Conservation Assessment
For

Schistostega pennata (Hedw.) Web. & Mohr.

October 27, 2005

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USDA Forest Service, Region 6 and
USDI Bureau of Land Management, Oregon and Washington

Updated by Camille Duncan in February 2010 (Update added Appendix 2: Photos)
Disclaimer

This Conservation Assessment was prepared to compile the published and unpublished information on the *Schistostega pennata*. It does not represent a management decision by the U.S. Forest Service or Bureau of Land Management. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the interagency Special Status/Sensitive Species Conservation Planning Coordinator in the Portland, Oregon Forest Service/Bureau of Land Management Offices via the website www.or.blm.gov/isssp/.
Executive Summary

Species and Taxonomic Group
*Schistostega pennata* (Hedw.) Web. & Mohr., Bryophyte

Management Status
*Schistostega pennata* is listed as Sensitive on the Region 6 U.S. Forest Service (R6) Sensitive Species List, and is considered a Bureau Assessment species in Oregon by the Oregon-Washington Bureau of Land Management (http://www.or.blm.gov/isssp/). In Oregon this species is ranked as S2, List 2 by the Oregon Natural Heritage Program (http://oregonstate.edu/ornhic/data/nonvasc.html) and is ranked as S2 by the Washington Natural Heritage Program (http://www.dnr.wa.gov/nhp/refdesk/lists/plantrnk.html).

Range & Habitat
*Schistostega pennata* is a circumboreal species that occurs in Europe, East Asia and North America. In the Pacific Northwest *S. pennata* is known from Alberta, Montana, Oregon, Washington, northward through British Columbia to Alaska. *Schistostega pennata* occurs on mineral soil in crevices on the lower and more sheltered parts of the root mass of fallen trees. It also has been found on soil around cave entrances.

Threats
There are potentially direct and indirect impacts that may occur to this species. Direct impacts result in the degradation or destruction of individuals or populations of *S. pennata*. Potential direct threats to this species include: damage to or removal of tip-overs, destabilization of soil by from sawing and yarding of a log tip-over, and fire. Indirect impacts would include: the lack of future tip-overs, and stand thinning which would remove trees that might tip over during natural stand succession.

Management Considerations
Consider leaving logs with *S. pennata* present on the root mass undisturbed.

When thinning stands, consider promoting stand variability either by means of untreated patches or variable-width spacing.

Consider deferring treatment of laminated root rot at occupied sites to allow for future tip-overs.

Avoid activities such as bucking of logs that would directly impact an occupied root mass.
Research, Inventory, and Monitoring Opportunities

How long does *S. pennata* remain on a single root mass?

How long does it take a root mass to progress between developmental stages?

How are spores of *S. pennata* dispersed?

Monitor occupied sites after management to determine the effectiveness of the management.
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Introduction

Goal
The goal of this Conservation Assessment is to summarize existing knowledge regarding the biology and ecology of *Schistostega pennata*, threats to the species, and management considerations to provide information to line managers to assist in the formulation of options for management activities. Federal management for this species follows Forest Service Region 6 Sensitive Species (SS) and/or OR/WA BLM Special Status Species (SSS) policies.

For OR/WA BLM administered lands, SSS policy details the need to manage for species conservation. For Region 6 SS policy requires the agency to maintain viable populations of all native and desired non-native wildlife, fish, and plant species in habitats distributed throughout their geographic range on National Forest System lands. Management “must not result in a loss of species viability or create significant trends toward federal listing” (FSM 2670.32) for any identified SS.

Scope
The geographic scope of this assessment includes consideration of the known and suspected range of the species within the Pacific Northwest. An emphasis of species-considerations is provided for federal lands in Oregon and Washington; however, species-knowledge compiled from non-federal lands is included as it is relevant to the overall conservation of the species. This assessment summarizes existing knowledge of a bryophyte species that is rare throughout its range. A summary of known or suspected threats is listed but may change with time. Management considerations may be applied to localities, specifically; however range-wide concerns are discussed. Uncertainties regarding impacts of management actions upon *S. pennata* are acknowledged where appropriate.

