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SHORTHAIK MEADOWS IN THE HIGH SIERRA NEVADA . . .

an hypothesis of their development

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Mountain meadows are normally thought to develop along streams and around lakes as a result of sediment accumulation. As mineral sediments deepen and plant remains accumulate, plant communities which prefer flooded conditions are succeeded by those preferring a moist soil.

Sedimentation and plant succession both contribute to the development of the shorthair (*Calamagrostis breweri* Thurb.)¹ meadow bands around high-elevation lakes in the Sierra Nevada of California (fig. 1). Because of certain characteristics of the lakes and shorelines, special processes of formation may be involved. These characteristics include: (a) the abundance of boulders at water's edge (presumably the results of lateral and terminal moraines and, more recently, avalanches), (b) the nearly vertical banks which do not conform to the general slope of the lake bottoms as would be the case with the normal process of sedimentation, (c) the relative stability of the water level in the lakes, which are fed throughout summer by streams and springs, (d) the presence of thick layers of moss around and upon some boulders, and (e) the presence of two shrubs, American-laurel (*Kalmia polifolia* Wang. var. *microphylla* [Hook] Rehd.) and Sierra bilberry (*Vaccinium nivivictum* Camp.), in the moss.

Just what are these special processes and how do they operate together to form the meadow bands around high-elevation lakes? On the basis of my observations made along the lake shores and at Charlotte Lake Meadow which is also in Kings Canyon National Park, I offer an hypothesis which may help answer the question.

OBSERVATIONS

At Charlotte Lake Meadow (fig. 2), an example of the Sphagnum meadow type,² many characteristics similar to those of the lake shore meadows are apparent. These include the great abundance of boulders, the thick moss layers, and a relatively stable water

Abstract: Bands of shorthair meadow are found around lakes in the high Sierra Nevada of California. A hypothesis, based on observations in the Kings Canyon National Park, to explain the development of these meadows is offered: Boulders form the foundation upon which American-laurel, Sierra bilberry, and moss combine to produce thick mats. The lower layers of the mats are gradually converted to acid bog or muck-soil, which becomes in effect the C horizon of soil supporting the shorthair meadow type. Herbaceous plants change the upper layers and, thereby, produce an A horizon and a succession leading to a shorthair climax.

Oxford: 187x462.1: 114.443.1: 175.2 *Calamagrostis breweri*.

Retrieval Terms: mountain meadows; meadow development; soil horizons; *Calamagrostis breweri*; Sphagnum; Kings Canyon National Park; Charlotte Lake Meadow.

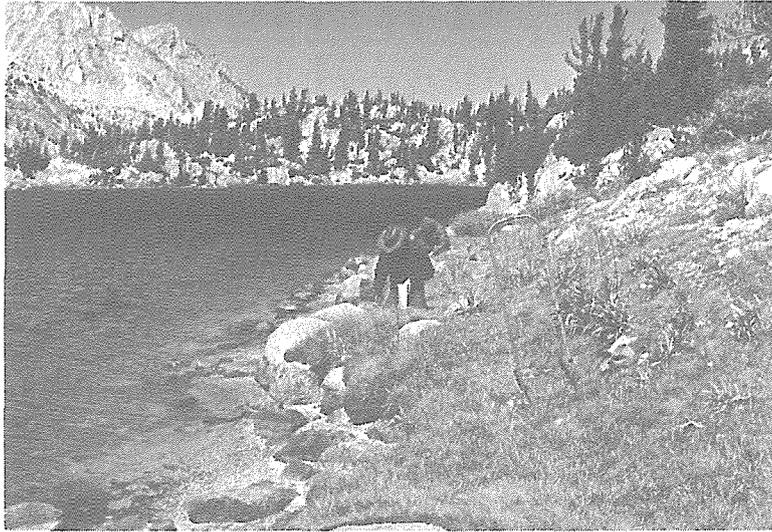


Figure 1—Narrow bands of shorthair meadow vegetation are usually found around the lakes in the high Sierra Nevada of California.

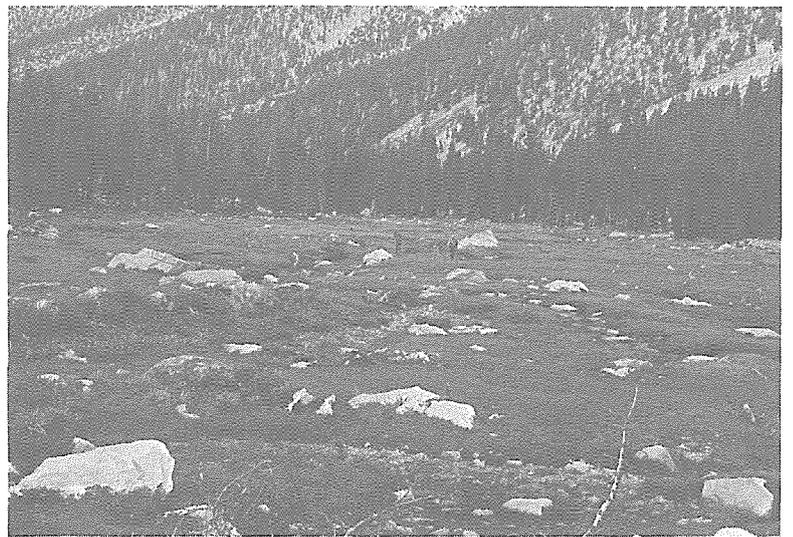


Figure 2—Boulder-strewn Charlotte Lake Meadow in Kings Canyon National Park, California, is one of the most southerly Sphagnum meadow types in the United States.

supply coming from Charlotte Lake and springs and seeps around the meadow. In addition, the vegetation of the meadow bands is similar to that at Charlotte Lake Meadow.

