THE VEGETATION OF A BAREFACED CLIFF IN WESTERN NORTH CAROLINA

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An extensive area of bare rock in otherwise wooded territory may often attract more attention than the surrounding forest. Barefaced cliffs are not at all uncommon in the southern Appalachians. Some, because of their extent and location, have become rather generally known. Whiteside Mountain, near Highlands, North Carolina, and Stone Mountain in Georgia are notable examples.

In the course of collecting trips in western North Carolina an area came to our attention which seemed of unusual interest. This barren outcrop is particularly striking because it is unusually steep, fairly extensive, and is surrounded on all sides by rich forest (fig. 1). The outcrop is in Jackson County, North Carolina, about six miles south of Tuckaseigee, beside North Carolina State Highway 106 leading from Sylva to Glenville. The road here is at an altitude of approximately 3,500 feet. The granitic mass rises abruptly from the roadside at about a 45° angle and becomes even steeper in some parts. The exposure is southwesterly. At its highest point it extends upward some 300 feet to the hardwood forest which appears above on the decreasing slope. The widest extent of the exposure irregularly parallels the road for several hundred yards.

GENERAL CHARACTER OF THE VEGETATION

The rock surface is smooth with only slight undulations and is remarkably free of crevices, large or small. There is, consequently, little opportunity for the accumulation of soil or for root anchorage and vegetation develops in slowly formed mats only in the occasional hollows. These mats are in no sense permanent and are so poorly anchored that they cannot be depended upon to support one's weight when climbing. The organic debris at the base of the cliff is evidence of the fate of previous mats washed down by water or released by their own weight. Scattered mats of all sizes, however, do survive and, if they persist long enough, go through a progression of changes in species and growth-forms as they develop.

The development of vegetation on exposed rock is quite generally recognized as an extremely slow process. Cooper's ('28) photographic records for Isle Royale show no appreciable change among the pioneers over a period of seventeen years. Studies in widely separated areas (Braun, '16, '28, in
FIG. 1. The bare slope as seen from a distance. Smaller openings at the left and the main line of seepage is marked by the woody vegetation extending down the center.

FIG. 2. The bare rock showing the steepness of the slope, the smooth surface, and the absence of crevices.

FIG. 3. Colony of *Rhacomitrium heterostichum ramulosum* invading the bare rock surface.

FIG. 4. A mixed patch of *Andreaea rupestris* and *Rhacomitrium heterostichum ramulosum* with the lichen, *Cladonia subcariosa*, invading the mosses.

FIG. 5. A mat in which *Cladonia rangiferina* has practically eliminated *Selaginella* from the central area.

FIG. 6. *Dianthus spicata* and *Carex* sp. growing on the upper edge of a mat where mineral soil has accumulated.
Ohio; Cooper, '13, in Michigan; Nichols, '14, in Connecticut; Whitehouse, '33, in Texas) indicate a general uniformity in pioneer lichens and mosses with the later species contributing to, and appearing on, the mats which are formed. The importance of crevice species in anchoring the vegetation mats and thereby permitting the later stages of development is also well known. Cooper ('13) describes areas without crevices which had not progressed beyond lichen-moss mats although surrounding rock was clothed with climax forest. The absence of crevices combined with the steepness of the slope may possibly explain the scarcity of vegetation on this outcrop in an otherwise heavily forested section. It is probable that there will not be any conspicuous permanent development beyond pioneer bare rock species until weathering reduces the slope or crevices and hollows form where anchorage is favorable and soil can accumulate.

