PRESIDENTIAL ADDRESS

Mosses and Their Uses

WINONA H. WELCH, DePauw University

A botanist is frequently asked if bryophytes (mosses and liverworts) have any economic importance. The usual reply is that they are of scientific interest but have very little financial value. For some time this question and answer have been a source of interest to the writer. During the search for the uses of these plants it has been found that the term moss has been applied to many things incorrectly, that is to say, to objects which are not mosses, or has had unusual correct applications.

Due to the great looseness or flexibility of the English language, we find mosses not only in each of the divisions of the plant kingdom, Thallophyta, Bryophyta, where they are correctly classified, Pteridophyta, and Spermatophyta, but also in the animal and mineral kingdoms, and in various additional fields of knowledge.

In the thallophytes, numerous algae and lichens have been called mosses. Among examples of the former are Protococcus (Chlorophyceae), a green alga which sometimes grows on tree trunks, fence posts, telephone and telegraph poles, old buildings, etc. The layman often refers to the algae, Chlorophyceae, chiefly, which form the green scum on water as mosses. Recently the author was presented with a booklet of marine, red algae (Rhodophyceae), entitled, "California Sea Mosses," and within is this quotation, "Mosses bright, behold them, flowers of the sea."

Another group of plants in the Thallophyta to which the name moss is often applied is that of lichens, the plant bodies of which are composed of algae and fungi. Iceland moss is an erect lichen *(Cetraria islandica)*, having a foliaceous habit which suggests the appearance of a moss. Another lichen *(Cladonia rangiferina)* is often referred to as reindeer-moss, because it is almost the only source of winter food for the reindeer and caribou in high northern latitudes. The so-called old man's beard or gray moss, hanging from trees in northern swamps, is also a lichen *(Usnea)*. The terms tree moss, rock moss, and coral moss are often popularly applied to lichens in general. A lichen *(Parmelia perlata)* is used in dyeing and is popularly called canary moss. Cup moss is the name of various species of lichens, particularly of the genera Lecanora and Cladonia. *Usnea barbata* and various other pendulous tree lichens are popularly known as idle moss or beard moss.

The liverworts which compose with the mosses the division of the plant kingdom, Bryophyta, are sometimes described as the scale mosses, more particularly the Jungermanniaceae, the largest class in the Hepaticae. Indiscriminately, liverworts are often classed as mosses.

The plants in the genera Lycopodium and Selaginella in the Pteridophyta are commonly known as fir moss, clubfoot moss, or club moss. Although tree-moss is a name for various species of Lycopodium, it is particularly applicable to *L. dendroideum.* Snake moss refers to *L. clavatum.*

Passing on to the Spermatophyta one finds numerous flowering plants having in their common names the word moss. Some of the most interesting examples have been included in this discussion. In the rush family (Juncaceae), one finds the moss rush *(Juncus squarrosus).* The commonly known Spanish Moss *(Tillandsia usneoides),* sometimes called long moss, black moss, crape moss, wool crepe, barba Hispanica, New Orleans moss, and Florida moss, in southern United States, is an epiphytic member of the Pineapple family *(Bromeliaceae).* According to Aldrich, DeBlieux, and Kniffen[1], the early Louisiana settlers called this plant Barbe Espagnol or Spanish beard, and the term Spanish moss has only recently come into general use. Flowering moss *(Pyxidanthera barbulata)* is a creeping, evergreen, flowering plant of the New Jersey pine-barrens. In the Phlox family (Polemoniaceae) there are the moss pinks *(Phlox subulata)* which grow on rocky hills in central United States and are often cultivated for their beautiful flowers. The moss rose *(Rosa centifolia muscosa)* bears an abundance of glandular hairs on the peduncle and calyx, which resembles a mosslike growth and thus suggests both the common and varietal names. In Europe, the common name for the fruit of the small cranberry *(Vaccinium Oxycoccus)* is mossberry as it grows only in peat bogs, usually among the mats of Sphagnum, a moss. A catchfly *(Silene acaulis)* which grows on the highest mountains of Europe and America and within the Arctic Circle appears mosslike and bears the common name of moss campion, because of its dwarf tufted moss-like habit. Moss-locust is the common name for the hispid shrub, *Robinia hispida.* The fruit of the bur oak *(Quercus macrocarpa)* has a very pubescent involucre, giving rise to the common name of mossy-cup oak. Moss wood has reference to tree trunks and stumps which are frequently found in peat bogs. Moss-oak is oak-wood preserved in a black state in peat bogs.

In zoology, one recognizes the names of bryozoan, moss-animal, moss-coral, and moss-polyp, given to small animals which have a mossy appearance. The common name of one of the American marine fish in the Herring family is mossbanker or mossbunker *(Brevoortia tyrannus).* Mossback is also applied to fish. Anglers attribute this name to large and old fish, especially bass, in allusion to a growth of algae. The large mouthed black-bass *(Micropterus salmoides),* which occurs in Indiana, bears the common name of moss-bass. The moss-back turtle is probably coated with algae rather than mosses. In ornithology, there is listed the moss-cheeper of Scotland for the titlark or reed bunting *(Emberiza schoeniclus),* the moss-duck of England for the mallard, the moss owl for the short-eared owl of England and Scotland, the moss hammer for

[1] Aldrich, C. C., M. W. DeBlieux, and F. B. Kniffen, The Spanish Moss Industry of Louisiana. Economic Geography **19.** 347-357. (1943).

the European bittern of England, and the mosshead for the hooded merganser *(Lophodytes cucullatus)* of South Carolina. In entomology, one of the bumble-bees bears the common name of moss-carder and the scientific name, *Bombus muscorum*, the specific epithet originating from *muscus*, the Latin word for moss.

