



Bog club-moss (*Lycopodiella inundata*) at Big Lagoon Bog, Humboldt County. All photographs by the author.



Bog club-moss with round-leaved sundew (*Drosera rotundifolia*).

THE RARE CALIFORNIA CLUB-MOSSES

by Gordon Leppig

Present-day club-mosses, like ferns and horsetails, are from an ancient and diverse spore-bearing lineage which was globally dominant during the Paleozoic Era. These lingering remnants of the Coal Age are members of the Lycopodiaceae or club-moss family. The name *lycopod* means “wolf’s foot” in ancient Greek and refers to the resemblance of the branch tips to a wolf’s paw. Today, this family of creeping rhizomatous evergreens is comprised of about 400 species in 10-15 genera; the family is represented worldwide except Antarctica. In temperate and arctic areas, club-mosses inhabit various forest and wetland habitats and prefer acidic

soils. In the tropics, club-mosses are often epiphytic. Individual plants can live for centuries and some species form fairy rings.

Though there are 27 species in North America and 11 in the Pacific Northwest, California has only two taxa: running-pine (*Lycopodium clavatum* L.) and the bog club-moss (*Lycopodiella inundata* (L.) Holub). Both species are on the California Native Plant Society (CNPS) List 2—“rare in California but more common elsewhere.” In North America, both species have bicoastal distributions, occurring in the Pacific Northwest as well as in the northeast including the Great Lakes region. The bog club-moss also

occurs across Eurasia, and running-pine, the most cosmopolitan lycopod, has a near-global distribution. Like many plants which are rare in California but common elsewhere in the northern hemisphere, these taxa have Pacific Northwestern distributions which terminate in the cool climate and moist habitats of northern California.

As spore-bearing plants, club-mosses have two life forms, a minute subterranean gametophyte (gamete producer) and the more obvious mat-forming sporophyte (spore producer). Spores, which are wind-dispersed, can persist in the soil for many years before germinating into gametophytes. (Incidentally, club-

moss spores are flammable and were the original flash powder in olden day photography; they continue to have diverse industrial uses.) Gametophytes as well as spores can be very long-lived, taking 10-15 years or more to develop (Andrews 1947) and requiring a mycorrhizal symbiont to reach sexual maturity. Bisexual gametophytes produce both eggs and biflagellate sperm. Despite their bisexuality, self-fertilization is quite rare in many species (Gifford and Foster 1987). Club-moss sperm therefore swim underground through wet soil to fertilize other gametophytes—not a life stage usually considered in rare plant conservation!

BOG CLUB-MOSS

Lycopodiella inundata, which is also rare in Oregon, has an enigmatic distribution in California of two disjunct populations. It occurs at sea level in Humboldt County at Big Lagoon County Park, and at about 900 meters in elevation in Nevada County at The North Columbia Diggings, an abandoned placer mine in the Sierra foothills. The Big Lagoon site is a rare coastal peatland or fen (known locally as Big Lagoon Bog). The peatland formed in the swale of a paleo-sand dune on a brackish marsh on Big Lagoon and is surrounded by Sitka spruce (*Picea sitchensis*) forest. This small population occurs mostly on sparsely vegetated organic soil (peat and muck) of regularly inundated pool edges and stream banks. Big Lagoon Bog is a biodiversity hotspot with occurrences of several other CNPS List 2 taxa: flaccid sedge (*Carex leptalea*), green sedge (*C. viridula*), and marsh pea (*Lathyrus palustris*), the CNPS List 4 Buxbaum's sedge (*Carex buxbaumii*), and the locally rare sundew (*Drosera rotundifolia*).

The Diggings is a 2,300-acre



Running-pine (*Lycopodium clavatum*) cones produce flammable spores with a number of industrial and scientific uses. Spores can live for years underground before germinating.



Closeup of running-pine cones.



