls of the spore split apart at the apex, exposing the part of the prothallium bearing the archeogonia, and these, after fertilization, contain the developing plants. On account of the early development of the prothallium, and various other features connected with



Spike of
Selaginella.

the manner of spore production, the selaginellas are thought by many students to be more nearly related to the flowering plants than are any other Pteridophytes. The fertile spikes differ very little from the flowers of the pines and their allies. The most noticeable distinction is that the microspores of the pines (called pollen) are borne in separate catkins.

In most other respects the selaginellas have a general resemblance to the lycopodiums, but except in tropical countries this is not close enough to be confusing. Our North American species are easily distinguished by their much smaller size; in fact they are so diminutive that they are much likelier to be confused with the mosses than with the lycopodiums.

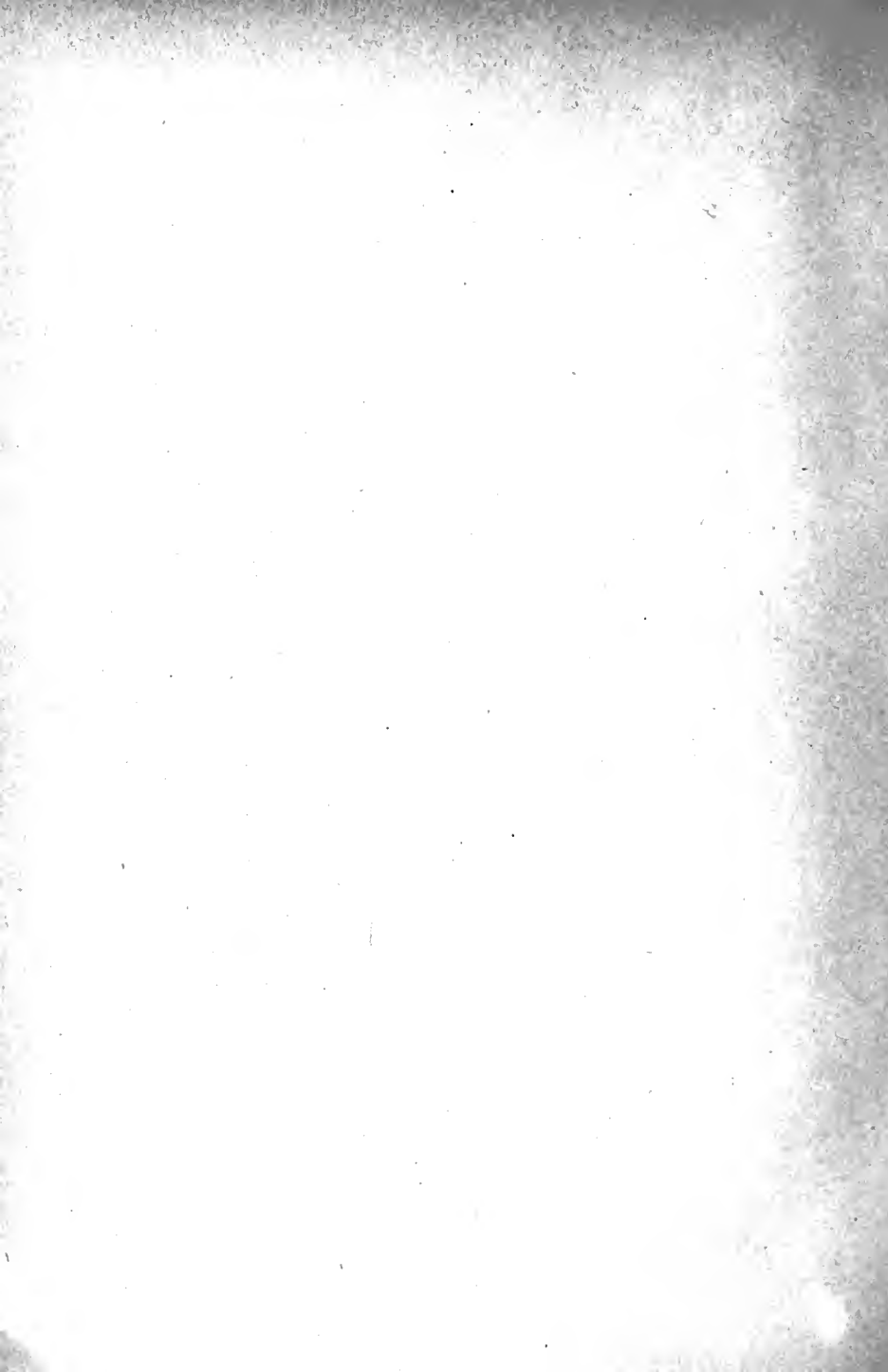
In our species the main stems seldom reach a length of more than six inches. Often they are trailing, but occasionally they are more erect. The trailing species, as in the lycopodiums, send out forking roots at frequent intervals, but the species with upright stems root only near the base. The stems are usually branched, though not dichotomously so, and the whole plant is generally very close to the earth.

The leaves are minute and very abundant, clothing both stems and branches. The form of the leaves has been made the basis for dividing the genus into two sections. In one they are all alike and arranged in many



PLATE VI. ROCK SELAGINELLA. *Selaginella rupestris*.

CCPR 5HT, 1911. BY FREDERICK A. STICKES COMPANY



rows, and in the other they are of two forms and arranged in four rows. Of these four rows, two contain large leaves and two contain small ones. The large leaves are in the two rows on the sides of the stem, while the small ones are on the upper side of the stem and alternate with them.



Two forms
of *Selaginella*
Leaves.

The fruit is borne at the ends of the branches, a spore-case in the axil of each leaf. In some species the fertile spikes are hardly to be distinguished from the ordinary branches, while in others the spore-bearing leaves are yellowish in colour, more or less changed in shape, and are assembled in little cones as in most lycopodiums. Often these cones are distinctly four-sided. The sporangia are nearly spherical and open transversely at the apex. The species mainly fruit late in the year.



Leaf of
Selaginella
rupestris.
(Enlarged.)

There are nearly four hundred species of *Selaginella* known to science, the great majority being found in the tropics, where their size and abundance render them a conspicuous part of the undergrowth in woods and on moist banks. In our region they are usually so small and moss-like as to be easily overlooked. The plants from the warmer parts of the world are often characterised by a delicacy in form and colour that causes them to be in great demand for cultivation in conservatories nearer the Poles. Several of them are climbing species. The famous resurrection-plant, or resurrection-moss, sold under various other names to the curious, is a species of *Selaginella*.

The name *Selaginella* is a diminutive of *Selago*, the ancient name of one of the lycopodiums which our species greatly resemble. Formerly the quillworts (*Isoetes*) were united with the genus *Selaginella* to form the Selaginellaceæ, but as they are regarded at present they not only form a distinct family, but are included in another order. The Selaginellaceæ, therefore, may be said to consist of the single genus *Selaginella*.

KEY TO THE SELAGINELLAS.

- I.—Leaves narrow, all alike
- Stems pendant, rooting throughout. Western
S. Oregana
- Stems erect, rooting at base only. Western
S. Bigelovii
- Stems creeping and tufted
- Branchlets under $\frac{1}{8}$ of an inch long. Western
S. cinerascens
- Branchlets longer
- Leaves tipped with a point. Western
S. Watsoni
- Leaves tipped with a white bristle
- Leaves closely appressed. Southern
S. arenicola
- Leaves somewhat spreading. Eastern
S. rupestris
- Fertile stems larger than the sterile. Northern
S. spinosa
- II.—Leaves broader, of two sizes
- Plants weak, trailing, rooting throughout
- Fertile spike roundish, leafy *S. apus*
- Fertile spike four-sided. Western *S. Douglassii*
- Plants slender, erect or ascending. Southern
S. Ludoviciana
- Plants stout, densely tufted, rooting only at base
- Leaves obtuse, awnless *S. lepidophylla*
- Leaves awn-tipped *S. Pringlei*

THE TRUE SELAGINELLAS, OR SELA-
GINELLA RUPESTRIS GROUP



THE SELAGINELLA RUPESTRIS GROUP.



MOST botanists consider that the shape, size, and arrangement of the leaves of *Selaginella* are of sufficient importance to warrant the separation of this genus into

four sub-genera. The first of these is called *Euselaginella* and contains those species with leaves all alike and arranged in many rows. From the fact that the common species in eastern North America are typical of this group, they are often spoken of as the *Selaginella rupestris* group. Although here called the true selaginellas they are relatively few in number, probably less than twenty-five in all, though distributed very widely over the earth.

The Rock Selaginella.

The student of the mosses is likely to be better acquainted with the haunts of the rock selaginella, (*Selaginella rupestris*) than the student of the fern allies himself, for it is a species of the dry ledges and mossy boulders, growing in situations shunned by

others of its kin, and so small as to be easily overlooked unless one is on a special hunt for it. One who has once seen it, however, will seldom overlook it again, for the whole plant has a characteristic grey-green colour not common to mosses, that is sure to catch the eye and make recognition at some distance possible.

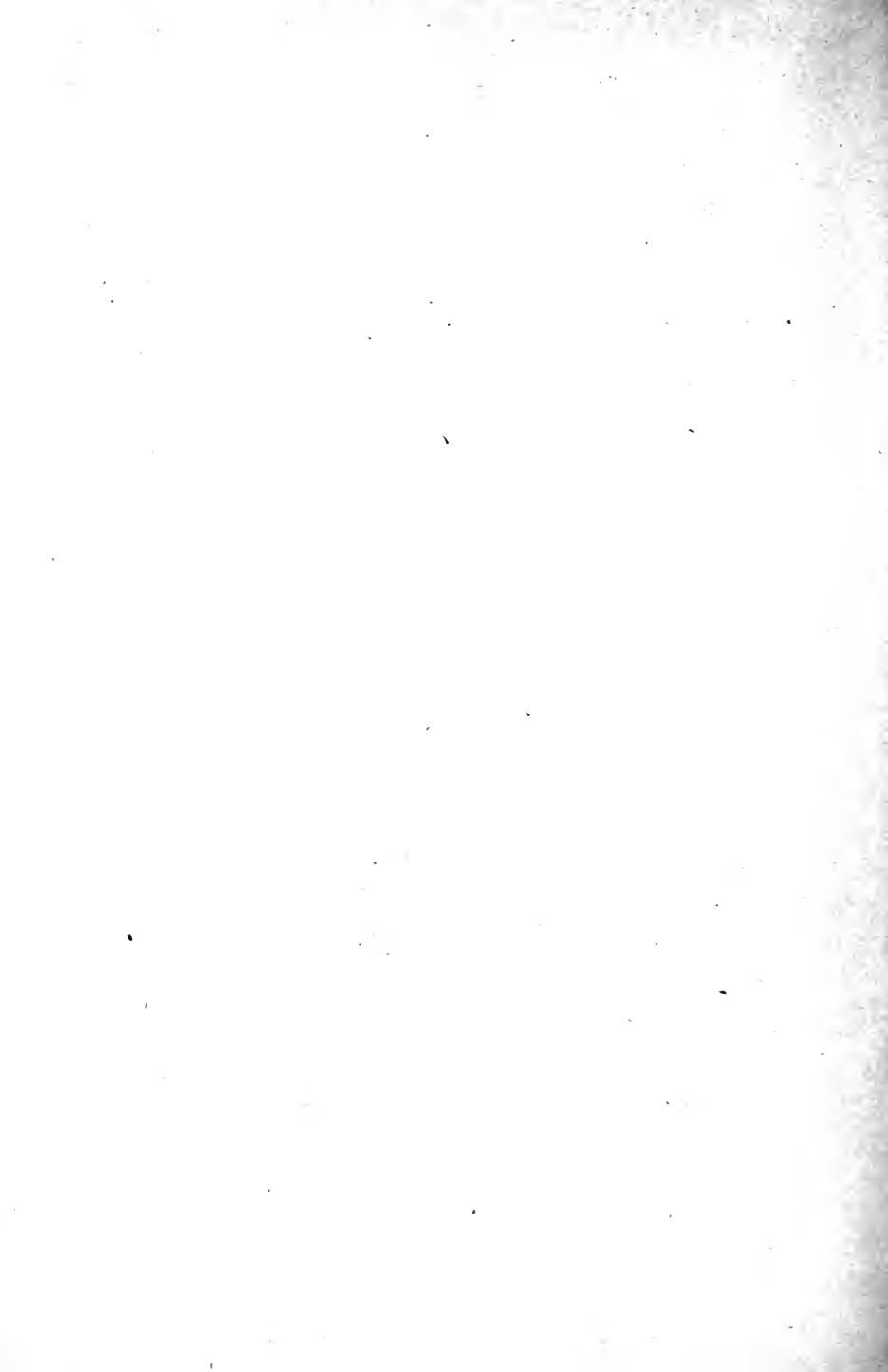
The main stems of this species are from one to five inches long and nearly prostrate. From these issue great numbers of secondary branches, several times forked, but all so short that the topmost branch does not reach a height of three inches. The plants grow in communities, with branches so intertwined that the individuals are difficult to distinguish, the whole forming a dense little mat that often covers an area of several square feet.

The leaves are arranged in about eight ranks, and so close together upon the stems and branches as to completely cover them. At the tips of the branches they are more or less spreading, but elsewhere they are rather closely appressed. They are frequently described as less than a sixteenth of an inch long, but in vigorous specimens they may reach more than twice this length, exclusive of the awn-like tip. They are narrow, with a deep groove on the back, and taper from the base to the rounded apex. Each leaf bears a slender white bristle at the tip, which is one third to one half the length of the leaf. It is these white bristles among the green that give the peculiar greyish colour to the plant. The leaves also bear numerous cilia on the margins, and the bristles also have very short ones.

The fertile spikes are similar to ordinary branches in appearance, the most noticeable differences being that they are erect and distinctly four-sided. The sporophylls



ROCK SELAGINELLA. *Selaginella rupestris*.



differ from the ordinary foliage leaves only in being broader at base and having rather more numerous cilia. They are arranged in four ranks, a row on each of the four angles of the spike, with the bases closely over-lapping. The spikes are from half an inch to an inch long. After the spores have fallen, the sporophylls become reflexed, and the sporangia, split nearly into halves, spread out in the axils like small greenish flowers. The megasporangia are supposed always to bear four megaspores, but all four do not always develop. They are bright orange yellow in colour and are large enough to be seen with the unaided eye. They are borne so plentifully by this species that they are often noticeable on the ground about the plants late in autumn. The megaspores and microspores are said to be borne in the same leaf axils.



Spike of Rock
Selaginella.
(Enlarged.)

Until a few years ago *Selaginella rupestris* was considered to be a widespread though somewhat variable species. Recently, however, it has become the fashion to describe each form as a distinct species, no matter what its characteristics, and about forty of these forms have been so described. It can scarcely be doubted that the species, as once regarded, covered too great a range of forms; but it is equally certain that many of the newly described species are mere forms due to conditions of environment. The points most relied upon for separating them are the presence or absence of the bristle tips of the leaves and the number of cilia on the leaf margins. Only the more noteworthy forms can be

treated here. The student who wishes to make further investigations is referred to the article by Dr. Hieronymus in the volume of *Hedwigia* for 1900. A synopsis, with a key to the American forms, was published in the *Fern Bulletin*, Volume 10, 1902.

A form from the mountain tops of North and South Carolina, in which the awns on the tips of the leaves are longer and twisted, was long ago described as a species and named *Selaginella tortipila*. It is more commonly called a variety. A plant allied to this, but with stems more erect, is the variety *Sherwoodii* (*Selaginella Sherwoodii*, Underwood.) Still another form from the coastal plain of the Carolinas and Georgia has been named *Selaginella acanthonota*. It differs from typical *Selaginella rupestris* in having about twelve cilia along the dorsal groove in the leaves and is probably best considered a variety and called *Selaginella rupestris acanthonota*. A densely tufted form from western Nebraska and Montana is the variety *densa* (*Selaginella densa*, Rydberg). A form with lax, less crowded leaves, and shorter awns, has been reported from Colorado and New Mexico as the variety *Fendleri*. Plants from New Mexico and Arizona with smaller megaspores and less angular fertile spikes is the variety *rupincola* (*Selaginella rupincola*, Underwood).

In Baker's "Handbook of the Fern Allies" the range of *Selaginella rupestris* is given as "North and South Temperate zones of both the Old and New worlds, also on the Andes, Himalayas, and mountains of Brazil and Ceylon." In the early editions of Underwood's "Our Native Ferns" it is recorded as growing from "New England to Florida, Texas, California, and northward." In the latest edition of the latter book its

range is given as "New England and Ontario southward to Alabama and westward to California and British Columbia," — this latter probably being nearly correct for our part of the world. It shows, however, how greatly the idea concerning this species has changed within ten years.

Selaginella rupestris is usually found on dry rocks, and, in the Eastern States at least, appears to have a preference for granite, gneiss, and mica schist. It is exceedingly irregular in distribution, being abundant in some sections of its range and extremely rare in others. In the vicinity of New York it is a common species and may be found in the public parks as well as on a large number of the rocky outcrops in the surrounding country. It is likeliest to be found in thin soil on the tops of the ledges, and, being an evergreen species, is most easily found in early spring. This species is sometimes called "grey moss."

Selaginella Watsoni.

The plant recently named *Selaginella Watsoni* may be recognised at once by the fact that it looks like a luxuriant form of *Selaginella rupestris*. The leaves are rather larger and thicker than in *Selaginella rupestris*, with few or no cilia, and end in a short, pale green awn. Owing to the colour of the awn and the scarcity of cilia, the plant has a tinge of deeper green than is found in the common plant of the East.

The main stems are from four to six inches long, nearly prostrate, and produce strong roots throughout their length. The fertile spikes are an inch or more long and sharply four-angled. This species is a plant of

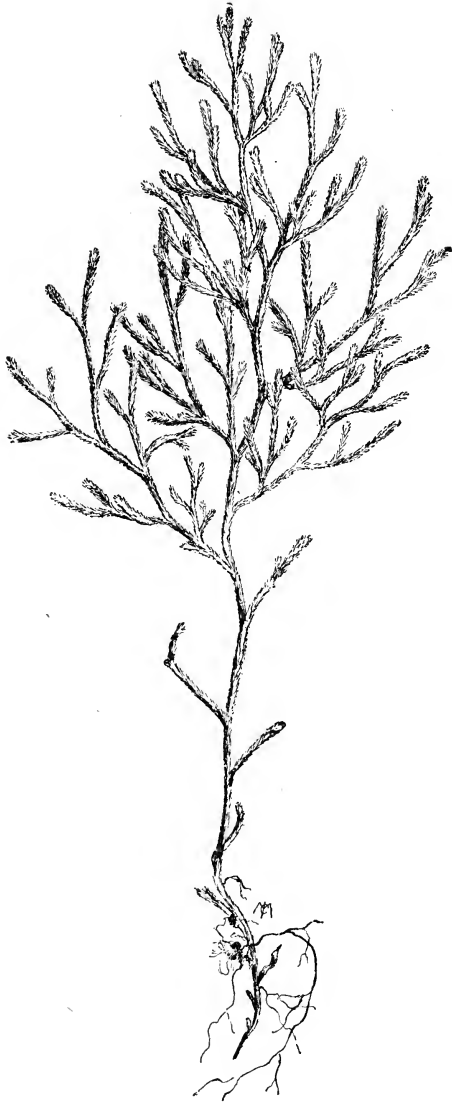
elevated regions and is found only in the West. It has been reported from various peaks in Utah, Nevada, and California, always at altitudes above 5,000 feet. A form very similar to this, but differing in having about eight cilia on the leaf-margins and no awn tips to the leaves, has been described as a species under the name of *Selaginella nutica*. The fact that the sporophylls usually have a short awn-tip seems to indicate that it is a form of *Selaginella Watsoni*, and this is further borne out by its habitat in the mountains of Colorado, New Mexico, and Arizona. We would therefore call it *Selaginella Watsoni nutica*, and give its range as high mountains from Colorado to New Mexico and California.



Branch of
Selaginella
Watsoni.
(Enlarged.)

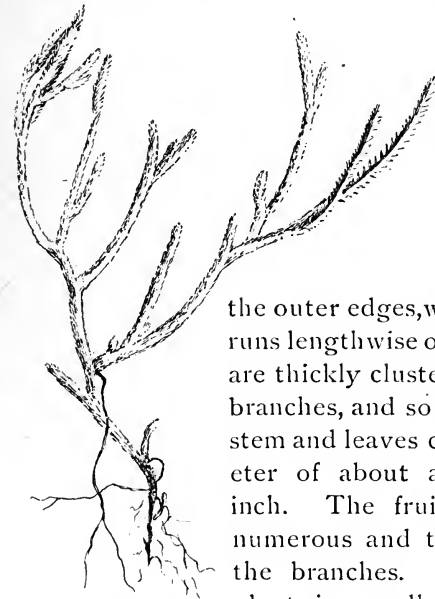
The Sand-Barren Selaginella.

It is almost certain that the sand-barren selaginella (*Selaginella arenicola*) and the common species of the Northeastern States, sprang from the same stock; but the former has lived so long in the sandy wastes that border the Gulf of Mexico that its appearance has been greatly changed in consequence. Possibly there may yet be found intergrading forms, but the typical plant is so distinct in appearance that it is properly considered a separate species. This species is an excellent illustration of the adaptation of plants to their surroundings. It grows in exposed sandy places, and accordingly its leaves are narrow, plentifully ciliated, and appressed closely to the stem, partly in an effort to avoid excessive transpiration, and partly, no doubt, to protect its green cells from the strong light.



Selaginella Bigelovii.

The stems, under the influence of the intense insolation, are nearly erect, but seldom become more than two inches high. They are densely tufted, much branched, and form compact little mats on the sand. From the part nearest the earth, slender branching roots descend into the soil, and in the search for moisture extend for long distances, being often three times the length of the aerial parts of the plant. The leaves are smaller



SAND-BARREN SELAGINELLA.

Selaginella arenicola.

the sterile stems are not distinguishable from one another by the unaided eye. Under a lens they are seen to be very narrow, with a whitish awn at the apex and many minute cilia on the outer edges, while the usual channel runs lengthwise of the outer side. They are thickly clustered on the stems and branches, and so closely appressed that stem and leaves combined have a diameter of about a thirty-second of an inch. The fruiting-spikes are very numerous and terminate the ends of the branches. Although the whole plant is usually under three inches high these fertile spikes may reach a length of an inch or more. They are sharply four-angled, with a diameter somewhat greater than that of sterile branches. The sporophylls are much larger than the leaves and are borne in four closely

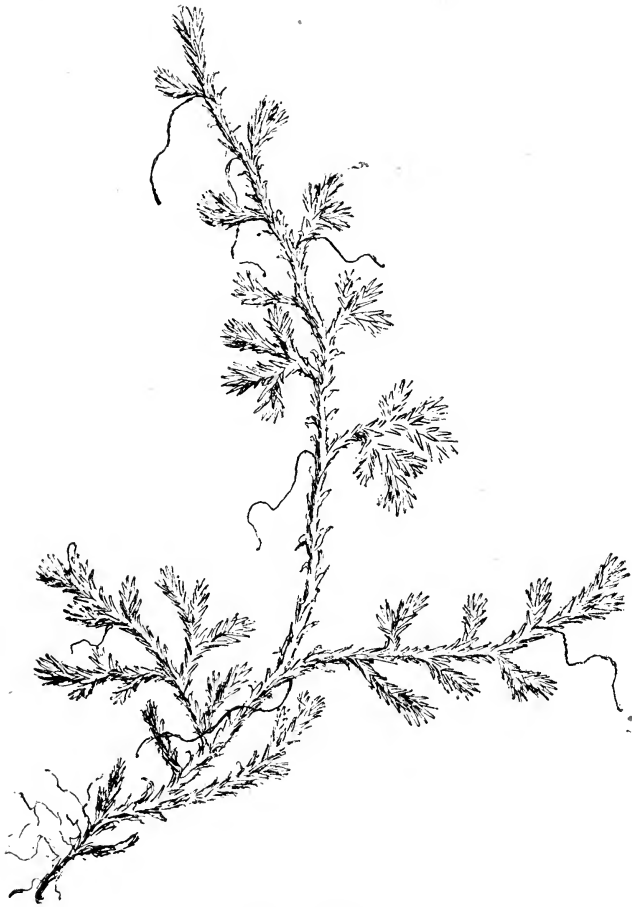
imbricated rows, one row on each angle of the spike. They are often triangular in outline, broad at base, and end in a short awn. The margins bear abundant cilia that are so small as not to be easily seen. The megasporangia are especially abundant and bright yellow in colour, quite distinguishable without a lens.

The sand-barren selaginella has thus far been reported from Florida, Louisiana, and Texas, but it is likely to be found in suitable situations in any of the sand-barrens along the Gulf coast. Its slender, cylindrical, grey-green, erect stems will be easily identified when found. It was originally described as *Selaginella arenaria*.

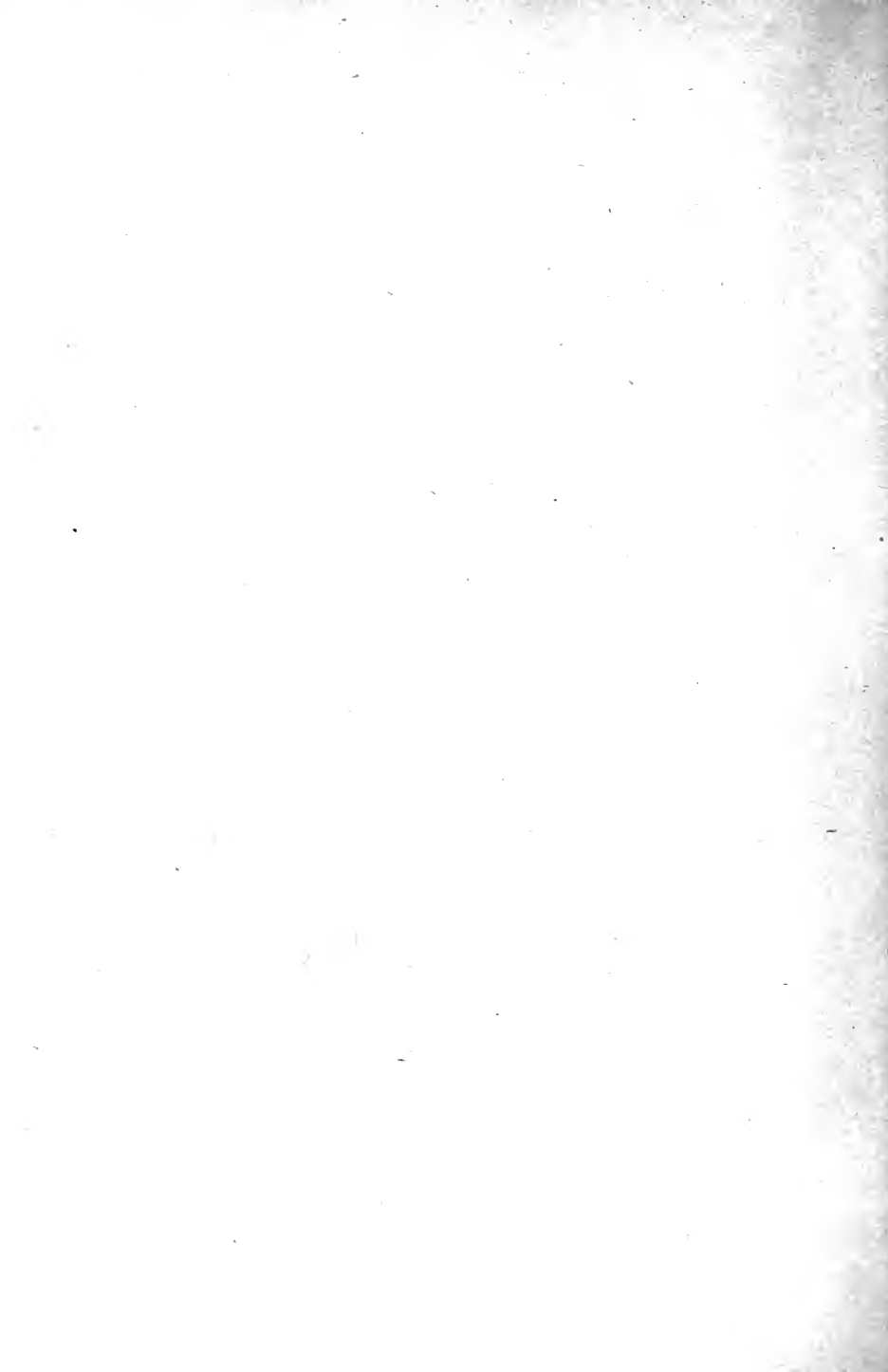
Selaginella Bigelovii.

In the days when it was customary to refer everything at all resembling *Selaginella rupestris* to that species, it was described as having stems from six inches to a foot long. The plant that is nowadays called *Selaginella rupestris* is much smaller, and at its best does not reach the minimum length quoted. An explanation of the discrepancy is found, however, when we take into consideration one of its forms recently named *Selaginella Bigelovii*. In this the stems ordinarily reach a length of six or eight inches, and in vigorous specimens are, of course, still longer.

It is likely to surprise the beginner to learn that *Selaginella Bigelovii* was ever referred to *Selaginella rupestris*. Aside from its long stems, its habitat and manner of growth are sufficiently different to separate it. It is an erect or ascending species, with stems that produce roots only near the base. For some distance above the soil, the stems are commonly unbranched, or,



Selaginella cinerascens.



if branched, the branches may be considered essentially like the main stems. Toward the apex the stems are pinnate, with short, alternate branches, the lowest from one to three inches long and increasing in length to the summit. These lateral branches are branched in the same way as the main stem, and their branches are again divided, the ultimate branchlets rarely reaching the length of half an inch. The leaves are narrowly linear, slightly channelled down the back, with numerous cilia on the margins and a short white awn at the apex. They are small, numerous, and closely appressed to the very slender branches. Those on the main branches are usually light brown, the rest being dark green. The fertile spikes are fairly plentiful and usually occupy the places of lateral branchlets a short distance from the tips of the branches. The cones are from a quarter to half an inch long, and quadrangular, the sporophylls being rather triangular, short, pointed at the apex, ciliated on the margins, and slightly eared at the base. The fruit may be found on the plant at all seasons of the year.

Selaginella Bigelovii is found in southern California only, but there it is not an uncommon species. It grows in the foothills at altitudes up to about 3,000 feet, and prefers half-shaded clay soil or the chinks of rocks. Like many of the mosses and ferns in this region, its chief period of growth is in the rainy or winter season. At other times it becomes dry and brittle, but revives at the next rainy season.

Selaginella Cinerascens.

Selaginella cinerascens is another of the segregates of *Selaginella rupestris* that has been described so recently

as to have no common name. In general appearance it is most like *Selaginella Bigelovii*, but may be at once distinguished from that species by the fact that it is a prostrate plant rooting from all parts of the stem.