Management Status
*Schistostega pennata* was originally rated under FEMAT, (Thomas et al 1993) and was identified as a Protection Buffer species in the original Northwest Forest Plan Record of Decision (USDA, USDI 1994). In 2001 it was moved into Category A because it was considered rare, and pre-disturbance surveys were practical (USDA, USDI 2001). Currently it is on the USFS Region 6 Sensitive species list and it is considered a Bureau Assessment species in Oregon by the OR/WA BLM. According to NatureServe (2004) the global rank for *S. pennata* is G3/G5 with a rounded G4 status. In Oregon it is ranked as S2, List 2 by the Oregon Natural Heritage Program (2004) and in Washington it is ranked S2 on the Working List of Rare Mosses (Washington Natural Heritage Program 2004).

Classification and Description

Systematic and Synonymy
*Schistostega pennata* (Hedw.) Web. & Mohr. was first described as *Schistostega osmundacea* Mohr.
Species Description

*Schistostega pennata* forms erect fern-like bluish-gray-green leafy shoots 4-7 mm tall. Leaves of sterile shoots are 0.5 – 1.2 mm long, in two rows in an opposite arrangement along the stem and they are flattened like a fern frond. The shoots often occur in clusters that may or may not have a reddish-purple tint to them. The leaves lack a costa or midrib. The ephemeral protonemal mat is composed of filamentous strands of tiny clear spherical cells that reflect light to give off a greenish-golden color. The chloroplasts move within the spherical cells to maximize their ability to collect the reflected light. The plants are not contorted when dry.

Biology and Ecology

Life History and Reproductive Biology

In *S. pennata*, male and female plants arise from the same protonemal mat. Male plants have narrowly lanceolate leaves and usually have two antheridia. A single archegonium develops among a rosette of lanceolate leaves. Small (0.4-0.5mm) light brown globose capsules occur on top of a seta that is erect, 1.5-4.0 mm tall. In Russia capsule development occurs very fast and occasionally the operculum falls of before the seta elongates (Ignatova and Ignatova 2001). The peristome teeth are lacking. The spores are small, (8-10 μ), sticky, ovoid with pitted-reticulate ornamentation. Occasionally sticky gemmae occur on the protonemal mat.

Range, Abundance, and Distribution

*Schistostega pennata* is a circumboreal species that occurs in Europe, East Asia and North America. In the Pacific Northwest *S. pennata* is known from Alberta, Montana, Oregon, Washington, northward through British Columbia to Alaska. In Washington it is reported from the Olympic National Park and Olympic National Forest (Grays Harbor, Jefferson Counties), Mt. Baker-Snoqualmie National Forest (King, Pierce and Whatcom Counties), on the Okanogan National Forest (Okanogan County), on the Wenatchee National Forest (Yakima County) and the Gifford Pinchot National Forest (Skamania County). In Oregon it is known from the Mt. Hood (Hood River and Wasco Counties), Deschutes (Klamath County), and Willamette (Lane County) National Forests, and reaches its southernmost occurrence on the Umpqua National Forest (Douglas County) and in Crater Lake National Park. One site in Oregon occurs in the Coast Range on Salem District BLM land in Lincoln County. *Schistostega pennata* is rarely abundant and occasionally only the protonemal mat is found.

Population Trends

Species such as *S. pennata* are sometimes referred to as “shuttle-species” because of their ability to colonize newly available habitats (Crum 2001). Characteristics of shuttle species include: a high sexual reproductive effort, rare or absent asexual reproduction, and they occur in habitats that remain suitable for 2-3 or slightly more years, and severe stress is absent (During 1979.) Because the substrate for *S. pennata* may be fairly short-lived it is important to understand the causal events that create substrate and evaluate the potential lifespan of substrates. In appreciation of the later point it was observed that the root mass associated with tree tip-overs undergoes several transitional stages ultimately
resulting in “mound and pit” topography (Oliver & Larson 1996). See The Appendix for the root mass developmental stages.

