CHAPTER 7-4
GARDENING: MOSS GARDEN DEVELOPMENT AND MAINTENANCE

Choice of Bryophytes

Careful selection of bryophytes will greatly increase the chances for success. These plants often have niches that are not provided by the typical garden spot, so care should be taken to select species with habitat requirements similar to that available in the garden.

When you collect different species of moss and then plant them together, their needs aren't always the same. You may think of moss as just moss, but of course there are many species and it's often difficult to discern differences without using a loupe or consulting a bryologist. I suggest that you learn the basics of identification by knowing your aerocarp from your pleurocarp and keep these two separated.

Most acrocarps do not like constant moisture while most pleurocarps do. My advice for your situation is to continue a regular watering schedule and allow the mosses that are flourishing to take over the ones that are not. Dead or dying mosses of one species can make a welcoming surface for other mosses to invade or spores to germinate on. You can speed up the process by fragmenting some of the flourishing mosses directly on top of the ones that are failing.

I have seen large areas transplanted with a moss that was not appropriate for the conditions and all of it die. The area continued to be watered as if the moss was still alive and after a couple of months the spores of another species germinated on top of the decaying moss which created a perfect nursery for the right species to develop.

This bed of dead moss (photo above) acted as a moisture retentive substrate, erosion control, and weed preventer. It allowed for spores of other mosses to have places to land.
and take hold without blowing away. Developing a moss area by transplanting will eventually lead to some of the species performing better than others and the faster growing species will subsequently dominate the area.

You can of course let mother nature decide what species to introduce by clearing the area down to bare earth and then begin watering just as though there was moss already present. By creating the conditions first, spores that are present will germinate and grow, this way the appropriate species will be encouraged. If you build it, they will come! Happy mossgardening!


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**Thallose Liverworts**

One seldom thinks of liverworts in the context of a "moss" garden, but several thallose liverworts are suitable for "moss" gardens. These can be pressed into soft soil so that they have good contact with the substrate (Fletcher 1991). Among the known successful ones are *Marchantia polymorpha*, *Lunularia cruciata* (both on garden paths, damp soil), *Conocephalum conicum* (moist soil), *Riccia sorocarpa*, and *Riccia glacaua* (both in damp fields and garden beds; small and easily overgrown).

**Sphagnum – peat mosses**

Most *Sphagnum* taxa require a wet, acid habitat, and most have a somewhat narrow range for both of these. Their habitat should be mimicked, and that means that they need to be supplied water from below (Fletcher 1991). This can be accomplished by placing them in flower pots in a shallow tray of standing water. *Sphagnum* is well constructed to soak up and transport the water externally through all the capillary spaces surrounding its stem. The proper pH can be maintained by growing the plants on their own peat. Tap water can easily kill them. If it has many minerals in it, they will accumulate on the surface and eventually kill them. Calcium is particularly lethal to *Sphagnum*. To solve this dilemma, distilled water or rainwater is the best watering medium. And by now you have guessed – no fertilizer is needed, and in fact should be avoided.

*Sphagnum* comes in a wide range of colors, and a bouquet of colors and hues can be arranged in the same garden by using some care in choices of species. Some of these may be maintained by placing them at greater distance from the water source, such as *Sphagnum fuscum* (Fletcher 1991).

Although many *Sphagnum* species are sun-loving, too much can fry them. Fletcher (1991) reports losing many of his plants during a hot summer when he forgot to move the plants into the shade. The problem is that sun will quickly dry out the plants, and most of the taxa are not drought tolerant. Furthermore, most lack protection against bright sun that can destroy the chlorophyll.

Birds can be a problem in a moss garden. The conditions that favor growth of *Sphagnum* also favor the presence of a number of invertebrates. Hungry birds, especially early in spring, can be quite disruptive as they rummage for dinner. And nesting can be an even bigger problem, especially if your garden provides lots of mosses in a city area where few other mosses exist. In my indoor garden, mosses and zebra finches simply cannot co-exist. The birds win every time, carrying off every bit of moss for nesting material. Fletcher (1991) suggests covering the mosses with netting to minimize the disturbance. Wire netting must be avoided because it is likely to release zinc or other metal that is toxic to the bryophytes.

Fletcher (1991) suggests *Sphagnum quinquefarium* for well-drained slopes in wet woods. *Sphagnum cuspidatum* does well in pools, where it looks like a wet kitten. Fletcher has even kept it in a jam jar for a year. On a bed of peat, *Sphagnum compactum* can tolerate drying, prefers shade, and does not like being water-logged.

**Polytrichum – hairy cap mosses**

The most common of the mosses in Japanese gardens (Figure 1) of all kinds is the common hairy cap moss, *Polytrichum commune*. This group of mosses is common in both temple gardens and private gardens. *Polytrichum* is difficult to transplant because the clump easily becomes disturbed in the process. For that reason, smaller, young clumps work best. But don't despair if those larger clumps collapse and turn brown. I have learned to trust the resilience of moss stems, and *Polytrichum* stems are a good example to support this trust. I transplanted some last year after they had collapsed from their original orientation. They looked pretty bad when they went into the garden, and they didn't improve much. This spring I was nearly ready to remove them, but didn't get the energy to do it. Then small green tips began to appear. Most of the sprawling clump still looks rather sad. They might have come back, but a chipmunk decided to occupy that part of the garden, building an entrance to its underground runway. Nevertheless, life is there, and perhaps with time the clump will fill in through stolons.

Members of the genus *Polytrichum* can resist disturbance by the broom or bamboo rake used to remove fallen leaves and other debris (Ando 1987), and they are unusual among mosses for their resistance to drought and ability to withstand direct sunlight as well as shade (Steere 1968). *Polytrichum juniperinum* and *P. piliferum* do well if the clump integrity is maintained, again making small, young clumps easier to transplant.

Like *Sphagnum*, lime can form on the leaves due to tap water (Fletcher 1991). One reason for this is that water must generally come from above. Although many mosses have good capillary action to move water externally, *Polytrichum* species have large, waxy leaves that tend to repel water and do not move it well externally. Although they have one of the best developed internal conducting systems, they still take in most, if not all, of their water through the tip of the plant. Thus, water must be supplied from above and needs to be almost completely free from minerals. Even so, dust splashing from the soil can easily reach the leaves and contribute to their mineral accumulation.
Chapter 7-4: Gardening: Moss Garden Maintenance

Fletcher (1991) contends that the most easily grown mosses are those that have strong rhizoids, because they are least damaged by lime. For the remaining majority, one can use peat as a substrate, but that is often too moist. Another alternative is to use a sand substrate or in some cases organic soil free of lime, and water only with distilled water. Rain water is also a good choice, but may be contaminated with lime in areas with alkaline soil or limestone rocks. Nevertheless, as Fletcher points out, the impact of rainfall helps to wash off the minerals. A good spraying system is essential in areas where rainfall is infrequent. Fletcher advises to wash the mosses off with a spray of rainwater when they have accumulated minerals on their leaves.

Fletcher has succeeded in keeping *Polytrichum* alive for 20 years, but he finds it necessary to transplant them every 1-2 years onto fresh peat. Once done, this permits old, dying shoots to produce new sprouts that emerge from the peat.

*Polytrichum commune* and *P. strictum* grow in bogs and fens. *Polytrichum strictum* is aided in its quest for water by a white tomentum on the lower part of the stem. *Atrichum* is a relative in the same family as *Polytrichum*. But its needs are somewhat different. Whereas *Polytrichum* has stiff, waxy leaves with lamellae across most of the surface, *Atrichum* has thin leaves with lamellae only in the middle over the costa. This genus does best on soil, not peat (Fletcher 1991). It is an invasive moss along paths and can easily regrow from fragments.

*Mniaceae*

*Mnium* can be similarly propagated, preferring damp, shaded places. *Plagiomnium cuspidatum* has been quite successful in my garden and thrived as an invader among the shrubs around the campus library. Several members of *Mniaceae* are known and used for their big, lush leaves (Figure 2).