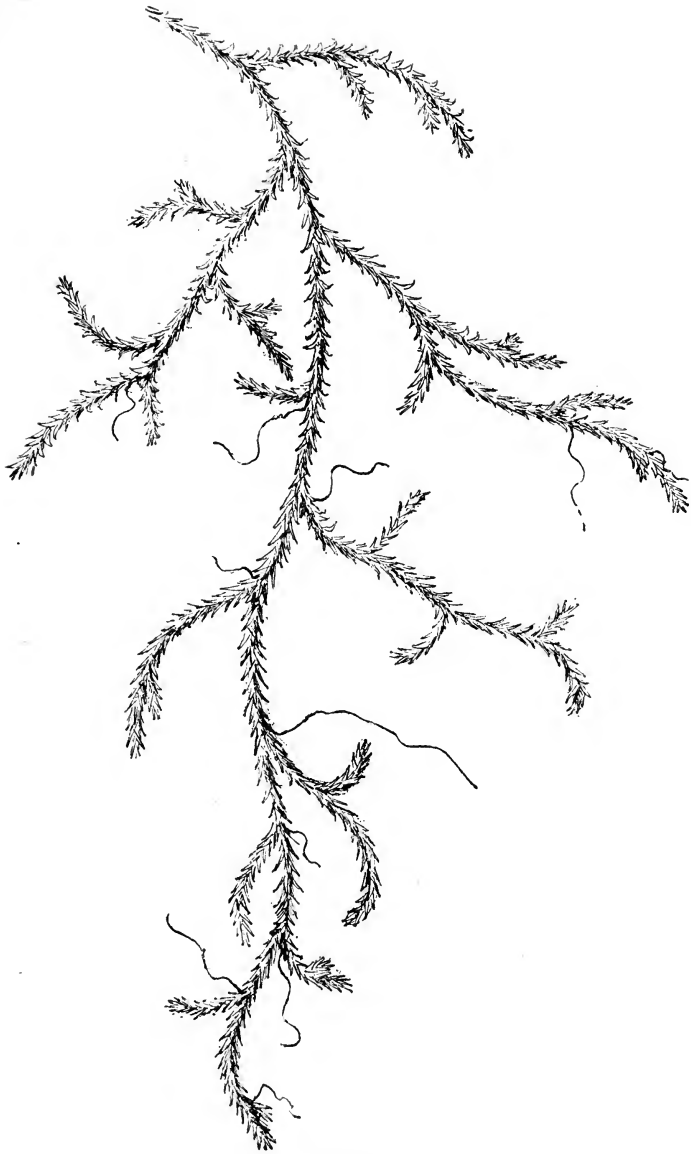
In robust specimens the main stems may reach a length of six inches or more, but they are usually shorter. These stems are pinnately branched, the branches short and rather numerous. From these branches still smaller branches, about a quarter of an inch long, arise, and upon these are usually borne a pair of branchlets so small as to be mere spurs, which, with the branch-tip, form a figure suggestive of the conventional *fleur-de-lis* design. All parts of the plant are covered with leaves, those on the main stems being closely appressed, and those on the branch-tips more spreading. The leaves are rather broadly linear, acute or rounded at the apex, with a suggestion of a terminal awn, and with few or no marginal cilia.

The spikes are short, and about twice the diameter of the stems, with the ovate-acute sporophylls in four ranks. The megaspores are of a pale lemon colour, and the microspores dark orange. According to Mr. Eaton, who described this species, the megaspores and microspores are developed in separate spikes.

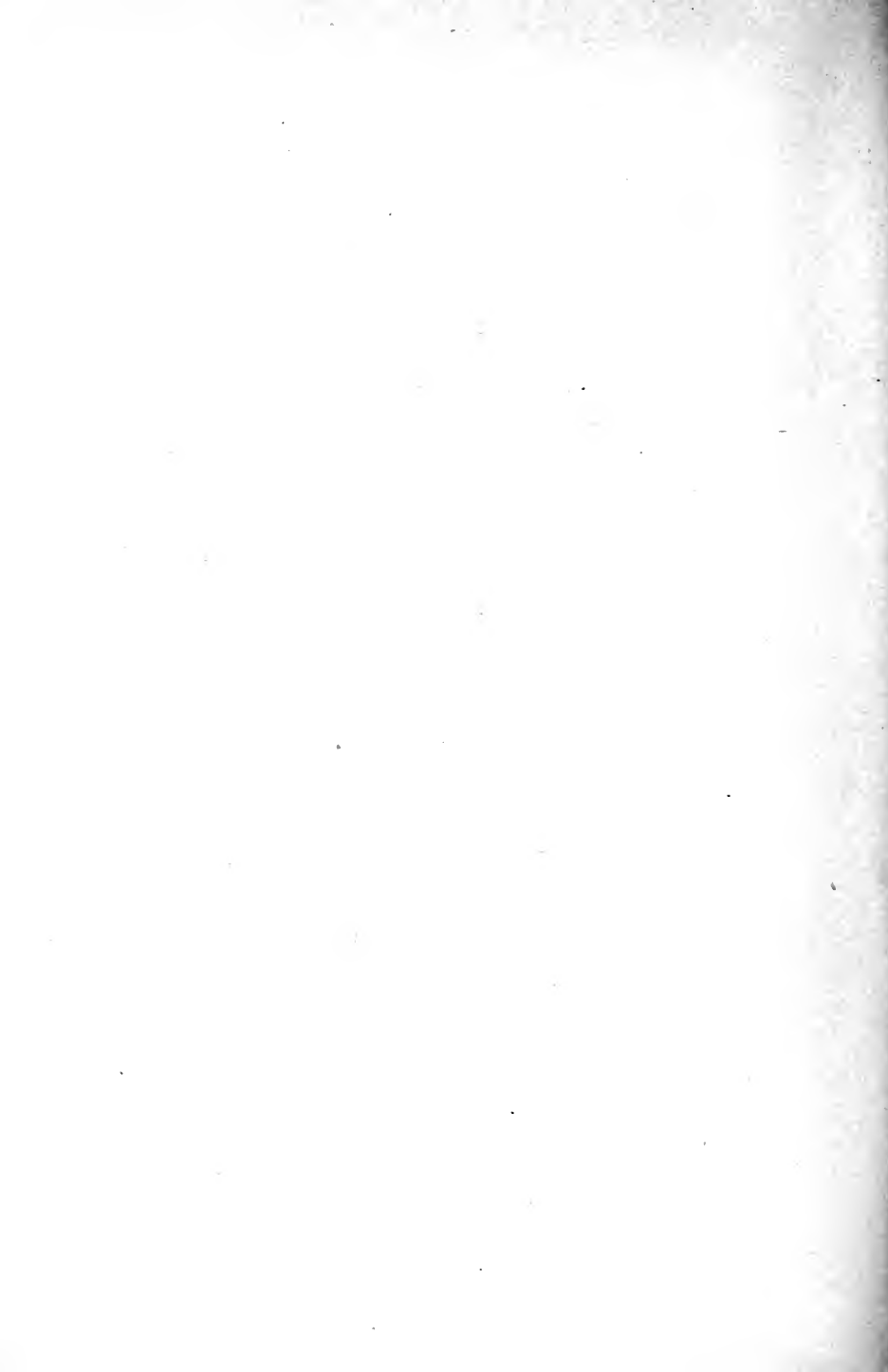
Selaginella cinerascens is found on dry, bare hills in southern California. For a time after it was described, it was confused with another species called *Selaginella bryoides*, described by Nuttall, and some of the earlier references to it will be found under the latter name.

The Oregon Selaginella.

One of the most remarkable of the selaginellas is the Oregon selaginella (*Selaginella Oregona*) which, until it



Selaginella Oregana.



was recently discovered in northwestern Washington by Mr. J. B. Flett, was supposed to grow in Oregon only.

Although its stems are less than a sixteenth of an inch in diameter, they are said occasionally to reach a length of six feet. As a consequence it is a pendent species, growing with mosses on the trunks of trees and emitting copious roots, from both stem and branches, that strike into the bark and hold the plant in place.

The stems are pinnately branched like those of *Selaginella Bigelovii*, though the lateral branches are longer and farther apart, with fewer branchlets. The stems are light brown in colour, and so sparingly covered with leaves as to be noticeable, especially in the older parts of the plant. The leaves are narrow, about a twelfth of an inch long, with a short white awn at apex and occasional cilia on the margin. Those on the branchlets are dark green and loosely spreading; on old branches they are light brown and half appressed. Some of the leaves early lose their terminal awns, and, in consequence, in some books this species has been described as awnless. The fruiting-spikes are slender, four-angled, and apparently not very abundant.

This species is found in the dense forests near the Pacific coast and grows in tangled mats. Mr. Thomas Howell, author of a "Flora of Northwest America," writes that he found it growing from the branches and prostrate trunks of maple trees, from which it hung to a length of from six inches to three feet. It often grows among mosses, one of which, *Hypnum loreum*, might be mistaken for it at first glance. Mr. Howell is of the opinion that its season of growth is from September to June. The plant has always been spoken of as *Selaginella Oregona* and will be found in most books under

that name, but it was earlier given the name of *Selaginella struthioloides* and this is one of the names by which it is likely often to be called in future.

The Prickly Mountain Moss.

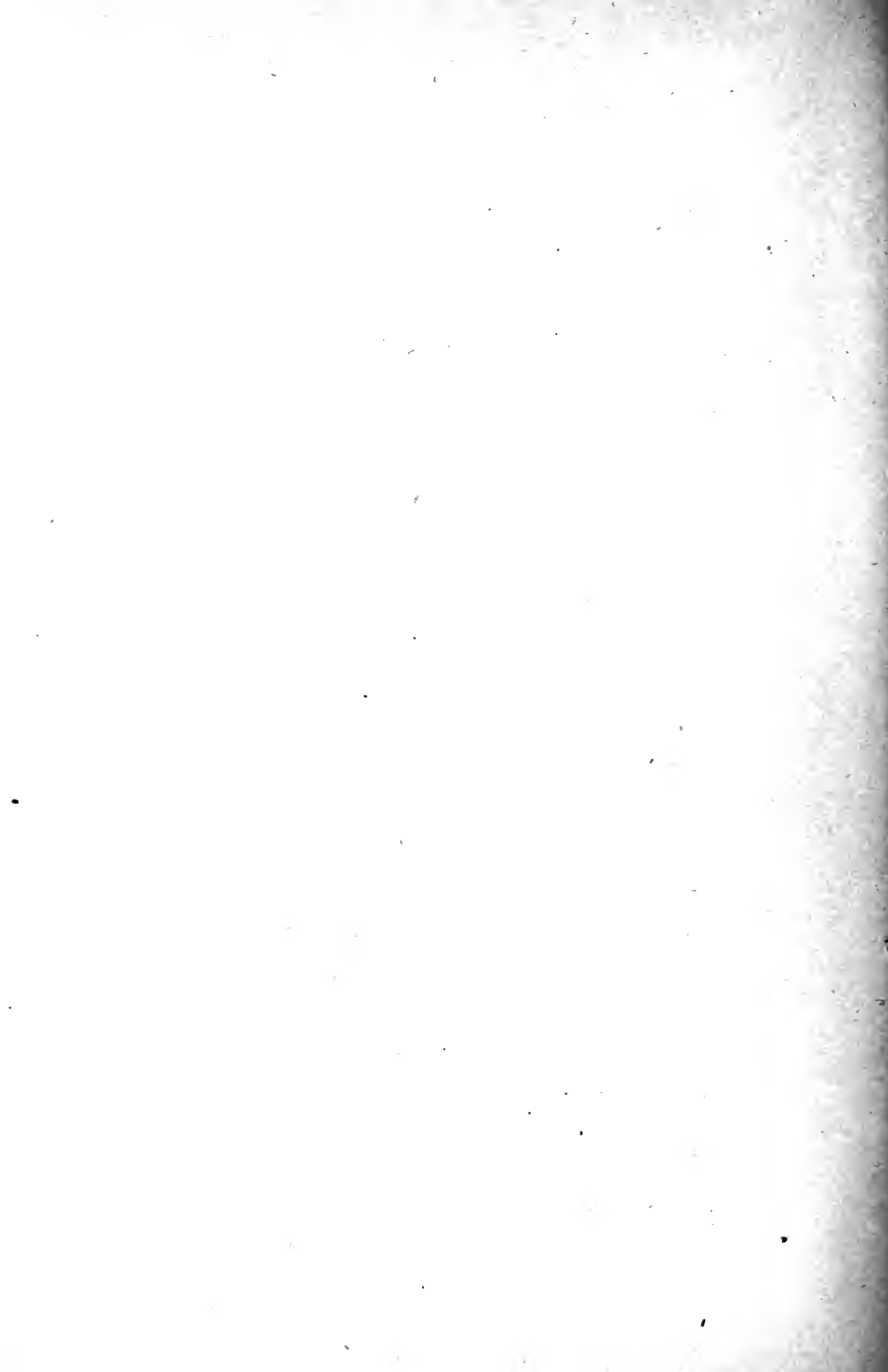
If the fern allies were placed in genera founded upon external appearances alone, that plant which the British call the prickly mountain moss (*Selaginella spinosa*) would be found among the lycopodiums. It has a very decided resemblance to the marsh club-moss and is about the same size, but the fact that the fertile spikes bear both microsporangia and megasporangia for ever separates it from the true club-mosses.

Like the bog club-moss, and unlike most of the selaginellas, there is a marked difference between the fertile and sterile stems. The latter are close to the ground, very slender and threadlike, with occasional short branches half an inch or more long. The entire sterile portion seldom reaches a length of more than four inches and bears roots only near the base. The leaves are loosely spreading and arranged on all sides of the stem. They are broadly lanceolate, acute, and the margins are beset with scattered teeth too stout to be called cilia.

The fertile spikes grow from near the base of the main sterile stems and reach a height of three inches or more. They are quite erect and resemble the fruiting-stems of a *Lycopodium* since they consist of a leafy stalk surmounted by a loose cone of sporophylls. The leaves on the stalk are similar to those on the sterile stem, though slightly larger and more closely appressed. As they merge into the sporophylls they become larger and

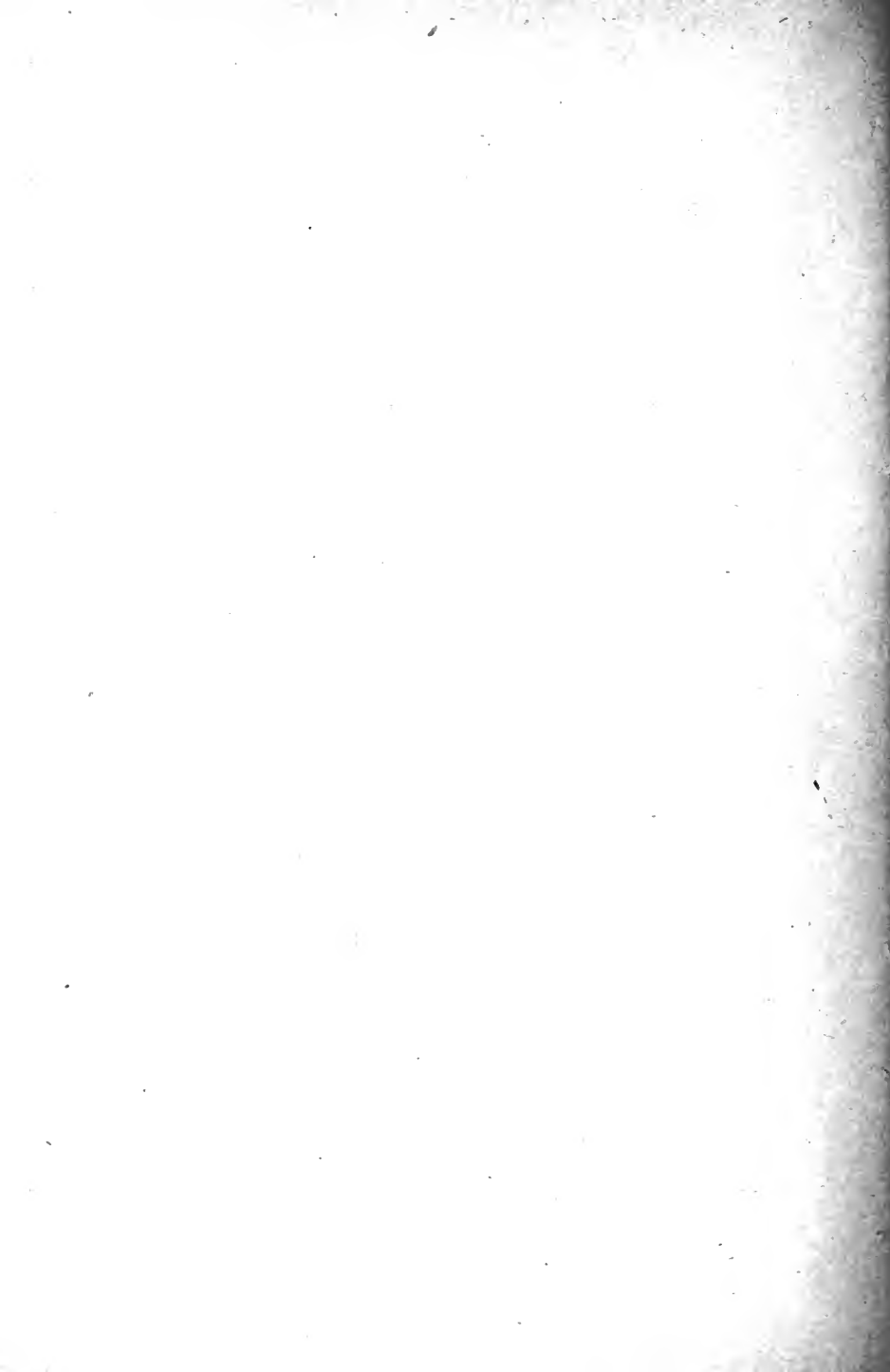


PRICKLY MOUNTAIN MOSS. *Selaginella spinosa*.
(Slightly enlarged.)

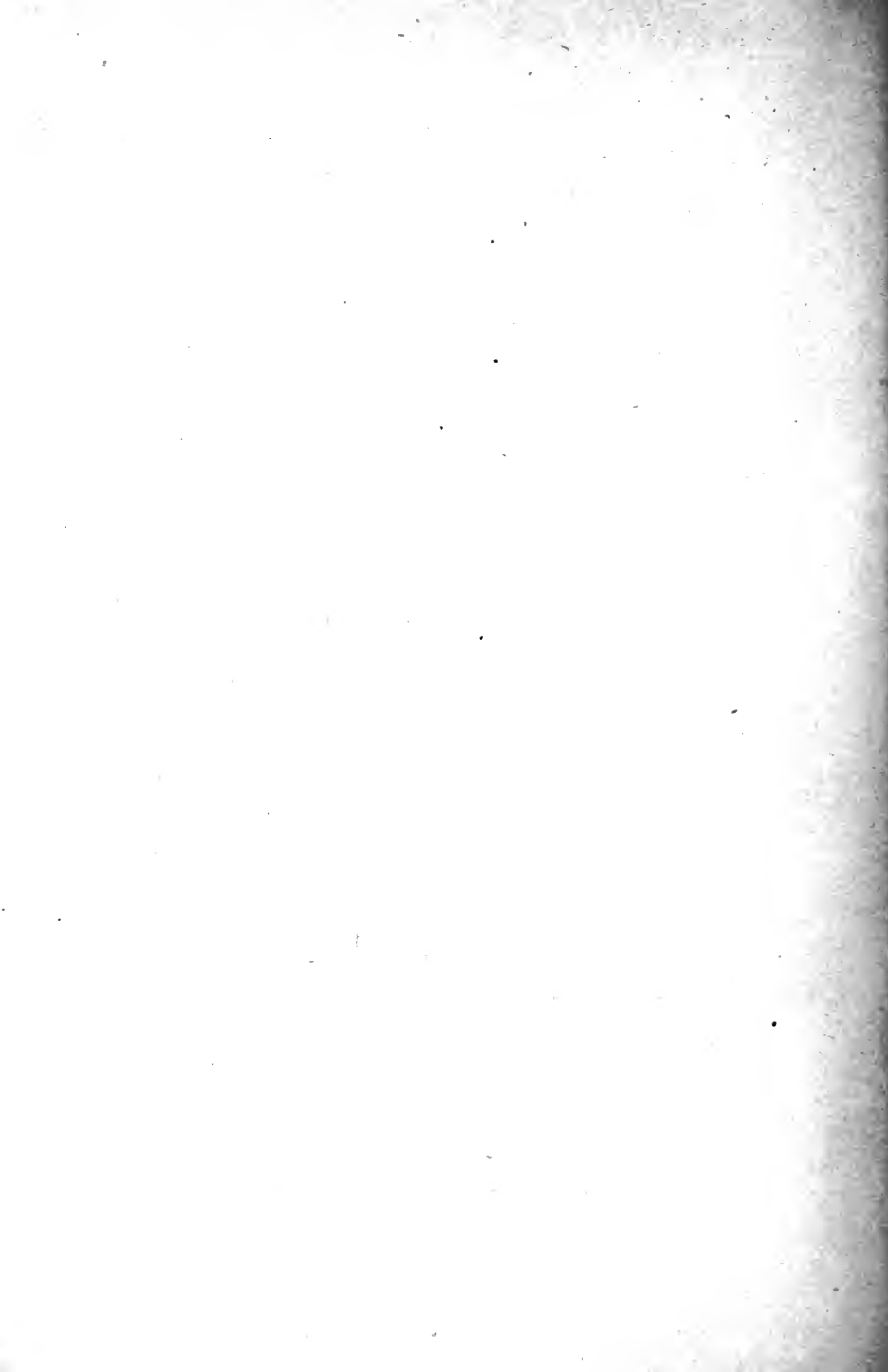


broader, with stronger teeth, and often stand at nearly right angles to the stem, making the cone quite conspicuous. The cones are an inch or more long, and usually there is but one fertile spike on each plant. The lowest sporophylls bear three or four megaspores, which are as large as the seeds of many flowering-plants. The fertile spike is deciduous, but the sterile stems survive the winter.

Selaginella spinosa is rare in the United States, being found only in the elevated parts of Maine, New Hampshire, New York, Michigan, and Colorado. In British America it is more abundant and found at lower altitudes. It is also found in both Alaska and Greenland. In the Old World it is reported from the British Isles and across the northern part of the Continent, extending south to Germany. It delights in moist, grassy places, being much like the club-mosses in this respect. The name of prickly mountain moss is in allusion to the toothed leaves, though these are in no wise either spiny or prickly. The specific name also alludes to this circumstance. In the days when this was thought to be a club-moss it was called *Lycopodium selaginelloides*, or the selaginella-like club-moss. Its transference to the genus *Selaginella* has made this specific name meaningless.



THE CREEPING SELAGINELLA
GROUP.



THE CREEPING SELAGINELLA GROUP.



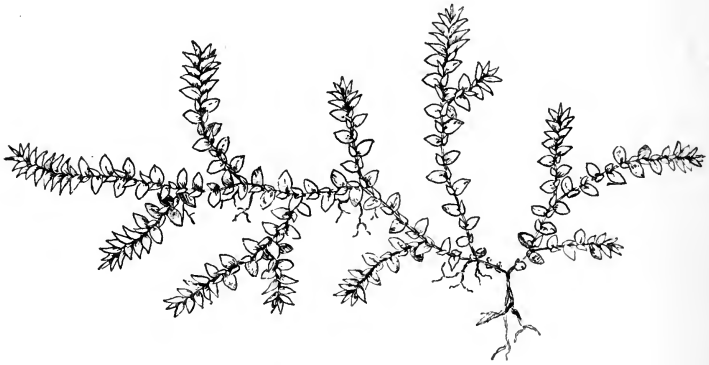
THE genus *Selaginella* contains by far the greater number of the fern allies, and the sub-genus *Stachygynandrum*, to which our creeping species belong, comprises nearly three fourths of the species in the genus. The sub-genus, however, was not founded upon the creeping habit, for many of the species have erect or ascending stems, but all agree in having two sorts of leaves like our creeping species, thus sharply distinguishing them from the relatives of *Selaginella rupestris*. Notwithstanding the great number of species in this section it is very poorly represented in North America. It is a characteristically tropical group, and our species seem in the nature of unusual extensions northward.

The Creeping Selaginella.

The creeping selaginella *par excellence*, and the least conspicuous, is the one known to botanists as *Selaginella apus*. What the curly grass or the little grape fern is to our other ferns, this species is to its relatives among the

fern allies. Owing to its small size, creeping habits, and general resemblance to the mosses and hepatics, it is very difficult to find for the first time; but when once its characteristic haunts are known, the collector finds it again with ease.

The stems are from two to four inches long and lie close to the earth, to which they are attached by numerous slender forking roots emitted from all parts of the



CREEPING SELAGINELLA. *Selaginella Apus*.

plant. From the main stems, scattered, alternate, prostrate branches are given off, the longest reaching a length of two inches or more and again branching. The leaves are borne on all parts of the stem and branches, and are remarkable not only for being of two sizes, but for being borne in two different planes. The larger leaves are scarcely an eighth of an inch long, ovate, acutish or obtuse, unequal-sided, with the broadest side toward the tip of the stem. They are very thin, with serrulate margins and distinct mid-ribs, and are arranged alternately on the stem, from which they spread at

right angles. Alternating with these larger leaves is a series of smaller ones attached to the stem on the upper side, to which they are closely appressed, with their tips pointing outward. These smaller leaves are about half the size of the others, and, like them, are somewhat unequal-sided. They are ovate at base and end in a tapering point.

The fruit-spikes are half erect and are borne on the ends of the branches, from which they differ little in appearance except in being more leafy. They are obscurely four-angled, and the lens shows them to consist of four rows of sporophylls of equal size. This is explained upon the supposition that in the fruiting-spikes the two rows of small leaves on the stems have become as large as the others. The spikes are under half an inch long and are usually borne singly. The sporophylls are ovate, sharp-pointed, and keeled in the upper half.



Spike. (Enlarged.)

The majority of our selaginellas are found in dry situations, but the present species is a lover of moisture and is found in wet meadows and pastures in company with mosses and sedges. It is frequently abundant on the bare soil at the base of sedge tussocks and on the sides of channels formed by tiny rills. It must often be sought on hands and knees, though it is occasionally so plentiful as to form close mats. In the vicinity of New York it is frequently found on damp lawns. It is exceedingly like some of the mosses of the genus *Mnium*, but can always be distinguished from them by its leaves of two sizes. Its colour is of a characteristic and deli-

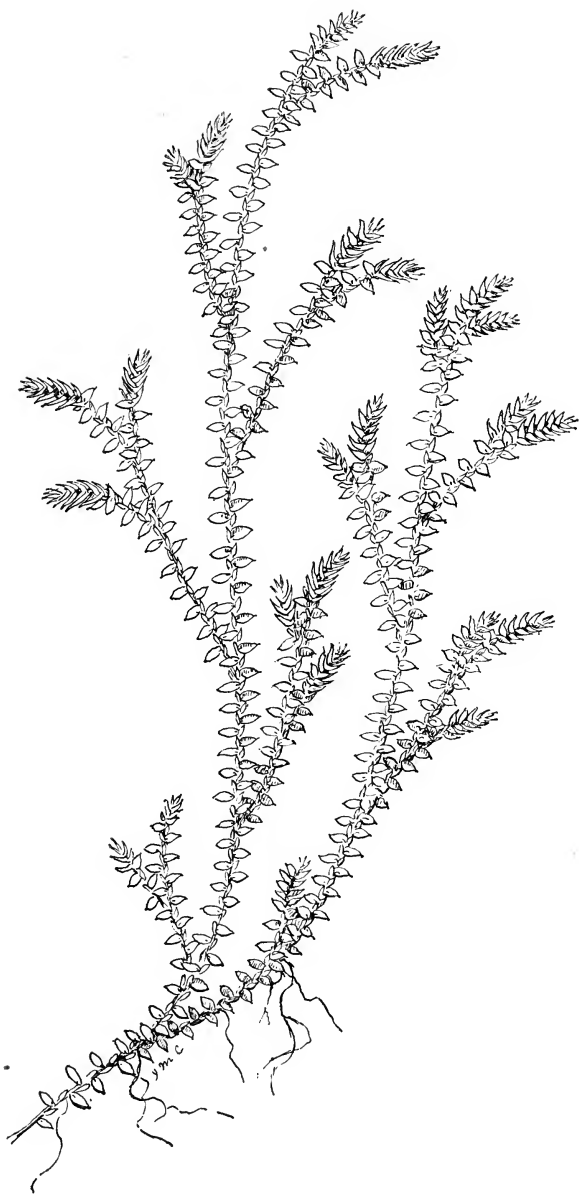
cate yellowish green, and in time becomes so well known as to be singled out by the eye at considerable distances.

Most authorities consider this plant an annual, but this is clearly a mistake. It may be found as soon as the snow disappears, though the spores are not ripe until August or September. The beginner has the best chance of finding it early in spring, before the grass has begun to green. It is then most easily found in wet pastures and in grass fields damp enough to permit of a growth of mosses. The hue of its fronds makes it then very conspicuous.

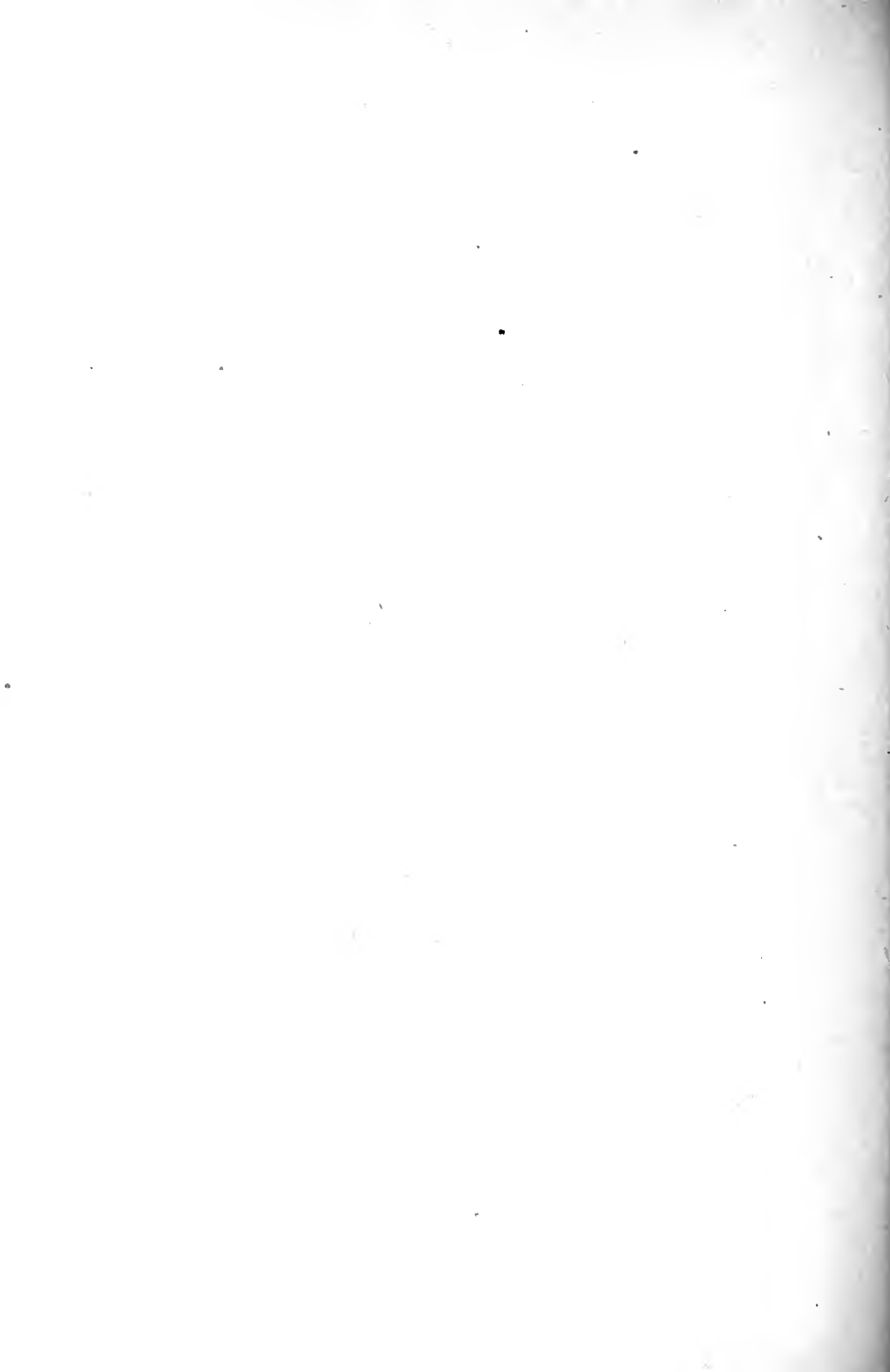
The creeping selaginella is found from Maine and Ontario to Florida, Texas, and British Columbia. In the greater part of its range it does not seem to be abundant, but its small size and resemblance to the mosses may often enable it to live undiscovered.