**Habitat**

In the Pacific Northwest *Schistostega pennata* occurs primarily on mineral soil in crevices on the lower and more sheltered parts of the root mass of fallen trees. It also occasionally is found on soil around cave entrances. One unique site on the Umpqua National Forest occurs on the shaded insides of a deep “pit” on the upper bank of a perennial creek.

*Schistostega pennata* is found within the silver fir (*Abies amabilis*) plant series and the western hemlock (*Tsuga heterophylla*) and mountain hemlock (*T. menziesii*) series. Coastal sites are commonly in the Sitka spruce (*Picea sitchensis*) series. Western red cedar (*Thuja plicata*) is often a common associate at sites. Sites on the Umpqua National Forest are in lodgepole pine (*Pinus contorta*) dominated stands.

Within Oregon and Washington canopy closure at sites range from about 20% at the southern edge of its range to 70% or more on the Olympic Peninsula. This wide range of canopy closure makes it difficult to establish a minimum or maximum requirement for this species.

Because *S. pennata* generally occurs on the root mass of fallen trees there is usually a gap in the canopy. Some sites, particularly those associated with streams, lakes or wetlands can be very open. Sites not immediately associated with water typically occur in stands with a relatively closed canopy, which helps to maintain humidity within the stand.

Stand structure is also highly variable. Most commonly, stands tend to be mature to old with varying amounts of understory development. Sites in lodgepole pine are the youngest recorded stands with the oldest trees around 90 years old. Sites occurring in stands of Sitka spruce are generally between 181-261 years. However most of the known sites, occur in stands where the trees are over 250 years old.

In some cases sites occur along the edge or margin of the stream or wet area. These high humidity sites provide ideal conditions for this species. In other cases, the sites are often on a stream terraces or lower slopes where the soils are relatively moist and humidity is high.

**Ecological Considerations**

Because bryophytes lack roots and have leaves that are usually only one cell layer thick they are extremely sensitive to desiccation. Species of moist habitats (e.g., *S. pennata*) are always killed by even slight drying (Proctor 1982). Although species that are adapted to arid environments can tolerate high temperatures for short periods, it has been demonstrated that the lethal temperatures for moister habitat species are generally around 40º C – 50º C (Proctor 1982). Therefore direct contact with fires or the heat generated by a fire may lead to the loss of individuals. The leaves of *S. pennata* are covered with a chloroform-soluble material that is similar to the epicuticular wax found in vascular
plants. This “wax”like coating gives the leaves a glaucous appearance and the ability to shed external water, which is very important for species that grow in shady crevices (Proctor 1982). Finally Ignatova and Ignatova (2001) suggest that the reflective protonema may serve to attract some animals to disperse spores, or it may act as a repellent to animals to protect the sensitive soil substratum.

Although S. pennata has occasionally been reported in pits and cave entrances, its persistence in the Pacific Northwest is dependent upon tree tip-overs in moist forest habitats. The factors most commonly associated with tree tip-overs are: windthrow, disease, insects, and fire. Windthrow and root rot in particular have been noted at several known sites. Snags generally break off above the root when they fall so the factors driving tree tip-over accumulation may be slightly different than the factors that result in downed wood in general. Because S. pennata sites are often associated with wet soils, their habitat will naturally be prone to windthrow.

In a study of riparian buffers on non-fish bearing streams in the North Cascades of Washington in second-growth stands, western hemlock and silver fir were more susceptible to windthrow than Douglas-fir, western red cedar, big-leaf maple (Acer macrophyllum), or red alder (Alnus rubra) (Grizzel and Wolf 1998). Buffers adjacent to clearcuts in these areas lost an average of 33 percent of stand density in the first few years, with uprooting being much more common than stem breakage. In addition, larger diameter trees of most species were more prone to windthrow than smaller trees. Habitat conditions in this study appear to be generally similar to S. pennata habitat although most known sites are in older stands. Also, according to Sinton et al. (2000), tall, exposed overstory Douglas-fir trees appear to be more susceptible to blowdown within the Bull Run area (Mt. Hood National Forest), in old-growth, fire-initiated stands that occur in topographically exposed landform positions, along natural or created edges.