*Hypnum* and *Racomitrium* are common in drier places and *Fissidens* (Figure 4) and *Atrichum* in wet places (Steere 1968). Both *Hypnum plumaeforme* and *Racomitrium canescens* are able to grow without deep shade, but require frequent watering and weeding (Ueta & Deguchi 1980). In his webpage, Svenson (2000) recommended *Racomitrium canescens* as a moss for both sun and shade. It is quite drought tolerant, and it can form large, thick mats that have a broad tolerance, even to trampling. Other mosses suitable for gardens include *Eurhynchium praelongum*, *Eurhynchium confertum*, *Brachythecium rutabulum*, and *Rhytiadiaefhus squarrosus* (Fletcher 1991).

Some mosses are especially adept at being transplanted and seem to survive despite drought or rainy season. Among these, I have been most successful with the medium-sized species of *Fissidens* such as *F. adianthoides* (Figure 4). It helps considerably if the shape of the original colony can be maintained, preventing exposure of longer stems by maintaining the shorter outer members of the cushion. This is especially true for cushion-formers like *Dicranum* and *Leucobryum*. If this is not possible, pushing a rock against the exposed broken parts of the cushion helps to maintain the moisture there.

I have attempted *Leucobryum glaucum* several times with only short-lived success. This moss seems especially susceptible to destruction by the leachates of leaf litter, even if the litter is cleared as soon as the snow melts.
Hylocomium splendens and Pleurozium schreberi likewise do not transplant well. Surprisingly, Rhytiadielphus triquetris does well. Thuidium delicatulum is somewhat successful, but mine was disturbed badly by a chipmunk that seemed to think that was the best way to enter its burrow. Followed by a very dry summer, T. delicatulum does not seem to be doing well.

Moss-of-the-Month - Leucobryum glaucum

Leucobryum glaucum is one of my favorite mosses. A common moss, it is easily recognizable by its pincushion appearance. The common names are cushion, pincushion or white moss. It is an acrocarpous moss, or mound type, growing primarily on a variety of soil substrates. It may be found in the shade but it can tolerate sun exposures. Because the new colonies start off in a round stage, looking like a pincushion, it makes a striking element in garden designs and borders. Also, as one of the lightest greens, it makes a great contrast to other mosses emphasizing design elements.

We often make the assumption that mosses grow only in the shade and in the deep woods. This moss grows in a variety of environments. Sure, it grows in the forests. But, it survives in urban areas as well. Not just a mountain moss, I’ve seen it growing in the piedmont and even at the beach. It can be found growing all around the world not just in North Carolina. Soil substrates range from rich loam to sandy gravel. As with most mosses, it mainly grows on soil that is less desirable for other vascular plants.

Although I talk about the year-round green of mosses, there are times when it may change appearance losing its brilliant shade of green. Of course, climate plays a role. If the humidity level drops and the moss colony is dry over a period of time, Leucobryum glaucum gets lighter and lighter until it becomes almost devoid of green color, looking "white-ish." Hence, the Latin "leuco" meaning white. The reason this dramatic color change occurs is that Leucobryum g. is the exception to the "single cell layer of the leaf" rule. When its top layers dry out, they become opaque blocking the green chlorophyll in lower layers. It is not uncommon for this moss to become lighter on hot days or during periods of drought. I use it as an indicator of when it is time to water my moss gardens. It is amazing to watch this moss change before your eyes as it rehydrates. Once I rescued a Leucobryum colony from a gravel road in the direct sun. It was truly white. I took it home and placed it among other Leucobryums in my garden. I watered it thoroughly on three separate occasions that evening. By morning, if I hadn't known exactly where I put it, I would not have been able to distinguish it from the established Leucobryum colony.

However, Leucobryum g. changes appearance for another reason, too. During its asexual reproductive stage, the top leaves break off, covering the colony with white fragments for dispersal to other areas via the wind. Don't be worried, it is not dying but it does look cruddy for a while. Using a broom, lightly sweep them off and they'll look better, and you'll be helping Mother Nature spread the moss to new locations. Sometimes I squirt them with the garden hose creating rivers of white in the miniature landscape spreading them in this manner. If conditions are right, each Leucobryum fragment can grow into a new moss plant.

Warning: If Leucobryum g. gets "black-looking," it might be suffering from prolonged wet conditions or maybe it has been compromised by disease or mold. Let it dry out and see if it starts to recover. This moss does not like staying drenched or soaked for long periods.

As for the tactile aspect of Leucobryum, it grows in a tight mound. Although the plant is relatively small, it does not feel velvety like the tiny Bryums. Large mounds, or older specimens, are compact and hard feeling when dry. Younger colonies, especially when wet, are like walking on a firm sponge. I normally, recommend walking on mosses right planting and watering, to help them attach to the surface. However, I avoid walking on the big colonies with heights of 4-5" because it compromises their round shape. When you walk on smaller cushions, it helps them blend together.

When retrieving Leucobryum, it is easy to pick up a pincushion without any special technique. Rarely, will soil be attached since most colonies grow on top of older generations. As always, please practice responsible land stewardship. Don't take any mosses from our parks or forests and always ask your neighbor before gathering these delightful plants for your own yard.

FUN FACT! Leucobryum grows from both sides! There is no top or bottom to the colony like we associate with other plants where there is no doubt the top is the flower and the bottom is the root system. If you flip over a Leucobryum pincushion, it will start growing from the bottom and turn green. On rare occasions, I've found a Leucobryum "cookie," that is green and growing on all sides. How is it possible for any plant to grow from either direction? Indeed, Leucobryum mosses are botanical magicians!

Annie Martin, Mountain Moss Newsletter winter 2010

For substitute lawns and gardens, Eurhynchium praelongum, Calliergonella cuspidata, and Polytrichum juniperinum serve well, although I doubt the North American populations of C. cuspidata would do so well in most terrestrial areas. In Europe this moss is found on dry hillsides, but in North America it behaves as an aquatic, at least anywhere I have seen it. For rooftops (the clay tile kind), concrete, and rock walls, Svenson (2000) recommends Didymodon vinealis (Figure 5) and Tortula muralis (Figure 5). If it is not too dry, Marchantia polymorpha does well. Within three weeks after planting it, mine had spread to most of the bare soil and dying Leucobryum cushions within a 50-cm radius by means of splashed gemmae. The following year the original clump was a forest of archegoniophores.
Moss gardening is a growing industry, even in the United States and other parts of the world outside Japan. However, not all plants touted as mosses are truly mosses. Spanish moss, a bromeliad, hence a flowering plant, is included among the types available from at least one moss seller. Rock mosses (Selaginella) and club mosses (Lycopodiaceae) are both cryptogamic tracheophytes, not bryophytes. Sheet moss, Sphagnum, and "bun" moss (growing in clumps) are other types listed and are true mosses. Sheet mosses include such mosses as Hypnum and Thuidium (Nelson & Carpenter 1965).

Sources
And one more blog entry, this one also mentions the Connecticut-based firm, Sticks and Stones, which installed the moss garden in the previous blog entry in Ithaca, NY. Perhaps contacting them would be spore-ful?:


In 2007 I read a paper entitled: Moss gardens and publicising mosses, with a Powerpoint presentation, for the PlantNetwork conference Mosses, ferns and lichens in gardens, at RHS Benmore Botanic Garden.

This was then adapted in 2008 for our local Horticultural Society in Surrey UK, as a more popular talk (also with Powerpoint) entitled: Moss Gardens – An Old Tradition, 45 minutes.

These are too large to email, but if you like I can send them on disc.

Sean Edwards

Lawns

David Benner developed a moss lawn so he would never have to mow again (Dunn 2008). He hasn't watered or mowed his lawn since the Kennedy Administration, and it's doing just fine, reports Janee Dundee in her "In the Garden" column (2008). Benner, a retired professor of horticulture, is a long-time moss lawn advocate. He is delighted that this approach is gaining momentum. But to visitors of his mossy lawn, he forbids high heels. (I wonder if it isn't as dangerous for the wearer as it is for the moss!)