Selaginella Ludoviciana.

In the American tropics there are at least half a dozen species of *Selaginella* so nearly like the creeping selaginella that they might easily be mistaken for it, and the species called *Selaginella Ludoviciana* is one of this number. Indeed it has often been suggested that *Selaginella Ludoviciana* may be only an erect variety of the common creeping species, the differences it presents being accounted for by the different climate in which it grows. To one who has seen it in its native haunts, however, it does not appear to possess many of the characteristics of *Selaginella apus*, except that in the shape and size of the leaves the two are nearly alike. The stems are from six to eight inches in length and strong enough to hold themselves nearly erect, and the roots usually appear



Selaginella Ludoviciana.



from only the lowest joints of the stem. The stem is branched as in *Selaginella apus*, but the longer basal branches are nearly upright, though their branchlets, especially during the growing season, droop gracefully away from the main axis of the plant.

This species begins growth early in the year, and by the middle of April the stems are mature. The sporangia are borne in the axils of the leaves at the tip of the branchlets, and the fruiting parts have more of a resemblance to a cone than they have in *Selaginella apus*, owing to the fact that the sporophylls are less spreading. The spikes of fruit are often more than half an inch long and are usually abundant. The spores are ripe in May or earlier.

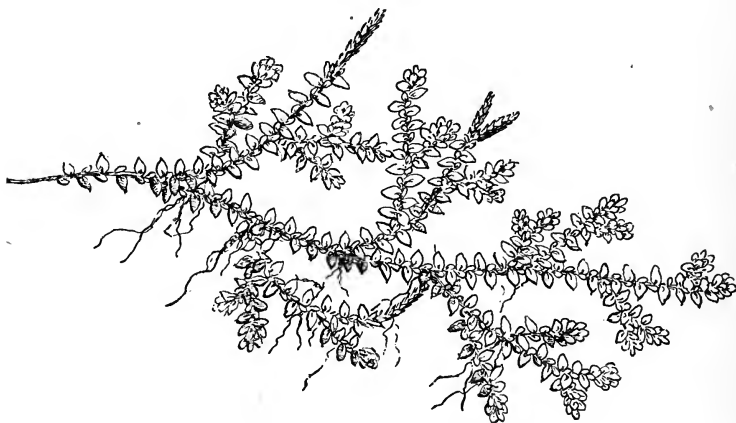
Although both kinds of leaves are like those of *Selaginella apus*, it may be noted that they are slightly longer for their width and somewhat thicker than in that species. The sporophylls also have longer tips. These differences, however, are not apparent until viewed with a lens.

Selaginella Ludoviciana has thus far been found only in a few scattered localities in Florida, Alabama, and Louisiana. It was first discovered by Drummond at Covington, in the latter State. The author has collected it at Pearl River, and it has been found in several other places in the vicinity of New Orleans. Its favourite haunts are the more open spots in the sandy pine barrens. It does not appear to be quite so dependent upon moisture as the creeping selaginella but it is by no means a dry-ground species. It is probably not uncommon in suitable situations along the Gulf coast and may yet be found in Texas. The illustration is made from plants collected by Prof. R. S. Cocks at Mandeville, Louisiana.

Selaginella Douglasii.

The species named *Selaginella Douglasii* is one of the rarest of the fern allies in collections. It is reported to grow in northern California, Oregon, Washington, and British Columbia, but it appears to be seldom found. It is more rigid than *Selaginella apus*, but has much the same appearance, spreading over the ground and rooting from various parts of the stem.

This is a somewhat larger plant than the creeping selaginella, often reaching a foot in length. It is regularly and alternately branched, and these branches are



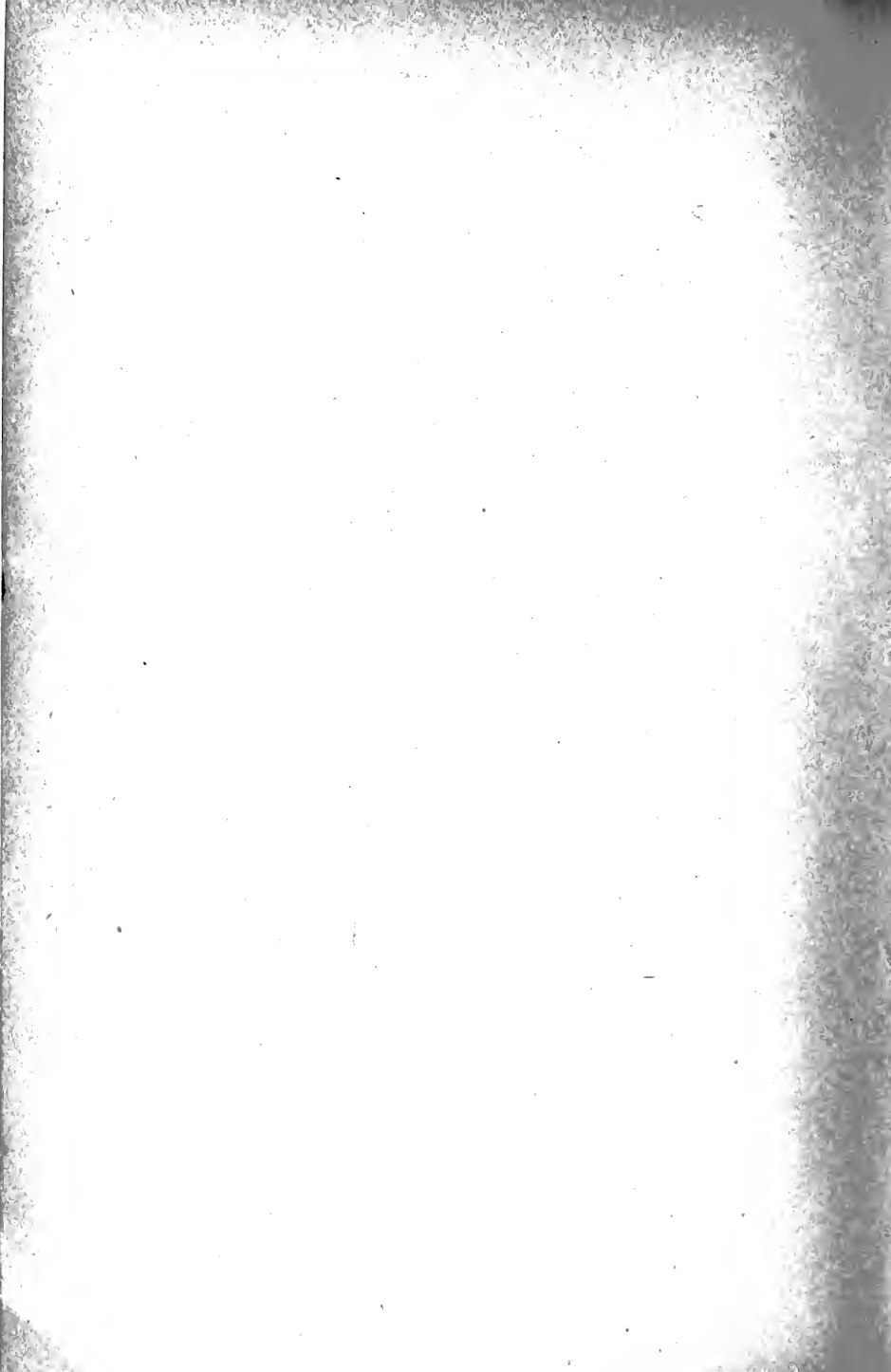
Selaginella Douglasii.

branched once or twice more in the same manner. The leaves are similar in size to those of *Selaginella apus*, but firmer in texture. The lateral rows are very blunt, but the small leaves, though blunt, are tipped with a short whitish point. The leaves are thickly crowded on the branches and branchlets, the lateral ones, as usual,



PLATE VII. SELAGINELLA LUDOVICIANA.

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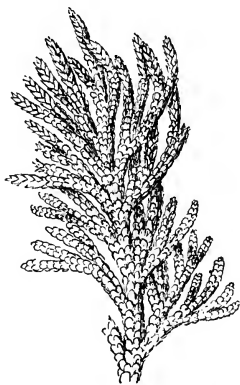
spreading at nearly right angles to the stem, and the upper leaves nearly parallel to it. Both kinds are occasionally ciliate at base. The spores are borne in distinct four-sided cones, about half an inch long, on the tips of the branches. The tips of the sporophylls are blunt, and until maturity are closely appressed to the stem. The cone alone is nearly sufficient to distinguish the species. Our illustration was made from specimens collected in northern Oregon, kindly sent by Mr. J. B. Flett.

The Resurrection Moss.

There are two principal ways by which the scanty vegetation of the more arid parts of the earth manages to exist in spite of the lack of moisture. In plants like the cactus, with a thick epidermis, the moisture accumulated during the occasional rains is carefully hoarded and very slowly given back to the air. In other plants, lacking this thick epidermis, it has been found possible to dry up in the intervals between rains and revive again at the first return of moisture. Many ferns and various flowering-plants have this faculty, but none are better known because of it than the little plant called the resurrection moss (*Selaginella lepidophylla*). This is due in large measure to the itinerant venders, who, in their efforts to sell specimens of it, have told many wonderful stories about it. It is commonly asserted that it needs only to be placed in water for a day to develop a handsome spike of flowers. The truth of the matter is that, when dried, the plant curls up, forming a compact brown ball which may be preserved in that condition for months, and then, upon being placed in water, will uncoil

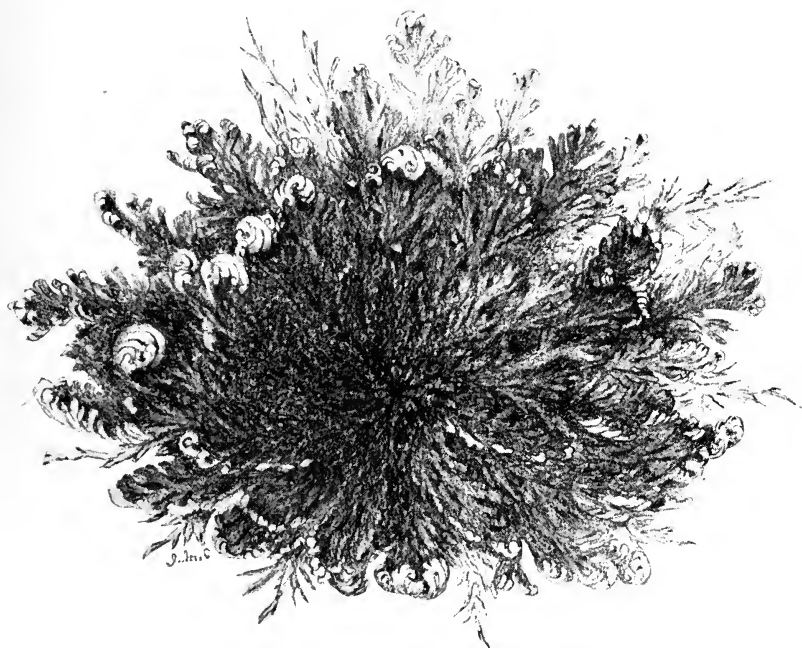
and become fresh and green again in a few hours,—a fact in itself almost as marvellous as the stories told of it. The plants may be thus alternately dried and relaxed many times, but it should not be supposed that such plants are alive and will grow. The spreading of the fronds is simply due to the way in which the tissues absorb water. When rooted in the soil of their native home, however, they do not die during drouth, and when they relax again in the rainy season new growth really takes place.

Selaginella lepidophylla is a native of our arid Southwest, and there grows on the tops of the sunbaked rocks in regions where rain does not fall for a year or more at a time. During such periods its fronds remain compactly folded, their colours blending with the dry earth. When rain comes they at once awake and spread out in bright green rosettes, appearing as luxuriant as if drouths were unknown. Notwithstanding the trying conditions to which they are subjected, they often cover considerable areas as thickly as dandelions on a lawn.

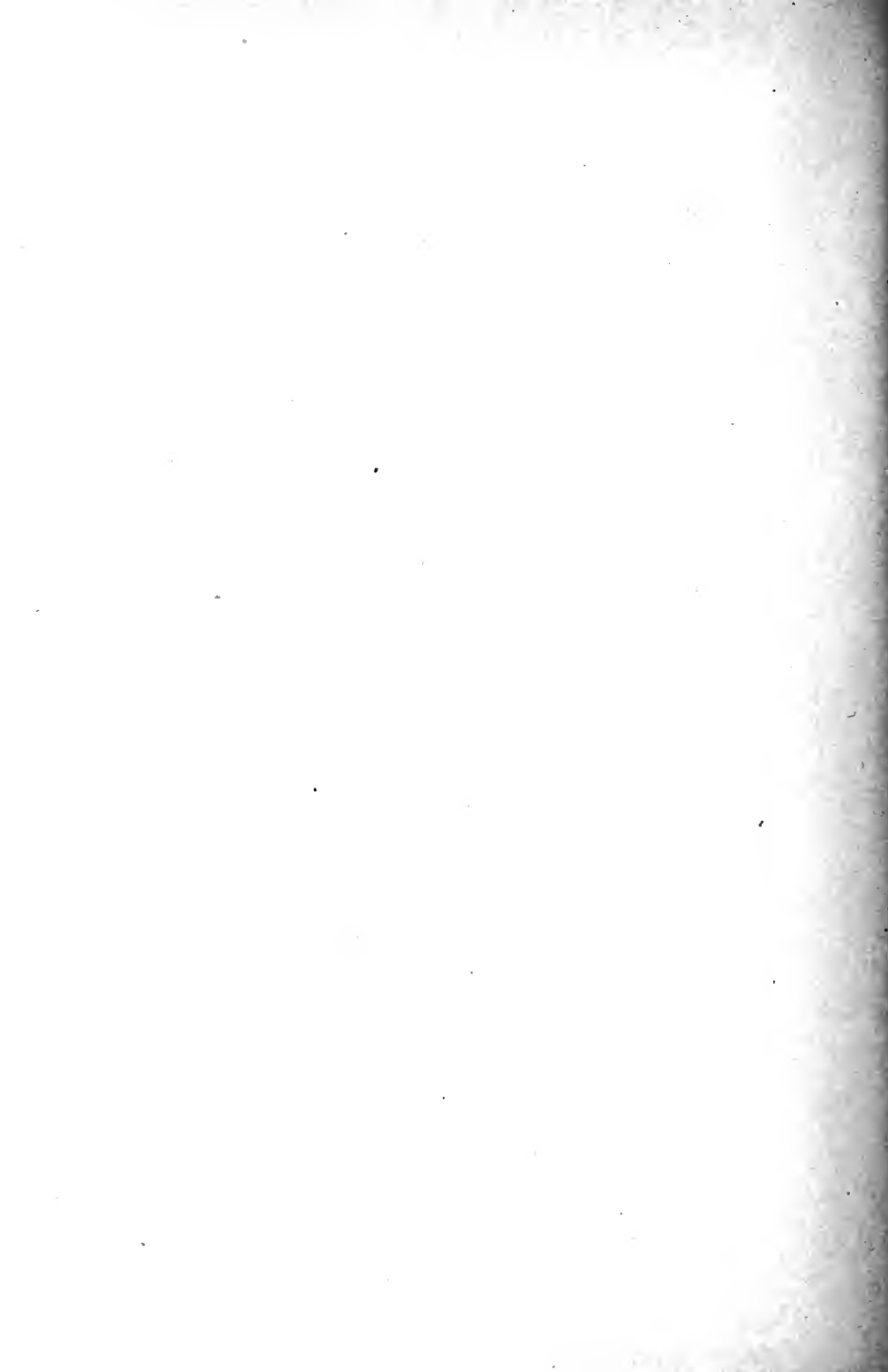


Branch of Resurrection Moss.

The branches, flattened dorsiventrally, rise from a central crown and produce roots only near the base. They are very numerous, from two to four inches long, with branchlets that fork at the extremities in such a manner as to be nearly fan-shaped. The leaves are arranged in four rows as usual, those on the sides of the stem being an eighth of an inch or less in length, thick, oblong, minutely ciliate, and very obtuse; those on the



RESURRECTION MOSS. *Selaginella Lepidophylla*.



upper surface are nearly as long and scarcely differ in shape. The lateral leaves are ascending, but the upper rows are nearly parallel with the branchlets that bear them. Both kinds are closely imbricated, and are likely to be faintly white-margined. The fruiting-spikes are borne on the end of the branchlets. They are square, half an inch or less long, with triangular sporophylls strongly keeled on the back. In old plants the leaves turn a reddish-brown on the under surface.

In recent years a considerable trade in this plant has sprung up, the large dealers ordering in lots of ten thousand or more. They are sold mostly to collectors of curios. Mr. J. H. Ferriss tells me that in the yards of settlers at the mouth of the Pecos River in Texas he has seen waggon-loads of this plant drying, preparatory to being shipped to Eastern dealers.

Selaginella lepidophylla is found in Arizona, New Mexico, and Texas in suitable situations. Though not widely distributed within our limits it is a very common species, and its range extends southward across the tropics to Peru. It is often called "bird's-nest moss," in allusion to the way the fronds roll up when dry. It is, however, most widely known as the resurrection plant.

Selaginella Pringlei.

This species, named for the veteran collector, C. G. Pringle, resembles *Selaginella lepidophylla* very much, spreading out in similar green rosettes in moist weather and rolling up when dry. The leaves are of the same size, but more pointed, and are further distinguished by being tipped with a hard, whitish, awn-like point nearly

as long as the body of the leaf. The fruiting-spikes are short, with less triangular sporophylls.

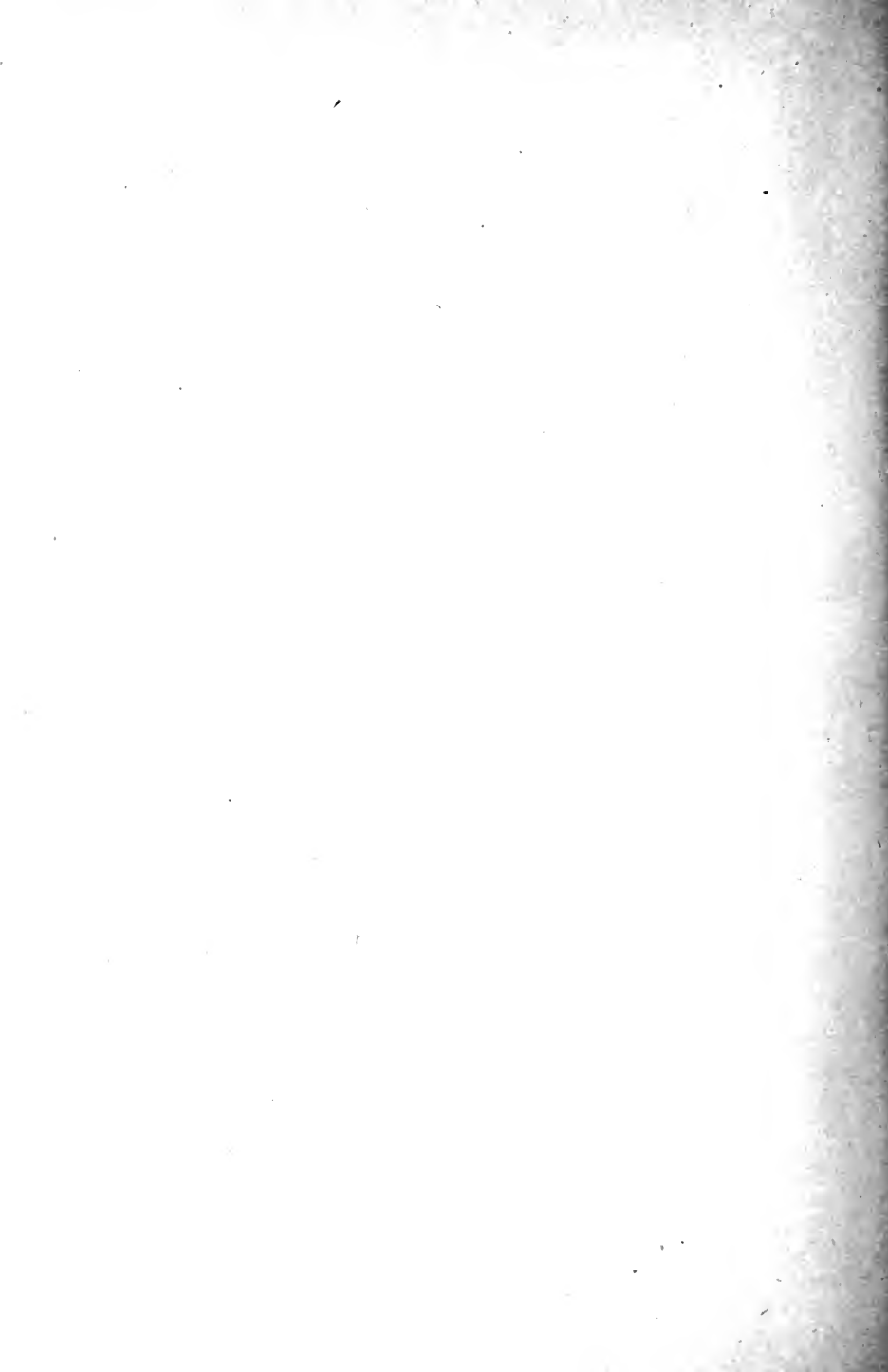
The plant has been collected in Mexico and was found in the Chenate Mountains of Texas by Neally. Owing to its being easily confused with *Selaginella lepidophylla*, but little is known about it, and even its range cannot be properly defined. More notes concerning it are very much needed. Both this species and the preceding, when growing, have a strong resemblance to the exotic selaginellas commonly cultivated, and, owing to their manner of growth in circular tufts, are desirable additions to the conservatory for their contrast to the other species.

Selaginella Pilifera.

According to Baker's "Fern Allies," *Selaginella pilifera* has been collected in Texas by Wright, but no recent collector has found it, and the opinion is held by most American students that the plant does not now occur within our limits. Its habitat is the plateau of central Mexico, and it may possibly stray northward in the Southwest. The following description should aid collectors in identifying it should they find it. The lateral leaves are ovate, oblique, very small, pale green, rigid, and tipped with a short point. They are serrulate, with the upper side of the base dilated and ciliated. The upper leaves are half as long as the others, lanceolate, and also cuspidate. The spikes are square, less than half an inch long, with ovate-lanceolate strongly keeled sporophylls. From the foregoing it will be seen that it is a plant much like *Selaginella Pringlei*, and col-

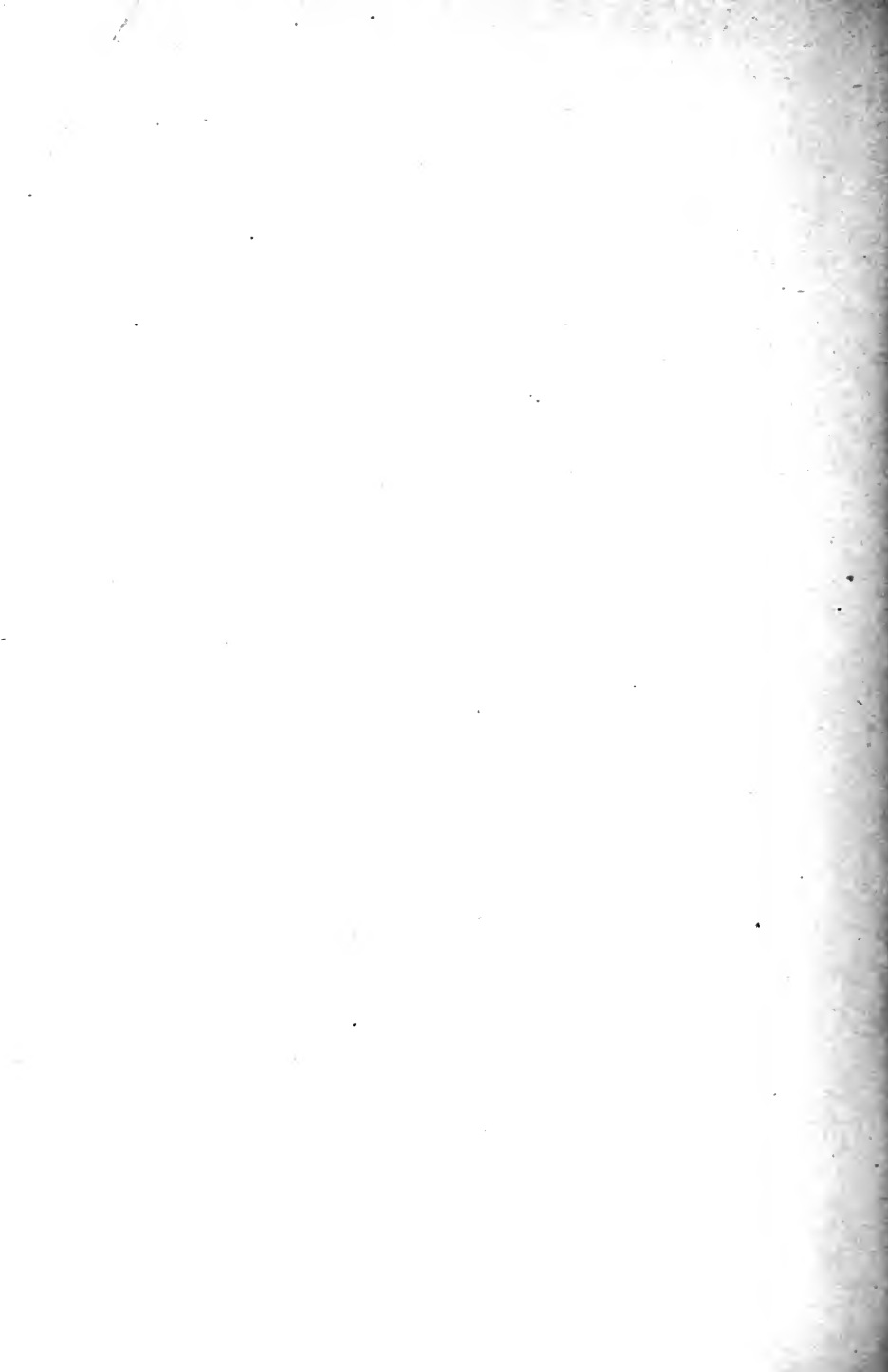


RESURRECTION MOSS. *Selaginella Lepidophylla*.
When dry.

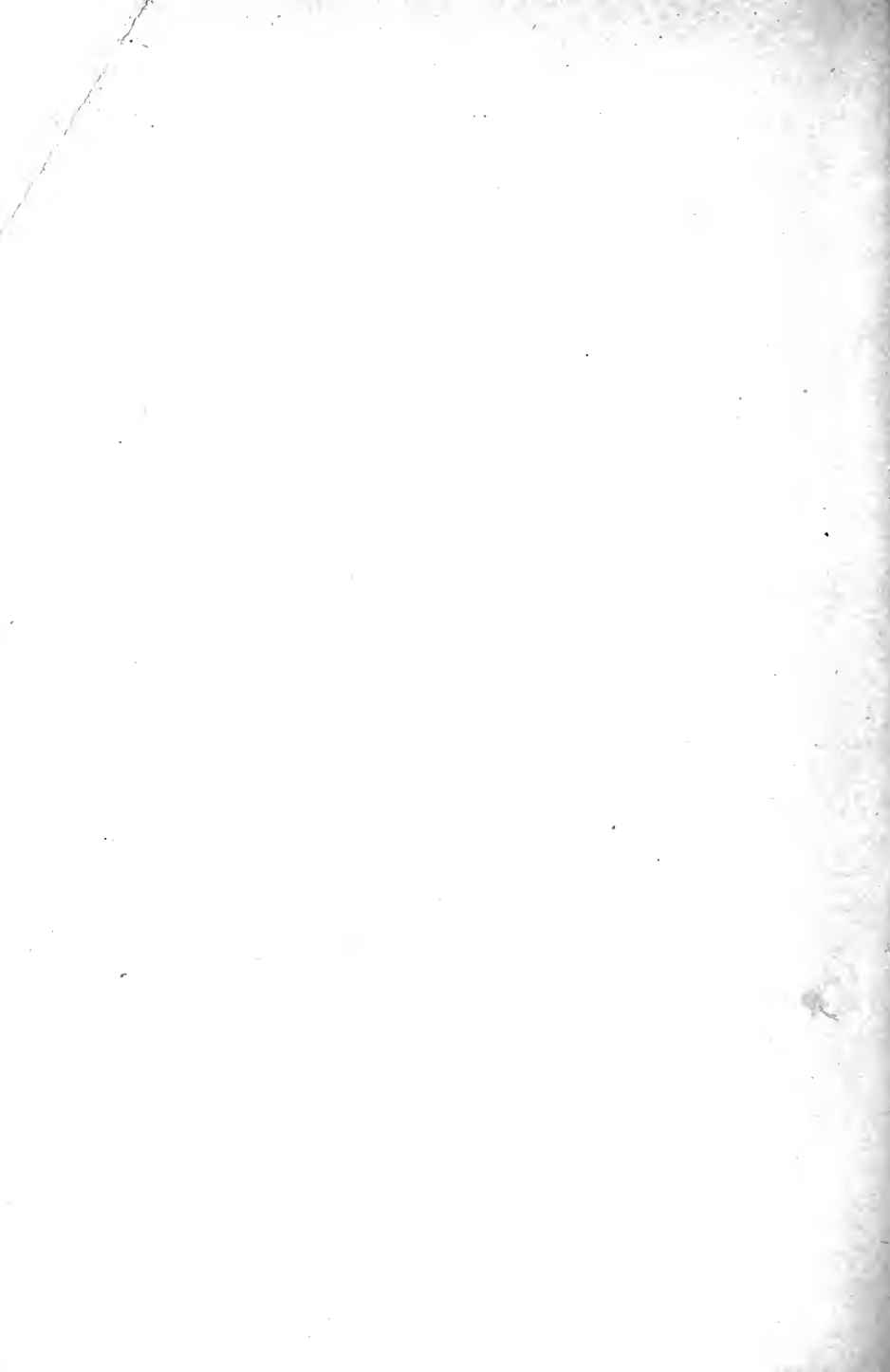


lectors who find the latter plant should look carefully for this one.