In the moss layers, both on the meadow bands around the lakes, and at Charlotte Lake Meadow, I found American-laurel and Sierra bilberry. One shrub often grows without the other, but often they were intermixed. Moss generally covered all but the tips of the branches so that the shrubs appeared more like forbs. The herbaceous vegetation consists largely of shorthair, fewflowered spikerush (*Heleocharis pauciflora* [Lightf.] Link), and dwarf spikerush (*Heleocharis parvula* [R. & S.] Link. var. *coloradoensis* [Britton] Beetle).

Sharsmith³ speculates that the mosses along the lake shores are rarely a Sphagnum. However, they

appear to serve the same general function as the Sphagnum at Charlotte Lake Meadow. Hence I believe that the special processes involved in development of the meadow bands around the lakes can be observed and studied as they function at the Meadow.

Ice formed on the lakes and thrusting against the shores may well account for keeping the boulders in place and creating the vertical banks. But ice-thrust alone, with sedimentation, cannot fully account for covering the boulders and the development of the meadow bands.

At Charlotte Lake Meadow and along the lake shores, I found Sierra bilberry and American-laurel advancing upon boulders. Generally they appeared to be forming a carpet over them. And it appeared that American-laurel preceded Sierra bilberry—at least in more moist places. Both, however, appeared to serve

THE HYPOTHESIS

at least one common function—a means of attachment for moss.

A clean granitic surface was exposed when the covering mat was lifted from a boulder. Therefore, neither the shrubs nor moss appeared to penetrate the boulders. Where part of the mat was removed, it appeared that the shrubs again extended over the boulders—followed by a new growth of moss. Thus, but for the shrub carpets, the moss would likely wash away.

The particular mosses involved appeared to absorb and retain a great amount of water. Therefore, as long as they were in contact with a stable water supply they could perpetuate their growth and that of the shrubs as well. Thick mats of moss and shrub stems over a jumble of boulders were seen in places where sub-surface flow had broken to the surface at Charlotte Lake Meadow. The same was observed on and around boulders next to water's edge at the lakes.

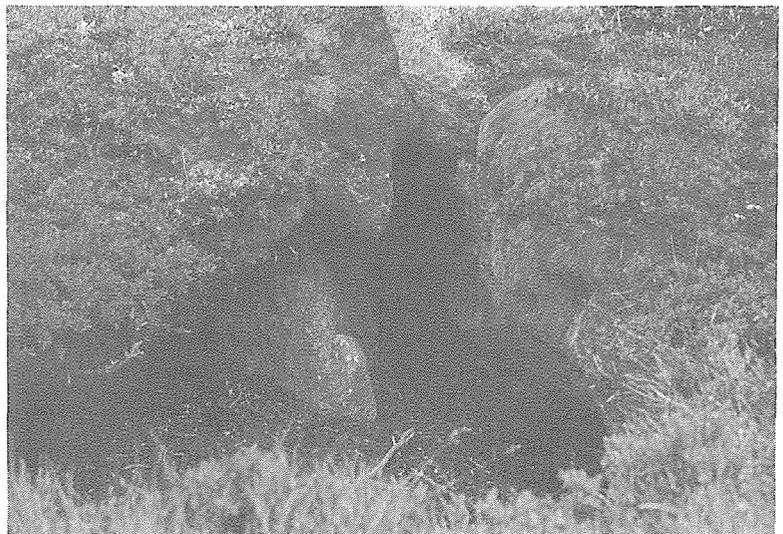
In both the shrub carpets and the moss, I found mineral matter, either washed in or weathered from the boulders. The buildup of the moss-shrub mats upon the boulders and the accumulation in the mats of organic remains and mineral matter appeared to produce eventually a soil supporting the shorthair meadow vegetation.

These observations tend to support the conclusion that the special processes involved in development of the meadow bands around the lakes were tied to (a) the presence of boulders, (b) a relatively stable water table, and (c) a relationship between the two shrubs and Sphagnum and other mosses. And to help explain how the bands developed, I developed the following hypothesis.