Tim Currier, owner of Sticks and Stones Farm, Newtown, CT, USA, has been selling mosses for gardening for ten years, but in the last year his sales increased by 30% (Dunn 2008). Celeste Kennedy, owner of Rolling Hill Farm in Green Bay, VA, USA, reports a 40% increase in the same time frame. Both homeowners and businesses have contributed to this rise in sales.

Dunn (2008) touts the advantages of mosses, including erosion prevention, density that repels weeds, no need for fertilizer, lack of herbivory by deer, and tolerates at least some trampling. It thrives in poor soil and only requires shade and occasional water.

The American Society of Landscape Architects predict that native drought-resistant plants such as moss will be a trendy change in 2008, providing a sustainable substitute for grass in lawns (Dunn 2008). Nancy Somerville, the executive vice president, states that the organization is seeing more creative plantings, with moss being "a great one." It satisfies needs for both better environmentalism and concerns about water. The EPA estimates that nearly one third of residential water use is for landscaping, a condition our diminishing water supply cannot sustain. The condition will only get worse with global warming.

Christine Cook, owner of Mossaics in Easton, CT, USA, contends that a moss lawn needs only one percent or less of the amount of water needed to maintain a suburban grass lawn (Dunn 2008). Benner's philosophy is even better – he doesn't water; "things have to tough it out."

Benner avoids raking leaves by covering the mosses with netting. He then collects the leaves and puts them in his compost heap. In 1962, when Benner first began his moss lawn, the only book he could find on the subject was written in Japanese (Dunn 2008). But he knew that moss thrives in acidic soil, whereas some people spread lime on a grassy lawn to eliminate moss. Therefore, he covered his walk with a mix of sulfur powder and aluminum sulfate to acidify it. Three months later he removed the dead leaves, exposing the soil. Winter was the wait and see period, but in the spring mosses began to sprout everywhere. "It was like magic" he remembers. He didn't even have to plant – he just waited for spores to blow in. He now has 25 different kinds, and he didn't plant any of them! He has found fern moss (Thuidium sp.), hair cap moss...
(Polytrichum), rock cap moss (Dicranum), and cushion moss (Leucobryum) to be the easiest to grow. These four taxa are now sold by his son, Al Benner, through Moss Acres, a commercial establishment in the Poconos of Pennsylvania, USA. This business has actually increased about 30% each year, with such customers as the New York Times' headquarters for its atrium garden.

Benner senior claims that "some sort of magical invigorating energy goes through you when you stand on a thick patch of wet moss" Dunn (2008).

It seems that moss enthusiasts are lurking everywhere. T. J. Turgeon, an executive vice president of a private bank for wealthy people, began his moss growing in 2004 (Dunn 2008). He says, "I'm having an absolute blast with it. I'm great at a dinner party, because I can talk about moss and no one's ever heard it before. People at work think I'm out of my mind. I don't know if other people do this, but wherever I go, I take moss."

Sallie Baldwin is a graphic designer from Greenwich, CT, USA, who has been turning her front yard into a moss lawn for 18 years (Dunn 2008). She sometimes amuses her neighbors by swapping a bit of "weedy" grass in her lawn for the "weedy" moss in theirs.

Special Use Species

You may choose to place some of your bryophytes in special locations that are more restrictive. These could include boulders, rock or concrete walls, or even paths. Some mosses are suitable for transplanting to these special situations.

Lawn Species

One of the most common lawn mosses is the pleurocarpous species Brachythecium rutabulum (Fletcher 1991). It is among the largest of the Brachythecium species, has the typical plicate leaves, and can be distinguished from the others by its papillose seta. Its ability to grow in more sunny areas makes it also a good candidate for gardens as well as paths. It has invaded between the stones of the path along the side of my house. The moss Eurhynchium praelongum will grow in similar areas, but is a smaller plant.

Another lawn species is Rhytidadelphus squarrosum. Well manicured and fertilized lawns are deprived of this species, but grassy meadows mowed by livestock may have it abundantly (Fletcher 1991).

Since mosses barely penetrate the soil with their rhizoids, only shallow soil of 1-2 cm is needed. Texture determines ability to attach but also determines moisture retention. Thus species that typically grow on sand are not likely to do well on humus or clay. Fletcher (1991) suggests bringing back a small plastic bag of soil that can be placed on top of a peat substrate. He contends that the soil type is more important for small moss plants than for large ones. Large plants most likely provide their own substrate after a few years of growth.

Wall Species

The common European moss Tortula muralis easily establishes itself on cement, bricks, or other walls (Fletcher 1991). Although it may be found on soil, this is not its best habitat.

Path Species

The most famous of the species growing on paths is Bryum argenteum, silver moss. It is easily dispersed by its deciduous tips whenever something walks across it. Hence, it is common in cemeteries and other soil areas with light foot traffic.

In addition to this ubiquitous species, Barbula (B. unguiculata, B. convoluta, B. cylindrica, and B. fallax) is common, especially between bricks or stones (Fletcher 1991).

Erosion Control

Shana Gross, Bryonet 23 January 2009

I have spent the past 2.5 years working on my masters thesis which investigates the use of mosses for erosion control along roadsides. I am currently in the process of writing my thesis, which will hopefully be complete by the spring. It is not as easy as placing specimens in a blender. I did multiple greenhouse trials with Bryum argenteum, Ceratodon purpureus, and Polytrichum juniperinum. I looked at multiple treatments influencing growth including fragment size, substrate, fragment location along the shoot, watering methods, hormone application, and nutrient application. In multiple instances, the treatment response was a specific quantitative response. I would be happy to provide answers to specific questions if anyone has them and hopefully sometime some of this data will be published and more easily accessible. The following reference is a good summary start to growing bryophytes: Shaw, Jonathan. 1986. A new approach to the experimental propagation of bryophytes. Taxon 35, (4) (Nov.): 671-5. As far as using bryophytes for erosion control I think it is an excellent idea, which is why I have been working on it. Unfortunately even less is written about this than about growing mosses. The problem I had with field plantings is 1) the moss I was able to successfully grow in the greenhouse was adapted to good greenhouse conditions and to date I have found a poor response when outplanted into the field and 2) if you plant fragments directly in the field you will need to come up with a method to secure the fragments in the field so that they have time to establish before being eroded away. My work has been based in Lake Tahoe, CA which is a Mediterranean climate with temperature and moisture stress. I was able to find some success with transplanting from existing field populations, but this is not a feasible technique on a larger scale for conservation purposes. The following reference found that inoculation of biological soil crusts helped speed up recovery for the crusts and you may find this of some use. Belnap, J. 1993. Recovery rates of cryptobiotic crusts: Inoculant use and assessment methods. Great Basin Naturalist 53, (1): 89-95. I would be happy to provide additional information if anyone is interested in more of the details of my work.

Alison Downing on BRYONET 23 January 2009

We successfully grew bryophytes on a range of soils when we compared bryophytes on calcareous substrates with those of non-calcareous substrates. The project included soils from Mungo National Park, a semi-arid area of south western NSW, where cryptogamic soil crusts are abundant, and can cover 80% of soil surface in some areas. We collected soil in the field, transporting it back to the lab in cotton bags to avoid problems with humidity which might be expected if we used plastic bags. We did not attempt to collect plants, just the top 10 mm of soil. This was carefully sieved in a clean environment. We steam sterilized the sand to eliminate
contamination from spores that might already be in the sand, and filled 10 cm diameter plastic horticultural pots to about 1 cm below the rim of the pots. It is important to use steam sterilization, as many bryophyte spores are not killed by dry heat, eg from ovens, even at exceptionally high temperatures. We then placed a layer of collected soil, approximately 5 mm deep, on the surface of the steam sterilized sand. The pots were placed in an enclosed glasshouse, watered carefully with demineralized water, and sheets of glass placed over the top of the pots to further reduce likelihood of contamination by airborne spores. The pots were checked daily and the surface kept damp, not wet, with occasional light sprays of demineralised water. In 8 weeks, we had 100% bryophyte cover (mosses/liverworts) on soils sourced from calcareous or arid soils. It took a few more weeks to give us the same cover on non-calcareous soils. The technique worked out extremely well, not only did we get exceptional growth on the pots, but we also were able to propagate species which we had not collected in the field (eg ephemerals, Stonea oleaginosa).