In geology there is the moss agate or Mocha stone which is a variety of agate containing brown, black, or green matter in filamentous or dendritic forms suggestive of vegetative growth, especially that of a moss. When gold occurs in dendritic forms it is called moss gold. If silver appears in filiform or dendritic shapes, it is known as moss silver. If zinc forms thin, brittle flakes when poured slowly into water, it is called granulated or mossy zinc.

In home economics, in dietetics, there are directions for preparing blanc mange. This food is made from a sea weed or red alga (Rhodophyceae), botanically known as *Chondrus crispus* and commercially recognized as Irish moss because of its abundance along the coasts of Ireland and Great Britain. (The rake used in gathering the Irish moss is known as a moss-rake.) Ceylon moss and Jaffna moss are common names for a seaweed or red alga *(Gracilaria lichenoides)* of Ceylon and the Indian archipelago, which is similar to Irish moss and is used for food in great quantities by the inhabitants of the above-mentioned places and by the Chinese. Corsican moss is an esculent alga *(Plocaria Helminthochorton)*. And, perhaps not irrelavent to the field of home economics is moss-starch which is a kind of starch obtained from Iceland moss and other lichens. In the New York Times, March 28, 1937, a new item for a breakfast menu was introduced under this interesting title, "Alaska 'Sourdoughs' add moss to menus." The new breakfast dish recommended is "mossolyte" croquettes. The prospectors found while working in Yukon Territory that their dogs thrived on the moss, so tried it for their own diet. Since in the far North, moss usually refers to lichens, it may be assumed that these croquettes were not made of true moss.

History also has included in its pages these small plants in records of the marauders which infested the border country between England and Scotland. These bandits were called moss-troopers because the country which they inhabited was mossy or boggy. During the Civil War in the United States the name of mossback was applied in the southern states to one who avoided conscription by hiding himself. In political slang we also have the mossback, a title referring to a partisan with such antiquated notions and extremely conservative opinions that he is compared with a stone or an old tree covered with moss.

In literature one finds a title by Nathaniel Hawthorne of "Mosses from an Old Manse," which is a collection of short stories. The idle moss of Shakespeare's books is a pendulous lichen which grows on trees and is botanically known as *Usnea barbata*. The references to mosses in stories and poems concerning nature are too numerous to cite, but one quotation from a poem, "Little Sermon of Peace," by Willis

Boyd Allen, contains the following quotation with reference to the third Beatitude which seems so appropriate to these plants and their habitats that it has been included. (It may be assumed that the poet has reference to true mosses.)

"Humblest creatures of the wood
To your peaceful brotherhood
Sweet the promise that was given
Like the dew from heaven:
'Blessed are the meek
They shall inherit the earth';
Thus are the words fulfilled:
Over all the earth
Mosses find a home secure."

The proverb, "A rolling stone gathers no moss," is familiar to all. It may be assumed that this reference is to stones in a swiftly flowing stream. If this assumption is correct, the plants under consideration were probably algae as true mosses usually grow on stones not in motion. Or, if we conjecture a stone rolling down a bare and exposed slope, the plants to which reference was made may be lichens.

In Webster's dictionary one finds moss used as a transitive verb, so that it is correct to speak of mossing. Not strictly in the sense that moss collectors sometimes jokingly use it when they say that they are going mossing, but meaning to cover or to roof with moss or to overgrow with moss, as illustrated by the following quotation from Shakespeare, "An oak whose boughs were mossed with age." Also, in the dictionary is the descriptive adjective, moss-grown, with the meaning of overgrown with moss, and the noun, mossiness, which refers to the state of being mossy. In addition, a mosser is one who collects mosses or works with them, and a mossery is a place where mosses are grown.

In art, two names of colors are old moss green and moss gray. In music, there are the words so often sung, "The old oaken bucket, the moss-covered bucket that hung in the well."

Even a list of beverages includes the mosses although misnomers.

The moss-alcohol of Norway, Sweden, and Russia is made from reindeer moss and Iceland moss, both of which are lichens. Irish-moss ale which is assumed to be potent in the treatment of some diseases has for one of its important ingredients the Irish moss, an alga.

Although this list of the unusual or incorrect applications is incomplete, it seems sufficiently long to now stress the importance to mankind of liverworts and true mosses. It is evident that plants which have permeated such numerous and varied areas of thought have attracted the attention of man for many years. It seems that a group of plants as large as the Bryophyta, approximately 8,800 species in the Hepaticae and 14,000 in the Musci, may have some members of both scientific and economic value, the common opinion quite to the contrary with regard to the latter, especially. Peat mosses (Sphagnales) and true mosses

(Bryales) are the largest orders of mosses. Thus, they are the chief contributors of the items of importance to mankind.

