

Management Concerns

Alien species

The very dense growth exhibited by two alien species in the park, *Pseudoscleropodium purum* and *Hypnum plumaeforme*, strongly suggests they displace native bryophytes along roads and trails. Both species are already widespread along park roads and trails so park-wide removal is unlikely. Neither species produces spores or other wind dispersed propagules and instead are spread by human or animal activity. Efforts should be made to reduce their accidental spread by staff and visitors. For example, mowing equipment should be thoroughly cleaned before transport to job sites not yet invaded by alien moss otherwise small fragments of both moss species clinging to the equipment can easily fall off during equipment operation and grow vegetatively on any damp substrate.

High traffic centers such as the Resources Management field station should be cleared of alien mosses to reduce accidental transport by park vehicles. Special effort should be made to prevent the introduction of *P. purum* into the Kahuku unit and to prevent the introduction of *H. plumaeforme* into the western side of the Kahuku unit. *P. purum* is also growing successfully in the Kipuka Puauulu forest well beyond the trailsides. *P. purum* should be controlled at Kipuka Puauulu where it is growing under the forest beyond the trailsides to prevent potential problems with seedling recruitment and prevent total replacement of the original native terrestrial bryophyte layer which may have unknown consequences for tree fern and seedling recruitment. Both *P. purum* and *H. plumaeforme* should be controlled at Thurston Lava Tube and Kilauea Iki Trail to maintain an easily accessible example of a diverse Hawaiian bryophyte community for public enjoyment and education. Mosses grow slowly compared to vascular plants such that even one or two days of work by a group of volunteers a year might be enough to stop the increase in alien moss cover at Kipuka Puauulu, Thurston Lava Tube, and Kilauea Iki. Because *Breutelia arundinifolia* is not found in natural habitats in the park it should be treated as an alien species and controlled in high traffic sites such as the Kilauea Visitor Center and the Resource Management field station areas to prevent accidental spread further along the park's roads and trails. *Sphagnum palustre* should be monitored to see if it starts increasing in abundance anywhere in or near the park. *S. subpinnatum* spreads by spores and is consequently now too widespread to possibly control. Roadsides and lawns in Volcano Village should be monitored every few years to watch for the appearance of new alien species that may come in with horticultural plantings. The State of Hawaii should be encouraged to ban the importation of live bryophyte material to prevent the introduction of potentially invasive mosses.

Rare species

In general, too little is known about the population sizes of uncommon moss to accurately assess their risk of extinction. This is true both locally and internationally. The online database of worldwide IUCN Red List of Threatened Species includes 39 moss species currently threatened with extinction (<http://www.redlist.org> accessed November 3, 2005). None of the listed species are found in HAVO. However, as discussed by the IUCN Bryophyte Specialist Group, the list is admittedly incomplete because so little is known about the actual distribution and population numbers of the world's moss species

(<http://www.dbs.nus.edu.sg/lab/crypto-lab/WorldBryo.htm> accessed November 3, 2005). It could be argued that at least one species in the park, *Scopelophila infericola*, should be considered a critically endangered species because of its extremely narrow distribution limited to only sulfurous steam vents at Sulphur Banks. On the other hand, a taxonomic review of this species could very well find that it should be considered an isolated population of the more widespread *S. ligulata*.

Species that have not been collected for many years such as *Breutelia affinis* are probably very rare. However, in some cases they may be simply difficult to find because they are so small or difficult to distinguish from other, more common species.

Education

High rainfall and diverse microhabitats, such as Thurston Lava Tube Trail, support a high diversity of mosses in a relatively small area. The accessibility and high use of this area makes it an ideal place to introduce park visitors to a wide range of relatively large and easily identifiable mosses and their role in the ecological community.

ACKNOWLEDGEMENTS

This inventory was supported by the National Park Service through the Resources Management Division at Hawaii Volcanoes National Park (HAVO) and the Pacific Island Network Inventory and Monitoring program. I am particularly appreciative of the encouragement of the Chief of Resources Management at HAVO, T. Tunison. The assistance of J. Moniz-Nakamura with access to the important cave habitats was appreciated as was the assistance of S. Roper, D. Hu, K. Sherry, R. Swift, K. Magnacca, T. Belfield, and K. Postelli. The assistance of Linda Pratt and David Foote with access to microscope equipment and herbarium material was much appreciated. Bill Halliday and Harry Shick were very kind to share their time and enthusiasm in showing me the steam caves of Kilauea. Access to Bishop Museum data and specimens was possible through the kind assistance of C. Puttock and N. Harbottle. David Webb at the University of Hawaii Department of Botany gave me a lot of help in access to microscopes and microscopy techniques. The valuable comments of B. Stone, L. Sack, K. Schlappa, and C. Smith during the preparation of this manuscript were very useful. This project was carried out under a cooperative agreement with the University of Hawaii at Manoa; David Duffy was serving as the principal investigator.