FLORA OF THE GUNNISON BASIN

BARRELL

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Gunnison, Saguache, and Hinsdale Counties, Colorado

JOSEPH BARRELL

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Gunnison, Saguache, and Hinsdale Counties, Colorado

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Gunnison, Saguache, and Hinsdale Counties, Colorado

A Study in the Distribution of Plants

by Joseph Barrell

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INTRODUCTION

Every chapter in science is a chapter in some scientist's autobiography, and I see no reason for presenting this flora in other form than as it grew out of personal experience. It was early in the 1950's when I first came to the Gunnison Basin, a visitor to the Rocky Mountain Biological Laboratory. The snowfall of the previous winter had been especially heavy. The roads were opened late; and when the spring burst in mid-June, it was especially splendid.

June is a month of little rain in the Gunnison Basin, and the skies glitter most of the time. In Gothic (site of the Rocky Mountain Biological Laboratory), the land glitters also, with meltwater running from every snowbank and the Veratrum, which the cowboys call "cabbage," growing an inch a day. Hillsides take on the color of a prevailing flower, and a hill now blue with Delphinium, can later be scarlet with Gilia, still later, yellow with Helianthella. So striking are these displays that the visiting botanist may easily acquire impressions that must subsequently be modified. If one's first sight, say, of the American bistort, is of a large subalpine meadow entirely white with the plant, it will be difficult to avoid thinking that this is how the plant occurs when, as a matter of fact, such a display may be an exception rather than the rule. I have met few botanists visiting the Rocky Mountain Biological Laboratory and the Rocky Mountain flora for the first time who have not received strong, indeed too strong, impressions of how the plants occur.

But of all the impressions of the botanical newcomer to the Gunnison Basin and the Rockies, the strongest is that of the zones. No doubt he has read about their imperfections, and knows that a number of manuals have abandoned them for direct representation of altitude in feet or meters. Hence he is not prepared for the striking appearance which they do, in fact, present. Not infrequently, the bottom of the subalpine, or spruce-fir,

zone extends across his vision like the shoreline of an ancient Lake Bonneville. The dividing line between the dark coniferous forest above, and the green of aspen or meadow below, is often as exact as if it had been surveyed.

The strength of this first impression of the zones is increased by their usefulness. True, on a southerly exposure, the aspen-and-meadow (or montane) zone may extend above the 10,000-foot "shoreline"; and in a sheltered ravine, the spruce-fir forest may well descend below it. But, making allowances for such irregularities of exposure or protection, one can nearly always tell by a glance at the flora where he is and how much farther he has to go before reaching the top of a mountain. The zones are indeed so useful that in this flora they will be employed to express the altitudinal range of the species. For one thing, the conventional values of the zones in Colorado hold pretty well for the Gunnison Basin. The lowest, or submontane, zone, although capable of extending hundreds of feet higher than its usual limit, generally passes into the montane zone at 8,000 feet. The next boundary, as already mentioned, occurs at about 10,000 feet; while timberline, which separates the spruce-fir forest from the alpine zone above it, is generally found at 11,500 feet. The zonal is not only a more general way of presenting altitudinal range but a more concrete way, for it more readily suggests the plant associations involved. Thus although a plant of the subalpine zone may be a plant of meadows, one will know that the meadows are bounded by the dark line of spruce and fir. Similarly, a meadow in the montane zone will be bounded, if not by aspen, then by Douglas fir, or lodgepole pine, or narrowleaf cottonwood. Finally, although aspen and Douglas fir and narrowleaf cottonwood in the Gunnison Basin descend to the lowest elevations of the submontane or foothills zone, the dominant impression is one of sagebrush-covered slopes and it will be recognized that in this zone the trees occur only in the shelter of the gulches and streambeds.

Nevertheless, useful as these conceptions may be to

the mountain climber or botanist, it does seem to me that they present an altogether too simple picture of the flora of the Gunnison Basin. The awareness of this fact came to me one morning in June when I was climbing and collecting on the north slope of Signal Peak Ridge, not more than five miles from Gunnison, in the very center of the Basin. The slope of the ridge starts at about 8,000 feet, some three hundred feet higher than the town of Gunnison. As one might expect, the forest of the montane zone also begins at this point, being here an almost pure stand of Douglas fir. I began collecting plants from the forest floor--Pachystima Myrsinites, and so forth. Finally when I came to Carex Geyeri, I said to my wife, "Look at this. We might as well be in the spruce-fir." She replied, "Why, of course. Listen to the birds." And indeed, so intent upon collecting had I been that I had not noticed that I was in the spruce-fir zone as well by sound as by sight. For singing, or calling their notes, were the Rocky Mountain Jay, the Rocky Mountain Chickadee, the Olive-backed Thrush, and the Ruby-crowned Kinglet, the very birds I had heard for years in the spruce-fir forests in July!

As if the shock of this dislocation in my mental habits by two thousand feet were not enough, a week or two later, when collecting eight or nine miles south of Gunnison on the sagebrush floor of the Basin, I suddenly came upon a population of Carex obtusata. Now this plant, along with Carex rupestris, forms part of the flora of North Pole Basin, that prize display of arctic plants just north of Schofield Pass to which visiting botanists at the Rocky Mountain Biological Laboratory are regularly conducted. Yet here, four thousand feet lower in elevation, the plant was growing in sagebrush desert instead of in alpine cirque! Is it any wonder that suddenly the impressions of a decade of collecting came over me and I recognized that the overwhelming fact of the flora of the Gunnison Basin is the unity of the flora of the Gunnison Basin, and that the zones, no matter how useful in practice, are in reality based upon only a few of the many species in the Gunnison Basin. Indeed it seems to me that the zones are based principally upon the

trees. For clearly, the alpine zone is essentially the zone above treeline, where there are no trees; and the subalpine zone (at least in the Gunnison Basin) is based upon a mere couple of species, upon Engelmann spruce and subalpine fir. Similarly, the montane zone is the zone of the greatest expansion of species of trees (although these are not many), and the submontane zone is the zone where the species of trees again contract, almost to the paucity of species in the subalpine zone. That the trees are also the most conservative of the species in the Gunnison Basin will be seen, at least by implication, when the remarkable variation of the other plants of the Gunnison Basin is discussed later in this introduction.

It was thus that the unity of the flora of the Gunnison Basin presented itself to me, an impression that the subsequent years of collecting have served only to strengthen.

But before this, another characteristic of the flora of the Gunnison Basin had also thrust itself upon me, so that the principle of unity properly becomes, not the first, but the second principle of this study. It happened while I was working in the herbarium of the University of Colorado, culling out, family by family, genus by genus, the sheets of earlier collectors in the Gunnison Basin. On this particular morning it was the turn of the asters, a turn I was not looking forward to since previous work with the genus had convinced me that here the outlines of the species were badly blurred by intergradation. Imagine my surprise, then, when the sheets from the Gunnison Basin fell into a certain number of discrete piles. A second time through the assembled sheets produced no other result, so that I called my friend Weber in from his office to try his hand at sorting the sheets in the pile. Once again, the results were the same, and it was then that the thought occurred to me that in taking for botanical study a province, not only of limited extent, but demarcated by high mountain ranges and high mesas, I had unwittingly stumbled upon what might well be called a "natural area" as opposed

to such an artificial area as the state of Colorado. Furthermore, since the sheets of the herbarium of the University of Colorado are filed alphabetically, the above episode happened early in my examination of the collections of my predecessors, and it is no exaggeration to say that the experience was repeated a dozen times before I got to the Violaceae. By this time I was convinced that the problem of intergradation between the species of plants is to no small extent an artificial problem engendered by taking artificial areas for botanical examination. Now I know the compelling economic reasons for taking artificial areas for botanical examination. Nevertheless it is at least interesting to consider how superior a flora, say, of the United States, might be if, instead of being assembled by states or groups of states, it were assembled by natural areas and put together like a patchwork quilt. Speaking of reality as a whole, William James once asked why it could not have grown in patches instead of all as a piece.* Now whatever the answer to James's question may be with respect to reality as a whole, biologists know that with respect to the biota the answer is "Yes." The biota has most certainly grown by fits and starts, by patches; and I am convinced that by taking the patches one at a time, the problem of the intergradation of the species of plants could be enormously reduced. For this reason (and for several others to be mentioned before the end of this introduction), the kinds of plants thus far collected in the Gunnison Basin will be presented as a series of discrete species.

Thus it was that early in my study of the plants of the Gunnison Basin two principles emerged from the very plants themselves, the first from the herbarium sheets of my predecessors, the second from my own experience in the field.

Now with two such empirical principles as premises one would scarcely be human if he did not draw a third principle by way of conclusion. Before long the thought occurred to me, in explanation of all this, that during

* Pragmatism, N.Y., 1907, p. 288.

the later part of the Pleistocene the Gunnison Basin had been, in fact, a unitary refuge for the plants; that during this time of glaciation (many times longer than the mere 10,000 years since), the plants in the restricted region at the center had been subject to an intense selection. In those years of extreme competition, it would seem (in accordance with recognized principles of organic evolution) that the first plants to perish would have been the alternate races of various species. Indeed, in many cases, it must have happened that even the best-adapted races were not well enough adapted to survive, and that entire species, even genera, once inhabiting the Gunnison Basin perished during the years of glaciation. In other words, the lack of intergradation to be found among the species of the Gunnison Basin would seem to be amply accounted for by the hypothesis of the Gunnison Basin as an isolated refuge for the plants during the later part of the Pleistocene.

The theory will also explain the unity of the flora of the Gunnison Basin. For at the end of the period of glaciation, as the snowfields and glaciers began to inch back from their greatest advance, the hardy, compact flora at the center must also have inched back with equal speed. It seems to me that the possibility of plant migration from beyond the Gunnison Basin can entirely be disallowed. Even if five hundred of Darwin's ducks, each with five hundred seeds on its feet, had been poised beyond the ice and snow to seize the inch of ground left bare by the glaciers, the plants poised at the edge of the inch would have got there first. It seems to me that the pressure to repopulate from the center must have been almost explosive, and that the present plant population of the Gunnison Basin must substantially be an expansion of the former population at the center. Again, as the population at the center expanded to fill the whole Basin, and as temperatures moderated so that outlying regions became attractive to hundreds of species hitherto confined to the center, nevertheless small colonies of these same species must have persisted in the center, still finding the essential conditions of their existence unchanged. Thus Carex obtusata, although growing more

luxuriantly in the alpine zone, nevertheless survives on the sagebrush floor of the Basin because here the conditions of its survival are still to be found.

In any event, the field work upon which this flora is based has revealed many species of plants, generally supposed to be bulwarks of the alpine zone, living quite contentedly (indeed, in some cases, flourishing) at the foot of the mountains. The field work of this study has also revealed many other species, supposed to be denizens of the lower zones, now living in the alpine zone. Presumably, in the general migration from center to exterior, these latter species moved farther than was presumed or known.

The above will suffice as a first sketch of the botanical theory of this study. Much of the annotated list may, in one way or another, be regarded as further evidence of the plausibility of this theory. In the meantime, it will be profitable to turn to the Gunnison Basin itself, to the endemic scene today of the expanded refuge of the past.