In 1904 Mr. C. F. Saunders discovered in southern California an apparently undescribed selaginella, of the *Selaginella rupestris* group, which has not yet been named. In the same year Mr. A. A. Eaton brought back from a trip to southern Florida specimens which have since been referred to the tropical *Selaginella Caribensis* a near ally of the creeping selaginella. This plant is not uncommon in the West Indies, but is likely never to be more than a rare or adventive plant in our territory. It is a stronger and heavier plant than the creeping selaginella and will be recognized at once from its resemblance to that species.



THE SALVINIACEÆ.



THE SALVINIACEÆ.



SINCE all vegetation requires a certain amount of water for its processes, it is not unusual for various species of plants to be found growing in swamps and bogs, or even in lakes and ponds, but cases in which plants have entirely severed their connection with the earth and taken to floating on the surface of the water are far less common. In

a survey of the vegetable kingdom, however, we find that all the great groups have species or even whole families that have adopted this mode of life. Among the flowering-plants the little duckmeats (*Lemna*) are likely first to come to mind, but there is the great water hyacinth (*Piaropus*), of Southern waters, and many another, like the bladderworts, nearer home. Among the liverworts various species of *Riccia* are found floating, and even the ferns have provided an instance in that remarkable floating fern, *Ceratopteris thalictroides*. It is not surprising, then, to find a family of the fern allies like the Salviniaceæ committed to such an existence. Indeed it is sometimes suggested that the Salviniaceæ

have arisen through some such ancestor as the floating fern, though as a matter of present relationships the species of this group appear to have closer affinities for the filmy ferns (Hymenophyllaceæ), especially as regards the formation of their sporocarps. In any event they are probably more closely allied to the ferns than any of the other fern allies except the Marsiliaceæ, and some are so much like ferns in their structure as to have received the common name of water-fern. As a class they are, with the Marsiliaceæ, sometimes spoken of as the Hydropterids (which may be translated as water-ferns), or as Rhizocarps, which refers to the way the sporocarps are borne in these families.

The Salviniaceæ contain but two small genera, *Salvinia* and *Azolla*, and these differ markedly in structure. All of them, owing to their position on the water, are dorsi-ventral, the stem growing horizontally. In *Azolla*, roots are sent down into the water, and at first glance this seems to be the case in *Salvinia* also, but a closer inspection shows that what appear to be roots in this genus are really dissected leaves and that the species are rootless. Above the water the vegetative leaves spread out, those of *Salvinia* oblong and entire, while those of *Azolla* are cut into more fern-like shapes. In most species numerous lateral branches are given off by the main stem, and these readily separate from the plant when the water is agitated, and form new plants. A rough day on the water, therefore, greatly assists in multiplying their numbers.

The spores are of two kinds, as in *Selaginella* and *Isoetes*, and are borne in structures called sporocarps, or conceptacles which appear to be special forms of an indusium. They are much like what would result if the

urn-like indusia of the filmy ferns should completely enclose the sporangia. In *Salvinia* the sporocarps are borne on the submerged leaves, usually in clusters of three; in *Azolla* they are borne in pairs in the axils of the aerial leaves. Some of the sporocarps in each cluster of *Salvinia* always bear megasporangia. There are about ten in each sporocarp, and each megasporangium bears a single large ovoid megaspore. The microsporangia are more numerous, globose, and contain a large number of microspores. In *Azolla* the pairs of sporocarps are usually of two sizes, the smaller bearing a single megaspore, and the larger producing several microsporangia and numerous microspores. The mature sporocarps drop from the plant and promptly sink to the bottom of the water, where they continue to enclose the spores for some time. The latter are finally liberated by the decay of the walls surrounding them. The micro-



Cross-section of *Salvinia* sporocarps. (Enlarged.)



Sporocarps of *Azolla*. (Enlarged.)

spores of *Azolla* are usually held together by a solid sort of protoplasm which produces hooked processes from the outer surface. The sporocarp appears to be an outgrowth of the leaf that, beginning with a ring surrounding the sporangia, slowly increases until it has completely enclosed them. Before this has happened, however, certain algæ take up their abode in the sporocarps, and when the latter mature they go into a resting condition, forming little colourless spheres. These spheres are seldom absent from the ripe sporocarps.

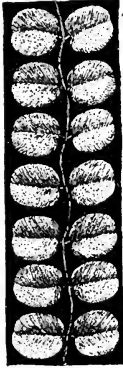
The genus *Salvinia* was named for Salvini, a Florentine professor. There are about a dozen species known

to science, most of them in tropical waters. The name *Asolla* is derived from two Greek words meaning "to dry" and "to destroy," and is most appropriately applied to these delicate little plants whose life is so closely dependent upon moisture. There are less than half a dozen species in the world. Like the salvinias they delight in the warm waters of tropical regions. The species in both genera are very small, the largest having leaves not more than two inches long, while in a majority they do not reach a length of half an inch. All are supposed to be short-lived, possibly annual plants, but a few seem to live to a greater age. A dozen or more species of *Salvinia* have been found in a fossil state, but usually in deposits of no very great age.

SALVINIA.



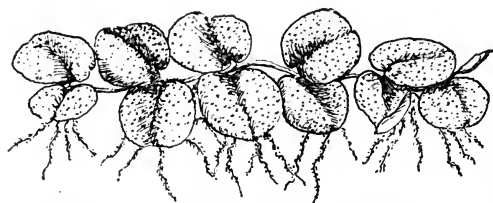
SALVINIA.



It may be seriously doubted whether any species of *Salvinia* is native to North America. In all books devoted to the Pteridophytes we are credited with one species, *Salvinia natans*, but the evidence to show that it is a native or even naturalised is far from convincing. It was reported from western New York by Pursh about a century ago, but the exact locality has always remained unknown, if it ever really existed. The only other record is the station at Oscher's Lake in the Bois Brulé bottoms in Perry County, Missouri, where it was collected by C. H. Demetrio in November, 1886. Mr. Demetrio has kindly favoured the author with part of the original collection in fine fruit and with an account of his finding it. It was collected but once, with *Azolla*, while on a fishing-trip to the lake, and was not noticed among the other specimens until they were being prepared for the press at home. It has apparently never been seen since at this station, nor has it ever been collected elsewhere in a location entirely free from the suspicion that it may have been introduced, and it seems but fair to conclude that the plant is not native to North America.

Paradoxical as it may seem, this plant, so rarely found

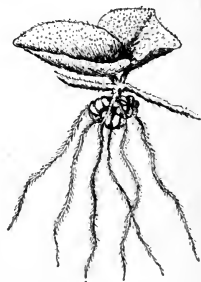
in this country, is really quite abundant, but always in cultivation. Few greenhouses in which there are tanks of water plants are without it, and it has become domesticated, as it were, in many small ponds, fountains, and artificial lakes.



Salvinia natans.

So far as known it has shown no tendency to spread to other waters unless its occurrence at Oscher's Lake is an instance.

The main axis of *Salvinia natans* may reach a length of two or three inches, but is usually shorter. Along this the leaves are thickly clustered in several longitudinal rows. Two of these rows on the under side of the stem are finely dissected into thread-like divisions, and go down into the water functioning as roots, since there are no true roots; the others float on the surface. These latter are half an inch or less in length, bright green, almost as broad as long, with a very blunt tip, and slightly heart-shaped base. Above they are thickly set with very short, soft, branching hairs that, though apparently so insignificant, are of great importance to the plant, since they keep it right side up in the water. It is practically impossible to make these plants float with the upper surface downward, for the tiny hairs hold great numbers of air

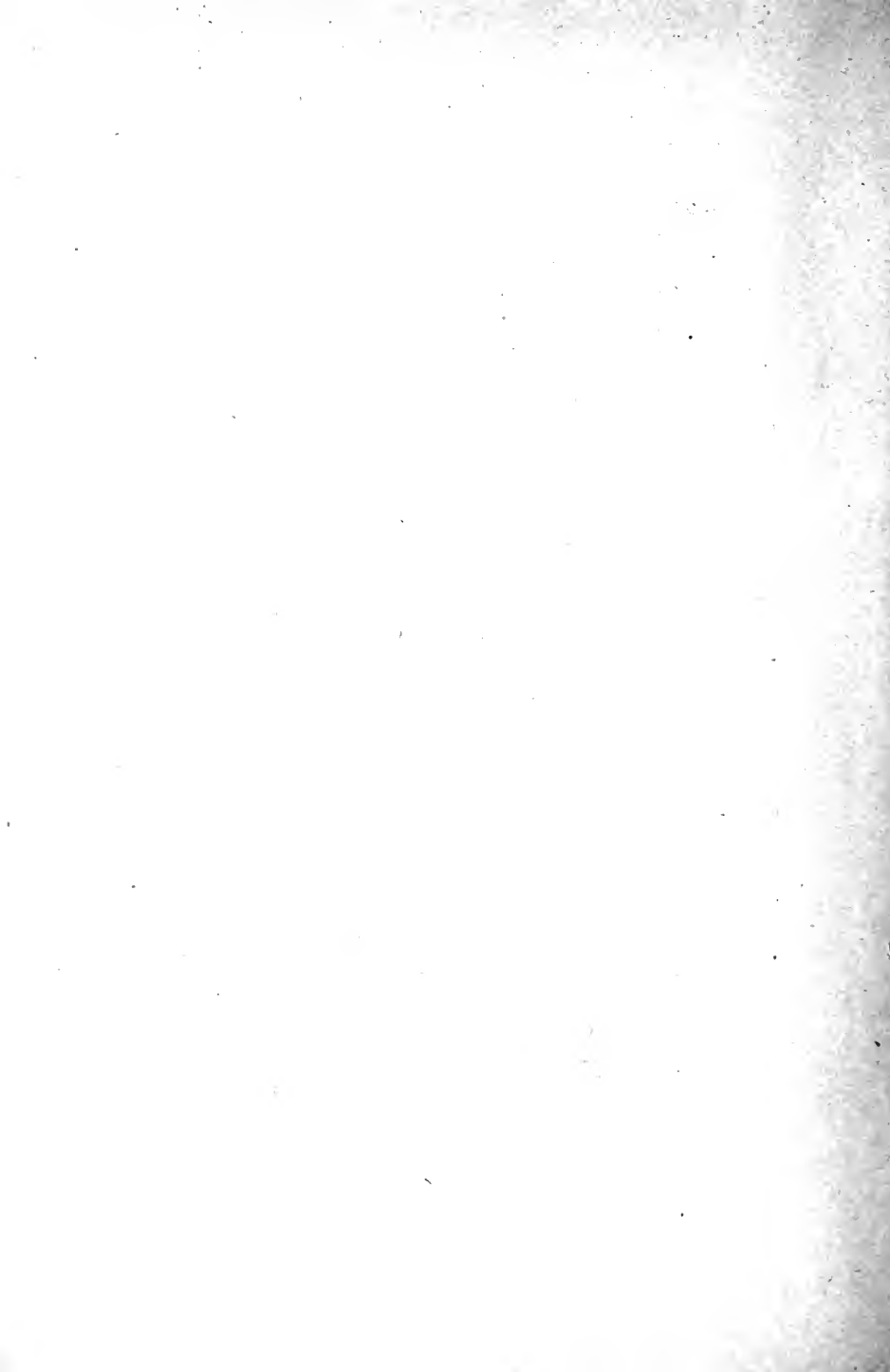


Sporocarps of *Salvinia*.

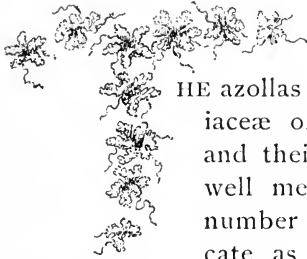
globules among them, which push the plant back as soon as it is overturned. Thus the plants can ride secure in the heaviest storms. On the under side of the leaves there are also numerous fine brown pellucid hairs. The sporocarps are from four to eight in a cluster, and are borne on a common stalk arising from the submerged leaves.

With the exception of the two questionable stations in the United States, *Salvinia natans* is found only in the Old World, extending from the south of France to India and northern China. It thrives well in sunny pools, spreading rapidly by division of the plant body. It is also easily grown in a dish of water in the house. Crayfish are said to feed upon the plant when other food is scarce.

THE AZOLLAS.



THE AZOLLAS.



THE azollas are the members of the Salviniaceæ oftenest called the water ferns, and their finely divided fern-like fronds well merit the name. Though few in number of species, and small and delicate as individuals, they have a wide distribution and are found in all the warmer parts of the world. In North America we have two species, one Western and the other with a wider range.

Azolla Caroliniana.

If asked to name the smallest of the North American fern allies one need have no hesitancy in mentioning *Azolla Caroliniana*. With the exception of its Western congener there are no others that even approach its diminutive proportions. Three or four full-grown plants may be hidden under a single copper cent, and yet so abundant is this species that vast stretches of water are often completely covered by it.

Taken singly, the plant is a handsome one. Its stems, so slender as to be invisible to the eye, fork several times, and are covered with the tiniest of two-lobed overlapping leaves, from pale green to deep red in colour.

As they float on the surface of quiet pools their resemblance to small green and red snowflakes is more than an idle fancy. From the stems slender rootlets go down into the water, and should it happen that the plant is stranded by reason of the lessening of the pools in summer, the rootlets are able to strike into the mud



Azolla Caroliniana.
(Enlarged.)

and so continue the existence of the plant. There is some reason for believing that the differences in the colour of the fronds are due to differences in habitat, those growing on the water in full sun being usually tinged with red, while those that root in the mud are nearly always deep green.

This species is supposed to be an annual, but the author has found it, though in lessened numbers, in mid-winter in New Orleans, often in pools liable to have a thin coating of ice. It develops very rapidly with the return of warm weather, and by mid-April the pools back of the levees along the lower Mississippi are entirely covered by it. Some idea of its possibilities of growth may be gained from a note by Prof. R. S. Cocks, in the *Fern Bulletin* for 1904, in which he says that in Audubon Park, New Orleans, between the months of June and September, there was removed from the surface of a pond about a quarter of an acre in extent no less than fourteen cartloads of this plant, with a total weight of seven tons.

The sporocarps are borne in the axils of the leaves, and in addition to the spore-cases nearly always contain the resting bodies of a certain alga (*Anabaena azollae*). As soon as the spores begin to germinate, these resting bodies of the alga do the same, and as soon as the



THE HOME OF AZOLLA.



Azolla leaves are developed, they creep into the hollow interior through a pore at the base of the larger lobe of the leaf, and there form colonies. These colonies are nearly always found in *Azolla* leaves.

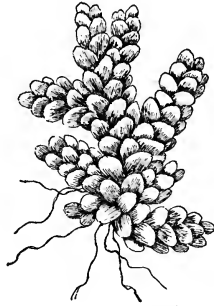
Azolla Caroliniana appears to grow naturally as far north as New York, but in the northern part of its range it is never so abundant or so conspicuous as it is nearer the equator. It is found throughout the South and extends to Arizona and Washington. It occurs in the Mississippi valley at least as far north as Iowa, but its northern range is not well defined. Beyond our limits it is found in suitable places as far south as northern Patagonia. It delights especially in still waters and is seldom found in streams. It is easily cultivated in ponds where it does not grow naturally, and has been thus naturalised in many places, one of the best known of which is on Staten Island, New York.

Azolla Filiculoides.

With the exception that *Azolla filiculoides* is a slightly larger plant than *Azolla Caroliniana*, it is almost exactly like it to the unaided eye. Study with the lens, however, shows that the branching in the present species is inclined to be pinnate in form and the fronds elongated, while in *Azolla Caroliniana* they are more deltoid in outline. The large lobe of the leaves in *Azolla filiculoides* is ovate, while that of the other is rhombic-oblong and obtuse.

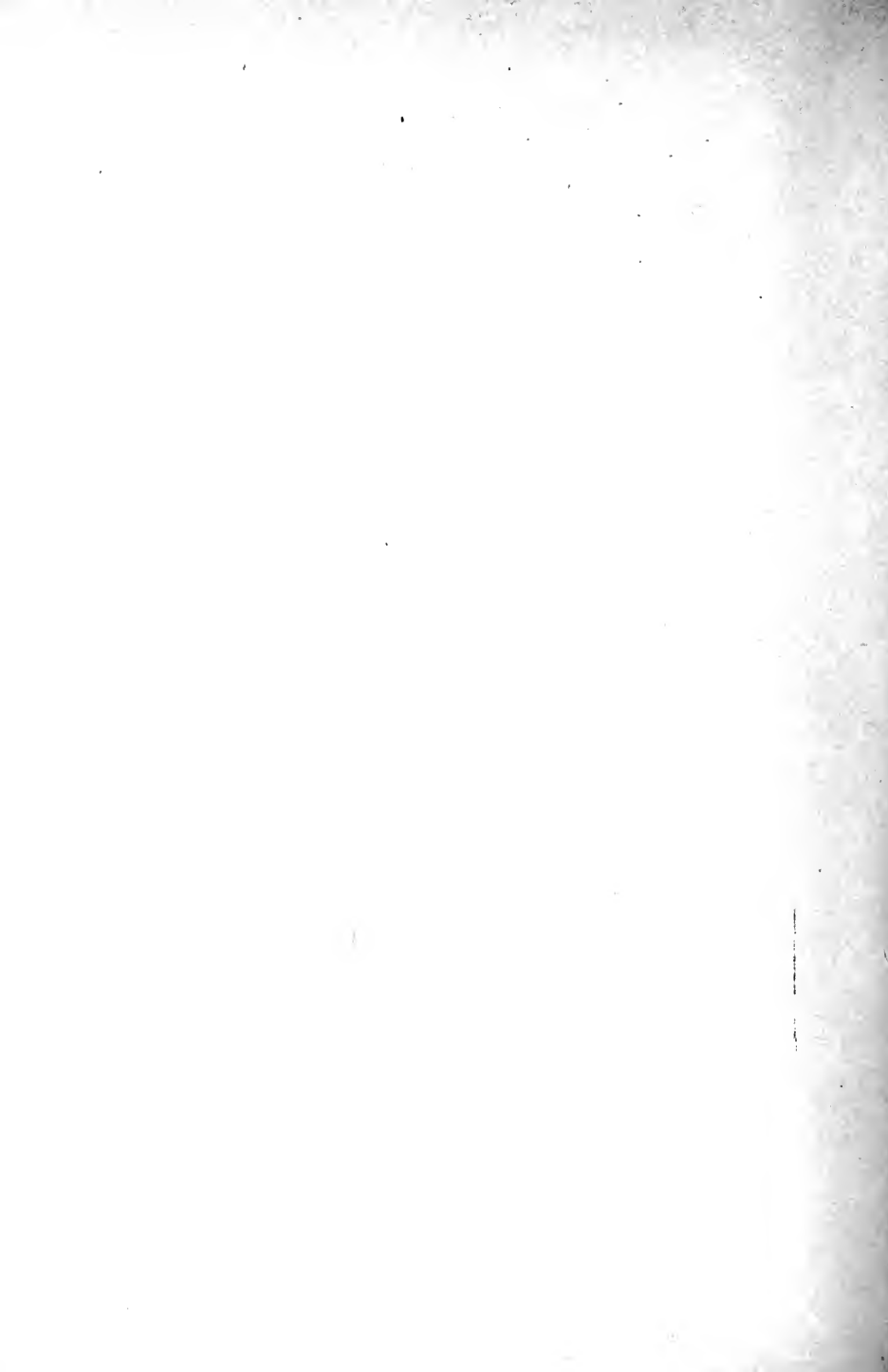
Azolla filiculoides is widely distributed in South America, being most abundant on the Pacific slope, and, according to Baker, is found in the Andes up to an elevation of 16,000 feet. Within our limits it extends to

California only, but is often abundant there. It has the same habitat as our common species and appears to thrive in cultivation. Mr. Eaton states that he has seen ditches in California covered two inches deep by the multitudes of this plant.

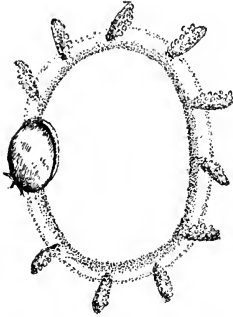


Azolla Filiculoides.
(Enlarged.)

THE MARSILIACEÆ, OR PEPPER-
WORDS.



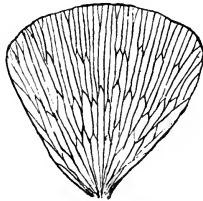
THE MARSILIACEÆ.



AN account of the way in which the spores originate, the Marsiliaceæ and Salviniaceæ are believed to be closely allied. They present several differences, however, quite as striking as their resemblances. All are lovers of the water, but while the species of Salviniaceæ are floating, those of the Marsiliaceæ are rooted in the mud in swampy places or at the bottom of ponds. The species of the first are all regarded as annual, while those of the latter are said to be perennial. Both bear their spores in sporocarps, but these are very different structures in the two families. In the Salviniaceæ the sporocarp represents a single sorus like that of ordinary ferns; in the Marsiliaceæ the sporocarp is really a modified leaf and contains several sori. It may be likened to the berry-like structure that encloses the sori in the sensitive fern (*Onoclea*). Like the Salviniaceæ, this family also consists of two small genera, *Marsilia* and *Pilularia*, both most abundant in the waters of the warmer parts of the globe.

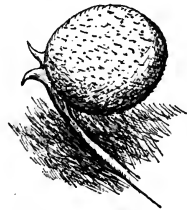
Although more closely related to the ferns than any of the other fern allies, the Marsiliaceæ are far from ferns in appearance. Nor do they have a greater resemblance

to any of the fern allies. The leaves of the marsilias are always four-parted, with slender petioles and much resemble those of oxalis or four-leaved clovers. Those of *Pilularia* are slender tapering organs, in outward appearance like the leafstalks of their relatives. In both genera the leaves rise from a jointed branching rootstock growing parallel to the earth and sending down abundant rootlets from the joints or occasionally from other parts of the stem. The leaves are coiled in the bud, like those of the ferns, and in *Marsilia* they are veined like them.



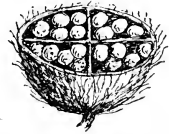
*Veining in leaf of
Marsilia.*

The sporocarps are from one to six in number and are borne on short pedicels that spring from the petiole of the leaf. Usually they are so close to the stem as to appear to be borne in the axils of the leaves, though in one exotic species, *Marsilia polycarpa*, they often number as many as twenty, and are strung along the petiole for some distance, each on a separate pedicel. In *Pilularia* they are usually solitary. In *Marsilia* the sporocarps are oblong, and in *Pilularia* they are round. From their shape and size, like peppercorns, the members are sometimes called peppercorns. The *Pilularia* sporocarp contains from two to four chambers, each of which contains a single sorus bearing megasporangia at the base and microsporangia at the tip. The megasporangia each contain but a single megaspore, while the microsporangia contain numerous microspores. In *Marsilia* each half of the sporocarp may be considered as a single cell, but



Sporocarp of Marsilia.
(Enlarged.)

these are separated by many transverse divisions, each containing a sorus. Around the inner wall of the sporocarp runs a gelatinous ring to which the sori are attached, and, when the sporocarp opens, this ring absorbs water and increases enormously in size, by this means pushing out of the sporocarp and drawing the sori with it. The whole process may be completed in half a day, and may be witnessed by any who will take the trouble to soak a *Marsilia* sporocarp in water. Before soaking, a small part of the outer covering of the sporocarp should be chipped off, so that the water may enter. The small oblong sori, attached to the almost transparent ring of jelly, make it a most interesting object.



Cross-section of
Pilularia sporocarp.
(Enlarged.)

An illustration of it will be found at the beginning of this chapter. Each sorus contains both megasporangia and microsporangia, the former few in number and each containing a single ivory-white megaspore. The sporocarps have a very thick, hard wall almost impervious to water, and may remain beneath the water for a long time without opening. So nearly impervious to liquids are the sporocarps when uninjured, that they have been kept in 95% alcohol for nearly six years, and then the spores still had vitality enough to germinate. Sporocarps dried and kept in the herbarium for eighteen years have also produced spores capable of growing.

The sporocarps of *Marsilia* finally open by splitting into halves. Those of *Pilularia* split into four valves from the apex. Since the sporocarps are modified leaves, the four valves of the *Pilularia* sporocarp may be taken to indicate that the original leaf was like that of *Marsilia*. Baker therefore states that the leaf in *Pilularia* is now

merely a filiform petiole. The prothallia are very rudimentary and develop with great rapidity. According to Campbell they may develop from the spores and produce mature sex-organs in twenty-four hours.

There are nearly fifty species in the genus *Marsilia*, mostly in tropical regions. Of *Pilularia* there are about six species, widely distributed. *Marsilia* was named for an early Italian naturalist, Aloysius Marsili. *Pilularia* is from the Latin word for a "little pill," and is in allusion to the small pill-like sporocarps.

KEY TO THE MARSILIAS.

Sporocarps usually two on each peduncle. Eastern.

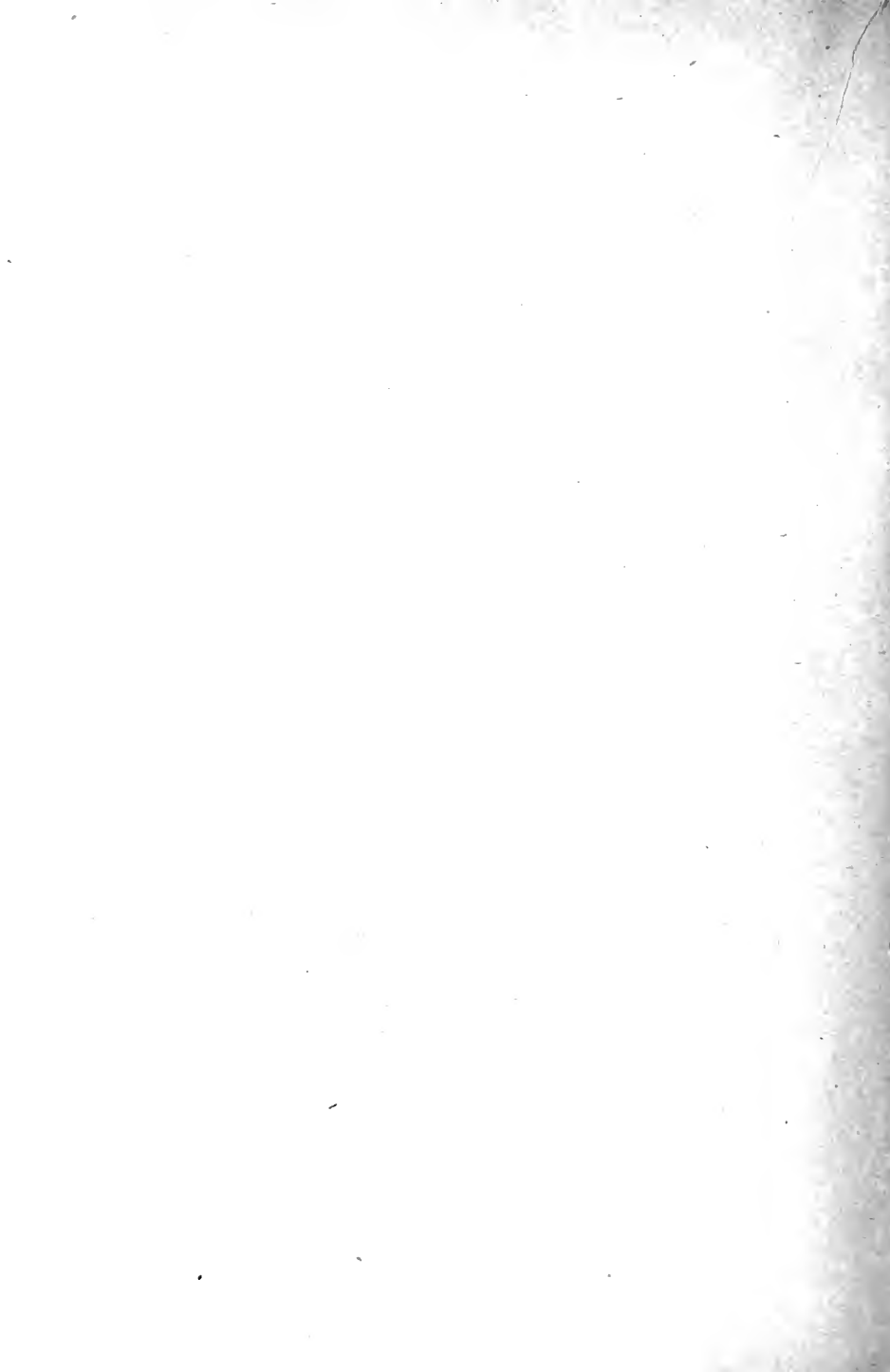
M. quadrifolia

Sporocarps rarely more than one on a peduncle

Plant nearly smooth. Southern . . . *M. uncinata*

Plant densely hairy. Western . . . *M. vestita*

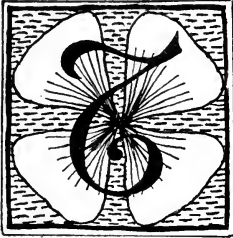
Plant larger, less hairy. Southwestern *M. macropoda*



THE MARSILIAS.



THE MARSILIAS.



HERE is scarcely a genus of plants anywhere whose species have a more general resemblance to one another than the genus *Marsilia*. The four-leaved clover is the unvarying pattern after which the leaves are cut, and when the collector has once seen a single species he will have no trouble in referring subsequent finds to its proper genus at least. Specific differences are found in such matters as size, hairiness, and the number and arrangement of the sporocarps. At least four good species are known within our limits, only one being found in the Eastern States, the others being confined to the West and Southwest.

Marsilia Quadrifolia.

Marsilia quadrifolia is a common species of the Old World extending from southern Europe to India, China, and Japan. In America it has been found at only a single station, Bantam Lake, Connecticut, and this circumstance has suggested the idea that it is not really native to our country. But, if not a native, the plant has become so thoroughly settled in its home that it may justly be claimed as a naturalised member of our

flora. From the original station plants have been sent to many other places, and in each they have grown luxuriantly, vying with the natives in their ability to hold their territory and to gain more. The pretty oxalis-like leaves resting upon the water or rising a short distance above it may be counted as an addition to our lakes and ponds, while the ease with which it may be grown makes it a general favourite. It may even be grown in a tub in the back yard, and is often seen in conservatories.

In its native haunts *Marsilia quadrifolia* usually roots in the mud beneath shallow water; the very slender rootstock, a yard or more long, creeping above the soil and sending up great numbers of leaves on slender petioles that elongate until they reach the surface. While this is the usual habitat, it may often be found quite out of water at midsummer. The leaves are then quite short, but such plants are usually very fruitful. The joints of the stem are short, and from each is produced a tuft of roots and a leaf. In the bud these leaves are coiled and the four divisions folded together, but as they reach the air they unfold and spread out on the water like the leaves of the water-lily. In vigorous specimens the petioles often hold the young leaves above the water. In outline the blade is nearly circular, from half an inch to two inches or more in diameter, and is divided into four equal leaflets, wedge-shaped at base and rounded on the outer margins. The divisions are marked by numerous fine veins that run from the petiole to the margin, forking several times. The young leaves are more or less hairy, but when full grown they are smooth.