Stolon, or runner, and aerial branches of running-pine.

former ponderosa pine foothill forest that was “moon-scaped” by decades of intensive hydro-mining for gold in the late 1800s (Pendall 1984). Aside from the catastrophic sedimentation of the Yuba River and San Francisco Bay, this mine also resulted in the so-called Valley of the Moon, a barren wasteland of bare hillsides and a mineral-soil wetland slowly being colonized by acid-loving montane and peatland plants. A large bog club-moss population now occurs in this bare-soil wetland. How this species arrived is unclear but it is presumably the result of wind-borne spore dispersal. An unusual occurrence of cranberry (*Vaccinium macrocarpon*) occurs at the Diggings, and while at one time it was considered a rare disjunction (Pendall 1984), it is now thought to be introduced. Because the Diggings is still owned by mining interests, the present status of the bog club-moss is unknown and this population is potentially threatened by future gold mining.

RUNNING-PINE

Lycopodium clavatum is restricted to redwood and coastal mixed evergreen forests in Del Norte, Humboldt, Mendocino, and Sonoma counties. It forms a large meta-population in Humboldt County from Big Lagoon to the Elk River south of Eureka. In Mendocino County it is much less common, occurring in and around Jackson State Forest. It was only recently discovered in Del Norte and Sonoma counties, where it is quite scarce.

Running-pine almost exclusively inhabits gaps in forest canopy with partial shade such as roadsides, trails, and forest edges. The majority of occurrences are on managed redwood timberlands where large mats commonly occur

with salal (*Gaultheria shallon*) and evergreen huckleberry (*Vaccinium ovatum*).

CONSERVATION

In the eastern United States, club-moss gathering for holiday garlands and the floral trade is a common hobby and “non-timber forest products” industry. However, over-collecting has resulted in local rarity of some taxa and is considered a threat to others (Nauertz 1999). In Wisconsin and Michigan alone over 85 tons of club-moss is harvested annually from local forests (Nauertz and Matula 2002).

In California, club-mosses are too rare for collecting. Conservation efforts focus on total avoidance of bog club-moss populations and on forestry practices that maintain running-pine populations in managed timberlands (Golec 2000). Club-mosses are difficult to cultivate and attempts to transplant running pine as a mitigation strategy by Redwood National and State Parks and others have had little success. Cultivation and transplantation may be hampered by the disruption of its mycorrhizal relationship. Indeed, the development of the critical relationship between gametophytes and their fungal associates may be an important factor in the rarity of these species and in their habitat requirements. A life-cycle that can require more than 20 years to complete may also contribute to their rarity.

To conserve the bog club-moss in California, maintenance of water quality and hydrologic regimes and avoidance of other impacts, such as invasive plants, appears to be the best management strategy. Running-pine has low survivorship in clearcuts and after other forest stand replacement events. Because of its shallow root system it does not tolerate direct impacts from heavy equipment and extensive ground

disturbance. The persistence of running-pine mats on managed timberlands necessitates partial canopy retention strategies and the avoidance of mats by heavy equipment. The California Department of Fish and Game is currently working with private timberland owners to develop strategies that best maintain this species and its habitat on the North Coast. These strategies include leaving shade trees, excluding heavy equipment, and not applying herbicide near running-pine occurrences.

REFERENCES

- Andrews, H.N. 1947. *Ancient Plants and the World They Lived In*. Comstock Publishing. Ithaca, NY. 279 pp.
- Gifford, E.M., and A.S. Foster. 1987. *Morphology and Evolution of Vascular Plants*. W.H. Freeman. New York, NY. 626 pp.
- Golec, C. 2000. Simpson Timber Company's Running-pine Assessment and Survey. Unpublished Report, Natural Resource Management Corporation. Eureka, CA. 14 pp.
- Nauertz, E.A. 1999. Impact of Various Silvicultural Practices on the Abundance and Frequency of *Lycopodium* Species in Northern Hardwood Forests. Master of Science in Forestry Thesis, Michigan Technological University. Houghton, MI. 164 pp.
- Nauertz, E.A. and C. Matula. 2002. *Lycopodium* Management. USDA Forest Service. Wisconsin Department of Natural Resources. www.extension.umn.edu/specializations/environment/components/lycopodium1.html.
- Pendall, D. 1984. A freshwater marsh at the North Columbia Diggings. *Fremontia* 12:11-14.

Gordon Leppig, California Department of Fish & Game, Habitat Conservation Program, Northern California-North Coast Region, 619 Second Street, Eureka, CA 95501. gleppig@dfg.ca.gov