The steepness of the slope (fig. 2) the wide southern exposure, the absence of pockets and crevices all combine to make the habitat appear extremely dry. As might be anticipated most of the pioneer species are those adapted to survival in such precarious habitats. On larger mats, however, there is a surprising number of species which are normally found growing only in wet or boggy soils. All such mats are directly below seepage zones issuing from the forest above. Water drains from all the margin of the woods but as the excess is reduced the lines of percolation become more definite and in these places the mats are the largest and oldest. The highly organic soil absorbs water in quantity and retains it for days after a rain. During extended dry periods even the larger mats become quite desiccated and, there being only solid rock for a substratum, the vegetation suffers accordingly. A rather unexpected assemblage of plants fringes the woods at the top of the exposed rock. Here, seepage encourages the growth of a thick mat of mosses, predominantly *Sphagnum subsecundum* Nees. with *Thuidium delicatulum* Mitt., *Sematophyllum carolinianum* (C. M.) E. G. B. and the hepatic, *Scapania nemorosum* (L.) Dum., as well as clumps of *Thalictrum revolutum* DC., *Aletris farinosa* L. in abundance, *Scleria pauciflora* Muhl. and *Rynchospora cymosa* Ell. scattered here and there. In late June the entire mat was dotted with *Calopogon pulchellus* (Sw.) R. Br. and scattered everywhere along the margins of the sphagnum was the little bladderwort, *Utricularia subulata* L.

**Successional Stages on the Cliff**

**Bare Rock Pioneers**

Among the first plants to appear on any bare rock outcrop are crustose lichens. The importance of these plants as rock pioneers has been fully emphasized in the literature and it has been generally assumed that crustose lichens are universal pioneers in rock succession. Frye ('27) showed that

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1 The writers are indebted to Professor H. L. Blomquist for the identification of the sphagnums and to Mrs. Gladys P. Anderson for determining the lichens.
these lichens collect small amounts of soil and in certain cases aid in actual disintegration of the rock itself. Here they seem to be of little importance in aiding the later pioneers, although they are scattered abundantly over the area. Careful examination showed that early moss pioneers occupy the rock regardless of whether crustose lichens are present or absent and those which start on a patch of a crustose lichen apparently have no advantage over those coming in on the bare rock. Two mosses may be considered as pioneers for building up a mat of vegetation such as that referred to above. They are *Rhacomitrium heterostichum* (Hedw.) Brid. var. *ramulosum* (Lindb.) G. N. Jones (fig. 3), and *Andreaea rupestris* Hedw., both of which are common elements of the bare rock flora at high elevations in this region. Small plants of both species grow in minute crevices of the rock not previously occupied by any visible sign of crustose lichens and once a colony of either *Rhacomitrium* or *Andreaea* is established it slowly spreads on the bare rock in a more or less circular fashion. When a moss mat, spreading on the bare rock, comes in contact with scattered lichens and other mosses which may be present they are engulfed and finally eliminated. Apparently small amounts of soil which collect in crevices are sufficient for spore germination, the plants themselves collect still more as they increase in size and in this manner sizeable colonies are built up. Whether *Rhacomitrium* or *Andreaea* first occupies an area seems somewhat a matter of chance, although, in general, the moister areas support *Andreaea*, while *Rhacomitrium* is more abundant in the drier places. In a few cases they grow intermixed and neither seems to crowd out the other.

**Beginning of Mat Formation**

The occupation of the rock by these pioneers evidently takes place over a long period of time since they grow very slowly and do not spread rapidly. Soil consequently collects at a proportionally slow rate which is still further retarded by the periodic washing rains. When a patch of either *Rhacomitrium* or *Andreaea* attains sufficient size and thickness to retain enough soil or organic matter, it is invaded by either of two lichens or in some cases both. These are *Cladonia subcariosa* Nyl. (fig. 4) and *Cladonia coccifera* (L.) Willd., which mark the beginning of definite mats. These lichens grow on and between the moss plants wherever bits of soil and organic matter have collected, finally almost completely crowding out the moss. A well-developed patch of the invading lichen will show only occasional moss plants persisting. In areas in which *Rhacomitrium* and *Andreaea* are growing intermixed, the two cladonias invade both and a complex mixture of the four results. Mats containing *Cladonia coccifera* are by far more common than those with *C. subcariosa*, the latter seldom occurring alone, while many patches of both *Rhacomitrium* and *Andreaea* were observed in which *C. coccifera* was invading and crowding out the moss. It is not uncommon, however, to observe both *C. coccifera* and *C. subcariosa* invading the same moss clump. Invasion by the lichen usually occurs in the center of the patch of moss where soil and
organic accumulation is greatest and spreads in all directions as the mat is gradually built up.

