photo by Carmen Converse, MN DNR

Plover Prairie, Lac Qui Parle County, MN

General Description

Rock Outcrop (RO) communities are open or shrub-dominated plant communities on horizontal or sloping bedrock exposures. They occur in landscapes where bedrock is at or just above the ground surface. Crustose and foliose lichens typically cover bare rock surfaces, with fruticose lichens also often present. Vascular plant cover is sparse to patchy, with abundance and distribution dependent on the amount of fracturing of bedrock surfaces and accumulation of soil in cracks, crevices, and shallow depressions. In this classification, RO communities are classified by bedrock type and geography, which are major determinants of plant community composition.[1]

In most of the Prairie Parkland (PPA) Province, bedrock is buried beneath glacial sediments generally greater than 100ft (30m) deep—often from 200ft to 500ft (60m to 150m) deep. RO communities are confined to a few localized areas in the province where glacial sediments are not deep enough to cover local bedrock highs or where glacial deposits have been removed by flowing water. In the Minnesota River Prairie Subsection of the CGP, RO communities occur fairly frequently along major portions of the Minnesota River valley between Ortonville and New Ulm, predominantly on Precambrian granite, gneiss, and diorite. RO communities also occur on gabbro, amphibolite, schist, quartz monzonite, quartzite, basalt, and sandstone bedrock in the Minnesota River valley, although much less commonly. Most of these outcrops were

[1]Although not specifically addressed in this classification, lichen-covered boulders and glacial erratics are present sporadically in upland and wetland communities across the PPA and TAP provinces. These boulders, which have been transported to their current locations by glacial ice and meltwater, are varied in mineral composition, with origins ranging from local bedrock, to limestone bedrock in Manitoba, to bedrock on the Canadian Shield of Ontario and northeastern Minnesota. The lichen flora of these boulders is often similar to that of local bedrock exposures. For example, granitic boulders typically support lichens common on granitic outcrops, while quartzite boulders support lichens characteristic of Sioux quartzite outcrops. Boulders and glacial erratics composed of rock types not represented in the bedrock outcrops of the PPA Province (such as limestone) typically have a lichen flora that is starkly different from that of local RO communities. The degree of similarity of lichen species composition between boulders and outcrops also appears to be related to distance between boulder and outcrop. The lichen communities on boulders and erratics have not been systematically studied in Minnesota; further collection and analysis of lichen data are needed to better understand species composition and patterns of distribution.

exposed during the most recent period of glaciation when the Glacial River Warren drained Glacial Lake Agassiz, carrying enormous volumes of ice and meltwater that scoured out the present-day Minnesota River valley. The erosive force of this torrent cut a deep trench through the thick blanket of drift down to the underlying bedrock, leaving numerous exposures along the valley floor flanking the much smaller Minnesota River, which succeeded the glacial river once Lake Agassiz had drained. (The glacial history of the Minnesota River valley is described in more detail on page PPA/TAP-FF5). Over the past 10,000 years, further erosion has exposed some additional areas of bedrock in the PPA Province, especially along streams. RO communities occur locally on quartzite bedrock outcrops in the Minnesota River Prairie Subsection of the CGP in Cottonwood County and in the Inner Coteau Subsection in Rock and Pipestone counties. These areas were not covered by ice during the Wisconsin glaciation, and these outcrops have been exposed thousands of years longer than many other bedrock outcrops in the state. RO communities do not occur in the Tallgrass Aspen Parkland (TAP) Province as there are no bedrock exposures to support them.

Vegetation Structure and Composition

The vegetation of RO communities is quite variable, although vascular plant cover is typically very sparse because of scarcity of soil. RO communities can be dominated by lichens, graminoids, or shrubs. Lichens are the dominant life form on most outcrops. Crustose and foliose lichens cover exposed rock surfaces. Fruticose species may also be common, especially in undisturbed sites. Mosses can be codominant with lichens along crevices and on bedrock margins. Vascular plant cover is sparse to patchy, limited mostly by the amount of soil present. Woody plants sometimes occur in areas of deeper soil and may dominate RO communities where patches of deep soil are prevalent. Even in these shrub-dominated outcrop communities, however, soil depths are much less than in surrounding prairie or woodland communities. On many outcrops, the amount of soil is closely tied to the degree of bedrock fracturing, with soil accumulating in cracks and crevices and providing rooting areas for plants.