This proved to be a relatively simple but very successful technique for us.

Cultivation

Fletcher (1991) has found that mosses can be grown in a variety of containers, including Perspex sandwich boxes, Tupperware, plastic ice cream boxes, glass jars, and aquaria. However, bryophytes kept in this way typically do not survive for more than a few months. He replaced this method with a seed tray, covered with a sheet of glass or sheet of acrylic plastic. These must be kept in cool, open air and shaded. But even this improved method does not work as one might hope; bryophytes fare well for only a few weeks to months. Fletcher even tried peat beds or other means to maintain moisture, but this made matters worse. Clearly there was a need for a better method.

Johannes Enroth related to Bryonet (5 March 2010) his experience growing Niphophrium (=Racomitrium) canescens (Figure 6) experimentally in a cemetary. They took advantage of the fragmentation growth capabilities of mosses and cut the shoots into small pieces. They spread these on sand and kept them moist until they became established. "The moss grew fast and formed a dense, beautiful cover that changed color along with changing air moisture" (Figure 7). This moss is a good suggestion for sunny areas.

from Mossin’ Annie:
http://carolinacountry.com/cgardens/thismonth/aug35.html

Thanks for sharing your moss gardening experience. I'm excited to hear that you are now tending to the garden that had been neglected. I totally disagree with Rick Smith's assessment about tap water. Like you, I've watered for over ten years without any negative impact. Since we have no references on the amounts of nutrients or micro-nutrients required by specific bryophytes to thrive, I'm not sure how he came to this conclusion. It appears that Smith's moss cultivation has been limited to small areas or containers.

However, I do believe that Rick's recommendation of felt is a good idea for propagation of mosses in nursery operations. I'm using 5 different substrates in my own moss cultivation research including 1/8 inch felt (synthetic); 1/4' felt with an adhesive plastic backing (used by carpet installers); basic landscape fabric (thin like paper); black landscape fabric (3/16" with perforations, similar to felt); and coco fiber mat (used in erosion control). I'm also using asphalt shingles as a substrate for Bryum, Ceratodon and Hedwigia types. Finally I'm testing using a wool felt that will eventually disintegrate in garden installations. Adding the netting is okay for field production/cultivation but looks BAD for an installation. I would only recommend netting if critters are disturbing the sites. My nursery watering regime includes creek water source and watering for three times each day when it doesn't rain.

I have a more eco-friendly approach that does not include adding plastic or synthetics into the landscape. It's just not natural in a sustainable approach to gardening. ALL my installations are planted directly on the ground without all this elaborate preparation.

However, in the nursery operations, there could be great value to felt substrates regarding the water retention issue.

I have a friend in Raleigh, NC, USA that is having great success with Mniums, including Plagiomnium. He is using Rick's method with 3 layers of felt, plastic underneath and netting on top. However, I believe his success is primarily due to his watering regime - 6 times every day for 4 minutes each session, even during the night. (I don't think it is necessary to water at night after the late afternoon/early evening session.) He is using creek water as his source for his misting irrigation system. Within a couple of months, there has been visible growth. Also, in another site, he just started his intensive watering regimes and a significant carpet of Plagiomnium has introduced itself and is thriving.

There are many more moss gardening issues to be addressed and lots of answers needed before anybody can accurately determine nutrient needs. It needs to be bryophyte specific not a generalization.

Please realize that not all mosses have the same nutrient or watering requirements. In fact, I'm convinced that Bryums need to dry out sometimes. Also, I've found Dicranum scoparium will not tolerate "wet feet" all the time.

I appreciate you contacting me and wish you the best of luck. Let's stay in touch.

Annie Martin, Bryonet 6 August 2010

I worked with Pleurozium schreberi, Dicranum polysetum and D scoparium, Ptilium crista-castrensis and Ptilidium ciliare in the forest. I collected them any time, dried them (in the shade) and chopped them with scissors, then stored them in paper bags for months. They grew beautifully – I just put them onto humus-y soil (with a hairnet over, to keep them in place), sprayed them thoroughly to wet them, and they
sprouted new shoots very quickly. I don’t think the yogurt, etc. is necessary, but it may help to stick them together.

I found that fragments about 1cm long sprouted new shoots directly. Smaller than that, and they seemed to have to form protonemata first – and those are much more fragile and vulnerable.

*Katherine A. Frego*, pers. comm. to Nancy Church 6 April 2010

Thank you Annie for the moss garden information! I have over the last couple of years been involved in renovating and maintaining a "stone & moss garden" in the courtyard (or quad if that’s the better word) of the Ministry of Education, right in downtown Helsinki, Finland. It was designed and established in the late 1980s but then left almost on its own for about two decades. Professor Timo Koponen originally planted three moss species there (*Racomitrium canescens*, *Plagiomnium cuspidatum*, *Climacium dendroides*); in 2007 I inventoried the moss flora and there were 15 species, heavily dominated by *Encalypta streptocarpa* which now forms a pure mat of several square metres on the sand in the middle of the yard. You can see that moss on pages 32 and 47 of the attached booklet. The text in the booklet is in Finnish, Swedish and English.

Just in June I planted some *Eurhynchium angustirete* in one shady corner of the yard, using the "moss mat system" of R. Smith's book "New Methods in Moss Gardening". The July was exceptionally hot and dry, but the moss was watered daily by the janitor - perhaps too much, as parts of the moss are not doing so well. I'll see what can be done about that.

By the way, Smith advises never to use tap water for mosses, as they contain too much calcium, magnesium etc. I am not sure if that is a problem here in Finland, as the tap water is low in calcium and probably also magnesium. I use tap water in my garden and mosses are doing just fine there, much to my delight and my wife's distress.

Best regards to you all,
Johannes Enroth, Bryonet 6 August 2010

SEE MinEduc_garden Johannes Enroth.pdf

To understand the best way to keep bryophytes, we must understand how they normally grow. Rather than being the moisture-loving plants portrayed in most popular literature, they actually prefer places with good air circulation and only a small percentage of species grow in the damp, enclosed places most people think of. Rather, many taxa grow on dry rocks, sand, or in open sun. Some
prefer acid rocks and some prefer limestone. Most cannot grow where leaf litter will cover them in the fall and remain there for the winter. Some do well in pine forests where they can grow over or between the needle litter.

I have a report of the experiments somewhere (in Finnish) but I cannot find it right now. I recall we tried sand/turf - mixtures but the ratios I do not remember. In the case of N. canescens the surface was just about covered with shoot fragments, but the layer was not thick. The moss grew in a matter of months rather than years to form a a nice mat. We also cultivated with the same method some species of Plagiomnium, probably affine and / or cuspidatum. Two Polytrichum-species were also tried, from spores and from individual shoots planted in the soil, but neither method gave very promising results. The growth was slow and the planted shoot often died, after producing some side-shoots and rhizome. I'll try to locate the report! I do not send this rather vague information to the bryonet. Best wishes, Johannes Enroth, Bryonet 9 Mrch 2010

I currently work with the Peatland ecology research Group (PERG) at Laval University (Quebec, Canada) and did my master thesis on restoration of sand pits with bryophytes. From my observation, bryophyte can colonize any kind of substrate, even sand. In my sand pit experiment, I have seen natural colonization of bryophyte on bare sand, but colonization was optimal when peat was mixed up with sand. For peatland restoration, sphagnum and other brown mosses grow well on peat. For your experiment, industrial peat could be a good option. It usually is free of any propagule. Also, you could pasteurize your substrate (It is a common method in horticulture). For peat, 1h30 of pasteurization at 60°C works well and does not degrade organic matter. Hope it helps! Sandrine Hogue-Hugron, Bryonet 31 May 2011 Sandrine.Hogue-Hugron@fsaa.ulaval.ca

Yes tulle is the same material as used by teen age girls for prom dresses and young women for wedding gowns. I try to use material readily available to everyone anywhere. The holes in the tulle netting are fine, 0.8 mm across yet even Sphagnum and Polytrichum will grow through it. Tulle will definitely discourage birds from pulling moss up and weed seeds are usually too big to pass through the tulle thus weed invasion is not likely. Richard R. Smith, Bryonet 30 August 2010

So happy to do something in return for all of the kindness you have shown me!!! The cellulose comes in 50 lb bales that are extremely compacted and have to be nearly chiseled apart. The cost per bale is about $13 but the shipping is $25! If you only need a freezer bag full (or two or three), we can send you some without you having to order.