Cradled as it is in the Continental Divide, and containing around 3,000 square miles, the Gunnison Basin cannot fail to excite the imagination of a person interested in the land or in the plants covering the land. It lies west of the Continental Divide in southern Colorado, a great saucer tipped to the west, or better yet, a great scallop shell tipped to the west; for most of its boundary, like the crinklings of the shell, is composed of mountain ranges; while in the west, like the hinge of the shell, the mountain ranges give way to high mesas. Visitors to the Gunnison Basin usually come to it, or cross it, by Route 50, which passes east and west, roughly dividing the Basin into two halves and going through Gunnison, the principal town. The portal on the east is Monarch Pass, where Route 50 crosses the Continental Divide at 11,300 feet. Twenty-four miles to the north a gravel road crosses Cottonwood Pass at 12,000 feet; and there are other high passes for jeep or horse. But there is no other general automobile pass until one comes to Kebler Pass, 10,000 feet high, in the northwest; and then no other until one returns to the continuation of

Route 50 in the west, which crosses Blue Mesa at 8,400 feet. In the south, there are two principal automobile passes, Spring Creek Pass and North Pass, which cross the Continental Divide at 10,900 and 10,000 feet, respectively. The Gunnison River, which drains the Basin and flows west, leaves the Basin by no pass, but by a narrow canyon in the hinge of the scallop shell. The canyon reaches spectacular depths in the Black Canyon of the Gunnison River, some twenty miles west of the Basin.

I mentioned that Route 50 divides the Basin into two halves. But this is not because the engineers planned it that way. The highway follows the Gunnison River, which in turn follows a gentle syncline in the rocks. In the western part of the Basin one can see the strata to the north dipping gently toward the river, and the strata to the south doing the same thing.

But except for this similarity in the western part of the Basin, the two halves are really quite different. The Gunnison Basin is not bilaterally symmetric with respect to the syncline, and the radius to the north is shorter than the radius to the south. Again, the northern half of the Basin is more mountainous than the southern half, and in fact around Gothic (as many visitors have declared), the country seems more like the Canadian Rockies than like the West of cowboys and roundups. On the other hand, the southern half of the Basin lies open practically to the wall of the Northeast San Juans; and as mesa succeeds mesa, it does suggest the West of cowboys and roundups.

The reason for this is, of course, geologic. The rocks of the southern half of the Basin are prevailingly volcanic, and the mesas and openness are attributable to the beds and flows of volcanic rock. If one bisects the Basin from east to west, not by Route 50, but by a line from Marshall Pass on the southeast to Swampy Pass on the northwest, he will find for the most part, not volcanic rock to the north, but sedimentary rock (generally tilted) and granite. In the center of the Basin, in various places, the lowermost pre-Cambrian rock is revealed by the loss both of the sedimentary and of the

volcanic layers.

I spoke earlier of first impressions and their modification. Here, perhaps, with topography and rock so dissimilar, one would be justified in assuming a correlative dissimilarity in the flora. But this simply is not the case. As the annotated list will show, a majority of the plants in the northern half of the Basin occur also in the southern half of the Basin, and vice versa. Once again, in spite of the difference in topography and geology, the unity of the flora of the Gunnison Basin seems to be the dominant botanical fact, and evolution and plant history seem to have been the controlling factors, not geologic or topographic setting.

Actually, this is not so surprising as it may seem. The volcanics in the southern half of the Basin are prevailingly sialic and light-colored, just as the rocks in the north are for the most part granites or derived from granites. Indeed it is at least possible that some of the quartz-latite extrusions in the south occurred at the same time as the quartz-monzonite intrusions in the north. The minerals are the same in any case, and thus along the Cimarron Fault in the southern half of the Basin, where one can find Tertiary rhyolite juxtaposed against pre-Cambrian granite, the same plants can be seen growing on either side of the fault.

But what forces, out of components so dissimilar, created a basin so unitary that everywhere one must climb to get out of it, that at a distance one cannot see the canyon in the western rampart by which the basin drains, so close are the walls together?

Curiously, the forces are few in number and relatively simple. In the east and north, the Gunnison Basin is bounded by the Sawatch and Elk Mountains respectively, which start out in the neighborhood of Marshall Pass by being a single, north-and-south fold in the earth's crust. But then, toward the northern part of the Gunnison Basin, the single mountain range forks, becoming a Y. The righthand fork continues north, carrying the Continental Divide. The lefthand fork turns west, forming the Elk

Mountains, and indeed the north wall of the Basin.

The west and south walls of the Basin, although also part of the general structure of the Rocky Mountains, occurred by a different process, by doming rather than by folding. Apparently the whole region now overlain by volcanic rock has, at intervals, been elevated until today it forms a vast, if irregular, dome extending from the San Miguel Mountains in the west to Marshall Pass in the east, from the Southeast San Juan Mountains in the south to the West Elk Mountains in the north. The center of this vast dome lies just west of the Gunnison Basin, in the Needle Mountains, where the elevation attains more than 14,000 feet.

Now it goes without saying that in the formation of such an enormous dome as this, the faults in the rock of the dome will not be thrust faults (as in the Elk and Sawatch Mountains), but normal faults, that is, breaks in the slopes radiating away from the center such as one would expect to occur when a dome is just too big to hold together. The Cimarron Fault, already referred to, is such a fault. And as the block to the northeast of this fault arose, so arose the west wall of the Gunnison Basin.

The southern wall of the Gunnison Basin is composed of the Northeast San Juans on the west and the Cochetopa Hills on the east (all part of the Continental Divide), and it slopes off in an easterly direction from the center of the dome in the Needle Mountains. Here also, the slope of the dome is interrupted by a major fault, the Cannibal Fault, running north and south through Spring Creek Pass, and elevating the Northeast San Juans to a greater height than the country immediately to the west.

Simplified as this account may be, it does, I think, do justice to the main forces that have entered into the making of the Gunnison Basin. I hope that it does not make the Gunnison Basin seem like an isolated marvel of nature. It all happened so slowly that in the intervals of uplift flows of lava spread out in level sheets; so slowly that throughout the uplift, the rivers maintained their courses. If the Gunnison Basin is a marvel of nature,

then the Black Canyon of the Gunnison River (caused by the same uplift that created the west wall of the Gunnison Basin) is a greater one. For the Black Canyon is not cut in a plateau like the Grand Canyon, but cut along the length of a hogback, with lower ground on either side. The block of the earth's crust northeast of the Cimarron Fault, in fact, went up so slowly that while the Gunnison River was cutting its way through the hard rock of the hogback, the soft rock on either side was being eroded to a depth of a thousand feet below the river!

That erosion, of course, is still going on. Erosion is always going on. So the real question becomes, "When did this last cycle of uplift and erosion begin? When did the Gunnison Basin as we know it today come into being?" Geologically speaking, the answer is "Yesterday." For prior to the interglacial preceding the last two phases of the recent ice age, the forces along the ancient faults had apparently been quiet for so long that the land was composed of rounded mountains and broad plains. This is what the geological evidence tells us, and this is what the plants tell us. For there are both plains plants and mountain plants in the Gunnison Basin and if, as this study assumes, they were both present when the refuge was formed, then the land, to begin with, was a combination of plains and of mountains. The present high mountains, and with them the Gunnison Basin, were formed in the course merely of the last two pairs of interglacial and glacial, this particular cycle of uplift and erosion being known as the Canyon Cycle. It may be dramatically viewed north of Lake City in the well-known "Gate," which is entirely the work of this cycle.

As for the time involved, this is a matter to be reckoned in thousands, not millions, of years. For our purposes, the most important fact is that the Gunnison Basin, including its isolated world of plants, had attained its present form when, not more than 10,000 years ago, the last major glaciation began its retreat. Since then, very little geologically has happened. The cabin in which I write these words stands on the glacial floodplain of Cebolla Creek, that is, on the flat of gravel and coarse

outwash which the swirling meltwaters of the Wisconsin glaciation deposited in the valley of Cebolla Creek. When these waters subsided, and the country returned to the normal runoff of spring melts and summer showers, the creek carved a new floodplain out of the old. To what depth? Less than fifty feet. The physical changes in the Gunnison Basin since its formation and the melting of the Wisconsin ice have been of this order, no more.

Can we not, then, since the lapse of time has been so short, go back to the Gunnison Basin as it was before the retreat of ice and snow? Can we not, on the basis of the evidence at hand, return to the Basin's glacial plant world, in existence for so many more years than have elapsed since then? I think we can. As mentioned in the preceding paragraph, all that has happened, physically, since the glacial world came to an end is that the ice and snow melted, filling the valley floors with gravel, and that subsequently, the modern streams cut new beds into the gravel. Hence in returning to the Basin's plant world of, say, 20,000 years ago, we should look only for continuities, not for abrupt changes; for degrees of difference, not for revolutions. Indeed the hypothesis is strongly suggested that the plant world of the Gunnison Basin before the beginning of the big melt was not drastically different from the plant world of the Gunnison Basin today.

In this respect I wish that every one who reads these pages could stand, as I have stood, on the floor of the Basin a few miles south of Gunnison in the last week of May after a snowy winter. It will be June in a week's time; yet as he looks east and north and west, from Mt. Ouray to the Elk Mountains to the West Elks, he sees an unbroken wall of white. It extends vertically from summits as high as 14,000 feet down to elevations of 11,500 feet and lower. Beneath the surface of the wall of white there are living plants, but few growing plants. Yet in three short months, the snows of winter may well return, and in the interim the existent snows must melt and the plants do nearly all their growing. Actually, the experience of many years of collecting in the Gunnison

Basin tells me that on the average the growing season is about two and one-half months long. This is all the plants can count on.

It would be helpful if here we could turn to published records and see just what the growing season is. Unfortunately, for most of the years in which records have been kept of the weather in the Gunnison Basin, there are no accounts of killing frosts, whether the last of spring or the first of autumn. But there are some. Prior to 1930, such records were kept for a few years at several stations. The records all terminate in 1930, and comparable records do not resume until 1961. Still, it is interesting to note that in Cathedral in the southern part of the Basin at an elevation of about 9,000 feet, the average growing season for the thirteen years of the record is fifty-four days, less than two months. In Crested Butte in the northern part of the Basin at the same elevation, the average growing season for the twenty years of the record is even shorter, only forty-one days. To be sure, the "growing season" of these records is almost certainly the growing season of agriculture and household gardens, not that of the native plants in their native habitats. Nevertheless the records, such as they are, support my rough impression that the average growing season for the native plants is about two and one-half months.

In other words, to return to the Gunnison Basin of 20,000 years ago, it would seem that all we have to do is to shrink the growing season and shrink the amount of land available for the plants. For although the snows melted later then than now, and came earlier, they did melt, and the only land withdrawn from the plants was the land occupied by the glaciers. Even the lowering of timberline would not necessarily have reduced the land available for plants, but would for the most part only have changed the kinds and numbers of plants growing on the land. Fortunately, the evidence of ice sculpture and of glacial moraine enables us to reconstruct each glacier of the last glaciation, and for the southwest quarter of the Basin this has been done, as graphically as if one were looking down from a helicopter, by Atwood

and Mather in Plate III of their Professional Paper 166.* In the southeast corner of the Basin there were no glaciers (as reported by Marius Campbell in 1922),** so that the glaciers of the southwest quarter become all there were for the southern half of the Basin. As such, they can be estimated, and it turns out that they occupied about 10 per cent of the southern half of the Basin.