The sporocarps are about half the size of peas and are



PLATE VIII. MARSILIA QUADRIFOLIA.

BY FRISCH, BY HERRER, J. K. A. STOCKS COMPANY.



borne two or three together near the base of the leaves. The common peduncle is about half an inch long, with a short stalk for each sporocarp and is usually united for a short distance with the petiole of the leaf. In colour the ripe fruits are dark purplish brown. When young they are clothed with minute yellowish hairs, but at maturity these disappear. The fruit is most abundant in shallow water. At the point where the pedicel appears to join the sporocarp there project from it two small points called teeth. In this species the teeth are very short and obtuse. There are from sixteen to twenty sori in each sporocarp.

Like the clover and oxalis, which it resembles, this species has the habit of closing its leaves at night. This is done by two of the leaves rising, folding face to face, and then being enfolded by the other two in the same position they had in the bud. The reason for this so-called sleep position is doubtless to be found in the fact that, like most water plants, the stomata or openings for transpiration are found on the upper surface, and this folding is in some way concerned with their protection. It is noticeable that only the young leaves or those rising above the water display these movements. When taken out of the water the leaves quickly close as in the night position. Baker spells the specific name *quadrifoliata*, but American writers do not.

Marsilia Uncinata.

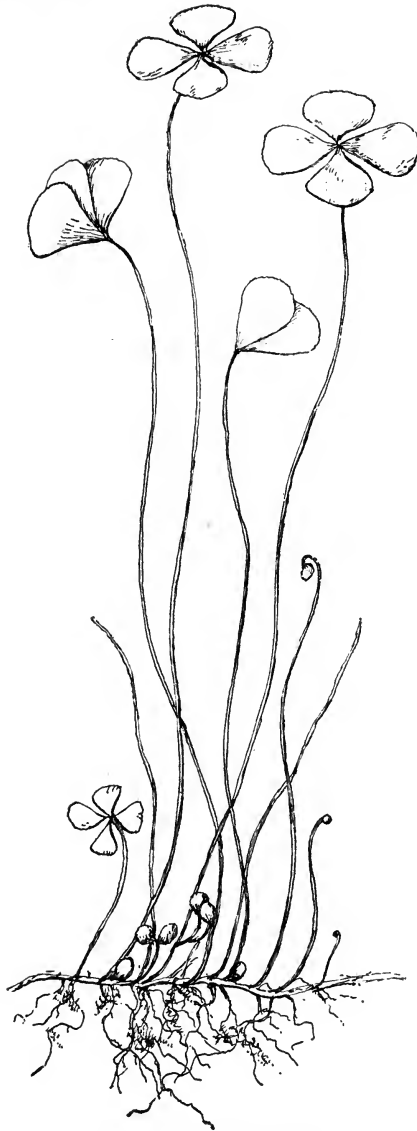
Marsilia uncinata is commonly regarded as a rare species, and in the latest edition of Underwood's textbook it is recorded from but two stations in the United

States. In reality it is an abundant plant in Louisiana, at least, being common for more than two hundred miles along the Mississippi. It probably occurs in moist grounds throughout the State. In the city of New Orleans it may be found along many roadside ditches, and in one street that the author knows of it grows quite across the street.

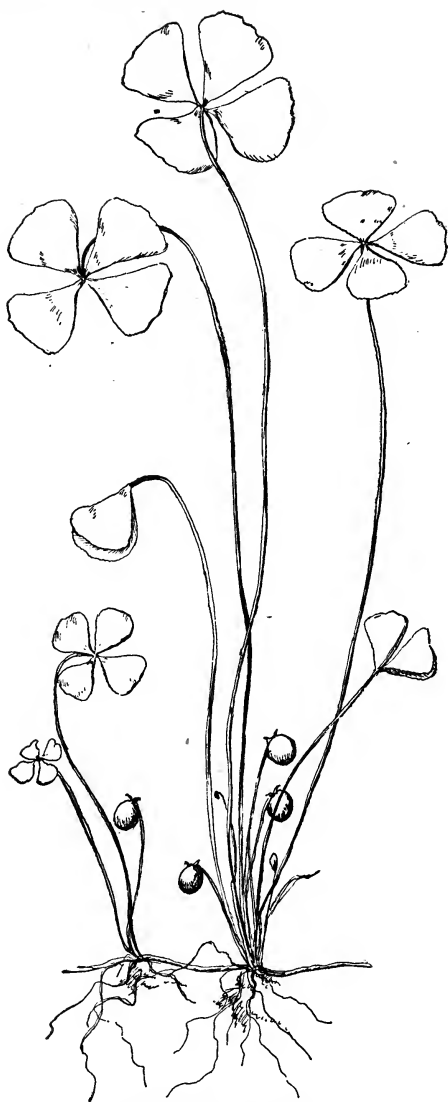
In books devoted to the fern allies, all the dimensions of the marsilias are rarely given. The length of the petiole depends almost entirely upon the depth of the water in which the plant grows, yet measurements of it are usually included, while nothing is ordinarily said about the length of the rootstock. In the present species the author has found rootstocks more than a yard long, and longer ones are probably common. Observations on this point for all our species are much to be desired.

In the size and shape of the leaf this species is almost like *Marsilia quadrifolia*. The blade, however, is likely to be sparsely hairy, even at maturity. The plant requires a wet soil, but is probably as common out of water as in it. It is often found, however, rooted in the shallow water on the edges of the bayous and sending long floating stems into deeper water. It bears fruit only on the stunted plants in drier situations, so that fruited herbarium specimens rarely indicate the beauty of this plant at its best.

The sporocarps are as big as peas and are borne singly on peduncles half an inch to an inch or more long, which appear to rise from the axils of the leaves. They are sparingly clothed with pale-brown hairs, even when ripe. The peduncle terminates in two rather conspicuous teeth, the upper of which is usually hooked, from which circumstance the plant derives its specific name.



Marsilia Quadrifolia.



Marsilia Uncinata.



There are often twenty-four or more sori in each sporocarp. A specimen is illustrated on page 188.

Marsilia uncinata is now known to occur from Louisiana to eastern Texas, and it is probable that its range will be still farther extended. It appears to be plentiful in the delta region of the Mississippi. When first described it was thought to be a variety of *Marsilia vestita*, but its longer rootstock, less hairy leaves, and sporocarps will distinguish it from that species. In its natural habitat *Marsilia uncinata* may be singled out from the surrounding vegetation for some distance by the peculiar fresh green colour of the leaves. During the winter months either the plants disappear, or the rootstocks remain in a resting condition without leaves, though they reappear early in the new year.

Marsilia Vestita.

The smallest of our marsilias, and the one with the least predilection for a watery habitat, appears to be *Marsilia vestita*. While it often grows in shallow water it is usually found on wet muddy banks, where it may either grow in dense tufts or put forth short extensions of its rootstock.

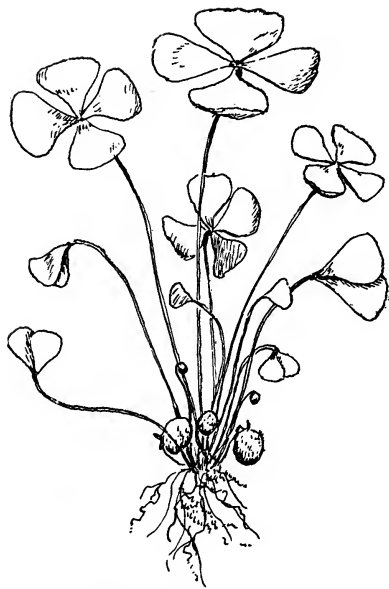
The petioles are from one to five inches long, and the leaves quite small, usually under an inch in diameter. Both leaf and petiole are clothed with soft, short, white hairs that may be either spreading or appressed. These are so numerous on the younger parts of the plants as to give them a hoary appearance. The outer edge of the leaflets is rounded, entire or occasionally slightly toothed. This is a variable plant, however, and all the characters do not hold for single specimens.

The sporocarps are smaller than those of *Marsilia uncinata*, but larger than those of *Marsilia quadrifolia*. They probably average a little less than a quarter of an inch long. They are borne on peduncles so short as to appear sessile or nearly so, and are densely covered with the fine whitish hairs found on other parts of the plant. The lower tooth of the sporocarp is short and blunt; the other is slightly longer and curved.

Marsilia vestita is found from Dakota and Washington to Texas and California. Southward it extends into Mexico. It has been reported as naturalised in central Florida, and according to Baker it is found in British Columbia also. Mr. A. A. Eaton notes that in the San Joaquin Valley, California, it is called "horse-clover" and is greedily eaten by horses. Prof. C. E. Bessey, however, reports in the *Fern Bulletin* that it is becoming a weed in several wet meadows in Nebraska. Campbell asserts that it is an annual, but upon this point more notes are desirable. Mr. Eaton is of the opinion that while the leaves may die the rootstock does not. Like an exotic species, *Marsilia hirsuta*, it is said occasionally to bear tuber-like bodies on the ends of certain branches of the rootstock, which under proper conditions may produce new plants.

Marsilia Macropoda.

The species called *Marsilia macropoda* is like *Marsilia vestita* in being more or less hairy, but it has a longer rootstock, much larger leaves, and sporocarps that are borne in clusters of from two to four instead of singly. It also probably lives longer than *Marsilia vestita*.



Marsilia Vestita.



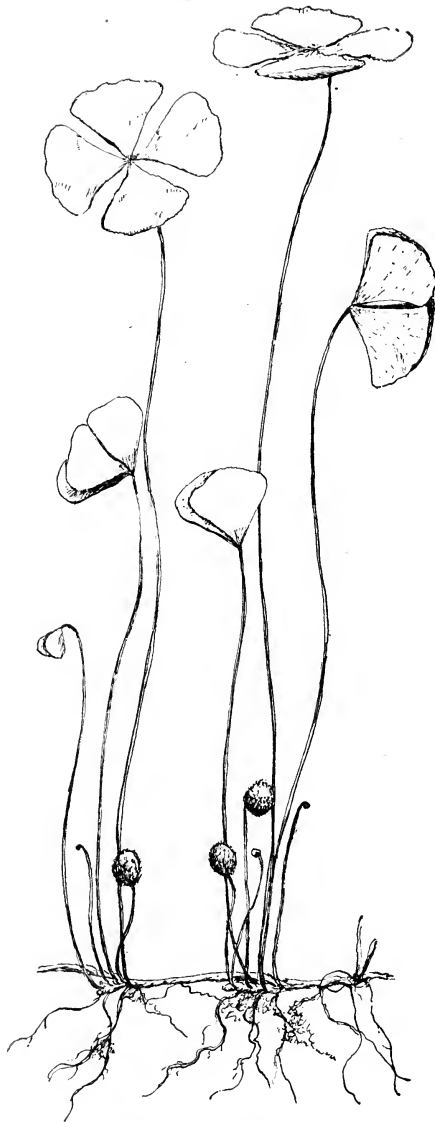
The rootstock of this species is like that of *Marsilia quadrifolia* in being wide-creeping. It grows beneath the water and sends up its large leaves to the surface. These are often two inches or more across, with deltoid segments having a rounded outer edge. Both sides bear silky whitish hairs that seldom fall off at maturity. The sporocarps are about a quarter of an inch long and are very densely covered with long, tawny, hair-like scales. The teeth are very small, the lower one often absent. There are about twenty sori in each sporocarp.

Marsilia macropoda has been thus far found only in southwestern Texas and New Mexico. The woolly nature of the leaves and fruit suggests that it may be an extreme form of *Marsilia vestita* that has been modified by its different habitat. While it is a lover of water it may often be exposed to the air by the drouths of summer, and appears to be most fruitful when growing with the minimum of moisture, as do most of the marsilias. Baker writes the specific name *macropus*.

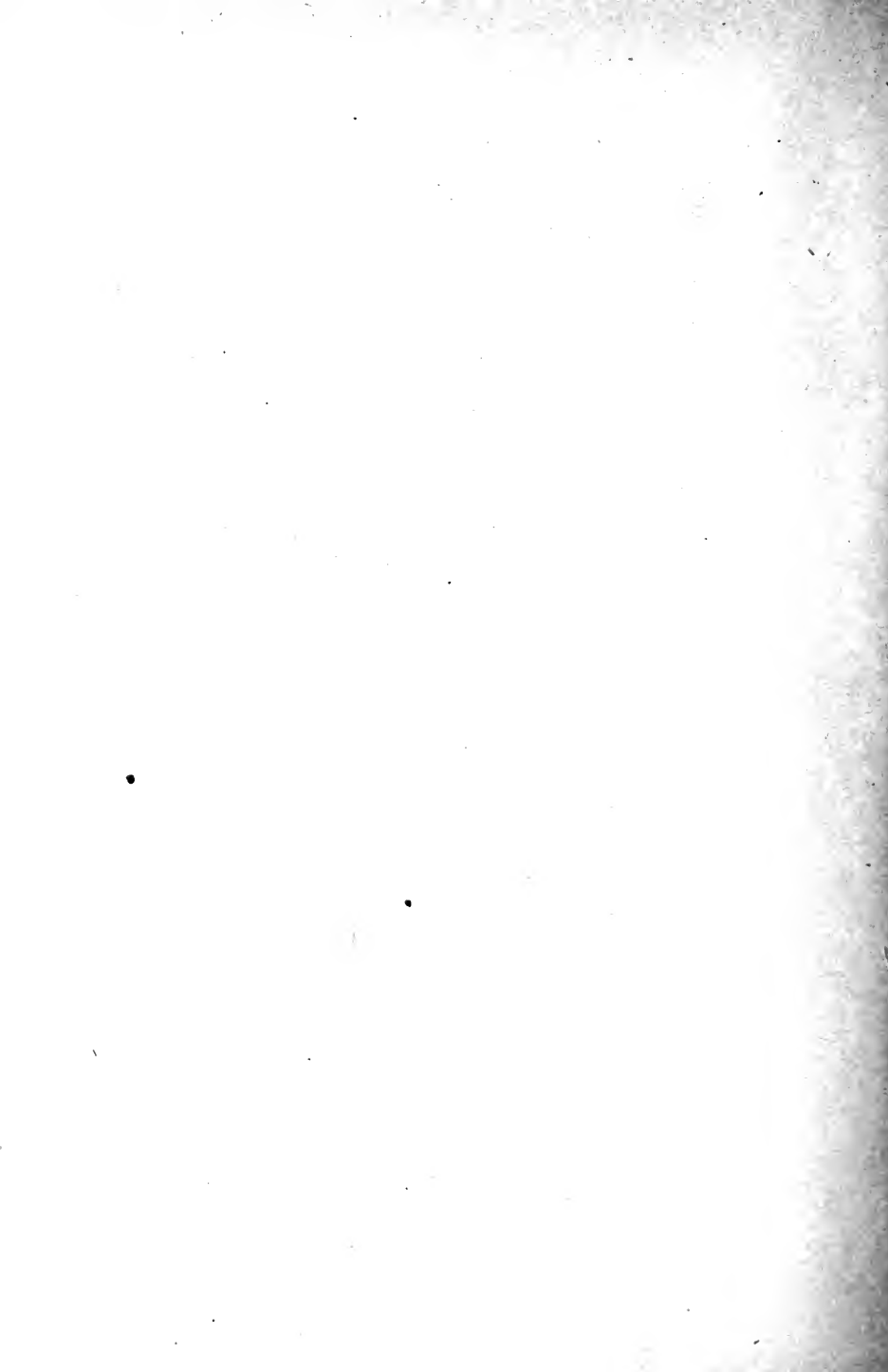
Marsilia Tenuifolia.

So far as known, the plant called *Marsilia tenuifolia* has been collected but twice, both times in western Texas. It has a close resemblance to *Marsilia vestita* and by some is thought to be a form either of that species or of *Marsilia macropoda*. It is described as being slenderer than *Marsilia vestita* with an extensively creeping rootstock. According to Underwood the leaves are villous with appressed hairs and toothed on the margins; according to Baker they are nearly or quite smooth, with entire margins. The sporocarps are said to be borne singly upon short pedicels and to be tomentose.

The plant has been so seldom seen as to be practically unknown, and it is small wonder that the authorities disagree regarding it. Until we have more definite information it seems permissible to consider it a form of *Marsilia vestita*.



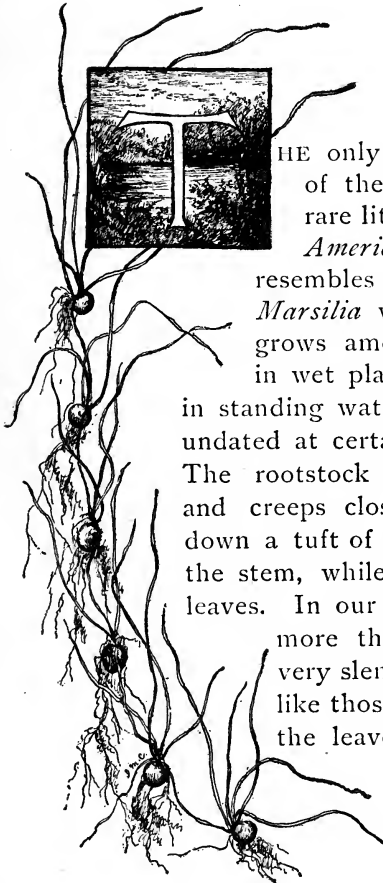
Marsilia Macropoda.



THE PILLWORT.



THE PILLWORT.



THE only American representative of the genus *Pilularia* is that rare little plant called *Pilularia Americana*. In structure it resembles a very small species of *Marsilia* without leaf-blades. It grows among grasses and sedges in wet places, but is seldom found in standing water, though it may be inundated at certain seasons of the year. The rootstock is fine and thread-like and creeps close to the soil, sending down a tuft of roots from each joint of the stem, while above rise the slender leaves. In our plant these are seldom more than two inches long, are very slender, and taper to a point like those of the quillworts. Like the leaves of the ferns they are coiled in the bud. The sporocarps are borne on short stalks in the axils of the leaves and are a

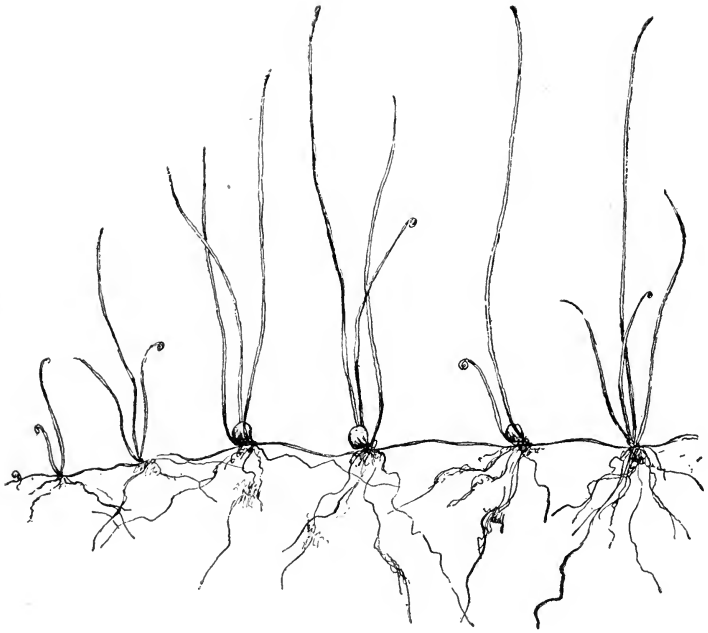
little more than one twelfth of an inch in diameter. They are round and dark brown and contain four cells, in each of which is a sorus bearing megasporangia and microsporangia. From the shape of the sporocarps this plant gets its name of "pillwort," while an allied species is known abroad, by the name of "water-pepper," from the same circumstance.

Pilularia Americana has been found in a few localities in California and Oregon, and is reported from Arkansas also. It is quite likely that it grows in many other places where its size and shape, so much like the immature rushes and sedges surrounding it, may aid it to go undetected. This species has also been found in Chili. An allied species is found throughout Europe.

Mr. S. B. Parish, writing of the habitat of our species in the *Fern Bulletin*, says:

"In winters of abundant rainfall little pools form in the hollows of the clay mesas about San Diego, and on the surface of these pools and on their muddy margins these plants find a congenial home. Often successive years pass with rainfall insufficient to maintain these pools, and consequently without affording the pilularias an opportunity for growth."

The plants are thus apparently annuals, though all the species of Marsiliaceæ are regarded as perennials.



PILLWORT. *Pilularia Americana.*



THE ISOETACEÆ, OR QUILLWORTS



THE ISOETACEÆ.



HERE is doubtless no family of plants so little known to the botanists of the regions in which they grow as the Isoetaceæ, or quillworts.

The flowers, fruits, and leaves of the flowering-plants make them conspicuous ; the ferns, lacking flowers, are still noticeable from the beauty of their fronds ; and even the fern allies, with the present exception, may attract attention by reason of their strange forms and curious manner of growth ; but the quillworts, most of which pass their whole existence beneath the waves of lake or river, far removed from the other objects of the botanist's pursuit, ordinarily escape observation, or, if seen, are dismissed with the thought that they are immature specimens of some sedge or rush. Even the botanists themselves for a long time paid little attention to them, usually referring such forms as were found to the single

species *Isoetes lacustris*. Although numerous species are now known to occur in the waters of the Eastern States, the early volumes on the flora of the region make no mention of them. Scarcely fifty years have passed since botanists began to study these plants understandingly, and students are yet by no means agreed as to the limits which should separate various species or the position they should occupy as a group in botanical classification. Baker, in his "Fern Allies," places them in the Selaginellaceæ; Campbell, in "Mosses and Ferns," considers them closely related to such ferns as the adder's-tongue (*Ophioglossum*) and the moonwort (*Botrychium*); while still others believe that their structure indicates a closer connection with the pines and their relatives. They are nowadays usually placed in a separate order, family, and genus, as we have placed them in this volume.

Notwithstanding the close superficial resemblance between the quillworts and other water vegetation, the difference between them is quickly recognised as soon as one has become acquainted with a single species. A quillwort is essentially a rosette of short, hollow, cylindrical, pointed leaves with sporangia in their axils. The central axis to which these leaves are attached is short and flat, so that there is never produced an elongated stem, as in the other fern allies. If one can imagine a fruit-spike of *Selaginella* in which the axis has failed to develop, and in which the sporophylls have lengthened into quill-like though flaccid leaves, he will have a good idea of the typical quillwort. The resemblance of the plant body to the bulbs of flowering-plants has also been frequently noted.

The trunk, main axis, or rootstock, though flat and

tuber-like, has a central vascular bundle surrounded by a region of growing cells that annually produce new bark on one side and add to the vascular tissue on the other. At two or more points this tissue is more active than at others, with the result that mature rootstocks are either two, three, or more lobed. In the hollows between these lobes, the roots are given off, and these are peculiar for forking two or three times like the selaginellas, instead of branching irregularly as those of most plants do.

The leaves number from ten to two hundred and are arranged spirally on the upper part of the rootstock.

At the point where they join it they are wide and somewhat triangular in cross-section, but above they approach cylindrical in form. In length they range from less than two inches to more than two feet. Running lengthwise through the centre of the leaf is a bundle of bast which,



Cross-section of leaf
near base.

with the surrounding tissue, separates the hollow interior into four parallel chambers containing many cross-partitions. In addition to the central

strand of bast there are frequently four others, called peripheral bast bundles, near the surface. One of these is at the back on the outer side, another is in the middle of the inner face, and the two others are found on either side of this on the inner edges of the leaf. In most of our species the peripheral bast bundles are absent; when two are present they will be found to be the dorsal bundle and the one in the middle of the inner face. The two on the inner edge of the leaf are usually absent.



Leaf
showing
sporan-
gium.

Only the outer earlier whorls of leaves produce sporangia. When the spores are ripe the fertile leaves slowly decay, but the sterile, somewhat rudimentary leaves remain green through the winter. In the terrestrial species these leaves may form somewhat spiny processes. The tips of ordinary leaves usually end in a long tapering point, which, with the hollow interior, is probably responsible for the name of quillwort applied to the plants.

The quillworts are usually about four years old when they begin to bear spores, and, as might be expected, their manner of fruiting shows most plainly their relationship to the fern allies. Their resemblance to the selaginellas is particularly striking, since they bear two kinds of spores. These are produced in the axils of the outer leaves in a hollowed-out portion of the leaf. In each of these hollows is a single oblong sporangium which may occasionally reach a length of more than a quarter of an inch. Over this sporangium the substance of the leaf projects in the form of a thin indusium or velum, in a few cases entirely covering the sporangium, but usually leaving a third or more exposed. The sporangia are said to be one-celled, but they contain partitions that divide them into several incomplete chambers. This feature is also found in fossil lepidodendrons. Just beyond the sporangium there arises from the inner surface of the leaf a small, thin, triangular flap called the ligule. It is most strongly developed in terrestrial forms, but its use is unknown. In many species some of the cells in the walls of the sporangium become thickened, giving it a spotted appearance which is sometimes considered of diagnostic importance. The spots, however, are not visible to the unaided eye.

The sporangia in the outermost leaves contain numerous large spores called megaspores, macrospores, or gynospores, while nearer the centre of the plant similar sporangia bear a much larger number of smaller spores called microspores or androspores. The megaspores always produce female prothallia, and the microspores those of the opposite sex. The megaspores are about one fourth the size of a pin's head, but are large enough to be seen with the unaided eye. Under a lens strong enough to resolve their structure they appear as spheres of dazzling white encircled by an elevated ridge near the middle, called the equator, and with three other ridges called commissures going from the equator to meet in the centre of the upper hemisphere. One half of the spore is thus divided into

three nearly equal areas, while the other is without ridges. Between the ridges, especially on the upper hemisphere, the surface is thrown into many curious patterns in which spines, crests, pits,



Megaspores. (Greatly enlarged.)

and labyrinthine forms predominate. Each separate species has its own pattern of marking, and thus the spores afford important characters for identification. The white coating of the spores has been found by Mr. Raynal Dodge to be silica, the same flinty matter that gives roughness to the stems of the scouring-rush.

The microspores are about one thousandth of an inch in length and very numerous. According to Dodge there may be as many as a million spores in a single sporangium. They are usually oblong, somewhat triangu-

lar in cross-section, and have a smooth papillose or spiny surface mimicking the megaspores. The size of the spores is usually given in thousandths of a millimeter, the Greek letter μ standing for a single thousandth. Three hundred and fifty thousandths of a millimeter would be written 350μ .



Microspores.
(Greatly enlarged.)

The prothallia of the quillworts lack chlorophyll, and, like the prothallia of *Selaginella*, do not separate from the spores. At maturity the spore simply opens along the three commissural ridges, exposing the archegonia, and in this position the eggs are fertilized by the sperms. Some of the aquatic forms have the power of producing buds in place of sporangia, and these finally float away and become new plants.

Of the fifty or more species of *Isoetes* a large number dwell constantly on the bottom in lakes, ponds, and slow-moving streams, at depths of from one to ten feet beneath the surface of the water. Others, however, occur in such situations that the receding water in summer exposes them to the air, while a few are rarely if ever submerged, though they always grow in wet places. Those that are exposed to the air have stomata or breathing-pores, but those always beneath the surface have none. It is interesting to observe that in those species that are only occasionally exposed to the air, the stomata are found only on the tips of the leaves, in the position where they would be most useful to the plant should the water leave any part of it exposed.

The species of *Isoetes* are so much alike externally that for exact identification a compound microscope is necessary. An examination of the ripe megaspores alone is

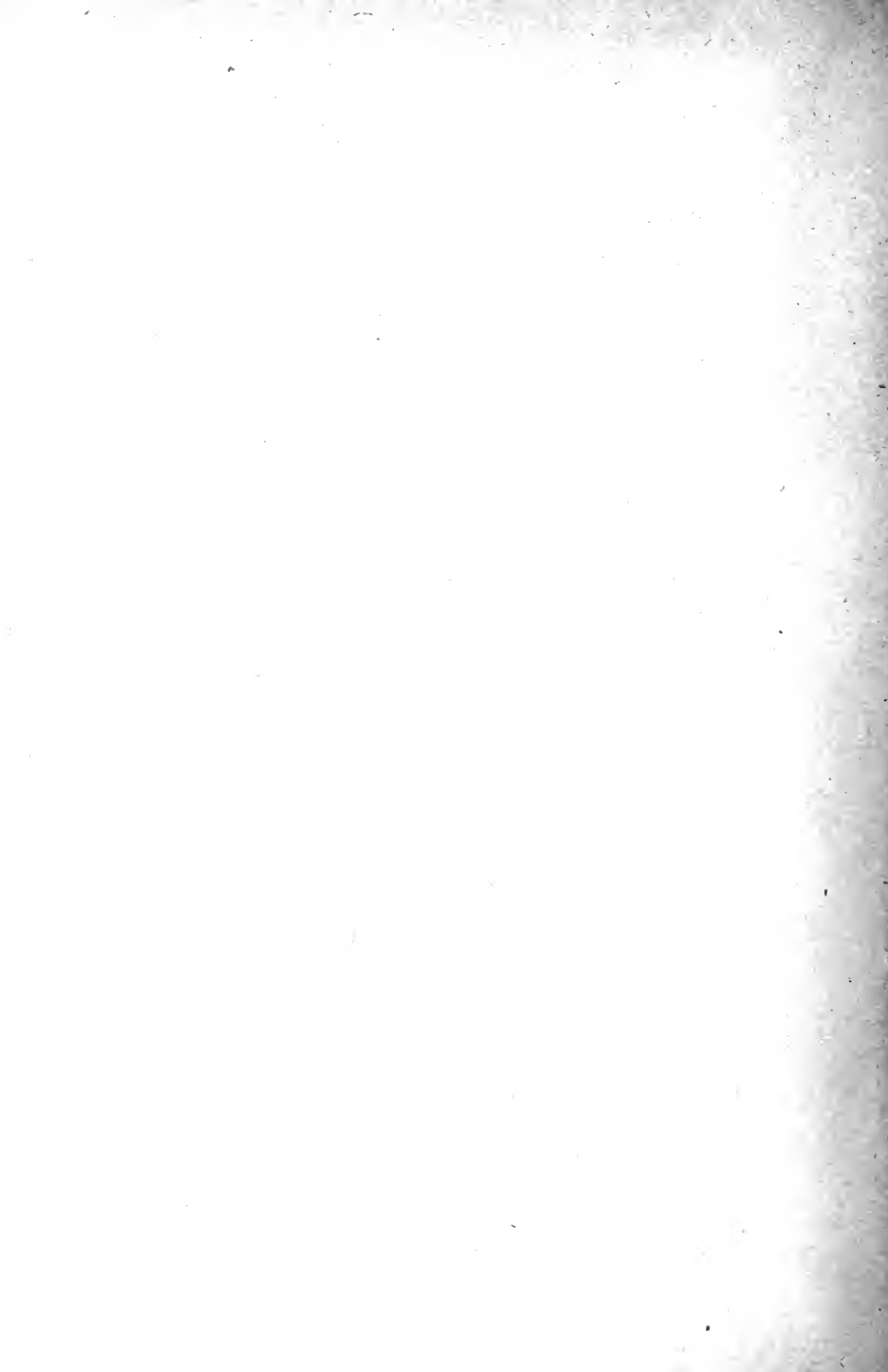
usually sufficient to indicate the group to which the plant belongs, but other considerations must often be taken into account in naming the species. In the following pages, illustrations of the megaspores only have been given. These all have the same magnification, so that the comparative size of the spores may be easily seen. It is expected that when the plants are better known than at present the species will be more easily distinguished, because more accurately described. Further notes on all our species are greatly desired.

