A Guide to

Easily Identifiable Mosses of UCSC

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Introduction

Bryophytes (mosses, liverworts, and hornworts) are all around us: on trees, soil and sidewalks, and on the buildings that we pass and inhabit everyday. Yet rarely are they noticed, and when we do notice them, it is easy to think of all bryophytes as just a few species. However, look closer and you will discover that what once appeared to be a single mat of moss includes many different species. Perhaps they are overlooked as a result of their size — since they are so small, they are easy to miss — or because they are largely considered a "primitive" plant, or, because studies of plants and biology often do not touch on the importance of bryophytes. However, these perceptions of bryophytes are largely misguided. Bryophytes are one of the most diverse phyla of plants, with over 23,000 species of bryophytes worldwide (Bahuguna et al., 2014), a number only rivaled by angiosperms (Bahuguna et al., 2014). There are over 200 species of moss in Santa Cruz alone (Kellman, 2003). Bryophytes also play a vital role in establishing ecosystems and storing carbon. Although bryophytes are often thought of as simple plants, they are incredibly diverse and sophisticated organisms. Few other organisms have evolved the ability to survive desiccation for up to decades and thrive in the most desolate environments. With their extensive diversity, adaptations, and roles in ecosystems, bryophytes are fascinating to learn about and will provide you with a greater understanding of the minute workings of ecosystems.

I began appreciating mosses primarily as an aesthetic plant in lush forests. As I began identifying vascular plants around me, I became interested in which species of moss also existed in the area. However, I found very few resources to help identify mosses. When I did find resources, they included specific keys with terms that I was unable to find definitions for online and that required the use of several microscopes to use. I quickly became frustrated and understood why so few people study mosses.

This guide aims to provide a basic introduction to mosses and identifying some of the most common (although not all common mosses) and easily identifiable mosses on the UCSC upper campus (and beyond) with only a hand lens. This guide does not give an extensive description of each moss, but will note other resources (on pg. 32) if you are interested in learning more about mosses. I hope you find this guide helpful in your natural history endeavors and that it gives you tools to more greatly appreciate mosses.

What are bryophytes?

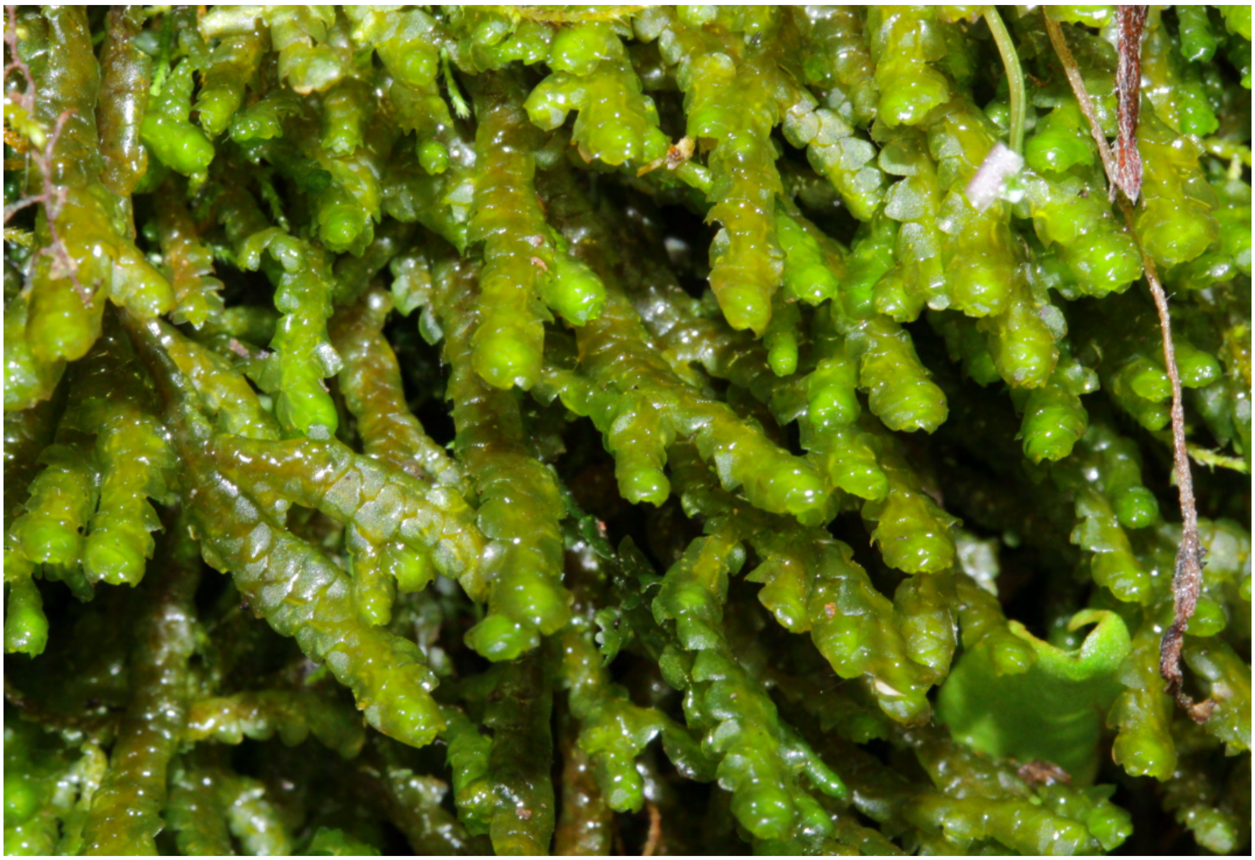
Bryophytes are the descendants of the first terrestrial plants, and just like larger plants, they photosynthesize and have stems and leaves. However, most bryophytes (with a few exceptions) do not possess a vascular system with which to transport and store water and rely on absorbing water directly into their tissues. Because they have no true vascular system, they must stay small and relatively close to the surface and can only grow to the size that the moisture in the environment allows. For this reason, in very wet or humid environments mosses can grow tall, while in dry climates mosses remain relatively small. The physiological diversity of mosses can be seen by comparing size of mosses. *Polytricum commune* and *Dawsonia superba,* which are adapted to wet environments, can grow to be 70 and 50 cm tall (Bahuguna et al., 2014), while in dry environments some mosses, such as *Aloina* spp. can be just 1 mm tall (personal observation).

Bryophytes vs Lichens - Bryophytes are often confused or grouped with lichens because they are both small organisms that live on the surface of substrates and can look similar to the inexperienced eye. However, lichens are very different from bryophytes and are not even plants. Lichens are a mutualistic relationship between fungi and algae. Lichens can be distinguished from bryophytes by their many different colors. While some lichens can be green, bryophytes are almost always green. Mosses and leafy liverworts can be easily distinguished from lichens by the fact that they have leaves, which lichens never have.

Bryophyte Taxonomy - Within the phylum Bryophyta there are three different classes: Hepaticopsida (liverworts), Anthocerotopsida (hornworts), and Bryopsida (mosses). They are not a monophyletic clade (meaning the entire group of organisms comes from a common ancestor), but they have similar lifestyles and are generally grouped together (Shaw & Renzaglia, 2004). When first looking at all bryophytes, it can be difficult to distinguish the different classes. However, there are some distinguishing differences between liverworts, hornworts, and mosses.