We use a cellulose product called Terra Blend70/30 with Ultra Grow. The 70/30 ratio refers to the wood fiber/paper fiber content. We believe the "Ultra Grow," the ingredients of which are kept a close secret of the manufacturer, is part of what makes this so effective with mosses. Keith Bowman, one of Dr. Kimmerer's graduate students, is working with us on experiments with the Ultra Grow cellulose, and we are curious to see if the fertilizer helps the vascular (weeds) plants or the moss more. It has certainly helped the moss in all of the amateur experiments we've done at Moss Acres.

We usually deal with a man named Jim Claxton at Newsome Seed, however he is out for a few months on medical leave. You can reach his colleagues, Allen or Steve at 800-553-2719, or contact Allen at allen@newsomseed.com. However, again, I extend the offer to have us send you some. Two freezer bags full will cover ~18 square feet or more. Nancy Church, pers. comm. 27 July 2010

I have found that advice I get on moss gardening from another part of the country often does not work for me, and I end up going back to my original methods. Alkaline soils or clay soils will require different watering regimes from those of humus, and ease of transplanting and growing will be much better in humid or rainy climates. For example, I found that mosses stay wet longer for me if I do NOT put them on layers of felt, but can understand that downstate where Rick gardens, limestone soils may serve as a desiccant and dry the mosses more quickly and the felt would protect against that. The felt and plastic do help reduce weed invasion. Janice Glime, bryonet 10 June 2011

As I recall from a traditional recipe, the addition of buttermilk and egg to a blender with a moss slurry was so that upon drying the buttermilk made the egg albumen polymerize and act as a protein binder like Haupt's adhesive. As mosses become established, the adhesive becomes a nice source of nitrogen.
Winter Culture

Winter is a good time to harvest and plant mosses... that is, if you don't have snow on the ground during the entire season. In the mountains of WNC, as with other places, we've had record snowfall this year and so mosses have been covered for a while. The brutal temperatures have not been conducive to planting because it's just too cold (for people, not mosses... at least this year). Last winter, I expanded my own moss garden between November and early January reclaiming a section of asphalt driveway. Over a year later, this moss garden retreat is still thriving, albeit under the snow at the moment. When the snow melts, the mosses around here are still green. In contrast, my bryologist friend, Janice Glime in Michigan, reports her mosses are brown but rejuvenate with new green growth in the spring.

Mosses don't mind freezing. In fact, research indicates that mosses grow in temperatures way lower than other vascular plants which go dormant with temperatures less than 55-65 degrees Fahrenheit. Mosses are actually still growing when temperatures hover around freezing! One recent research project was examining microscopic growth occurring at temperatures far below zero. You can plant moss on frozen ground. I know, I've done it. But, the moss needs to be thawed out first.

One hampering factor to winter moss gardening is that most people turn off outside water sources to prevent the bursting of frozen pipes. Water and walk on your mosses is my motto for planting. This process helps ensure the successful establishment of moss colonies. Even in the winter, you still need to water and walk on your mosses. So, on warmer days, when temperatures are above freezing, hook that garden hose back up so you can water and walk on your winter moss garden, especially during the first few weeks after planting. Don't forget to remove the hose again after this occasional use.

Studies are inconsistent in determining exact growing seasons but there is no doubt that mosses grow in opposite seasons to most plants, even in the winter. Bryologists have documented growth in the fall, winter and spring, with summer being the least desirable growing season due to higher temperatures resulting in lower humidity. I can guarantee there is visible evidence in the spring that Thuidium, last newsletter's featured moss, has been growing in leaps and bounds during the winter months. It spreads over other types, like Leucobryum and Dicranum, invading and sometimes covering these mound mosses resulting in a more homogeneous moss carpet. Winter growth can dramatically change your moss landscape design.

Moss Plantations

When visiting a commercial moss plantation in Japan near Nagoya, I found the ground planted in several species of *Polytrichum* and its relatives *Pogonatum* and *Atrichum*. The landscape was dotted with small pine and fig trees, providing light shade for the mosses beneath (Figure 8). Other growers cover the mosses with straw or bamboo screens to provide shade. The proprietor proceeded to show me, with hand motions and occasional translations by N. Takaki (for whom *Takakia* is named), how the mosses were dried, then pulverized between the hands, and sown like grass seed in wooden flats. These flats were kept well watered in full shade until the mosses were well established. Then they were transplanted outside under the shade of the pines and figs until they formed a carpet (Figure 8).

When they were harvested for a buyer, they were removed in squares about 20x20 cm and stacked to dry (Figure 9). Their new owner would then plant them, checkerboard fashion, in a dooryard garden or along a small backyard path, trampling them into the ground and once again breaking off small fragments of moss. A small board can be used to press and spread the mosses instead of trampling, but pressing them into the ground is important. It is the ability of mosses to regenerate from fragments that makes this process work so well. The fragments and new growth eventually fill in the empty squares of the checkerboard, providing a continuous carpet for the moss garden, although Schenk (1997) advises us that it can take 2-3 years for a *Polytrichum* carpet to fill the gap. Mosses such as *Brachythecium*, with their horizontal growth form, may fill the gap within a year.

Figure 8. This plantation in Nagoya, Japan, uses pine trees to provide shade for growing mosses. Photo by Janice Glime.

Figure 9. Stacks of *Polytrichum* are ready for delivery to a private garden near Nagoya, Japan. Photo by Janice Glime.
This ancient art of planting mosses by pulverizing has been adopted by the American Horticulturist Society. In their Fact Sheet for Moss Gardening, they recommend grinding dried moss and spreading it as powder, cautioning the gardener never to buy moss from a grower unless you are certain that the moss has been propagated by the seller and not taken from the wild – good conservation advice. Experimental studies support this pulverizing method as well. Miles and Longton (1990) found that fragmentation was superior to spores in the development of upright shoots in such common garden mosses as Atrichum undulatum and Bryum argenteum. In fact, Shaw (1986) contends that whether in an industrial setting or in the laboratory, starting cultures from spores is impractical for many species. He found, using the pulverizing method, that within a month, new gametophores were evident in most species, and within three months regenerated plants filled his pots. He had the best results when the plants were misted for six seconds every thirty minutes. Svenson (2000), on his moss gardening website, recommended filling in the bare spots between patches of moss by using the pulverizing method. This can be done by putting pieces of moss in a blender with a small quantity of water for two minutes, then spreading them between the transplanted mosses.

A mixture of 50% coarse sand, 30% vermiculite, and 20% peat provides a good substrate, and the optimum growth temperature for temperate zone mosses is believed to be around 10°C (Iwatsuki 1979). In the laboratory, Petri plates with layers of filter paper saturated in tap water have been successfully used to regenerate Atrichum undulatum leaf fragments (Gemell 1953); in nature, the soil will do just fine if kept moist. [Note that not all tap water is created equal; it may kill some species and be worse in some areas.]

My students at Michigan Technological university successfully grew protonemata of five North American taxa in genera commonly used in moss gardens (Atrichum oerstedianum, Dicranum scoparium, Fissidens adianthoides, Leucobryum glaucum, Plagiomnium affine) in a dish garden, using this method and a modified version with a strip of cheesecloth over the fragments to retain moisture (Plante et al. unpublished data 1993). Protonemata developed in 2-3 weeks. Fragments placed on sand failed to produce any growth during the experiment. In addition to the fragments, whole plants were planted, and at least a few plants of Atrichum oerstedianum, Fissidens adianthoides, and Plagiomnium affine produced new branches, although the original branches became brown and wilted. Subdued light (900 lux for 8 hr d⁻¹) and moderate temperatures (ca. 20°C) seemed more favorable than a higher light intensity and temperatures of 38°C.