In general, RO communities are perhaps more usefully treated as heterogeneous assemblages of several plant communities rather than as a single vegetation type. A typical example may include a bare rock community composed mostly of lichens such as *Candelariella vitellina* and *Rhizocarpon disporum*, a crevice and thin soil community with specialized vascular plants such as brittle prickly pear *(Opuntia fragilis)* and false pennyroyal *(Isanthus brachiatus)*, a deeper soil community with prairie or woodland species such as big bluestem (*Andropogon gerardii)* and prairie wild onion *(Allium stellatum)*, and a shallow pool community supporting aquatic plants such as water hyssop (*Bacopa rotundifolia*) and Carolina foxtail (*Alopecurus carolinianus*). Overall, the flora of RO communities is distinctive, containing many species of vascular plants, mosses, and lichens that occur in no other habitat in Minnesota. One such species is devil's tongue (*Opuntia humifusa)*, which in Minnesota is restricted to RO communities (although to the west in the Great Plains it is distributed more widely, occurring in prairies as well as in rock outcrop communities).

Plant Adaptations

Species in RO communities are subjected to greater environmental extremes than species in surrounding terrestrial communities. Many plants that grow on bedrock outcrops have adaptations to withstand frequent desiccation due to the low moisture-holding capacities of substrates and exposure to direct sunlight and strong winds. Many of the characteristic plants of RO communities utilize the C_4 metabolic pathway in photosynthetic carbon fixation, a physiological mechanism that makes photosynthesis more efficient with respect to water use in the typically high-light, high-temperature, and water-limited environment of RO communities. Fleshy water-storing tissues are present in such vascular plant outcrop specialists as prickly pears *(Opuntia* spp.) and small-flowered fameflower *(Talinum parviflorum)*. During periods of drought some

species, such as rusty woodsia *(Woodsia ilvensis)*, die back to their roots and then resprout when rains return. Plants must also withstand rapid fluctuations in substrate temperatures, which are colder at night and much hotter during midafternoon on sunny days than in surrounding prairies, woodlands, and forests. Limited nutrient availability also influences community composition by preventing more nutrient-demanding species characteristic of other systems from competitively excluding characteristic RO species. Species in RO communities commonly reproduce by vegetative structures such as rhizomes, runners, or stolons and tend to persist from year to year once established at a site; species that disperse and reproduce by seed alone are much less common. The annual species present in RO communities germinate only when moisture levels are high enough to make it likely that the plants will be able to complete their life cycle; they mature rapidly to produce seeds before moisture is depleted, and the seeds remain dormant until the next wet period. Some of the long-lived species, such as brittle prickly pear, tend to flower and produce seeds only during periods of above-average rainfall. RO communities often share a number of plants with communities in the Cliff/Talus (CT) System due to similarities in environmental conditions.

Landscape Setting and Disturbance Regime

RO communities are present where local bedrock highs are exposed in level to strongly rolling landscapes composed variously of alluvium, terrace deposits, outwash, glacial till, or loess-mantled till. In most of the PPA Province, RO communities occur in fire-prone landscapes dominated by Upland Prairie communities. Along the Minnesota River valley downstream from Montevideo, RO communities occur in landscapes dominated by a mix of Floodplain Forest, Fire-Dependent Forest/Woodland, Mesic Hardwood Forest, Upland Prairie, and Marsh communities.

RO communities are small features, rarely covering more than 10 acres (4ha) and most often less than 5 acres (2ha). Exposed (bare) rock often makes up just a portion of a typical community occurrence, with individual exposures rarely larger than 2 acres (1ha) and usually much smaller (often 1/4 acre or less). Most RO communities are embedded in a matrix of prairie, savanna, woodland, forest, or marsh vegetation. Because of their small size, RO communities are often mapped as complexes or described as inclusions within prairie, savanna, woodland, forest, or, occasionally, cliff and talus communities. Complexes with these communities may be larger than 10 acres but are rarely more than 25 acres (10ha).