Liverworts

There are several different types of liverworts, but they generally can be grouped into leafy liverworts or thalloid (having no leaves, just a vegetative body) liverworts. Thalloid liverworts have what appears to be one large vegetative body covering the substrate that it is growing on, but have several different forms and complexities. Leafy liverworts appear similar to mosses, with many small leaves covering their stem. Leafy liverworts can be distinguished from mosses by their scaly appearance, and that leafy liverworts can have lobed leaves while the leaves of mosses are never lobed. Mosses appear to have tiny leaves and generally look softer, while leafy liverworts appear scaly and thick. No mosses in this guide look similar to any of the leafy liverworts. The sporophytes (reproductive structures) of liverworts are varied, and can look like a black ball on a glassy seta, an umbrella on a seta, small outgrowths on the top or bottom of the thallus, or small cups on the top of the thallus (K. Kellman, personal communication, February 2023).



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Porella cordaeana - Leafy liverwort - *Porella* spp. are one of the most common leafy liverworts on trees in Santa Cruz

Conocephalum conicum - Complex thallus liverwort

Hornworts

Hornworts only have a thalloid body, and most are only present in the springtime. The thallus appears slightly gummy and has a translucent quality. Hornworts have evolved stomata, but only have them on their sporophytes. The sporophyte of hornworts is a green tube that looks like a horn and extends from the thallus. The tube splits in two as the spores mature and are released (K. Kellman, personal communication, February 2023).

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Anthoceros spp. - Hornwort - The tall green stalks are the sporophytes.

Mosses

Mosses take the form of stems bearing leaves. Their sporophytes consist of a seta (sporophyte stem) with a hollow capsule at the top. There are two types of mosses: acrocarps and pleurocarps. Acrocarps are not highly branched and only bear the sporophyte at the end of their stem. Pleurocarps are highly branched and have sporophytes all along their stems and branches. Mosses have evolved stomata, but only on the capsule of the sporophyte (K. Kellman, personal communication, 2023).

Claopodium whippleanum - Moss

Key to Bryophytes

A. Bryophyte has a thalloid (no leaves, one flat vegetative body).

B. Thallus appears slightly gummy and translucent; has a hollow tube-like sporophyte…...*Hornwort*

B' Thallus does not appear gummy and translucent, but has texture of a leaf; sporophytes are not tube-like……………………………………………………………………………… *Thalloid Liverwort*

A' Bryophyte has leaves.

C. Leaves appear scale-like; sporophyte does not have a capsule ………………….. *Leafy Liverwort*

C' Leaves do not appear scale-like; sporophyte has a capsule…………………………………..*Moss*

Where do you find bryophytes?

Bryophytes can be found everywhere. They are abundant in damp, sheltered forests, but also thrive in dry deserts and busy metropolitan areas. They tend to prefer to grow in areas that collect moisture or help protect them from drying wind, such as crevices and embankments. They also grow in highly disturbed areas and are often the first plants to grow in those areas, stabilizing the soil and helping to collect moisture. If you look over the soil in dry deserts and highly disturbed ecosystems, you will often see many mosses covering the soil. They are part of a vital structure called the soil crust, which helps stabilize the soil, fix nutrients, and absorb water (Smith & Stark, 2014). I discuss this more in the section "Mosses and Ecosystems".

On the UCSC campus, mosses can be found in every ecosystem. One of the ecosystems with some of the most abundant, easily identifiable mosses are hardwood and mixed evergreen forests, where mosses grow readily on oaks and Pacific madrones. Mosses tend to be less abundant on conifers, as conifer bark usually does not hold as much moisture. But some species, such as *Isothecium cristatum,* grow readily on the bases of redwood trees. Mosses also love soils, especially steep embankments on the sides of trails or service roads. Some, such as *Fissidens* spp. can grow directly on the path, but most are found on the sides where less disturbance occurs. Mineral soils (soils without a lot of organic matter) are great places to find mosses, as well as areas that have soil covering rock.

Although there are exceptions to this trend, I have found that while pleurocarps (highly branched) grow on both wood, soil, and rocks, acrocarps (not highly branched) are more likely to be found on soils and rocks than wood. The only acrocarp in this guide that grows on trees is *Orthotricum papillosum.*

Mosses and Water

Mosses, like all plants, require water to photosynthesize and grow. However, mosses are unique, as they are one of few plants that can survive desiccation (complete loss of water) for years, sometimes decades, and continue living (Green et al., 2011; Proctor et al., 2007). This adaptation is crucial to their survival, as mosses have no true vascular system and no ability to transport water from sources in the ground or store water during times of drought. Some mosses, such as *Polytrichum* spp. (Brodribb et al., 2020) do have vascular-like cells, however, this is not common among mosses. These vascular-like cells primarily function to support the moss and do not store water. Thus, *Polytricum* spp. must still be desiccation adapted. Instead of a vascular system, mosses absorb water directly into the cells in their leaves. This also means that mosses can lose the water just as quickly as they absorbed it.

<u>*Desiccation Tolerance in Mosses*</u> - Almost all mosses are desiccation tolerant, yet desiccation tolerance varies between species and between seasons of the year (Green et al., 2011), and some mosses can only survive desiccation if dried out slowly (priming) (Wood, 2007). The ability of a moss to survive complete, quick, desiccation depends on what

environment it is adapted to. Dry climate mosses, such as *Syntrichia ruralis* can survive quickly drying out and desiccation over a long period much better than mosses that are adapted to wet environments (Green et al., 2011). Moss' ability to survive desiccation can also change with seasons. Mosses become more desiccation tolerant in the summer when there is less water available, and less tolerant in the winter (Proctor et al., 2007).

In order to be desiccation tolerant, mosses create specific sugars and proteins, yet this takes time and energy. Mosses that have been wet for a long period of time have less of these materials and need time to build them. Priming, such as drying out slowly or experiencing several short dry periods, allows the moss to create sugars and proteins for surviving a long period of desiccation (Proctor et al., 2007). If a moss dries out too quickly, it will not have the molecules that are necessary for it to survive desiccation and will be much less likely to survive.

Photosynthesis of Mosses - Recovering from desiccation requires a large amount of energy to fix any damage done to the plant. Recovery of the photosynthesis mechanics takes time after the moss is rehydrated, and thus all processes of photosynthesis often cannot start immediately (Proctor et al., 2007). Mosses can only grow significantly if they are wet for long enough to make up the energy required for reviving photosynthesis. Mosses require 85 percent humidity in their direct environment (which is often higher in humidity than the larger environment) to photosynthesize (K. Kellman, personal communication, 2022), but also need to balance their need of moisture with not being too wet, as to much water will block gas exchange required for photosynthesis (Proctor et al., 2007).

Mosses and Nutrients

Mosses do not acquire nutrients through roots as many vascular plants do, instead, they absorb nutrients directly into their cells (Bates, 1992). Mosses acquire nutrients from the air, water, and vascular plant litter, and may recycle nutrients from their dead vegetation. The primary way that each moss acquires nutrients varies among species (Bates, 1992), and presumably environment.