Downed wood across the landscape has been observed to occur in a clumped or at least non-random distribution pattern (Marcot et al. 2001). It is possible that clumped distribution of tree tip-overs would facilitate local dispersal and establishment of S. pennata.

There is essentially no data or observations regarding either the effect of fire on S. pennata or the role of fire disturbance in habitat for S. pennata. The moist habitat that S. pennata requires would be inconsistent with a high fire-return interval system and fire scars have never been recorded at any known sites. It is likely however that many sites have seen some manner of fire within the last century or so (although not necessarily while S. pennata was present) and fire has been observed to contribute to tree tip-overs in some circumstances. Because tree tip-overs often occur after a fire it is possible that in wetter habitats S. pennata could invade a recently burned area. However S. pennata is probably best considered a fire “avoider” since its microhabitat requirements are far too restrictive and it does not tolerate high temperatures.

According to Ignatova and Ignatova (2001), spiders, mites, beetles, birds, mice, frogs and ants may serve as dispersal agents for the sticky spores. Various species of small flies have also been observed around the root masses and thus may also disperse the spores.
Competition from other bryophyte species (*Atrichum selwynii*, *Dicranella* spp., *Fissidens* spp., *Pohlia* spp., and *Polytrichum* spp.) would also limit the distribution of this species.

**Conservation**

**Threats**
There are potentially direct and indirect impacts that may occur to this species. Direct impacts result in the degradation or destruction of individuals or populations of *S. pennata*. Potential direct threats to this species include: damage to or removal of tip-overs, destabilization of soil by from sawing, bucking and yarding of a log tip-over, and fire. Indirect impacts would include: the lack of recruitment of future tip-overs, and stand thinning.

**Conservation Status**
Because *S. pennata* is a species that occupies short-lived, unstable substrates, it is a challenge to meet the objective of providing a reasonable likelihood of persistence of the taxon at that site. Risk to persistence of *S. pennata* at any given site will depend upon: 1) the structural integrity of existing occupied root masses, 2) maintenance of a suitable microclimate, and 3) the potential for future tip-overs. Factors affecting insect or other vectors for spore dispersal may also be critical but there is currently no data to assess this risk.

**Known Management Approaches**
There were no prior management approaches applied to this species.

**Management Considerations**
Below are options to consider when managing a site for continued site persistence.

The structural integrity of existing root masses may be addressed using the five-stage classification described in The Appendix. Use of this classification reduces but does not eliminate uncertainty since the classification has not been tested over multiple years. Assessment of suitable microclimate for this species should be determined at each specific site. Some sites are very open while other sites are in deep shade. Risk to the site through project activities will generally be lessened by maintaining approximately the current conditions.

Putting a small area of no-disturbance around a single tree tipover is unlikely to provide for persistence at the site unless some provision is made that will allow for, or at least not diminish the potential for, future tree tip-overs to occur. This is the habitat condition that carries both the most risk and uncertainty. Windthrow events that provide suitable substrate for *S. pennata* without diminishing favorable microclimate conditions will ultimately be up to chance unless trees are deliberately pushed over. Silvicultural stand treatments typically result in short-term increased chance of windthrow but long-term reduction of windthrow potential. The likelihood of *S. pennata* persisting at a site is improved if the short-term risk of windthrow is not likely to be excessive (i.e., conditions in which the entire edge of the stand would be susceptible to blowing over in a single
event). It will likewise be improved over the long run if the prescribed stand conditions are not so uniform that the potential for future windthrow is minimized.

Thinning of stands will accelerate growth of trees, however, it should be noted that trees that grow in widely spaced stands are likely to develop resistance to wind. For this reason, at known sites of this species, when planning vegetation management projects, consider thinnings to provide for stand variability either by means of untreated patches or variable-width spacing. Immediately after thinning, trees may be more susceptible to windthrow. Created edges will also increase windthrow potential in the short run by exposing previously sheltered trees to wind and the environment. The vast majority of down logs created from a timber harvest-created edge are likely to be confined to the edge environment (Chen et al. 1992) which, depending upon the habitat type, may limit colonization by *S. pennata*. The potential for immediate inputs of windthrow versus the potential for a more wind-firm stand over subsequent decades should be evaluated on an individual site basis.