In the northern half of the Gunnison Basin the glaciers of the Wisconsin glaciation have not been mapped, and all I have to go on are the impressions formed during my field work in that part of the Basin. But these impressions are strong that in the northern half, the glaciation was perhaps twice as extensive as in the southern half, but not more than twice as extensive. This would give an over-all average of 15 per cent, which I offer as a likely estimate of the amount by which the viable land of the Gunnison Basin was reduced by the glaciers of the Wisconsin glaciation.

It is not an impossibility that this is also the figure by which the growing season was reduced, which would make my estimate of two and one-half months drop to two months and three or four days. In any event, one must be warned against revising the temperatures of the Gunnison Basin during the recent ice age too drastically downward. It is not needed to account for the glaciers, since accumulation of snow can explain glaciation as well as decrease in temperature, and it is difficult to see how the flora of the Gunnison Basin could have survived at all with a growing season of much less than two months and three or four days.

As for the present-day plants of the Gunnison Basin, probably their chief characteristic is the tolerance they show for the widest possible range of conditions. Often, this tolerance of the two extremes of a spectrum leads

* United States Geological Survey, Washington, D.C., 1932.

** United States Geological Survey, Bulletin 707, Part E, Washington, D.C., 1922.

to conspicuous variation in form. Thus at 8,000 feet, on an open brushy slope near the Sapinero Guard Station, Descurainia Richardsonii grows to a height of two feet and a half. At 12,000 feet, on the Continental Divide east of Spring Creek Pass, this same plant is unbranched and less than six inches tall. Again, south of Cathedral in Hinsdale County, at an elevation of 9,000 feet, Phacelia glandulosa grows along the gravelly roadside a foot and a half high. Yet almost directly above, at the head of Sheep Creek Gulch and at an elevation of 13,000 feet, the stout woody plant of the montane zone has become a mere rosette of basal leaves supporting a cluster of blossoms only an inch or two above the ground. So, too, Senecio amplectens in the spruce forests along Copper Creek and around Lake Irwin also reaches heights of a foot and a half; yet at 12,000 feet, on Slumgullion Mesa, west of Slumgullion Pass in Hinsdale County, it becomes a dwarf only a few inches tall. With all these species, plants of intermediate size are also found, and it is clear that the variation is in response to the mildness or the rigors of the situation.

But just as often, there is no visible accommodation and one can only wonder at the mechanism which permits the species to tolerate such diverse conditions. Take wet and dry, and Oxytropis deflexa, the commonest loco of the Basin. I have collected it at Gothic growing in the shade of spruce trees on the very edge of the East River, where it must have had feet as wet as it is possible for a plant to have. Yet I have also collected it growing in the middle of an old field near Gunnison, and in the light shade of aspen woods on the south-facing slope of Cebolla Creek Valley. The latter two habitats were distinctly median, if not dryish; the first as wet as wet may be. Yet without the labels, the herbarium sheets of these three collections would be indistinguishable. On the other hand, if one takes wet and dry and Aster foliaceus, then there is accommodation, and the accommodation is the same as that described for low and high! On the open, boggy bank of the East River just south of Gothic, it can be collected twenty-five inches high, with its thin red rhizomes long and smooth. But it can also be col-

lected three miles farther up the valley on a dry, steep slope of Mancos shale. Here the plant grows only about four inches high, and the thin red rhizomes are short and crumpled. Interestingly enough, these two accommodations are what are known, taxonomically, as varities Canbyi and apricus respectively. And the interest here is more than passing. For there is much field evidence that all varieties in the Gunnison Basin are phenotypic only, that, as already mentioned, in the intense selection of the refugial Basin, only a single ecotype of a species survived, and sometimes not even that.

But let us return to the general adaptivity of the Gunnison Basin plants, and take saline and nonsaline conditions. Here it must be said that the Gunnison Basin, being exceptionally well drained, has very few alkaline areas in the usual sense. But there are some, and adjoining Cebolla Hot Springs near Powderhorn, there is a saline area including overflowing springs, wet bogs, and even dry slopes. And what do we find in the runoff of one of the larger springs? Triglochin maritima and Triglochin palustris indistinguishable in appearance from their occurrence in numerous fresh-water habitats of the Basin. To be sure, this range of habitats is pointed out in the manuals, and I mention it merely to illustrate that I claim only adaptivity for the plants of the Gunnison Basin, not the appearance of new forms. My point is, rather, that study of the adaptivity of the plants in such a natural area as the Gunnison Basin might open our eyes to an inherent adaptivity as yet unobserved elsewhere. Thus Eleocharis palustris and Eleocharis pauciflora in the Gunnison Basin also grow equally well in the runoff of fresh or saline springs. But here I cannot find mention in the manuals I have consulted.

The above, of course, is adaptivity without modification, and it might be claimed that if we only knew it, all marsh plants have a similar adaptivity. But there are other marsh plants in the Gunnison Basin, tolerant both of fresh and of salt water, which yet tolerate the salt water only with modification. A couple of these are Juncus bufonius and Plagiobothrys scopulorum, of the

rush and borage families respectively. Both species are common bog plants of the Gunnison Basin, where in fresh-water habitats they grow lax and soft and green. Curiously, both plants show the same accommodation to the saline conditions of Cebolla Hot Springs, where they grow browner, and stiffer, and more erect. In fact, the accommodation brings the two species together, and until I had the Plagiobothrys in my hand I thought it was the Juncus, a confusion that would not have happened in the more usual fresh-water habitats of these plants.

And there is modification, or variation, with the adaptive significance obscure. Almost any plant in the Gunnison Basin can be collected, not with occasional, but with systematic rhizomes. Thus I have collected Eleocharis pauciflora and Hordeum brachyantherum with conspicuous cordlike rhizomes linking together various individuals of a given population. The Eleocharis was growing in a grassy bog; the Hordeum in a dry, stony place. Neither place is out of the normal range of habitats for these species in the Gunnison Basin, and I cannot grasp the significance of the rhizomes. But significance there surely was, or such a systematic development of rhizomes would not have occurred throughout the plants of the given locality.*

But to leave modification for a moment, and to return to simple tolerance, which is a much more important trait of the plants of the Gunnison Basin, I should like to speak of the tolerance for frost shown by all the native plants of the Basin. After a July descent of the thermometer to 28°F., visitors to the Gunnison Basin never cease to marvel both that such a thing can occur and that the

* Upon reading an early draft of this introduction, J.F. Pelton remarked that such systematic development of rhizomes would enable a plant to survive "perhaps for thousands of years at a time without maturing seed." I think the reason this idea did not occur to me is that rhizomes were associated in my mind with migration. But of what use migration, if in the meantime the plant becomes extinct?

plants, the next morning, look more beautiful than ever as the frost melts upon their leaves and flowers. Scarlet gilias, blue lupines and flaxes, pink roses, yellow aspen sunflowers--all seem to have been oblivious to the rigors of the night before. The temperature can, and does, in fact, fall to 28° during any night of the summer. Yet I have never seen a frost-killed native plant in the Gunnison Basin until the last week in August, when then the temperature may drop to 24° or lower for two or three nights in a row. When this happens, it is the end of the growing season, and there is a general turning of the plants from green to brown.

Again there is tolerance with respect to sun and shade, and here the spectrum extends from the full blaze of the Colorado sun on a broad valley floor to the dense shade of deep, spruce-fir forest. The parsley, Conioselinum scopulorum, is a good example. The plant is widespread in the Gunnison Basin, and ranges in altitude from the meadowy bottomlands of the Basin to the upper limit of the forest. It seems only not to occur on the sagebrush foothills and in the alpine zone--in which zone must be included the belt of Krummholz, where the low, scattered trees do not prevail over the wind and dryness of the altitude. With the exception of these two habitats, Conioselinum scopulorum can be found anywhere in the Basin if the moisture is sufficient: in the dense shade of the pre-Columban spruce-fir forest of the Gothic Natural Area at 10,000 feet; on the meadowy edge of Fish Creek at 9,000 feet, where only the steep walls of the valley limit the sunshine; and in an open cow pasture near Powderhorn Postoffice, at 8,000 feet, where the distant hills do not limit the sunshine, which floods in from morning till night.

Nor does there seem to be significant modification. True, the plant from the spruce-fir forest is the tallest and the sprangliest, being thirty inches high, with basal leaves nine inches long; while the plant from the cow pasture is only fifteen inches high, with basal leaves only seven inches long. Still, these are not measurements to draw conclusions from, and the plant seems to be tolerant of everything except a lack of moisture. Moisture it must have, and moisture alone seems to be the factor controlling its occurrence in the Gunnison Basin.

Flowering season is another respect in which there seems to be great latitude among the plants of the Gunnison Basin. Again and again, to the botanical collector in the Gunnison Basin, the plants seem to flower at any and all times. He seems forever to be collecting in midsummer, or indeed at the end of it, a plant in full blossom which previously he had regarded as a spring flower. To some, his surprise may well seem naive, and the claim of variability in flowering season may seem to be the weakest of the claims of this introduction. For it is a commonplace in the Rocky Mountains that if one misses the blooming of a plant in a lower zone, all one has to do is to wait until it blooms in a zone higher up. Thus in the Gunnison Basin Geum triflorum can be found blooming not only at the end of May in Waunita Park at an elevation of 9,000 feet, but also at the end of August on Slumgullion Mesa at an elevation of 12,000 feet. And collections from the two different stations at the two different times will be found to be identical.

This, however, is not the variability claimed here. The variability claimed here occurs when the two collections come from the same station! Thus Astragalus Pattersonii, with its plumes of white blossoms and low, reddish stems, is a conspicuous plant in the east part of the Basin around Doyleville. It can be collected in flower both late in May and late in August, the only difference being that in August the specimens are usually also in fruit. This condition is characteristic of many other plants of the Gunnison Basin. Thus late in the summer, and in its habitat, Cornus stolonifera can be collected almost anywhere in the Basin both in fruit and in flower.

To make a long story short, it seems to me that the ability to flower at any and all times must have had a selective advantage during the refugial period even as now. For then, as now, the seasons at times must have been wildly irregular. Thus I can remember returning to Crested Butte on June 14, 1957, for the 1957 collect-

ing season, only to find that snow was still in the streets and that the good citizens of the town had not yet removed the community Christmas tree; and until I had to leave the Basin on the 14th, I remember September of 1959 as being composed of nothing but warm, sunny growing days.

Now with an average growing season of only two months and a half, and with this period, on the whole, consisting of the last three weeks of June, all of July, and the first three weeks of August, a species that can flower in May, or bear fruit in September (or perhaps both), will have a selective advantage even if the chance occurs only once in a lifetime. This is the meaning, it seems to me, of the countless plants in the Gunnison Basin that blossom too late to bear fruit, a situation that is particularly characteristic of the grasses and sedges of the alpine zone, which are frequently caught by the coming of winter in late August while they are still in a state of inflorescence. The one year in which they can mature fruit, no matter how rare, will make up for the many years in which they cannot, and will give them an advantage which, no matter how slight, will be of value in the world of intense plant competition that still obtains in the alpine zone of the Rocky Mountains. How much greater this value may have been in the refugial period of the Gunnison Basin the reader himself must determine.