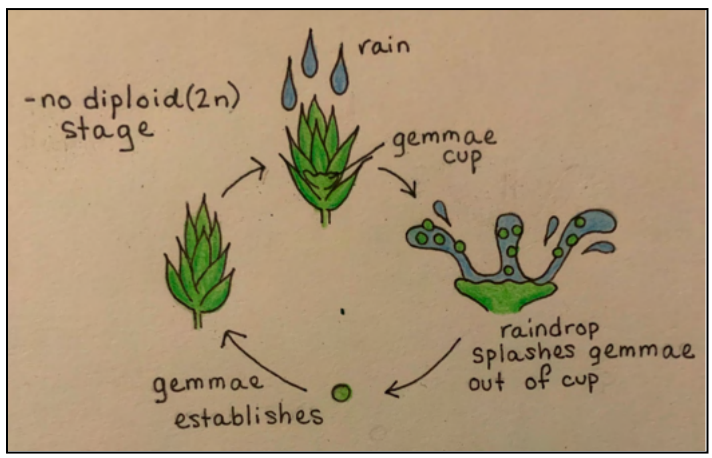
Lifecycle of Mosses

The lifecycle of mosses differs greatly from vascular plants. All plants go through the alternation of generations, which is a cycle of sexual and asexual stages and stages of ploidy (how many sets of chromosomes each cell has). These cycles generally have a dominant (vegetative body) and a non-dominant (sexual reproductive) stage. In vascular plants, the sporophyte (diploid) stage is dominant, while the gametophyte (haploid) stage is non-dominant (Naramoto et al., 2022). The opposite is true for mosses, with the gametophyte stage being dominant and the sporophyte stage being non-dominant (Naramoto et al., 2022). This dominant gametophyte stage is a unique feature among bryophytes that occurs in no other plants.

Reproduction - Mosses can reproduce asexually or sexually, with each method being advantageous in differing situations.

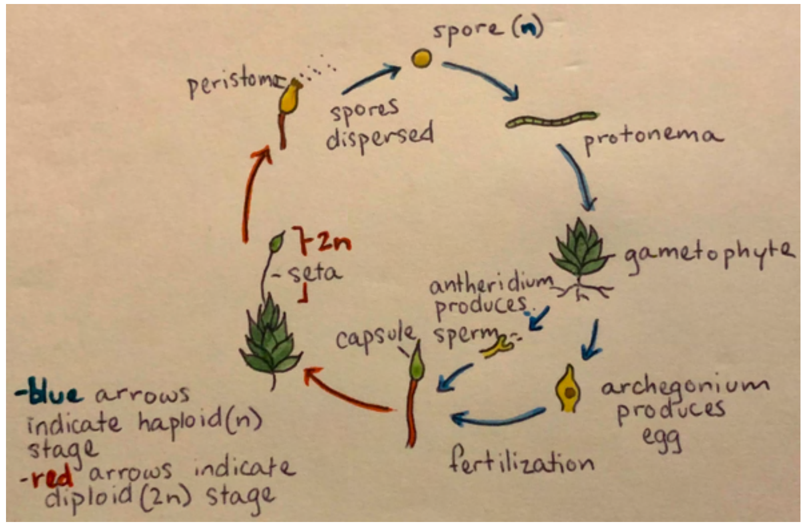
Asexual reproduction - Asexual reproduction is advantageous when directly expanding a colony of moss and/or maintaining the population of a colony (Frey & Kürschner, 2011) and has a much higher establishment rate than sexually produced spores (Longton, 2006). Asexually produced propagules do not travel far enough to establish new colonies. But because they have a much higher success rate than sexually produced spores, mosses in sparse populations that need to expand quickly will put much more of their energy into asexual reproduction than sexual reproduction (Longton, 2006).

Mosses use several different methods for asexual reproduction. They reproduce asexually through regenerating specialized organs in a plant (ie. a leaf or branch), fragmentation, or cloning (Frey & Kürschner, 2011). Mosses have specialized structures called gemmae that are similar to spores, although they are unable to move as far as a spore can. They are moved by water, often by a drop of water splashing onto the moss and propelling the gemmae from the parent plant. There are many different types of gemmae (eight in total), but all carry out the same function of asexually producing a new bud away from the parent plant (Frey & Kürschner, 2011).



Sexual reproduction - Sexual reproduction is advantagous when establishing a new colony (Longton, 2006). Spores are very small and able to be carried by the wind to a location far from the parent colony (Longton, 2006). However, establishment rates of spores are low

(Longton, 2006), and are therefore usually produced when the colony does not need to grow and can put energy into establishing colonies further away.



Sexual reproduction occurs when an archegonium (female reproductive organ) enclosed egg is fertilized by sperm, creating a diploid (2n) sporophyte. Sperm are only able to travel to the egg through water (Kimmerer, 2003). If there is any break in the water, the sperm will not be able to get to the egg. After fertilization, the sporophyte begins to grow, producing a capsule at the end of a seta. Haploid spores are produced inside the capsule (K. Kellman, personal communication, 2022) and are then distributed.

Being able to distribute their spores by the wind has required mosses to overcome the obstacle of getting out of the boundary layer. The boundary layer is a layer above a surface, that differs in thickness depending on qualities of that surface, that creates still air. Mosses are able to increase this boundary layer in order to retain moisture and to stay at a warmer temperature (Kimmerer, 2003), however this poses an obstacle to spore dispersal as there is no wind to disperse the spores. In order to overcome this, most mosses produce tall sporophytes that escape the boundary layer and allow the spores to be dispersed by the wind (Kimmerer, 2003). In summary, a population will put more energy into reproducing asexually if the population is sparse, and will put more energy into reproducing sexually if the population is stable.

Mosses have a wide range of lifespans. Some live just one year, while others can live for thousands of years (During, 1979). As talked about previously, mosses take a long time to grow due to significant dry periods, which makes reestablishing difficult when a population is destroyed.

Ecosystem Role of Mosses

Mosses have many different roles in the environment. These roles include habitat establishment, nutrient cycling and fixation, microhabitat creation for micro and macro invertebrates, serving a pollution indicator, and being a large carbon sink (Bahuguna et al., 2014; Clymo, 1998)

Habitat Creation - Mosses are extremely important as pioneer species. They are some of the first plants to colonize uninhabitable environments, such as loose, low nutrient, mineral soil, and rock surfaces (Bahuguna et al., 2014), and slowly make the environment more habitable to species that require more nutrients and water. Because mosses are able to tolerate desiccation and can take up the necessary nutrients from the air and water (Bates, 1992), they are able to establish in places that lack both. Mosses can establish and provide a structure that accumulates soil by forming a place for it to gather. Over time, this forms a stable patch of soil that is resistant to runoff and is able to accumulate organic matter both from the moss and form additional debris.