The word *Isoetes* is said to be derived from two Greek words meaning "equal" and "year," and was applied to these species because of the perennial character of the leaves. The species are widely distributed throughout the world, but are most plentiful in the glacial lakes and the streams leading from them in the northern hemisphere. They are an isolated group not closely connected with any other living forms, but exhibiting in their structure certain features that seem to indicate that the modern monocotyledons, to which the grasses, lilies, and orchids belong, may have arisen from the same parent stem. As recognised at present, *Isoetes* is the only genus in the family Isoetaceæ, and this family the only one in the order Isoetales.

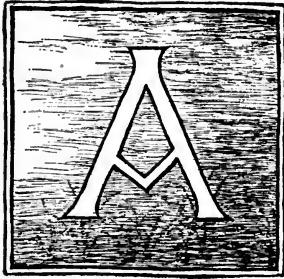
KEY TO THE ISOETES.

- I. — Plants normally submerged
- Spores with low tubercles or warts. *I. Bolanderi*
 - Spores with slender spines *I. echinospora*
 - Spores with short rounded crests *I. Macouni*
 - Spores with worm-like crests *I. hieroglyphica*
 - Spores with thin crests sparingly anastomosing
I. lacustris
 - Spores with many anastomosing ridges
I. Tuckermanni
- II. — Plants normally exposed in summer
- Indusium complete
 - Spores with fine warts *I. melanospora*
 - Spores with heavy tubercles *I. flaccida*
 - Indusium incomplete
 - Spores with faint crests and warts *I. Howelli*
 - Spores with numerous truncate spines *I. Gravesii*
 - Spores with spines and short crests
 - Mostly spinulose *I. saccharata*
 - Crests often anastomosing *I. riparia*
 - Spores reticulated
 - Ridges sub-continuous *I. Canadensis*
 - Ridges anastomosing
 - Ridges thin *I. Engelmanni*
 - Ridges moderately thick *I. valida*
 - Ridges very thick *I. foveolata*
- III. — Plants seldom if ever submerged
- Spores smooth *I. Orcutti*
 - Spores faintly warty
 - Warts few *I. Nuttallii*
 - Warts many
 - Commissures wide *I. melanopoda*
 - Commissures narrow *I. Butleri*
 - Spores with short spines *I. minima*

THE AQUATIC QUILLWORTS.



THE AQUATIC QUILLWORTS.



SERIES of *Isoetes* specimens could easily be selected which would show every gradation from the most deeply submerged plants to those habitually living in dry ground, but such a series would of necessity include specimens of many species. The water-loving species, however, keep close to their own element, and it is only under exceptional circumstances that they appear above the surface; while the terrestrial forms are for a great part of the year entirely above water, though growing in moist places. Between these two there are certain species that always live for a part of the year under water and a part of the year exposed, so that for purposes of study it is very convenient to divide the genus into three groups containing aquatic, amphibious, and terrestrial species respectively, though a hard and fast line between them cannot be drawn. The species of the first group have been selected for description in this chapter.

Braun's Quillwort.

If, while floating upon the quiet surface of some small mountain lake, the collector should discern two or three

feet below the surface, a colony of plants like small green rosettes, he may conclude that he has found Braun's quillwort (*Isoetes echinospora Braunii*). Since all the aquatic quillworts have the same general plan for the plant body, it is possible that such a conclusion may have to be modified later and his specimens referred to some other species, but Braun's quillwort is so abundant and so widely distributed that until its spores have been examined one is fairly safe in assuming that any new find is this species.

The leaves are from ten to thirty in number and occasionally reach a length of ten inches, though the average is probably less than five. They are dark green, occasionally reddish at base, and while in the water are half erect. When fresh from the water they are somewhat rigid and inclined to curve backward. There are a few stomata present on the tips of the leaves, but the peripheral bast bundles are absent, as is usual in the submerged species. The sporangium is pale spotted, and the velum or indusium about half covers it.



Megaspore of
Isoetes echinospora
Braunii.

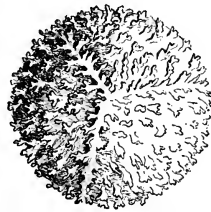
The principal distinguishing character is found in the megaspores. These are from 350μ to 550μ in diameter and covered with broad spinules which are often forked or toothed and sometimes recurved. Occasionally, too, the spinules may become confluent into short crests. The microspores are from 26μ to 30μ in length, white or grey in colour, smooth, and very numerous. Three hundred thousand microspores have been found in a single sporangium. The spores retain their vitality for some time, and plants have been raised from the spores taken from herbarium specimens.



BRAUN'S QUILLWORT. *Isoetes echinospora Braunii*.

The typical *Isoetes echinospora* is an Old World species found in the lakes of northern and central Europe. It differs from our plant in having an unspotted sporangium, a narrower indusium, and no stomata. These differences have been considered sufficient to make our plant a separate variety. There can scarcely be a doubt that the two forms have arisen from a common ancestor. Our plant holds the same position in North America that the type does in Europe. In the "Ferns and Fern Allies of New England," Dodge gives its habitat as "margins of ponds often wholly submerged; also on the muddy shores of streams or on the tidal tracts of rivers, often where the water is very brackish." The author has seen it in many of the small glacial lakes of northern Pennsylvania, but he has never collected it in a locality in which it was ever likely to be above water. There seems, therefore, to be some difference in its habitat in different parts of its range. The fact that it bears stomata may be taken as an indication that it is prepared for an occasional exposure to the air.

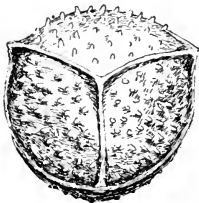
Our plant ranges from Pennsylvania, Utah, and Washington to Alaska and Greenland. According to Baker it is also found in Iceland. The American plant has several forms or varieties. A stouter plant with more numerous leaves and abundant stomata is called the variety *robusta*, and a form with long slender spinules on the megaspores is called the variety *Boottii*. *Robusta* is recorded as growing in Vermont and New Hampshire, and *Boottii* has never been found except in the few localities in Massachusetts where Boott first found it. These forms



Megaspore of
Isoetes echinospora
muricata.

appear to be trivial ones produced by the habitat in which they grow. Most botanists now give little attention to them. According to Eaton *Boottii* is found in sand, and this may account for its characteristic slender leaves.

Isoetes echinospora muricata is a more pronounced form.

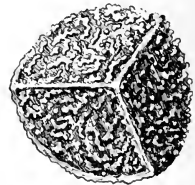


Megaspore of
Isoetes echinospora
Flettii.

The leaves are longer, slenderer, and inclined to be spiral and the megaspores are slightly larger, and covered with shorter, thicker, and more confluent spinules. In deep water the slender leaves are inclined to take on a spiral form. This variety is found from Nova Scotia to New Jersey. *Isoetes echinospora Flettii* comes from a few lakes in Washington and British

Columbia, and differs from the type in having stout leaves, and the spines of the megaspores few, very short, almost wart-like. This is an extreme form and by some might be considered a distinct species. In spore characters it approaches the various other species of the Northwest, and except for the size of the spores might be considered a variety of *Isoetes Bolanderi*.

A stout plant, also from northwestern America, has been named *Isoetes echinospora truncata*. This has megaspores thickly covered with short truncate columns. The spores are noticeably flattened on the hemispheres containing the commissures, and are not easily confused with those of other



Megaspore of
Isoetes truncata.

species. This form is reported from Vancouver Island to Alaska, but is as yet not common. The author would

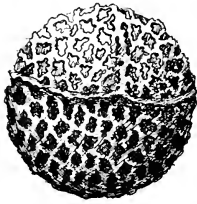
be inclined to call this a distinct species and to name it *Isoetes truncata*.

In 1888 Underwood described a new species from specimens collected on Vancouver Island, to which he gave the name of *Isoetes maritima*. This, Mr. Eaton is convinced, is but a variety of *Isoetes echinospora*. When it was described it was supposed to be a terrestrial species, and the resemblance of its megaspores was not considered important; but inquiries of the collector having since shown that it is regularly inundated by the tide, Mr. Eaton seems warranted in calling it *Isoetes echinospora maritima*. It is described as having from eight to twelve rigid leaves one to two inches long. The megaspores are covered with rather thick, bluntish spines.

In many lakes and ponds *Isoetes echinospora* and its varieties form an almost unbroken carpet over large areas, the width depending upon the rate with which the water deepens, being widest in shallow ponds and ending usually when depths of three or more feet are reached. It grows either in sand or mud, though it is said to prefer mud, and is most luxuriant where exposed to the sunlight. It appears to be also fairly abundant in certain rivers, usually only where it is covered with water most of the time. Until one has become accustomed to its appearance it is often likely to be mistaken for the other water plants with which it grows. Should our common plant ever be considered distinct from the European species it would have to have a new name, since *Braunii* is preoccupied as a specific name. Braun has suggested that in this event it be called *Isoetes ambigua*. The crisp bulbs of this species are favourite morsels with muskrats, and cattle are said to feed upon the leaves of any species that are accessible.

The Lake Quillwort.

The lake quillwort (*Isoetes lacustris*) was not named because it is the typical quillwort of our lakes, but because it was first found and is quite abundant in the lakes



Megaspore of
Isoetes lacustris.

of Europe. There are good botanists who doubt that it has ever been found in America, though it was often reported by early collectors. At that time, however, it was customary to refer all our plants to Old World species of similar appearance, and this probably explains the many reports of its occur-

rence in regions where nowadays it cannot be found.

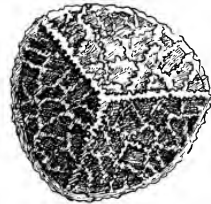
Isoetes lacustris is described as having from ten to thirty dark-green leaves from three to six inches long. There are no stomata in the leaves, and the indusium covers about one third of the unspotted sporangium. The megaspores are from $500\ \mu$ to $800\ \mu$ in diameter, marked all over with short, thin, wavy ridges. The microspores are $35\ \mu$ to $45\ \mu$ long, light grey, and smooth. The American plant differs from the European in the larger megaspores, and Durieu proposed that it be called *Isoetes macrospora*. It would seem wise, in view of the apparent absence of true *Isoetes lacustris*, to refer all our plants to *Isoetes macrospora*. Mr. A. A. Eaton concurs in this opinion, but since *Isoetes lacustris* has long had a place in our flora we have here included *Isoetes macrospora* with it.

The typical *Isoetes lacustris* is spread widely through the lakes of northern Europe, and is well enough known to receive the common name of "Merlin's grass." It grows in from one to six feet of water. Fish are said to be fond of the tender leaves, and are reported some-

times to root them up. The fleshy corms or rootstocks have occasionally been eaten in Europe, but are said to have an earthy taste that is scarcely palatable. The American range of this species is given as from New Jersey, Lake Superior, Colorado, and California northward. The plant originally described by Engelmann as *Isoetes lacustris*, variety *paupercula*, is considered by Mr. Eaton as entitled to specific rank. It has fewer, thinner, and shorter leaves and smaller spores. It is found in Colorado and California. This form was also collected by Henderson, who named it *Isoetes occidentalis*.

Tuckerman's Quillwort.

In Tuckerman's quillwort (*Isoetes Tuckermani*) we have a plant with much the habit of Braun's quillwort, but with spore characters that link it more closely with *Isoetes lacustris* and *Isoetes riparia*. It may be distinguished at sight, however, by the leaves, which are very slender and tinged with red. They are from two to five inches long and usually spirally twisted. It was long thought that this species lacks stomata, but it is now known occasionally to bear them in small numbers, especially if growing in situations where they may be exposed to the air. The sporangia are small, sparingly pale spotted, and the upper third is covered by the indusium. The megaspores are 450μ to 560μ in diameter, marked with parallel and anastomosing ridges on the upper segments, and somewhat more reticulated below.



Megaspore of
Isoetes Tuckermani.

In New Hampshire, Mr. Eaton has discovered plants in which the spores were of various diameters up to 750μ but otherwise like the type. The microspores are smooth and 26μ to 32μ long.

So far as known, Tuckerman's quillwort is confined to the New England States. It was formerly considered rare, but a more careful study of the material has shown that much of what was once referred to *Isoetes lacustris* and *Isoetes riparia* really belong to this species. Mr. A. A. Eaton asserts that within its range it is likely to occur in any large pond with sandy shores, especially if a little silt has been deposited upon the sand. It grows in from one to four feet of water, forming extensive colonies, and is rarely found in situations where the water is not at least a foot deep during the drouths of summer. The depth at which it grows suggests the possibility that the red colouring-matter in the leaves may aid in assimilation, just as the same colour is known to do in the red seaweeds.

Plants from Maine and New Hampshire, in which the leaves are longer and stouter, have been named the variety *borealis*. This is said to have enough likeness to plants of *Isoetes lacustris* to be almost entitled to rank as a form of that species. Still another form, described as *Isoetes Harveyi*, has recently been found in Maine. In this the leaves are stout and very numerous, often one hundred or more, though less than three inches in length. The sporangia are small, unspotted, and about one-third indusiate. The megaspores are 525μ to 650μ in diameter, but may occasionally be found of diameters up to 800μ . The spores are similar to those of typical *Tuckermani*, but the leaves are very different. In the opinion of the describer, however, it is not sufficiently

distinct to be called a species, and it has recently been reduced to a variety of *Isoetes Tuckermani*.

Under the name of *Isoetes heterospora* Mr. A. A. Eaton has described a species from Mount Desert Island, Maine, which the author would be inclined to call a form of *Isoetes Tuckermani* also. In this form the leaves are two or three inches long, from fifty to seventy-five in number, and lack stomata. The sporangia are thickly spotted and are one third or more indusiate. The megaspores are normally 540μ to 675μ in diameter, but specimens with a diameter of 1150μ are often found. They are densely covered with thick, jagged, anastomosing crests, often honeycombed below. The microspores are 30μ to 40μ in length, dark brown, and papillose. The megaspores often have neither commissures nor equatorial ridge. Occasionally what answers to the latter is present, but misplaced, often enclosing but a small area on one side of the spore. This seems to indicate an aberrant plant. Thus far it has been found in but two localities, both on Mount Desert Island, Maine.

Bolander's Quillwort.

In the western part of America the lakes occasionally contain a species of *Isoetes* called Bolander's quillwort (*Isoetes Bolanderi*), which by the single item of the spore markings may be separated from all our Eastern species. In its own region, however, it is easy to confuse with other species, which are marked much like it. In appearance this species has a resemblance to the members of what, for convenience, may be called the *Isoetes echinospora* group. Its leaves are erect, bright green, from five to twenty-five in number, and from two to four inches long. They generally have few stomata

and no peripheral bast bundles. The sporangia are broadly oblong or elliptical, and sparingly spotted. The megaspores are $300\ \mu$ to $450\ \mu$ in diameter, marked



Megaspore of
Isoetes Bolanderi.

with small dots or warts which rarely run together to form wrinkles. The microspores are deep brown, $26\ \mu$ to $31\ \mu$ long, spinulose or rarely smooth. This species is found in western Colorado, Utah, and California, and grows in streams as well as in ponds. The form called *Sonnei* was

described from plants collected at Donner Lake, California.

In 1866, Bolander, after whom this species was named, found at Mono Pass, on the eastern slope of the Sierra Nevada, at an altitude of 7,000 feet, a peculiar form which has since been known as *Isoetes pygmaea*. Its resemblance to *Isoetes Bolanderi* is so marked that there should be no doubt of their being two forms of the same species. The principal difference is that the plants of *Isoetes pygmaea* have shorter leaves, seldom reaching an inch long. The microspores also are less spinulose. To the author this seems but a mere form of the better-known species, and he would call it *Isoetes Bolanderi pygmaea*. Its small size is undoubtedly due to its place of growth in a cold mountain stream. The megaspores are exactly like those of *Isoetes Bolanderi*, only a trifle smaller. It has been collected but once, though often searched for during the past half century.

Isoetes Hieroglyphica.

From certain lakes in Maine have been collected specimens of an *Isoetes* which, to judge from spores alone, is distinct from all others. This has recently been

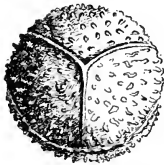
named *Isoetes hieroglyphica*. It is described as having ten to twenty leaves two or three inches long, which are recurved and somewhat blunt at the tip. The sporangium is unspotted and about one third indusiate. The megaspores are very characteristic, being from 485μ to 590μ in diameter, and marked, except near the equator, with rather large wormlike ridges. The body of the spore is quite smooth and greyish in colour. The microspores are from 31μ to 44μ long and are warty. In outward appearance the plant has great resemblance to *Isoetes Tuckermanni*, to which it is no doubt closely related, though the spore characters are distinctive.



Megaspore of
Isoetes hieroglyphica.

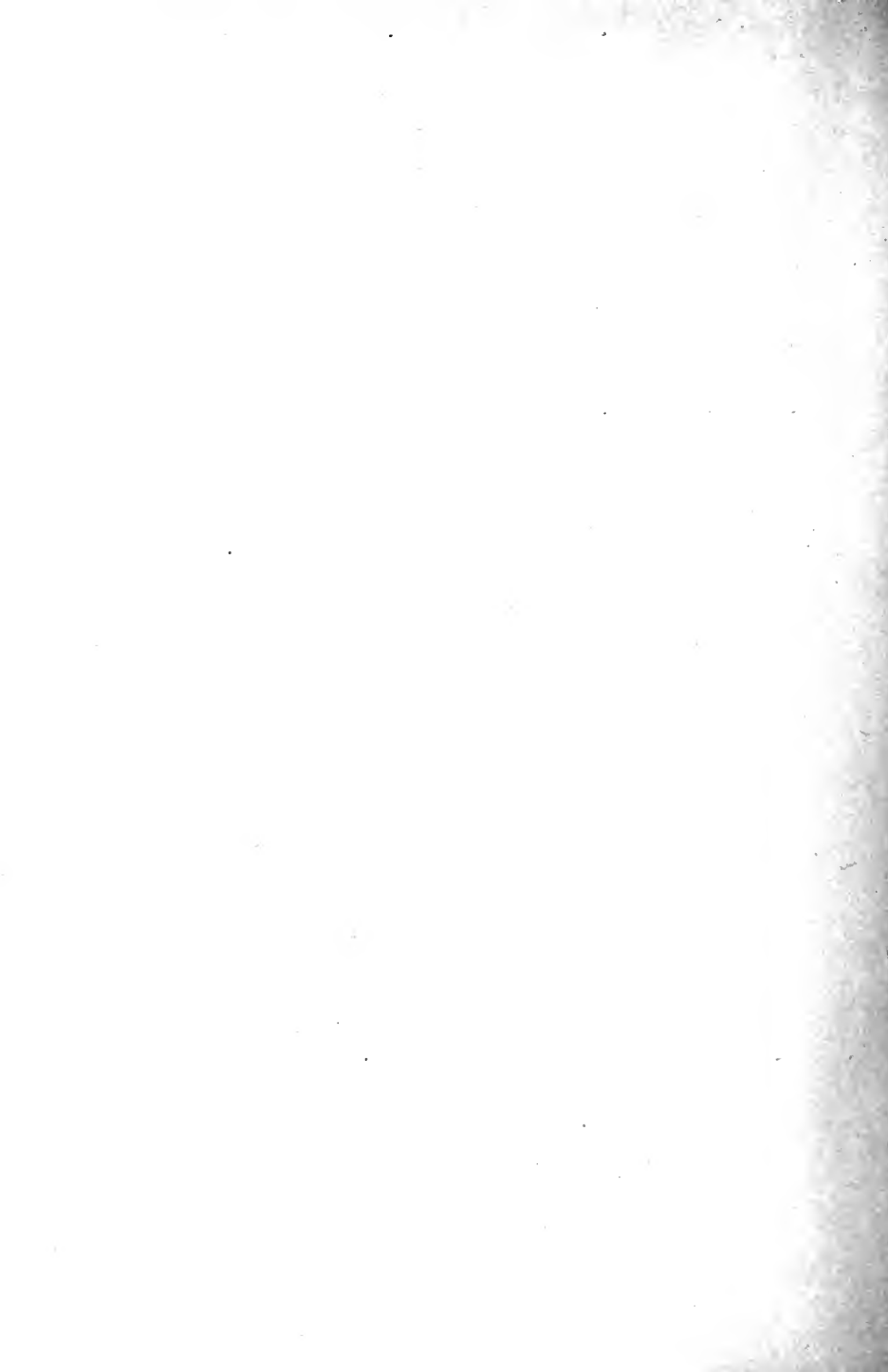
Isoetes Macouni.

Isoetes Macouni is known to grow only on Atka Island, off the coast of Alaska, from whence it was brought by J. M. Macoun in 1891. The plants were found in a pool on the side of an extinct volcano, and apparently in such a position as to be always submerged. The



Megaspore of
Isoetes Macouni.

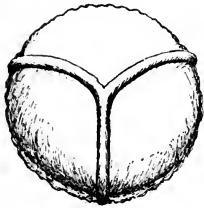
leaves are from five to twelve in number, about two inches long, and quite stout. The megaspores average about 450μ in diameter and are set with stout blunt spinules usually about twice as long as broad. The microspores are finely and densely papillose and about 40μ long. It is possible that this is still another form of *Isoetes echinospora*. It has considerable resemblance to the variety *Flettii*, and the differences it presents may be due to its habitat.



THE AMPHIBIOUS QUILLWORTS.



THE AMPHIBIOUS QUILLWORTS.



THE aquatic quillworts are naturally found in lakes and ponds, since few other situations present the unvarying water-level and other conditions favourable to their growth. The amphibious quillworts, on the contrary, are more frequently to be found along rivers and streams where the receding waters leave them exposed to the air for at least a part of the summer. The few members of this group that grow in lakes and ponds are to be found close to the margin, in which situations they are usually above the water for a part of the summer at least.

Engelmann's Quillwort.

Among American students of the *Isoetes* there are few whose names are more closely associated with the genus than that of the late Dr. George Engelmann, of St. Louis, and it is most fitting, therefore, that the species, *Isoetes Engelmanni*, which commemorates his name, should be both common and widely distributed.

This species may at once be distinguished from the aquatic quillworts by its much longer leaves. In the quiet waters of lake and pond the leaves of the quillworts are inclined to be short and arranged in a distinct

rosette ; but in rivers where the species are exposed to more or less current the leaves are likely to be longer, and, though arranged in circles, the rosette appearance is often obscured because the flaccid leaves all extend in the direction taken by the current. In the present



Megaspore of
Isotetes Engelmanni.

species the leaves are sometimes upward of a hundred in number and twenty or more inches long. Ordinary forms, however, are usually less than a foot in length. Being exposed to the air for a large part of the year, the leaves have abundant stomata, and the peripheral bast bundles necessary

to give strength to the aërial leaves are also present.

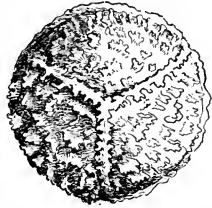
The plants usually grow on the margins of streams. During winter and spring they are covered by the water, but as the waters diminish with the warm weather the leaves are soon exposed to the air, either by floating on the surface of the shallow water or by being left entirely exposed. The leaves found early in spring are the ones that bear the sporangia. They are long and flaccid, and upon exposure to the air are likely to decay, being replaced by circles of shorter recurved leaves, some of which, if the season is long enough, may also perfect sporangia. It is probable that these leaves are normally sterile and alternate with the fertile leaves.

The sporangia are unspotted and have a narrow indusium. The spores are released by the decay of the sporangium, and for some time after the leaves have fallen the sporangia may be found attached to the plant. The megaspores are from 350μ to 550μ delicately honeycomb reticulated. The microspores are 24μ to 28μ in length, and nearly smooth. In the southern parts of this



ENGELMANN'S QUILLWORT. *Isoetes Engelmanni*.

species' range the spore-markings are less constant and the species breaks up into varieties. The variety *fontana*, distinguished from the type by having many stomata, four or more peripheral bast bundles, and a spotted sporangium, has been reported from eastern Pennsylvania. A very slender form, with about a dozen leaves, often found with the type, is named variety *gracilis*. It is probably due to plants growing in deep water or in dense shade. The variety *Georgiana* has few leaves and slightly larger megaspores. More pronounced is the form from North Carolina described as *Isoetes Engelmanni Caroliniana*. In this the leaves and indusium are slightly broader, and the megaspores are marked by thin and broken crests which often present spinules like those of *Isoetes echinospora* and have few if any reticulations. The microspores also are slightly larger and densely spinulose.



Megaspore of
Isoetes Engelmanni
Caroliniana.

Isoetes Engelmanni is found most abundantly on the gravelly shores of rivers and streams. Eaton says that in New England it is very common in clay soil in ponds and ditches, but rarely occurs in mud and sand. In parts of New Hampshire it is reported as common in nearly every millpond and ditch with a clay bottom. It is likely that the plants growing in ponds are seldom above water, which shows how arbitrarily the amphibious group of quillworts has been constituted. The species ranges from Maine to Delaware, Pennsylvania, and Missouri. The variety *Georgiana* is found only in the State for which it is named. *Isoetes Engelmanni Caroliniana* has been found in several localities in North Carolina.

Eaton's Quillwort.

In 1867 Engelmann described a gigantic species of quillwort from eastern America, which he considered a form of *Isoetes Engelmanni* and to which he gave the name of *Isoetes Engelmanni valida*. It is described as having from fifty to two hundred leaves two feet or more long, springing from a very massive trunk, and is in fact the largest form of *Isoetes* in America, if not in the world. It has never been reported from New England, but within recent years there has been discovered in that region an equally large quillwort which has been named *Isoetes Eatonii*. These forms are so nearly alike as to suggest that they are two forms of the same species. If *valida* is really different from *Eatonii* and a mere form of *Isoetes Engelmanni*, it is not easily explained why it does not occur in New England, where the species is so



Megaspore of
Isoetes valida.

common. The fact that *Isoetes Eatonii* is confined to New England seems to indicate that this is the New England counterpart of *valida*. When the New England form was discovered it was considered a distinct species, and in this opinion the author concurs. As a species, however, it should be known as *Isoetes valida*, since this varietal name was given before that of *Isoetes Eatonii*.

The trunk of this form is occasionally four inches in diameter, and the leaves have been known to reach a length of twenty-eight inches. The summer leaves are usually much shorter, often under six inches long. The peripheral bast bundles are usually present, though weak, and there are abundant stomata. The sporangia are remarkably large, frequently half an inch long, but the

megaspores, curiously enough, are smaller than the average, being from 300 μ to 450 μ in diameter. The megaspores of *Isoetes Eatoni* are described as being marked with "convolute labyrinthiform ridges, cristate on the angles of the inner face." The markings of the spores alone are nearly sufficient to constitute this a good species. They appear like those of *Isoetes Engelmanni*, in which many of the connecting crests have disappeared. The fact that the so-called variety *valida* is described as having spores smaller than the type is also significant. Mr. Eaton, who has made a very careful study of this genus, is of the opinion, however, that the two forms are not identical.

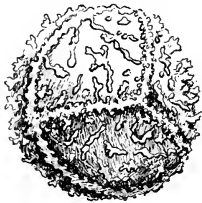
If we consider them two forms of one species the range may be given as from New Hampshire to Delaware and Virginia. The plant is rare, however, and has been found only in a few localities within this territory. A curious thing about the plants from New England is that they appear to be diœcious. Microspores are seldom found, but the megaspores are abundant. It is surmised that the same sporangium may occasionally bear both kinds of spores, as is sometimes the case in *Isoetes Tuckermani*.

Isoetes Canadensis.

The history of the quillwort now called *Isoetes Canadensis* is a good illustration of the way small and easily overlooked differences may affect our conception of species in the genus *Isoetes*. It was first called the variety *Canadensis* of *Isoetes riparia*. Later the same species was found in New England, and, its identity being overlooked, it was described as *Isoetes Dodgei*. The name first given

to the plant of course holds good, and since it seems certain that this is a separate species it is therefore properly called *Isoetes Canadensis*. For some time, however, the name of *Isoetes Dodgei* is the one it has commonly borne.

In appearance *Isoetes Canadensis* is much like *Isoetes Engelmanni*. The leaves are from eight to fifteen inches long, often seventy-five in number, and when under water are half erect and inclined to twist. The leaves that appear in summer are shorter, as usual. The sporangia are about one fourth indusiate and spotted. The megaspores are $500\ \mu$ to $675\ \mu$ in diameter, with irregular,



Megaspore of
Isoetes Canadensis.

low, sub-continuous, thin crests scattered over them. The hemisphere that bears the commissures is decidedly flattened, and the commissures themselves are inclined to produce thin, short, lateral projections. In appearance the spores suggest the spores of *Isoetes Engelmanni*, in which the crests have so nearly disappeared that vestiges of only the heaviest remain. The microspores are $22\ \mu$ to $40\ \mu$ long, ashy in colour, and wrinkled.

Mr. Eaton has described a variety of this species from Massachusetts, in which the leaves contain four bast bundles and are rather stiff and erect, even when out of the water. To this the varietal name of *Robbinsii* has been given. The megaspores are described as being thickly beset with anastomosing jagged walls, much as in *Isoetes riparia*, though thicker. A variety, *Amesii*, of *Isoetes saccharata*, appears to be enough like *Robbinsii* to be classed with it. So intermediate are the characters that distinguish *Robbinsii* that it might with equal propriety be regarded as a variety of *Isoetes riparia* or

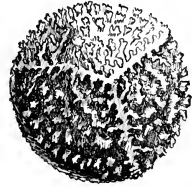
of *Isoetes Canadensis*; but it is probable that *Isoetes riparia* does not occur in New England. This is doubtless the plant that has so frequently been mistaken for that species in this region.

Isoetes Canadensis has been found in various localities from Maine to Pennsylvania, and also in Ontario and British Columbia. It is doubtless more abundant than it is at present known to be. It grows in shallow water in rivers.

The River-Bank Quillwort.

The river-bank quillwort (*Isoetes riparia*) was found near Philadelphia by Nuttall in 1815, but, as was usual in those days, it was referred to the common European *Isoetes lacustris*, and it was not until thirty years afterward that its distinctness was recognised and the name it now bears was assigned to it.

Isoetes riparia is a medium-sized species with from fifteen to thirty round leaves that occasionally reach a length of a foot, but are commonly several inches shorter. The leaves have abundant stomata, are without bast bundles, and the sporangia are spotted and about one third indusiate. The megaspores are 450μ to 650μ in diameter, with thin, jagged, irregular crests that so nearly resemble those of both *Isoetes lacustris* and *Isoetes Tuckermanni* that good students of the genus cannot always agree as to their identity. They may usually be distinguished from *Isoetes Tuckermanni*, however, by the crests being more numerous, thicker, and longer, and from *Isoetes lacustris* by the crested commissures.

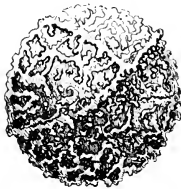


Megaspore of
Isoetes riparia.

The true *Isoetes riparia* has apparently never been found anywhere except along the lower Delaware, though often reported from other localities.

Isoetes Saccharata.