This leads to the last adaptivity of the plants of the Gunnison Basin of which I wish to speak. In 1959, acting upon a report of two students at the Rocky Mountain Biological Laboratory, I was fortunate enough to come upon what is apparently the second known station for Eriophorum Scheuchzeri in the United States. This was in a small alpine basin of the Elk Mountains, hidden by its own lip from the eye of man, and visible only from the air. Behind the lip formed by the glacier that had once been there was now a pool; surrounding the pool was a large bog; then a zone of more median plant life; and finally the sparsely vegetated alpine slope that ascended to the crest of the mountain above. At the edge of the pool, and over a large part of the bog, were the gay, bobbing heads of the cotton grass. It was an unforgettable

sight; and in 1961 I brought a fellow botanist to view it. The next year the botanist brought a group. Imagine their surprise and disappointment (although the month was August) to find the small basin completely filled with snow, with not a chance of its melting before the snows of September came to add their increment.

In other words, the entire plant world of this small basin, composed of numerous grasses, sedges, and forbs, was destined to go two years between growing seasons. Indeed this must occasionally be the case for more than two years, and for a number of other alpine basins in the surrounding mountains of the Gunnison Basin. During the colder years of the last glaciation, the situation must have happened frequently.

Thus the last adaptivity claimed for the plants of the Gunnison Basin is the adaptivity of going for a year, or years, without a growing season. True, this adaptivity must now be largely latent. But there were hundreds of different species in that small alpine basin, species that grow far and wide in the larger Gunnison Basin; and these species (or at least the Gunnison Basin races of these species) must all possess the ability to go for a year or more without the normal emergence into leaf and flower. This seems to me to be the most remarkable ability of the plants of the Gunnison Basin.

So much for what is probably the chief characteristic of the plants of the Gunnison Basin, a characteristic that I have called indifferently tolerance, variability, adaptivity, and even modification. By whatever name is most suitable, the characteristic is clearly a result of the refugial years of the plants in the Gunnison Basin, and of the intense selection of that time.

The second and last general characteristic of the plants of the Gunnison Basin which I wish to point out is their indigenousness. This quality is second only because it obtrudes itself upon the consciousness of the observer more slowly than does the variability of the plants. It is, in fact, well known among botanists that the absence of familiar plants is much more tardily

recognized than the appearance of new ones. Thus it is usually not until the first impressions have worn off that the botanical visitor to the Gunnison Basin begins to notice that the world of adventive plants, so conspicuous in the East, is here remarkably constricted. In his Natural Geography of Plants, Gleason observes that in the northeastern United States and Canada the plants of foreign origin constitute 18 per cent of the flora.* In this study, they account for only 7 per cent of the Annotated List, and even this figure is clearly too high. For of the 77 species forming the 7 per cent, more than a third are known only from single collections, so that whether or not they are established and thus truly adventive is still to be proved. My own belief is that 5 per cent is the highest figure that can be given to the adventive plants of the Gunnison Basin.

I should like to make this scarcity of foreign plants as real as I can. For it is not that the Gunnison Basin is without weeds, but that the weeds are native weeds. There are roadcuts aplenty in the Gunnison Basin, and it is instructive to observe the plants that populate the exposed native soil. One of these is Oenothera caespitosa. The flowers open in the night, and in the morning the white fragrant blossoms, as much as five inches in diameter, are still displayed and do not fail to catch the eye of botanists setting out on a day's expedition. I have seen an automobile load of these brought to a stop by the sheer magnificence of the display. For the individual blossoms, although destined to wither in the course of the day, are carefully spaced out both to cover the available soil and to preserve the particularity of the individual flowers themselves. And there are a host of other wayside plants equally ready to seize exposures of native soil left by the highway department. Some that come to mind are Senecio atratus and Senecio eremophilus, for higher and lower elevations respectively, and Penstemon Whippleanus and Penstemon strictus, also for higher and lower ele-

* Gleason & Cronquist, The Natural Geography of Plants, N.Y., 1964, p. 34.

vations. Again, Corydalis aurea is probably as common as Oenothera caespitosa; and Lathyrus eucosmus is as showy, if blue may be compared with white. Even plants like Mentzelia Rusbyi and Leucampyx Newberryi are common wayside weeds in their more restricted areas. On the floor of the Basin there are also native "weedy" weeds like Lappula Redowskii and Cryptantha Fendleri, ready and willing to seize most waste places of a dry or sandy sort.

On the other hand, such adventive plants as occur either receive the help of man and his animals, or are permitted those places which the native plants can afford to neglect. Thus the common dandelion is certainly widespread; but its prevalence is largely restricted to pastures and grazed meadows. Again, I have made a few collections of Phleum pratense (the plant is not common as an escape in the Gunnison Basin); but one was in an abandoned section of dirt road where the road metal was so hard that this species and Dactylis glomerata were the only plants growing, while another was in a bed of pure gravel, recently exposed by Cebolla Creek. In contrast, Phleum alpinum grows everhwhere, in wet places and in dry, above timberline, below timberline, and on the floor of the Basin along the dirt roads of Powderhorn Valley. Again, both the melilots can be found, the yellow even in abundance, although for the most part hugging the pavement of the new highways, or restricted to the rock ballast supporting them. As a last example I should like to mention Verbascum Thapsus. Despite its commonness elsewhere, it is rare in the Gunnison Basin. In fact I know of but one place where it grows, in the southern half of the Basin, close to the pavement of the highway and restricted to fifty or a hundred feet on just one of the sides.

But the indigenousness of the plants of the Gunnison Basin has produced more interesting experiences than the observation of the disproportion between native and foreign plants. Several years ago I was in search of a collecting area near Gunnison, and in the course of it came upon an abandoned schoolhouse about five miles

northeast of Gunnison. With its empty carriage sheds and neglected field to the rear, it was completely desolate, and reminded me of similar abandoned schoolhouses and churches in the New England of my boyhood. The abandoned field behind the schoolhouse was especially inviting, and I plunged into it expecting to find some native plants, but chiefly a concentration of the foreign weeds to be found in the neighborhood of Gunnison. The field, however, turned out quite differently from what I expected. There was a brook at one edge of it, and curiously, the field seemed to be divided into wet and dry places. It was in one of the wet places that I made my first collections, including two orchids and a carex that has not yet been collected elsewhere in the Basin!

Now in the abandoned fields of my youth in New England one did not find orchids and rare carices, at least not until the fields had ceased being fields, and the woods had taken over. The circumstances were, in fact, so unusual that I conducted a small inquiry as to the origin of this abandoned field with its surprising native plants, and in so doing, unearthed what I can only regard as a great ecological opportunity missed. For I discovered that a few years prior to my coming, the field had been leased to a contractor in search of gravel. Originally part of the floodplain of the Gunnison River, the field, of course, had a substratum of gravel, and the contractor was supposed to push aside with his heavy machinery the superimposed soil, and then, after the gravel was removed, push it back. In other words, after the removal of the gravel, there was suddenly offered to the disseminating seeds of the Gunnison Basin a field of soil as fresh as if the melting of glaciers or the drying of outwash had occasioned it, the only difference being that in the days of the retreating glaciation there were no botanists available, that now they were available but not informed. What an opportunity missed! What a chance to see just what plants came first and how long they survived! The best I could do was merely to observe, several years late, the surprising invasion by the native flora; and even this belated opportunity was of short duration. For

within a year or two of my arrival, the field was leased for pasturage, and with the coming of the animals came the inevitable invasion of foreign plants. However, short as the belated opportunity was, it nevertheless afforded additional proof of the superior adaptation of the native plants to the conditions of the Gunnison Basin.

Another example of the indigenousness of the flora of the Gunnison Basin is to be found in the meadows which, together with their adjoining sagebrush slopes, compose what may be called the floor of the Basin. From around Gunnison, where the elevation is 7,700 feet and they attain their greatest extent, these meadows radiate in every direction, now narrowing, now broadening, but without perceptible gradient, until they reach the mountains that form the boundary of the Basin. It is instructive to look down from one of these mountains upon the meadows of the floor of the Basin. From Mt. Emmons, which rises steeply above Crested Butte at the northern edge of the Basin, the meadows of the floor form a remarkably level surface at an elevation of slightly under 9,000 feet. All the meadows of the floor are, in fact, old floodplain; all of them (with the exception of those that follow the Gunnison River down to Sapinero) rise, as they approach the mountains, to about the same altitude; and all of them compose the foundation of the cattle industry, in that from them comes the hay that keeps cow and horse alive during the long winter.

These meadows, for the most part, have never been plowed. In fact a son of one of the pioneers, speaking of the meadows at Powderhorn, told me that all that the pioneers did was to grub out the willows by hand with a mattock. The report for the meadows around Doyleville, in the east part of the Basin, and for the meadows southwest of Cathedral in Hinsdale County, is the same. They have never been plowed or seeded; they have only been fenced and mowed. To see what the meadows southwest of Cathedral contained, I went one day to a field that had just been mowed, and walked back and forth, sampling the new-mown hay. My sampling showed that the two principal "grasses" (to use the names by which they are

known among the ranchers) were Junegrass (Deschampsia caespitosa) and wiregrass (Juncus balticus). Two minor grasses were wild redtop (Agrostis scabra) and squirreltail (Hordeum brachyantherum). In addition, there were scatterings of Beckmannia and Alopecurus (in wet spots), of Carex (at the edges), and of a very few forbs such as Castilleja sulphurea and Potentilla anserina.

In passing, it might be of interest to observe (in evidence of the native quality of the meadows) that the ranchers with one accord value most highly Juncus balticus. Although the cattle will not eat it in pasture, they will as hay; and the ranchers are agreed that it has no equal for protein content, or perhaps one should say, for protein-forming content. They all would like a greater concentration of it in their meadows, and would like to procure seed to achieve this end. It was here that I suggested that they take a hint from the growing of iris in gardens, plant small sections of root here and there, and let the plantings grow and merge into a pure stand.

But not all the meadows of the Gunnison Basin are the result merely of enclosure and mowing. Apparently in and near the mountains, where the horses and mules used in the mining industry created a need for feed, the original floodplain meadows were plowed and seeded to grain. Later, when the mining industry came to an end, and cattle raising became very nearly the sole industry of the Basin, the grainfields were turned to hayfields, and the meadows reverted to their native condition. But not quite; for today they certainly contain a greater proportion of adventive plants than the meadows that were never plowed. Yet this is not the chief impression they make upon a botanist. A botanist at once notices the surprising increase of native forbs! Thus in the hayfields of Quartz Creek Valley south of Ohio City (which were once used for grain), in and among the grasses are growing in great luxuriance Lilium philadelphicum, Spiranthes Romanzoffiana, Habenaria hyperborea, Castilleja sulphurea, and other native forbs that apparently make as good hay as the grasses for which the

fields are cut. As a matter of fact, these meadows are the only known station for Lilium philadelphicum in the Gunnison Basin.

I should like to offer one last example of the indigenousness of the plants of the Gunnison Basin. One day, a few years ago, I made my first collection of Ribes aureum in the Gunnison Basin. The shrub was growing vigorously in a small population near the former hamlet of Madeira Siding, on either side of the abandoned bed of the narrow-gauge railroad that used to go up the Lake Fork to Lake City. Theoretically, there was no reason why the plants should not have been native. But the cautiousness of many of my botanical colleagues, who seem always to favor ad hoc hypotheses of accidental seed dispersal, made me pause. Perhaps a brakeman, walking along a train stopped at the siding, and bending over to examine the journals of his cars, had dropped some currants that he was carrying in his pocket. But then, a year later, on Quartz Creek one day, I noticed a vigorous hedge of the plant behind a turn-of-the-century house that was well kept up and tenanted. I stopped and inquired. The mistress of the house, herself the daughter of pioneers, gave me just the information that I wanted. The hedge behind her house came from the hedge behind the house of Alonzo Hartman, chief of the Gunnison pioneers, and "Lon" had got the original plantings from Taylor Park where the plant was growing wild. Indeed, as a result of this and many similar experiences, I have formulated for my own use the working principle that if a plant in the Gunnison Basin can be native, then it is native.