The leaves of Sphagnum have a very peculiar structure and due to this peculiarity Sphagnum has many uses which cannot be attributed to other mosses. The thickness of the leaves consists of one layer of cells. There are two distinct kinds of cells in Sphagnum leaves. One type consists of large, colorless, empty cells open to the exterior by a pore. These empty cells make possible the absorbent and retaining qualities of this moss. The porous cells are surrounded by smaller, chlorophyll-containing cells.

Sphagnum bogs consist of layers of peat varying from a few feet deep to unknown depths. Animals and persons have been found in bogs, remarkably well preserved by the antiseptic properties of the peat. According to Dana, in peat bogs of Europe, in recent times, there have been discovered horses and knights in armor, from the days of the Wars of the Roses, in a very good state of preservation, and bodies of humans clothed in haircloth of a prehistoric period.

Peat moss (Sphagnum) is most efficient of all mosses in conserving water. Much sphagnum from swamps is of no commercial value because it is brittle and is of the single stem type. The plants which are of economic importance grow in mats, shaped like sponges, and can be cut out of bogs in masses. The top portion of the mass is of better quality than that beneath it, as it will absorb about 25 times its own weight in moisture in comparison with the moss in the next layer below which will contain 16-20 times its weight in water. A bale of dry sphagnum weighing only 20 pounds has been found to weigh approximately 500 pounds when soaked with water.

The peat which underlies the moss is excellent fuel material, and while burning, produces a pleasant odor. It is cut into blocks or slabs and dried. Some kinds are reported to burn longer than hard wood or coal. It has been estimated that 1⅘ tons of peat is equivalent to 1 ton of coal for heating purposes. Thus approximately one-half the heating power of good coal and more than two times the heat of wood. Peat is built by Sphagnum plants at the approximate rate of 1 foot in 100 years. Ground peat is pressed into small cubes a few inches square and sold for kindling material. A small quantity placed on wood and lighted will burn easily and will hold heat long enough to ignite hard wood.

Sphagnum, mixed with bone dust, is frequently employed by flower gardeners in the greenhouse as a mulch on top of the soil in the flower pots in which plants are being started for later transplanting in the garden. It shields the earth from the sun and stimulates root growth toward the surface.

Sphagnum is of considerable commercial use in florist and nursery trade where it is used for keeping living plants fresh during shipment. It is excellent packing material for the shipment of perishable articles to distant markets, such as fruits, vegetables, tubers, and bulbs, because it is relatively sterile, holds moisture for a long period, and acts as an insulator against heat and cold during shipment. Greenhouse operators

and nurserymen have found wet peat moss useful in packing roots of plants for transportation and market. Live fish have been shipped long distances packed in sphagnum.

A form of granulated or pulversized peat moss, sometimes called peat-humus and consisting of 92% organic matter, is marketed in bags and is used by gardeners as a moisture retaining humus. It may be incorporated with soil or spread over the surface of soil as a mulch. This moss keeps the earth loose, prevents a hard top crust, discourages weed growth, and prevents the soil from cracking. Sphagnums are largely used in the propagation and cultivation of rare orchids, because of their efficiency in retaining moisture.

Peat moss is employed in forming a top-dressing for golf-course greens, and for providing an absorbent layer on poultry house floors in winter months. Dachnowski-Stokes[2] has included additional uses of Sphagnum peat: employment of it as a sanitary bedding for horses, cattle, and other livestock, with the accompanying advantages that it decays relatively slowly, absorbs and retains liquid manure more completely than do other kinds of litter, decreases losses in available nitrogen, prevents odors, checks insect pests in dairy barns, horse stables, poultry houses, and fur-bearing animal sheds; an absorbent in places lacking sewer systems; and in finely shredded condition, as a medium for germinating seeds, rooting cuttings, transplanting and growing evergreens and heaths, and as a mulch for protecting plants and soil against the effects of alternate freezing and thawing, and for reducing the number of weeds.

Warden[3] reports that sphagnum peat, valued at more than $1,200,000 is imported to the United States annually, for use of gardeners and poultrymen, and that wholesale, the peat moss brings $20 per ton.

By rapid and unlimited growth, dense mats of Sphagnum gradually fill in hollows, bogs, ponds, and small lakes. Vegetable débris is washed and blown in until vast beds of peat are formed. The mats also aid in the formation of soil which is capable of supporting the growth of higher types of vegetation, thus playing an important role in plant succession in bogs. Sphagnum mats are often large constituents of floating islands upon which trees will eventually grow. Peat mosses helped to build much of the muck land that produces our celery and other garden truck. Indirectly blueberries and cranberries are dependent upon the Sphagnum or peat moss bogs because blueberry and cranberry bogs are basically peat bogs.

Peat charcoal has been used for smelting iron and for working and tempering certain kinds of steel. Tests have proven Sphagnum to be an efficient insulating material, and peat dust to be a very effective deodorizer.

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[2] A. P. Dachnowski-Stokes, Moss Peat, its Uses and Distribution in the United States. U. S. Dept. Ag., Washington, D. C., Circular No. 167, pp. 1-11. 1931.