This was formerly supposed to be a distinct species, but additional collections and further study have shown it to be so nearly like *Isoetes riparia* that it is now often suggested that they are two extreme forms of the same species. Not only are typical plants very much alike, but various intergrading forms have been found. Notwithstanding this, it will be retained as a species here, in order not to confuse the beginner, who will find it so treated in the text-books.



Megaspore of
Isoetes saccharata.

The leaves are from ten to twenty in number, dark green, slender, and from two to five inches long. They have no bast bundles, and the stomata are abundant. The indusium is narrow, and the sporangium spotted. In diameter the megaspores measure from 400μ to 550μ and appear "as if sprinkled with minute grains of white sugar." They may be distinguished from those of typical *Isoetes riparia* by the markings being slenderer and shorter, with a faint resemblance to those of *Isoetes echinospora*.

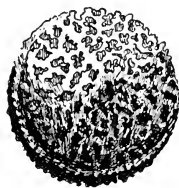
At present, typical plants of *Isoetes saccharata* have been found only on tidal flats about the head of Chesapeake Bay and the rivers that empty into it. A complete list of the stations, with a map and discussion of its distribution, was published in the *Botanical Gazette* for September, 1903. Two seasonal forms, named

reticulata and *Palmeri*, respectively, have been found. It is a remarkable fact that *Isoetes riparia* forms should be found only at the head of Delaware Bay, and *Isoetes saccharata* forms only in similar situations in a neighbouring bay, especially since the two are so closely related. It would seem as if the progeny of a single species settling in the region have been modified by the surroundings until they have assumed their present forms. Mr. Eaton apparently considers that *Isoetes saccharata* is represented in New England, since he has recently described the variety *Amesii* from Massachusetts. It appears, however, better referred to *Isoetes Canadensis Robbinsii*.

Isoetes Foveolata.

Whatever may be the status accorded this form, at present, it is certainly closely related to *Isoetes Engelmanni*. The patterns of the markings on the megaspores are almost identical, but there is so much difference in the thickness of the reticulations that the spores present a very different appearance.

Isoetes foveolata is a stouter, shorter plant than *Isoetes Engelmanni*, with from fifteen to sixty pinkish leaves two to six inches long, bearing stomata mostly near the tips. The peripheral bast bundles are absent, and the sporangia are thickly spotted with dark cells which are often assembled into groups. Some plants appear to bear only megaspores. These are from 380 μ to 560 μ in diameter, flattened on the hemisphere bearing the commissures, and covered with reticulations so wide and so



Megaspore of
Isoetes foveolata.

numerous as to almost obliterate the openings between them, which thus resemble little pits. This appearance gives the plant its specific name. The microspores are dark brown, 22μ to 34μ long, and marked like the megaspores.

Isoetes foveolata plenospora is a larger form, with longer and more numerous leaves, pinkish in colour. The megaspores are similar to those of *Isoetes foveolata*, but with higher, thinner crests, especially in the lower part of the spore, and thus have a great resemblance to the spores of *Isoetes Tuckermanni*. Both the species and variety have been found in New Hampshire and Massachusetts only, and there in but few stations.

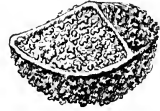
Isoetes Gravesii.

It is possible that geological conditions play an important part in the making of *Isoetes* species. It has been noticed that a very slight change in the composition of the soil makes a change in the species inhabiting it. A close student of the genus wrote recently:

“You may always expect to find certain species in certain soils. As soon as I see a pond in my region I can usually tell what species of *Isoetes* you will find in it if they occur at all.”

No experiments appear to have been made to discover whether the same species will take on different forms when grown in different soils; but, should this be proved to be true, it would throw much light upon the relationship of *Isoetes riparia* and *Isoetes saccharata*, and perhaps give a clue to the origin of the plants which have been named *Isoetes Gravesii*. Thus far they have been found in only a few stations in the State of Con-

necticut. When first discovered they were referred to *Isoetes Eatoni*, but a later opinion is that the plants are specifically distinct. In the shape and size of the spore they resemble that species, but the markings are more like those of *Isoetes riparia*. As in *Isoetes Eatoni* the microspores are seldom found.



Megaspore of
Isoetes Gravesii.

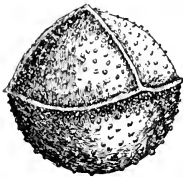
The plants have from fifty to seventy-five leaves, which are erect and sharp-pointed, and possess four bast bundles. The indusium is narrow, and the sporangium light cinnamon colour. The megaspores are from 350μ to 400μ in diameter, greatly flattened in the upper hemisphere, and densely covered with stout truncate, mostly single columns. The shape of the spores is very characteristic. It is difficult to believe that a species of this genus should be restricted to so small a region, and the idea suggests itself that this is still another form of the species which goes under the name of *Isoetes Engelmanni valida* or *Isoetes Eatoni*. The author would be inclined to call it *Isoetes valida Gravesii*. The presence of the bast bundles in the leaves, the small size of the megaspores, and the marked flattening they display, the lack of microspores, and the dioecious nature of the plant, all point to a close relationship to the form described as *Isoetes Eatoni*, and Mr. Eaton writes that if this plant is ever reduced to a variety it must be made a variety of this form.

Isoetes Melanospora.

This peculiar species was discovered in 1869 by Canby, who found it growing in shallow excavations in granite rock on Stone Mountain, Georgia. It is remark-

able for having very dark grey, almost black, megaspores, being unique in this respect among the species of eastern America. It is also one of the few species in which the indusium completely covers the sporangium.

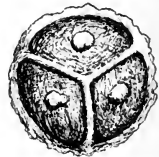
This species has from five to ten tapering, slender leaves about two inches long. The sporangia are rather roundish, and the megaspores are from 350μ to 450μ in diameter. The surface is marked by many slight projections that are roundish or confluent, forming low, short, scale-like crests. The microspores are smooth or slightly papillose. The plant has been found in several localities, but never outside of Georgia. It is so different from the other species of the East that identification will be easy, even for the beginner.



Megaspore of
Isoetes melanospora.

Isoetes Flaccida.

The only species of quillwort with which the State of Florida is credited is the one bearing the name of *Isoetes flaccida*. In general appearance it is like all the amphibious quillworts, but the spore-characters are unlike any others of our region, being more closely related to various tropical species. This difference, and the limited area it inhabits, make it another species easily identified by the beginner.



Megaspore of
Isoetes flaccida.

The leaves are from ten to thirty-five in number, and from three inches to two feet long. The plant usually roots beneath the water, and the long leaves float on the

surface, though the whole plant may sometimes be found exposed. The sporangia are rather small and are completely covered by the indusium. The megaspores are from 300 μ to 400 μ in diameter and are marked in a distinct and remarkable way. In some there is a single large button-like tubercle in the centre of each of the three areas outlined by the commissures and equator; in others, there are several smaller tubercles in these areas. On the lower hemisphere these tubercles incline to run together, forming thick wrinkles. The equator and the commissures are unusually heavy.

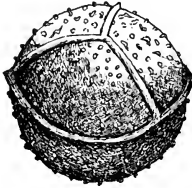
Two varieties of this species have been named. The variety *rigida* is smaller, slenderer, with more erect leaves. The variety *Chapmani* is distinguished by having larger megaspores that are almost smooth on the upper hemisphere. Thus far *Isoetes flaccida* has been found only in Florida. It may possibly occur in the southern parts of the other Gulf States, but will probably always be a rare species.

Isoetes Howelli.

This species may be described by saying that it is like *Isoetes Nuttallii*, with the exception that the megaspores are not so conspicuously marked with roundish warts, but usually have low crests that may be either isolated or confluent, especially in the lower hemisphere. The spores are practically of the same size, often dark grey or nearly black, and the author is inclined to regard it as a form of *Isoetes Nuttallii* in spite of the differences in habitat.

The species has a larger number of leaves than *Isoetes Nuttallii*, which is to be expected from its location under

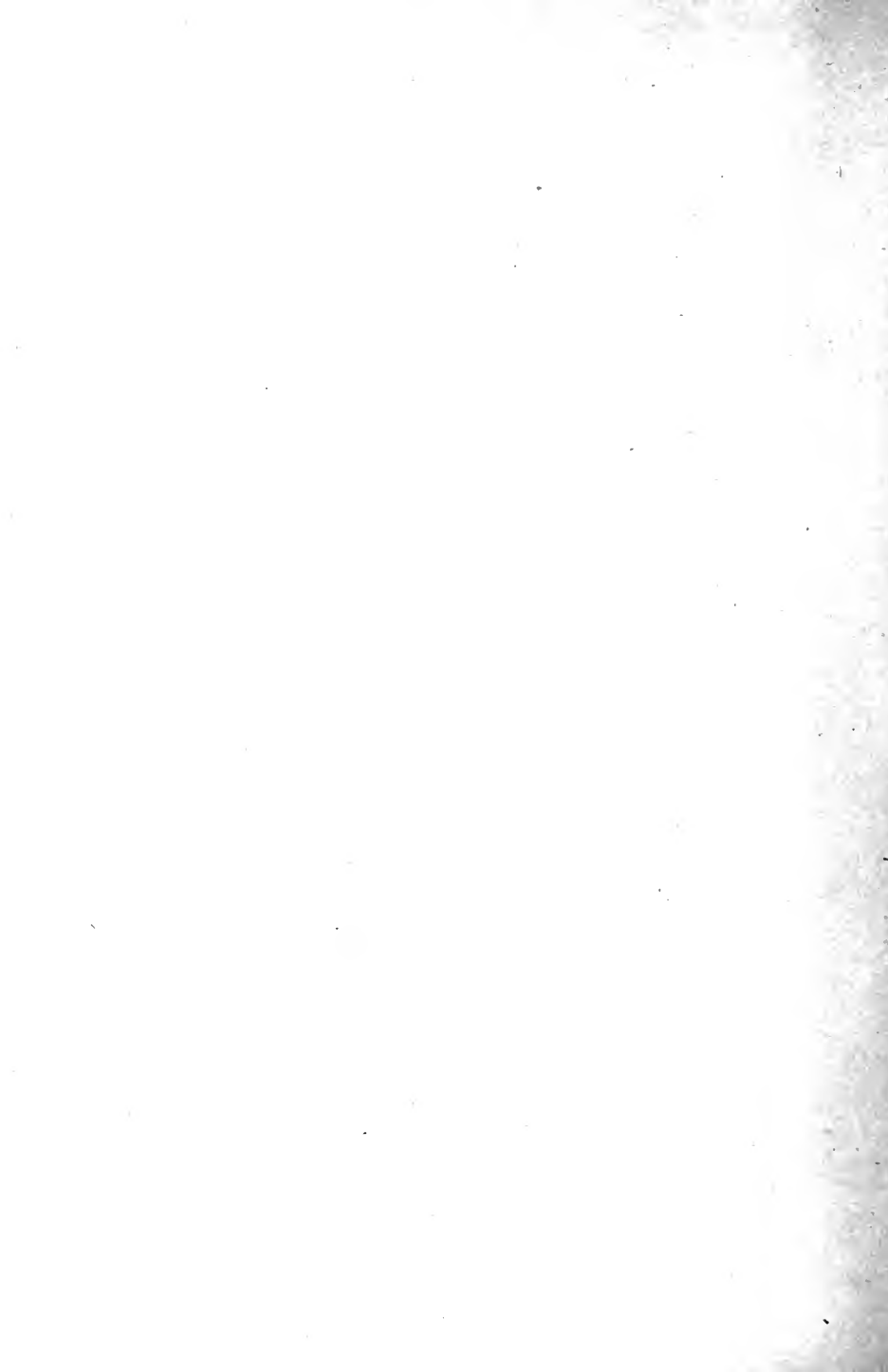
water, but it is significant that the peripheral bast bundles prominent in *Isoetes Nuttallii* are also present, while the numerous stomata found indicate that it, too, is often exposed to the air. It is found only within the range of its relative—from California to Idaho and Washington. Two other forms, described as *Isoetes Underwoodii* and *Isoetes nuda*, are now believed to be the same as *Isoetes Howelli*. Mr. Eaton has recently described a plant from the same



Megaspore of
Isoetes Howelli.

range which he calls *Isoetes Piperi*. It is distinguished by heavier markings on the megaspores and would seem to be still another variety.

THE TERRESTRIAL QUILLWORTS.



THE TERRESTRIAL QUILLWORTS.



IT is singular that while the quillworts of eastern America are mostly characterised by megaspores marked with spines and crests, those of the West, especially in the warmer parts, are marked with fine dots and warts. This apparent influence of temperature on the markings of the spores is also observed in the Southeast, where the spines and crests fade into tubercles. Along

with these peculiar patterns of spore-markings in the West goes a tendency of the plants to grow out of water, and in that region there are several species that are by courtesy called terrestrial. That they are terrestrial in the sense that a lily or a dandelion is terrestrial is of course incorrect. Many of these species are covered with water for a part of the year at least, and the whole genus is so fully committed to a watery habitat that they always grow in moist places. When, for any reason, the places in which they grow become dry, the plants go into a state of æstivation in which the leaves disappear and the whole plant assumes

a resting condition. The spores of all are very much alike and show a regular gradation from one extreme to the other. Evidently all the species are closely related.

Isoetes Melanopoda.

One of the best-known of the terrestrial species is *Isoetes Melanopoda*, which was first discovered in Illinois and appears to be peculiar to the prairie region extending from that State southwestward. It is often found in alkaline flats, and its behaviour there is described as follows :

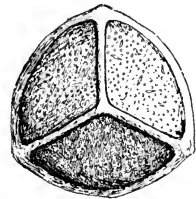
“ Many of the wells and springs running into or passing through this clay are damaged or sometimes rendered unfit for use by the quantities of sulphates of magnesia and soda entering into solution there from. Occasionally this clay rises to the surface, forming low level places which are popularly known as alkaline flats. During winter and spring, while the rainy weather lasts, the flats, owing to their level surface and imperfect drainage, are very wet, but by or before the first of July, when the dry summer has well begun, they have become the driest of all dry places, for the clay prevented the water from soaking in, and the soil is so thin that an adequate store of moisture could not be laid up. These flats are the home of *Isoetes Butleri*. There are occasional basins in the flats which contain more or less water, and here *Isoetes melanopoda* grows. It also occurs in nearly all ponds, ditches, and wet-weather streams. It is more common than the other, or at least it appears so, and it is so much easier to find, owing to its greater size and paucity of companions. It disappears in August.”

From this it will be seen that this plant is scarcely a dry-ground species, though Underwood so lists it. Baker places it among the amphibious species. It is found in damp sands, however, and has been collected in a water-melon patch. A certain amount of dryness seems ac-

ceptable to it, at least so far as the production of fruit is concerned, for it has been found that, when covered with water, the leaves last through the season, though spores are seldom produced.

The leaves of this species are from fifteen to sixty in number, slender, erect, and from six inches to a foot long. They are usually black and shining at base; hence the specific name. As in all the species that are exposed for a considerable time to the air, the leaves possess

stout peripheral bast bundles which aid in holding them erect. The indusium is very narrow or sometimes absent, and the sporangium is spotted. The megaspores are usually small, but vary in size, averaging from 250μ to 400μ in diameter. They have broad,



Megaspore of
Isoetes melanopoda.

low commissures and are marked with indistinct dots and low vermiform wrinkles. Except for the fact that they are not dark coloured, they have a close resemblance to those of *Isoetes melanospora*. The microspores are spinulose. The megaspores and microspores are usually borne on separate plants.

As the water in its habitat disappears, the leaves begin to shrivel, and soon little holes are left in the soil at the bottom of which are the bulbs and sporangia. With the renewal of moisture the spores and the parts surrounding them rise and float away, to form new colonies. This species is found from Illinois, Iowa, and Nebraska to Texas, and it also has a variety in California which differs in having smooth megaspores and larger microspores. In some parts of its range, *Isoetes melanopoda* is abundant, but it is not evenly distributed, being often rare or absent. In Texas a larger plant with pale

leaf bases and a broader indusium is called the variety *pallida*.

Isoetes Butleri.

Closely related to *Isoetes melanopoda* by spore characters, at least, is the species called *Isoetes Butleri*, which is able to grow in even drier localities, and closely approaches our idea of a terrestrial species. The effect of the lack of moisture is doubtless shown by the fact that it is a smaller plant with shorter and fewer leaves. It shows its dependence upon water, however, by disappearing earlier in the year than *Isoetes melanopoda*, often, in the South, before the first of July.

In this species the sexes seem always to be separate.



Megaspore of
Isoetes Butleri.

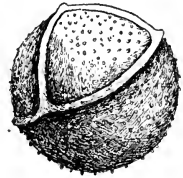
The megaspores are larger than those of *Isoetes melanopoda*, measuring from 400μ to 600μ in diameter, and marked with heavier warts or points; otherwise they are quite like them. *Isoetes Butleri* has been reported from Missouri, Oklahoma, and Tennessee, and is as yet a rare species. It doubtless occurs

at many other points. The variety *immaculata* is larger, with unspotted sporangia.

Isoetes Nuttallii.

Isoetes Nuttallii is a species of the Northwest, first found along the Columbia River, in Oregon, by the botanist whose name it bears. It is usually about three inches in height, with firm, erect leaves from twenty to sixty in number. It grows in wet places, but apparently never under water. The sporangia are entirely covered by the indusium, and the megaspores are usually quite

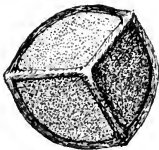
small—from 250μ to 500μ in diameter. The megaspores are very characteristic, being white or light grey in colour, with a peculiar glassy lustre, as though made of porcelain. They are marked by small, regular warts, which are sometimes so minute as to be barely distinguishable. They have the greatest resemblance to the spores of *Isoetes Bollanderi*, and the two might be regarded as forms of a single species, one growing beneath the water and the other modified for an aerial existence. The two are found in the same general region, *Isoetes Nuttallii* being reported from California to British Columbia and Idaho.



Megaspore of
Isoetes Nuttallii.

Isoetes Orcutti.

The plants referred to *Isoetes Orcutti* belong to the same general group of which *Isoetes Nuttallii* may be taken as the type. The megaspores, however, are very smooth, at best having only a faint granular appearance. They have the same glassy lustre as those of *Isoetes Nuttallii* and are dark blue-grey in colour. The indusium is entire. From resemblances of the spores, indusium, and habitat, the author has no doubt that this is a southern form of *Isoetes Nuttallii*, and believes it would be better characterised by calling it *Isoetes Nuttallii Orcutti*.



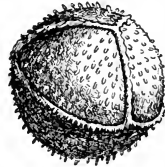
Megaspore of
Isoetes Orcutti.

The leaves of this form are few, from two to four inches long, and contain from two to four bast bundles. The megaspores are from 240μ to 300μ in diameter, and the microspores are dark

brown, 22μ to 35μ long. This form was found in the vicinity of San Diego, California, and has since been discovered in Lower California. It grows in the evanescent pools mentioned as the habitat of *Pilularia Americana*, and, like that plant, it disappears soon after the pools dry up. When, through lack of winter rains, the pools do not appear, the plants remain dormant sometimes for two years or more in succession.

Isoetes Minima.

This diminutive species, with leaves from one to two inches long, was collected by Suksdorf on a damp prairie near Waverly, Washington, and has not been found elsewhere. The leaves have the bast bundles usual to terrestrial species, and the indusium nearly covers the unspotted sporangia. The megaspores are from 290μ to 350μ in diameter, covered with short, blunt, slender spinules that in arrangement suggest what would result if the warts on the spores of other species common to the same general region were elongated. The equator is also set with these points, making it "resemble a ship's wheel." This is, so far as known, the smallest American species.



Megaspore of
Isoetes minima.

CHECKLIST OF THE FERN ALLIES.

CHECKLIST OF THE SPECIES AND PRIN-
CIPAL VARIETIES OF FERN ALLIES IN
NORTH AMERICA, NORTH OF
MEXICO.

AZOLLA.

Azolla Carolinianum Willd.

Azolla filiculoides Lam.

EQUISETUM.

Equisetum arvense L.

Equisetum arvense f. campestre Schultz

Equisetum arvense f. decumbens Meyer

Equisetum arvense f. diffusum A. A. Eaton

Equisetum arvense f. pseudosilvaticum Milde

Equisetum Ferrissi Clute

Equisetum fluviatile L.

Equisetum fluviatile f. limosum (L.)

Equisetum Funstoni A. A. Eaton

Equisetum hiemale L.

Equisetum hiemale intermedium A. A. Eaton

Equisetum hiemale robustum (A. Br.)

Equisetum robustum A. Br.

Equisetum laevigatum A. Br.

Equisetum litorale Kuhl.

Equisetum palustre L.

Equisetum pratense Ehrh.

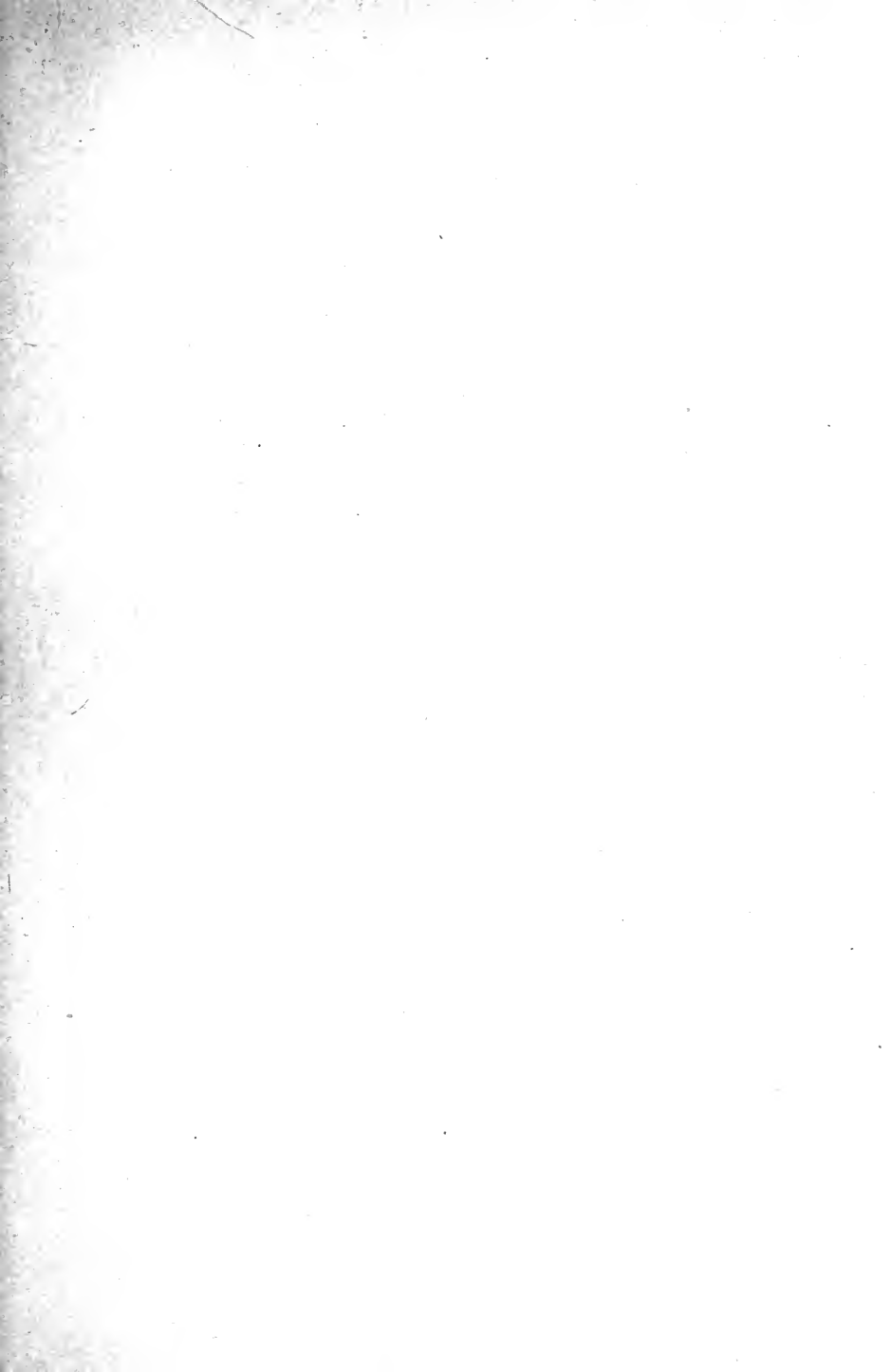
Equisetum scirpoides Michx.

Equisetum silvaticum L.

Equisetum telmateia Ehrh.

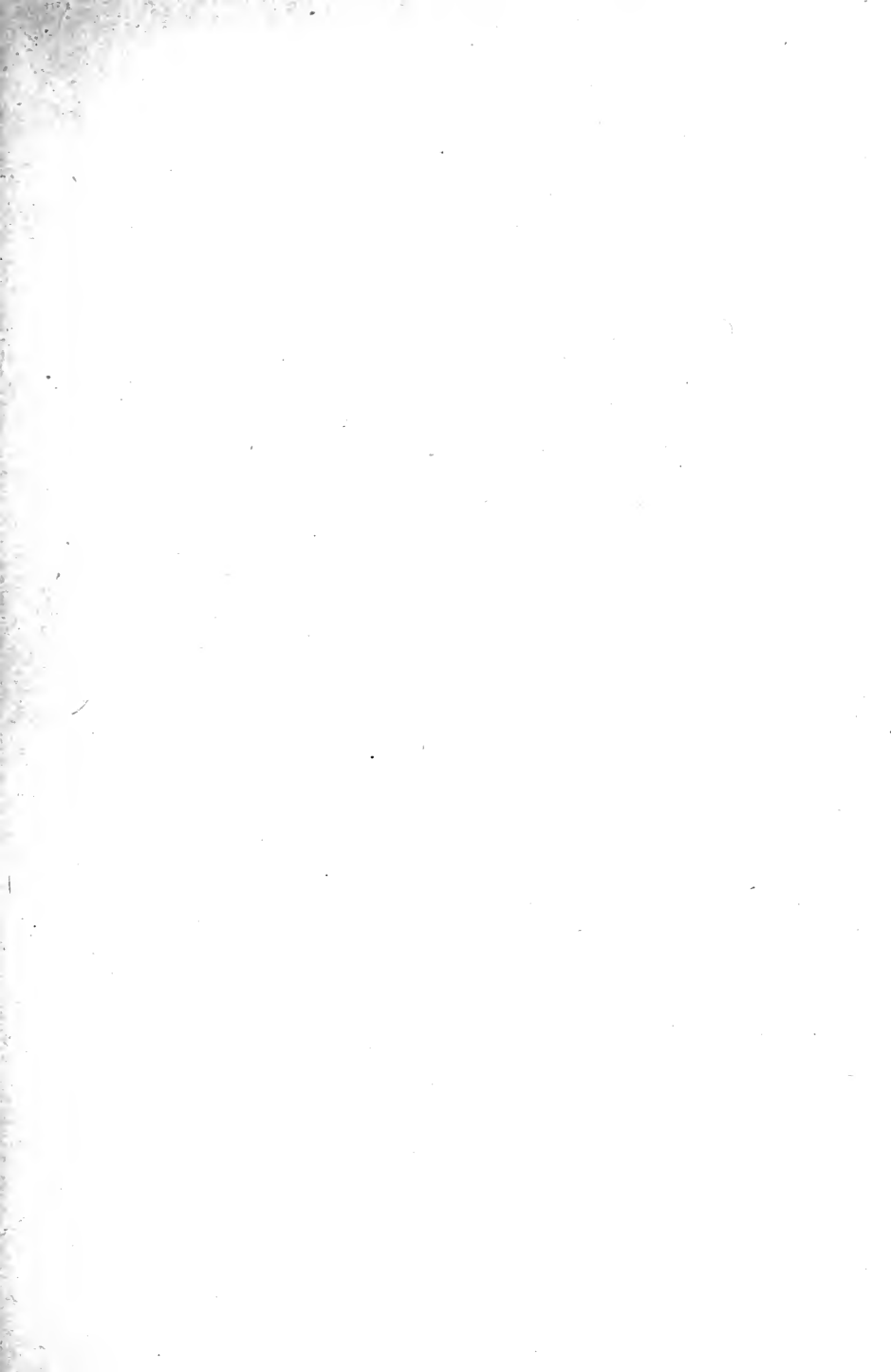
Equisetum variegatum Schleich.

Equisetum variegatum Alaskanum A. A. Eaton



ISOETES.

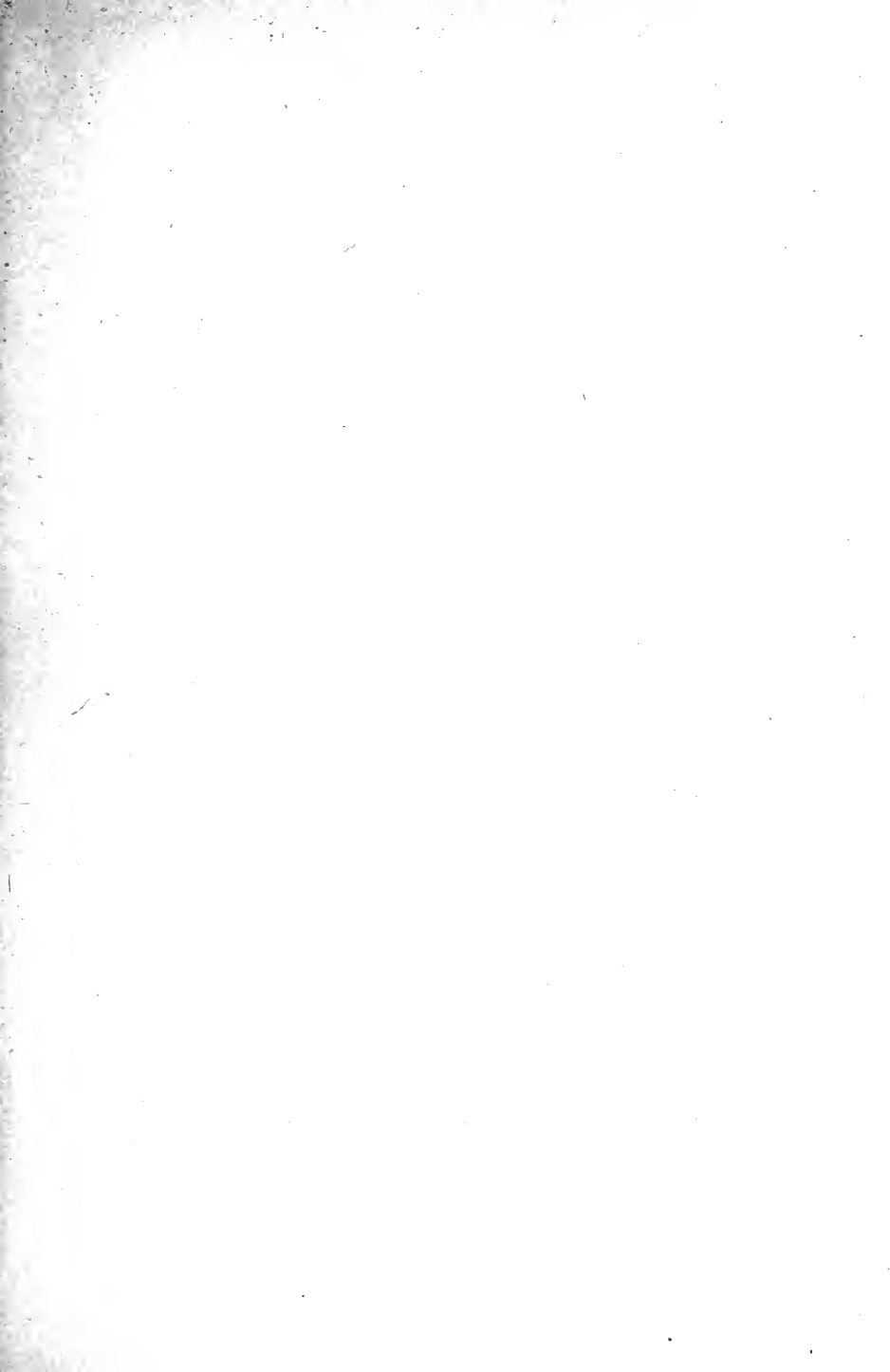
- Isoetes Bolanderi* Engelm.
Isoetes Bolanderi pygmaea (Engelm.)
 Isoetes pygmaea Engelm.
Isoetes Bolanderi Souinei Henders.
Isoetes Butleri Engelm.
Isoetes Butleri f. immaculata Engelm.
Isoetes Canadensis (Engelm.)
 Isoetes Dodgei A. A. Eaton
Isoetes Canadensis Robinsii A. A. Eaton
 Isoetes saccharata Amesii A. A. Eaton
Isoetes echinospora Braunii (Dur.)
Isoetes echinospora Braunii f. Boottii (A. Br.)
Isoetes echinospora Braunii f. robusta (Engelm.)
Isoetes echinospora Flettii A. A. Eaton
Isoetes echinospora maritima (Underw.)
 Isoetes maritima Underw.
Isoetes echinospora muricata (Dur.)
Isoetes Engelmanni A. Br.
Isoetes Engelmanni Caroliniana A. A. Eaton
Isoetes Engelmanni f. fontana (A. A. Eaton)
 Isoetes Engelmanni fontana A. A. Eaton
Isoetes Engelmanni f. Georgiana Engelm.
Isoetes flaccida Shuttlw.
Isoetes flaccida f. Chapmani Engelm.
Isoetes flaccida f. rigida Engelm.
Isoetes foreolata A. A. Eaton
Isoetes foreolata plenospora A. A. Eaton
Isoetes Gravesii A. A. Eaton
Isoetes hieroglyphica A. A. Eaton
Isoetes Howellii Engelm.
 Isoetes nuda Engelm.
 Isoetes Underwoodii Henders.
Isoetes Howellii Piperi (A. A. Eaton.)
 Isoetes Piperi A. A. Eaton.
Isoetes lacustris L.
Isoetes lacustris paupercula Engelm.
 Isoetes paupercula A. A. Eaton
 Isoetes occidentalis Henders.