Cooper ('13) found that *Rhacomitrium canescens ericoides* (Web.) Schimp. was the pioneer moss upon which cladonias later became superimposed, there being three species of importance, *C. rangiferina* (L.) Web., *C. sylvatica* (L.) Hoffm., and *C. alpestris* L. He likewise described central mat formation spreading in a circular manner.

Occasionally clumps of *Rhacomitrium* are mixed with *Hedwigia ciliata* Hedw., although the latter seldom reaches any great degree of development, and in a few mats in which some soil has collected *Dicranum scoparium* Hedw. invades the periphery. Although the pioneer mosses are regularly invaded by the two species of cladonia mentioned above, other species may come in at random, particularly on mats with a large amount of organic matter as well as on twigs, sticks, and other debris which happen to lodge in the mat. Among these are *Cladonia fimбриata* (L.) Fries, *C. furcata* (Huds.) Schrad., *C. coniocraea* (Floerke) Spreng., *C. strepsilis* (Ach.) Vainio and *Parmelia molluscuscula* Ach. Any of these species which happen to invade the mat aid in the further collection of soil and debris, furnishing bulk and perhaps increasing the water-holding capacity of the mat thus facilitating occupation by other species. Decaying wood and vegetable matter often furnish suitable habitats for *Cladonia caespiticia* (Pers.) Floerke and *C. floerkeana* (Frk.) Floerke var. *intermedia* Hepp., which also increase the general bulk of the mat, and frequently, at this stage, *Polytrichum ohiense* R. & C. was found growing around the edges.

*Mature Mats*

As soon as *Cladonia coccifera* or *C. subcariosa* gains sufficient hold on the moss mats, the patch increases in thickness by additional invasion of the species of *Cladonia* described above and thus the collection of soil and other materials is greatly increased. When this development has progressed for some time *Selaginella tortipila* A. Br. or either of three larger cladonias, *C. rangiferina* (L.) Web., *C. tenuis* (Fik.) Harm., or *C. mitis* Sandst., may appear. Mixed clumps of all may, in rare cases, appear simultaneously. If *Selaginella* invades first it may occupy the mat to the complete exclusion of the other species for a time. Then usually *C. rangiferina* makes its appearance, growing in with *Selaginella* until there is a mixture of the two or finally it may eliminate the club moss from the central area entirely (fig. 5). Mats with a dense growth of either or a mixture of *C. rangiferina*, *C. tenuis*, or *C. mitis* in the center, surrounded in successive rings by *Selaginella tortipila*, *Cladonia coccifera* or *C. subcariosa*, and either *Rhacomitrium* or *Andreaea* are common. If *C. rangiferina* precedes *Selaginella* on the mat it may occupy it exclusively and large mats often develop in which *Selaginella* never appears. This is especially true of luxuriant *Rhacomitrium-C. coccifera* mats in which there are relatively large amounts of soil and organic matter.
The history or stages of development of most mats can be determined by dissecting them and even in extremely large mats bits of the original pioneer moss can be detected as well as successive invaders. Consequently the order of invasion by Selaginella and the later cladonias can be determined in this manner. Other mats are seen in which Selaginella and C. rangiferina, C. tenuis, or C. mitis appear at about the same time, in which case it may be assumed that the lichens eventually crowd out the former or at least dominate it in somewhat the same manner as when Selaginella appears first. Mixtures of the three larger species of Cladonia are common and extensive mats four to six feet in diameter are prevalent.