[3] Carl Warden, Waste Land Yields Treasure in Peat Moss, Center Barnstead, New Hampshire. Pop. Sci. Mon. **136**, 112-114. (1940).

According to Newsweek, November 22, 1948, page 53, Russian mining engineers are compressing peat moss into briquettes and dipping these into liquid oxygen, in the preparation of an explosive which can be used like dynamite, with the advantages of being non hazardous in storage and transit, as well as less costly.

Laplanders and Icelanders have used sphagnums for cradle linings. The American Indians used it for diaper material. In cold countries these mosses have served as warm linings or stuffings for the loose deer-skin boots which the reindeer drivers wear.

Some of the species with the greatest absorbing power have been found to be very satisfactory dressings for wounds, because it not only absorbs puss and drainage from wounds but also has antiseptic properties. History does not record how long Sphagnum has been used by the country people as a dressing for boils and discharging wounds. The story of the discovery of its value by a surgeon in the seventies of the nineteenth century is fully recorded by Heald in the Scientific American[4]. "A laborer in a peat moor in northern Germany was seriously wounded in the forearm. Not having surgical dressings at hand his companions applied 'first aid' in the form of 'peat moss' picked up from the ground. Surgical help could not be obtained for ten days. Meantime the dressings were not changed. When finally the surgeon undid the wound, he was astonished to find it practically healed. He communicated his findings to his fellow physicians, and further investigation showed the great superiority of Sphagnum moss as a dressing for discharging wounds. It then became a standard dressing in hospital and private practice. In the Russo-Japanese War, the Japanese physicians used it extensively as a first-aid dressing at the front, and sometimes these dressings were not removed for as much as ten days, and yet the wounds were generally found to be in much better condition than similar wounds dressed with cotton."

Porter[5] states that sphagnum pads absorb liquids much more rapidly than cotton, approximately three times as fast, in much greater amounts, cotton absorbing five to six times its weight of water and sphagnum sixteen to twenty-two times, retains the liquids much better and therefor fresh dressings being needed less frequently, distribute absorbed liquids more uniformly throughout their mass, are cooler, softer, and less irritating, and can be produced at less expense and more speedily in times of emergency.

Only species with dense foliage and closely set branches have the qualifications to give the advantages of Sphagnum such as high absorption capacity, sponge-like matting, porosity, softness, elasticity, lightness, and strong acid reaction. The porosity of the large but microscopic empty cells of the leaves enable Sphagnum to take up liquids much more rapidly and in amounts several times greater than the same amount of absorbent cotton.

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[4] G. H. Heald, Sphagnum Moss. Sci. Am. Supp. **87**, 48. (1919).

[5] J. B. Porter, Sphagnum Surgical Dressings. Int. J. Surg. **30**, 129-135. Figs. 1-8. (1917).

During World War I, a few species of Sphagnum were used in large quantities by the Allied Armies as a substitute for absorbent cotton in surgical dressings. Long ago the country people of Europe used Sphagnum and Sphagnum peat as sanitary bedding and in treatment of boils and discharging wounds of man and domestic animals. The Canadian Red Cross made over 200,000 moss dressings per month during the summer of 1918 and near the end of the war the British used approximately 1,000,000 moss dressings per month. The American Red Cross officially adopted Sphagnum moss as a standard dressing material in 1918, developed a monthly output of over 20,000 pads for American military hospitals, and prepared half a million Sphagnum dressings for the Italian Army. The species having the greatest efficiency in surgical dressings are *Sphagnum magellanicum*, *S. papillosum*, *S. imbricatum*, and *S. palustre*.[6] Sphagnum is recommended for hospital mattresses and sanitary appliances because of the absorbent and deodorizing properties, but it probably will not be used extensively because of the superior substances now in general use.

Large quantities of moss peat are produced in Europe at comparatively low cost and shipped over seas. Its consumption in our country is continually growing. In the United States there are three areas which are promising in supplying desirable moss peat, Maine, northern part of Wisconsin and Minnesota, and along the Pacific coast in northern Washington and Alaska. According to the Scientific American **166**: 198. 1942, "Alaska has a virtually untouched 'Klondike' in its 110 million acres of peat muskegs, if anyone can develop satisfactory and inexpensive ways of packing and transporting the peat."

Let us now consider the liverworts and the true mosses. The origin of the word, liverwort, was from the resemblance of some of the thallose plants to the lobes of the liver. The "doctrine of signatures" claims that these plants had valuable medicinal properties for treating liver ailments.

Liverworts and mosses are small plants, the former thallose or leafy in habit and the latter, leafy. The bryophytes lack true roots, stems, leaves, and vascular system found in the Pteridophyta and Spermatophyta. The majority of leaves are one cell in thickness. The Bryophyta are spore-bearing plants, producing the spores in the capsule of the sporophyte which is completely or almost entirely parasitic upon the gametophyte. Because of the dependence of the plants upon water for fertilization, and the inefficiency of most of the species for conserving moisture, they are usually found in shaded habitats of high humidity and low evaporation. Liverworts and mosses grow on soil, rocks, wood, and in water. Numerous species are epiphytic on the stems and leaves of other plants. Occasionally bryophytes are found in dry and sunny habitats.