Although *S. pennata* would rarely, if ever, occupy sites prone to historic high-frequency fires, some sites may be susceptible to increased risk of stand-replacement fire due to fuel accumulation across the landscape. In using prescribed fire or other fuel reduction treatments, consider minimizing disturbance and use of fire in proximity to the known site. Consider using hand treatments to pull fuels out from around the occupied area prior to prescribed fire or other fuel reduction treatments. The cautions above regarding windthrow in thinned stands may apply in fuel-reduction treatments as well.

Sawing and yarding of a log from a tip-over may result in destabilizing the soil on the root mass. The root may even spring back into the hole if the log is cut close to the base. Consider leaving logs with *S. pennata* present on the root mass undisturbed.

Because *S. pennata* is largely dependent upon trees being uprooted, the canopy cover at sites is rarely entirely closed and is sometimes quite open. Based on recent information it is clear that *S. pennata* can persist in considerably more open canopy if the site is moist enough (i.e., associated with a wetland). In these conditions, shading of the microsite is typically provided by low herbaceous vegetation or shrubs or, most often, by the upturned root mass structure itself. Sites not directly associated with wetlands tend to have greater canopy-cover and retention of a closed canopy in these situations may be prudent.

Since *S. pennata* occupies an ephemeral substrate, to help maintain sites consider the potential and need for future tree tip-overs. This could require active management in the future to help replace reduced or decaying root masses, to provide additional substratum at the known site for the species to colonize.

Size of the uprooted tree doesn’t appear to be a direct determinant of suitable habitat although most known sites are associated with large trees that were uprooted. It appears that large trees are simply more likely to uproot the soil when they fall than smaller trees. Lodgepole pine, which rarely attains much size but grows in seasonally saturated soils, is
an exception to this. Also a cluster of small trees will occasionally fall as a unit, uprooting a root mass suitable for *S. pennata* colonization.

The root mass stages described in The Appendix may be used to assess the quality of the existing habitat and determine how much longer a patch of *S. pennata* is likely to persist at the site. If all the root masses at a site are in an advanced stage 3, it is likely that *S. pennata* will not persist at that site for long without recruitment of new tree tip-overs. Consider the need for active management, to recruit/create new tipped-over trees. This should be considered a strictly experimental approach at this time since it is unknown if creating new tipped over trees (through pushing them over, inoculation, etc) will provide for a suitable root mass morphology. A site consisting of a mix of Stage 1-3 root masses, may provide for longer term site persistence. It also indicates that the site may be subject to chronic blowdown which would be ideal for persistence of *S. pennata* at the site.

**Research, Inventory, and Monitoring Opportunities**
Information on vectors for spore dispersal is lacking. This information could give insight into what potential indirect barriers to colonization exist.

The length of time *S. pennata* can occupy a single root mass is currently unknown. The period of time that the root mass takes to progress between stages is also not known.

Post project monitoring, to determine the effectiveness of management considerations is needed in support of adaptive management.

**Definitions of Terms Used**

**Management Considerations**
Potential management activities designed to achieve the conservation of a species at a site. Management considerations are not mandatory.

**Site (Occupied)**
The location where an individual or population of the target species (taxonomic entity) was located, observed, or presumed to exist and represents individual detections, reproductive sites, or local populations. Specific definitions and dimensions may differ depending on the species in question and may be the area (polygon) described by connecting nearby or functionally contiguous detections in the same geographic location. This term also refers to those located in the future. (USDA, USDI 1994). Other terms such as known site, species location, and element occurrence are included in this definition.
References


USDA Forest Service and USDI Bureau of Land Management. 2001. Record of decision and standards and guidelines for amendments to the survey and manage, protection buffer, and other mitigation measures standards and guidelines. Portland, OR

USDA Forest Service and USDI Bureau of Land Management. 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl and standards and guidelines for management of habitat for late-succession and old-growth forest related species within the range of the northern spotted owl. Portland, OR.
Appendix 1: Root Mass Development Stages

The following stages are described based on observations of root masses on moist soils: Developed by Richard Helliwell.