Now this principle (which I try to use with scientific moderation) poses an interesting botanical problem in reverse. What if a plant, assumed by everyone to be non-native, nevertheless behaves in every detail as if it were native? A number of years ago I came across Rumex Acetosella growing in one of the most perfectly native spots in the Gunnison Basin, a moist, open swale, removed from the haunts both of man and of his animals. The soil was rich, and there was an unusually vigorous

growth of native plants: clumps of Salix Wolfii, and many individuals of Geum macrophyllum, Mertensia fusiformis (the largest specimens I have ever seen), Deschampsia caespitosa, Carex Raynoldsii (not common in the Basin), Ranunculus alismaefolius, Epilobium saximontanum, and many other similar plants. Not only have I never found an adventive plant in such a community of native plants, but this Rumex was the only one in the community reputed to be adventive. Furthermore, far from wilting under the intense competition of this favorable site for plants, it was showing the unusual vigor of all the rest.

Is it any wonder, then, that I asked myself whether this plant was really a foreign plant, whether it might not be, after all, another of the many circumboreal species that populate all the northern continents? I do not say that it is. I offer only my experience with the plant, and the possibility that, like Achillea Millefolium, it may turn out to be, not a botanical migrant, but a plant quite as native to North America as to Europe and Asia.

So much for the variability and the indigenousness of the species that compose the flora of the Gunnison Basin. Both peculiarities surely stem from the conditions of heightened plant selection that obtained in the Gunnison Basin not so long ago.

But what about the species, not as composed of the individual plants that make them up, but as entities in their own right, to be distinguished from other species, also as entities in their own right? What about the species in the strict abstract sense? To this question the answer among botanists, two times out of three, is that it "depends upon your concept of the species." My own view is that it surely does, and in the remaining pages of this introduction I should like, not only to set forth my own conception of the species, but to gather together loose threads and draw out the implications of my conception for the plants of the Gunnison Basin.

It so happens that one of the most memorable botanical experiences of my life is connected with just this problem of the concept of the species. During two of

my undergraduate years I was fortunate enough to have a summer position in one of the state forest services in the East. The job involved camping in the forests in which we worked, and much enjoyable work out-of-doors. But most memorable was the association with the foresters themselves; and the most vivid recollection I have of them is of their cruising through the rich deciduous woods, and with merely an eye-level glance at the bark of the trees, selecting this tree or that according to their purposes. None of the foresters ever had to look at a leaf or a flower or a fruit. And none of the foresters ever made a mistake.*

Now these foresters were employing what I regard as the common-sense concept of the species. In the first place, it was practical, not academic. If it happened that they were selecting for timber, then the lumber from the sawmill would test the dependability of their concept of the species. Again, it was macroscopic. The characters that differentiated one species from another did not require optical equipment for their detection, and indeed could be observed at a fairly rapid walk. Still again, this concept of the species was not based upon a single, key character, but upon many--upon color and geometrical design and relief, these characters being complex in their turn, and the whole trailing off into what could conceivably be caught by photograph or by drawing, but could be expressed only with difficulty in words. Nor let it be said that because practical this concept of the species has no place in plant taxonomy. What

* Upon reading this passage in manuscript, F.J.Hermann recalled the difficulties of his students at Temple University with the genus Lechea. Laboratory material made them almost desperate on account of the smallness of the flowers and the fineness of the distinctions. But when on field trips they saw the plants growing in the pine barrens, and were able to see the totally different aspect of each species, their difficulties vanished and they were able finally to identify the plants from a car going forty miles an hour.

other concept does the botanical instructor use in going through his interminable piles of student collections? And not only the botanical instructor. A few years ago A.A. Beetle (my mentor in all things agrostological) and I were in considerable puzzlement over an odd grass I had collected in one of the alpine basins above Gothic. I happened to mention our puzzlement to Hugh Iltis who said, "Why don't you get in touch with Shoichi Kawano who has been specializing in just this sort of thing but who, unfortunately, is returning to Japan in a few days." The interesting thing is not that I caught Dr. Kawano before he left for Japan, but that he wrote, "I recognized your grass as soon as I opened the package."

Clearly, the multiple-character, common-sense concept of the species stands at one end of a spectrum, the single-character, key concept at the other. How many come in between I do not know; but I am convinced that most concepts of the species do come in between, and may be judged by the multiplicity or singleness of the characters which they employ. Indeed, in his classic Species Concepts and Definitions, Ernst Mayr observes that there has been a trend toward a synthetic concept of the species.* I would claim for my notion only the distinction of its being the most synthetic of all. Nor would I derogate from the usefulness of any of the other concepts.

Even the single-character concept is no less useful for being at the opposite end of the spectrum. By what other means does one become acquainted with a new plant? The trouble with the single-character concept lies not in itself, but in the fact that many never get beyond it. All lumpers and splitters, in my opinion, never get beyond it. The splitter has a tendency to find a new, key character in every plant he examines. The lumper has a tendency to take a key character and unite into a single taxon every plant that possesses it. These persons stop with mere acquaintance, and do not go on

* The Species Problem, ed. Ernst Mayr, Washington, D.C., 1957, p. 17.

to full knowledge.

But I do not wish to labor the distinction between the common-sense and the single-character concept of the species, and would rather turn to a concrete problem presented by the flora of the Gunnison Basin to show how useful the common-sense concept may be in straightening out a bad taxonomic muddle, if not a botanical scandal.

For it is a matter of record that in 1955 when I first became interested in the lupines of the Gunnison Basin, no resident or visiting botanist connected with the Rocky Mountain Biological Laboratory could determine the chief lupine about Gothic. Indeed, this lupine was not only the chief lupine about Gothic but the chief flowering plant. For by common consent, the most beautiful and striking floral display of the whole summer around Gothic is presented by the lupine that Greene called amplus. Individual plants make large bushes, which grow in large populations. The blossoms in their turn are large, profuse, and strikingly two-colored. And when the plants are set off by the local species of Wyethia (which bloom at the same time), the spectacle makes you stop your car. Yet there simply was no agreement among the botanists in residence or visiting the Rocky Mountain Biological Laboratory as to what this lupine was. The plant was called a variety of names. But always, at least in one character, there was a glaring contradiction between the plant in the hand and the description in the manual that was consulted.

Then one day, in turning over some early collections of Lupinus from the Gunnison Watershed (as it was called then), I began noticing some multiple, macroscopic characters in certain of the sheets I was examining. I think this first happened with the lupine that Green called rubricaulis. I noticed that its leaflets were of a peculiar green; that they were not the usual pointed ellipses, but clavate, with a small mucro at the blunt end; that there was always at least one fully flattened leaflet to a sheet, a thing by no means common among the lupines, whose leaflets usually close upon the moment

of collection. Here, then, was a common-sense character that seemed to separate this lupine from all the others growing in the Gunnison Basin.

The usefulness of this character made me turn to Greene's Lupinus amplus, the lupine that was always central in my interest and the one I most wanted to understand. It is, of course, the largest lupine in the Basin, with blossoms as much as five-eighths of an inch, and leaflets as much as three inches, long. But since all organisms can produce dwarfs, I wanted a macroscopic, common-sense character that would work even if the plant were undersized. This I seemed to find in the attenuated finial of the raceme. For the fact remains that Lupinus amplus (to use Greene's name) can possess such a finial of undeveloped blossoms even when the lower blossoms are already passing into fruit. On the other hand (and one should remember that the "other hand" is always part of a complex, common-sense character)--on the other hand, the Gunnison Basin lupines confusable with amplus usually do not possess such a finial, but on the contrary, present a cylindrical raceme of blossoms that can appear even truncated at the top and at the bottom.

I do not intend to go on in this way and discuss the macroscopic, common-sense characters of the three other most frequent bushy lupines of the Gunnison Basin, namely, argenteus, caudatus, and floribundus. These can be given in the Annotated List, and by this time another spring was at hand, and I was ready to go into the field. Here the results of a macroscopic, common-sense examination were fully as rewarding. For it was clear that open roadsides and open meadows in the foothills zone were the particular province of Lupinus floribundus, while Lupinus caudatus, for its part, preferred the company of sagebrush, especially in that zone where sagebrush and aspen meet. Again, it was clear that Lupinus argenteus, was, in general, a plant of the lower montane zone, with a particular liking for the partial shade of ponderosa pine or aspen. With Lupinus rubricaulis and Lupinus amplus, the consequences of a fresh

behavioristic look in the field were even more gratifying. For it was clear that both the alpine and the subalpine zones were the province of Lupinus rubricaulis, and that the entire montane zone was the home of Lupinus amplus, where it seeks the less-shaded habitats. And here is an interesting thing. When Lupinus rubricaulis occurs as a relict in the montane zone and is associated with Lupinus amplus, then it will be found that rubricaulis seeks the coolness of the interior of the aspen groves, amplus the sun and warmth of the openings or edges of the groves. And this is not all. For when the two are found together (and they can be found growing within feet of each other), then it will be noted that amplus is always ten days or two weeks earlier in flowering season than rubricaulis, rubricaulis always ten days or two weeks later than amplus.

This is one of the most intriguing aspects of the flora of the Gunnison Basin. Again and again it seems as if the plants (and especially the species of a single genus) have not only staked out their territories (like the birds), but even staggered their flowering seasons. Thus when Oxytropis deflexa and Oxytropis splendens are found growing together it will be observed that deflexa is earlier than splendens by the same differential as Lupinus amplus is earlier than Lupinus rubricaulis! Now no one doubts that the various techniques of what may be called micro-ecology are the only possible basis for a statistical study of populations and the incidence of species. But there are floristic questions beyond the approach of micro-statistics, questions, it seems to me, that might receive their answers by taking a natural area like the Gunnison Basin as a whole, and by observing the behavior of the different species in it, especially the different species of a single genus. I am convinced that the rewards of such a macro-ecology would be very great, and that such questions as the reasons for the scarcity or abundance of individuals, the reasons for the rarity or commonness of species, might thus receive significant answers.

In any event, when it comes to a difficult genus like

Lupinus, the rewards of a macroscopic, common-sense approach would appear to be considerable. And surely the first counsel of such an approach would be to restrict the field of study, as has been done in this flora. For in the case of Lupinus, it would seem that one simply cannot know all the lupines of North America or the United States well enough to write an account of them for a large section of North America or the United States where they are frequent and diversified. At any rate, with the possible exception of Rydberg's Flora of the Rocky Mountains and Adjacent Plains, none of the manuals or treatments of Lupinus available in the 50's or early 60's came near coping with the problem of Lupinus in the Gunnison Basin, and Rydberg's Flora suffered from the compression of text necessitated by the large scope of the work. The lupines need a maximum, not a minimum, of detail to bring out the full diversification of species, and this is best achieved by taking, if not a natural area, then an area small enough to permit many collections and much field observation. Lupinus is one genus where I think my idea of the patchwork quilt would be more satisfactory than the present system of revising whole genera, or sections of genera, for large areas.