The Bryophyta are important from a purely scientific view point as their morphology aids in tracing theories of development of the plant kingdom from the Thallophyta to the Pteridophyta.

[6] A. P. Dachnowski-Stokes, Sphagnum Moss for Use in Surgical Dressings. Sci. Mon. **55**, 291-292. (1942).

Also of scientific interest are the collections of mosses and liverworts from various parts of the world because they have been of considerable significance in the study of plant migration and in the determination of the relationship of floras. W. C. Steere[7] has indicated that for the purpose the lack of important economic uses has been very advantageous for these studies because the bryophytes have not been taken from their native habitats as the inhabitants have moved from place to place.

People who collect and study mosses and liverworts do so for the sake of scientific contributions to knowledge rather than for financial or commercial profit.

The Hepaticae share with the Musci in the ability to form soil, prevent erosion, increase humus, and absorb moisture quickly through the chlorophyll-bearing parts. **Conocephalum conicum** at one time was thought to have some medicinal properties. Various species of the liverworts are attractive plants for terraria.

From an economic standpoint, it seems that their contributions to the formation of soil from bare rock surfaces and to the preparation of habitats favorable for the germination of the seeds of the herbs, shrubs, and trees which are to be their successors, compose the greatest value of the true mosses to mankind. Without soil to support the growth of herbaceous and woody plants, the sources of food, clothing, and shelter, directly or indirectly, would be greatly limited. The great economic importance of a moss covering on rock or soil is evident upon the observation of the growth of the seedlings of plants more highly evolved, growing in the mat of mosses, all of which leads to the eventual tree associations. Economically and in nature, mosses are more significant than liverworts, and in the Musci, it seems that the Sphagnales are of greater direct importance, and the Bryales of more general and indirect value.

During the summer of 1932, while a student in the laboratory of Dr. A. J. Grout, the common question, "Of what use are mosses?", was discussed. Since that date notes have been assembled regarding their importance. Dr. Grout's reply, published in the Scientific Month 38: 270. 1934, is aptly and characteristically stated, "We can neither eat nor wear them, but certain kinds have been used to stuff beds on which to sleep."

Certainly no one can be unaware of the esthetic value of the mosses and liverworts. A few moments spent in imagining the faces of canyons, rocky slopes, the sides of a spring, the forest floor, tree trunks or logs in a dense woods, stones along the brooks, and even the shaded roofs of old buildings, without bryophytes, quickly bring to our attention the beauty produced by these small and frequently unnoticed plants, which are available at all seasons of the year. The majority of the principle

[7] W. C. Steer, The Collecting of Mosses and Liverworts. Instructions to Naturalists in the Armed Forces for Botanical Field Work, No. 3, pp. 1-13. 1944. Ann Arbor.

families are world-wide in distribution, and by carefully searching it is possible to find representatives in almost any locality.

Bryophytes are the lowest, in an evolutionary way, of the existing terrestrial, chlorophyll-bearing plants, and are composed of tissues so delicate that those of the past ages have left few recognizable traces of their geological history. The study of bryophytes entails minute observation, but shows them to be of great scientific interest, because they present a special type of life history and in some groups give definite evidence of evolutionary trends in spite of the absence of reliable evidence from fossil remains of their geological history.

Recalling the "doctrine of signatures" which claimed that the medicinal uses of plants were indicated by their shape and structure, a decoction of the Hair-cap mosses was formerly much used to aid in the growth of hair.

Dicranum scoparium is often used by florists to form banks of green in show windows. Dr. T. C. Frye of the University of Washington has informed the author of the use of *Rhytidiadelphous triquetrus*, *R. loreus*, and *Hylocomium splendens* as a "green carpet" for the Rhododendron, rockgarden, and general floral shows in Seattle. These mosses grow on the floor of the Douglas Fir forests and are brought to the city for the floral exhibits in five-ton loads each year.

Conard[8] reports that some of the giant west coast mosses are serving as replacements for excelsior or shredded paper in packing crockery.

Schistostega pennata is an exceedingly interesting plant. It grows on soil and stone of caves, dark holes, and other habitats having very little light. This bryophyte is called the Luminous Moss because from the persistent protonema there comes a golden-green glow by reflected light on the luminous subspherical cells at the ends of the filaments. Dr. Grout states in Moss Flora of North America 2: 103. 1940, "This beautiful plant is probably the reality upon which is based the fairy tales of goblin gold."

Young moss capsules full of spores are rich in protoplasm and serve as food for mice and insects both in field and herbarium. However, mosses rarely serve as hosts to parasitic fungi or as food for animals.

In Europe during the past, in the process of sinking a shaft in rock, a moss-box has been employed. In this procedure dry moss was used for packing to aid in making tight joints. Concrete is now used instead of the moss.

One of the Christmas traditions in Switzerland is the custom in the homes of the mountainous regions of making a manger of moss and placing it at the hearth for the spirit of the Christ Child.

In Britain, according to Bagnall,[9] *Hypnum triquetrum*, because of its extreme elasticity and lightness, is used for packing brittle wares,

[8] H. S. Conard, How to know the Mosses. P. 10. 1944. Iowa.