In addition to gathering organic materials, they provide a desirable habitat for nitrogen fixing cyanobacteria (Bahuguna et al., 2014; Rousk, 2022), which further incorporate nitrogen into the soil. As organic material and soil builds up, water is retained for longer periods of time. Along with the increased nutrient levels, this creates a microhabitat suitable for germination and recruitment of other plant species. In some habitats, such as tropical forests, bryophytes help with establishment of seedlings, and are especially important in restoration sites where older woody litter and nurse logs may not be available for seeds to germinate in (Rehm et al., 2019).

Mosses, along with cyanobacteria, bacteria, lichens, fungi, form an important structure called a soil crust (W. Wang et al., 2023). They reduce soil erosion of bare land by up to 135%, and cover 12% of earth's terrestrial surface (W. Wang et al., 2023). While they cover most areas of exposed ground that receive sunlight, soil crusts are especially prevalent in arid environments with low vegetative ground cover, such as deserts (Belnap, 2006). Most soil crusts with large amounts of mosses and lichens gather sediments, organic matter, and water in between patches of mosses and lichens, which can aid in germination and establishment of seeds (Belnap, 2006). This is especially important in arid environments, as spaces that harbor water and nutrients are especially important for seed germination and establishment.

Carbon sequestration: Peatlands, which are dominated by *Sphagnum* moss, are one of the largest carbon sinks on earth. Peatlands sequester around 600 Gt of carbon, or around ~30%

(close to how much carbon is in the atmosphere), while they only cover around 3% of the earth's surface (Clymo, 1998; Oke & Hager, 2020). Peatlands contain large layers of organic matter, are continuously flooded, and have very low oxygen levels, which causes the organic matter to not break down (Oke & Hager, 2020). As a result, large amounts of carbon are stored in these peatlands, where organic matter continuously builds up.

Like many ecosystems, peatlands are being negatively affected by humans. Lower water levels due to drainage for formation of agricultural lands and, assumingly, drought have caused degradation of over 11% of peatlands, (Knox et al., 2015; H. Wang et al., 2015). As water levels decrease, decomposition often increases, causing the peatlands to become a carbon source (H. Wang et al., 2015). Peatland ecology is complicated, and not all peatlands respond the same to degrading factors. While it is clear that draining and drought impact the carbon sequestration abilities of peatlands, particularly in the short term, there is the possibility that degraded peatlands can become a carbon sink again (Laiho, 2006). The mechanisms that affect whether or not a degraded peatland will be a carbon source or sink are largely unknown. However, the rate of decomposition of pre-degredation peatland, and the rate of input and decomposition of new organic matter are known to affect whether carbon is stored or released in the degraded peatland (Laiho, 2006).

The possibility that some peatlands may not become a carbon source in the future is not an excuse to drain them or to avoid conservation and restoration efforts. These ecosystems are rare and are home to many organisms that rely on the function of intact peatlands. Although degraded peatlands may not be as much of a carbon source as previously thought, conserving and restoring them has many more benefits than carbon sequestration, and must be given priority.

Habitat for animals - Mosses house many different microinvertebrates, such as tardigrades, rotifers, nematodes, and protozoans, and macroinvertebrates such as insects, spiders, and mollusks (Bahuguna et al., 2014). Micro and macro invertebrates are important decomposers and are vital for nutrient cycling (Donald et al., 2018; McCary & Schmitz, 2021). Micro and macro invertebrates are able to increase the decomposition rate of organic matter by 19-20% (McCary & Schmitz, 2021). By providing habitat for these invertebrates, mosses influence the nutrient cycling and decomposition in the ecosystem. While the importance of mosses as a habitat for invertebrates may differ between species and ecosystems, it can be assumed that removal or degradation of the mosses in the habitat could result in decreased decomposition and nutrient cycling, affecting the larger ecosystem.

Pollution indicators - Mosses are strongly influenced by pollutants in an environment (Bahuguna et al., 2014). Different species have different reactions to certain pollutants, but as a whole, their populations tend to dramatically decrease in size when exposed to pollutants, while only a few species can withstand them (Bahuguna et al., 2014). Mosses are also able to indicate site conditions, such as levels of different metals and minerals in the soil (Bahuguna et al., 2014). Declined noticed in moss populations may indicate pollutants in the environment before declines in other organisms are noticed.

Human Uses for Mosses

Like many plants, mosses have been used by humans throughout the world for centuries, and are still used in some commercial modern ventures, albeit rarely. Most uses of mosses are medical. Although the reasons are unknown, mosses are not a common food source for either humans or invertebrates (Haines & Renwick, 2009; Harris, 2008). However, they have many therapeutic uses.

In a categorical analysis of the uses of bryophytes, the highest uses were medicinal (41%), decoration (14%), and chinking (12%), with all other individual categories falling under 10% (Harris, 2008). The genus *Sphagnum* has the most widespread ethnobotanical uses (by country), while the genus *Polytricum* and the liverwort genus *Marchantia* fall close behind (Harris, 2008). The uses of *Sphagnum* include diapers, sanitary pads, wound dressings during World War II, and fuel (Harris, 2008; Toner, 2018). As stated previously, bryophytes have many medicinal uses, and have been used throughout the world. These uses range from treating cardiovascular issues to cancer to tuberculosis, and many more common diseases and illnesses (Harris, 2008). This widespread history of using bryophytes medicinally indicates that they can be effective at treating illness.

Mosses have high levels of secondary compounds which cause moss to have high antimicrobial activity. Research on different species has shown that extracts from mosses have inhibited the growth of different bacteria, although each bryophyte extract was not universally antibacterial (Mishra et al., 2014). Some extracts have also been able to treat drug resistant pathenogenic fungi, which could be extremely useful as drug resistance increases (Mishra et al., 2014). There have been a few (successful and unsuccessful) attempts to commercialize bryophyte extracts for treatment of fungal pathogens, both for plants and for animals and humans, but no large scale operations that involve moss extracts have existed (Frahm, 2004). Frahm (2004) claims that bryophytes would be a sustainable source for anti-fungal treatments, but I hesitate to agree, as many bryophytes grow very slowly and could take many years to regenerate. Small personal use of bryophytes as fungicide may be sustainable, but large scale operations using bryophytes would most likely not be healthy for wild populations.

Although mosses have been used historically, commercializing their use could put moss populations at risk. Personal use of mosses as medicinal treatments may not be advisable, as it is difficult to correctly identify many mosses, and may result in no change to the condition being treated or dangerous side effects. Additionally, most individuals do not have the traditional knowledge of how to prepare and use the mosses for medicinal use. While there is a large amount of evidence that mosses are effective medicinal tools, I do not suggest incorporating them into a personal medical treatment.

Mosses of UCSC Upper Campus

This guide covers a very small percentage of the 200 moss species in Santa Cruz county, but should give you an easy to identify guide to many common ones on the UCSC upper campus (Kellman, 2003).

Identifying mosses - I cannot emphasize enough how important it is to identify mosses dry. Many mosses are distinguishable by their form when dry, such as particular curling patterns. When wet many mosses look extremely similar and are quite difficult to identify.

Although not all species in this guide require a hand lens, use of one is highly recommended. To use a hand lens, hold it steady directly next to your eye (think about where eyeglasses would sit), and without moving the lens, bring the object close to the lens. Move the object around and to different distances to change the focus and what you are looking at.