A large number of mats in this stage of development are present scattered over the area, and subsequent growth and increase in size is assumed to be extremely slow. Both Selaginella and Cladonia as well as the other pioneers are capable of withstanding extreme drought as evidenced by their common habitat in dry exposed regions so that mat formation up to this point is not influenced so much by moisture. With the later invasion by the higher plants which are less drought resistant, however, further development is certainly influenced greatly by the amount of water present. This is shown by comparing mats on dry areas with mats directly beneath seepage lines from the adjoining forest. The mats in the moister places show the presence of higher plants much sooner than those in more desiccated places and for the same reason the latter become much more extensive before they are invaded by these plants. Extensive Selaginella-Cladonia mats are scattered over the dry portions of the cliff without supporting any abundance of herbaceous or woody plants. If conditions at any time become favorable for herbaceous plants they may appear and grow for a time only to be killed off by a period of drought, while the pioneer species can withstand such periods and continue to grow and increase the size and general bulk of the mat. In the steeper places, mats not securely anchored increase in weight to the point of toppling down the incline and collecting at the foot of the cliff. Mats in all stages of development can be found here although some of these which are dislodged stop in depressions or behind more secure mats, but it is uncertain whether they continue development. One or two mats were observed in which decay had already begun and superimposed upon both Selaginella and Cladonia rangiferina were forms of Cladonia pyxidata (L.) Hoffm. var. neglecta (Floerke) Vanier.

Mats spread in somewhat the same manner as they are built up, with the pioneer mosses spreading out over the bare rock, Cladonia coccifera or C. subcariosa pushing out over the moss, and Cladonia rangiferina, C. tenuis, or C. mitis and Selaginella tortipila in turn invading. This gives the developing mat a decided concentric appearance as has already been noted. Although nearly all of the mats develop in about the same sequence as outlined, certain isolated cases were observed which deviated from this general course of development. In one instance plants of Cladonia rangiferina were invading...
Rhacomitrium directly and apparently were spreading. This appears to be rare. Around the edges of the large forested areas occasional plants of Saxifraga leucanthemifolia come in directly on Rhacomitrium, but this condition is unusual as is a similar case in which the moss, Sematophyllum carolinianum (C.M.) E.G.B., growing in a very moist area was spreading directly on the bare rock followed in turn by Selaginella tortipila.

Between the complex Selaginella-Cladonia mats mosses and other lichens were distributed throughout the area. These species no doubt play a part in the vegetational development on the rock by retaining a certain amount of soil and organic matter, although they do not aid directly in mat formation. Quite an area is occupied by rather coarse growths of two species of Umbilicaria, U. dillenii Tuck. and U. pustulata (L.) Hoffm. var. papulosa Tuck., both of which exclude other species and thus actually hinder mat formation. Isolated patches of Hedwigia ciliata appear scattered over the area and the lichen, Physcia tribacea (Ach.) Nyl. grows in crevices throughout. In the more scantily vegetated areas both Parmelia molliscula Ach. and P. conspersa Ach. are rather commonly present. Any one of the species may eventually collect sufficient soil or debris to favor invasion by either Cladonia coccifera or C. subcariosa in which case further development proceeds in the manner already described. There are so few of these cases, however, that they are relatively unimportant in the formation of the larger mats.

**Herbaceous Invaders**

As would be expected, soil collects most rapidly on the upper side of the mat, which, after a time becomes sufficient for certain other species of mosses to come in. Among such mosses are Polytrichum ohioense, Dicranum scoparium, Thuidium delicatulum Mitt., and occasionally tufts of Leucobryum glaucum Schimp. These additional plants greatly facilitate the collection of soil and as accumulation continues Saxifraga leucanthemifolia Michx. appears around the outer edges especially of the moister mats (fig. 7). On the mat proper, either separately or together, the grasses, Danthonia spicata (L.) Beauv. and Panicum huachucae Ashe, establish themselves (fig. 6). Cynthia montana (Michx.) Standley sometimes appears with the grasses. On some of the larger clumps Carex sp. may occur and in two places Dryopteris marginalis (L.) A. Gray (fig. 8) had gained a foothold but was not thriving.