[9] J. E. Bagnall, Handbook of Mosses. P. 85. 1886. British.

and dyed an intense green for sale in shops for decorative purposes; *H. purum* serves anglers for a medium of scouring worms; *H. tamariscinum* is used for shipping leeches; and in northern England, *Polytrichum commune* is used for mattresses and regarded as superior to straw, is woven into door mats, and its stems are used for making brushes for dusting beds, curtains, carpets, hangings, etc.

The Laplanders use *Polytrichum commune* as bed and bedding. They select a patch of male plants, cut an area large enough for a bed or bolster, and separate this layer of entangled plants from the soil. This mossy cushion is said to be very soft and elastic, not to grow hard by pressure, and to be quickly restored to original elasticity by moisture if it becomes too dry and compressed. A similar portion serves as a coverlet. Linnaeus recorded that he had often used the Hair-cap moss in this way with much satisfaction, and added that the Laplanders tie this bed and coverlet in a roll, when necessary, and carry it with them from place to place. They have also used it for stuffing pillows and beds. At one time *P. commune*, being slightly astringent, was used as a medicine in Sweden. In Germany it is considered as a sudorific. This moss has been reported as serving as stuffing for cheap pillows and upholstery in the United States.

In parts of Sweden, *Fontinalis antipyretica* has been used for filling spaces between the chimneys and the walls, and thus, by excluding air, preventing fire. This custom was the basis of the specific epithet, *antipyretica*, and the erroneous idea that this moss is incombustible.

According to Campbell,[10] Spruce, when collecting plants in South America, found the bryophyte vegetation so luxuriant that when the forest was very wet and the mosses and liverworts were soaked with water, that their weight was sufficient to break off the branches of the trees upon which they were growing.

Even without practical importance, it is of interest to observe *Fontinalis biformis*, one of the aquatic mosses in Indiana, which produces two kinds of leaves of distinct appearance during the year. The flaccid, plane leaves develop in the spring and are replaced during the summer with firm, concave, and narrower blades. The former are commonly described as the vernal leaves and the latter as the aestival.

Moss has been used in the names of places of sufficient importance to be cited in encyclopedias. The following have been noted: Moss, Norway, Moss, district in West Africa, Mossvale, New South Wales, Moss, Mississippi, Moss, Tennessee, Moss Beach, California, Mossybrook, Washington, Mossyhead, Florida, Mosspoint, Mississippi, and Mossville in Arkansas, Illinois, Kentucky, and Louisiana.

Some scientists have found the mosses and liverworts to be sources of interesting and profitable experiments in photography of minute and microscopic structures for projection slides.

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[10] D. H. Campbell, An Outline of Plant Geography. P. 284. 1926. New York.

Proceeding to contributions more scientific, some bryophytes serve as plant indicators as do some of the spermatophytes. Fires of recent occurrence may be indicated by an abundant growth of Marchantia, Funaria, and Bryum. *Fissidens minutulus* and *F. incurvus exiguus* have been found to be indicators of sandstone substratum and *Grimmia apocarpa*, *Desmatodon Porteri*, and *Bryum argenteum* of alkaline substratum, and *Dicranum scoparium* and *Leucobryum glaucum* of one somewhat acid.

When it rains, mosses absorb water very rapidly through the thin-walled cells of their leaves, and as the atmosphere becomes dry the leaves close tightly to retain the moisture. The arrangement of leaves similar to the shingles of a roof, also aids in the retention of water. According to Grout,[11] "One of the most important economic services of mosses is due to this power to absorb and retain moisture. Forests are given credit for retaining moisture, preventing floods and keeping up a steady flow of water in streams, but a very large part of the water-conserving power of forests is due to the mosses which grow in the shade of the trees."

Bryophytes colonize bare rock, following the lichens. They also cover areas of soil made bare by erosion, fires, and landslides, and, when firmly established, hold the particles of earth until larger plants are able to establish themselves.

In beds of mountain streams the stones and soil are usually covered with mosses when the water is low. These plants accumulate soil which is washed down from above, continuing to collect a fresh layer of mud each season at the base of the stems, which in turn continue to elongate. Moss-covered stones in brooks are frequently found stopping quantities of sand and gravel which otherwise would have been carried away by the water.

Moss portonema is one of the first vegetative growths on soil made bare by man or nature. This forms an attached cover over the loose soil which prevents the water of spring floods and summer showers from washing away the soil. Bryophytes, especially the mosses, are of some degree of importance in breaking the force of rain upon the substratum and in the prevention of soil erosion. Those which are terrestrial anchor the particles of soil by means of their rhizoids.

The plants which are dominant in our vegetation receive their water supply through roots. Bryophytes absorb water through rhizoids and through their chlorophyll-bearing organs whenever they are moistened by rain or dew; especially is this true of the prostrate forms. In erect mosses with stems more or less solitary, the rhizoid absorption probably exceeds that of the leaves except when the plants are wet with dew or rain. Cushion plants such as *Leucobryum glaucum*, *Bartramia pomiformis*, and *Dicranum scoparium* absorb water readily through the aerial parts.

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[11] A. J. Grout, Mosses. Sci. Mon. 38, 270-273. 1934.