Nor is the desirability of the common-sense approach in botanical science limited to the delineation of species. It can have a therapeutic effect upon the vexing problem of plant names. For the fact remains, as a glance at any group of manuals will show, that in spite of an increasing awareness of the International Code of Botanical Nomenclature, there is no agreement in the use of plant names where the Code does not apply.

Let me give some examples. In 1939, in Madroño 5: 123-124, although admitting that the two entities can "easily be distinguished," Ledyard Stebbins gave his reasons for thinking that Lactuca pulchella, the common roadside lettuce of the Gunnison Basin, is in reality only a subspecies of the Old World Lactuca tatarica. Since then, many manuals have been published, and what do we find in a representative sampling of these manuals? Weber in his Handbook of Plants of the Colorado Front Range (1953), Munz in A California Flora (1959), and Ferris in the Illustrated Flora of the Pacific States (1960) accept the nomenclatural change. But Fernald in the eighth edition of Gray's Manual (1950), Harrington in his Manual of the Plants of Colorado (1954), and Cronquist in Vascular Plants of the Pacific Northwest (1955) reject it. Indeed, to judge only by the consequences, and not at all by the merits of the case, it would seem that the result of Stebbins's well-intentioned suggestion has been simply to create two names instead of one for the common wild lettuce of the Western states. Again, in 1956, Verne Grant in El Aliso 3: 351-362 published his reasons for believing that the scarlet gilia, a conspicuous plant in the Gunnison Basin, should, along with its close kindred, be separated from Gilia and given the old generic name of Ipomopsis. Fewer years have elapsed since 1956 than since 1939; but a sampling of the manuals published since 1956 reveals the same picture of divided acceptance. Thus Munz in his California Flora goes along with the proposed change, and so do Howell and McClintock in the second edition of the Arizona Flora of Kearney and Peebles (1960). But Cronquist does not in Vascular Plants of the Pacific Northwest (1959), St. John does not in his Flora of Southeastern Washington (1963), and Hermann does not in his Notes on Western Range Forbs (1966). Finally in 1957, in Brittonia 9: 231-239, Cronquist and Keck proposed a similar change in the genus Aster, suggesting that the taprooted asters, also conspicuous in the Gunnison Basin, be separated from Aster and put back into Nees's old genus of Machaeranthera. Once again, the proposal seems only to have produced a multiplication of names. For although Munz and Ferris in their respective manuals accept the change, Hermann in his manual and Welsh, Treshow, and Moore in their Guide to Common Utah Plants (1964) do not; while Howell and McClintock evidently have their doubts.

Now the men who proposed these changes are men of eminence. Their influence has been so wide in plant science that all botanists stand in their debt. How does it happen, then, that in this matter of nomenclature they have not been convincing? I think I can give an explana-

tion. It seems to me that here, even if unwittingly, they have given expression to personal opinion rather than to thinking that is strictly scientific.

Curiously, this is a matter that since the days of the Greeks has been a business of fruitful concern to philosophers if not to botanists. Both Plato and Spinoza classified the departments of knowledge, giving an inferior position to "the opinions of men." More recently, Charles Peirce, the American philosopher of science, conceived a happy phrase to describe, not the opinions of men, but the kind of knowledge that science, through its empirical method, has been steadily accumulating. This knowledge, in Peircean phrase, is knowledge with which all who investigate are fated to agree. It seems to me that this phrase of Peirce's can be used to discriminate between changes in botanical nomenclature that are matters of opinion, and changes that are strictly scientific.

Once again let me give an example from recent plant science. In 1953, in Leaflets of Western Botany VII: 17-18, Arthur Cronquist published a brief note asserting that what was then known as Astragalus decumbens had originally been named Astragalus miser. His note was based upon the type of the latter in the British Museum, and I have no doubt that all who similarly investigate the type of Astragalus miser will be fated to agree with Dr. Cronquist. As a matter of fact, this nomenclatural change (as far as I know) has been accepted by all subsequent authors. On the other hand, nothing of the sort has been the case, or will be the case, with the above-mentioned changes in Lactuca, Gilia, and Aster, for these changes are clearly in a different realm.

As a matter of fact, with changes of this latter sort, it seems to me that we are in a realm not even of contemporary human opinion, but rather, have returned to the old dispute about particulars and universals that went on in the Middle Ages between the Nominalists and the Realists. Now this dispute was about the extremes of a spectrum, with the Conceptualists trying to maintain the position of common sense in the center. It is this latter position that is the natural point of view of biologists,

namely (in the words of Lewis White Beck),* that all organisms possess a "whatness" (or universal quality) and a "thisness" (or particular quality), a "whatness" that unites them with other organisms, a "thisness" that is theirs alone, and confers individuality upon them. Thus a dog (to use Professor Beck's example) has a "whatness" that enables the veterinarian to prescribe for him, and a "thisness" that permits his master to recognize him among a hundred others of his breed.

Oddly enough, although most biologists would unhesitatingly accept the Conceptualist position that all things are an inseparable mixture of the two, there are botanists (at least in plant taxonomy) who linger on the "whatness" of plants to the exclusion of their "thisness"; or on their "thisness" to the exclusion of their "whatness." It seems to me that the latter, with their lingering on the particularity of plants, are once again the splitters who, if they don't watch out, will end by believing each plant to be a species. By contrast, it seems to me that those who dwell upon the "whatness" of plants, with their similarity to the Medieval Realists, can be either lumpers or splitters, now lumping species, now splitting genera, but in any event, paying more attention to the classifications of plants than to the plants themselves.

I hope there is no one who thinks this is much ado about nothing. Certainly, the vacillation about names has been unfortunate upon herbaria. It is a common sight to see herbarium sheets so profusely annotated that the plants themselves have yielded first place to their nomenclature. In fact, so widespread is the belief that plant taxonomy is nomenclature that when John M. Gillett's revision of Gentianella appeared, I know of one graduate student who, without asking permission of the curator, printed annotation labels and went through the folders of Gentiana in the herbarium of his university, automatically making all the changes proposed by Gillett. Incidentally, a good many of Gillett's proposed changes seem to have met the equivocal fate of those already mentioned.

* Philosophic Inquiry, N.Y., 1952, pp. 124-128.

But there is a more deleterious consequence of the uncertainty in names than its effect upon herbaria. It seems to stifle any budding enthusiasm that an amateur may have for contributing to botanical knowledge. Now this is serious. Several years ago it was my good fortune to spend a summer at Gothic with Herbert Mason at the Rocky Mountain Biological Laboratory. Toward the end of the session we were talking about the possibility of writing a flora of the Gunnison Basin, and I well remember his comment on the Basin: "The surface of it hasn't even been skimmed!" Indeed this flora, now terminated (but not finished), can be regarded only as a first skimming.

But how can this be? The botanists (most of them amateurs) arrived in Colorado with the pioneers, and by the beginning of the twentieth century enough information had been accumulated for the appearance of manuals that still have their place. Dependable collections were made in the Gunnison Basin as early as the 1880's. How can it be that this present flora, published in the 1960's, can be regarded only as a first skimming? The answer is that in the West there were never enough amateur collectors, and that the few that there were have largely gone out of existence since the great debate about names began in the 1930's. Fernald, in his Preface to the eighth edition of Gray's Manual, pays handsome tribute to the amateurs who contributed to his work. Yet even if there had been an equal number in the West (and there never were), they would not have been equal to the task, so large is the West in comparison with the East. That these few should be cut off by the war about names is nothing short of tragic for the state of Western botanical science. I remember one interested amateur telling me of having sent a plant to a specialist. He waited more than a year for the reply, which was then that the plant could be given either of two names depending upon the individual's point of view. Is it any wonder that this amateur said to me, "What is the use?" In the name of common sense, and for the sake of accumulating an adequate body of knowledge about our Western flora, let us give up this constant revision of the species and genera

except where there is reason to believe that all botanists who investigate will be fated to agree.

To conclude, let me return for a last time to Ipomopsis, Machaeranthera, and the plants of the Gunnison Basin. From 1913 to 1950, I suppose there was not a more widely used botanical manual in North America than the second edition of Britton and Brown. Even the famous seventh edition of Gray's Manual was not, it seems to me, used so far from Boston as Britton and Brown was used far from New York. I was early familiar with it, and particularly liked the division of the Leguminosae into three families, the Compositae into three, the Liliaceae into several, and so on. I still regret that Britton could not win the Europeans to his view. But taxonomically, this is all beside the point. The taxa exist independently of man's debate about them. It so happens that I am writing these words after a collecting trip to southern New Mexico and Arizona. There I collected mimosaceous peas, caesalpinaceous peas, and fabaceous peas. These different, naturally occurring groups were as existent as existent may be; and it seemed to me (almost in terms of the Gunnison Basin) that I could see them parceling out the arid landscape so as to make sure that no group got more than its due share. And so, as I write these words, I ask myself, "What difference does it make whether we term these groups families, subfamilies, or tribes?" The groups are there, term them as we will, and the botanical challenge is to understand their evolutionary relationships, and their present-day behavior.

Verne Grant understands the business perfectly. It is a business of convenience--human convenience. In his Summary to the above-mentioned article in El Aliso he writes, "The transfer of a large series of species to the new genus Ipomopsis will work a temporary inconvenience on botanists in the western states; but against this inconvenience must be set the advantage to be gained by having a more natural and workable system of classification." Yet the history of the human race shows that such decisions of convenience are never made by indi-

viduals, not even engineered by individuals, but result from the slow consensus of all the people concerned. And in this slow consensus the greatest convenience is always not to change. Thus the days of the year are naturally occurring entities, and may be grouped in a number of ways. In the French Revolution, many reasons prompted a change from the seven days of the week to the ten of the décade. But in spite of the advantages, the change endured for only a few years. Surely, some of the proposed changes of botanical convenience are going to fare no better than the décade of the First French Republic.

Needless to say, in the ensuing Annotated List I shall follow the International Code of Botanical Nomenclature whenever I can. When the International Code cannot be invoked, and a decision must be made between a new name and an old name, I shall look for the element of fatality, or inevitability, in the evidence advanced in support of the new name. If this element is present, and if as a consequence there appears to be some agreement among botanists, I shall be happy to add my concurrence to the gathering consensus. But if there is no inevitability, and no gathering consensus, then I shall follow common sense and employ the name used in Harrington's Manual of the Plants of Colorado, the book that will be most consulted by those using this flora. In fact, so great is the need for an agreement between this flora and Harrington's Manual that in those cases where the name used here differs significantly from the name in the Manual, the name in the Manual will appear in brackets after the name in this flora. These will be the only synonyms given.

PREFACE TO THE ANNOTATED LIST

In the Flora of the Crested Butte Quadrangle by J.H. Langenheim,* to whose pioneer work in the Gunnison Basin this study owes something on nearly every page, the vegetation of the Crested Butte Quadrangle is divided into eight major elements: Circumboreal, Boreal America, Widespread North America, Widespread Western North America, Rocky Mountains, Great Basin-Colorado Plateaus, Southwestern United States, and Adventive; the Rocky Mountain element is then further divided into six minor elements. In a study such as the present one, announcedly interested in the distribution of plants, it probably goes without saying that first among the annotations of the following list will come the element to which a species belongs.