Pleurocarps

Alsia californica

Size: Branches range from ~8-40 mm in length extending from the trunk.

Growth habits: *A. californica* grows in plumose mats with individual ascending branches.

Habitats: *A. californica* is extremely common and commonly grows on hardwood bark, such as that of Pacific Madrone (*Arbutus menziesii*), Oaks (*Quercus* spp.), and Tan Oak (*Notholithocarpus densiflorus*). It can be found on live trees or decomposing hardwood logs. It is most common in mixed-evergreen and oak woodlands, and is often found alongside *Dendroalsia abietina*. This moss is common all over campus.

Sporophyte: The sporophyte do not extend far from the main branch, and the entire sporophyte is generally less than 5 mm from the base to the top of the capsule.

Physical Identifying Features: *A. californica* is the most common pleurocarpous moss growing on hardwood trees that curves out and upwards when dry. This distinguishes it from *D. abietina*, which curls downwards when dry. The leaves are arranged radially around the stem and are not julaceous when dry. The leaves are a light green color and are elliptically shaped. They do not have an awn, but do have an acute tip.

Notes: *A. californica* is the only species of the genus *Alsia* found in California.

A. californica branches (dry)

Claopodium whippleanum

Size: Leaves are generally 0.5-1 mm in length. Branches are ~1 cm long, but are very fine.

Growth habits: *C. whippleanum* forms thick mats.

Habitats: *C. whippleanum* is generally found on soil or rocks in mats. I have had the most luck finding it in wetter areas, but it is also found on road and trail banks.

Sporophyte: No information.

Physical Identifying Features: *C. whippleanum* is most identifiable by having leaves that dry and curl to look like a chain. The leaves have a radial configuration around the stem, and are not julaceous. Their branches are very thin, almost feathery like, and the leaves are located with space between them, so that the branches are easily visible. *C. whippleanum* has no awns, but just an acutely pointed tip. Through a hand lens leaves appears to have a triangular shape.

Notes: *C. whippleanum* is the only species of *Claopodium* in Santa Cruz.

C. whippleanum branches (dry)

Dendroalsia abietina

Size: Branches extending from the trunk of the tree are 25-80 mm in length, with shorter secondary branches extending from the primary branch.

Growth habits: *D. abietina* grows in plumose mats. They are highly branched, with the base branches being wider than those at the tip.

Habitats: *D. abietina* is extremely common and is often found on live, dead, or decomposing hardwood trees. It is often found alongside *Alsia californica*. This moss is common all over campus.

Sporophyte: The sporangia are generally found folded between the secondary branches when the moss is dry, and tend to be ≤5 mm in length (base to capsule tip). Mature sporophytes appear deep rusty red in color with a light yellow peristome.

Physical Identifying Features: *D. abietina* is relatively large and extends out from the trunk of the tree. When dry, it curls downwards and in on itself, like a claw. When it is wet, the branches and leaves open up, sticking out from the trunk and forming an 'umbrella' like structure. Secondary branches form a triangle shape, with greater width at the base of the stem, tapering to a point near the tip of the stem. The leaves are inserted radially around the branches, and are not julaceous. They grow densely, and are plumose in form. Leaves are light to dark green in color, long and lanceolate, with no awn, but do have an acute leaf tip.

D. abietina branches (dry)

Homalothecium nuttallii

H. nuttallii branches (dry)

Size: Branches of *H. nuttallii* are generally ~3 mm long, each extending from the main stem, there are no secondary branches.

Growth habits: *H. nuttallii* grows in creeping tendrils and occasionally forms mat-like structures.

Habitats: *H. nuttallii* is common on live, dead, or decomposing trees, and can occasionally be found growing on rocks or concrete. *H. nuttallii* is found almost everywhere, but I have had the most luck finding it in mixed-evergreen forests.

Sporophyte: Mature sporophytes are ~13 mm in length. The capsule is long and orange-golden in color with a yellow peristome.

Physical Identifying Features: *H. nuttallii* is the most easily identifiable species in the genus *Homalothecium*. It is easily distinguishable by its form of a creeping stem along tree bark, with short branches curled up and inward, however, the stem does not curl. *H. nuttallii* forms either long creeping branches or can sometimes look like a curly mat. *H. nuttallii* are light green to golden. Leaves are thin and are inserted radially around the branch. The leaves are not fully julaceous, and the tips of the leaves often spread out from the stem, giving the plant a slightly feathered appearance. The leaves appear silky and have a sheen when viewed from afar and the leaves do not have awns, but are very long and tapered.

H. nuttallii growth habit

Isothecium cristatum

Size: Branches of *I. cristatum* range from around 4-20 mm in length. Leaves are ≤1 mm long.

Growth habits: *I. cristatum* grows in dense mats.

Habitats: *I. cristatum* commonly grows on tree bark and can be found on the trunks of conifers and hardwoods, specifically at the base.

Sporophyte: No information.

Physical Identifying Features: *I. cristatum* has a slight sheen to the branch, and a thin branch that tapers to a smaller width at the tip of the branch. The branches do not form a triangle shape and generally only one branch extends off the stem attached to the substrate. The leaves are julacous when dry and open up and point outwards when wet. Leaves are light green in color and can usually have an orange-rusty tint. The leaves do not have awns and the tips of the leaves come to an acute point.

I. cristatum growth habit

Kindbergia praelonga

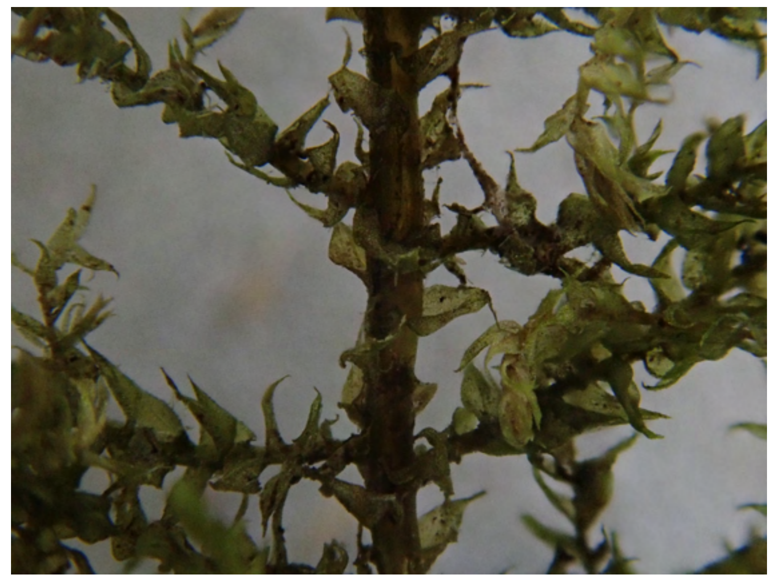
Size: Stems are ~18 mm long, with primary branches ~6 mm in length.

Growth habits: *K. praelonga* grows in mats.