It is during the critical early establishment stage that moisture is very important, and the Japanese often time their planting to coincide with the rainy season so that the mosses get natural watering daily. Yet, the entire first year and often the second require careful attention to water requirements. As discussed in the chapter on "Water Relations: Rehydration and Repair," frequent wetting and drying is quite detrimental to a moss because each time it is dried and rewet it must repair damaged membranes, often requiring a full day before there is any net energy gain. Transplanting brings with it its own share of damage and adjustment that makes the mosses less tolerant of natural stresses.

It is interesting that Schenk (1997), with his long-time experience as a moss gardener, reports that few mosses will grow successfully from fragments. He touts Leucobryum, Racotritum, and Dicranoweisia with this ability, but finds others to be reticent to yield to the gardener’s wishes. Nevertheless, as he acknowledges, all mosses share this ability to regenerate from fragments, and I have observed in nature young shoots of Scapania undulata (Glime 1970) and Atrichum (Glime 1982) developing from leaf fragments to which they were still attached. Fissidens species are especially adept at this, and I soon found new colonies all over my garden room, presumably transported about as fragments by my turtle – they had never produced any capsules. In the lab, Plante et al. (unpub. data 1993) were successful with both whole plants and fragments of Fissidens.

One of the most luxurious growths of moss I have seen outside of nature was on a discarded piece of carpet that was able to soak up and maintain moisture over long periods of time (see, for example, Figure 10). This is reminiscent of the technique of using cheesecloth on flats to grow mosses that are to be draped over rocks or uneven landscapes. The cheesecloth method takes advantage of fragments, although spores can be used as well (McDowell 1968). Partially dried moss fragments must be spread over cheesecloth that overlies a sand-peat moss or sawdust mix in a flat. The pH can be lowered by soaking the mix in a solution of 1 part skim milk or prepared powdered milk to 7 parts water (McDowell 1972). These are covered with a second piece of cheesecloth and kept moist by misting. When the plants are well established (about 4 ½ months), it is easy to transplant them by lifting the soil/cheesecloth layer. The cheesecloth can be cut to shape as needed. Some gardeners have been successful in growing rock-dwelling taxa this way as well. The cheesecloth can easily be draped over rocks. The mosses grow through the cheesecloth, and eventually the cloth will rot away. If the white color of the cheesecloth is bothersome, coffee (soak in 3 teaspoons instant coffee per cup boiling water for 10 minutes) can be used to stain the cloth (McDowell 1972). Crum (1973) has found that Brachythecium salebrosum and Plagionmniun cuspidatum are relatively easy to grow in this way, emphasizing that regeneration works better than transplantation.
Mountain Moss Receives 2010 WNC AgOptions Grant for Moss Cultivation

As tobacco farmers struggle to adapt to the decline in demand for their product, our native mosses could be new "cash crop" alternatives. Environmentally-friendly mosses have marketing potential as viable horticultural choices to be featured in the creation of moss lawns, green roofs, outdoor living spaces, and moss gardens. Mountain Moss Enterprises, with funding from a 2010 WNC Agricultural Options grant, will focus on developing effective moss propagation procedures in the project: Mountain Moss Nursery: Green Alternatives for WNC Farmers. WNC Agricultural Options partners - N.C. Cooperative Extension, Rural Advancement Foundation International-USA and N.C. Tobacco Trust Fund Commission have designated Mountain Moss Enterprises, located in Transylvania County, as a recipient of a WNC AgOptions 2010 grant. This project emphasizes entrepreneurial initiatives in the field of horticulture, specifically the emerging moss industry, and the utilization of value-added sustainable agricultural practices in farming operations. Forty-one other mountain farmers, and their respective agricultural projects, have been selected for this year's funding cycle. Van Burnett, my childhood friend, has gotten a grant this year, too. He's growing hops and blueberries as well as other plants indigenous to this region on his family farm in Black Mountain. WNC AgOptions is invested in helping agriculture grow and thrive in western North Carolina as farmers diversify or expand their operations in our changing economy.

In contrast with tobacco farming, moss cultivation requires far less time, labor and equipment for daily/long-term maintenance and annual harvesting. The investment of money related to this agricultural parallel is significantly reduced for start-up or continued moss farming activities. The potential market value of moss plants, measured in square feet rather than pounds per acre, could far exceed the typical winter "cash bonus" so many mountain farmers have expected with tobacco. Because of the unique botanical aspects of mosses, these indigenous bryophytes offer an extended growing season encompassing the entire year, including winter months. The environmental benefits of mosses are numerous in moss cultivation for farmers and the target market of residential and commercial customers who recognize the value of mosses as a viable horticultural choice in sustainable landscapes. Because of its botanical characteristics, mosses require NO chemicals - NO fertilizers - NO pesticides - NO herbicides. Groundwater pollution or agricultural runoff into our mountain streams and rivers is eliminated. The carbon footprint directly related to growing mosses is nil. Typical oil-burning farm or landscape maintenance equipment, such as tractors and mowers, are simply unnecessary. Therefore, there is no associated air pollution related to eco-friendly moss production. FYI - Did you know that just one typical push lawn mower running for one hour equals 43 new automobiles running for the same time? The reduced environmental impact of mosses could reveal benefits to our overall quality of life. With over 450 bryophytes indigenous to our region, there are all types of mosses that have potential as cash crops. We have fast-growing mosses, like Thuidium and Pseudoscleropodium; those that grow in the shade, such as Dicranum and Rhodobryum; and sun-tolerant types, including Bryum and Ceratodon. With the exception of Sphagnums (peat mosses), few significant research studies have been conducted on moss propagation in the fields of horticulture, agriculture or bryology. Therefore, there are no established industry methods for successfully cultivating mosses.

This practical research project, a Mountain Moss Nursery, addresses the need for determining optimal growth conditions for a variety of moss types that will yield the best economic return as income-generating cash crops. Based upon bryophyte research, observation of moss growth patterns found in natural settings, and over ten years of moss gardening experience, Annie Martin, a moss landscape designer and an aspiring moss farmer, has selected twenty different types. These mosses will be grown in containers and for field production. Growth patterns and recommended methodologies will be analyzed. The results of this project, pertaining to efficient moss propagation, will be shared with other small farmers, nursery operators and moss gardeners. This WNC AgOptions grant will fund operational activities for Mountain Moss to conduct this field testing, but additionally, others will benefit from this value-added research necessary for entering the burgeoning moss industry. Go Green With Moss!

Annie Martin, Mountain Moss Newsletter, winter 2010

Transplanting

For those preferring the transplant method, the best place to gather moss is rich woodland areas (Pullar 1966/1967) and the best time of year to collect is from autumn into the winter months (Iwatsuki 1979). But mosses should not be gathered without permission of the owner, and on public lands a collecting permit is usually required. Furthermore, they should not be imported from other countries for one's personal gardens, and when such importation is necessary, proper permission must be gained from both the country of origin and the one of import.

Pinning the bryophytes to the substrate with wooden toothpicks angled through the mat, a technique I learned from Jon Shaw, helps to maintain contact with the substrate during dry periods, and of course keeps them where you put them. In this regard, Schenk (1997) advises...
maintaining as much soil depth as possible when gathering the clump of moss, whereas Bland (1971) advises one to remove as much as possible to prevent curling up at the edges, turning the moss upside down and washing away the soil to prevent shrinkage. I recommend the former because it causes the least disruption of rhizoids and one doesn't have to worry about destroying possible mycorrhizal connections, which may be more common than we realize.

Signs of death occur rapidly in transplants, but if not, the clumps will become stabilized within a few weeks; once they do, Ando (1971) suggests that regular watering can be discontinued. Seike et al. (1980), on the other hand, recommend daily watering.