Yet this study is also interested in theory, and for the sake of theory the above kinds of elements can certainly be reduced. Circumboreal and Boreal America can certainly be reduced simply to boreal, all the more since the distinction between Circumboreal and Boreal America frequently rests upon the individual author's taxonomic opinion as to whether two species are involved or only one. Boreal in this study, then, will stand for that broad belt of vegetation, whether of arctic wastes or coniferous forest, that extends southeasterly across the North American continent from Alaska to the Gaspé Peninsula and the mountains of New England.

As for Widespread Western North America and the Rocky Mountains, it seems to me that these can conveniently be condensed into cordilleran. Not only does the flora of the Sierra Nevada and the Cascades merge in the northwest with that of the Rocky Mountains, but two years of residence close to the ponderosa pines of the Sierran forest early left me with an inextinguishable impression of the unity of the two floras. In this study, cordilleran will refer to the vegetation of the mountains

* Madroño 13: 64-78; 1955.

and intermontane valleys of western North America, whether meaning the mountains on both sides of the Great Basin or the Rocky Mountains alone.

Next comes the Great Basin-Colorado Plateaus element, which can be reduced to a Great Basin element, since it is well known that the Great Basin floristic province far exceeds the Great Basin hydrographic province.

It was here that I first experienced difficulty. Although using the conservative criterion of center of distribution, and going out of my way to consult monographs as well as manuals, my first statistical rundown gave me unexpected figures. The cordilleran element turned out to constitute nearly 55 per cent of the total, the boreal about 30 per cent, while the Great Basin element amounted only to about 1 1/2 per cent.

Now I had known that the cordilleran and boreal elements would preponderate in that order; but not to that extent! And as for the Great Basin element, such a small proportion as 1 1/2 per cent seemed scarcely worthy of the term "element." In fact my next thought was to question the accuracy even of the 1 1/2 per cent. Perhaps here was no migration at all, but a 1 1/2 per cent identity of descent from a common stock. Perhaps the Great Basin itself was but the largest of the cordilleran intermontane valleys, its flora totally derived from cordilleran stocks, although increasingly specialized as the climate became more arid. If this were true it would make as much sense to talk of a Gunnison Basin element in the Great Basin as of a Great Basin element in the Gunnison Basin!

Unwittingly, I had stumbled upon the unified theory of floristic origins I had long been looking for. For as surely as the two branches of the cordilleran flora join in the northwestern United States and in southwestern Canada, so the united cordilleran flora indistinguishably merges with the boreal flora in Alaska and in the Yukon and Northwest Territories. In fact, by looking south from Alaska and the Yukon and Northwest Territories,

instead of north from the United States, it is clear that a good deal of the cordilleran flora can be regarded as a specialization of the boreal flora, a specialization that increases the farther south that one goes.

But only a good deal of the cordilleran flora can be so regarded, for it is clear that one can also look north from Mexico into the western United States, in which case the cordilleran region, especially that of the Rocky Mountains, has served as a vehicle for the northward migration of Sierra Madrean plants. In either case, from Miocene times onward, the greater moisture of the cordilleran mountains (even if low) would have provided an avenue for the migration of plants not furnished by the drier grasslands of either side. Indeed there must have been a continuous double migration, and the plant geographer will surely be pardoned an amused query as to when Purshia tridentata, with its small three-toothed leaf, passed, on its way north, Artemisia tridentata, with its small three-toothed leaf, on its way south.

In any event, whether composed of Sierra Madrean offspring that never got beyond Colorado, or of cordilleran offspring that can no longer live north of Colorado, the southwestern element in this flora will comprise plants found only in Utah, Colorado, Arizona, and New Mexico, with perhaps an occasional extension to western Texas, or to eastern California, or to northern Mexico. These species constitute a small, but interesting, segment of the flora of the Gunnison Basin.

By the same token, the term "Coloradan" will refer to species confined to Colorado whether representing a refinement of cordilleran or of Sierra Madrean stock, while the term "Gunnison Basin" will indicate the very small number of species endemic to the Gunnison Basin. No Great Basin element will be recognized in this flora, and no element from the plains and prairies to the east. As suggested in the Introduction to this work,* a plains or prairie species found in the Gunnison Basin will be

* See above, p. 11.

regarded as a relict of that time, geologically not so far distant, when instead of high peaks and Great (as well as Gunnison) Basins, the landscape consisted of plains and mountains of low relief. A few plants will also be listed as widespread North American, these plants, too, being regarded, not as migrants, but as ancient residents. Thus in the following Annotated List, boreal, cordilleran, southwestern, Coloradan, Gunnison Basin, relict of the plains, and widespread North American will be the phytogeographical terms used for the native plants, and these will appear first in the annotations.

But before taking up the remaining annotations that will appear in the ensuing list I should like to devote a final page or two to this theory I am proposing to account for the origins of the flora of the Gunnison Basin. I wish to stress that the sources of this theory are entirely botanical although, as it appears, the theory is supported by recent geological thinking.

For instance, among American botanists, it seems generally to be believed that the species of Astragalus in other parts of the country came from the Great Basin, although if from anywhere, it would seem more logical to me to suppose that they came from Asia via the cordilleran link.* However this may be, in order to test the Great Basin theory of astragalan origins, I examined the 120 species of Astragalus listed for Nevada and Utah in Tidestrom's well-known flora of that region. Of these 120 species, less than 10 per cent have been collected in the Gunnison Basin. In other words, more than 90 per cent of these Great Basin species are not known in the Gunnison Basin, while at the same time, more than

* Thus in speaking of the Prairies and Plains Province, Gleason, in perhaps my favorite of all botanical books, The Natural Geography of Plants, states that the buffalo grass and the grama grasses came from the Sonoran Province and that the Great Basin Province furnished the various species of Artemisia and Astragalus. Cf. Chapter 17, page 222.

than half of the Gunnison Basin species are not listed in Tidestrom. In the light of such disparate figures, would it not be more reasonable to assume a similar, and even contemporary, colonization of both basins from cordilleran sources? As a matter of fact, with such a plastic genus as Astragalus, there would be endemism as well as colonization. Indeed, two of the twenty-two Gunnison Basin species of Astragalus are endemic to the Gunnison Basin, and one would expect a similar or greater proportion to be endemic to the Great Basin.

As a matter of fact I am at a loss to understand how the Great Basin ever came to be regarded as a center of exportation of plants to the surrounding regions. The Great Basin floristic province is a creation of the double rain shadow cast by the Sierra-Cascades on the west, and by the Rockies on the east. Yet this double rain shadow, geologically speaking, like the Gunnison Basin itself, is a thing of yesterday. Gerald Richmond tells us that where now stand the Rocky Mountains, as recently as the end of the Middle Pliocene stood only "widespread rolling hills and gently sloping pediments."* Daniel Axelrod is equally emphatic about the Sierra Nevada. He finds their present-day uplift to have occurred almost entirely after the Pliocene, and as a matter of fact, uses the paleobotanical evidence of a lack of rain shadow to prove his point.**

My own belief is that as late as the Yarmouth interglacial there was grassland to the west, as well as to the east, of the unspectacular Rockies of those days, and that the very forces which began at that time to create the Gunnison Basin began at the same time to create the double rain shadow of the Sierra and the Rockies, and thus the floristic Great Basin that we know today.

Second in the annotations will appear the altitudinal range of a species expressed in zones. This is of im-

* The Quaternary of the United States, Princeton, 1965, page 217.

** Bulletin of the Geological Society of America, 73: 183-198; 1962.

portance because in the altitudinal range of a plant appears not only the ecology of the species but that remarkable unity within diversity already discussed as one of the chief characteristics of the flora of the Gunnison Basin.*

There could be no better case in point than that of Artemisia tridentata, the common sagebrush of the West. At home principally in the submontane, or foothills, zone of the Gunnison Basin, nevertheless, as pointed out in J. H. Langenheim's Vegetation of the Crested Butte Area,** it climbs in favored sites to over 12,000 feet. In other words, although the chief plant of the foothills zone, it yet occurs in all the other zones. Furthermore it occurs not alone, but usually in a shrub-grass association, the common grass of this association in the foothills being Poa secunda, while in the upper zones of the northern half of the Basin it is Festuca Thurberi, in the upper zones of the southern half, Festuca arizonica.

The foothills, or sagebrush, zone must comprise at least a third of the Gunnison Basin. Gazed at from Mt. Ouray above Marshall Pass, it takes on a brownish color in the sun, and seems to be the real, although sloping, floor of the Basin, since the meadows of the river floodplains are too narrow to be seen. Such a view brings out the long-recognized similarity between the Gunnison Basin and the northern Great Basin. For there is no pinyon-juniper zone, no zone that can be called transitional. The sagebrush-grass association climbs the gentle slopes right up to the forests of the montane zone, and what individual junipers there are are lost to view in the universal expanse of sage.

The remaining three zones are less extensive than the foothills zone, and not much needs to be added to their presentation in the Introduction.*** It is possible that students of the vegetation of the Gunnison Basin may

* See above, pp. 3-4, 6-7, and 9.
** Ecological Monographs, 32, 256-258; 1962.
*** See above, pp. 1-2.

wish to divide two of them into upper and lower components. Thus the lower montane zone, from 8,000 to 9,000 feet, is the zone where forests of Douglas fir or of ponderosa pine may be encountered. When the 9,000-foot mark is passed, there is an obvious change toward greater luxuriance of plant growth, and it is in this upper montane zone that aspen forests become their own climax. The beauty and vigor of these forests must be seen to be believed, a good example in the northern half of the Basin being found at the head of Ohio Creek, and in the southern half of the Basin, in the valley of Elk Creek, along the road from the Lake Fork to the Alpine Guard Station.

The alpine zone also yields profitably to a division into upper and lower parts. The lower alpine zone, from 11,500 to 12,500 feet, is the zone of the upland herb community, so well set forth in Langenheim's Vegetation of the Crested Butte Area. Of this striking formation, the most accessible example occurs on the top of Slumgullion Mesa, a few hundred feet above, and to the west of, Slumgullion Pass in Hinsdale County. Here, at 12,000 feet, are acres and acres of tallish sedges and grasses, variegated with colorful penstemons, castillejas, senecios, cerastiums, and other flowering herbs. It, too, must be seen to be believed (and visited in a year of normal summer rain). In contrast, the upper alpine zone, from 12,500 to 13,500 feet, is the zone of cushion plants and of low grasses, sedges, and forbs seeking the protection of ridges of rock that may be only inches in height. Here more than half the land is without vegetation.

However, in the annotations to follow, the divisions into upper and lower, montane and alpine, zones will not be used. Furthermore, since one of the striking characteristics of the vegetation of the Gunnison Basin is the continuous distribution of a species from its lowest to its highest altitude, this continuity will be assumed of all the species although, needless to say, the actual records are not complete for each and every one of them.

Third in the annotations will appear the lateral distribution of a species expressed by means of representative

collections. Since one of the uses of this flora will be as an atlas of where the plants can be found, the stations of the representative collections will be set down with a good deal of care, and a glossary of place names will be provided at the end of the volume to assist the plant collector in his search for the place of occurrence. Usually, only one collection will be cited for a given station; but if there is a question of the permanence of a station, then a second collection will be cited to show that the station was extant at the time of the second collection. Sometimes a second collection will be cited to show an interesting difference of form or of habitat. Many collections contain the year of collection in the collection number; but if they do not, the year will be given. In the collections of the author and of his assistant, Stephen Spongberg, the year of collection appears at the end and at the beginning of the collection number respectively, even some of the joint collections using this system to keep track of who did the actual collecting. The author's collections range from 1952 through 1967, those of his assistant from 1962 through 1967.