Mosses are able to establish themselves and to thrive in regions unfavorable to more advanced plant bodies because of their capacity to dry up and then to revive in a fresh supply of moisture, because of their hardiness, and because of their ability to assimilate, apparently at very low temperatures, more quickly than the seed plants. One may be convinced, also, of the immense value of a moss covering in the conservation of water supply, by considering the amount of moisture retained by this mat of plants on rocky slopes and on the sides of canyons.

The bryophytes are considered as colonizers because they can gain a foothold on bare rock, soil, and wood, where more highly developed plants, as to evolutionary standards, have failed, and thus, over a period of time, prepare a suitable substratum for those higher forms of plant life.

Bare areas on moist ditch banks along roadsides occasionally are covered with a mat of the green felt-like persistent protonema of Poponatum, especially if the soil has been recently disturbed. The leafy gametophytes occur singly and scattered. The protonema not only supplies a large part of the nutrition and retains water for the plants, but also holds the soil in place, preventing errosion to a great extent.

In the stages of plant succession from a primary bare area of rock to climax vegetation, the mosses follow the first and second stages of crustose and foliose lichens, respectively, and precede the herbs which are succeeded by shrubs and trees. Each in turn has possession of a habitat, produces profound influences upon it, and makes conditions favorable for the next community by increase in humus and accumulation of soil, and by the production of a more mesophytic habitat.

Weaver and Clements[12] cite a moss xerosere consisting of *Grimmia, Polytrichum juniperinum, P. piliferum, P. commune,* and *Tortula.* These xerophytic mosses follow the lichens as soon as sufficient amounts of soil have accumulated in the minute crevices and depressions in the rock. These mosses can endure desiccation. The plants continue growth above and die below, and rapidly accumulate soil between the erect stems, thus continually adding to the substratum which was begun by the pioneer lichens. The depth of soil under a cushion-like moss has been found to be one inch or more, according to Weaver and Clements.

Ceratodon purpureus has been found by Gates[13] to be the pioneer in plant succession on a bare area of sand in Michigan and *Polytrichum juniperinum* to be second in the sere. The Hair-cap mosses, *Polytrichum piliferum* and *P. juniperinum* are frequently successful pioneers on sandy soils because they readily establish themselves by dense growths of rhizoids, and when covered by blown sand quickly produce long branched etiolated shoots.

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[12] J. E. Weaver and F. E. Clements, Ecology. P. 67. 1929. New York

[13] F. C. Gates, Moss in the Revegetation of an Area in northern Michigan. Bryologist **49**, 66-71. (1946).

In the succession of mosses on Lake Michigan dunes, Taylor[14] found the pioneer mosses to be xerophytes, such as *Ceratodon purpureus*, *Bryum caespiticium*, and *B. ventricosum*, in scattered tufts or cushions. She also found thick and continuous mats of mesophytic mosses. *Thuidium delicatulum*, *Hylocomium triquetrum*, and *Calliergon Schreberi*, frequently excluding all seed plants, as well as many species of mosses, and thus exerting a controlling influence upon plant succession. In the Chicago region, Taylor found *Bryum argenteum*, *Grimmia apocarpa*, and *Ceratodon purpureus* as successors to the crustose lichens in rock succession.

Glenn and Welch[15] found in studying the stages of plant succession in Monroe County, Indiana, that *Fissidens minutulus* and *F. incurvus exiguus* are pioneers on bare sandstone areas and that *Grimmia apocarpa* followed the lichens on exposed limestone.

Leach[16] reports that in England, *Polytrichum piliferum*, *P. juniperinum*, and *Ceratodon purpureus* are pioneers on various types of soil, including heath-land where Calluna has been burned. that *P. piliferum* and *P. alpinum* are pioneer species on certain kinds of rock detritus, that *P. piliferum* is a pioneer on noncalcareous soils, and that above altitudes of 600 meters, *P. alpinum* is the first moss to enter on rock detritus. In these higher altitudes *Rhacomitrium lanuginosum* forms a surface carpet against weather action but its rhizoids are not efficient to bind the soil and this layer is frequently destroyed, so *Polytrichum alpinum* serves as the pioneer and stabilizer.

Warming[17] gives special attention to the covering of moss because it differs from any other vegetative covering in its effect on the amount of water in the soil, the effect varying with the species. Species of Hypnum and of other genera in the Hypnaceae produce dense cushions, 5-6 centimeters in thickness, which lie loose on the soil. The felt of rhizoids and the protonemata of plants of Polytrichum and Dicranum permeate the soil and promote the formation of raw humus. In Arctic and Antarctic areas, Warming explains, the dense, soft carpet of moss merges into either the Polytrichum moss-tundra or the Sphagnum bog or tundra. Species of Polytrichum and Dicranum form dense, firm tufts, and intermingled with them are species of Hylocomium, Hypnum, and Rhacomitrium and liverworts belonging to the genus Jungermannia. It has been found that a carpet of moss does not desiccate the soil because the plants obtain little or no moisture from the soil by absorption and conduction, and at the same time the mosses prevent by their presence the drying out of the soil.

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[14] Aravilla M. Taylor, Ecological Succession of Mosses. Bot. Gaz. **69**, 449-491. (1920).