When a mat has persisted for some time it is invariably made up of a series of girdles each migrating in a centrifugal direction encroaching on its neighboring species. On a flat rock this spreading or enlargement results in a more or less concentric arrangement but on this steep slope the protection afforded by the mat facilitates the growth of pioneers on the lower side and the spread is consequently mostly downward forming an oval. Two factors contribute to the eccentric form of the mats, namely, the physical protection against erosion and the supply of moisture which is extended over several
Fig. 7. One of the moister mats with *Saxifraga leucanthemifolia* around the margin.
Fig. 8. An older mat, anchored behind a log, which supports *Danthonia spicata*, *Carex* sp. and *Dryopteris marginalis*.
Fig. 9. *Chionanthus virginicus* the first woody species to establish itself.
Fig. 10. An opening in the forest where *Panicum virgatum* is dominant and *Chionanthus* is making a scattered appearance.
Fig. 11. *Juniperus virginiana* appearing. The low material on the upper side of the mat is mainly *Diervella sessilifolia*.
Fig. 12. *Talinum teretifolium* growing on a bare ledge. (Note pencil.)
days as it gradually seeps from the lower edge. This seepage from the larger mats continues for days after a rain and, where this occurs, the lower margin instead of having the characteristic bare rock pioneers will be fringed with a strong development of Sphagnum capillaceum (Weiss) Schrank, Thuidium delicatulum, Campylium chrysophyllum (Brid.) Bryhn., Hypnum imponens Hedw., and an abundance of Saxifraga leucanthemifolia.

Woody Invaders

When a mat has built up to a depth of several inches the first woody species, Chionanthus virginica L. (fig. 9), makes its appearance and somewhat later seedlings of Acer rubrum L. commonly gain a foothold. All the woody plants which start do not survive and those which survive grow slowly. This is particularly true of Juniperus virginiana L. (fig. 11) which often germinates but rarely lives to reach any size. One red maple, ten feet tall, was over 25 years of age; fringe trees 1.5 to 2 inches in diameter were often 40 years old. Unless the woody species find anchorage in crevices, which are rare, the mats are still not permanent, and even with strong herb development the roots are imbedded only in a mat which can be raised at the margin and rolled like a heavy rug. As a consequence even the larger mats supporting woody plants sometimes slide to the bottom in a jumbled mass. If such a falling mass strikes a more stable or better anchored mat it may lodge there and, if the whole mass holds, add to and speed up the vegetational development on that area. When large or small tree trunks slide down from above and are miraculously checked somewhere on the slope a new mat rapidly forms above them. Several of the larger mats are anchored behind windfalls.

The mats in which Chionanthus and Acer occur that have been established for some time are relatively stable and tend to maintain their condition indefinitely. A transect from the lower to the upper margin of one of the more stable, older mats shows the complete successional series from Andreacea and Rhacomitrium. On the grassy mat Littium superbnum L. is characteristically present and Cynthia montana not infrequent. Above the trees Diervilia sessilifolia Buckl. (fig. 11) forms a narrow zone fringed with Pycnanthemum dubium A. Gray.

Forest on Old Mats

Two of the vegetated areas are much more extensive than any others. These are characterized by a more varied woody flora and are the oldest mats present. Neither mat is isolated since both extend down over the rock as tongues from the forest above. The woody species consequently grade from those of the hardwood forest above to Acer and Chionanthus near the lower margin. Between are species which are seemingly indicative of the trend of development of any of the mats if they could progress without interruption. The dominant tree species are Tsuga canadensis (L.) Carr., Juniperus virginiana L. and Pinus strobus L., all of which are undersized and have grown
very slowly. Borings showed a hemlock 2 inches DBH to be 48 years old; a juniper 4 inches DBH, 58 years; white pine 3 inches DBH, 42 years. The trees highest on the mat and nearest the hardwoods have obviously made better growth than those lower down the slope for near the top an 8 inch hemlock was only 61 years old.