Because RO communities are typically small and surrounded by more expansive prairie, woodland, and forest communities, they are often affected by disturbances originating in these other settings. For example, removal of adjacent forest canopies by fire or windstorm results in warmer and drier local microclimates on adjacent outcrops, which further favors drought-tolerant RO species. Fires, as evidenced by the presence of charcoal on some rock outcrops, can also burn through and around RO communities, removing shallow accumulations of organic matter along margins of exposed rock. Removal of this organic matter prevents soil development over the rock surface, which if not checked would eventually lead to the replacement of the outcrop community by prairie or woodland communities (this occurs over decades or centuries, depending on the height of the bedrock above the surrounding terrain). Severe fires can remove at least the aboveground portions of most vascular plants from outcrops, and repeated severe fires effectively reduce woody cover and eliminate other fire-sensitive species. Even during severe fires, however, areas in outcrop communities with thin soils and bare rock burn infrequently because of their sparse vegetation cover and low levels of fuel. As a result, the specialized plants characteristic of outcrops—which are typically present on microsites with very low levels of fuel—often escape combustion. RO communities that are surrounded by forest or wetland communities likely experience lower fire frequencies and intensities than those surrounded by prairies. Because of their lack of fuels, the largest and most continuous patches of exposed bedrock, such as in some RO

communities along the Minnesota River valley, rarely burn. In general, RO communities are resistant to successional change because of limited habitat for root establishment and prevalence of species that persist from year to year. In the absence of fire and other succession-suppressing disturbances, RO communities and the complexes in which they occur will succeed over centuries to woodland or forest.

With fire suppression since Euro-American settlement, woody plant cover is increasing in native plant communities throughout the PPA Province, including RO communities. Historically, RO communities were likely refugia for native woody plants in prairie landscapes because, as noted above, large areas of exposed rock and low fuel levels slowed the intensity and spread of fire. Although woody plant cover on rock outcrops usually was not eliminated by fire, fires did burn through matrices of RO communities in the past, controlling the vigor and abundance of woody vegetation. At present, as woody plants increase in abundance across the PPA Province, the seed source for species that colonize RO communities has likewise increased, exacerbating the effect of fire suppression. Notable examples include eastern red cedar (*Juniperus virginiana*) and exotic species such as European honeysuckles (*Lonicera tatarica*, *L. bella*, and *L. morrowii).*

Grazing and browsing by large mammals, primarily bison and elk, were major processes in prairie landscapes prior to Euro-American settlement and likely impacted the structure and composition of RO communities. Because bison and elk prefer grasses over forbs and woody plants, it is unlikely that they affected the vegetation of RO communities directly through grazing and browsing, but they may have suppressed vegetation by trampling or by rubbing on woody plants or rock surfaces. They very likely helped to disperse seeds and, by disturbing the soil with their hooves, probably contributed to regeneration of short-lived species characteristic of RO communities. Because they are too rocky for cultivation, complexes of outcrop communities and prairie are often used at present as pastures for domestic livestock. Confined grazing of outcrops by domestic livestock facilitates invasion by exotic species and by eastern red cedar, which is avoided by cattle.

Floristic Regions

Communities in the RO System are divided into two floristic regions based on geographic variation in climate and plant species composition (Fig. RO-1). One of these regions, the Southern Floristic (ROs) Region, is present in the PPA and Eastern Broadleaf Forest provinces. The other, the Northern Floristic (ROn) Region, is present to the north in the Laurentian Mixed Forest Province. Vascular plants with high fidelity for RO communities in the ROs Region include brittle prickly pear, devil's tongue, small-flowered fameflower, false pennyroyal, rusty woodsia, rock spikemoss *(Selaginella rupestris)*, bulbostylis *(Bulbostylis capillaris)*, Carolina foxtail, disk hyssop *(Gratiola neglecta)*, mousetail *(Myosurus minimus)*, Carolina cranesbill *(Geranium carolinianum)*, slender knotweed *(Polygonum tenue)*, and water hyssop *(Bacopa rotundifolia)*. Only one native plant community class is recognized in the ROs Region, Southern Bedrock Outcrop (ROs12). Additional sampling, especially of lichens and mosses, may result in changes in the classification of ROs communities.

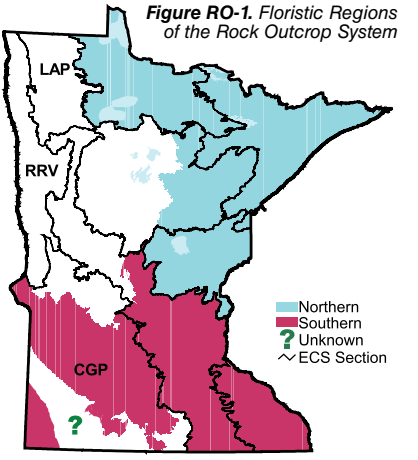

Figure RO-1. *Floristic Regions of the Rock Outcrop System*