Boulders along the lake shores provide the foundation upon which the bands of meadow vegetation develop. Rooting around the boulders, both American-laurel and Sierra bilberry form a carpet by growing up and over the boulders. These shrub carpets provide support and a means of attachment for Sphagnum and other mosses, which (given a stable water table) takes hold within them. As the moss grows among the shrub stems, it effectively raises the water table. Bennett² states that Sphagnum carries its own water supply upward through capillary action and its sponge effect. Therefore, the moss provides a source of water for its own continued growth and that of the shrubs as well. The shrubs extend new roots through the developing moss mat and may seed and establish directly upon it. Also, the moss provides complementary support to the shrub stems. This support permits them to extend between boulders and, thereby, to promote development of the moss (*fig. 3*).

As this process continues, the lower mats of moss are cut off from air and light and die. They become compressed by the overlaying mats. Because of lack of oxygen the lower mats are not completely decomposed and are converted to acid bog or muck-soil.² Contributing to this soil are bits of granite from the boulders, sand washed in from the slopes, and dust. But the rate of mineral deposition appears to be slower than that of the buildup of organic matter. Hence, the bog and muck-soils formed are of the cumelic subgroups.⁴ In such soils, what would normally be considered the A horizon (the growing

Figure 3—Moss can gradually build up on and between boulders by using shrubs as a means of attachment. The shrubs do extend roots through it, thereby permitting them to extend upward and between boulders.



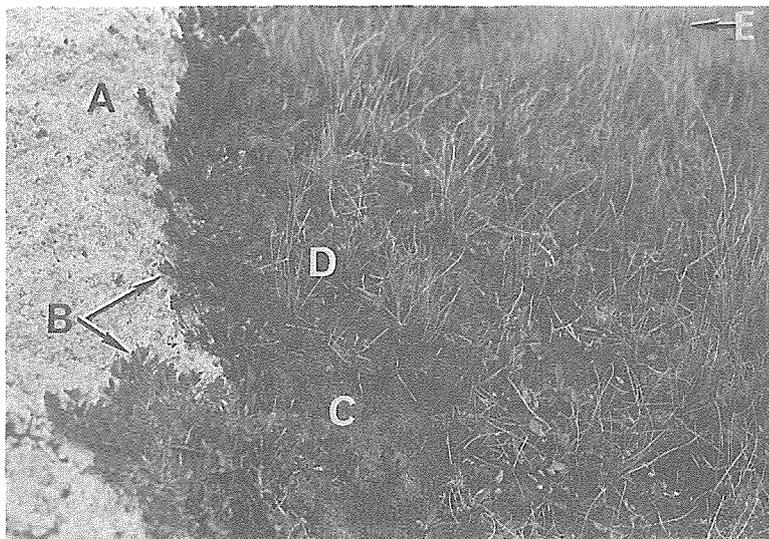


Figure 4—The generalized succession to shorthair meadow: A, boulder, B, American-laurel and Sierra bilberry, C, moss building upon the shrubs, D, herbaceous plants invading the shrub-moss mat, and E, shorthair.

moss-shrub mats) is in fact the parent material of what would normally be considered the C horizon. The developing moss-shrub mats have thus produced the C horizon of the soils supporting the bands of shorthair meadow around the lakes.

While the moss mat is developing, other plants invade the moss. Plants and shrubs soak up moisture from the moss, and change the character of the upper layer. This process becomes effective when a height above the water table is reached or when the lake level drops to the point where capillary action and the sponge effect of the moss can no longer support additional moss growth. The upper layer of moss is gradually dried, and compressed by decomposed material from "higher" plants. Along with these changes, the herbaceous root systems extend through the upper layer, with the net result that in time a more typical A horizon is developed.

The succession of plants upon the upper moss layer is not clear, but based upon my observations, the apparent climax is the shorthair meadow type (fig. 4).

DISCUSSION

Obviously, my observations do not prove the validity of the hypothesis. Specific research is needed to verify or reject it. Also, specific points require clarification. For example: Is there, as implied, a symbiotic relationship between the moss and the shrubs (shrubs

are present in shorthair meadows where moss is no longer evident), and which is really the first to become established—the shrubs or the moss? Also, are the boulders really being covered by a buildup of vegetative material, or are they just sinking into the meadows?

An abundance of boulders was also observed in other shorthair meadows away from the lake shores. In many such cases a moss layer and a stable water table are not now apparent. But I suspect that the same processes were involved in development of these meadows. Therefore, learning how the shorthair meadows of the lake shores developed should aid in an understanding of other shorthair meadows and provide a basis for deciding the management needed to restore damaged sites.

NOTES

¹Scientific plant names follow Philip A. Munz, and David D. Keck. *A California flora*. Berkeley: Univ. Calif. Press. 1068 p., illus. 1965.

²Bennett, Peter S. *An investigation of the impact of grazing on ten meadows in Sequoia and Kings Canyon National Parks*. (Unpublished Master of Arts thesis, on file at Dep. Biology, San Jose State College, 1965).

³Personal correspondence with Carl W. Sharsmith, Department of Biology, California State University, at San Jose, Sept. 6, 1972.

⁴Soil Survey Staff. *Soil classification—a comprehensive system*. 7th Approximation. U.S. Dep. Agric., Washington, D. C. p. 20. 1960.

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