Maintenance of the integrity of the clump is of utmost importance. If it is necessary to expose the lower part of the stems due to using only part of a clump or other disruption, these lower parts should be protected either by building up soil around them or pressing a rock next to them. If some of the stems are taller than the other stems, they can be cut to avoid having them dry out. For many bryophytes, a new branch will form and continue growing.

Weeding of the imported moss is important so that competition is not planted with the mosses. Leaf, stick, and seed litter should be removed, but caution must be used to prevent disruption of the clump.

Some gardeners recommend making a depression, laying a bed of gravel, then putting the mosses on top, but still within the depression. Exposure of the lower parts of the moss seems to be a prescription for disaster due to excessive drying.

It is to our benefit in gardening that the mosses respond quickly to the stress of sun, showing bleaching or browning of leaves in only a day (Schenk 1997). This quick forewarning tells us to try a different location, a different moss, or provide more care and maintenance.

Substrate Conditioning

Successful moss gardening requires at least a modicum of knowledge of the ecology of mosses, and a student of their ecology has much to learn from the successful moss gardener. Aside from the expectation that they will require a moist, shaded habitat, most non-bryologists have little understanding of bryophyte requirements. Most mosses seem to prefer a pH of about 5.5, attainable by spreading powdered sulfur over the soil (about 1.1 kg per 9 m²) (Schenk 1997). Alternatives include powdered skimmed milk, aluminum sulfate, or rhododendron fertilizer. A light misting from the sprinkler will help to affix these to the ground. However, Alison Downing reminded us on Bryonet (20 April 2005) to be careful using milk (or any lime) on sandstone because the calcium in milk can completely change the nature of a sandstone habitat. Instead of Campylopus, Lophocolea, Sclerodontium, and other typical sandstone taxa, you will find instead introduced or cosmopolitan taxa such as Funaria or Bryum.

Maintenance

Famous gardens such as Saihoji in Kyoto require constant maintenance to encourage the mosses against the competing tracheophytes. Leaf litter and weeds must be removed lest the mosses be crowded out, but care must be taken to maintain the natural, unmanicured look. Wire or bamboo rakes or soft brooms (Figure 11) are used for such maintenance; brooms should be firm but not harsh to reduce damage to the delicate moss leaves. There is a Japanese saying that only old men and little boys can tend the moss gardens because anyone else would be too careful and the gardens would lose their natural look (Takaki, pers. comm.; Figure 12).

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One dealer recommends daily misting as opposed to intermittent watering to avoid drying or water logging. But one must exercise caution here. Bryophytes that suffer frequent wetting and drying (to the point of damage) will not have sufficient time for repair during the intermittent moist periods. Consider a sprinkling system to keep things moist, preferably on a timer to water at night, permitting the bryophytes to photosynthesize in the cool morning.

I live in western North Carolina and cultivate a variety of mosses for moss gardens, lawns, green roofs, vertical living walls and more. I have conducted my own research on substrates and watering regimes for various bryophyte types. I have installed moss gardens in public venues as well as private retreats. Mountain Moss Enterprises (my business venture) includes a demonstration moss garden and moss lawn as well as my own Mossery where I cultivate mosses in both container and field production (about 2000 sq ft at this time). Through practical application and experimentation for over a decade, I've
developed expertise in moss applications. In January 2012, I installed a 200 sq ft learning moss garden at the Highlands Biological Station in Highlands, NC where both scientists and the general public can see at least 20 different types of mosses identified and creatively used in landscape design. This week, I'm happy to report that Polytrichum commune and Entodon seductrix mosses from my Mossery will be featured in a garden at the NC Museum of Natural History for their new Nature Research Center in Raleigh, NC (dedication is April 13).

As for substrates, I prefer direct soil planting for landscapes but I utilize Geo-Tex fabric as my primary substrate for container liners and field production -- mainly for moisture retention and as a weed barrier. I've also experimented with felt, shoddy pad (mattress filler), coco fiber erosion mats, sisal rugs and EnkaDrain products. My method for cultivation includes using hand-sized colonies with fragments used in between. More important than substrate is the supplemental watering regime. There is definitely a direct correlation with appropriate watering and faster growth.

Actually, I am writing a book on moss gardening to share my experience with others. There is so much information to share. Yet, many questions are still left unanswered and call for methodical research from trained bryologists. As an active participant in discussions on Bryonet. I'm delighted to see more inquiries regarding LIVE MOSS horticultural options among the scientific community. If we work together and share our experience, the body of knowledge could grow. I hope y'all will want to establish an on-going dialog. There has been little formal research on cultivation, specific to bryophyte types, within the world of bryology... and horticulturalists seem to still see mosses as weeds ignoring the value of mosses as a horticultural choice.

One quick personal comment before I close this note: I did a rescue this week off a roof and harvested at least 100 sq ft of Hedwigia ciliata. As I began traying it up yesterday evening, I was so delighted to discover some of the colonies were in sporophytic stage. Hedwigia sporophytes are quite small and inconspicuous. It's the first time I've seen them!

I look forward to hearing back from each of you. Please include me in conversations with your other contacts. I invite you to join my Facebook group -- Go Green With Moss! Please visit my Web site: www.mountainmoss.com. Also, a couple of summers ago, the Bryology Times published a two-part article on moss gardening which you can access through IAB. Annie Martin, Bryon 8 march 2012

Fertilizers

Fertilizers must be applied to mosses with caution. An "elixir" of manure seems to be a suitable supplement (Schenk 1997). Svenson's (2000) website suggested steeping cow manure in a burlap or cheesecloth bag in a bucket of water for 3 weeks (outside, I hope!) before applying it. An alternative is using 1 part of skim milk or buttermilk to 7 parts of water and applying twice per day for two weeks in spring to acidify the soil. Most other fertilizers, especially if applied dry, can kill the moss.

Iwatsuki and Kodama (1961) caution that fertilizer should never be used for mosses, and contrasting to the powdered sulfur acidifier recommendation of Schenk (1997), Stubbs (1973) recommends the use of fertilizer based on iron sulfate as a means of killing moss fast. In fact, fertilizer is the most commonly suggested means for getting rid of unwanted mosses. On these one-cell-thick leaves, the dry powder soon goes into solution when water becomes available, greatly altering the osmotic relationship between outside and in and introducing the potential of membrane damage. Furthermore, dry fertilizers tend to be hygroscopic and draw water from the delicate and unprotected moss leaves. The effect is much like the desiccation seen among the mosses on Mount Rainier shortly after the eruption of nearby Mt. St. Helen's (Figure 13). However, if applied in liquid form followed by frequent watering, fertilizer can benefit the moss. Lime fertilizers, however, should be avoided due to their alteration of the pH. The seeming contradiction to the advice of Schenk is that he suggests applying the acidifiers to the soil and wetting them down before the moss is planted there.

Horticultural magazines and texts extol the advantages of a wide variety of human foods as starters for mosses. Gillis (1991) describes making moss beds by mixing a handful of moss, a can of beer, and a half teaspoon of sugar in a blender, then spreading the mix 5 mm thick on the ground. She found that the mosses grew within five weeks. In addition to beer, egg whites, and buttermilk, others have successfully used rice water, carrot water, potato water, and just water as the medium. Ellis (1992) claims that such mixtures, even the water, are particularly helpful in adhering the moss fragments to rocks.

Watering

Hi Janice,

Annie emailed me about the book a few weeks ago so I think she got a copy from Moss Acres.
I am on Bryonet and during the Fall of 2007 Annie Martin asked Bryonet for help so on my way back from visiting clients in South Carolina (I am a financial advisor for John Hancock) in December I stopped by and saw Annie for about a day and a half. That was when she was working on her proposal for the NC Arboretum.

I told her I was working with a botanic garden as well as a nature center at that time and had done a lot of work on different methods of moss gardening. I gave her some advice and what information that I could.

Her proposal to NC Arboretum was interesting but very expensive.