Habitats: *K. praelonga* grows on leaf litter, moist soil, and decomposing wood. It likes damp spaces in particular.

Sporophyte: No information.

Physical Identifying Features: *K. praelonga* is two or three times pinnately branched, which distinguishes it from *Kindbergia oregana* which is only once pinnately branched. The branches look very thin, feathery, and spindley, and form a triangle shape. *K. praelonga* forms loose mats along the ground or wood. *K. praelonga* is light green with yellow tints. With a hand lens you can notice that the leaves on the stem are wider and larger than those on branches, which are more narrow. All of the leaves are not densely packed (you can see the stem/ branch through the leaves). The leaves do not have an awn, but do come to an acute tip.



K. praelonga leaves - notice leaves on stem are wider than those on branches

Sclerepodium tourettii

Size: Branches are 3-7 mm long and about 1 mm wide. Leaves are ≤ 1 mm long.

Growth habits: *S. tourettii* grows in dense mats.

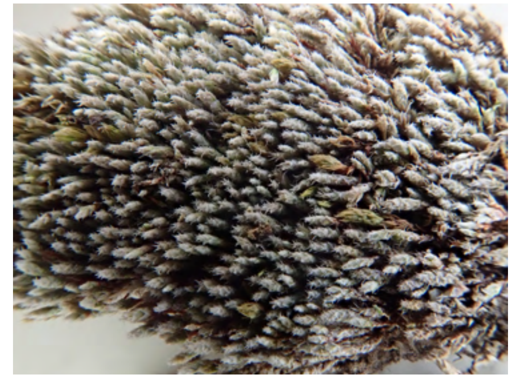
Habitats: *S. tourettii* grows on soil and rock. I have mostly found it in mixed-evergreen and redwood forests along the side of pathways and near the bases of trees.

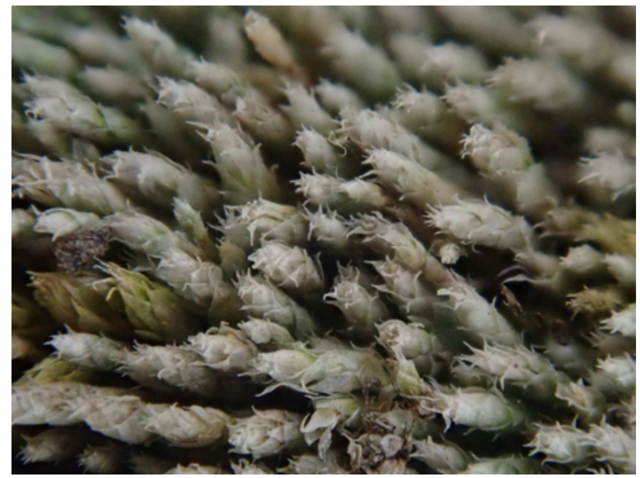
Sporophyte: No information.

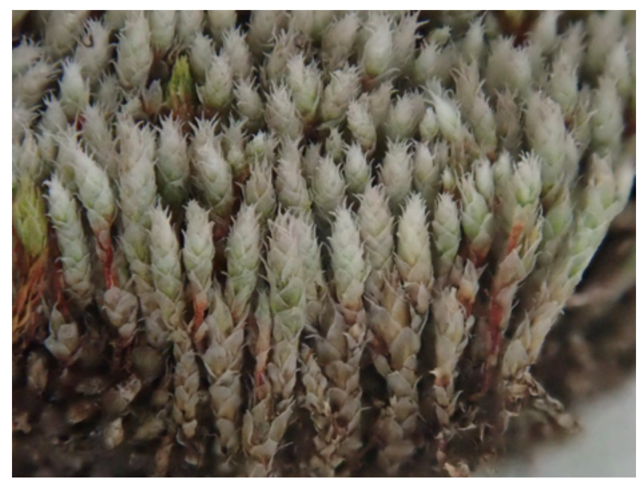
Physical Identifying Features: *S. tourettii* has julaceous leaves when dry, and generally has a shiny sheen. The branches look thicker and a little bit "juicy". The leaves are inserted radially all around the branch, and do not have an awn, but do have a pointed, acute leaf tip. Leaves have a light green color. *S. tourettii* can be differentiated from *Isothecium cristatum* by a thicker branch and "juicier" appearance and *S. tourettii* grows on soil whereas *I. cristatum* grows on tree bark or wood, and appears to have an orange tinge.

Acrocarps

Bryum argenteum







Size: Stems are ~5 mm in length. Stems are <1 mm wide.

Growth habits: *B. argenteum* grows in, sometimes very small, dense mats, with individual stems visible.

Habitats: *B. argenteum* grows on disturbed and compacted soil, and is one of the mosses that colonizes a habitat first.

Sporophyte: No information.

Physical Identifying Features: *B. argenteum* is most easily identifiable by its white appearance. Without any magnification, the leaves appear white, but when looked at under a hand lens, a small amount of green can be seen at the base of the leaves. This appears as a tint of green. Leaves are julaceous, with the tips occasionally pointing outwards. The leaves are very small (making the shape somewhat difficult to distinguish), and the bases of the leaves are significantly wider than the top, the tip of the leaves is acuminate.

Fissidens spp.

Size: *Fissidens* spp. vary in height of the stem, but are generally no greater than 5 mm on campus. A species that grows in streams can be much taller.

Growth habits: *Fissidens* spp. usually does not grow in mats, but grows in patches with decumbent stems close to each other.

Habitats: *Fissidens* spp. are usually found on soil, including on highly disturbed pathways or in streams.

Sporophyte: Sporophytes vary between different *Fissidens* species.

Physical Identifying Features: *Fissidens* spp. are most easily identifiable by the positioning of their leaves, which are inserted in a flat plane. Locally, this arrangement of the leaves is only found in the *Fissidens* genus. *Fissidens* spp. are generally a medium-dark green. Leaf shape varies among species, but leaves are generally wider around the middle before rounding to point at the tip. No *Fissidens* spp. have awns.

Notes: There are at least nine *Fissidens* spp. in Santa Cruz.

F. bryoides - Notice the 2-ranked leaf arrangement

F. curvatus

Funaria hygrometrica

Size: Stems ~5-10 mm in length.

Growth Habits: *F. hygrometrica* grows in mats.

Habitats: *F. hygrometrica* grows in moist environments, especially in highly disturbed areas. It can especially be found below air conditioning vents. It is also a fire-following moss and can be found in fairly recently burned areas.

Sporophyte: Mature sporophyte is ~25 mm tall. Immature sporophyte is ~15 mm tall. Immature sporphytes are curly near the end. Mature sporophytes are bright orange.

Physical Identifying Features: The distinctive feature of *F. hygrometrica* is the sporophyte. *F. hygrometrica* is the only moss with curly immature sporophytes, and has a bright orange mature sporophytes. The only other moss genus that has a similar immature capsule is *Rosulabryum*, which has a pendant capsule. The leaves of *F. hygrometrica* are not distinct, and cannot be identified without the sporophyte. They are light green, are not julaceous, are slightly wavy, and curl slightly inwards.

F. hygrometrica sporophytes - mature

F. hygrometrica sporophytes - immature

Grimmia spp.