The herbaria in which the cited collections are to be found, as well as the collectors who did the collecting, will be indicated by abbreviations, the meaning of which will also be given in a glossary at the end of the volume. The collections that are assigned to no herbarium are in the author's own working herbarium, which contains the largest single collection of Gunnison Basin plants and has been indispensable to the compilation of this flora, but the disposition of which has not yet been decided. Most of these unassigned collections have distributional significance only. The taxonomic significance that a few of them have will be brought out in the text.

Fourth and last among the annotations will come various details of plant geography, ecology, and taxonomy. In this respect, the reader is entreated to remember that this work is an annotated list and not a manual.

ACKNOWLEDGMENTS AND FINAL REMARKS

A study that has been in progress for many years acquires an indebtedness to many individuals all along the way. To the curators of the three principal Colorado herbaria, C.W.T. Penland, H.D. Harrington, and W.A. Weber, at Colorado College, Colorado State University, and the University of Colorado respectively, I owe my thanks for much hospitality and many favors. It was W.A. Weber who proposed this study and gave me encouragement in the early years when it was most necessary. To my wife, Beth Barrell, and to Stephen Spongberg, I owe my further thanks for companionship and assistance on innumerable collecting expeditions. And my gratitude extends to the many residents of the Gunnison Basin who, in the absence of topographic maps for various sections of the Basin, were unwearied in passing on to me all the information at their command. To A.A. Beetle and to F.J. Hermann I owe a peculiar debt. Many years ago I started sending to them and discussing with them the grasses and sedges and rushes of the Basin. If these sections of the ensuing flora have any extra worth, it will be in no small part owing to them. To P.A. Munz and to G.A. Argus I am indebted for assistance with the difficult genera of Epilobium and Salix.

A few words are finally in order about the use of this list as a practical guide to the plants of the Gunnison Basin. As the years wore on, and the compactness of the flora of the Gunnison Basin kept pace with an increasing familiarity on my part with its diverse species, it became easier and easier to separate them. This increasing ease I wished to convey to the readers of my flora. Take Cirsium. Whether on account of overlapping characters or because of ambiguity of terms, I know of no really successful key to the genus--at least none that students can use and not go astray on. Yet in the Gunnison Basin there are only half a dozen species, and it does seem that a person who knows them should be able to make their differences clear to students and newcomers. For instance, there is arvense, the only species with

numerous small heads--an adventive found in disturbed soil in the lower parts of the Basin. Then there is Parryi, the only thistle with yellow flowers--found in moist meadows and woods in the upper parts of the Basin. There is also undulatum, confined to sagebrush, Douglas-fir, and ponderosa-pine habitats. It usually has a constriction around the middle of its heads; and below the spines at the top of the bracts or phyllaries, it always has a glutinous ridge that when pressed (and looked at under a handlens) appears like a pleating. Again, there is Drummondii, the only thistle occurring in populations showing all ranges in height from complete stemlessness to stalks a yard high. Every year there is a display of this plant, at all heights, inside the fences and along the grassy roadside ditches of Route 50 west of Gunnison. Then there is hesperium, a thistle restricted to rocky slopes at higher altitudes, with pink flowers and crinkled, three-dimensional leaves. Finally there is Hookerianum, much like hesperium, but with two-dimensional leaves and with arachnoid hairs in addition to the multicellular hairs of the involucre. In other words, it seemed to me that in some degree the annotations themselves could take the place of the usual keys, freeing the text of many pages and at the same time giving the reader a more immediate guide to the plants.

To this end, when I wrote this flora, I did not regard the species as units, but rather, regarded the genera as units, frequently giving the most telling character of a species, not under the species itself, but under the preceding or following species, or wherever it seemed most effective. In other words, the way to use this list as a practical guide to the plants is to browse around in the genus.

Finally, I hope that the person using this flora will have access to some of the illustrated books that deal with the plants of western North America. The illustrated manuals of the Pacific States and of the Pacific Northwest have already been mentioned.* It is surprising how well they work for the Gunnison Basin. Again, the Hitchcock-Chase Manual of the Grasses of the United States (still available from the Government Printing Office for less than five dollars) illustrates every grass to be found in the Basin. As for the members of the genus Carex (almost as numerous in the Gunnison Basin as the grasses), the two large volumes of the Creutzburg drawings are also to be had at moderate cost, thanks to the generosity of the author, Kenneth Kent Mackenzie, who not only paid for the drawings but left ten thousand dollars to pay for their publication. And as if these riches were not enough, F. J. Hermann's Manual of the Carices of the Rocky Mountains and Colorado Basin, with individual drawings for each of the plants described, will be appearing about the time of publication of this particular study.

* See above, p. 35.

Nor should one be contemptuous of the illustrated booklets in the drugstores. Many of the drawings and photographs are excellent. Even the most hardened professional might well pick up an interesting insight, or a stray observation, from one of these little books. In any event, it is assumed that the user of this flora will be familiar with most of the genera before consulting its pages, that he will know what a thistle is, a goldenrod, a maple, a buttercup, a lupine, and so on. If he does not, then he had certainly better begin with one of the popular texts. What he needs in the way of specialized vocabulary he can pick up from the glossary of terms included in this volume.

THE ANNOTATED LIST

ACERACEAE, The Maple Family

Acer L., The Maples

Acer glabrum Torrey; cordilleran; montane-submontane; Gothic, B 121-52; Signal Peak Ridge, B 14-61; Steuben Creek Valley, B 174-65. The Rocky Mountain maple is a shrub rather than a tree; but with its characteristic maple leaf (even if well dissected), it cannot be mistaken. The box elder (A. Negundo L.), which has compound leaves, has been collected in the Black Canyon, twenty miles west of the Gunnison Basin, but as far as I know does not emerge on the floor of the Basin.

ADOXACEAE, The Muskroot Family

Adoxa L., The Muskroot

Adoxa Moschatellina L.; boreal; montane-alpine; Cathedral, B&S 211-62; Gothic Natural Area, B 265-61; Snow Mesa, B&S 322-62. The muskroot is the only species of its genus and family, and is a delicate, low, woods and rock plant. It sends out slender rhizomes between the rocks and under the leaves and humus, and may be identified by the small head of green flowers or fruits arising on its peduncle from between a pair of compound leaves.

ALISMACEAE, The Waterplantain Family

Alisma L., The Waterplantains

Alisma Plantago-aquatica L.; boreal; submontane; Gunnison, B 199-60 RMBL. Known only from the ditches around Gunnison, this plant is nevertheless easily recognized. The smooth, oval leaves on their long petioles are all basal, and the flower stalks bearing their ascending whorls of peduncles rise more than two feet high.

AMARANTHACEAE, The Amaranth Family

Amaranthus L., The Amaranths

Amaranthus albus L.; widespread North American; submontane; Parlin, W 9439 (1955) COLO. This tumbleweed may be recognized by its small, axillary clusters of flowers without a corolla, and by its small, oval leaves on relatively long petioles. Both this and the next species were named by Linnaeus from Pennsylvania specimens, but their geographic origins are uncertain.

Amaranthus retroflexus L.; widespread North American; submontane-montane; Gunnison, B 334-61; Jack's Cabin, B 204-60 RMBL; Fish Creek Valley, B&S 555-62. The apetalous flowers of this amaranth differ from those of the preceding by occurring in spikes rather than in clusters. The leaves also are obtusely lanceolate rather than oval, while the pointed bracts surrounding the flowers are more prominent.

ANACARDIACEAE, The Cashew Family

Rhus L., The Sumacs

Rhus radicans L.; widespread North American; montane; Glacier, S 65-202 RMBL. With its large trifoliate leaves characteristically indented on the sides, it does seem as if poison ivy should be known to every one. It is not frequent in the Gunnison Basin; in fact the above is the only known station.

Rhus trilobata Nuttall; cordilleran; montane-submontane; Almont, B 121a-59; Cathedral, B&S 426-62; Parlin, B 10-65. The squawbush, or skunkbush, as it is called indifferently, also has trifoliate leaves; but they are small, and the leaflets are round-toothed at the top, wedge-shaped at the bottom. The fruits are red berries, and the flowers appear before the leaves in early spring.

APOCYNACEAE, The Dogbane Family

Apocynum L., The Dogbanes

Apocynum androsaemifolium L.; widespread North American; montane-submontane; Gothic, B 122b-59 RMBL; Fish Creek, B&S 415-62; Gunnison, B&S 74-66. This plant, the spreading dogbane, is closely related to the milkweeds, and the small, individual blossoms certainly suggest it in coloring and general appearance. It is a bushy plant, with numberless lanceolate leaves that are very nearly sessile, and it seems partial to disturbed soil.

ASCLEPIADACEAE, The Milkweed Family

Asclepias L., The Milkweeds

Asclepias Hallii Gray; Coloradan; montane-submontane; Cement Creek Valley, L 788 (1950) COLO; Gunnison, B 93-60 RMBL; Cochetopa Park, H 9090 (1959) CS; Cathedral, B&S 280-62; Red Creek Valley, S 64-103. The most frequent of the two Gunnison Basin species, Hall's milkweed may be identified by its flat-topped umbellate clusters of flowers, and by its long, lanceolate leaves.

Asclepias speciosa Torrey; cordilleran; montane-submontane; Gothic, B 122a-59 RMBL; Gunnison, B 88-60; Lake City, S 62-49. In contrast to the preceding species, the showy milkweed has hemispherical umbellate clusters of flowers and broadly lanceolate to oblong leaves.

BERBERIDACEAE, The Barberry Family

Berberis L., The Barberries

Berberis repens Lindley; cordilleran; submontane-subalpine; Sapinero, Wh 597 (1898) COLO; Gothic, L 184-48 COLO; Marshall Pass, B 88-61; Fish Creek Valley, B&S 33-62; Lake San Cristobal, Ke 6/25/49 WS. Growing low to the ground, the Oregon grape is one of the handsomest and most widespread of plants in the Gunnison Basin. Its leaves are hollylike, its flowers bright yellow, and its berries blue.

BORAGINACEAE, The Borage Family

Cryptantha Lehmann, The Cryptanthas

The cryptanthas are supposed to be a difficult genus, and indeed they are, if one takes a large area for his field of study. But in the Gunnison Basin only seven species have been collected, and it does seem that if these seven are divided into two or three groups, the individual species can be separated without too great an effort. As a matter of fact, most of the species seem to be either compact plants, with inflorescences that are dense, rounded thyrses, or more open, brushy plants where the thin, individual racemes unroll themselves in scorpion fashion. The former thyrsoid plants, with their conspicuous, white or yellow inflorescences, are the more handsome of the two groups, the ones that amateur collectors will chiefly enjoy collecting. The latter, scorpioid plants seem rather like weeds (which indeed some of them are), and will be apt to interest the professional more than the amateur. Both groups, of course, bear a marked resemblance to each other, much of which is owing to their copious pubescence, a pubescence composed both of capillary and of setose hairs.

The thyrsoid cryptanthas

Cryptantha Bakeri (Greene) Payson; southwestern; submontane-montane; Hierro, W 9145 (1955) COLO; Sargents, B 91-61; Midway, B 14-64; Lake Fork Canyon, B&S 114-62. This is the common thyrsoid cryptantha of the sagebrush country stretching from Sargents to Sapinero. The thyrses are set off by occasional linear leaves that curve out and point upward,