The understory on these larger mats is made up of reproduction in all sizes of the above species and, locally, well developed clumps of *Rhododendron catawbiense* Michx. and *Kalmia latifolia* L. Neither of these was more than four to five feet tall and borings, difficult to obtain because older branches are much decayed, showed their ages to be well over 40 years. Other shrubs present include *Aronia melanocarpa* (Michx.) Britton, *Vaccinium arboreum* Marsh, and *Gaylussacia baccata* (Wang.) C. Koch. The floor covering was composed of *Hypnum imponens* Hedw., *Polytrichum ohiense*, *Leucobryum glaucum*, *Tetraphis pellucida* Hedw. (*Georgia pellucida* Rabenh.), *Polzia nutans* Hedw., *Sphagnum compactum* DC., *Cladonia squamosa* (Scop.) Hoffm., and *C. strepsilis*.

Increment borings of the trees showed marked irregularities in rates of growth at different periods in the past. Comparison of numerous borings revealed that these irregularities were the same in different individuals. All of the species began growth at a very slow rate and this was followed by a period of uniform growth with slightly larger rings. Regardless of age the annual increment was suddenly much reduced about 23 to 25 years ago and very poor growth followed until 12 years ago when all species showed a marked increase in annual growth that continued to the present. This trend was apparent in hemlock and red cedar regardless of age or size and to a lesser extent in white pine. The trees bored ranged from 40 to 60 years of age and from 2 to 8 inches in diameter. Comparison of actual ring widths was not practical because some trees grew much better than others. Measurements for a 58 year red cedar, 4 inches in diameter, illustrate the general trend for all species: first 15 years, 0.25 inch; next 18 years, 0.75 inch; then 13 years, 0.25 inch; and the past 12 years, 0.75 inch.

The early slow growth can be explained as due to competition under overtopping species or possibly the mat was much more open and exposed at the time with attendant poor moisture conditions. That this should be followed by a rather extended period of uniform growth when the individual had established itself might reasonably be expected. What caused the abrupt decrease in growth 25 years ago is, however, highly problematical. Several large, partially decayed, stumps may possibly explain the rapid growth initiated 12 years ago. The stumps do not appear as though they had been cut and the presence of several partially decayed logs at the base of the cliff and suspended on different mats would indicate that they may be windfalls. The increased moisture made available by the elimination of these larger trees might well have been the factor which stimulated the more rapid growth of the survivors.
Woody species on the larger mats, beside the conifers and shrubs mentioned, include *Quercus montana* Willd., *Q. coccinea* Muench., *Prunus serotina* Ehrh., *Rubus* spp., *Amelanchier* sp. and rarely a stunted hickory. An ash of which all individuals present were small appears to be *Fraxinus biltmoreana* Beadle. Around the margins several herbs, not previously discussed, are characteristic. These include *Coreopsis major* Walt., *Kneiffia tetragona* (Roth.) Pennell, *Lysimachia quadrifolia* L., *Uvularia sessilifolia* L., *Polygonatum biflorum* (Walt.) Ell., *Smilacina racemosa* (L.) Desf., *Aralia nudicaulis* L. and *Dryopteris marginalis* (L.) A. Gray. The outer fringe, in addition to coarse growths of *Selaginella tortipila*, *Cladonia rangiferina*, *C. tenuis*, and *C. mitis*, contains *Sphagnum capillaceum*, *Sematophyllum carolinianum*, *Aulacornium palustre* Schwae gr., *Hypnum molluscum* Hedw., *H. imponens*, *H. crista-castrensis* Hedw., *Thuidium delicatulum*, *Eurhynchium serrulatum* (Hedw.) Kindb., *Plagiothecium striatellum* (Brid.) Lindb., *Leucobryum glaucum*, *Cladonia incrassata* Floerke, *Peltigera rufescens* (Weis.) Humb., and *Cladonia pyxidata neglecta*.