Size: Generally less than 15 mm tall.

Growth habits: *Grimmia* spp. grow in cushion-like forms.

Habitats: *Grimmia* spp. tend to grow on rocks.

Sporophyte: Sporophytes vary between different *Grimmia* species.

Physical Identifying Features: *Grimmia* spp. are identifiable by their growth form, which is very cushion-like, with very defined edges. The leaves of *Grimmia* spp. are usually julaceous when dry, and are densely, radially clustered around the stem. Our local *Grimmia* spp. have visible white awns at the ends of their leaves that look like small hairs covering the top of the cushion. Leaves are generally slightly triangularly (wider at the base and smaller at the top) shaped.

Orthotricum papillosum

Size: Branches are 10-20 mm long. Leaves are 2-3 mm long and <1mm wide.

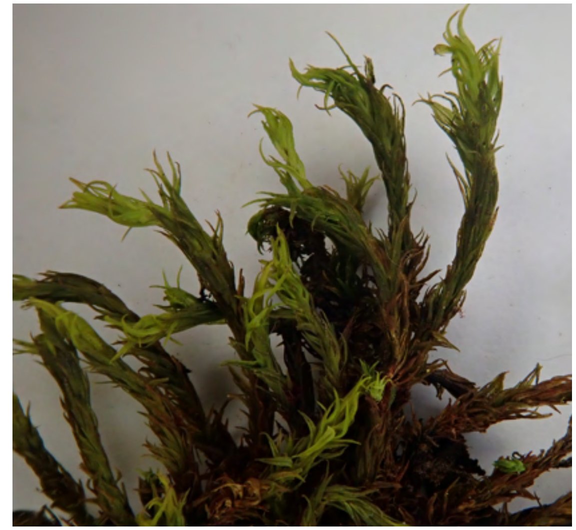
Growth habits: *O. papillosum* grows together in mats with ascending individual branches.

Habitats: *O. papillosum* grows on hardwood trees, soil, or rock. I have had the most luck finding it on hardwood trees.

Sporophyte: *O. papillosum* has a distinctive wrinkled capsule when mature. Sporophytes are not common in *O. papillosum*.

Physical Identifying Features: Leaves appear radially around the stem, and because this is an acrocarp, there is no branching of the stem. *O. papillosum* generally does not have julaceous leaves. Leaves appear light-dark green, and are lanceolate in shape with no awn, but a very acute leaf tip. Stems curl upwards from their growing substrate, and can be distinguished from *Alsia californica* by the fact that *O. papillosum* is an acrocarp, there is no branching, its leaves are lanceolate.

Notes: *O. papillosum* may be being moved to the genus *Pulvigera* under the species name *P. papillosa.*



O. papillosum branches (dry)

Polytricum juniperinum

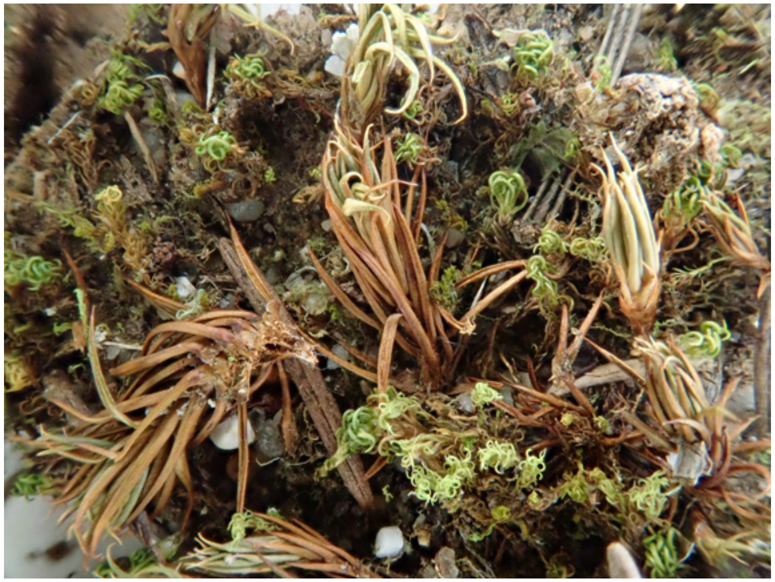
Size: Plants are generally 10-70 mm tall. Leaves are between 5-8 mm in length.

Growth habits: *P. juniperinum* grows in patches with singular erect plants. Sometimes they can look as though they are dried leaves from another plant that have been strewn along the ground.

Habitats: *P. juniperinum* grows on sandy, disturbed soils. It can often be found in chaparral or open field habitats, but is not limited to these areas.

Sporophyte: No information.

Physical Identifying Features: Leaves appear deep, rusty red-brown, and are very stiff and thick, slightly woody. When dry, the leaves all point upwards, occasionally pointing slightly outwards near the tip. The leaves are long (up to 8 mm) and skinny (usually less than 1 mm wide). They taper to an acute point, which can snap off if pressure is placed on it. *P. juniperinum* can be distinguished from other *Polytricum* species by its red leaf apex.



Timmiella crassinervis

Size: Stems are ~5 mm tall.

Growth Habits: Grows in loose mats along the ground, occasionally stems grow alone.

Habitats: Grows on nearly all soil types, can be found on mineral or organic soil.

Sporophyte: Mature sporophyte is ~15 mm long. Capsule is 1-2 mm long. The mature capsule is a light golden brown color, and has white peristome teeth.