Moss Acres refer to me as their consultant and for the last couple years have referred all their more difficult cases to me. Unfortunately some of the more grandiose moss gardens attempts were done by landscape architects who had never done a moss garden. Rana Creek who did the green roof with over a million plants for the California Academy of Sciences ordered moss and never told Moss Acres about doing an indoor moss wall. The wall was the feature for a high end restaurant called the Moss Wall Restaurant. Rana abandoned the client who hired other landscape architects who called Moss Acres who called me. Unfortunately the moss was dead. The sent me samples and one look under the microscope and it was evident the moss wasn’t coming back.

The NY Times new building in Manhattan with a large glass atrium had inside the atrium a live birch and moss garden which also had a total moss failure as well.

Both failed because of using potable water and not rainwater.

Richard R. Smith, pers. comm.

My recommendations for your moss garden.

1. Grow moss in shade, on moss mat system, with some hardwood fines or softwood fines under moss species that in situ are known to be compatible with such organic material. Try other mosses directly on fabric.

2. Water moss with collected rainwater or do not water at all. The latter is my preferred method unless a drought is experienced.

3. Moss garden should be sited to get rainfall and windblown dust.

Richard R. Smith, pers. comm. 4 April 2010

Overwatering can have some interesting invertebrate consequences. Too much water encourages earthworms to live closer to the surface, resulting in castings (Spain 2012). If this is a moss garden with thin mats, the castings are deposited on the moss (Figure 14). When these are numerous, as they can be, they become unsightly. The prevention is to decrease the watering.

Figure 14. Earthworm castings on a moss mat. Photo by Ken Gergle for Moss and Stone Gardens.

Earthworm castings can be removed by letting them dry and removing them with a knife or crumbling them (Spain 2012). The remaining hard portion can be removed by using a pump sprayer to soften them and gently wash them away. Using a hose or other high-power sprayer should be avoided because it will make the moss and soil wet again, once again encouraging movement of the worms near to the surface.

Herbicides

Of course mosses are slow growing and soon succumb to the encroachment of tracheophytes, so it is no wonder that herbicide applications can result in luxurious moss carpets. Schenk (1997) has witnessed the ready success of Polytrichum, Pohlia, and Atrichum following such applications, and Ella Campbell, at a bryological meeting, once commented that the hornworts were ready colonizers following herbicide applications. Herbicides such as Paraquat, Simazine (Bond 1976), 2, 4-D, Atrazine (D. H. Wagner, pers. comm.), and Roundup (Schenk 1997) will encourage moss growth by eliminating invading tracheophytes (Bond 1976). Weeding is of course a safer option, but be sure to hold the mosses down as you pull each weed to avoid disrupting the rhizoids too badly.

Richard R. Smith, pers. comm. 4 April 2010

A Doctoral student in Australia recently completed a study of herbicides on mosses. His conclusion: for the most part, it seemed as if it was the surfactants in the herbicides that did more damage than the herbicide chemical itself. His results would seem to concur with Gordon’s statement that the response of bryophytes to herbicides (and possibly other chemicals as well) is complex. But, then, that is how Nature works.

Rod Seppelt, Bryonet 17 April 2011
Bryophyte "Predators"

Bryophytes are not without their share of enemies – playing roles with impacts that few ecologists have begun to imagine. I cannot keep mosses in my garden room – even when I bring in vast quantities; my finches soon have strewn them about the room in their efforts to carry them to their nests. Newly established protonemata are soon disrupted and destroyed by birds gathering new plants or scratching for grit. In my terrarium, the pillbugs (*Porcellio scaber*) eradicated them from the rocks completely in just a few weeks, and the beautiful carpet I draped on a rock outside was transformed literally overnight into the look of Swiss cheese. Picking up the moss carpet to understand the problem resulted in hundreds of pillbugs falling to the ground! As mentioned earlier, those wanting to use moss they collect are often encouraged to spray a 50% mix of buttermilk and water on the desired surface and then presumably spread a moss carpet over it, but I tried a similar recommendation of raw eggs to little avail. It was that patch of moss that became devoured by pillbugs and I suspect the egg helped make it so.

To keep your bryophyte garden healthy and green, Mizutani (1975, 1976) and Fukushima (1979a, b, 1980) advise eliminating potential destroyers such as moles, slugs, crickets, and ants. Good luck!

A few years ago there was a discussion on Bryonet about temperatures for freezing to kill bugs in Herbarium specimens.

When I relocated the ADT collections from one building to another, we froze the entire collection – 11 drawer cabinets as well – in two -30C freezer shipping containers.

One of the responses I received was from the herbarium in Auckland, New Zealand (AK).

They asked: why -30C?

Their comment was that they had done experiments and discovered that for things like Silverfish - the scourge of books, herbaria, households, etc. – it was not the very low temperature that worked, but a number of cycles of room temperature to -15C over a few days.

This is certainly less severe on the specimens but apparently effective on the live insects.

A domestic freezer will give you about -15C.

Rod Seppelt, Bryonet 6 February 2012

Overwintering

Generally the predominantly perennial mosses will come through winter just fine. And in most cases, they will look bright green as soon as the snow recedes, being the earliest of the green plants (Figure 15).
The benefit of mosses in the garden can extend beyond their aesthetic value to that of enhancing the quality of other garden plants. Schenk (1997) reports that his friend, Gordon Emerson of Ohio, finds that bulbs, tubers, and corms increase more readily under moss cover than when planted in bare ground. Presumably the increased moisture permits them to produce and store more energy.

**Vertical Gardens**

http://www.verticalgardenpatrickblanc.com/

**Summary**

Among the most common "moss" garden plants are thalloid liverworts, especially Marchantia polymorpha, peat mosses (Sphagnum), Polytrichum, Atrichum, members of the Mniaceae, Leucobryum (but it is somewhat difficult), Rhizogonium in Asia, Rhytidiadelphus squarrosus, Euryhynchium (sensu lato), and Bryum argenteum. Fissidens species seem to be particularly easy to grow in temperate North America.

Special habitats may support only a few species, including Rhytidiadelphus squarrosus and Brachythecium rutabulum for lawns, Bryum argenteum and Barbula for paths, and Tortula muralis for walls.

Mosses cultivated in containers will need plenty of ventilation. Flats are good starter containers, with the mosses later transplanted to a "plantation" with light shade. Both can be planted by pulverizing the plants and spreading them like grass seed. A sprinkling system may be needed in a climate without a rainy season, where it exists, by planting just before it so the young plants or transplanted ones get plenty of water. When transplanting mosses from the wild, the integrity of the clump or mat must be maintained. Of course one must have permission, and care should be taken not to decimate the population.

The substrate may be amended with a variety of substances to lower the pH, but liming and fertilizers are detrimental to bryophyte health. Herbicides may eliminate tracheophyte competition, but hand care by pulling weeds and clearing away litter is most likely a safer choice. Avoid giving the garden a manicured look and use only a light broom or wooden rake to clear away litter. Winter care need be no more than removing deciduous litter.

**Arranging the Garden**

Give some thought to the arrangement of the mosses and other plants. For the mosses to offer their peaceful appeal, flowering plants must be kept at a minimum. One long-blooming highlight is enough for a garden of 4m², and it should be set off to the side or back to avoid detracting from the mosses. Be sure the plant won't crowd the ground, lie on top of the moss, or prevent light and/or water from reaching the moss.

Most mosses will need light shade, especially in the afternoon. A small tree, large shrub, building, or fence can provide this.

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Thank you Ken Kellmann and steve Soldan for calling our attention to the delightful New York Times article on moss lawns through Bryonet.

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**Literature Cited**


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"Springtails are generally susceptible to low humidities, so drying would tend to kill them. Washing with a surfactant before drying should increase the kill. Also, most springtails have a highly hydrophobic cuticle and tend to float, so immersion in water will reduce populations. Some of the predatory mites used in biological control of fungus gnats and western flower thrips (species of Gaeolaelaps and Stratiolaelaps – often marketed as Hypoaspis) will eat springtails, but not bryophytes. Other than that you’d probably have to use a chemical toxin like naphthalene or a commercial insecticide."

Eleanor Edye, Bryonet 2 Febuary 2012