[15] Gail G. Glenn and Winona H. Welch, Ecological Relationships of the most common Mosses in a certain Vicinity near Bloomington, Indiana. Proc. Ind. Acad. Sci. **40**, 87-101 (1931).

[16] W. Leach, On the Importance of some Mosses as Pioneers on Unstable Soils. J. Ecology **19**, 98-102. (1931).

[17] Eug. Warming, Oecology of Plants. pp. 76, 198 (1909). Oxford.

According to Braun-Blanquet,[18] *Rhacomitrium hypnoides* is an important constituent of the homogeneous moss and lichen tundra in Spitzbergen; in the moss seres in cold moist regions such as parts of Siberia, Lapland, Faroe Islands, and Spitzbergen, the climax vegetation is Rhacomitrium heath; and in Auvergne, France, there is a notable lateral advance of the *R. lanuginosum* association upon basalt rubble.

The true mosses not only contribute to the formation of soil and the increase of humus, but also to the building of rocklike substances such as tufa and travertine. Taylor has found *Brachythecium rivulare* to be a prominent tufa former. "The chemical substances (iron compounds) in the water penetrate the plant tissues which, as they grow old, resist decay and form a porous rocklike mass."

Emig,[19] in the study of travertine formation in the Arbuckle Mts. of Oklahoma, found two species of mosses, *Didymodon tophaceus* and *Philonotis calcare*, taking prominent part in the depositing of calcium carbonate, and *Brachythecium rivulare* in the depositing of iron ore. The deposits of soft limestone and travertine increase the height and width of waterfalls. Emig explains, "In spite of successive erosions, travertine continues to grow by aid of algae and mosses. The mosses act only indirectly in the precipitation of calcium carbonate, principally by supplying a larger absorptive and adsorptive surface for the evaporation of the calcareous water."

Cowles found *Cratoneuron filicinum* active in tufa formation at Turkey Run, Indiana.

Taylor[20] has found moss having a part in the formation of bog iron ore. "At Otis, Indiana, and New Lenox, Illinois, are numerous springs, water of which is highly impregnated with iron compounds. In the outlet of such a spring is frequently found large quantities of *Brachythecium rivulare* B. and S. As the iron compounds penetrate the moss tissue, a hard porous tufa is formed which becomes a part of the accumulation of bog iron ore about these springs."

Taylor continues regarding mosses contributing to the formation of floating islands in northern Indiana along Lake Michigan. "Floating islands, which seem to have had their origin in a surface mat, formed over the water as in the case of quaking bogs. Portions of mats have here broken loose from shore, and now form small islands floating without attachment to bottom or margin. One of the chief agents in formation of mat is *Campylium stellatum* (Schreb.) Bryhn. This species does not form a tufa but takes a large part in filling up bodies of water by growth upon the ground either submerged or emerging, and by aiding in the formation of a surface mat." "Wherever mosses appear, either floating or along the margin of ponds, they aid greatly in the

[18] J. Braun-Blanquet, Plant Sociology. Translated, revised, and edited by G. D. Fuller and H. S. Conard, pp. 38, 307, 335. (1932). New York.

[19] W. H. Emig, Mosses as Rock Builders. Bryologist **21**, 25-27. (1918).

[20] Aravilla M. Taylor, Mosses as Formers of Tufa and of Floating Islands. Bryologist **22**, 38-39. (1919).

conversion of depressions into land by promoting the advance of other terrestrial plants."

Mosses aid in the prevention of floods because of their ability to absorb water rapidly, to conserve moisture, and to lose it slowly.

On the other side of the ledger, moss is of economic importance in that there is cost in eradicating it in infertile bluberry fields on moist soil. Certain herbicides are recommended for controlling it on untillable land.[21]

On labels of some of the Fontinalis collections studied by the author, interesting comments contribute to the expense produced by these mosses. With a collection of *F. antipyretica* from Uinta River Canyon above Big Park, Utah, is the note that it is filling the pond above the old beaver dam. A collection of *F. Duriaei* from Cassia county, Idaho, in the Burley Irrigation District, is accompanied by the following data: "Submersed in canals, on hard bottoms, catches on most anything and holds silt, forming mounds in the canals. It is hard to kill and costs considerable to keep it out."

If one objects to mosses growing in the lawn, especially under or near trees, time and expense are required to eradicate them by means of chemical solutions, acid-bearing fertilizers, and proper plant foods for lawn and trees.

In conclusion, the peat mosses are of commercial value, today. From the utilitarian and dollar and cent point of view, true mosses and liverworts have only a few uses, if one defines use as that which immediately adds to man's material wealth, supplies man with nutritious food, or contributes in some way to man's comfort. But, quite to the contrary, if one regards the numerous general contributions and takes the long look both into the ages past and into the far distant future, in addition to the consideration of the present, an inestimable value may be placed on the direct and indirect economic importance of bryophytes to man. And, if one includes, also, scientific information, there is no doubt of the incorrectness of the statement, "Bryophytes are of little importance."

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[21] F. B. Chandler and I. C. Mason, Blueberry Weeds in Maine and their Control. Maine Ag. Exp. Sta. Bull. **443**. (1946). Orono, Maine.