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## **Vegetational Succession in Subalpine Ponds in the Rockies**

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In the summer of 1958, an ecological study was made of a group of 19 small subalpine ponds in the Elk Mountain range of Colorado. The ponds are located on two shelves on the eastern slope of Galena Mountain, a peak approximately ten miles north of Gothic, the site of the Rocky Mountain Biological Laboratory. The laboratory is about 35 miles north of Gunnison.

Galena Mountain is composed of sedimentary material, the rock upon which the ponds are located being limestone. Two of the ponds, the upper-most, are located at the base of a cirque while the remainder are scattered about in depressions on the shelves. Those on the upper shelf occur in limestone basins while the lower shelf ponds have formed in depressions apparently resulting from glacial scour. The ponds are oriented in a general line with numerous glacial striae on the rock surface, whereas the rock jointing is almost 45° from this line. The ponds are all located within an altitudinal range of 11,150 feet to 11,450 feet and are fed by the melted snow and the sporadic summer rains. A complex drainage pattern exists which allows water from the melted snow to drain through the ponds to the valley floor almost 800 feet below.

Very little moisture fell in the period during which the area was being investigated. As soon as the major portion of the melted snow had disappeared, the areas surrounding the ponds rapidly began to dry up.

For the most part these areas consist of coarse rocks with very little soil, and are all elevated from five to twenty feet above the level of the ponds (Fig. 1). By the last of June the vegetation on the higher levels had already flowered and fruited, and thus escaped the soil drought. In addition to the flowering plants on these upper areas there were several mosses, and *Selaginella standleyi* Maxon, which simply dried up, but which apparently successfully survived the dry periods.

Due to the large amount of melted snow which maintains a relatively constant water level in the ponds a hydrarch succession results. Primary succession is initiated in ponds which have a rock bottom without any soil. Presently there are only two ponds which fall into this category. They are the highest of the series, and both are subjected to fresh talus falls, and a rapid flow of water during the spring thaw which washes out any accumulated soil. The vegetation of the remaining ponds and their surrounding area has been classified into the five following successional stages:

- I Pioneer Vegetation: submerged, floating, and emergent aquatics.
- II Rush-Grass Associes: communities of rushes and grasses.
- III Willow-Heath: large, dense, masses of willows in intermittently flooded areas, too dry for Stage I but too wet for Stages II and IV.
- IV Herb-Grass Associes: communities of herbs and grasses in the more mesic areas.
- V Spruce-Fir Climax: ultimate climax of subalpine fir and Engelmann's spruce.

### I PIONEER VEGETATION

The vegetation in this stage is found within the ponds, either submerged, floating, or emergent, or around the perimeters in the very moist soil. The most commonly encountered plant in the water was the submergent, *Isoetes bolanderi* Engelm. which was found scattered randomly, but almost universally on the muddy bottoms. *Callitriche palustris* L., a submergent, and *Potamogeton gramineus* var. *maximus* Morong, a floating-leaved aquatic, were also found in the ponds but in more limited numbers.

*Carex nebraskensis* Dewey and *Carex aquatilis* L. were very common where layers of soil had been built up around the edges of the ponds. At several points these two wet-land plants were holding the soil layers thus facilitating the invasion of the ponds by vegetation.

*Sphagnum* sp. was found in two spots among *C. nebraskensis* and *C. aquatilis*. In one *Sphagnum* area a clump of *Saxifraga planifolia* Pursh var. *montica* (Bebb) Schm. had become established but did not appear to be substantially increasing in size or area. In the second area where *Sphagnum* was found, a floating mat, some 30 feet wide, had formed. Many of the herbs found in the Herb-Grass Associes were observed on this peat bog.

### II RUSH-GRASS ASSOCIES

Two distinct rush-grass communities were located in the area near the ponds. The first, consisting of *Juncus confusus* Coville and *Deachampsia caespitosa* (L.) Beauv., appeared to be the more primitive of the two. It occurred in much more hydric conditions than the second community which consisted of *Juncus drummondii* Meyer and *D. caespitosa*.

The *J. confusus*-*D. caespitosa* community occurred as pure stands in wide flat drainage areas which were very wet for a relatively long time during the growing season (Fig. 2). The *J. drummondii*-*D. caespitosa* community was found in more mesic areas. A number of invading herbs

from the Herb-Grass Associates occurred in this community. The most common herb present was *Polygonum bistortoides* Pursh. Perhaps a more detailed study would reveal that this plant is not an invader but a link between the two stages. *Carex nova* Bailey and *Phleum pratense* L. were also found in this stage but were of limited importance.

### III WILLOW-HEATH

The willow-heath stage is quite limited in the area but nevertheless it has been assigned a definite place in this successional series. The stage is characterized by large masses of willows where the drainage water has reached a flat area and allowed the suspended particles to form a shallow layer of soil over the bed rock. The willow encountered in this stage is *Salix planifolia* var. *monica* while its associate, found in the limestone crevices, is *Vaccinium caespitosum* Michx.

The soil, although not continuously inundated, is saturated to the point that the herbs and grasses of Stage IV cannot survive. They may also be washed out each year by the swift flow of water from the melted snow. The willows, with their woody stems and roots, become well attached, and form a dense cover which excludes all aquatic and wet-land vegetation. This stage is a prolonged one, and little of the vegetation passes through Stage III in reaching the spruce-fir climax. Most of the herbs and grasses invade the Rush-Grass Associates directly.

### IV HERB-GRASS ASSOCIATES

The vegetation in this stage was all located above the high water level of the various ponds but below the rock ledges. The most important grasses were *D. caespitosa* and *Calamagrostis canadensis* (Michx.) Beauv., whereas *P. pratense*, although present, was of little importance. A very large number of species and individuals were present in this association, the most numerous being *Pedicularis groenlandica* Retz., *Sedum rhodanthum* A. Gray, *Swertia perennis* L., *Erigeron peregrinus* (Pursh) Greene, and *Gentiana thermalis* Kuntze.

This stage was found, most often, to be the steppingstone to the Spruce-Fir climax. As the grass-herb communities built up the soil the young spruce and fir trees became established.

### V SPRUCE-FIR CLIMAX

The Spruce-Fir stage is the temporal climax in the pond area. This association, of *Abies lasiocarpa* (Hook.) Nutt. and *Picea engelmanni* Parry, is dominant on the mountain side from the valley floor, at approximately 10,600 feet, to just above the uppermost ponds where it gives way to *Krummholz* and timberline.

The spruce and fir trees were found wherever the soil was elevated well above the subsurface water level. The expansion of this area was observed about the many ponds where the younger spruce and fir trees were found nearer the edge of the water (Fig. 2).



**Figure 1** Limestone ridges surrounding ponds.



**Figure 2** Rush-Grass stage invading ponds and young spruce and fir trees invading the Herb-Grass Associates.

**SUMMARY**

The vegetational succession in the subalpine ponds studied may be divided into five stages.

- I Pioneer Vegetation
- II Rush-Grass Associes
- III Willow-Heath
- IV Herb-Grass Associes
- V Spruce-Fir Climax

Individual stages are occasionally omitted as the vegetation progresses toward the temporal climax of Spruce-Fir.

The succession is hydrarch and is governed by water. The water supply for the ponds comes from melted snow and the limited summer rains.