- Isoetes Macounii* A. A. Eaton
Isoetes macrospora Dur.
Isoetes melanopoda J. Gay
Isoetes melanopoda f. pallida Engelm.
Isoetes melanopoda f. Californica A. A. Eaton
Isoetes melanospora Engelm.
Isoetes minima A. A. Eaton
Isoetes Nuttallii A. Br.
 Isoetes Suksdorfii Baker
Isoetes Orcutti A. A. Eaton
Isoetes riparia Engelm.
Isoetes saccharata Engelm.
Isoetes saccharata f. Palmeri A. A. Eaton
Isoetes saccharata f. reticulata A. A. Eaton
Isoetes Tuckermanni A. Br.
Isoetes Tuckermanni Harveyi (A. A. Eaton)
 Isoetes Harveyi A. A. Eaton
Isoetes Tuckermanni heterospora (A. A. Eaton)
 Isoetes heterospora A. A. Eaton
Isoetes Tuckermanni f. borealis A. A. Eaton
Isoetes truncata (A. A. Eaton)
Isoetes echinospora truncata A. A. Eaton
Isoetes valida (Engelm)
 Isoetes Engelmanni valida Engelm.
 Isoetes Eatoni Dodge

LYCOPODIUM.

- Lycopodium alopecuroides* L.
Lycopodium alopecuroides adpressum Chapm.
 Lycopodium adpressum (Chapm.)
 Lycopodium Chapmanni Underw.
Lycopodium alopecuroides f. pinnatum Chapm.
 Lycopodium pinnatum (Chapm.)
Lycopodium alpinum L.
Lycopodium annotinum L.
Lycopodium annotinum pungens Spring.
Lycopodium Carolinianum L.
Lycopodium cernuum L.



- Lycopodium clavatum* L.
Lycopodium clavatum f. monostachyon Hook.
Lycopodium complanatum L.
Lycopodium complanatum chamæcyparissus (A. Br.)
 Lycopodium chamæcyparissus A. Br.
 Lycopodium tristachyon Pursh.
Lycopodium complanatum f. flabelliforme Fernald
Lycopodium complanatum f. Wibbei Haberer
Lycopodium lucidulum Michx.
Lycopodium lucidulum porophyllum (Lloyd & Underw.)
 Lycopodium porophyllum Lloyd & Underw.
Lycopodium lucidulum f. occidentale Clute
Lycopodium inundatum L.
Lycopodium inundatum f. Bigelovii Tuckerm.
Lycopodium obscurum L.
 Lycopodium dendroideum Michx.
Lycopodium sabinæfolium Willd.
Lycopodium selago L.
Lycopodium Sitchense Rupr.

MARSILIA.

- Marsilia quadrifolia* L.
Marsilia macropoda Engelm.
Marsilia uncinata A. Br.
Marsilia vestita H. & G.

PILULARIA.

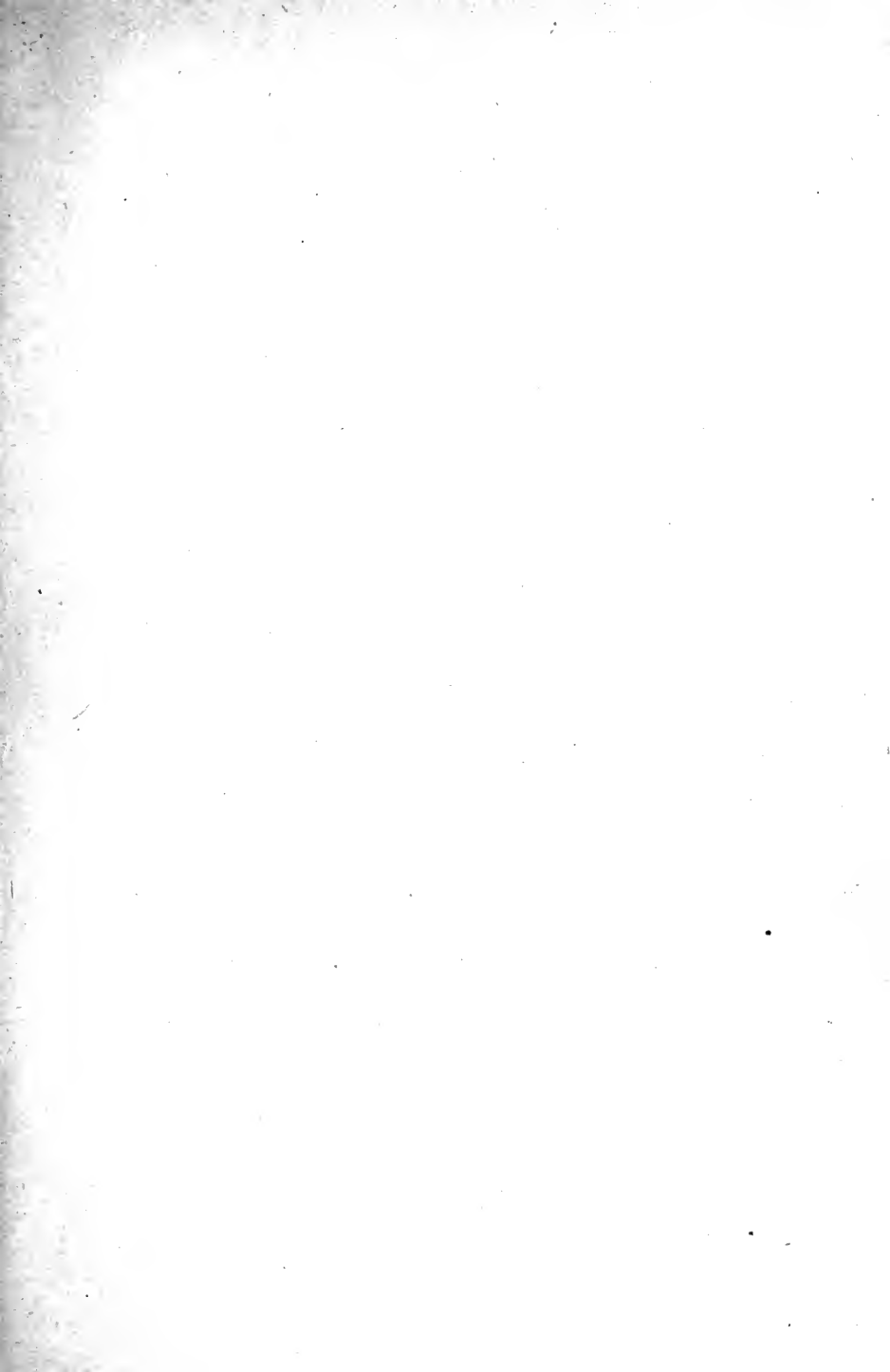
- Pilularia Americana* A. Br.

PSILOTUM.

- Psilotum triquetrum* Sw.
 Psilotum nudum (L.)

SELAGINELLA.

- Selaginella apus* Spring.
Selaginella arenicola Underw.
 Selaginella arenaria Underw.
Selaginella Bigelovii Underw.



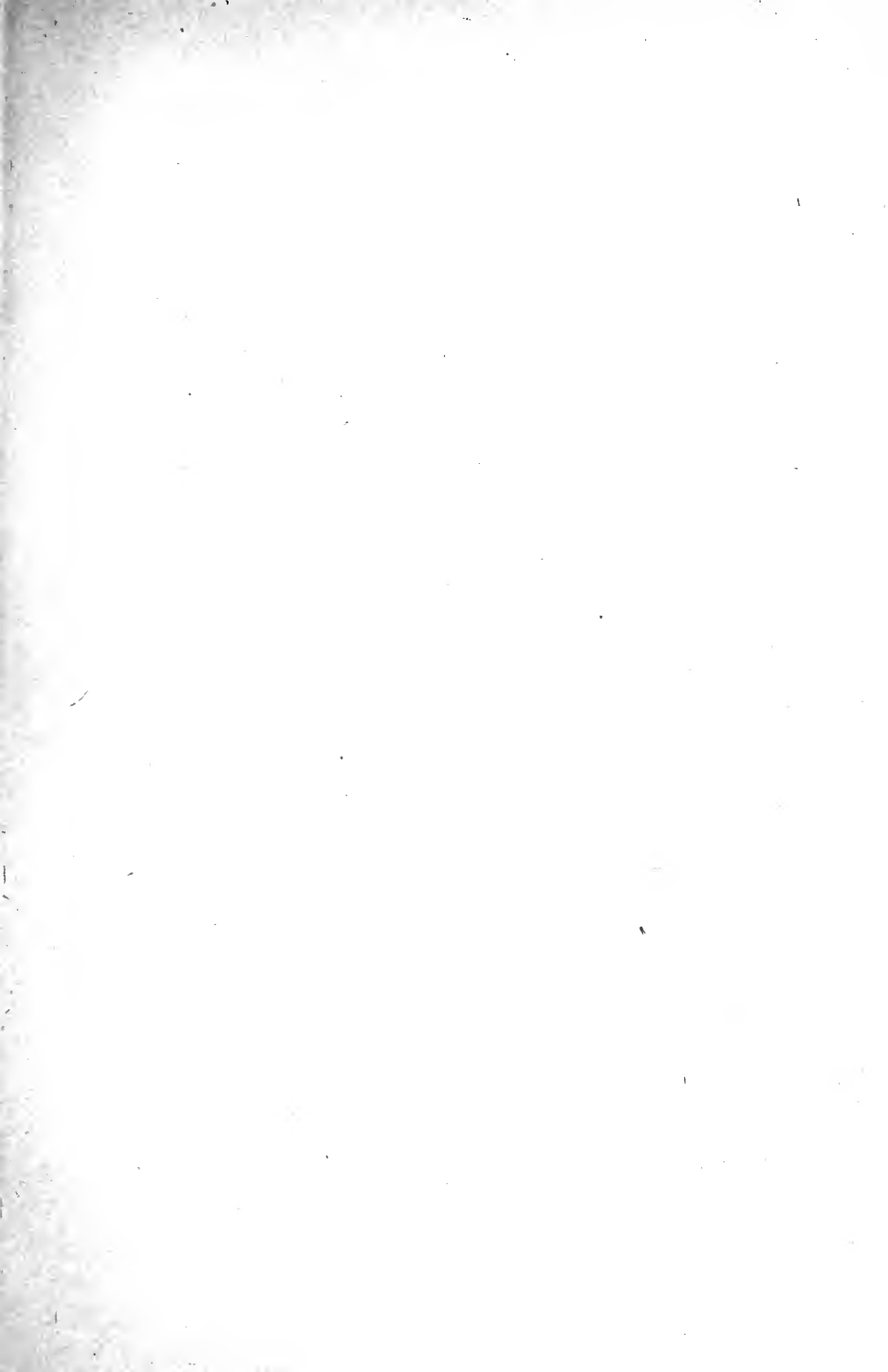
- Selaginella cinerascens* A. A. Eaton
Selaginella bryoides (Nutt.)
Selaginella Douglasii (H. & G.)
Selaginella lepidophylla Spring.
Selaginella Ludoviciana A. Br.
Selaginella Oregana D. C. Eaton
Selaginella struthiolozides (Presl)
Selaginella Pringlei Baker
Selaginella rupestris (L.)
Selaginella rupestris Sherwoodii (Underw.)
Selaginella Sherwoodii (Underw.)
Selaginella rupestris Fendleri Underw.
Selaginella rupestris acanthonota (Underw.)
Selaginella acanthonota (Underw.)
Selaginella rupestris tortipila (A. Br.)
Selaginella tortipila A. Br.
Selaginella rupestris rupincola (Underw.)
Selaginella rupincola Underw.
Selaginella rupestris densa (Rydb.)
Selaginella densa Rydb.
Selaginella spinosa Beauv.
Selaginella selaginoides (L.)
Selaginella Watsoni Underw.
Selaginella Watsoni mutica (D. C. Eaton)
Selaginella mutica D. C. Eaton

SALVINIA.

- Salvinia natans* Hoffm.

EXCLUDED SPECIES.

- Equisetum Mexicanum* Milde
Equisetum ramosissimum Desv.
Marsilia tenuifolia Engelm.
Selaginella pilifera A. Br.



AUTHORS' NAMES ABBREVIATED IN THE CHECKLIST OF FERN ALLIES.

A. Br. A. Braun.	Kuhl. Kuhlewein.
Beauv. P. de Beauvois.	L. Linnæus.
Chapm. A. W. Chapman.	Lam. J. B. de Lamarck.
Desf. R. L. Desfontaines.	Michx. A. Michaux.
Dur. Durieu.	Nutt. Thomas Nuttall.
Ehrh. F. Ehrhart.	Rupr. Ruprecht.
Engelm. G. Engelmann.	Rydb. P. A. Rydberg.
H. & G. Hooker & Greville.	Schleich. Schleicher.
Henders. L. F. Henderson.	Sw. O. Swartz.
Hoffm. G. F. Hoffman.	Tuckerm. E. Tuckerman.
Hook. W. J. Hooker.	Underw. L. M. Underwood.
	Willd. K. S. Willdenow.

GLOSSARY.

- ACULEATE.—Armed with prickles.
- ACUMINATE.—Tapering to a slender point.
- ACUTE.—Pointed ; ending in a sharp point.
- ADVENTITIOUS.—That which comes from abroad ; as a plant introduced by chance.
- ADVENTITIOUS BUDS.—Buds produced without order on any part of the plant.
- AMPHIBIOUS.—Said of plants that are covered with water for a part of each year.
- ANASTOMOSING.—Forming a network ; as veins uniting with one another.
- ANDROSPORE.—The smaller spore in *Isoetes* and various other fern allies ; a microspore.
- ANNULUS.—A ring, especially that which surrounds the spore-cases in most ferns.
- ANTHERIDIA.—The male organs on the prothallium.
- APICULATE.—Terminating abruptly with a small point.
- APPRESSED.—Turned upward against the stem ; said of small leaves.
- ARCHEGONIA.—The female organs on the prothallium.
- AREOLA (PL. AREOLÆ).—A space enclosed by anastomosing veinlets.
- AREOLATE.—Having areolæ.
- ARTICULATED.—Jointed or having the appearance of a joint.
- AURICLED.—Eared.
- AURICULATE.—With ear-like appendages.
- BAST.—Strands of strengthening tissue.
- BIPINNATE.—Twice pinnate.
- BIPINNATIFID.—Twice pinnatifid.
- BLADE.—The expanded, leafy portion of a frond.
- BRISTLE.—A stiff hair ; any slender outgrowth from the plant, as in the fruiting parts of filmy ferns.
- BULBIFEROUS.—Bearing little bulblets.

- BULBLET.—A small bulb, especially such as are borne upon leaves or in their axils.
- CARINA (PL. CARINÆ).—A small ridge, especially the ridges on the stems of *Equisetum*.
- CATKIN.—A name given to the fruiting parts of many fern allies.
- CAUDATE.—With a slender, tail-like appendage.
- CAUDEX.—A trunk, especially that of a tree-fern.
- CHAFF.—Slender, papery scales.
- CHARTACEOUS.—Having the texture of parchment.
- CHLOROPHYLL.—The green colouring matter of plants.
- CILIATE.—Fringed with fine hairs.
- CIRCINATE.—Coiled, as the buds of ferns, from tip to base.
- CLAVATE.—Club-shaped.
- COMPOUND.—Divided into two or more portions; said of the frond.
- CONCEPTACLE.—The structure that encloses the sori in certain fern allies; a sporocarp.
- CONE.—A name applied to the fruiting parts of *Equisetum*.
- CONFLUENT.—Blended together.
- CORDATE.—Heart-shaped; ovate with a sinus at base.
- CORIACEOUS.—Like leather in texture.
- CRENATE.—With rounded teeth; said of margins.
- CRENULATE.—Scalloped with small rounded teeth.
- CROSIER.—An uncoiling frond.
- CROWN.—The growing end of the rootstock or caudex.
- CUNEATE.—Wedge-shaped.
- CUSPIDATE.—Terminating in a sharp, hard point.
- DECIDUOUS.—Not evergreen; subject to being shed at certain seasons.
- DECOMPOUND.—Several times compounded or divided.
- DECUMBENT.—Not erect; bending along the ground.
- DECURRENT.—Extended downward along the rachis; said of the bases of pinnæ, etc.
- DEFLEXED.—Bent abruptly downward.
- DENTATE.—Toothed; said of the margins.
- DENTICULATE.—Finely toothed.
- DEPAUPERATE.—Starved; prevented from coming to its natural size through lack of nourishment.
- DICHOTOMOUS.—Forked in pairs; two-forked.

- DIMIDIATE.—Halved, or as if one half were wanting, as in the pinnules of some adiantums.
- DIMORPHOUS.—Of two forms; said of ferns whose fertile and sterile fronds are not alike.
- DISSECTED.—Cut into many lobes or divisions.
- DORSI-VENTRAL.—Having an evident upper and under surface; flattened in a plane parallel with the earth.
- ELATER.—One of the two bands into which the outer coat of the *Equisetum* spore splits at maturity.
- ELLIPTICAL.—Oblong with rounded ends.
- EMARGINATE.—Notched at the summit.
- ENTIRE.—Not divided; said of fronds or pinnules whose margins are without notches or teeth.
- FALCATE.—Scythe-shaped; curved upward.
- FERTILE.—Producing spores.
- FIBRO-VASCULAR.—Consisting of wood-fibres and ducts, as in the stems of the fernworts.
- FILIFORM.—Thread-like.
- FLABELLATE.—Fan-shaped.
- FOVEOLATE.—Honeycombed.
- FROND.—A fern leaf. Properly the word frond includes both *stipe* and *blade*, but frequently it is used simply to designate the leafy portion.
- FRUIT.—Sporangia.
- FRUIT-DOT.—A sorus.
- FUGACIOUS.—Short-lived; falling early.
- GLABROUS.—Smooth.
- GLAND.—A minute globular or pear-shaped organ which usually secretes a resinous, waxy, gummy, or aromatic product.
- GLANDULAR.—Furnished with glands.
- GLAUCOUS.—Covered with a very fine powdery substance, as plums are.
- GLUTINOUS.—Covered with a sticky exudation.
- GYNOSPORE.—The larger spore in *Isoetes* and other fernworts; a megaspore.
- HABIT.—The general appearance of a plant.
- HABITAT.—The natural dwelling-place of an animal or plant.
- HETEROSPOROUS.—Producing spores of two sizes or kinds.

- HIRSUTE.**—Having coarse stiff hairs.
- IMBRICATED.**—Overlapping or breaking joints, like shingles on a roof.
- INCISED.**—Cut into deep, sharp teeth.
- INDUSIUM (PL. INDUSIA).**—The thin, scale-like covering of immature sori.
- INTERNODE.**—The spaces between the nodes of the stem, especially in *Equisetum*.
- INVOLUCRE.**—The cup-shaped process surrounding the sporangia in the filmy ferns; an indusium.
- ISOSPOROUS.**—Producing spores of one kind.
- LACINIATE.**—Cut into deep, narrow, irregular lobes; slashed.
- LANCEOLATE.**—Rather narrow and tapering to the apex; occasionally tapering at base also.
- LAMINA.**—A blade; the leafy portion of a frond.
- LEPTOSPORANGIATE.**—Producing sporangia from the superficial tissues of the frond.
- LIGULE.**—A small triangular tongue-like organ on the leaves of *Isoetes*.
- LINEAR.**—Long and narrow.
- LOBE.**—One of the small divisions of a frond.
- LUNATE.**—Shaped like a half-moon.
- MACROSPORE.**—A megaspore.
- MARGINAL.**—Situated on, or close to, the margin.
- MEGASPORE.**—The larger spore in those species having two sizes of spores, especially in *Isoetes*.
- MEMBRANACEOUS.**—Like a membrane; very thin and flexible.
- MICROSPORE.**—The smaller spore in those species with spores of two sizes, especially in *Isoetes*.
- MIDRIB.**—The prolongation of the stipe through an undivided frond or pinna.
- MIDVEIN.**—The principal vein in a pinnule or segment.
- MUCRONATE.**—Having the midvein prolonged beyond the pinnule, forming a point.
- NODE.**—The swollen regions of a stem from which the leaves grow, especially in *Equisetum*.
- OBLANCEOLATE.**—The reverse of lanceolate; broadest near the apex.
- OBLONG.**—Two or three times longer than broad.

- OBOVATE.—The reverse of ovate.
- OBTUSE.—Blunt; without point.
- ORBICULAR.—Circular.
- OVATE.—Egg-shaped; the broadest part near the base.
- PALEACEOUS.—Clothed with chaff.
- PALMATE.—With spreading divisions, like the fingers of the hand.
- PANICLE.—A cluster of fruit in which the stems branch more or less.
- PAPYRACEOUS.—Paper-like.
- PEDICEL.—A tiny stalk; especially the stalk of the sporangium.
- PEDUNCLE.—A stalk; especially the stalk of the fruiting parts in *Lycopodium*.
- PELTATE.—Shield-shaped; said of scales and indusia that are attached to the frond by their centres.
- PERSISTENT.—Not falling away; remaining on the plant.
- PETIOLE.—Same as stalk and stipe.
- PINNA (PL. PINNÆ).—One of the primary divisions of a frond.
- PINNATE.—Consisting of several leaflets arranged on each side of a common petiole or rachis.
- PINNATIFID.—Divided in a pinnate manner, but with leaflets not entirely separate.
- PINNULE.—One of the small divisions of a pinnate leaf.
- PROCUMBENT.—Lying along the ground.
- PROLIFEROUS.—Giving rise to new plants.
- PROTHALLIUM (PL. PROTHALLIA).—The minute scale-like growth from the spore of a fernwort.
- PUBESCENCE.—A covering of soft, short hairs.
- PUBESCENT.—Covered with fine, soft hairs.
- QUADRIPINNATE.—Four times pinnate.
- RACHIS.—The continuation of the stipe through a compound frond.
- RECEPTACLE.—The part of the frond to which the sporangia are attached, especially in the filmy ferns.
- REFLEXED.—Abruptly bent downward or backward.
- RENIFORM.—Kidney-shaped.
- REVOLUTE.—Rolled backward, as the margins of some fronds.
- RHIZOME.—An underground stem; a rootstock.
- ROOTSTOCK.—Same as rhizome. The portion that produces the fronds or stems in most of our species.
- SCALES.—The chaff on the stems of ferns.

- SCANDENT.—Climbing.
- SEGMENT.—One of the smaller divisions of a pinnatifid frond.
- SERRATE.—With saw-like teeth ; said of margins.
- SESSILE.—Without a stalk.
- SHEATH.—The circle of confluent leaves in *Equisetum*.
- SINUATE.—Wavy ; said of margins.
- SINUS.—The re-entering space between two lobes.
- SORUS (PL. SORI).—An assemblage of sporangia ; a fruit dot.
- SPATULATE.—Spoon-shaped.
- SPIKE.—A name given to the fruiting parts of the fern allies.
- SPINE.—A sharp point ; a thorn.
- SPINULOSE.—Thorny ; set with small spines.
- SPORANGIUM (PL. SPORANGIA).—A tiny globe in which the spores are produced.
- SPORE.—A one-celled body, the fruit of the higher cryptogams ; it is produced asexually and is the analogue of a seed.
- SPORE-CASE.—Same as sporangium ; the case in which the spores are borne.
- SPOROCARP.—A capsule-like structure enclosing the sori in certain fern allies, as in *Marsilia*.
- SPOROPHYLL.—A leaf that bears spores, often modified for the purpose.
- STALK.—Same as stipe.
- STERILE.—Barren. Said of leaves or stems that do not produce spores.
- STIPE.—The petiole or stalk of the fern leaf which bears the leafy portion aloft.
- STOLON.—A trailing, or often underground, branch.
- STOMATA.—Minute openings in the leaves of plants.
- SUBULATE.—Awl-shaped.
- TERNATE.—With three nearly equal divisions.
- TOMENTOSE.—Covered with matted wool.
- TOMENTUM.—Close matted woolly hairs.
- TOOTH.—The smallest division of a frond ; a slender prolongation from the sheath in *Equisetum*.
- TORTUOUS.—Bent or twisted in different directions.
- TRIPINNATE.—Three times pinnate.
- TRUNCATE.—Appearing as if cut off abruptly.

UNDULATE.—Wavy-margined.

VALLECULA (PL. VALLECULÆ).—A hollow; especially the grooves in the stem of *Equisetum*.

VALLECULAR.—Pertaining to the valleculæ.

VASCULAR.—Containing vessels, ducts, etc., as the stems of ferns.

VEIN.—One of the small branches in the framework of a leaf.

VELUM.—The indusium in *Isoetes*.

VENATION.—The manner in which the veins are arranged in the leaf.

VERNATION.—The arrangement of leaves in the bud.

VIVIPAROUS.—Producing young upon various parts of the plant.

WHORL.—A circle; as of leaves on a stem.

WINGED.—Bordered with tissue, as the rachis of some ferns.

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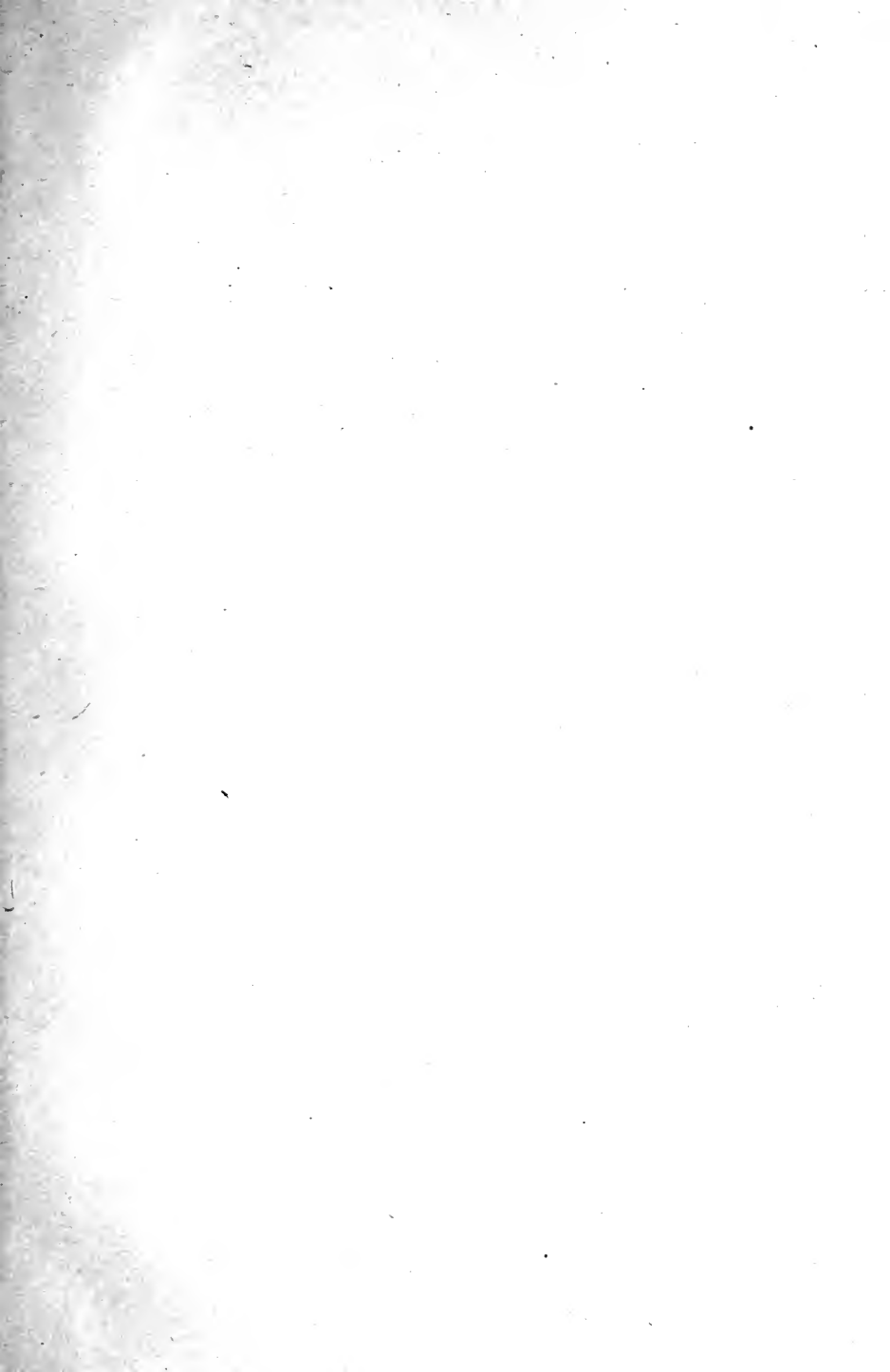
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