<table>
<thead>
<tr>
<th>Stage 1.</th>
<th>When the tree is first uprooted there is generally abundant soil attached to the matrix of roots leaving behind a well-defined pit. There is generally little vegetative cover in the initial phase and bryophyte colonization typically precedes vascular plants. Bryophytes, including <em>S. pennata</em>, may colonize the root mass the first year although cover is rarely extensive. Often there will be a shaded overhang formed by the root mass. The log will be in decomposition class 1 (Maser et al. 1979).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 2.</td>
<td>At the second stage there is increasing vegetative cover and some sloughing off of soil. Usually there will be some vascular plant cover, particularly at the top of the root mass. Bryophyte cover is often extensive at this stage. The root mass is mostly intact but there will typically be some sloughing of soil with accumulation of soil at the base of the root mass. At this point the pit is still well-defined. The log will be in decomposition class 1-3.</td>
</tr>
<tr>
<td>Stage 3.</td>
<td>By the third stage the root mass is sloughing off in earnest. The soil may fall in large chunks leaving gaps in the outline of the root mass (Fig. 2) or simply accumulate as a sloping mound within the pit (Fig. 3). The pit will always be at least partially filled in. Vegetative cover can be highly variable since the soil movement will create bare patches. Brittle roots may be exposed at the top. The log will be in decomposition class 2-3.</td>
</tr>
<tr>
<td>Stage 4.</td>
<td>The root mass will begin to assume a mounded form by the forth stage but is still quite distinct as being formally a root mass. The root structure will have largely disintegrated and vegetation will normally be well-developed upon the mound. Vascular plant cover is most often dominant and bryophyte composition will shift to forest floor species. The log will be in decomposition class 3-4.</td>
</tr>
<tr>
<td>Stage 5.</td>
<td>By the fifth stage the root mass has become part of the topography of the forest floor. This feature has been described as “mound and pit” or simply hummocky topography (Oliver &amp; Larson 1996). There is no longer external evidence of the roots. The mound is gently sloping on all sides. Vegetative cover of the mound will be typical of the stand in general. Sometimes the shallow remnant of the pit may have some relatively moist indicator plants but more often it too is similar to the vegetation at large. The log will be in decomposition class 5.</td>
</tr>
</tbody>
</table>
Schistostega pennata is most often found on Stage 1 and 2 root masses but not uncommonly Stage 3 depending on the nature of the soil sloughing. Stage 3 appears to represent transitional habitat for S. pennata. Schistostega pennata may be present and even abundant if only part of the soil has sloughed off and may even recolonize bare soil in sheltered microsites created by the soil movement. Stage 4 and 5 root masses are no longer considered suitable habitat. The period of time required for transition from one stage to the next is uncertain. However tree tip-overs known to have occurred during the 1996-97 winter were observed to be in Stage 3 by 2003. Also some root masses with S. pennata

**Figures 2 & 3. Examples of Root Mass Development Stage Three.** In the upper photograph taken on the Umpqua National Forest, a large section of the root mass has fallen away in a single large block. The mosses evident in the photo consist principally of Polytrichum commune, Pohlia nutans, and Atrichum selwynii although Schistostega pennata persists in crevices along the base of the root mass.

In the lower photograph taken on the Mt. Hood National Forest, soil is gradually sloughing from the center of the root mass and accumulating in a gradually sloping mound in the root pit. In this circumstance, S. pennata continues to find a suitable niche in the narrow gap between the root mass and the soil mound.
*S. pennata* observed on them in 1998 have began transitioning to Stage 3 during the 2002-03 winter with a concomitant lose of microhabitat. There is no data for estimating the longevity of *S. pennata* occupancy of a single root mass, but based on the above anecdotal observations, some root masses may cease to provide suitable habitat within 10 years. It should be cautioned that further investigation is needed and some sites may provide stable habitat for much longer periods of time.
Appendix 2: Photos
All photos by Dr. Judy Harpel, under contract with the Oregon/Washington Bureau of Land Management

Whole mount

Whole mount
Top of whole mount

Upper medial cells
Protonema