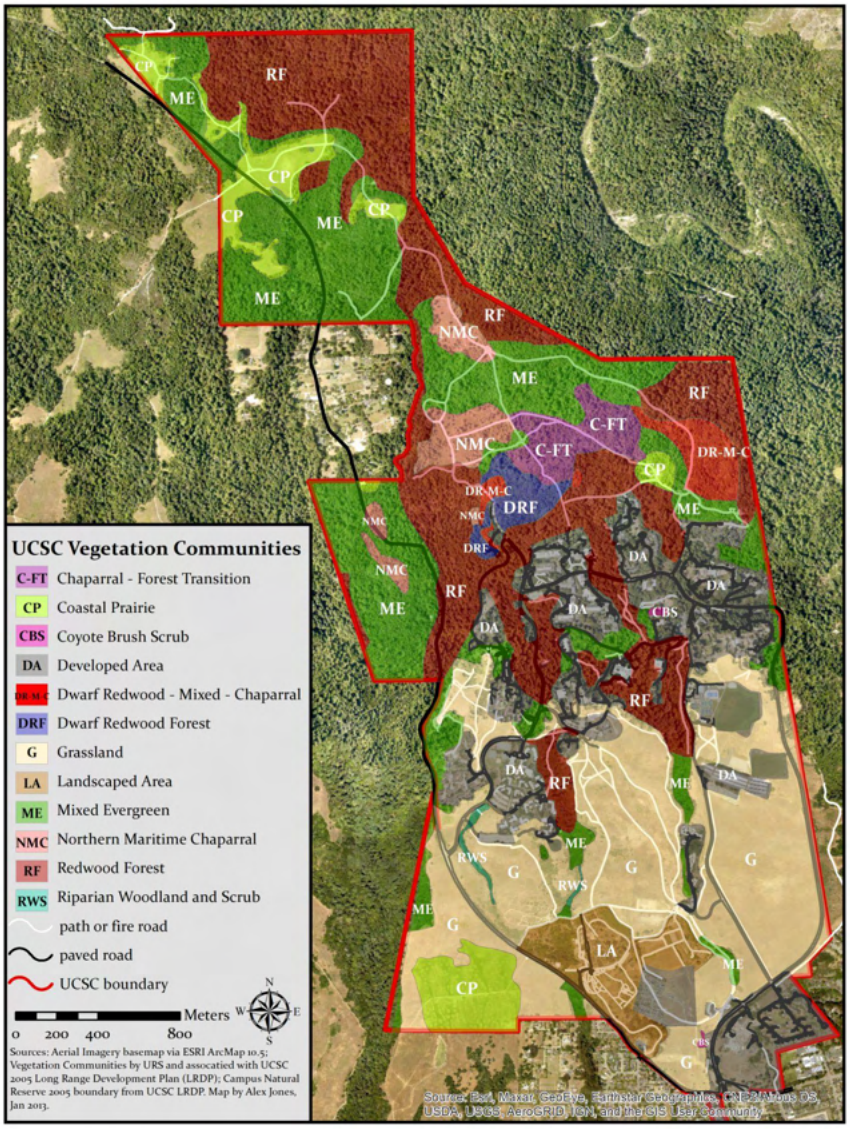
Physical Identifying Features: *T. crassinervis* has thick leaves that curl in on themselves, then around the other leaves in the stem when dry. This forms a very curly looking mat. Leaves are medium green, and appear very linear when dry. The leaves do not have awns, but do have an acute leaf tip. *T. crassinervis* can also be identified when wet. It has opaque leaves when wet, has a distinct, thick costa, and is ~5mm tall. If it meets both of these criteria it is *T. crassinervis.* Keep in mind that a lot of acrocarps have a similar form to *T. crassinervis* when wet, so do not use the form of the moss to identify *T. crassinervis,* but rather the opacity of the leaves.

Notes: *Weissia controversa* looks very similar to *T. crassinervis* when dry, however it is much smaller. The stems of *W. controversa* are always <3 mm tall.

T. crassinervis leaves (dry)

T. crassinervis leaves (wet)

Map of UCSC Campus Habitats



Hardwoods found in: Chaparral - Forest Transition, Mixed Evergreen, Riparian Woodland and Scrub

Conifers found in: Chaparral - Forest Transition, Dwarf Redwood - Mized - Chaparral, Dwarf Redwood Forest, Mixed Evergreen, Redwood Forest.

Mineral soils often found in: Chaparral - Forest Transition, Coastal Prairie, Coyote Brush Scrub, Grassland, Northern Maritime Chaparral, and along paths and roads.

Additional Resources

Books:

"Gathering Moss" - Robin Wall Kimmerer - This is a great easy to read and informative introduction to mosses through use of prose.

"Introduction to Bryophytes" - Alain Vanderpoorten and Bernard Goffinet - This provides a more in depth review of physiological processes of bryophytes.

Websites:

CNPS Bryophyte Chapter - bryophyte.cnps.org - This website has a large amount of information and links about California mosses. It is a helpful resource for beginning and intermediate bryologists.

Glossary

Acrocarp - A moss form, compare to 'Pleurocarp'. Individuals are not highly branched and sporophytes are only produced at the end of the stalk.

Acrocarp

Acuminate - The apex of the leaf curves inward to a long, acute point.

Acute - The point of the leaf is <90°and there is no curve to the margin.

Angiosperm - The group of plants that sexually reproduces through flowers. All flowering plants.

Antheridium - The male sex organ on a moss.

Apex - The tip of the leaf.

Archegonium - The female sex organ on a moss.

Awn - An extension of the midrib of the leaf past the apex.

Branch - An extension off of the main stem that produces leaves or branches.

Calyptra - A thin hood-like covering over the capsule that forms from the archegonium.

Capsule - Structure located at the tip of the seta that contains and disperses spores.

Complanate - Leaves arranged so they appear in one plane.

Costa - The midrib of a moss leaf.

Cyanobacteria - Photosynthetic bacteria, many are capable of fixing nitrogen.

Decumbent - Lying along the ground.

Desiccation - Dehydration of something.

Diploid - Having two sets of chromosomes.

Elliptical - Leaf is 2x as long as it is wide, with the widest portion in the middle of the leaf.

Erect - Upright arrangement of leaves.

Gametophyte - Haploid life stage, the primary life stage in mosses and reproductive life stage in vascular plants.

Gemmae - Small, asexual reproductive structures that are produced on bryophytes.

Haploid - Having one set of chromosomes.

Julaceous - A form where the leaves are smooth and appressed against the stem; wormlike.

Lanceolate - Leaf shape that is wider at the base than the apex, has a 3:1 length to width ratio, and comes to an acute or acuminate point.

Monophyletic - All organisms descended from one common ancestor.

Nurse Log - A fallen, decomposing tree that provides nutrients and habitat for establishment of seedlings.

Peristome - A highly toothed structure at the opening of the capsule that assists dispersal of spores.

Phyla - Taxonomic rank that describes a group of plants below kingdom and above class.

Pleurocarp - A moss form, compare to 'Acrocarp'. Characterized by highly branched individuals and sporophytes that grow along entirety of the stem and branches.

Ploidy - The number of sets of chromosomes an organism has in a cell.

Pleurocarp

Plumose - A form that appears upright, dense, and slightly feathered.

Primary - With regards to branching, the main, first branch.

Protonema - A thin chain of cells that forms the first stage of a gametophyte in mosses.

Radial - Inserted symmetrically on all different sides of an axis (i.e. on all sides of a stem).

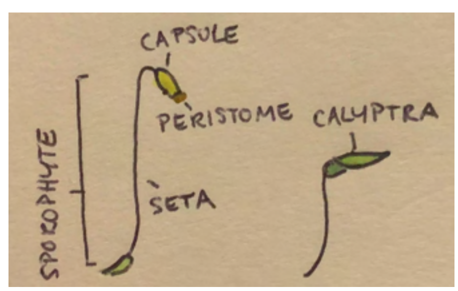
Secondary - With regards to branching, the branches that come off of the primary branch.

Secondary Compounds - Metabolites synthesized by plants that are not vital for functioning, but often provide benefits such as being antimicrobial, anti-herbivorous, and growth hormones.

Seta - The stalk of the sporophyte that holds up the capsule.

Spore - One celled, sexually produced reproductive unit capable of producing a mature plant.

Sporophyte - The reproductive structure as a whole. Consists of the seta, capsule, calyptra, capsule, peristome, and spores.



Sporophyte anatomy

Stem - The primary branch from which all other branches extend.

Stomata - Small pores in the outermost layer of plant tissue that allow for gas exchange.

Thallus - A vegetative plant body that is not differentiated into stems or leaves. It is common in thalloid liverworts and hornworts.

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