**The Surrounding Forest**

The forest surrounding the cliff is predominantly oak-chestnut. Several of the chestnut trees (*Castanea dentata* (Marsh.) Borkh.) on the lower slopes appear untouched by blight but on the ridges almost all are dead. The most important oaks in the order of their apparent abundance are *Q. montana*, *Q. borealis* var. *austriaca* (Alarshall) Ashe., *Q. alba* L., *Q. coccinea*, and *Q. velutina* Lam. Less important trees are *Acer saccharum* Marsh., *Liriodendron tulipifera* L., *Fraxinus biltmoreana* Ashe., and an occasional hickory. The understory and shrubs include *Juniperus virginiana* L., *Cornus florida* L., *Aesculus octandra* Marsh., *Chionanthus virginica* L., *Azalea calendulacea* Michx., *Kalmia latifolia* L., and *Rhododendron catawbiense* Michx. The trees are uneven aged and vary considerably in size. Some are three feet in diameter and exceed 300 years in age. The forest at the top of the ridge appears younger but the rate of growth is apparently much slower for the average large oaks which were 20 to 25 inches in diameter, were 300 to 350 years of age. The habitat becomes drier and the soil, due to erosion, is not as deep. Here chestnut oak is less abundant and white and black oak relatively more important. Numerous dead chestnuts are scattered throughout, and hickory forms a strong understory in the drier parts.

As seen from a distance the woods seem to cover the surrounding slopes fairly uniformly even though the bluffs appear as steep as the bare area. Closer observation, however, discloses that the wooded slopes have rough and irregular surfaces, the manner of weathering having resulted in numerous broad, outcropping ledges and many crevices of all sizes. Herein lies the explanation of the bare and forested bluffs. The ledges and crevices prevent wholesale denudations when mats are released and soil is retained in some quantity wherever it accumulates at all. Then, the woody plants which be-
come established, their roots anchored in the crevices, bind themselves and
the soil firmly to the face of the cliff. The smooth rock faces, retaining
scarcely any soil and fairly few crevices in which trees and shrubs may be-
come anchored, remain indefinitely in a semibarren state conditioned by the
rate and amount of soil accumulation.

On the forested bluff small rock areas frequently outcropped which had all
the stages of succession characteristic of the larger areas. With one excep-
tion where Talinum teretifolium Pursh. (fig. 12) was thriving and nothing
else, these small areas were too small or too steep for soil to accumulate in
quantity. The rate and amount of soil accumulation can be satisfactorily
used to explain the nature and development of the vegetation on the entire
bluff.

Summary

The vegetation of and surrounding a barefaced cliff in the mountains of
western North Carolina is described. Stages in development were observed
from bare rock pioneers, to woody species.

Bare rock pioneers are Rhamanthus heterostichum var. ramulosum or
Andreaeae rupestris, from either of which complex mats are built up through
the successive invasion of either Cladonia coccifera or C. subcariosa, Selagin-
nella tortipila, and any or all of C. rangiferina, C. tenuis, or C. mitis, with
anomalous species of mosses and lichens intermingled. Invasion by higher
plants is initiated by Saxifraga leucanthemifolia, followed by either Danthonia
spicata or Panicum huachucae or both. Mats spread centrifugally in the same
order.

Mats reaching sufficient size are invaded by woody plants such as Chio-
nanthus virginica, Acer rubrum, and Juniperus virginiana and still larger mats
are dominated by Tsuga canadensis, Juniperus virginiana, and Pinus strobus.
The understory is composed of reproduction of these species as well as Rhodo-
dendron catawbiense, Kalmia latifolia, Aronia melanocarpa, Vaccinium arbo-
reum, and Gaylussacia baccata.

The surrounding forest is predominantly oak-chestnut including Quercus mon-
tana, Q. borealis maxima, Q. alba, Q. coccinea, Q. velutina, and Castanea
dentata (mostly dead). With the above were associated Acer saccharum,
Liriodendron tulipifera, Fraxinus biltmoreana, and an occasional hickory.
The understory and shrubs included Juniperus virginiana, Cornus florida,
Aesculus octandra, Chionanthus virginica, Azalea calendulaeae, Kalmia lati-
folia, Rhododendron catawbiense.

Mat formation accompanied by soil accumulation and consequently all
stages of succession are influenced by the presence of crevices in the rock
combined with the steepness of the slope. Moisture may at times become an
important factor in local areas. In general it is concluded that the amount
and rate of soil accumulation determines the nature of the vegetation on the
entire bluff.
Bibliography


